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International code of practice IAEA TRS-457 and the need for updates

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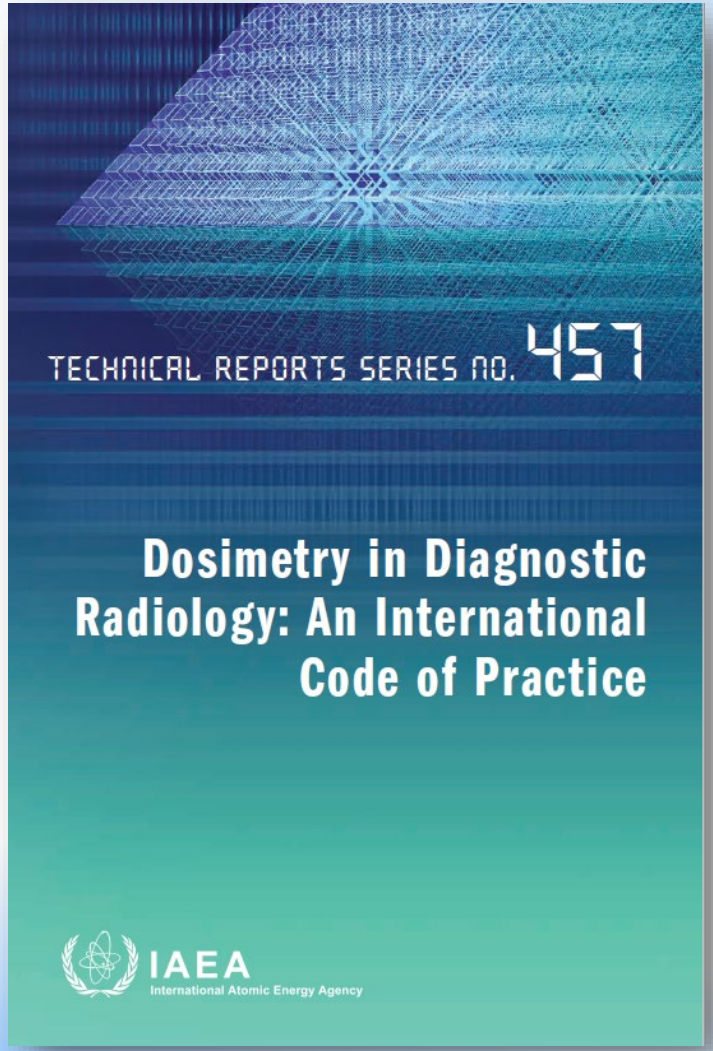
CCRI Webinar: X-ray imaging dosimetry challenges



Background

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International standardization in dosimetry is essential for the safe and effective optimization of radiation technology in the clinical environment

IAEA TRS 457 (2007):

- Different irradiation conditions (radiation quality and X ray beam geometry);
- Application specific dosimetric quantities;
- Specific dosimetric methods.

Need to update the TRS?
How do we know?

Performance test of multi-parameter measuring devices used for quality assurance in diagnostic radiology

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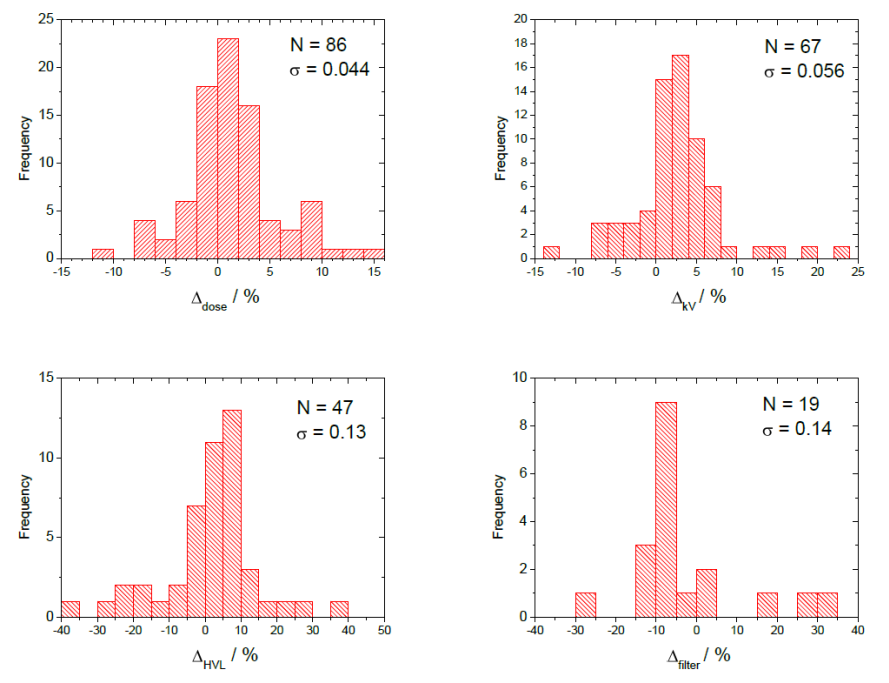
Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

IDOS 2010, E2-CN-182, Paper No 080

Abstract

The results of a performance test of four different types of semiconductor-based multi-parameter …….. **It turned out that a remarkably high amount of all measured data points (20 % - 50 %) fall beyond the limits of accuracy stated by the manufacturers.** ……need for the international standardization of the performance of semiconductor-based multi-parameter measuring devices, especially for those quantities which are essential for quality assurance in diagnostic radiology.



Performance of semiconductor dosimeters with a range of radiation qualities used for mammography: A calibration laboratory study

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Purpose: To investigate the radiation quality dependence of the response of commercial semiconductor-based dosimeters, and to estimate potential errors and uncertainties related to different measurement and calibration scenarios.

Methods: All measurement results were compared to reference values measured at the IAEA dosimetry laboratory which is traceable to the international system of units (SI). Energy dependence of the response of eight semiconductor dosimeters were determined for five different anode-filter combinations and tube voltages from 25 to 35 kV. For systems capable of deriving half value layer (HVL) and tube voltage from measurements, calibration coefficients for these measurements were calculated.

Results: For six dosimeters, the maximum deviations from the reference value of the air kerma measurement were within ±5% as required by IEC 61674. Calibration coefficients for radiation qualities (anode-filter and tube voltage combinations) relative to reference radiation quality Mo-Mo 28 kV deviate up to 12%. HVL and tube voltage measurements exhibited deviations up to 11% and 10%, respectively.

Conclusions: The air kerma responses of modern semiconductor dosimeters have a small energy dependence. However, no dosimeter tested complied with the accuracy limits stated by the manufacturer for tube voltage measurements, and only two dosimeters complied with the limits for HVL measurements. Absolute measurement of HVL and tube voltage with semiconductor dosimeters have to be verified for actual clinical radiation conditions on clinical mammography systems. Semiconductor dosimeters can be used for quality control measurements if individual calibration coefficients are available for the radiation condition applied. If other conditions are applied, additional uncertainty needs to be considered, particularly in the case of HVL and tube voltage measurements. © *2019 International Atomic Energy Agency. Medical Physics published by Wiley Periodicals, Inc. on behalf of American Association of Physicists in Medicine.* [https://doi.org/10.1002/mp.14005]

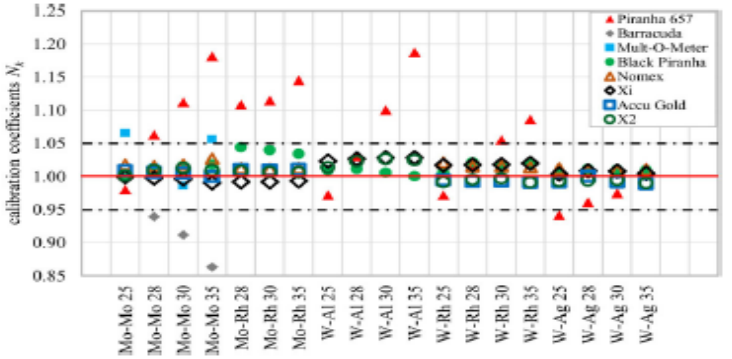

FIG. 2. Air kerma calibration coefficients N_k for all semiconductor dosimeters tested as a function of radiation quality. The horizontal red line indicates the ideal calibration coefficient of 1.0, the dashed black lines represent ±5% tolerance level. Piranha 657, Barracuda, Mult-O-Meter, Black Piranha, Nomex, Xi, Accu Gold, X2. [Color figure can be viewed at wileyonlinelibrary.com]

The role of medical physicists
Impact on MGD calculations

Med. Phys. 47 (3), March 2020 0094-2405/2020/47(3)/1372/7

Investigation of single-shot beam quality
art solid-state dosimeters for routine qu
in mammography

Frédéric Bemelmans [a], Nicholas W. Marshall [a,b], A
Sonja Ivanovic [c], Joke Binst [b], Lara Struelens [d], An
Hilde Bosmans [a,b,*]

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 16, NUMBER 4, 2015

Investigation of the clinical performance of a novel solid-state diagnostic dosimeter

Jason Tse,[a] Donald

Medical Ph

, ACT 2605,

DOI: 10.1002/acm2.13389

RADIATION MEASUREMENTS

Accuracy of HVL measu
detectors for radiography and fluoroscopy

Performance testing of dosimeters used in interventional radiology: Results from the VERIDIC project

Nikola Kržanović [a,*], Valentin Blideanu [b], Olivera Ciraj-Bjelac [a], Johann Plagnard [b],
Werner Schoonjans [c], Miloš Živanović [a], Jérémie Dabin [c]

and measurement with
mmographic dosimeters using ionization chambers and solid-state detectors

C J Hourdakis, A Rozi

TECHNOLOGY TALK

MAHADEVAPPA MAHESH, MS, PhD, RICHARD L. MORIN

Meaningful Data or Just Measu
Differences Between Ionization and Solid-State Detectors

Libby F. Brateman, PhD, Philip H. Heintz, PhD

Solid-state dosimeters: A new approach for mammography measurements

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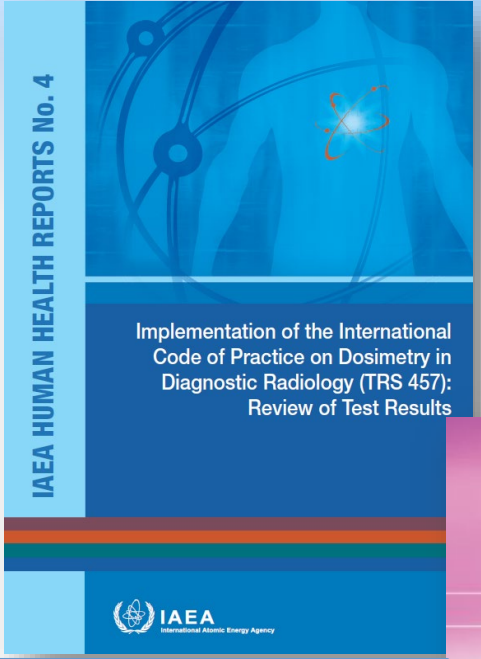
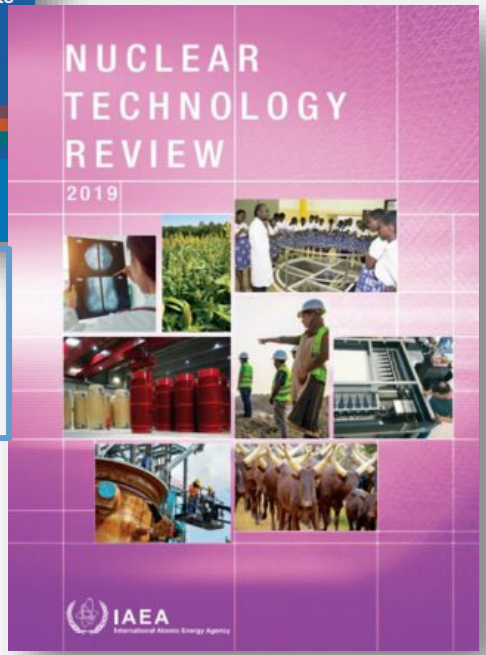
Coordinated Research Projects (CRPs): bring together research institutions from its developing and developed Member States to collaborate on research projects of common interest.

- Previous CRP: CRP (E2.10.06, 2005-2008): testing of various procedures described in the IAEA TRS-457

- Recommendations relating to TRS 457 implementation (30)
- Recommendations for future review of areas in TRS 457 (6)
- Recommendations for future action (7)





- Challenges with using the semiconductor-based dosimeters highlighted in the review

- Survey in MS conducted in 2017
- Recommendations by the **SSDL** Scientific **Committee (SSC)**

Consultancy Meeting to advise on CRP for the update of IAEA TRS-457, 10-13 November 2020

- The experts supported the idea to revise the guidance so that the dosimetry in diagnostic radiology to the level of measurable modality-specific dosimetry quantities, was addressed;
- CRP to provide input for the update of IAEA TRS-457, by:
  - Bridging the gap between dosimetry in diagnostic radiology from the perspective of PSDL/SSDLs and clinical medical physicists;
  - Providing international data about clinical practice in different imaging modalities, including those that are not included in the current version of the document;
  - Providing data on use of semiconductor-based dosimeters from the perspective of uncertainties in dose measurements.

CRP: Evaluation of the Dosimetry needs and practices for the update of the code of practice for dosimetry in diagnostic radiology (TRS-457) E24024)

CRP launched and duration: 2021-2025

Main objective

To standardise radiology medical physics dosimetry instrumentation, equipment and procedures in laboratories and hospitals, and support the update of the IAEA TRS No. 457.

Participation

- Experienced radiation metrologists from the IAEA/WHO Secondary Standards Dosimetry Laboratory (SSDL) Network members providing services in the diagnostic radiology field
- Clinically qualified medical physicists from public hospitals providing comprehensive diagnostic and interventional radiology services
- Scientists from Primary Standards Dosimetry Laboratories (PSDLs) providing services in the diagnostic radiology field

CRP: Evaluation of the Dosimetry needs and practices for the update of the code of practice for dosimetry in diagnostic radiology (TRS-457) E24024)

Specific objectives

- To provide recommendations on the performance specifications for **reference dosimeters in laboratory and clinical environments** for different beam qualities (standard radiation beam qualities (RQR), radiation qualities for computed tomography (CT) applications (RQT) and radiation qualities for mammography applications (RQM));
- To assess the accuracy of measurements performed using **semiconductor-based dosimeters** (in standard radiation qualities (RQR), mammography applications (RQM), CT applications (RQT)) e.g. practical peak voltage (kVp), kerma rate, total filtration, half value layer (HVL), etc.;
- Develop and test harmonized methodologies for **kerma-area product** (P_{KA}) measurements relevant to calibration laboratories and end users at the hospitals in cone beam computed tomography (CBCT), dental radiology and interventional procedures;
- To obtain data pertaining to **intra- and inter-scanner variations** in measured vs. displayed CT dose indices.

CRP: Evaluation of the Dosimetry needs and practices for the update of the code of practice for dosimetry in diagnostic radiology (TRS-457) E24024)

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Republic of Namibia
Ministry of Health & Social Services

IAEA project officers: Z. Msimang, O.Ciraj-Bjelac

Instruments

Reference standards

- Definition of a reference instrument for dosimetry in diagnostic radiology
- Survey to collect data on types of reference instruments used (IAEA data, SSDL input)
- To define conditions for testing (radiation qualities, ionization chambers available): testing in monoenergetic radiation beams, ISO N radiation qualities, RQR radiation qualities, non-standard radiation qualities

X ray multimeters (XMMs)

- Guidelines on disseminating traceability for quantities measured by the XMMs
- Requirements for type test *vs* verification test vs conformity tests *vs* calibration
- Beam qualities and measurement protocol at laboratories and clinics
- Quantities/Parameters measured by XMMs (air kerma/rate, HVL, tube voltage)

Other considerations

- Evaluation of the method for HVL measurements (described in the IAEA TRS No. 457)
- Guidance how to transfer traceability from reference instrument to various modalities
- To investigate reference dosimetry for interventional procedures and CT
- Role and relevance of a monitor chamber at calibration laboratories
- Use of voltage dividers (necessity, availability)
- Guidance on commissioning of dosimetry equipment

Uncertainty assessment

- To define what measurement uncertainties are required in diagnostic radiology for clinics;
- Estimate measurement uncertainties in diagnostic radiology for laboratory and clinical measurements based on the procedures followed;
- Preparing uncertainty budgets in a hospital environment is a challenge;
- Need for training of medical physicists working in hospitals on measurement uncertainties and preparation of uncertainty budgets.

KAP and CT

Work in Progress

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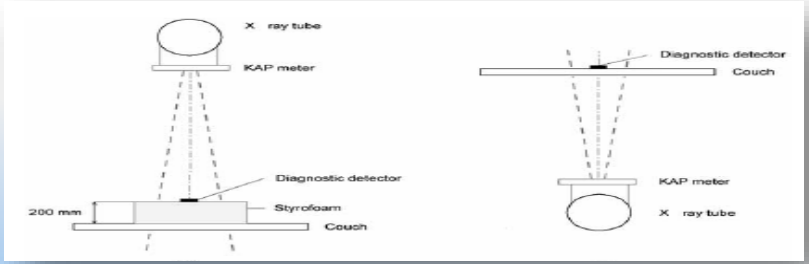
KAP measurements
Look at available standards and literature (TRS457, EFOMP CBCT, ICRP ….)
Identification of modalities for which KAP is a relevant quantity (other than dental)
Dental (CBCT, panoramic, intraoral): protocol, calibration of KAP indication, clinical measurements
Other CBCTs: protocol, calibration of KAP indication, clinical measurements
Data analysis and uncertainty assessment
Dissemination

CT dose measurements
Collecting already available data (ACR, clinical data from CRP participants)
Data analysis
Consider a "new" survey or data collection
Data analysis and uncertainty assessment
Dissemination
Consideration of different beam qualities (Sn)- link to first objective



Summary & points for discussion

- Concept of reference-class dosimeter in diagnostic radiology
- Definition, selection & establishment radiation beam qualities
- Transfer of traceability from reference instrument to imaging modalities
- What is the best approach to the XMMs from radiation metrology perspective?
- Should SSDLs perform calibrations/verifications/conformity test for measurement of HVLs, total filtration, exposure time, etc.?
- Reference measurements in certain imaging modalities (e.g. IR, CT)
- Need for accuracy and uncertainty assessment

For SSDLs:

- How many diagnostic radiology ionization chambers you calibrate per year (for users)?
- How many XMMs you calibrate per year?
- To what extend are you comfortable with software and interface? Does the setting match lab conditions?

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Thank you!