Selected Research Topic number: **SRT-n13**
Version: 1.0

Title: Harmonisation, update and implementation of standards related to radiation protection dosimeters for photon radiation

Abstract

The recent update of the basic standard for photon reference radiation fields, ISO 4037, presented huge challenges to calibration laboratories and industry in the field of radiation protection. To avoid a failure to implement ISO 4037, collaborative research is needed to solve several serious issues that became apparent during initial implementation. ISO 4037, in conjunction with the new quantities proposed in ICRU Report 95, provides the basis for type testing standards that must be harmonized early to ensure timely development of new dosimeters. This research, which is beyond the capabilities of a single NMI or country, will additionally provide metrology networks, IAEA, and policymakers with the necessary scientific data to guide a possible implementation in metrology institutes and industry.

Keywords

ISO 4037, standardisation, reference radiation fields, X-ray spectrometry, uncertainty, harmonised measurement methods, type testing, ICRU 95, new operational quantities.

Background to the Metrological Challenges

Photon dosimeters are universal in all radiation practices, from personal and ambient monitoring to environmental monitoring, emergency response and the protection of workers and the public. A large variety of active and passive dosimeters exists, and a diverse range of calibration methods are in use including AI or machine learning, and other novel methods based purely on computational techniques. The number of corresponding standards (e.g., IEC 60846, IEC 60532, IEC 61017, IEC 62387) is also large, with some overlaps and inconsistencies, but also with some gaps associated with new and upcoming technologies based on computational dosimetry, spectro-dosimeters, machine learning, and radionuclide identifiers.

Council Directive 2013/59/Euratom establishes the requirement for dose monitoring, with the ISO 4037 standard series describing the requirements and procedures to set-up photon reference fields for the calibration of radiation protection dosimeters. In 2019, all 4 parts of ISO 4037 were updated, but the new requirements result in significantly higher costs and manpower requirements for establishing reference fields. This makes it more challenging for emerging metrology institutes or other laboratories to calibrate dosimeters to its requirements. The ICRU proposal for new operational quantities poses another significant challenge in radiation protection that requires research on the implications of these changes and guidance for decision makers and standardisation bodies to facilitate implementation and the generation of harmonised measurement approaches.

The metrology infrastructure for photon-based radiation protection dosimeters is based on a network of primary and secondary dosimetry laboratories, using air kerma standards. Measurements are commonly performed in gamma and X-ray reference fields, produced according to ISO 4037 requirements. On the other hand, operational measurements by end users are performed in terms of operational quantities – ambient, directional and personal dose equivalent. The link between these is established in calibration laboratories using conversion coefficients from air kerma to the operational quantities. To ensure that uncertainties are kept within ISO 4037 prescribed limits, the similarity between the calibration laboratory spectra generated and the calculated standard values for conversion coefficients from that beam spectra to the operational quantities derived is of critical importance. The evaluation of the consequences of the changes to ISO4037 on photon dosimeters (i.e. is it necessary to redesign dosimeters), reference fields (new conversion coefficients and updated requirements e.g. for filter thickness deviation), and type testing standards (which standards need to be changed) is needed to inform decision makers, and the entire measurement chain from metrology networks to end users in calibration laboratories and industry. Guides for the implementation of the existing standards would fulfil this requirement. In addition, guidance for the use of new and upcoming technologies will aid their implementation in radiation protection, while maintaining high accuracy, reliability, and measurement uncertainty standards.

Many laboratories are struggling to implement new version of ISO 4037, for example, there is insufficient data to include ^{241}Am reference fields in the main part of the standard, and guidance and training for performing spectrometry, for determining measurement uncertainties, and for half value layer measurements is lacking. Spectrometry offers significant advantages over other methods, especially regarding measurement uncertainty and can be used to validate radiation qualities and to determine the conversion coefficients from air kerma to the operational quantities used. However, X-ray spectrometry, usually performed with High Purity Ge spectrometers, comes with specific challenges, including the handling of very high counting rates, the need to calibrate spectrometers for low photon energies and to deconvolute spectra. A standardised procedure, as simple as possible, is urgently required to aid implementation of ISO 4037 in more laboratories.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to enable standardisation in photon-based radiation protection dosimetry for the new operational quantities proposed in ICRU Report 95.

The specific objectives are

1. To develop measurement protocols for X-ray spectrometry that meet the requirements of ISO 4037 based on: (i) the evaluation of discrepancies between measured and calculated half-value layers of X-ray spectra and the reduction of these, and (ii) the determination of X-ray tube high voltage. In addition to produce the required data to enable ^{241}Am reference fields to be included in this standard.
2. To develop cost effective, manpower efficient procedures and guidance for the calibration of dosemeters and doserate meters, and for the determination of their response as a function of photon energy to enable smaller emerging metrology institutes and other calibration laboratories who have limited resources to implement ISO 4037.
3. To produce written guidance on validated procedures for harmonized type testing based on ISO and IEC standards with the determination of valid metrological solutions for situations where: (i) requirements in existing standards (e.g., for workplace and environment dosemeters) deviate and (ii) standardisation gaps, especially related to new and upcoming technologies (e.g. computational dosimetry) exist.
4. To produce a guidance document for the implementation of the new operational quantities proposed in ICRU Report 95 into standards and regulations based on the knowledge and scientific data generated in Objectives 1, 2 and 3, and to disseminate the document to policymakers, radiation protection authorities, metrology networks, standardisation bodies, calibration laboratories.
5. To collaborate with the ISO and IEC technical committees responsible, and the users of their dosimetry standards (including the EMN on radiation protection and the IAEA) to ensure that the outputs of the project are aligned with their needs, including the provision of a report containing guidance on the implementation of the new operational quantities proposed in ICRU Report 95 into standards and regulations and recommendations for incorporation of this information into future standards at the earliest opportunity. In addition to disseminate project outcomes for consideration for inclusion into ISO 4037.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR projects 17RPT01-RMG2 and 17RPT01 DOSEtrace and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€ and has defined an upper limit of 1.2 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the ‘end user’ community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the ‘end user’ community (e.g., letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the radiation protection and environmental monitoring sectors.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of the Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.