SSDL Newsletter

Prepared by the Joint IAEA/WHO Secretariat of the Network of Secondary Standards Dosimetry Laboratories https://ssdl.iaea.org

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From the Editor

In December 2020 we bid farewell to Ms Paula Toroi. We thank Ms Toroi for her contribution to the IAEA/WHO SSDL network. She remains in the SSDL family as she is now working for the SSDL of Finland. We wish Ms Toroi all the best in her new journey. We welcome Ms Zakithi Msimang as an SSDL officer. She comes with more than ten years of experience working at the SSDL in South Africa, having initially trained as a medical physicist. The IAEA's Dosimetry and Medical Radiation Physics Section (DMRP) also welcomes Ms Olivera Ciraj Bjelac, a Medical Physicist (Imaging); Mr Egor Titovich, Associate Database Officer (Medical Physics); Ms Cherry Abraham-Ponti (Dosimetry Services Assistant) and bids farewell to Ms Karen Christaki, Head of Dosimetry Laboratory.

This issue of the SSDL newsletter is focussed on the members. It highlights the international measurement system for radiation dosimetry and includes contributions from members on their capabilities, resources and a short history on when their laboratories were established. We trust this newsletter will assist laboratories to identify possible collaborators for future projects. This newsletter would not have been possible without having these laboratories submit their stories.

Incoming and outgoing SSDL officers, Ms Zakithi Msimang and Ms Paula Toroi

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Services provided by the IAEA 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 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 postal dose assurance 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). The IAEA Calibration and Measurement Capabilities (CMCs) have been reviewed and published in Appendix C of the Comité International des Poids et Mesures (CIPM), Mutual Recognition Arrangement (MRA).

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

The range of services is 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 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 to dosimeters for radiation protection	X rays and γ rays from ^{137}Cs and ^{60}Co beams

* Brachytherapy calibration services are not included in the IAEA CMCs.
** Technical procedures and protocols for calibrations and comparisons are available on our website https://ssdl.iaea.org/
***Thermoluminescence dosimeters (TLDs) were replaced by RPLDs in 2017.

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

Contents List

International Organizations

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SSDL Members

The International Measurement System for Radiation Dosimetry

Mr. S. Judge, Mr. D. Burns, Ms. C. Kessler, Ms. P. Toroi and Ms Z. Msimang

Accurate measurement of radiation dose is key to the safe and effective use of ionizing radiation for cancer therapy and radiation protection. All such measurements rely on the international measurement system – the technical and administrative infrastructure that has been developed over many years to ensure measurements can be carried out at an accuracy that is fit for purpose.

This infrastructure is often invisible, but it underpins all SSDL calibrations and services. This short article aims to explain how the international system gives confidence in radiation dosimetry and how it is implemented in practice. The article will clarify why it is important to ensure that measurements and calibrations can be linked to a single standard that is accepted worldwide.

The metric system of measurement

The story goes back to the origins of the metric system of measurement. Towards the end of the 18th century, it became clear that the bewildering confusion of units of mass and length (different units were used in different towns and by different professions) was hindering trade. The problem was particularly acute in France where there was no unified system, and a group of academics set out to define new units based on 'universal natural units' that belonged to no particular country, to avoid the problem of national pride. Gradually the logic and simplicity of this approach was appreciated in other countries, and this eventually led to an international treaty called the Metre Convention [1].

The treaty was signed in Paris on 20th May 1875 and it established a structure for governments to work together on measurement science and standards. Delegates from governments attend a conference (the Conférence Générale des Poids et Mesures (CGPM)), which normally takes place once every four years, to discuss the arrangements for the propagation and improvement of the International System of Units (SI). The treaty also set up 'a scientific and permanent International Bureau of Weights and Measures (the BIPM) with its headquarters in Paris' (see Figure 1); the BIPM operates under the direction of the International Committee for Weights and Measures (CIPM).

The CIPM meets twice a year and has eighteen members from different countries. All the members are experienced senior managers and metrologists and are elected by the CGPM. In turn, the CIPM is advised by technical committees which cover specific fields of metrology: radiation dosimetry, the measurement of radioactivity and neutron metrology are covered by the Consultative Committee for Ionizing Radiation (the CCRI) which is chaired by a member of the CIPM. The mission of the CCRI is to 'enable all users of ionizing radiation to make measurements with confidence at an accuracy that is fit-for-purpose'. The IAEA is a liaison organization in the CCRI, linking the work of the IAEA Laboratories and the SSDL network to the international measurement system.

The influence of the Metre Convention has grown from the original 17 countries to 62 member states plus 41 associated states and economies[1]. The work was strengthened in 1999 with the publication of the CIPM Mutual Recognition Arrangement (CIPM MRA) [2], which describes in more detail how the international measurement system functions.

Figure 1. The Bureau International des Poids et Mesures in Paris, France, (Photo by BIPM)

[1] Numbers as on 26 January 2021

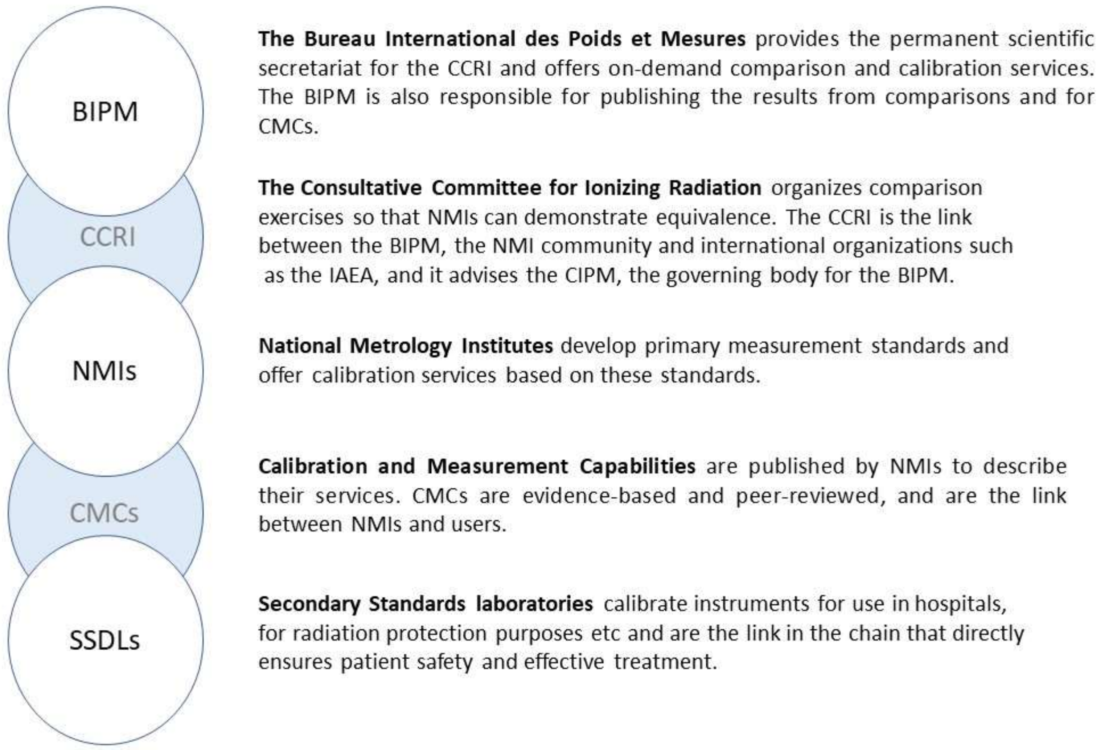

Figure 2. The traceability chain for measurements for Ionizing Radiation

Radiation dosimetry in practice

The Metre Convention and the CIPM Mutual Recognition Arrangement set out the framework for the system to ensure accurate and harmonized measurements worldwide. From a scientific point of view, national metrology institutes (NMIs) are at the heart of this system (see Figure 2). The NMIs develop and maintain primary measurement standards and offer calibration services based on these standards to secondary laboratories and other users. Primary standards for radiation dosimetry are complex and sensitive instruments; several approaches can be used to realize standards for absorbed dose and kerma (an overview of common methods is given in [3]). The different methods have advantages and disadvantages, the challenge is how to ensure that a primary standard realized in one country is equivalent to a primary standard in another country.

The CIPM MRA addresses this problem and describes the steps that an NMI should take to demonstrate the equivalence of their primary standards and the associated services to those in other countries. There are three main requirements, similar in many ways to those for SSDLs in the IAEA/WHO network:

- Participating in international comparison exercises
- Operating a quality assurance management system (ISO17025)
- Ensuring independent peer-review of services

For the first requirement, the CCRI has established a robust approach for organizing comparisons of primary dosimetry standards. The Ionizing Radiation Department at the BIPM has a set of primary standards and reproducible radiation beams, for energies from low-energy X rays through to radiotherapy beams from a LINAC. In 1999, the CCRI agreed that the BIPM standards would be accepted as the world standard (setting the so-called 'Key Comparison Reference Value'), against which all primary standards would be compared. This decision was taken due to the proven stability and accuracy of the BIPM standards; the main advantage is that comparisons are simple to organize (an NMI sends their standard to the BIPM for comparison against the BIPM standards). The CCRI oversees a regular programme of comparisons, with NMIs expected to send their standards to the BIPM on a ten-year cycle.

The requirement for an ISO17025 quality assurance management system is well known to all calibration and test laboratories and is particularly important for a field such as radiotherapy where calibration errors can have serious consequences.

However, the CIPM MRA places an additional requirement on services offered by NMIs: documentary evidence that the services are accurate must be peer reviewed by colleagues from other NMIs. This gives further confidence in the services.

The results from comparisons and the list of peer-reviewed services are published in a database called the Key Comparison Database (KCDB) which is available on the BIPM website (www.bipm.org).

Consequences for Secondary Standard Dosimetry Laboratories

The system described above has several consequences for the SSDL network:

- SSDLs can arrange calibrations of their secondary standards at any of the IAEA or affiliated Primary Standards Dosimetry Laboratories, confident that a calibration performed by these laboratories will be equivalent to a calibration at another affiliate (Figure 3).
- The IAEA Dosimetry Laboratory can use the high-accuracy services of the BIPM to calibrate its instruments, so the measurement uncertainties for calibrations at the IAEA Laboratory are comparable to those at affiliate laboratories.
- If an SSDL needs a specific calibration service, the Key Comparison Database can be used to find a metrology institute that offers the service.

Conclusions

In conclusion, all calibrations in the SSDL network are harmonized, as they are based on calibrations carried out by a partnership of hub institutes (the IAEA Dosimetry Laboratory, affiliated national metrology institutes and the BIPM). The international measurement system therefore enables the SSDL network to help ensure the safe and effective use of ionizing radiation for patients and radiation workers worldwide.

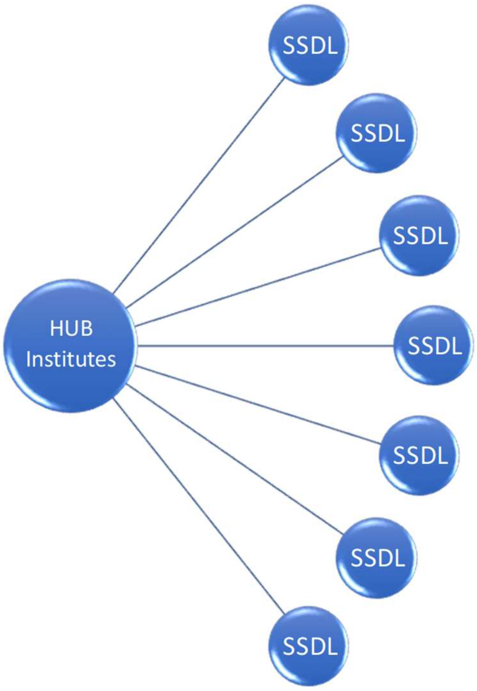

Figure 3. A partnership of hub institutes (the IAEA Dosimetry Laboratory, affiliated national metrology institutes and the BIPM) provide traceability to the SSDLs.

REFERENCES

[1] The Metre Convention, available from the BIPM website: www.bipm.org.

[2] CIPM Mutual Recognition Arrangement, available from the BIPM website: www.bipm.org

[3] SHARPE, P, ed. Special issue on radiation dosimetry, Metrologia 46 (2009).

IAEA Dosimetry Laboratory

P. Toroi, L. Czap, J Cardoso

The IAEA's Dosimetry laboratory (DOL) works as a central laboratory in the SSDL Network. DOL provides calibration, reference irradiation, comparison and audit services for the Member States. The laboratory was established in 1961 with the aim of preparing a dosimetry system suitable for postal dose comparisons amongst radiotherapy hospitals. The calibration service for radiation therapy were established first. Later the services were extended to cover radiation protection, brachytherapy and diagnostic radiology. The IAEA signed the CIPM MRA in 1999 and its CMCs are published in the key comparison database (KCDB). The IAEA has a comprehensive quality management system (QMS) in place for its own CMCs and it is peer-reviewed periodically by external experts. This provides confidence to the SSDL Network for the traceability of the calibrations performed by the IAEA.

Figure 4. The IAEA DOL calibration team. September 2020, from left to right: L. Czap (Dosimetrist), P. Toroi (Previous SSDL Officer), J. Cardoso (Dosimetrist)

DOL is part of the Dosimetry and Medical Radiation Physics section and is located in Seibersdorf, Austria. The laboratory consists of five bunkers and control areas. One of the main activities of DOL is to maintain the reference standards for dosimetry in radiation therapy, radiation protection and diagnostic radiology. The technical details of the actual calibration capabilities of the IAEA can be found on page 3, the IAEA SSDL website and the BIPM KCDB database. The IAEA provides periodic calibration for SSDL reference standards and reference irradiations for passive dosimeters. The services are provided through the SSDL Network, free of charge. Only the transportation cost to the IAEA should be covered by the SSDL. SSDLs in Member States send their reference dosimeters in for calibration and receive a calibration certificate. In this way, the IAEA establishes the link of radiation dosimetry in Member States to the International System of Units (SI). Figure 5 shows the number of calibration certificates that have been issued since 2007.

In addition, the IAEA also conducts bilateral comparisons with SSDLs to validate their measurement capability. This confirms that the measurement capabilities of an SSDL are internationally comparable to results obtained in other countries.

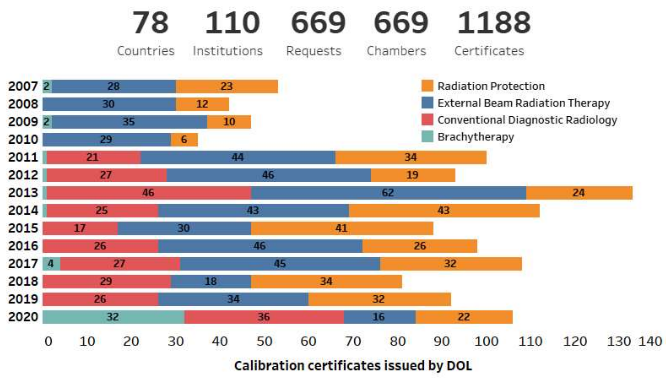

Figure 5. Number of certificates issued at DOL since 2007

REFERENCES

[1] IAEA Dosimetry Laboratory Celebrates 50 Years of Work in Medical Dosimetry

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, SSDL Charter 2nd edition, Vienna (2018).

[3] https://ssdl.iaea.org/

AUSTRALIA

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) operates a primary standard dosimetry laboratory at its Melbourne site. The laboratory sits within the Medical Radiation Services Branch, (MRSB) alongside two other sections, the Australian Clinical Dosimetry Service (providing remote and on-site dosimetry audits), and Medical Imaging (providing diagnostic reference levels, advice and training). The branch's goal, and responsibility, is to promote the safe and effective use of ionizing radiation in medicine across Australia.

The absorbed dose primary standards are a key element within this work because they underpin the high accuracy dosimetry required in radiotherapy.

ARPANSA is authorized by the National Measurement Institute to be the Designated Institute (DI) for radiation dosimetry. Under this authority ARPANSA operates the dosimetry laboratory which maintains and disseminates the standards for Australia.

In addition to medical radiation, ARPANSA has branches for radiation health and regulation. There are 130 staff in Melbourne and 30 in Sydney. With a population of 25 million, Australia is small enough for the primary standards laboratory to provide the majority of radiotherapy calibrations, and so it also acts as a SSDL, providing regular calibration services which are accredited to ISO 17025.

The Medical Branch maintains two linear accelerators, a ^{60}Co teletherapy unit, a ^{137}Cs irradiator, and two X-ray units: 10-100 kVp and 40-320 kVp to support its activities. There are four primary standards: a graphite calorimeter (for absorbed dose to water in MV and ^{60}Co beams), a carbon cavity chamber (for air kerma in ^{60}Co beam) and two free air chambers for air kerma in kilovoltage X-ray beams. The linear accelerators are shared with the Australian Clinical Dosimetry Service, which develops and executes on-site audits for complex radiotherapy treatments throughout Australia. MRSB focuses on providing traceability and quality assurance irradiations for all Australian radiation dosimetry service providers, including the irradiation of personal monitors, calibration of ionization chambers, and on-site measurements of air kerma rate.

The standards laboratory staff are actively involved in international metrology, including regular international comparisons under the CIPM MRA and educational activities.

On-going research into radiation dosimetry includes calculating correction factors for ionization chambers (for the IAEA review of TRS-398), the dosimetry of high dose rate (6,000 Gy/s) synchrotron beams, and the spatial response of radiotherapy detectors, including solid-state detectors and ionisation chambers, with a spatial resolution of 0.1 mm. MRSB also offers an annual week-long dosimetry course which attracts applicants across the region.

Figure 6. Staff of the Primary Standards Dosimetry Laboratory

Figure 7. From left to right: Elekta Versa HD linac at ARPANSA, Medium energy X-ray facility (40-320 kVp)

For further details, please see https://www.arpansa.gov.au

or contact Duncan.Butler@arpansa.gov.au

CANADA

National Research Council of Canada (NRC-CNRC)

The NRC is the National Measurement Institute for Canada. Ionizing radiation metrology activities address the four main application areas of:

- Radiation therapy and imaging
- Personnel and environmental radiation protection
- Radiation processing (high-dose)
- Security and safety

The NRC IR laboratories are located in Ottawa, the capital city of Canada, and operation dates back to the early 1950s (beginning with kV X-rays and Co-60).

Currently there are 20 research and technical staff working on measurement standards, detector development and investigation, calibration services, and certified reference materials. A wide range of facilities support these activities including:

- Co-60 irradiators (both therapy and protection level)
- Cs-137 irradiator (protection level)
- kV X rays, 10 kV-250 kV (for therapy, protection and diagnostic radiology applications)
- Brachytherapy systems for HDR (Ir-192) and LDR (I-125) delivery
- Linear accelerators, two clinical linacs (one with 120-leaf MLC), one specialized research machine (4-35 MV photon, 3-35 MeV electron; protection to industrial dose rates)
- Neutron sources (Am-Be, Cf, d-p generator)
- Radiochemistry lab (source preparation)
- Radionuclide metrology lab (α, β, γ measurements)

For more details on the NRC facilities and the calibration services: https://nrc.canada.ca/en/certifications-evaluations-standards/instrument-calibration-services/ionizing-radiation-standards-calibration-services.

Figure 8. Facilities at the NRC. From top left to bottom right: Co-60 therapy level calibration laboratory, 10-50 kV X ray primary standard, Ir-192 brachytherapy source characterization; low-scatter laboratory for radiation protection measurements, 5-40 MeV research linear accelerator, IGRT-enabled clinical linear accelerator

In addition to physical standards and calibration services, NRC maintains the Monte Carlo radiation transport system EGSnrc, recognized as one of the most accurate and efficient systems for the simulation of photon and electron beams.

For more details and to download please visit: https://nrc.canada.ca/en/research-development/products-services/software-applications/egsnrc-software-tool-model-radiation-transport.

NRC is an active member of the SIM (Sistema Interamericano de Metrologia) MWG6 working group on ionizing radiation metrology and a member in all three sections of the Consultative Committee on Ionizing Radiation (CCRI) at the BIPM.

NRC demonstrates the international equivalence of its standards through participation in the BIPM comparison programs (www.bipm.org/kcdb).

NRC is currently the pilot laboratory for a comparison of Co-60 air kerma and absorbed dose standards within SIM and also the pilot laboratory for a global high-dose Co-60 comparison organized under the CCRI (for industrial applications). NRC staff publish through refereed journals, conference proceedings and technical reports and an institutional repository is maintained at https://nrc-publications.canada.ca/eng/home/.

For further details, please contact malcolm.mcewen@nrc-cnrc.gc.ca

GERMANY

Physikalisch-Technische Bundesanstalt (PTB)

The Dosimetry for Radiation Therapy and Diagnostic Radiology department of PTB (the National Metrology Institute of Germany) comprises the fields of external radiation therapy, diagnostic radiology and medical X ray imaging. The broad spectrum of metrological tasks is aimed at enabling and supporting high-level quality-assured and traceable dosimetry and imaging in routine clinical work. In addition to the operation of primary standards and the calibration of secondary standards, the execution of legal tasks stipulated by German legislation, research and development and the preparation of standards and recommendations are addressed in the department. In detail, the tasks are:

- Realization and dissemination of the unit "gray" for the measurand absorbed dose to water for X radiation (≤ 300 kV) and high-energy photon and electron radiation (≥ 1 MeV).
- Realization and dissemination of the unit "gray" for the dose quantity air kerma free-in-air for X and gamma radiation.
- Development of dose measurement procedures and of measurement technology for the quality assurance of dosimetry in modern radiation therapy and diagnostic radiology.
- Research and Development of dosimetry for modern external radiation therapy and diagnostic radiology.
- Medical imaging using X radiation: quantification of image quality depending on the diagnostic problem.
- Quality assurance for clinical dosimetry within the scope of the German Medical Devices Act.
- Type approval of dosimeters for diagnostic radiology in compliance with the German Measures and Verification Act.
- Involvement in the development of national and international recommendations and standards.

The department (Head: Dr. Ulrike Ankerhold) consists of five working groups: First working group (Head: Dr. Ludwig Büermann) is responsible for the tasks in dosimetry for diagnostic radiology; second and third groups (Heads: Dr. Ralf-Peter Kapsch, Dr. Achim Krauss) address dosimetry in radiation therapy; fourth group (Head: Dr. Mathias Anton) is focused on the image quality assessment for X ray diagnostics; and fifth group (Head: Dipl.-Ing. Markus Meier) is responsible for the infrastructure of the department, i.e. further development and operation of the irradiation facilities, measuring stations and experimental set-ups.

Figure 9. PTB's water calorimeter (with the cooling system) in front of the clinical linac

Several irradiation facilities with complex measuring stations and control techniques are available in the department:

- Several X ray facilities (tube voltages: 6 kV to 450 kV) for generating reference fields for diagnostic radiology, radiation therapy and radiation protection dosimetry.
- A gamma irradiation facility equipped with several Cs-137 and Co-60 sources of different activities for tasks in dosimetry for diagnostic radiology and radiation protection dosimetry.
- A gamma irradiation facility equipped with a high-activity Co-60 source for tasks in dosimetry for radiation therapy.
- Two clinical electron linear accelerators (6 photon fields from 4 to 25 MV and 9 electron fields from 4 MeV to 22 MeV).
- An electron accelerator for research with energies tunable from 0.5 MeV to 50 MeV.

The unit "gray" of the absorbed dose to water, D_w is realized by means of water calorimetry. In Co-60 gamma radiation under reference conditions, D_w can be determined using the primary standard water calorimeter with a combined standard measurement uncertainty of 0.2 %. A copy of the Co-60 primary standard is used to determine D_w in high-energy photon and electron beams produced by PTB's two clinical linear accelerators.

The realization of the absorbed dose to water for radiation therapy with medium energy X rays (tube voltage: 70 kV to 300 kV) is also based on water calorimetry. Within the scope of research collaborations, D_w was realized by means of a water calorimeter in clinical C-12 ion radiation at the Heidelberg Ion Beam Therapy Center (HIT) and in the radiation field of an MR linac for the new MR-guided radiotherapy modality. For more information, please visit: https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/fb-62/623-unit-of-absorbed-dose-to-water.html).

For the primary realization of the unit "gray" of kerma free-in-air, K_a, several primary standards are used depending on the photon energy.

It is realized in Cs-137 and Co-60 gamma radiation fields by means of graphite cavity chambers as primary standards (expanded standard measurement uncertainty: 0.4 %).

For X radiation up to 400 keV, three free-air chambers are in operation (expanded standard measurement uncertainty: 0.6 %): a parallel-plate chamber for energies from 10 keV to 120 keV; a cylindrical free-air chamber for 30 keV to 300 keV; and a large parallel-plate chamber for 50 keV to 400 keV.

For more information, please visit:
https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/fb-62/625-dosimetry-for-diagnostic-radiology.html.

The international key comparisons of the primary standards organized by the BIPM substantiate the Calibration and Measurement Capabilities (CMCs) of PTB.

A list of the services provided by this department, together with the respective contact persons, can be found at: https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/measurement-and-calibration-capabilities/dosimetry.html.

For further details, please see https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/fb-62.html or contact ulrike.ankerhold@ptb.de

ITALY

Istituto Nazionale di Metrologia della Radiazioni Ionizzanti (ENEA-INMRI)

The Italian Institute of Ionizing Radiation Metrology (INMRI) was established in Rome in the 1980s within the now called Italian Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and was officialized in 1991 as a National Metrology Institute (NMI) by the Italian Parliament. In 1999, ENEA-INMRI became one of the three Italian NMIs signatories of the Mutual Recognition Arrangement (MRA). Since its very beginning, the Institute was oriented towards the establishment of standard instruments in the areas of dosimetry, radioactivity, and neutron measurements. ENEA-INMRI became official member of the BIPM CCRI sections I (dosimetry) and II (radioactivity) in the 1990s and of the CCRI section III in the 2010s. The Institute is organized in three sections (dosimetry, radioactivity, neutrons) and currently counts about 15 staff persons (70% research scientists, 30% research technicians, one administrative assistant).

In dosimetry, the Institute has two X ray tubes, multiple sources of ^{241}Am, ^{137}Cs and ^{60}Co for radiation protection dosimetry and a high dose rate ^{60}Co source for radiotherapy dosimetry. Primary standards include free-air chambers, cavity chambers and graphite calorimeters, including two primary standards for brachytherapy dosimetry in low and medium dose rates. ENEA-INMRI activities are also focused on the standardization of measurement procedures for dosimetry, including the study and characterization of radiation detectors (ionization chambers, solid state detectors, radiochromic films), Monte Carlo calculation of dosimetric parameters and correction factors, and participation in commissions operating in the field of standardization within the ISO and IEC.

In radioactivity, the Institute has several sources of various chemical and physical forms, and offers primary standards based on the $4\pi\beta$-γ coincidence counting method, liquid scintillation counting methods (CIEMAT/NIST and TDCR techniques), the $4\pi\gamma$-integral counting method, the 2π windowless gas flow proportional counting method for large area source, radon primary standards. Several secondary standards are also in operation based on well-type ionization chambers, HPGe photon spectrometers, and secondary standards for radon activity measurements.

In neutron measurements, the Institute holds several radionuclide neutron sources, a thermal neutron flux density standard, a MnSO4 bath, and a DePangher type precision long-counter.

Figure 10. Part of the staff of ENEA-INMRI, during a solar eclipse that was visible from Rome in May 2015

At the national level, the Institute cooperates with the Italian accreditation body, ACCREDIA, in the operation of a network of Calibration Laboratories covering the national calibration needs in the area of radiation protection and radiation diagnostics dosimetry. Outside this network, the Institute directly offers calibrations and Inter Laboratory Comparison services in the fields of therapy level dosimetry, radioactivity, radon and neutron measurements for health, environment, radiation protection and industrial applications.

For further details, please see www.inmri.enea.it or contact pierino.defelice@enea.it

NETHERLANDS

VSL

VSL, the Dutch National Metrology Institute (NMI), is situated in the historic town of Delft in The Netherlands. It is appointed by the government to maintain and develop the national measurement standards.

VSL provides measurements traceable to internationally accepted standards and contributes to the reliability, quality and innovation of products and processes. VSL's services are relevant for (inter)national trade, innovation in science, industry, safe and effective healthcare.

The VSL dosimetry standards have a long-standing history, originating from the first primary standard developed by one of the founding fathers of the Dutch radiotherapy, Dr. Daniël den Hoed (MD), back in the 1920s at the Antoni van Leeuwenhoekhuis (currently Netherlands Cancer Intitute, NKI, in Amsterdam). After WWII, the standard was moved to the Rotterdams Radio-Theraputic Institute (currently Erasmus Medical Centre in Rotterdam), and later to the Dutch institute of public health (RIVM) in Bilthoven.

With the privatization of the Dutch national metrology infrastructure in 1989, the dosimetry standards were finally moved to what is currently known as VSL.

Today, the focus of the VSL ionizing radiation department is on dosimetry for advanced radiotherapy applications. The historical relationship with the Dutch radiotherapy and its innovative approach is still strong, which is demonstrated by various active collaborations, such as in: the development of Codes of Practice [3], (inter)national research projects [1-3] and the development of tailored primary measurement standards [1,2].

The department is known for its development of a transportable water calorimeter as a primary standard for advanced radiotherapy applications such as MRI-linacs [1].

The ionizing radiation department consists of 6 highly qualified technical-scientific staff members and provides accredited calibration and proficiency-tests (PT) for radiotherapy, radio-diagnostics and radiation protection applications. Primary and secondary dosimetry standards are maintained for radiotherapy: ^{60}Co, MV-photons, MeV-electrons and kV X rays (D_w and K_a), HDR brachytherapy (K_a).

Figure 11. VSL water calorimeter in the ^{60Co} facility

Services for radio-diagnostics and radiation protection are based on measurement standards for X ray, ^{137}Cs and ^{60}Co beam qualities.

To provide traceability at the highest metrological level under the CIPM-MRA, VSL is fully accredited for calibrations (ISO 17025) and proficiency-tests (ISO 17043).

An overview of the calibration measurement capabilities (CMCs) can be found at the BIPM website.

Key publications

[1] LA de Prez, et al., Phys. Med. Biol. 2016

[2] LA de Prez, et al., Phys Med Biol. 2019

[3] JA de Pooter, et al., Phys Med Biol. 2020

For further details, please contact Ldprez@vsl.nl or JdPooter@vsl.nl

SLOVAK REPUBLIC

Slovak Institute of Metrology (SMU)

National standard of Dosimetric Quantities of Gamma Radiation No. 028/02 was established in 2002. The standard consists of several parts: the primary chamber OMH ND 1005/A; secondary chambers PTW TW 23361, OMH ND 1000, OMH ND 1007, LND 5120, PTW TW 30013, Thermo 2571A; two gamma irradiators TEMA IM6/M and IM4/P containing seven ^{137}Cs sources; the gamma irradiator Chisobalt B75 containing one ^{60}Co source; the electrometers Keithley 6517A and 6517B and other ancillary equipment such as temperature, pressure and humidity meters, cavity meters and PMMA phantom.

The primary standard is a cylindrical graphite walled cavity ionization chamber ND1005/A, serial number 8111, shown in figure 12, constructed by the Országos Mérésügyi Hivatal (OMH) in the 1980s. The focus of the institute is the development, calibration, verification and type testing of dosimetry equipment in the field of radiotherapy and radiation protection. The person responsible for the national standard of Dosimetric Quantities of Gamma Radiation is Mr. Stanislav Sandtner.

The primary function of the dosimetry laboratory for gamma radiation is to disseminate traceability of the physical quantities such as air kerma, dose equivalent and absorbed dose to water. For this purpose, it maintains and develops the national standard. This standard is used to ensure traceability of measurements for strategic entities in the Slovak Republic such as nuclear power plants, Nuclear and Decommissioning Company, food companies, hospitals and companies providing distribution of gamma measuring instruments. The traceability is ensured by using the reference calibrated gamma ray fields of seven ^{137}Cs sources and one ^{60}Co source. Each of these fields are regularly calibrated using the primary standard and traceable secondary standards. Calibrated fields are used to provide traceability and calibration of the measuring instruments, such as personal dosimeter, survey meters, measuring probes and ionization chambers applied in the industries of personal and environmental monitoring, human health protection, radiation therapy and diagnostic radiology.

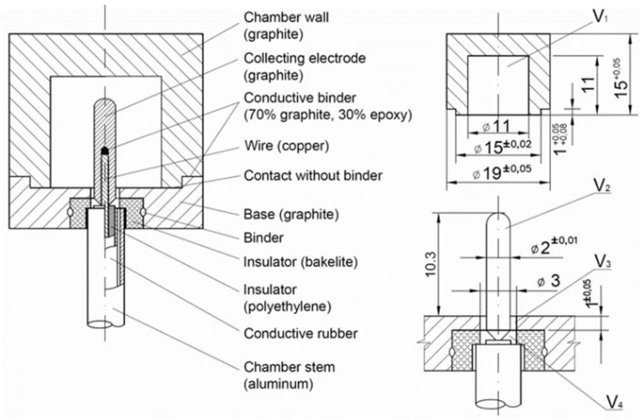

Figure 12. Construction details of the primary standard ND1005/A

For further details, please contact sandtner@smu.gov.sk

SPAIN

Centro de Investigaciones Energéticas, Medio Ambientales y Tecnológicas (CIEMAT)

The Spanish National Laboratory of Metrology of Ionizing Radiations (hereinafter LMRI), began its metrological walk in 1961.

The LMRI currently has eight internationally accredited laboratories in the area of dosimetry, radionuclides and neutrons. The main objectives of the LMRI are:

- Establish, maintain and disseminate on behalf of the Spanish State, the National Patterns of SI units of Activity (becquerel), Exposure (coulomb.kg^{-1}), Kerma (gray), Absorbed Dose, neutron fluence and dosimetric neutron radiometric magnitudes of H*(10) and H_p (10).
- To assume national representation in the field of metrology for ionizing radiation before international organizations, such as the International Committee of Poids and Mésures (CIPM), Comité Consultatif pour les Rayonnements Ionisants (CCRI), the International Bureau for Radionuclide Metrology (ICRM), the European collaborative alliance of National Metrology Institutes (EURAMET) and others.
- Ensure the international comparability of National Standards for ionizing radiation and compliance with the requirements of the CIPM Mutual Recognition Arrangement by participating in the CIPM / BIPM Key comparisons and the EURAMET supplementary comparisons.

The LMRI develops and establishes the National Standards for ionizing radiation through three specialized radioactive facilities:

- Radionuclide Metrology Laboratories, where appropriate measurement techniques are used to metrologically characterize the radiation disintegration and emission processes, which allow the definition of the National Standards of the magnitude Radionuclide activity for α, β or γ emitters.
- Dosimetry Laboratories, where appropriate measurement techniques are used to characterize the processes of interaction of radiation emitted with matter in terms of the energy deposited, allowing the definition of the National Standards of Exposure, kerma and Absorbed dose, for γ (^{60}Co, ^{137}Cs), X rays (ISO 4037:2019 10 to 300 kV and ISO 61267) and β (^{147}Pm, ^{85}Kr, ^{90}Sr / ^{90}Y).
- Neutron measurement standards laboratory with neutron sources of ^{241}Am / Be and ^{252}Cf source of high activity.

Figure 13. The Spanish National Metrology Laboratory of neutron standards

For further details, please see http://rdgroups.ciemat.es/web/lmri or contact miguel.embid@ciemat.es

COLOMBIA

Servicio Geológico Colombiano (SGC)

Throughout history, metrology has been established as a fundamental pillar in the development of society, from ancient commercial activities in which quantities of anthropometric origin were used, to the industrial revolution that promoted the homogenization of measurement standards, which resulted in the current International System of Units (SI).

In Colombia, the development of radiation protection regulations and the medical and industrial applications of ionizing radiation have evolved simultaneously with the techniques implemented in the LSCD Secondary Standards Dosimetry Laboratory (SSDL). The laboratory was first established in the late 1980s and is an active member of the IAEA/WHO SSDL Network. It is accredited under ISO/IEC 17025 for protection level quantities.

The LSCD belongs to the Servicio Geológico Colombiano (SGC), affiliated to the Ministry of Mines and Energy of the Republic of Colombia. Within the institution, the LSCD belongs to the Radioactive Research and Applications Group (GIAR) of the Technical Directorate for Nuclear Affairs (DAN). The technical activities of the laboratory are performed in a building with two bunkers, an area for administrative offices and an area for customer service, reception and delivery of equipment.

Figure 14. From left to right: Staff of LSCD and calibration set up in a Cs-137 beam

Currently the LSCD provides calibration services in:

- Ambient dose equivalent rate H*(10)
- Personal dose equivalent: $H_p(10)$, $H_p(0.07)$
- Air Kerma, for reference ionization chambers: K_{air}
- Surface contamination
- Reference Irradiations for personal dosimeters (OSLD and TLD)

Services under development are:

- Therapy level calibrations in Co-60
- Brachytherapy calibration using Ir-192 and Co-60
- Nuclear medicine calibrations
- X ray calibrations for protection, diagnostics and therapy level
- X rays quality control

Publications

- Interlaboratory comparisons at protection level with transfer ionization chamber using radiation quality ^{137}Cs. C. E. Calderón, L. Quintero, W. E. Moreno, J. A. Niño. Revista de Investigaciones y Aplicaciones Nucleares, n.° 2, pp. 55-61, 2018. Doi: 10.32685/2590-7468/invapnuclear.2.2018.59.
- Determination of characteristic parameters of the X-ray beam in radiodiagnostic: implementation of RQR3 quality. Camilo E. Calderon. Momento, Revista de física, No 58, Ene-Jun, 2019 Doi: https://doi.org/10.15446/mo.n58.73555
- Metrología de la dosimetría de radiaciones ionizantes en Colombia. Camilo Calderón, Wilson Moreno, Julian Niño. Memorias del congreso internacional de metrología, 2018, INM, Colombia.
- Probabilistic safety assessment for 60Co irradiator, for calibration of detection equipment at the therapy level, to be installed in the Secondary Standard Dosimetry Laboratory of the Servicio Geológico Colombiano. Ramírez González, Juan Guillermo. 2020.
- Metrología de las Radiaciones Ionizantes y Retos del Nuevo Laboratorio Secundario de Calibración Dosimétrica (LSCD), Congreso de Protección Radiológica, Secretaría Seccional de Salud de Antioquia, 2019.
- Automatización del método de calibración a diferentes distancias con haces bien definidos. Edwin Bolívar, Guillermo Flórez, Mary Peña, Julián Niño, Wilson Moreno, Camilo Calderón. VIII Congreso Internacional de Ingenierías Mecánica y Mecatrónica, Energía y Medio Ambiente. Medellín, Colombia, 2017.
- Comparaciones Interlaboratorios como herramienta de armonización de la dosimetría de referencia en la región, G. Walwyn, J. Niño, E.D. Arévalo, A.L. Romero, J.A. Tamayo. XI Congreso Regional de Seguridad Radiológica y Nuclear, 2018.

ETHIOPIA

National Metrology Institute of Ethiopia (NMIE)

The National Metrology Institute of Ethiopia (NMIE) was established by the council of ministers' regulation number 194/2011 to give metrology related services which were previously given by quality and standards authority of Ethiopia, Ethiopian scientific equipment center and Ethiopian radiation protection authority. The institute was previously accountable to the ministry of science and technology but now it is under the Ministry of Trade and Industry. The Ionizing Radiation Calibration Laboratory of NMIE (SSDL) is dedicated to work in the field of calibration of Ionizing Radiation. It is a Secondary Standard Dosimetry Laboratory (SSDL), which was established in 2008 by Ethiopian Radiation protection Authority (ERPA). and a member of the IAEA/WHO SSDL network. The operation of the SSDL is governed by the Radiation Protection Regulations of Ministerial Decree 571/2000. The SSDL develops and maintains the national measurement standards and is able to provide calibrations in terms of air kerma, absorbed dose to water, personnel equivalent dose ($H_p(10)$ and $H_p(0,07)$), and ambient dose equivalent ($H^*(10)$).

The activities and calibration services are in accordance with ISO/IEC 17025 and the laboratory is preparing documentation for an accreditation process. NMIE is in a process of building new laboratories for expansion of calibration activities on different departments including bunkers for the SSDL for radiation protection, radiotherapy and diagnostic radiology calibration capabilities.

Figure 15. Set up preparation for ionization chamber X-ray and Gamma irradiator

For further details, please see www.nmie.net

FINLAND

Radiation and Nuclear Safety Authority (STUK)

The Finnish national standards for ionizing radiation are maintained by the Radiation Metrology Laboratory (DOS) at Radiation and Nuclear Safety Authority (STUK) in Helsinki. STUK maintains national standards for ionizing radiation in accordance with Finnish legislation (Radiation Act 859/2018). STUK was established in 1958 operating under the Medical Administration as the Department of Radiation Physics with the task of inspecting radiation sources used in hospitals. At the end of 1960's, STUK became an independent safety authority operating under the Ministry of Social Affairs and Health. The national standards for ionizing radiation have been maintained since 1971.

Figure 16. Personnel of the Radiation Metrology Laboratory and Occupational Exposure (Photo by Ilkka Elo)

STUK has been a member of the European Association of National Metrology Institutes (EURAMET, formerly EUROMET) since 1980's and in 2002 STUK became a designated institute under The Committee for Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA).

STUK has been a member of the IAEA/WHO SSDL laboratory network since 1970's. The DOS laboratory's Quality Management System is consistent with the requirements of ISO 17025:2017 and follows the Self-Declaration approach in the CIPM MRA. The number of employees in the laboratory is 12 persons including the previous IAEA SSDL officer (Paula Toroi), scientists, inspectors, laboratory engineers and head of the laboratory. Currently, STUK has 30 CMCs (Calibration and Measurement Capabilities) in the field of dosimetry that are published in the BIPM KCDB and other services not published.

The facilities at the STUK premises comprise of equipment for calibrations, testing and irradiation of active and passive targets, such as electronic components.

The following radiation qualities are available:

- Gamma-ray sources: 4 x Cs-137 and 5 x Co-60
- Am-241 photon source
- Two X ray devices with voltage span from 10 kV to 320 kV
- Beta-active point sources (Sr-90, Kr-85, Pm-147)
- Neutron sources (Am-Be, Cf-252)
- Planar sources (Sr-90, Cl-36, Co-60, C-14, Am-241, Pu-239, Cs-137)

An air kerma rate from 700 nGy/h to 30 Gy/h is available. In addition, the laboratory is equipped with a medical X ray imaging facility with digital radiography. The calibration and irradiation premises include three separate irradiation halls.

STUK also conducts research in the field of dosimetry and metrology. Research topics have generally been related to the use of radiation, such as dosimetry, occupational and clinical radiation exposure, X ray imaging and measuring methodologies.

For further details, please see www.stuk.fi

GERMANY

PTW-Freiburg

The calibration laboratory of PTW was founded and has grown with the company since 1922 and shares 98 years of development and experience. With the initiation of the German Secondary Standard Laboratory network DKD, now DAkkS, the PTW calibration laboratory was accredited as SSDL in 1979. In the year 2000 the PTW lab became a member of the IAEA/WHO SSDL Network. The laboratory is an independent unit in the PTW-Freiburg organization. The 15 staff include 2 physicists and 10 technicians. With three therapy level Co-60 units, two Cs-137 units (one of those a VF-OG8 with multiple sources) and eight X ray installations the lab can provide a multitude of calibrations ranging from 10 kV to 300 kV X ray and including Ir-192, Cs-137 and Co-60 isotopes.

Also, diagnostic radiology kVp-meters can be calibrated in several ranges. All the above calibrations are traceable to PTB. As an additional service, TLD detectors are provided to hospital users for therapy level comparison irradiations as an external audit.

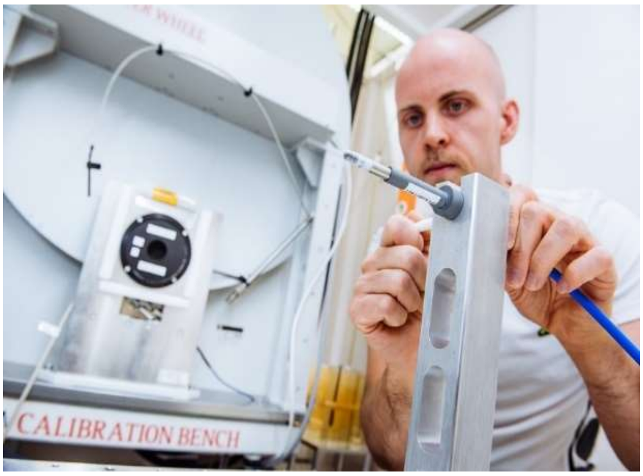

Figure 17. Reliable calibration needs care and precision

For further details, please see https://www.ptwdosimetry.com

ISRAEL

Radiation Control Unit, Israeli Ministry of Health

The Israeli Secondary Standard Dosimetry Laboratory (ISDL) within the Israeli Ministry of Health was established in the mid-1970s. Since its inception, the laboratory has been responsible for the calibrations for radiotherapy, diagnostic radiology and radiation protection using X rays. The main measuring equipment used was the NE instrument: 2561 chamber (still in use) and 2560 electrometer. The equipment is extremely stable.

Between 2006 and 2015, the laboratory was upgraded under the IAEA TC project. A new building was constructed in the Sheba Medical Center located in Ramat Gan city. There are two operating rooms in the laboratory for Co-60 and X ray calibrations. The UJP Terabalt T100 Irradiator is used for Co-60 calibrations, while the HDI X82-225-Mo-E X ray Irradiator with two X ray tubes (W and Mo anodes) and automatic 5-meter linear positioning system are used for X ray calibrations.

The ISDL offers calibration services for radiotherapy (for Co-60 in air and in water and for low energy X rays in air), diagnostic radiology (conventional radiology including calibration of CT and KAP meters and mammography) and radiation protection (including calibration of personal dosimeters). The following X ray radiation qualities are available: diagnostic – RQR, RQA, mammography with Mo and W anode and different filters, RQT; therapy – Co-60 and CCRI; protection (narrow beam series).

Figure 18. The SSDL staff (S.Ish-Shalom and M.Smekhov) preparing for Co-60 calibrations

The laboratory holds the secondary standards traceable to the IAEA dosimetry laboratory for all stated services. The ISDL is part of the Radiation Control Unit within the Ministry of Health. All the laboratory work is currently performed by two medical physicists (one of whom is part-time). The Unit's Head and secretary are also providing some administrative assistance. The short description of the ISDL activities is presented on the WEB site: www.health.gov.il/English/MinistryUnits/HealthDivision/MedicalTechnologies/RegulationRadiation/Pages/dosemeters_calibration.aspx

LATVIA

Latvian Environment, Geology and Meteorology Centre

The SSDL of Latvia was established from 2000 to 2001 with the financial and technical support of the IAEA. In 2002 it became a member of the IAEA/WHO SSDL network.

The SSDL facilities are in Salaspils, just outside Riga, the capital of Latvia, on the territory of the former nuclear research reactor. The SSDL is part of a LEGMC Laboratory.

Currently SSDL has 5 specialists (including head of Laboratory and quality manager) that are highly qualified and experienced professionals in the field of calibration and testing of ionizing radiation measuring and monitoring devices.

There is Internal Quality Assurance system implemented in SSDL to guarantee required precision and accuracy of measurement results. The quality of services provided by the SSDL is ensured by a regular participation in international comparison measurements. The laboratory irradiators include the PANTAK PMC-1000 X ray irradiation unit (40 kV to 225 kV), as well as the gamma irradiators OB-2 (Co-60, 3.7GBq), OB-6 (Cs-137, 740 GBq) and panoramic gamma irradiator OB-34 (with four Cs-137 and three Co-60 sources) for the calibration and testing of protection and diagnostic radiology dosimeters and measuring devices.

The reference standards used to perform calibration and testing activities are: PTW 32002 1L spherical ionization chamber (LS-01), PTW 32003 10L spherical ionization chamber (LS-02) and Exradin 3cc Magna A650 ionization chamber. PTW Unidos Webline type T10022 and PTW-UNIDOS type 10002 electrometers are used in the laboratory. Since 2001, SSDL is accredited by the Latvian National Accreditation Bureau according to standard LVS EN ISO/IEC 17025. The accreditation scope of the SSDL covers calibration services in the radiation protection including calibration of surface contamination monitors and diagnostic radiology. The SSDL provides services to State and private organizations such as scientific institutions, clinics, hospitals, military organizations, custom, radiation safety centre and other customers mainly from Latvia and Estonia. Calibration certificates issued by the SSDL are traceable to the International System of Units (SI).

SSDL performs:

- Calibration of gamma and X-ray dosimeters and measuring devices.
- Calibration of personal dosimeters.
- Calibration of surface contamination monitors.
- Testing of radiation measuring devices (stationary radiation monitoring system for vehicles and trains, personal dosimeters).
- Radiation monitoring.
- Calibration, testing and consultation services for developers of new radiation measuring equipment.

Figure 19. From left to right: SDDL irradiation room, the control room

For further details, please see:
https://videscentrs.lvgmc.lv/laboratorijas-pakalpojumi/sekundaras-standarta-dozimetrijas-laboratorijas-ssdl-pakalpojumi

NEW ZEALAND

SSDL-Food and Drug Administration

ESR is a crown research institute owned by the New Zealand government. It has a staff of over 320 over four science centre locations and covers a wide range of testing and consultancy areas from water safety through to forensics (https://www.esr.cri.nz/our-services/testing).

ESR's National Centre of Radiation Science (NCRS) section, which our ionizing radiation calibration service is part of consists of 6 scientists and 2 technicians. Our roles include regulator support; provision of scientific and technical advice; calibrations of radiation detectors; operation of national waste store; provision of training; monitoring, research, emergency and incident response.

NCRS has facilities to support clients' traceable ionizing radiation calibration needs, which are:

- Calibration of survey meters using our Cs-137 facility
- Calibration of contamination meters (Am-241, Sr/Y-90, Cl-36, C-14, I-129 & Cs-137)
- Calibration of diagnostic x ray dosimeters (radiography, fluoroscopy and mammography)
- Calibration of non-invasive kVp meters (radiography, fluoroscopy and mammography)

Figure 20. Radiation safety and security training course at ESR

For further details, please see www.esr.cri.nz

PHILIPPINES

SSDL-Food and Drug Administration

The Radiation Health Service (RHS) of the Department of Health (DOH) was created in 1974 under Presidential Decree (PD) No. 480 and amended by PD 1372. This law gave the responsibility to RHS to establish and maintain a National Radiation Standard Section, commonly known as Secondary Standard Dosimetry Laboratory (SSDL). On 17 February 1977, the RHS-SSDL became a member of the IAEA/WHO SSDL Network.

Since the establishment of the SSDL, the Radiation Health Service (former name of the Center Device Regulation, Radiation Health, and Research) has undergone several reorganizations over time. At present, the SSDL operates as part of the Physics Laboratory Support Division (PLSD) of the Common Services Laboratory (CSL) - Food and Drug Administration (FDA) Department of Health (DOH). The SSDL-FDA DOH is operated and maintained by three fulltime Medical Physicists and part-time Radiologic Technologist and Medical Equipment Technician.

Its Theratron Phoenix Co-60 machine was installed in 2010 and is used for calibration of therapy level dosimeters. The laboratory is also equipped with reference secondary standard dosimeters (electrometer with ionization chambers) including brachytherapy and protection level instruments traceable to the IAEA Dosimetry Laboratory. These instruments are calibrated every five years. Field dosimeter are used during on-site dosimetry audits. Local facilities perform traceable calibration of thermometers, barometers, and a hygrometer. There are also suitable phantoms available for horizontal and vertical beam set-up for radiotherapy level calibration and on-site dosimetry audits.

The SSDL follows a set of quality control procedures to maintain the quality of services rendered to its clients. Its primary services offered include:

- Annual calibration of therapy level dosimeters of different radiation oncology centres in the Philippines
- On-site visits and radiotherapy quality audit of new and existing external beam radiation oncology facilities (LINAC and Co-60)
- Participation in and coordination of the annual IAEA/WHO Postal Dose Quality Audit for SSDL and radiation oncology centres

Figure 21. Cobalt-60 machine and different phantoms used in the calibration of radiotherapy dosimeters

References

[1] Presidential Decree No. 480 &1372
[2] Primer on Radiation Dosimetry and the SSDL of the DOH, Jan 2006

Publications

- Lingatong, N. O. (2007, December). The National Quality Audit of Radiotherapy Facilities in the Phil.Australasian Physical & Engineering Sciences in Medicine, 30(4), 485.

For further details, please see www.fda.gov.ph/

SAUDI ARABIA

King Faisal Specialist Hospital and Research Centre (KFSHRC)

The establishment of the Secondary Standard Dosimetry Laboratory (SSDL) is a significant achievement for Saudi Arabia. The SSDL is based at the Biomedical Physics Department of the King Faisal Specialist Hospital and Research Centre, in Riyadh. It provides calibration of radiation measuring instruments used within the hospital and extends its calibration services throughout the Kingdom, the Gulf region and beyond. In June 1988, the SSDL was accepted as a member of the joint IAEA/WHO network of Secondary Standard Dosimetry Laboratories with only one multisource gamma irradiator providing only radiation protection calibrations.

With the installation of a ^{60}Co in 2014, and two x-ray units, the KFSH&RC's SSDL became the only active laboratory in the Middle east region offering the calibration of therapy level ionization chambers in terms of absorbed dose to water and diagnostic radiology detectors in terms of air kerma, kVp, HVL and air kerma length. Furthermore, in 2020, started using the after loading ^{192}Ir brachytherapy machine to start calibrating HDR brachytherapy well type chambers.

The calibration and Measurements Capabilities of the KFS&HRC's SSDL include:

- Calibration of ionization chambers used in radiotherapy using a ^{60}Co unit (cylindrical and plane parallel in terms of absorbed dose to water).
- Calibration of HDR Brachytherapy Well Type chambers using Ir-192 source
- Calibration of radiation protection measuring instruments (ionization chambers, Survey-meters and personal dosimeters) using:
  - Gamma beams from one rotational multisource and one sliding gamma irradiators having respectively six ^{137}Cs sources (from 0.04 to 110 Ci and 390 Ci as of Oct 2020).
  - ISO 4037, N40 to N300 narrow beam X ray qualities obtained from a 320 kVp Gulmay X ray tube.
- Calibration of contamination meters and radioactivity measuring instruments using reference sources (Tc-99, Cl-36 and Sr-90).
- Calibration of detectors and instruments used in diagnostic radiology using IEC 61267 RQR, RQA and RQT X ray beam qualities and soon Mammography detectors using a 150 kVp Gulmay X ray tube.
- Reference irradiation in terms of air kerma, ambient and personal dose equivalent in ^{60}Co and ^{137}Cs gamma beams as well as in X ray beams.

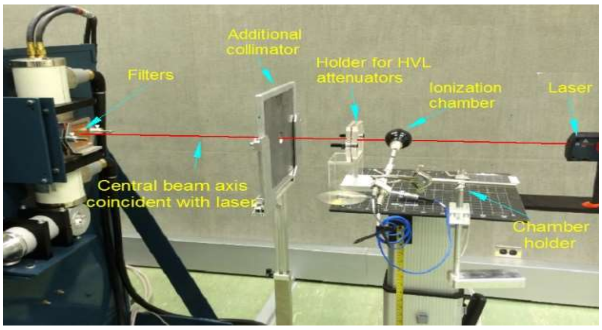

Figure 22. ISO 4037 and IEC61267 X-ray Calibration set up at KFS&HRC's SSDL

The SSDL is running an ISO 17025 Quality Management system which was audited by an IAEA expert in 2019. The SSDL is planning to apply for accreditation in 2021. The certificates issued by the SSDL are recognized by the Saudi Regulatory Authorities.

The SSDL is planning to offer the following services in the near future:

- Calibration of Neutron dosimeters with a traceability to NRC Canada. A new Hopewell Designs Neutron irradiator has been purchased, already delivered and its installation, which was delayed because of COVID19 pandemic situation, in scheduled for February 2021.
- Calibration of radiotherapy ionization chambers using radiotherapy linear accelerators, with traceability to the PTB - Germany.
- Calibration of small volume chambers in terms of absorbed dose to water using the modified ^{60}Co unit with Brain Lab conical.

Besides the calibration duties, the SSDL is performing many other activities, among which but not limited to:

- On site calibration of radiation detectors (at the cyclotron facilities, airport and borders detection systems) using a reference ^{137}Cs source and a high accuracy calibrated survey meter (Identifinder).
- Training of medical physicists and radiation protection technologists.
- Supervision of students from the Kingdom universities (Bachelors, Master and PhD).

- Organizing, on a quarterly basis, a Medical Radiation Safety Officer course and upon demand a Radiation safety Course for Technologists/Nurses & Physicians/Medical Practitioners.
- Participating biannually to the organization of the International Conference on Radiation Medicine (ICRM) (Even years) and ICRM workshops and Symposium (Odd years).
- Assistance in performing the patient dosimetry using TLD chips.
- Participation in the IAEA activities (counterpart SSDL in the Regional Technical Cooperation Projects (RAS6084 and RAS 6095), organizing regional intercomparisons for H_p (10) measurement using TLD and OSLD and radiation protection calibration in 2017, provision of experts for the establishment of SSDLs.

For further details, please see www.kfshrc.edu.sa/en/home

South Africa

National Metrology Institute of South Africa (NMISA)

The national metrology institute of South Africa (NMISA) was established under the Measurement Units and Measurement Standards Act, No.18 of 2006, to provide for the use of measurement units of the International System of Units (SI) and to provide for the keeping and maintenance of the national measurement standards. The history of metrology, however, began with the National Metrology Laboratory (NML) during 1947, the date of the first calibration records and not at the date of creation of the Council for Scientific and Industrial Research (CSIR) itself (1945) or the National Physical Laboratory (1946).

It was only at the beginning of 1978 that the Ionising Radiation Laboratory was established. The capabilities cover both the radiation dosimetry and the measurement of radioactivity. The radioactivity laboratory is a primary standard laboratory and provides calibration for various industries including nuclear medicine departments. Since the beginning of the 90's, the dosimetry activities moved away from maintaining primary standards. Instead, focus became more on maintaining internationally traceable secondary standards covering the scope of the needs in the country. The current staff complement is nine, including an intern position for dosimetry and three in the radioactivity laboratory. The SSDL hosts students working towards their qualifications, for in-service training. Importantly, as a regionally designated centre for English speaking countries, the SSDL hosts training of regional scientists. Available Resources for the SSDL: NMISA has over the years established new services and improved most of existing services.

Figure 23 shows some of the available setups for the SSDL. The radiation dosimetry section was first accredited for ISO 17025 in 2003 and has maintained accreditation ever since.

Figure 23. From left to right: The Co-60 irradiator with a water phantom and some setup equipment for air kerma measurements, A Scientist setting up for a calibration of a contamination monitor.

Measurement Area	Measurement parameter	Status
Radiation therapy	Absorbed dose to water: Co-60	Fully Established
	Reference air kerma rate: Ir-192 & Co-60	
	Medium energy x-rays	
Dignostic Radiology	RQR, RQT, RQA Beams	Fully Established
	RQR-M, RQA-M Beams	
	X-ray tube voltage	
	Air kerma length product	
	Air kerma area product	
Radiation Protection	Air Kerma: Co-60, Cs-137, Am-241	Fully Established
	Ambient Dose equivalent: Co-60, Cs-137, Am-241, Am-Be 241	
	Personal Dose equivalent: Co-60, Cs-137, Am-241, Am-Be 241	
	ISO Narrow spectrum beams	
	Surface Emission Rate	
	Absorbed dose to tissue: Sr-90, Kr-85, Pm-147	
	Radon Measurements	Under Development
Radiotherapy Clinical Audits	Reference Dosimetry using posted glass dosimeters.	Fully Established
	End to end clinical audits	

Table 1. Measurement capabilities for dosimetry and clinical audits at NMISA

The SSDL will focus on ensuring that established measurement capabilities are fully utilised by the industry, both locally and regionally. NMISA sees a huge role to play in the next decade clinically, both, in diagnostic radiology and therapeutical dosimetry as newer/hybrid technologies have introduced more complex dosimetry challenges that needs to be addressed by metrology. A dosimetry audit capability has been established for radiotherapy and nuclear medicine departments.

The SSDL will also focus on the following areas:

- Building metrology capacity for the region.
- Improvement in measurement capabilities.
- Development of new measurement capabilities that are fit for purpose for the region, addressing regional challenges.

For further details, please see www.nmisa.org or *contact* dosimetry@nmisa.org or radioactivity@nmisa.org.

SUDAN

Sudan Atomic Energy Commission (SAEC)

The secondary standard dosimetry laboratory of Sudan is part of the Sudan Atomic Energy Commission (SAEC) and was established in 1997. It is now part of the IAEA/WHO SSDL network. The laboratory is located in Soba.

Figure 24. SSDL-Sudan staff during an IAEA expert mission

The SSDL is equipped with secondary standards that are traceable to the IAEA.

The functional irradiator used in the laboratory is the OB – 85 with a diameter 50 cm at a distance of 2 m from the source to the detector. Lead attenuators are used for varying the beam output as needed. There are five physicists working in the laboratory.

Since August 2000, the SSDL provides calibrations in terms of air kerma, personnel dose equivalent $H_p(10)$, ambient dose equivalent H*(10) and irradiation of thermoluminescence dosimeters. The services offered include:

- Calibration of survey meters and electronic personal dosimeters.
- Irradiation of TLDs for calibration purposes.
- Training of students in the field of radiation dosimetry.

The SSDL is planning to start a calibration service for radiotherapy. And the process of the implementation of ISO 17025:2017 is ongoing.

United Arab Emirates

Federal Authority for Nuclear Regulation (FANR)

In December 2011, FANR Board of Management agreed to establish an SSDL in collaboration with Khalifa University of Science & Technology, in Abu Dhabi. The purpose was to build the radiation protection infrastructure in the UAE and address the needs for calibration of radiation measuring instruments for the medical, nuclear, industrial and academic sectors. The building was constructed on a land adjacent to the campus of Khalifa University, FANR, with the support of the IAEA.

In October 2017, two IAEA Experts Missions enabled the SSDL to complete its commissioning and get a first evaluation of its Quality Management System. In February 2018, FANR SSDL became a member of the IAEA/WHO SSDL Network.

In December 2018, the Emirates National Accreditation System (ENAS) granted the ISO/IEC 17025:2017 accreditation to FANR SSDL, making it the first SSDL in the GCC to be accredited and the first laboratory in the Gulf region to be accredited based on the 2017 version of the ISO/IEC 17025 Standard.

Figure 25. Building hosting the UAE SSDL in Abu Dhabi

The accreditation scope is available on the ENAS website: http://www.enas.gov.ae/Documents/Accreditation%20Sope%20-%20NAL131-IN3.pdf

For further details, please see https://www.fanr.gov.ae/en/services/others/ssdl-calibration-services

Courses, Meetings and Consultancies in 2021

Please note that due to COVID-19 crisis many events have been postponed and the dates are still to be decided (TBD). In some cases, new dates have been proposed but there might still be some further changes.

TC Courses and Workshops related to DMRP activities

- RAF6053: Regional (AFRA) Training Course on the Harmonized quality control programme in Nuclear Medicine, date TBD (virtual event)
- RAF6053: Workshop on introduction of Harmonized quality control programme in Radiology, February 2021 (virtual event)
- NER6012: National Training Course for radiation medical professionals in the optimization of patient doses in diagnostic imaging, Niger, Q3 2021
- RLA6082: Quality Management in a Radiotherapy Centre, 22 March – 2 April 2021 (virtual event in collaboration with ANL)
- RAF6055 Regional (AFRA) Training Course on quality audits for English speaking countries, DOL Seibersdorf, Austria, 16 – 20 August 2021
- RAF6053: Regional (AFRA) Training Course on Train the Trainers in Imaging QC/QA and Analysis of the Results, Accra, Ghana, 27 September – 1 October 2021
- RAF6055 Regional (AFRA) Training Course on quality audits for French speaking countries, DOL Seibersdorf, Austria, 27 September – 1 October 2021
- RAF6053: Regional (AFRA) Training Course on QA/QC protocols (English), Laos, Nigeria, 11 – 15 October 2021
- RAF6053: Regional (AFRA) Training Course on QA/QC Protocols (French), Rabat, Morocco, 11 – 15 October 2021
- RER6036 Regional Training Course on Practical Advanced Radiotherapy Treatment Planning, Moscow, Russian Federation, Q4 2021
- RER6036 Regional Training Course on Commissioning and Quality Assurance for Radiotherapy Treatment Planning Systems, Moscow, Russian Federation, Q4 2021
- E2-TR-1904408 Joint ICTP – IAEA Workshop on Medical Physics Aspects of Stereotactic Radiotherapy Techniques, Trieste, Italy, Q3/Q4 2021
- E2-TR-1905979 Joint ICTP–IAEA Workshop on Dosimetry in Radionuclide Therapy and Diagnostic Nuclear Medicine, Trieste, Italy, TBD

Training courses and ESTRO Courses

- RER6036 IAEA/ESTRO IAEA/ESTRO Inholland Academy Course on IMRT, VMAT and SABR, Haarlem, The Netherlands, 15 January – 10 June 2021 (virtual event)
- RER6036 IAEA/ESTRO Training Course on Evidence Based Radiation Oncology, Brussels, Belgium, 22 February – 5 March 2021 (virtual event)
- RER6036 IAEA/ESTRO Training Course on Comprehensive quality management in radiotherapy, 19 April – 17 May 2021 (virtual event)
- RER6036 IAEA/ESTRO Training Course on Dose Modelling Verification for External Beam Radiotherapy, Budapest, Hungary, 31 May – 4 June 2021
- RTC on 3D Brachytherapy in Gynae (English), Lusaka, Zambia, 12 – 16 July 2021
- RER6036 IAEA/ESTRO Training Course on Basic clinical radiobiology, Tallin, Estonia, 4 – 8 September 2021
- RER6036 IAEA/ESTRO Training Course on Advanced treatment planning, Prague, Czech Republic, 5 – 9 September 2021
- RTC on 3D Brachytherapy in Gynae (French), Rabat, Morocco, 6 – 10 September 2021

- RER6036 IAEA/ESTRO Training Course on Image guided radiotherapy and chemotherapy in gynaecological cancer, 11 – 15 September 2021 (virtual event)
- RER6036 IAEA/ESTRO Training Course on Target volume determination - From imaging to margins, Brussels, Belgium, 19 – 22 September 2021
- Train-the-trainers on how to set-up clinical training for medical physicist, Nairobi, Kenya, 27 – 29 September 2021
- RER6036 IAEA/ESTRO Training Course on Image-Guided and Adaptive Radiotherapy, Ljubljana, Slovenia, 3 – 7 October 2021
- RER6036 IAEA/ESTRO Training Course on Best Practice in Radiation Oncology - Train the RTT (Radiation Therapists) Trainers – Part I, Brussels, Belgium, 11 – 15 October 2021
- RER6036 IAEA/ESTRO Training Course on Positioning and immobilisation for radiation therapy, Tallin, Estonia, 6 – 7 November 2021
- RER6036 IAEA/ESTRO Advanced skills in modern radiotherapy, Lisbon, Portugal, 14 – 18 November 2021 (virtual event)
- E2-TR-1805156 Joint IAEA and 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, Argonne, United States of America, 8 – 12 November 2021
- RER6036 IAEA/ESTRO Training Course on Paediatric radiotherapy, Brussels, Belgium, 5 – 7 December 2021

DMRP Meetings and Consultancies

- Consultancy Meeting to finalise the update of Technical Reports Series 398 (TRS-398), Vienna, Austria, 14 – 18 June 2021
- Second Research Coordination Meeting on Doctoral CRP on Advances in Radiotherapy Techniques, Vienna, Austria, 5 – 9 July 2021
- Consultancy Meeting to kickstart the review of the Safety Report Series (SRS) 16 on Calibration of Radiation Protection Monitoring Instruments, Vienna, Austria, July 2021
- First Research Coordination Meeting on Development of Methodology for Dosimetry Audits in Brachytherapy, Vienna, Austria, 26 – 30 July 2021
- First Biennial Meeting of Dosimetry Audit Networks, Vienna, Austria, 9 – 13 August 2021
- Consultancy Meeting on collection and reporting of annual metrics to indicate the success/benefit from the use of the linac, Vienna, Austria, 4 – 6 October 2021
- First Research Coordination Meeting on Advanced Tools for Quality and Dosimetry of Digital Imaging in Radiology, Vienna, Austria, 27 September – 1 October 2021
- First 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, 22 – 26 November 2021
- Third Research Coordination Meeting on Dosimetry in Molecular Radiotherapy for Personalized Patient Treatments, Vienna, Austria, November 2021

Other events

- International Conference on Advances in Radiation Oncology (ICARO-3), Vienna, Austria, 16 – 19 February 2021 https://www.iaea.org/events/icaro-3 (virtual event)

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