EESTI STANDARD **EVS-ISO 4037-3:2019**

KIIRGUSKAITSE
Dosimeetrite ja doosi kiiruse mõõteseadmete kalibreerimiseks ning nende footoni energiast sõltuva koste määramiseks kasutatav röntgeni- ja gammareferentskiirgus
Osa 3: Pindala- ja isikudosimeetrite kalibreerimine ning nende koste mõõtmine kiirguse energia ja langemisnurga funktsioonina

Radiological protection
X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy
Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence
(ISO 4037-3:2019, identical)

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION

EESTI STANDARDI EESSÕNA	NATIONAL FOREWORD
See Eesti standard EVS-ISO 4037-3:2019 „Kiirguskaitse. Dosimeetrite ja doosi kiiruse mõõteseadmete kalibreerimiseks ning nende footoni energiast sõltuva koste määramiseks kasutatav röntgeni- ja gammareferentskiirgus. Osa 3: Pindala- ja isikudosimeetrite kalibreerimine ning nende koste mõõtmine kiirguse energia ja langemisnurga funktsioonina“ sisaldab rahvusvahelise standardi ISO 4037-3:2019 „Radiological protection. X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy. Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence“ identset ingliskeelset teksti.	This Estonian Standard EVS-ISO 4037-3:2019 consists of the identical English text of the International Standard ISO 4037-3:2019 „Radiological protection. X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy. Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence“.
Ettepaneku rahvusvahelise standardi ümbertrüki meetodil ülevõtuks on esitanud EVS/TK 28, standardi avaldamist on korraldanud Eesti Standardikeskus.	Proposal to adopt the International Standard by reprint method has been presented by EVS/TK 28, the Estonian Standard has been published by the Estonian Centre for Standardisation.
Standard EVS-ISO 4037-3:2019 on jõustunud sellekohase teate avaldamisega EVS Teataja 2019. aasta juunikuu numbris.	Standard EVS-ISO 4037-3:2019 has been endorsed with a notification published in the June 2019 issue of the official bulletin of the Estonian Centre for Standardisation.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Käsitlusala

See dokument määratleb lisaprotseduurid ja -andmed kiirguskaitse individuaalseks ja pindala seireks kasutatavate dosimeetrite ja doosi kiiruse mõõteseadmete kalibreerimiseks. Kiirguskaitse doosi (kiiruse) mõõteseadmete kalibreerimise üldist protseduuri ja koste määramist kirjeldatakse standardis ISO 29661 ning seda järgitakse nii palju kui võimalik. Sel eesmärgil kasutatakse standardis ISO 4037-1 kirjeldatu kohaselt footoni referentskiirguse väljasid, mille keskmine energia asub vahemikus 8 keV kuni 9 keV. Lisas D on toodud lisateave normtingimuste, vajalike standardsete katsetingimuste ja elektronide ulatusega kaasnevate mõjude kohta. Individuaalse seire puhul käsitletakse nii kogukeha- kui ka jäsemedosimeetreid ning pindala seire puhul portatiivseid ja fikseeritud doosi (kiiruse) mõõteseadmeid.

Referentsväljade jaoks on vajalik laetud osakeste tasakaal, kuigi see pole alati kindlaks määratud töökohal olevas väljas, mille jaoks dosimeeter tuleks kalibreerida. See kehtib eriti footoni energia kohta referentssügavusel *d* ilma laetud osakestele omase tasakaaluta, mis sõltub energia ja referentssügavuse *d* tegelikust kombinatsioonist. Elektronid, mille energia on üle 65 keV, 0,75 MeV ja 2,1 MeV, võivad läbida vastavalt 0,07 mm, 3 mm ja 10 mm ICRU kudet ja nendest väärtustest suuremate footoni energiate korral loetakse kiirgusparameetrid sellel sügavusel defineeritud suuruste jaoks sisemise tasakaaluta laetud osakeste kiirgusparameetriteks. See dokument tegeleb ka koste määramisega pealelangeva footoni energia ja kiirguse langemisnurga funktsioonina. Sellised mõõtmised võivad kujutada endast osa tüübikatsest, mille käigus uuritakse lisasuuruste mõju kostele.

See dokument on kasutatav ainult selliste õhukerma kiiruse väärtuste korral, mis on suuremad kui 1 μGy/h.

See dokument ei hõlma fikseeritud pindaladosimeetrite *in-situ* kalibreerimist.

Dokumendis kirjeldatakse eri dosimeetrite puhul järgitavaid protseduure. Soovitused on esitatud kasutatava fantoomi ja rakendatavate teisendustegurite kohta. Soovitatavad teisendustegurid on antud ainult vastavuses olevatele kiirguse referentsväljadele, mis on määratletud standardi ISO 4037-1:2019 peatükkides 4 kuni 6. Standardi ISO 4037-1:2019 lisad A ja B, mis on mõlemad teatmelisad, hõlmavad fluorestsentskiirgusi ja radionukliidi ^{241}Am, S-Am gammakiirgust, mille kohta publitseeritud detailne teave ei ole kättesaadav. Standardi ISO 4037-1:2019 lisas C esitatakse täiendavaid röntgenikiirguse väljad, mis on kirjeldatud kvaliteedinäitajaga. Teisendustegurid kõigi nende kiirgusparameetrite korral on toodud lisades A kuni C, kuid ainult ligikaudse hinnanguna, kuna nende teisendustegurite üldine määramatus tegelikes kiirguse referentsväljades pole teada.

MÄRKUS Terminit „dosimeeter“ kasutatakse üldmõistena kõigi individuaalseks ja pindala seireks kasutatavate dosimeetrite ja doosi kiiruse mõõteseadmete kohta.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 17.240

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www. iso. org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www. iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www. iso. org/iso/foreword. html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies and radiological protection*, Subcommittee SC 2, *Radiological protection*.

This second edition cancels and replaces the first edition (ISO 4037-3:1999), which has been technically revised.

A list of all the parts in the ISO 4037 series can be found on the ISO website.

Introduction

The maintenance release of this document incorporates the improvements to high voltage generators from 1996 to 2017 (e.g., the use of high frequency switching supplies providing nearly constant potential), and the spectral measurements at irradiation facilities equipped with such generators (e.g., the catalogue of X-ray spectra by Ankerhold[1]). It also incorporates all published information with the aim to adjust the requirements for the technical parameters of the reference fields to the targeted overall uncertainty of about 6 % to 10 % for the phantom related operational quantities of the International Commission on Radiation Units and Measurements (ICRU)[2]. It does not change the general concept of the existing ISO 4037.

ISO 4037, focusing on photon reference radiation fields, is divided into four parts. ISO 4037-1 gives the methods of production and characterization of reference radiation fields in terms of the quantities spectral photon fluence and air kerma free-in-air. ISO 4037-2 describes the dosimetry of the reference radiation qualities in terms of air kerma and in terms of the phantom related operational quantities of the International Commission on Radiation Units and Measurements (ICRU)[2]. This document describes the methods for calibrating and determining the response of dosemeters and doserate meters in terms of the phantom related operational quantities of the ICRU[2]. ISO 4037-4 gives special considerations and additional requirements for calibration of area and personal dosemeters in low energy X reference radiation fields, which are reference fields with generating potential ≤30 kV.

The determination of the response of dosemeters and doserate meters is essentially a three-step or two-step process. First, a basic quantity such as air kerma is measured free-in-air at the point of test. Then the appropriate operational quantity is derived by the application of the conversion coefficient that relates the quantity measured to the selected operational quantity. These two steps may be merged into a single-step if a standard for the phantom related quantities is used. Finally, the device under test is placed at the point of test for the determination of its response. Depending on the type of dosemeter under test, the irradiation is either carried out on a phantom or free-in-air for personal and area dosemeters, respectively. For area and individual monitoring this document describes details of the methods and provides, if applicable, the recommended conversion coefficients to be used for the determination of the response of dosemeters and doserate meters in terms of the phantom related operational quantities of the ICRU for photons. The use of these recommended conversion coefficients requires that the corresponding radiation quality of the reference field used for the irradiation is validated. For all non-validated radiation qualities, the recommended conversion coefficients cannot be used. For these radiation qualities, the dosimetry with respect to the phantom related operational quantities of the ICRU – see ISO 4037-2:2019, Clause 6 – or the spectrometry – see ISO 4037-2:2019, Annex B – should be performed. For tube potentials of 30 kV and below ISO 4037-4 gives special requirements.

The general procedures described in ISO 29661 are used as far as possible in this document. In addition, the symbols used are in line with ISO 29661.

Radiological protection — X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy —

Part 3:
Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence

1 Scope

This document specifies additional procedures and data for the calibration of dosemeters and doserate meters used for individual and area monitoring in radiation protection. The general procedure for the calibration and the determination of the response of radiation protection dose(rate)meters is described in ISO 29661 and is followed as far as possible. For this purpose, the photon reference radiation fields with mean energies between 8 keV and 9 MeV, as specified in ISO 4037-1, are used. In Annex D some additional information on reference conditions, required standard test conditions and effects associated with electron ranges are given. For individual monitoring, both whole body and extremity dosemeters are covered and for area monitoring, both portable and installed dose(rate)meters are covered.

Charged particle equilibrium is needed for the reference fields although this is not always established in the workplace fields for which the dosemeter should be calibrated. This is especially true at photon energies without inherent charged particle equilibrium at the reference depth *d*, which depends on the actual combination of energy and reference depth *d*. Electrons of energies above 65 keV, 0,75 MeV and 2,1 MeV can just penetrate 0,07 mm, 3 mm and 10 mm of ICRU tissue, respectively, and the radiation qualities with photon energies above these values are considered as radiation qualities without inherent charged particle equilibrium for the quantities defined at these depths. This document also deals with the determination of the response as a function of photon energy and angle of radiation incidence. Such measurements can represent part of a type test in the course of which the effect of further influence quantities on the response is examined.

This document is only applicable for air kerma rates above 1 µGy/h.

This document does not cover the in-situ calibration of fixed installed area dosemeters.

The procedures to be followed for the different types of dosemeters are described. Recommendations are given on the phantom to be used and on the conversion coefficients to be applied. Recommended conversion coefficients are only given for matched reference radiation fields, which are specified in ISO 4037-1:2019, Clauses 4 to 6. ISO 4037-1:2019, Annexes A and B, both informative, include fluorescent radiations, the gamma radiation of the radionuclide ^{241}Am, S-Am, for which detailed published information is not available. ISO 4037-1:2019, Annex C, gives additional X radiation fields, which are specified by the quality index. For all these radiation qualities, conversion coefficients are given in Annexes A to C, but only as a rough estimate as the overall uncertainty of these conversion coefficients in practical reference radiation fields is not known.

NOTE The term dosemeter is used as a generic term denoting any dose or doserate meter for individual or area monitoring.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4037-1, *Radiological protection — X and gamma reference radiations for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 1: Radiation characteristics and production methods*

ISO 4037-2:2019, *Radiological protection — X and gamma reference radiations for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 2: Dosimetry for radiation protection over the energy ranges from 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

ISO 4037-4:2019, *Radiological protection — X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 4: Calibration of area and personal dosemeters in low energy X reference radiation fields*

ISO 29661, *Reference radiation fields for radiation protection — Definitions and fundamental concepts*

ISO 80000-10, *Quantities and units — Part 10: Atomic and nuclear physics*[1)]

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4037-1, ISO 4037-2, ISO 29661, ISO 80000-10, ISO/IEC Guide 99 and the following apply:

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
back-scatter factor
ratio of air kerma in front of a phantom to the air kerma at the same position free-in-air without the phantom. The field is considered to be unidirectional with a direction of incidence perpendicular to the phantom surface

Note 1 to entry: The value of the back-scatter factor depends on the point of test (distance from the surface and from the beam axis), beam diameter, phantom size and material and radiation energy.

4 Procedures applicable to all area and personal dosemeters

4.1 General principles

4.1.1 Radiation qualities

All radiation qualities shall be chosen from, and produced in accordance to, ISO 4037-1. In general, it is useful to select an appropriate validated radiation quality taking into account the specified energy and dose or dose rate range of the dosemeter to be tested.

1) Under preparation. Stage at the time of publication ISO/Guide 80000-10:2019.