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Radiation protection instrumentation – Dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation

Instrumentation pour la radioprotection – Systèmes dosimétriques avec détecteurs intégrés passifs pour le contrôle radiologique individuel, du lieu de travail et de l'environnement des rayonnements photoniques et bêta



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIATION PROTECTION INSTRUMENTATION –
DOSIMETRY SYSTEMS WITH INTEGRATING PASSIVE DETECTORS
FOR INDIVIDUAL, WORKPLACE AND ENVIRONMENTAL MONITORING
OF PHOTON AND BETA RADIATION**

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International Standard IEC 62387 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition of IEC 62387 published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Modification of title.
- Addition of performance requirements for dosimeters to measure $H'(3)$ for both photon and beta radiation.
- Adoption of the cylinder instead of the slab phantom for the quantity $H_p(3)$.
- Correction and clarification of several subclauses to obtain a better applicability.

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/945/FDIS	45B/954/RVD

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INTRODUCTION

A dosimetry system may consist of the following elements:

- a) a passive device, referred to herein as a *detector*, which, after the exposure to radiation, stores a signal for use in measuring one or more quantities of the incident radiation field;
- b) a “dosemeter”, that incorporates some means of identification and contains one or more detectors and may contain electronic components, e.g. for the readout (e.g., in a direct ion storage (DIS) dosimeter);
- c) a “reader” which is used to readout the stored information (signal) from the detector, in order to determine the radiation dose;
- d) a “computer” with appropriate “software” to control the reader, store the signals transmitted from the reader, calculate, display and store the evaluated dose in the form of an electronic file or paper copy;
- e) “additional equipment” and documented procedures (instruction manual) for performing associated processes such as deleting stored dose information, cleaning dosimeters, or those needed to ensure the effectiveness of the whole system.

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RADIATION PROTECTION INSTRUMENTATION – DOSIMETRY SYSTEMS WITH INTEGRATING PASSIVE DETECTORS FOR INDIVIDUAL, WORKPLACE AND ENVIRONMENTAL MONITORING OF PHOTON AND BETA RADIATION

1 Scope

This document applies to all kinds of passive dosimetry systems that are used for measuring:

- the personal dose equivalent $H_p(10)$ (for individual whole body monitoring),
- the personal dose equivalent $H_p(3)$ (for individual eye lens monitoring),
- the personal dose equivalent $H_p(0,07)$ (for both individual whole body skin and local skin for extremity monitoring),
- the ambient dose equivalent $H^*(10)$ (for workplace and environmental monitoring),
- the directional dose equivalent $H'(3)$ (for workplace and environmental monitoring), or
- the directional dose equivalent $H'(0,07)$ (for workplace and environmental monitoring).

This document applies to dosimetry systems that measure external photon and/or beta radiation in the dose range between 0,01 mSv and 10 Sv and in the energy ranges given in Table 1. All the energy values are mean energies with respect to the fluence. The dosimetry systems usually use electronic devices for the data evaluation and thus are often computer controlled.

IEC 62387:2020
Table 1 – Mandatory and maximum energy ranges covered by this document

Measuring quantity	Mandatory mean energy range for photon radiation	Maximum mean energy range for testing photon radiation	Mandatory mean energy range for beta-particle radiation ^a	Maximum mean energy range for testing beta-particle radiation ^a
$H_p(10)$, $H^*(10)$	80 keV to 1,25 MeV ^b	12 keV to 7 MeV	–	–
$H_p(3)$, $H'(3)$	30 keV to 250 keV	8 keV to 7 MeV	0,8 MeV ^c	0,7 MeV ^c to 1,2 MeV
$H_p(0,07)$, $H'(0,07)$	30 keV to 250 keV	8 keV to 1,25 MeV ^b	0,24 MeV to 0,8 MeV	0,07 MeV ^d to 1,2 MeV ^e
^a The following beta radiation sources are suggested for the different mean energies: For 0,06 MeV: ¹⁴⁷ Pm; for 0,8 MeV: ⁹⁰ Sr/ ⁹⁰ Y; for 1,2 MeV: ¹⁰⁶ Ru/ ¹⁰⁶ Rh. ^b 1,25 MeV is the mean energy of photon radiation from ⁶⁰ Co. ^c For beta-particle radiation, an energy of 0,7 MeV is required to reach the radiation sensitive layers of the eye lens in a depth of about 3 mm (approximately 3 mm of ICRU tissue). ^d For beta-particle radiation, an energy of 0,07 MeV is required to penetrate the dead layer of skin of 0,07 mm (approximately 0,07 mm of ICRU tissue). ^e 0,07 MeV, 0,8 MeV and 1,2 MeV beta mean energy are almost equivalent to an E_{max} of 0,225 MeV, 2,27 MeV and 3,54 MeV, respectively.				

NOTE 1 In this document, “dose” means dose equivalent, unless otherwise stated.

NOTE 2 For $H_p(10)$ and $H^*(10)$ no beta radiation is considered. Reasons:

- a) $H_p(10)$ and $H^*(10)$ are a conservative estimate for the effective dose which is not a suitable quantity for beta radiation.
- b) No conversion coefficients are available in ICRU 56, ICRU 57 or ISO 6980-3.

NOTE 3 The maximum energy ranges are the energy limits within which type tests according to this document are possible.

NOTE 4 Direct ion storage (DIS) dosimeters are covered in this document as they are often operated without an online display but a separate reader.

The test methods concerning the design (Clause 8), the instruction manual (Clause 9), the software (Clause 10), environmental influences (Clause 13), electromagnetic influences (Clause 14), mechanical influences (Clause 15), and the documentation (Clause 16) are independent of the type of radiation. Therefore, they can also be applied to other dosimetry systems, e.g. for neutrons, utilizing the corresponding type of radiation for testing.

This document is intended to be applied to dosimetry systems that are capable of evaluating doses in the required quantity and unit (Sv) from readout signals in any quantity and unit. The only correction that may be applied to the evaluated dose (indicated value) is the one resulting from natural background radiation using extra dosimeters.

NOTE 5 The correction due to natural background can be made before or after the dose calculation.

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.

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

ISO 4037 (all parts), *Radiological protection – X and gamma reference radiation for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy*

ISO 4037-3:2019, *Radiological protection – X and gamma reference radiation for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy – Part 3: Calibration of area and personal dosimeters and the measurement of their response as a function of energy and angle of incidence*

ISO 6980 (all parts), *Nuclear energy – Reference beta-particle radiation*

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

ISO 8529 (all parts), *Reference neutron radiations*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

Several quantities with specific subscripts are explained in Table 6.

3.1

ambient dose equivalent

$H^*(d)$

dose equivalent at a point in a radiation field, produced by the corresponding expanded and aligned field, in the ICRU sphere at a depth, d , on the radius opposing the direction of the aligned field

Note 1 to entry: The recommended depth, d , for environmental monitoring in terms of $H^*(d)$ is 10 mm, and $H^*(d)$ may be written as $H^*(10)$.

[SOURCE: IEC 60050-395:2014, 395-05-43 – Note 1 to entry is note 3 in the source]

3.2

calibration coefficient

N_0

quotient of the conventional quantity value to be measured and the corrected indication of the dosimeter, $G_{r,0}$, normalized to reference conditions

Note 1 to entry: The calibration coefficient for the reference radiation quality U and the angle of incidence α is equivalent to the calibration factor multiplied by the instrument coefficient. It is given by

$$N_0 = \frac{C_{r,0}}{G_{r,0}} = C_f(U, \alpha) \cdot c_i$$

where

$C_{r,0}$ is the conventional quantity value, see 3.5

$G_{r,0}$ is the corrected indication, see 3.14

$C_f(U, \alpha)$ is the calibration factor for the radiation quality U and the angle of incidence α , see 3.3, and

c_i is the instrument constant, see 3.18.

Concerning the dimension of the calibration factor and the calibration coefficient, see notes to 3.3 and 3.18.

Note 2 to entry: The reciprocal of the calibration coefficient is the response under reference conditions. The value of the calibration factor may vary with the magnitude of the quantity to be measured. In such cases a dosimeter is said to have a non-constant response (or a non-linear indication).

[SOURCE: ISO 29661:2012, 3.1.5, modified – Note 3 to entry has been deleted]

3.3 calibration factor

$C_f(U, \alpha)$

factor by which the product of the corrected indication, $G_{r,0}$, and the associated instrument constant, c_i , of the dosimeter is multiplied to obtain the conventional quantity value to be measured under reference conditions

Note 1 to entry: The calibration factor is dimensionless.

[SOURCE:ISO 29661:2012, 3.1.7]

3.4 coefficient of variation

v

ratio of the standard deviation s to the arithmetic mean $\bar{G}$ of a set of n indicated values G_j (indicated value)

$$v = \frac{s}{\bar{G}} = \frac{1}{\bar{G}} \sqrt{\frac{1}{n-1} \sum_{j=1}^n (G_j - \bar{G})^2}$$

3.5 conventional quantity value

C

quantity value attributed by agreement to a quantity for a given purpose

Note 1 to entry: The conventional quantity value C is the best estimate of the quantity to be measured, determined by a primary standard or a secondary or working measurement standard which are traceable to a primary standard.

[SOURCE: ISO/IEC Guide 99:2007, 2.12]

3.6 correction for non-linearity

r_n

quotient of the response R_n under conditions where only the value of the dose equivalent is varied, and the reference response R_0

$$r_n = \frac{R_n}{R_0}$$

Note 1 to entry: For a linear dosimetry system, r_n is equal to unity.

3.7 coverage factor

k

numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

Note 1 to entry: A coverage factor k is typically in the range 2 to 3.

Note 2 to entry: In case of a normal distribution, using a coverage factor of 2 results in an expanded uncertainty that defines an interval around the result of a measurement that contains approximately 95 % of the distribution of values that could reasonably be attributed to the measurand. For other distributions, the coverage factor may be larger.

[SOURCE: GUM 2.3.6:1995, modified – The symbol k has been added]