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Radiological protection — Criteria and performance limits for the periodic evaluation of dosimetry services for external radiation

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Foreword

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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 document 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).

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For an explanation of 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 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,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 430, *Nuclear energy, nuclear technologies, and radiological protection,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 14146:2018) which has been technically revised.

The main changes are as follows:

— the addition and clarification of several definitions;

— the modification of the requirements to environmental dosemeters;

— the addition of a requirement at reference conditions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Radiological protection — Criteria and performance limits for the periodic evaluation of dosimetry services for external radiation

1 Scope

This document specifies the dosimetric and organizational criteria and the test procedures to be used for the periodic verification of the performance of dosimetry services supplying personal and/or area, i.e., workplace and/or environmental, dosemeters used for individual (personal) and/or area, i.e. workplace and/or environmental monitoring.

NOTE The quality of a supplier of a dosimetry service depends on both the characteristics of the approved (type-tested) dosimetry system[1)] and the training and experience of the staff, together with the calibration procedures and quality assurance programmes.

The performance evaluation according to this document can be carried out by a dosimetry service to demonstrate the fulfilment of specified performance requirements. The irradiation qualities used in this document are representative for exposure situations that are expected or mimic workplace fields from the radiological activities being monitored using the dosemeters from the services.

This document applies to personal and area dosemeters for the assessment of external photon radiation with a fluence-weighted mean energy between 8 keV and 10 MeV, beta radiation with a fluence-weighted mean energy between 60 keV and 1,2 MeV, and neutron radiation with a fluence-weighted mean energy between 25,3 meV, i.e., thermal neutrons with a Maxwellian energy distribution with kT = 25,3 meV, and 200 MeV.

It covers all types of personal and area dosemeters needing laboratory processing (e.g. thermoluminescent, optically stimulated luminescence, radiophotoluminescent, track detectors or photographic-film dosemeters) and involving continuous measurements or measurements repeated regularly at fixed time intervals (e.g. several weeks, one month).

Active direct reading as well as semi-passive or hybrid dosemeters, such as direct ion storage (DIS) or silicon photomultiplier (SiPM) dosemeters, (for dose measurement) can also be treated according to this document. Then, they are treated as if they were passive, i.e. the dosimetry service reads their indicated values and reports them to the evaluation organization.

In this document, the corrected indicated (corrected indication) value is the one given by the dosimetry systems as the final result of the evaluation algorithm (for example display of the software, printout) in units of dose equivalent (Sv).

Environmental dosemeters usually indicate the quantity $H^*(10)$ but they can, in addition or alternatively, indicate the quantity $H'(3)$, $H'(0{,}07)$, air kerma, K_a, or absorbed dose, D. All these dosemeters can also be treated according to this document. If K_a or D is indicated (in Gy) the dose values in this document stated in Sv shall then be interpreted as equivalent values in Gy.

1) If this document is applied to a dosimetry system for which no approval (pattern or type test) has been provided, then in the following text approval or type test should be read as the technical data sheet provided by the manufacturer or as the data sheet required by the regulatory body.

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 radiation 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, *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 2: Dosimetry for radiation protection over the energy ranges from 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

ISO 4037-3, *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 6980-1, *Nuclear energy — Reference beta-particle radiation — Part 1: Methods of production*

ISO 6980-2, *Nuclear energy — Reference beta-particle radiation — Part 2: Calibration fundamentals related to basic quantities characterizing the radiation field*

ISO 6980-3, *Nuclear energy — Reference beta-particle radiation — Part 3: Calibration of area and personal dosemeters and the determination of their response as a function of beta radiation energy and angle of incidence*

ISO 8529-1, *Neutron reference radiations fields — Part 1: Characteristics and methods of production*

ISO 8529-2, *Reference neutron radiations — Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field*

ISO 8529-3, *Neutron reference radiation fields — Part 3: Calibration of area and personal dosemeters and determination of their response as a function of neutron energy and angle of incidence*

ISO 12749-2, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 2: Radiological protection*

ISO 12789-1, *Reference radiation fields — Simulated workplace neutron fields — Part 1: Characteristics and methods of production*

ISO 12789-2, *Reference radiation fields — Simulated workplace neutron fields — Part 2: Calibration fundamentals related to the basic quantities*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/TS 18090-1, *Radiological protection — Characteristics of reference pulsed radiation — Part 1: Photon radiation*

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

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

IEC 61267, *Medical diagnostic X-ray equipment — Radiation conditions for use in the determination of characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12749-2, ISO 29661 and the following apply.

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

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

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

3.1
approved dosimetry system
dosimetry system that is used by a dosimetry service that has been approved or authorized for use by the qualification body

Note 1 to entry: Several dosemeter designs can be operated using the same associated processing system (dosemeter reader, etc.). Then, they are regarded as separate dosemeters/dosimetry systems.

3.2
area dosemeter
meter designed to measure the ambient dose equivalent (rate) or the directional dose equivalent (rate)

Note 1 to entry: For a general definition of dosemeter, see 3.7.

Note 2 to entry: Area dosemeters are used for area monitoring which comprises environmental and workplace monitoring, see 3.3.

[SOURCE: ISO 29661:2012, 3.1.2, modified: Notes 1 and 2 added.]

3.3
area monitoring
monitoring in which a workplace or an area in the environment is monitored by taking dose (rate) measurements

Note 1 to entry: Area monitoring is usually performed in terms of $H'(0,07)$, $H'(3)$ or $H^*(10)$.

Note 2 to entry: Definition orientated at ICRP 103 and ICRP 116.

[SOURCE: IEC 62387:2020, 3.46]

3.4
background dose
radiation dose
dose (or an observed measure related to the dose) attributable to all sources other than the one(s) specified

Note 1 to entry: Strictly, this applies to measurements of dose or counts from a sample, where the background dose or counts must be considered (usually subtracted) from all measurements. However, background is used more generally to refer to the effects of other sources in any situation in which a particular source (or group of sources) is under consideration. It is also applied to quantities other than doses, such as activity concentrations in environmental media.

Note 2 to entry: The background dose can contain dose fractions from transportation and/or other events such as X-ray screening for security checks.

Note 3 to entry: To determine the background dose, usually, a group of control (background) dosemeters is used.

[SOURCE: IAEA Safety Glossary 2022, modified: “dose” and “(radiation dose)” added to the term; “dose rate” removed; second sentence in note 1 rearranged; notes 2 and 3 added]

3.5
control dosemeter
personal, area or environmental dosemeter that provides an estimate of any radiation dose received by the evaluation sample apart from that given by the irradiation laboratory or by a controlled exposure to environmental radiation

Note 1 to entry: The control dosemeter provides a means of estimating and eliminating the contribution to the dose from natural background radiation and that received during the time between zeroing and read out, i.e., the dose during handling, transportation, etc.

Note 2 to entry: The control dosemeters are used to determine the background radiation dose.

3.6
corrected indication
corrected indicated value
G_{corr}
indication of a dosemeter corrected for any differences of the values of the influence quantities from reference conditions

Note 1 to entry: The corrected indication G_{corr} can be calculated with the correction factor k_n for non-constant response, the q correction factors, k_f, for the influence quantities of type F and the p correction summands, G_w, for the influence quantities of type S. It is given by

$$G_{corr} = k_n \cdot (G - \sum_{w=1}^{p} G_w) \cdot \prod_{f=1}^{q} k_f$$

The equation above is a model function of the measurement necessary for any determination of the uncertainty according to the ISO/IEC Guide 98-3 (GUM).

Note 2 to entry: Some *dosimetry systems* (3.9), especially such for neutron radiation, can have different correction factors (or functions) k_w for different workplace categories w, each with its own reference radiation quality (e.g. ^{252}Cf(bare) for one workplace category and ^{252}Cf(D_2O moderated) for another workplace category). Then, to obtain the correspondingly corrected indicated dose value G_{corr}, the uncorrected indicated values G, needs to be multiplied by $k_w \neq 1$: $G_{corr} = G \cdot k_w$. Further information on the use of different correction factors (or functions) for different workplace categories can be found in ISO 21909-2[2]. In ISO 21909-2, the symbol for the correction factor (or function) is $k_{n,E,\Omega}$ instead of k_w.

[SOURCE: ISO 29661:2012 + Amd.1:2015, 3.1.11, modified: term “corrected indicated value” added and original note 2 deleted and new note 2 added]

3.7
dosemeter
device having a reproducible, measurable response to radiation that can be used to measure absorbed dose (in Gy) or personal, ambient or directional dose equivalent (in Sv)

Note 1 to entry: In a wider sense, this term is used for meters designed to measure other quantities related to radiation such as exposure, fluence, etc. Such use is deprecated.

Note 2 to entry: This apparatus may require a separate reader to read out and software to evaluate and display the indicated value of the absorbed dose or dose equivalent.

Note 3 to entry: For specific types of dosemeters, see 3.2, 3.10, 3.17 and 3.25.

[SOURCE: ISO 12749-2:2022, 3.4.12, modified: “(in Gy)”, “(in Sv)” and “ambient or directional” added and notes 1 and 2 added]

3.8
dosimetry service
organization that operates a personal, area and/or environmental dosimetry system which includes the evaluation of the reading of dosemeters after their use and includes:

— providing the user with dosemeters;

— recording the results;

— reporting the results to the user.

Note 1 to entry: The dosimetry service fulfils basic quality management and independency requirements if it fulfils the requirements stated in ISO/IEC 17025.

Note 2 to entry: The user includes not only external clients but also internal personnel who wear dosemeters provided by their own organization and are engaged in radiation protection activities inside or outside the organization. The same quality of dosimetry service which is provided to external users is also provided to organizations' employees (internal users), in accordance with their own quality management system.

3.9
dosimetry system
dosemeter, reader and all associated equipment and procedures including software used for assessing and visualizing the indicated value

[SOURCE: IEC 62387:2020, 3.12, modified: “including software” and “and visualizing” added]

3.10
environmental dosemeter
dosemeter used for environmental monitoring

Note 1 to entry: For a general definition of dosemeter, see 3.7.

Note 2 to entry: Environmental dosemeters are used for environmental monitoring, see 3.11.

Note 3 to entry: Environmental dosemeters are typically used in areas of the environment close to or inside an installation emitting ionizing radiations such as nuclear installations or medical accelerators. In these areas usually no occupationally exposed person is present.

Note 4 to entry: Environmental dosemeters are generally used for monitoring the dose limits of the general population, which are significantly lower as for occupationally exposed individuals. Consequently, the requirements for environmental dosemeters are stronger than for workplace dosemeters, especially the lower dose limit of 35 µSv and the extended range for the angle of incidence of the incident radiation ranging from 0° up to ±75°.

3.11
environmental monitoring
area *monitoring* (3.3) by the measurement of external dose (rate) in the environment

Note 1 to entry: Environmental monitoring is usually performed in terms of $H'(0,07)$, $H'(3)$ or $H^*(10)$.

[SOURCE: IEC 62387:2020, 3.48]

3.12
evaluation sample
randomly selected representative group of personal, area or environmental dosemeters used to evaluate the performance of a *dosimetry service* (3.8)

Note 1 to entry: The evaluation sample includes dosemeters that are irradiated, remain unirradiated or serve as control dosemeters for the evaluation procedure.

3.13
evaluation organization
impartial organization that administers the performance evaluation of *dosimetry services* (3.8) and assesses the results

Note 1 to entry: The evaluation organization may include the irradiation laboratory.

Note 2 to entry: The evaluation organization fulfils basic quality management and independency requirements if it fulfils the requirements stated in ISO/IEC 17043.

3.14
irradiation laboratory
impartial laboratory possessing radiation sources, calibration equipment and associated facilities traceable to national, i.e., to primary or secondary, standards able to irradiate dosemeters from the evaluation sample to a high degree of metrological accuracy

Note 1 to entry: The irradiation laboratory fulfils basic quality management and independency requirements if it fulfils the requirements stated in ISO/IEC 17025 for calibration laboratories. Accreditation according to ISO/IEC 17025 impartially confirms the competence of the irradiation laboratory.

3.15
indication
indicated value
G
quantity value provided by a measuring instrument or a measuring system

Note 1 to entry: The units of the indication of the dosemeter are not necessarily the same as that of the measurand. For example, for measurements with ionization chambers the instrument indication is, in general, the value of the current I or of the charge Q. It is necessary to document whether the indication is normalized to the reference conditions to account for influence quantities and is corrected for intrinsic background and other influences. The corrected indication is named G_{corr}.

Note 2 to entry: It may be necessary that a measured dose (e.g. by control dosemeters) or a transport and/or background dose determined by other means be considered (usually subtracted) by the *dosimetry service* (3.8) or by the evaluating organization, see notes to the definition of 3.18, irradiated dose.

Note 3 to entry: This definition means the same as "indicated value" in IEC 62387:2020, 3.14.

[SOURCE: ISO 29661:2012 + Amd.1:2015, 3.1.15, modified: term "indicated value" added and original notes 1 and 3 deleted and new notes 2 and 3 added]

3.16
personal dosemeter
dosemeter used for individual (personal) monitoring

Note 1 to entry: For a general definition of dosemeter, see 3.7.

Note 2 to entry: Depending on the wearing position and type of construction a personal dosemeter may be a whole-body dosemeter, an eye lens dosemeter or and extremity dosemeter.

Note 3 to entry: Personal dosemeters are used for individual monitoring, see 3.17.

3.17
individual monitoring
monitoring using dose (rate) measurements by equipment worn by individual workers

Note 1 to entry: Also called personal monitoring. Usually contrasted with workplace monitoring.

Note 2 to entry: Individual monitoring is performed in terms of $H_p(0,07)$, $H_p(3)$ or $H_p(10)$.

[SOURCE: IEC 62387:2020, 3.49, modified: ", or measurements of quantities of radioactive material in or on their bodies" deleted in the end]

3.18
irradiated dose
H_{ref}
conventional quantity value of the dose to which the *dosemeter* (3.7) is irradiated

Note 1 to entry: In most cases, H_{ref} is a dose irradiated by a calibration laboratory using artificial radiation sources (such as radionuclide sources, X-ray tubes or others) in addition to the background dose and, consequently, the background dose must be considered (usually subtracted) to calculate the corrected indicated dose value G_{corr}.

Note 2 to entry: Especially for environmental dosemeters, H_{ref} can include or be identical to a dose received from a controlled exposure to natural environmental radiation. In these cases, it is not considered (usually subtracted) to calculate the corrected indicated dose value G_{corr}. The conventional quantity value for natural environmental radiation can be assessed as described in the literature[3].

3.19
lower dose limit
H_0
dose below which irradiations should not be performed