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Routine calibrations of ionizing radiation dosimeters in the context of the sustainability of measurements in radiotherapy

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Laboratory accredited by the Polish Centre for Accreditation, accreditation No AP 155*
*** an actual scope of accreditation No AP 155 is available on the PCA website: www.pca.gov.pl**

Introduction

In 2024, **the theme of World Metrology Day** was **sustainability**.

World Metrology Day is the annual celebration of the signing of the Metre Convention on 20 May 1875.

The Convention's original goal was worldwide uniformity of measurement, which remains as important today as it was in 1875 [1].

Introduction

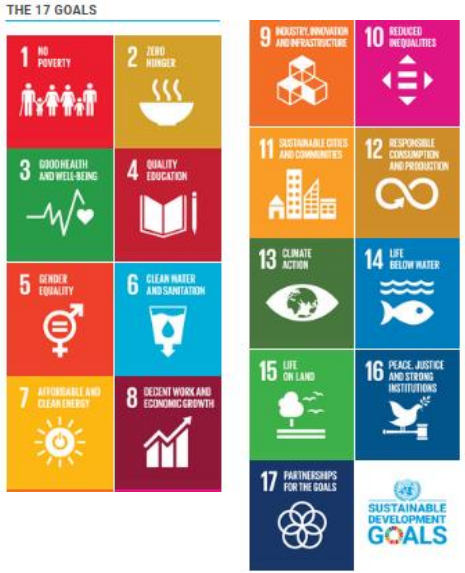
Sustainability
The word sustainable derives from the Latin „sustentare” which means to sustain, support, conserve, and care.

In 1987, the United Nations Brundtland Commission defined sustainability as “**meeting the needs of the present without compromising the ability of future generations to meet their own needs.**” [2]

Introduction

At first sight, **sustainability** does not seem to have much overlap with the activities of secondary standards dosimetry laboratories. However, when one considers the meaning of sustainability in the light of the **17 United Nations Member States Sustainable Development Goals (SDGs) it becomes more obvious that ionizing radiation measurements play an important role in achieving the goals set in 2015.**

These **17 goals** are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies **that improve health** and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.



Introduction

Ionizing radiation metrology contributes to "Ensure healthy lives and promote well-being for all at all ages" (**Sustainable Development Goal 3**).

This contributes to <u>effective and safe treatment of patients</u>.

Ionizing radiation is one of humanity's main tools in the fight against cancer, with radiation therapies becoming increasingly varied and tailored to the biological specificities of each patient.

Introduction

Calibration of ionizing radiation dosimeters is an essential process ensuring that dosimeters used in radiotherapy centers to measure radiation **provide valid measurement results that correspond to the actual radiation dose delivered to the patient**.

In Poland these calibrations are performed by the Secondary Standards Dosimetry Laboratory in Warsaw.

Currently, the SSDL offers regular calibration services for teletherapy and brachytherapy - within the scope of accreditation No. AP 155 granted by the Polish Centre for Accreditation for compliance with the requirements of the ISO/IEC 17025 standard [3].

Note:
The accreditation No. AP 155 granted on 28 May, 2014 covers the **calibration of ionization chambers together with electrometers in a ^{60}Co gamma ray beam in terms of dose absorbed to water and calibration of well chambers with a ^{192}Ir source in terms of air kerma**. The Polish SSDL performs its laboratory activities in the aforementioned accreditation scope for radiotherapy centers in Poland.

Introduction

Radiotherapy becomes more and more advanced. Here are some selected radiation therapy devices and dosemeters used in the past and nowadays.

Co-60 therapy device, beginning in the 1950s, replaced by other technologies such as linear accelerators.

The Siemens ARTISTE system launched in 2006, equipped with an MLC (Multi Leaf Collimator) system, capable of delivering IMRT and equipped with a Portal Vision system for simultaneous imaging of the treatment area.

The Varian VitalBeam, this linear accelerator was first unveiled on April 27, 2015, it allows advanced radiotherapy technologies, such as IMRT and RapidArc, to be implemented in a single process.

The Accuray Radixact System featuring integrated CT imaging and helical radiotherapy, was launched for clinical use in Germany in July 2018.

The Siemens-Reiniger-Weke "Universal-Dosismesser" dosemeter with the normal ionisation chamber, designed in 1938, introduced to radiotherapy departments after the Second World war.

The PTW-Freiburg UNIDOS E Universal Dosemeter, produced in 1992.

The PTW-Freiburg UNIDOS Romeo (on the left) and UNIDOS Tango (on the right), released for sale in 2020.

The Standard Imaging TomoElectrometer™ was recognized for outstanding development in 2008. Specifically, it received a Certificate of Merit and a Best of State award (First Place, Small Employment Category).

Introduction

In this work we will discuss **some aspects of the Polish SSDL routine activity in the context of the sustainability of measurements in radiotherapy with reference to the previously mentioned Sustainable Development Goal 3**.

We will also pay attention **to the challenges faced in the field of calibration** as radiotherapy becomes more and more advanced.

Methods

Ensuring sustainability in ionizing radiation measurements requires a comprehensive approach, which **includes a lot of activities**.

The Polish SSDL is committed to the **sustainability of its laboratory services, among others, by**:

- **maintaining the laboratory's standards and equipment**;
- **continuously monitoring the validity of results**.

Currently, the Polish SSDL consists of three person staff.

Methods

Maintaining the laboratory's standards and equipment includes, among others, **calibration** to provide an unbroken chain of traceability to international standards:

- **performed at the National Metrology Institutes** that maintain state standards of units of measurement, whose calibration services are suitable for the intended application and covered by the CIPM MRA agreement;
- **performed in competent calibration laboratories** (laboratories meeting the requirements of PN-EN ISO/IEC 17025) whose calibration services are suitable for the intended application, and whose scope of accreditation includes the corresponding calibration, and whose accreditation body is a signatory to the EA MLA and/or ILAC MRA or regional agreements recognized by ILAC.

Note:
Calibration services are suitable for the intended application when: they have a suitable calibration range and a suitable measurement capability (CMC) for the range of measurements to be performed with the calibrated measuring instrument and for the expected uncertainty of the measurements, in the specific case of measurement application in the conformity assessment area.

Methods

Monitoring the validity of results includes the following activities so called „**internal activities**" performed by the Polish SSDL staff:

- ✓ **visual check of the equipment which is not a measuring instrument** (i.e., measuring bench, water phantom, ionization chamber holder, etc.) but it is necessary to perform calibrations – performed before each use;
- ✓ **metrological control of an additional measuring equipment** (i.e. thermometers, barometers, hygrometers) – performed with the frequency established in the current edition of the procedure developed by the Polish SSDL;
- ✓ **monitoring atmospheric conditions** (ambient temperature, relative humidity, atmospheric pressure) on calibration days
- ✓ **intermediate checks**:
  - on the working standard dosimeter – performed on the same day the working standard is used for the calibration of the customer dosimeter;
  - on a reference dosimeter – performed during calibration of the working standard dosimeter;
- ✓ **replicate calibrations of the same calibration object** - performed by different members of the SSDL staff in accordance with the currently valid calibration instruction being within the scope of accreditation No. AP 155.

Methods

Monitoring the validity of results includes, but is not limited to, either or both of the following activities, so called „**external activities**”:

- ✓ participation in proficiency testing (PT);
- ✓ participation in interlaboratory comparisons (ILCs) other than proficiency testing.

Proficiency testing (PT)
Evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons (ISO/IEC 17043).

Note
ISO/IEC 17043 [4] contains additional information on proficiency tests and proficiency testing providers. Proficiency testing providers that meet the requirements of ISO/IEC 17043 are considered to be competent.

Interlaboratory comparison (ILC)
The organization, performance and evaluation of measurements or tests on the same or similar items by two or more laboratories in accordance with predefined conditions (ISO/IEC 17043).

Note
Participation in ILCs other than PTs should only be considered when PTs are not available or appropriate. (EA-4/21) [5]

Results

Since the beginning of its activities in the area accredited to the requirements of the ISO/IEC 17025 standard, the Polish SSDL has been performing the activities established in its management system to ensure sustainability in ionizing radiation measurements. **All the results of these activities were within the limits of acceptance**.

Fulfillment of the requirements established in the Management System of the Polish SSDL **has been confirmed annually since 2014 by a positive assessment by the Polish Centre for Accreditation.**

Since the beginning of its activities in the area accredited to the requirements of the ISO/IEC 17025 standard, the Polish SSDL **has been faced challenges in adapting calibration methods** to the constantly improving radiotherapy methods being implemented for clinical use in Poland. This involved the purchase of new equipment, such as holders for newly introduced types of ionization chambers and some necessary modifications to the way calibration is performed.

Conclusions

The Polish SSDL provides an unbroken chain of traceability to international standards, ensure the quality of laboratory results, and perform calibrations for all our customers in a timely manner.

Thanks to cooperation with international organizations such as International Atomic Energy Agency **the Polish SSDL** plays a key role in ensuring high standards in the field of **dosimeter calibrations in radiotherapy**, which contributes to progress in cancer treatment and public health protection in Poland and **achives Sustainable Development Goal 3 set** by the United Nations Member States in 2015.

References

[1] https://www.worldmetrologyday.org/
[2] https://www.un.org/en/academic-impact/sustainability
[3] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, General requirements for the competence of testing and calibration laboratories, ISO/IEC 17025:2017, ISO, Geneva (2017)
[4] ISO/IEC 17043:2023-10 Conformity assessment – General requirements for proficiency testing.
[5] EA-4/21 Guidelines for the assessment of the appropriateness of small interlaboratory comparisons within the process of laboratory accreditation.

Thank you for your attention.