

22NRM07 GuideRadPROS

D4 Open access e-learning resources for calibration of the dosimeters according to the ISO 4037 standard series.

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Deliverable Cover Sheet

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1 Introduction

The GuideRadPROS e-learning material has been developed within the framework of the European metrology project 22NRM07 GuideRadPROS, which aims to support the harmonised implementation, update and future development of standards for photon radiation protection dosimetry, with particular focus on the ISO 4037 standard series and the new operational quantities introduced in ICRU Report 95.

The training content has been developed to support the needs of calibration laboratories, metrology institutes, standardisation bodies and end users involved in radiation protection dosimetry.

2 Overview of the e-learning material

The e-learning material is organised into thematic units covering the main aspects of setting up reference fields for radiation protection dosimetry and calibration according to ISO 4037. Each unit includes presentations, instructional videos, quizzes and/or exercises designed to support self-directed learning.

The material combines theoretical content with practical demonstrations in laboratory environments, supporting both conceptual understanding and application. Quizzes are included at the end of each presentation to assess learning outcomes, while selected exercises with sample solutions facilitate knowledge consolidation.

All training material is designed to be self-contained, technically consistent and suitable for users with different levels of expertise in radiation protection dosimetry.

The training presentations are based on lectures delivered during the GuideRadPROS workshop held in May 2025 at the Greek Atomic Energy Commission (EEAE) and have been appropriately adapted to form self-explanatory e-learning material. The video material was recorded during the practical sessions of the workshop, with the participation of workshop attendees, providing a direct link between theoretical content and experimental practice.

All training material has been peer-reviewed.

The e-learning material is openly available to registered users through the BIPM e-learning platform as EURAMET course under the title “Calibration of Radiation Protection Dosimeters: Reference Fields (ISO 4037), Instrument Setup, Spectrometry and Uncertainty Analysis”. A record of this deliverable will also be created in the Zenodo repository to enable citation via a persistent identifier (DOI).

3 Structure of the training material

The training material is structured into four thematic units:

- Introduction
- Establishing the calibration set-up
- Spectrometry
- Calibration process and end-user needs

Each unit addresses specific aspects of radiation protection calibration procedures and associated metrological requirements.

4 Description of content

4.1 Introduction

Scope of GuideRadPROS

Type: Presentation

Description: Introduces the objectives of GuideRadPROS project, including the harmonization of photon dosimetry standards, development of spectrometry guidance, improvement of reference data, and preparation of training and e-learning material for radiation protection.

System of Interlaboratory comparisons and CMCs

Type: Presentation

Description: Describes the system of interlaboratory comparisons and Calibration and Measurement Capabilities (CMCs) used to ensure traceable, reliable and consistent measurements, supporting quality assurance, method validation and compliance with international metrology standards.

4.2 Establishing the calibration set-up

Setting up X-ray and gamma reference fields – Use of monitor chambers

Type: Presentation

Description: The presentation describes establishing X-ray and gamma reference fields, ensuring accurate air-kerma measurements, beam-quality assessment, HVL determination, and monitor-chamber use for reliable radiation-protection calibrations.

Generators and high voltage dividers

Type: Presentation with audio narration

Description: Introduces the principles of high-voltage generators used for X-ray reference radiation fields and high-voltage dividers, including their requirements according to ISO 4037-1:2019.

Half value layer measurements

Type: Presentation with audio narration

Description: Presents the concept of half-value layer (HVL), methods for its measurement and associated challenges, and explains its role in the characterisation of radiation beams according to ISO 4037.

Field homogeneity and uniformity: Measurements and requirements

Type: Presentation with audio narration

Description: Covers the requirements for field homogeneity and uniformity according to ISO 4037-1:2019, including measurement methods and illustrative examples for radiation protection fields.

K_{air} and/or $H^*(10)$ measurements in a SSDL calibration laboratory

Type: Video

Description: Demonstrates the measurement workflow of air kerma (K_{air}) and ambient dose equivalent $H^*(10)$ in an SSDL using a Cs-137 source, highlighting detector selection, attenuation methods, corrections and traceability aspects. Video associated to theoretical material.

HVL measurements using ionizing chamber

Type: Video

Description: Demonstrates half-value layer (HVL) determination for X-ray radiation protection fields using an ionization chamber, including detector alignment, use of aluminium filters for attenuation and application of correction factors. Video associated to theoretical material.

4.3 Spectrometry

Spectrometer and set-up for radiation protection fields

Type: Presentation

Description: Presents the principles of X-ray photon spectrometry in radiation protection calibration laboratories,

including detector types, experimental set-ups, calibration procedures, and challenges in spectral measurements and unfolding.

Determination of response function

Type: Presentation

Description: Describes the determination of detector response functions for X-ray photon spectrometry, including Monte Carlo modelling, efficiency validation, binning strategies and uncertainty sources for reliable spectrum unfolding.

Spectrum unfolding, tube voltage determination and calculation of conversion coefficients

Type: Presentation and exercises

Description: Presents the analysis of X-ray spectra to derive photon fluence distributions and calculate dosimetric quantities, including half-value layer (HVL) and conversion coefficients, for radiation protection applications.

Spectrometry set-up and measurements

Type: Video

Description: Demonstrates the spectrometry set-up used in a GuideRadPROS practical session, including detector preparation, equipment configuration and data acquisition, providing a visual overview of key concepts presented in the Spectrometry section. Video associated to theoretical material.

4.4 Calibration process and end-user needs

Performing calibrations – Traceability

Type: Presentation

Description: Presents the principles of calibration and traceability for radiation protection dosimeters, including practical guidance on detector positioning, use of PMMA layers and other key aspects to ensure reliable measurement results.

Type testing

Type: Presentation

Description: Covers type testing procedures and performance assessment of radiation protection dosimeters for relevant influence quantities, illustrated with examples of active and passive instruments for personal and area monitoring.

Uncertainty evaluation with Monte Carlo techniques

Type: Presentation and exercises

Description: Presents the use of Monte Carlo techniques for uncertainty propagation in radiation protection measurements, highlighting their application to HVL estimation and their advantages compared to classical GUM-based approaches.

Measurement uncertainty – basic concepts

Type: Presentation

Description: Presents the basic principles of measurement uncertainty evaluation, introducing uncertainty analysis and its application in radiation protection calibrations.

Measurement uncertainty in radiation protection calibrations

Type: Presentation

Description: Provides guidance on the evaluation of measurement uncertainty in radiation protection calibrations according to ISO 4037 and other relevant documents, focusing on practical applications for dosimeter calibration.

5 Access to the e-learning material

The GuideRadPROS e-learning material is openly available through the BIPM e-learning platform as EURAMET course and it is accessible to registered users of the platform, providing access to the training resources developed within the project. The platform hosts the complete set of presentations, videos and supporting materials described in this deliverable, enabling users to access the content in a structured and user-friendly environment.

In addition, this deliverable will be made available through the Zenodo repository, providing a persistent identifier (DOI) for citation.

The e-learning resources are accessible at the following link on the BIPM platform:

<https://e-learning.bipm.org/course/view.php?id=128>