

TraMeXI WP2 results - Classification of dosimeters based on their performances

Workshop for radiation metrologists on calibration of dosimeters used for X-ray
2nd September 2025
EEAE, Athens, Greece

Alessia Ciccotelli, ENEA-INMRI, on behalf of the WP2 partners



- TraMeXI and WP2 - Classification of dosimeters based on their performance
 - Investigation of current X-ray dosimetry and the usage of dosimeters
 - Selection of relevant criteria for the dosimetry performance evaluation and classification
 - Evaluation of the performance of the commercially available dosimeters
- Highlights on the current situation regarding the calibration services of X-ray imaging dosimeters in Europe

Traceability in Medical X-ray Imaging dosimetry

Three main research areas, interconnected among them

See Scope of TraMeXI, P.Toroi (Day 1)

Coverage of clinical
radiation qualities in
calibrations



WP1:

Physikalisch-Technische Bundesanstalt
National Metrology Institute

Revision of
Reference

Radiation Qualities

See WP1 Results and New
qualities for calibration for
DR, S.Pojtinger (Day 1)



Understanding the
performance of dosimeters

WP2:



Classification of
dosimeters based
on their
performance

Harmonized **calibration and
measurement procedures**

WP3:



Development of
harmonised calibration
and measurement
procedures for X-ray
multimeters

See XMMs measurements quantities
and Performance of XMMs,
M.Zivanovic and N.Krzanovic (Day 2)

Investigation of current
X-ray dosimetry and
the usage of
dosimeters

Selection of relevant criteria for the
dosimetry performance evaluation
and classification

Evaluation of the performance
of the commercially available
dosimeters

All activities have been completed

Investigation of current
X-ray dosimetry and
the usage of
dosimeters

The aim of this task is to evaluate the usage of different dosimeters in clinical and calibration practice and therefore identify the most relevant dosimeters for further studies.

Information is collected based on two **surveys, on different aspects of the clinical usage and calibration services of the dosimeters.**

Medical physicists survey

- What radiation qualities are clinically relevant
- What dosimeters are used
- How the measurements are currently performed
- Which quantities are measured
- How the measured quantities are used

Dosimetry laboratory survey

- What dosimetry equipment is currently used as reference instruments for calibration purposes
- Usage and calibration of field instruments based on the calibration data available in the laboratories
- Traceability

Usage of dosimeters: results

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Calibration services for X-ray multimeters in Europe: current situation and future needs

Ivana Komatina^{a,b}, Vedrana Makarić^c, Miloš Živanović^a, Paula Toroi^{d,e,*}, Aino Tietäväinen^d, Massimo Pinto^f, Luigi Rinaldi^f, Markus Borowski^g, Sjarhei Saroka^h, Nikola Kržanović^h, Alessia Ciccotelli^f, Bartel Jansenⁱ, Stefan Pöjttinger^j, Ana Fernandes^k, Vittorio Cannata^l, Mika Kortensniemi^e

^a Vinca Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovica Alasa 12-14, Vinča, Belgrade 11351, Serbia

^b Faculty of Physical Chemistry, University of Belgrade, Studentski trg 12-16, Belgrade, Serbia

^c Institute of Metrology of Bosnia and Herzegovina (IMBIH), Branilaca Sarajeva 25, Sarajevo, Bosnia and Herzegovina 71 000, Serbia

^d STUK – Radiation and Nuclear Safety Authority, Jokiniemenkuja 1, Vantaa 01370, Finland

^e HUS Diagnostic Center, Radiology, University of Helsinki and Helsinki University Hospital, Finland

^f ENEA-INMRI, Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti, Via Anguillarese 301, Santa Maria di Galeria, Rome 00123, Italy

^g Städtisches Klinikum Braunschweig gGmbH, Salzdlammer Str. 90, Braunschweig D-38126, Germany

^h I.P. Institutul Național de Metrologie, Str. Eugen Coca, 28, Chisinau MD2064, Republic of Moldova

ⁱ VSL National Metrology Institute, Thijsseweg 11, Delft 2629 JA, Netherlands

^j Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, Braunschweig D-38116, Germany

^k UL-IST, Laboratório de Proteção e Segurança Radiológica, Centro de Ciências e Tecnologias Nucleares, Portugal

^l IRCCS Bambino Gesù Children's Hospital, Rome, Italy

Overview on the current situation regarding the calibration services of X-ray imaging dosimeters in Europe

- All essential XMM quantities
- Review of standards and technical documents
- Best calibration capabilities available (based on the BIPM KCDB)
- Assessment of the XMM calibration needs and current state of calibration services in Europe

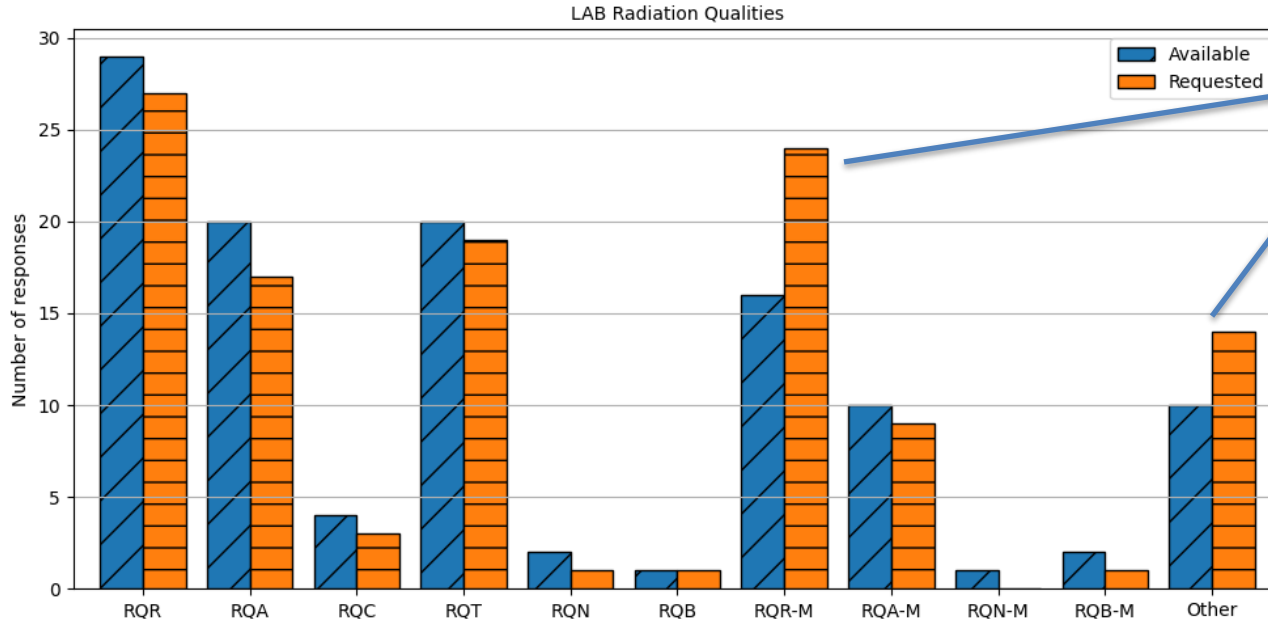
Medical Physicist Survey: XMMs and ICs

- **Uptake of XMMs by medical physicists is almost universal (~90 %), ICs also still widely used (e.g. for computed tomography) (~75 %)**
- **Most of the respondents stated that they perform air kerma and HVL measurements either with ICs or XMMs.**
- **Calibration of dosimeters: in case of XMMs, regular calibrations are performed almost twice more often at manufacturers' than in other calibration laboratories. However, in case of ICs, calibrations are more often performed in other calibration laboratories.**
- **Calibration periodicity: most of the respondents every 2-3 years, a smaller number does annual calibrations and an even smaller number every 4-5 years**

Analysis was based on 84 replies from European clinical centers

Lab survey: Radiation Qualities

What IEC 61267 reference radiation qualities are available at your organization/laboratory (if any) and which radiation qualities are requested for calibration by your customers/users:

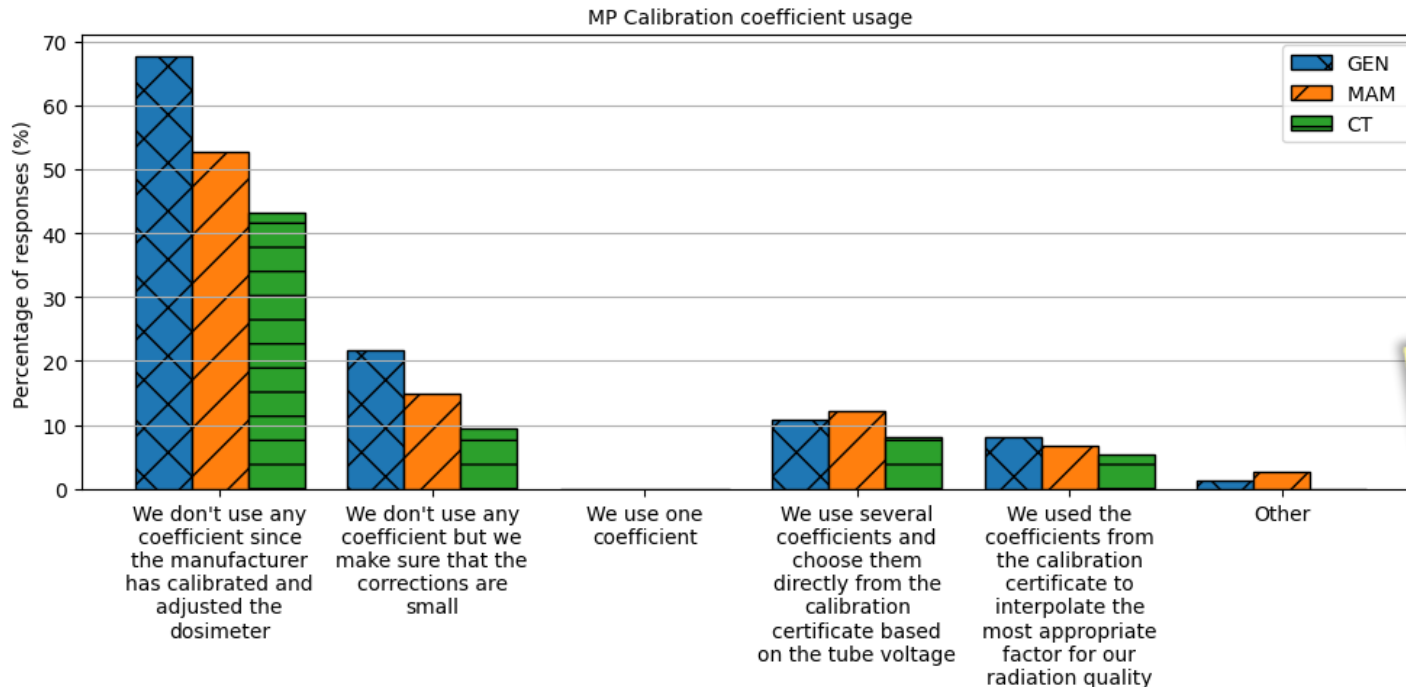


Mammography:
Mo/Mo vs non-standard
but clinically used target-
filter combinations

*Most laboratories meet
the requests of their users
regarding the availability
of radiation qualities*

Medical Physicist Survey: use of calibration factors

- How do you use calibration factors (coefficients) for your XMM air kerma measurements?



Calibration coefficients for XMMs should always be taken with great care during the calibration and the clinical use.

Calibrations are performed in standard rad. qualities, which in some cases differ from clinical radiation qualities. Interpolation not suitable in many cases

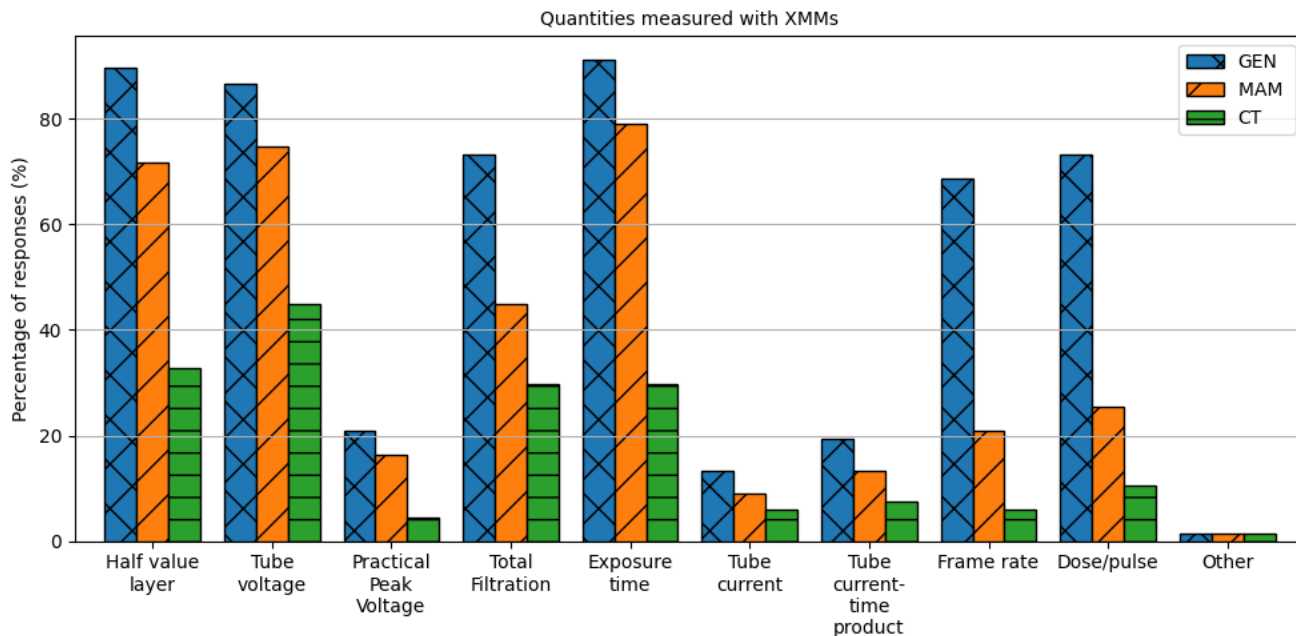
Medical Physicist Survey

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- Most of the respondents stated that they perform air kerma and HVL measurements either with ICs or XMMs.
- **Additional quantities related to X-ray tubes and X-ray beams besides air kerma are measured.**
- **Based on the survey, additional quantities are generally required by national regulations to be measured.**

Analysis was based on 84 replies from European clinical centers

Medical Physicist Survey: other quantities measured

- Which other quantities/parameters measured with the XMM are used for quality control in different modalities?



Six respondents use XMMs for air kerma measurements only

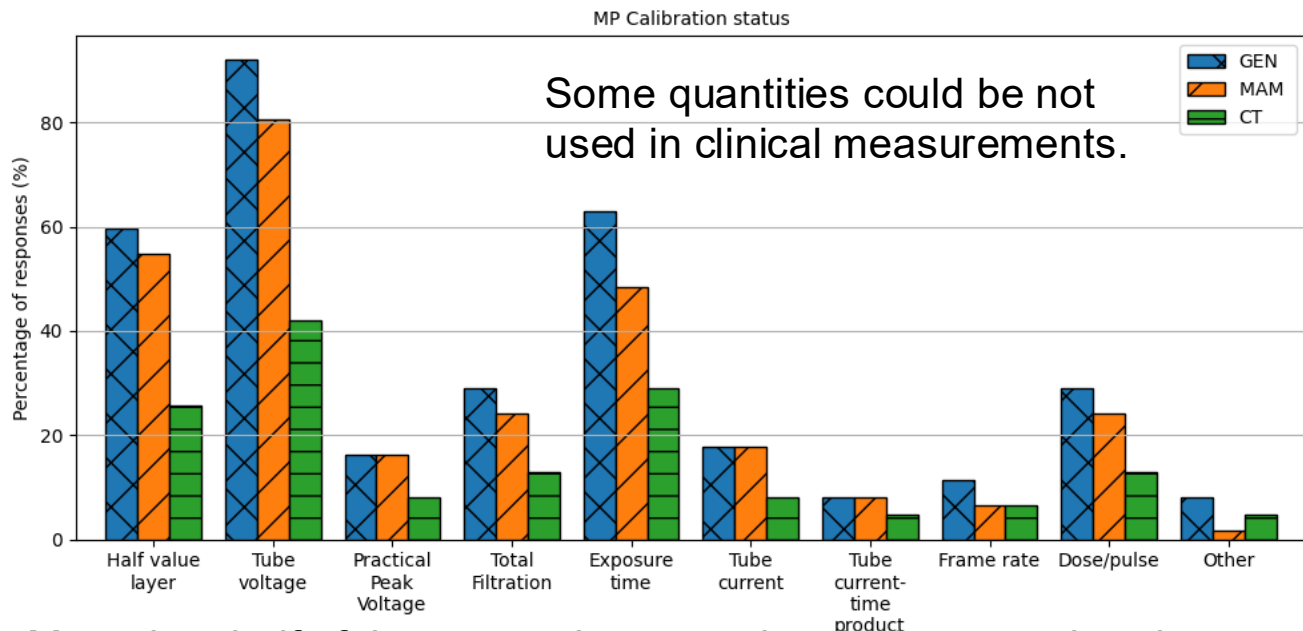
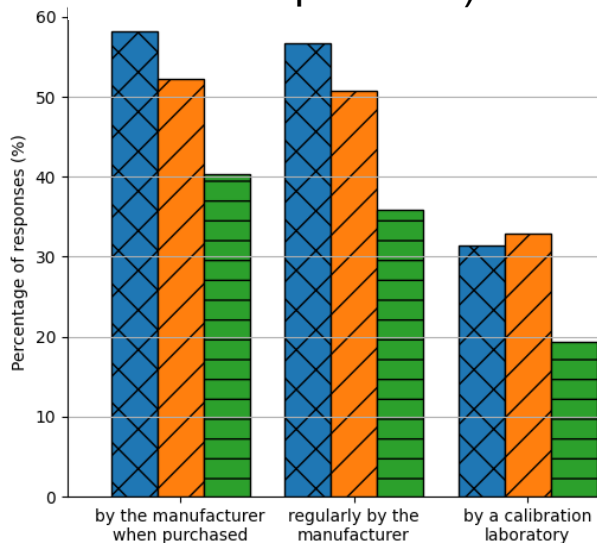
And the calibration in terms of the other quantities?

Medical Physicist Survey: XMM calibration

Are the XMMs calibrated for other quantities and parameters?

The XMMs are calibrated for the other quantities and parameters:

(for at least some of the additional quantities)

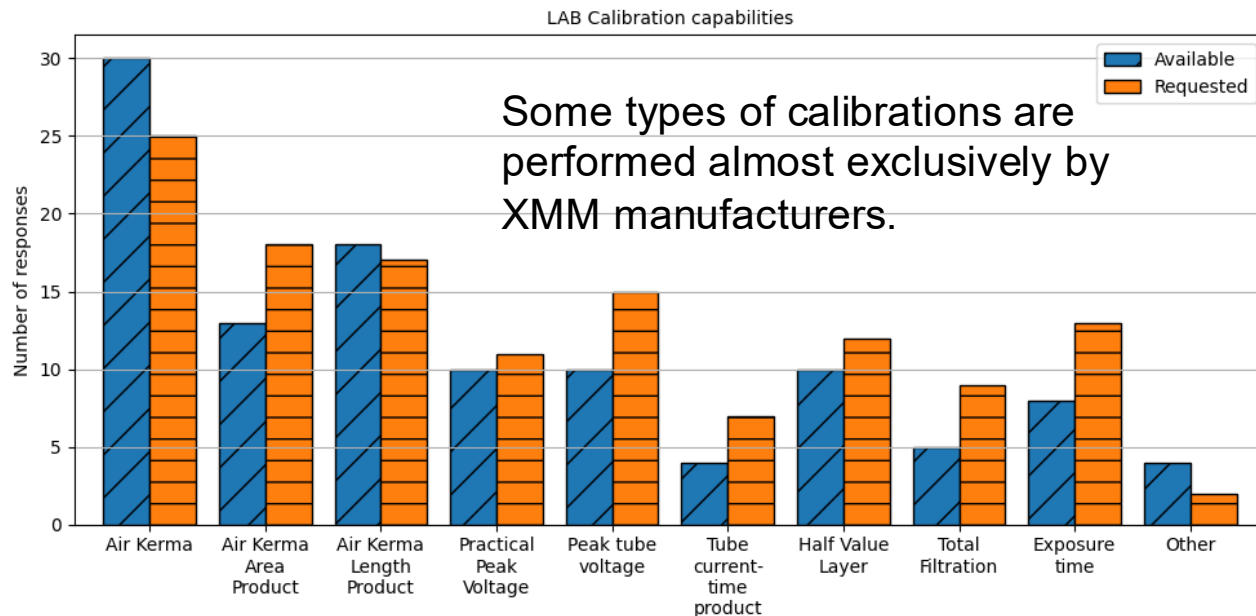


More than half of the respondents receive dosimeters already calibrated, and 85 % calibrate them regularly.

Analysis was based on 84 replies from European clinical centers

Lab survey: available and requested services

Which quantities and/or parameters are available and requested for calibration purposes?



Calibration laboratories in many cases are not able to provide the whole range of requested calibrations.

Regarding the quantities, air kerma calibrations are widely available to the users, but there is a gap for all other quantities

Analysis was based on 32 replies from Calibration Laboratories

Medical Physicist Survey

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- Most of the respondents stated that they perform air kerma and HVL measurements either with ICs or XMMs.
- Additional quantities related to X-ray tubes and X-ray beams besides air kerma are measured
- Based on the survey, additional quantities are generally **required by national regulations** to be measured.
- **Many different requirements for dosimeter calibration, testing and verification in different European countries, without a clear consensus about the best approach**

Analysis was based on 84 replies from European clinical centers

Review of Standards and Technical documents

See Standardization landscape ISO& IEC, DR, S.Pojtinger and P.Toroi (Day 1)

This is a preview - click here to buy the full publication

NORME
INTERNATIONALE
INTERNATIONAL
STANDARD

CEI
IEC
61267

Deuxième édition
Second edition
2005-11

Équipement de diagnostic médical
à rayonnement X –
Conditions de rayonnement pour utilisation dans
la détermination des caractéristiques

Medical diagnostic X-ray equipment –
Radiation conditions for use in the
determination of characteristics

Intended for testing and calibration of X-ray
equipment under harmonized conditions
defined to **mimic typical clinical radiation**
beams, e.g. RQR, RQA, RQC, RQT, RQR-M



INTERNATIONAL
STANDARD

NORME
INTERNATIONALE

IEC 61674

Edition 3.0 2024-07

Performance requirements for diagnostic
dosimeters with VENTED IONIZATION
CHAMBERS and/or SEMICONDUCTOR
DETECTORS in X-ray diagnostic imaging for
the measurement of AIR KERMA

Medical electrical equipment – Dosimeters with ionization chambers and/or
semiconductor detectors as used in X-ray diagnostic imaging



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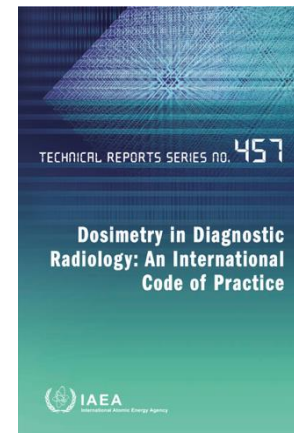
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IEC 61676

Edition 2.0 2023-03

Non-invasive measurement of
X-RAY tube voltage in terms
of practical peak voltage

Medical electrical equipment – Dosimetric instruments used for non-invasive
measurement of X-ray tube voltage in diagnostic radiology



Review of Standards and Technical documents

See Standardization landscape ISO& IEC, DR, S.Pojtinger and P.Toroi (Day 1)

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*Standardization gap:
Harmonized calibration
procedures and standard
requirements for other
quantities that are
measured by XMMs are
not available yet*

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IEC 61674

Edition 3.0 2024-07

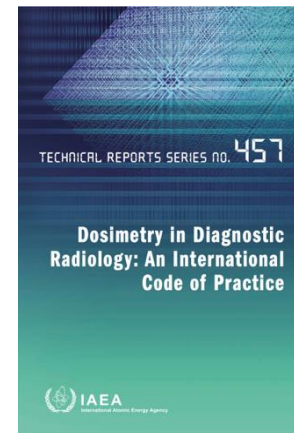
Performance requirements for diagnostic
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Non-invasive measurement of
X-RAY tube voltage in terms
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- Additional quantities related to X-ray tubes and X-ray beams besides air kerma are measured.
- Based on the survey, additional quantities are generally **required by national regulations** to be measured.
- Regarding the quantities, air kerma calibrations are widely available to the users, but there is a gap for all other quantities
- Many different requirements for dosimeter calibration, testing and verification in different European countries, without a clear consensus about the best approach
- **Clear need for better communication between regulatory bodies, calibration laboratories and the end users.**

Analysis was based on 84 replies from European clinical centers

Criteria for the dosimetry performance evaluation



The minimum rated range of an influence quantity is defined as the range of values for which the dosimeter fulfils the limits of variation

Investigation of current X-ray dosimetry and the usage of dosimeters

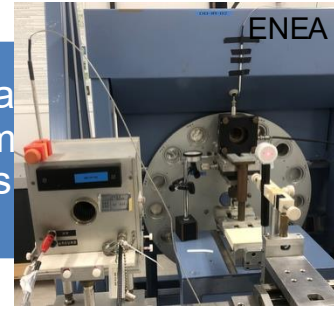
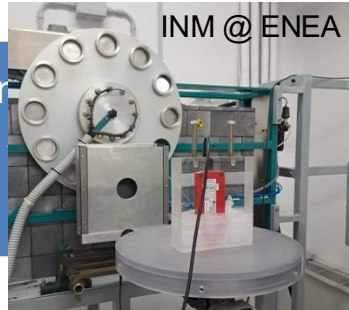
Selection of relevant criteria for the dosimetry performance evaluation and classification

WP1
(clinical radiation qualities)

WP3
(clinical use of dosimeters)

- Taken together, responses to the surveys provided an indication of the **types and models of ionisation chambers and XMMs used within the surveyed community**.
- Current performance criteria and potential for classification of dosimetry equipment based on literature and existing standards.
- The **minimum rated ranges** of influence quantities defined in IEC 61674 were compared with the conditions covered in the clinical practice. Based on this information, influence quantities that will require extension were selected and updated minimum rated ranges were proposed.

Evaluation of the performance of dosimeters



Evaluation of the performance of the commercially available dosimeters

- Experimental determination of the performance of commercially available dosimeters to propose a distinction between reference and field-class dosimeters.
- Harmonized test protocol for ICs and for XMMs.
- Measurements were carried out by the NMIs/DIs in their laboratories.
- Results on the performance of many commercially available X-ray dosimeter types:

“X-ray imaging dosimeter performance in standard and non-standard radiography radiation fields in terms of air kerma”, N.Kržanović et al (submitted to Physica Medica)

See Performance of XMMs in standard and non-standard conditions, N.Krzanovic (Day 2)

Investigation of current X-ray dosimetry and the usage of dosimeters

The current situation regarding the calibration services of X-ray imaging dosimeters in Europe was investigated.

<https://doi.org/10.1016/j.ejimp.2025.105055>

Selection of relevant criteria for the dosimetry performance evaluation and classification

Recommendations on the specific requirements such as compliance tests and rated ranges for reference- and field-class dosimeters enabling traceable clinical measurements with the targeted uncertainty 7% ($k=2$) and to be updated in future revisions of IEC 61674 and evidence submitted to IEC SC 62C WG 3 (May 2025, S. Pojtinger)

Evaluation of the performance of the commercially available dosimeters

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alessia.ciccotelli@enea.it

