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Radiation protection instrumentation – Passive integrating dosimetry systems for environmental and personal monitoring –

Part 1: General characteristics and performance requirements

Instrumentation pour la radioprotection – Systèmes dosimétriques intégrés passifs pour la surveillance de l'environnement et de l'individu –

Partie 1: Caractéristiques générales et exigences de fonctionnement

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – PASSIVE INTEGRATING DOSIMETRY SYSTEMS FOR ENVIRONMENTAL AND PERSONAL MONITORING –

Part 1: General characteristics and performance requirements

FOREWORD

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International Standard IEC 62387-1 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45B/544/FDIS	45B/554/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62387 series, under the general title: *Radiation protection instrumentation – Passive integrating dosimetry systems for environmental and personal monitoring*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC 62387 is published in separate parts according to the following structure:

Part 1: General

General characteristics and performance requirements

Part 2: Thermoluminescence dosimetry systems

Specific characteristics of, and performance requirements for, thermoluminescence dosimetry systems

Up to now, this part is represented by the second edition of IEC 61066.

Parts 3 and following: Other dosimetry systems

The further parts (to be published later) contain specific characteristics of, and performance requirements for, other detectors like direct ion storage, optically stimulated luminescence etc.

A dosimetry system may consist of the following elements:

a) a passive device, referred to here as a *detector*, which, after the presence of radiation, provides and 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;

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 dosemeters, or those needed to ensure the effectiveness of the whole system.

The main objectives of this international standard IEC 62387-1 are to:

- specify performance requirements for complete dosimetry systems including detectors, dosemeters, readers, and additional equipment. In addition, the corresponding methods of test to check that these requirements are met are given in detail;
- harmonize requirements for all types of passive dosimetry systems detecting external photon and beta radiation;
- specify the use the operational quantities according to ICRU 51;
- harmonize tests using radiation with relevant ISO standards on reference radiation and calibration: ISO 4037 for photon radiation, ISO 6980 for beta radiation and ISO 8529 for neutron radiation. For this reason, no conversion coefficients from air kerma (or absorbed dose or fluence) to the operational quantities are given in this standard. Those given in the ISO-standards are applicable;
- incorporate basic terms of the concept that a result of a measurement essentially consists of a value and an associated uncertainty, as expounded in the introductions of IEV 311 and IEC 60359 and refer the reader to an IEC technical report for complete uncertainty analysis in radiation protection measurements and to the GUM;

- align IEC uncertainty requirements on dosimetry systems for measuring personal dose equivalents with those stated in ICRP Publication 75: *General Principles for the Radiation Protection of Workers*.

RADIATION PROTECTION INSTRUMENTATION – PASSIVE INTEGRATING DOSIMETRY SYSTEMS FOR ENVIRONMENTAL AND PERSONAL MONITORING –

Part 1: General characteristics and performance requirements

1 Scope and object

This part of IEC 62387 applies to all kinds of passive dosimetry systems that are used for measuring the personal dose equivalents $H_p(10)$ or $H_p(0,07)$ or the ambient dose equivalent $H^*(10)$. It applies to dosimetry systems that measure external photon or beta radiation in the dose range between 0,01 mSv and 10 Sv and in the energy ranges given in the following Table. All the energy values are mean energies with respect to the prevailing dose quantity. The dosimetry systems usually use electronic devices for the data evaluation and thus are often computer controlled.

Measuring quantity	Energy range for photon radiation	Energy range for beta-particle radiation
$H_p(10)$, $H^*(10)$	12 keV to 7 MeV	---
$H_p(0,07)$	8 keV to 250 keV	0,07 MeV[a] to 1,2 MeV almost equivalent to E_{max} from 225 keV to 3,54 MeV
[a] For beta-particle radiation, an energy of 0,07 MeV is required to penetrate the dead layer of skin of 0,07 mm (almost equivalent to 0,07 mm of ICRU tissue) nominal depth.		

NOTE 1 In this standard, "dose" means personal or ambient dose equivalent, unless otherwise stated.

NOTE 2 For $H_p(10)$ and $H^*(10)$ no beta radiation is considered. Reasons: 1) $H_p(10)$ and $H^*(10)$ are a conservative estimate for the effective dose which is not a suitable quantity for beta radiation. 2) No conversion coefficients are available in ICRU 56, ICRU 57 or ISO 6980.

This standard 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 dosemeters.

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

In this standard, requirements are stated for minimal ranges of influence quantities, for example 80 keV to 1,25 MeV for photon energy (see Tables 3 to 5). A dosimetry system shall at least fulfil the requirements stated for these *minimal* ranges. However, the manufacturer may state larger ranges for the different influence quantities, for example 60 keV to 7 MeV. These larger ranges are called *rated* ranges. In such cases, the dosimetry systems must fulfil the requirements stated for these rated ranges. Thus, dosimetry systems can be classified by stating a set of ranges (for dose, energy, temperature etc.) within which the requirements stated in this standard are met (Capabilities of the system, see Clause 7). In addition, usage categories are given in Annex D with respect to different measuring capabilities.

For the dosimetry systems described above, this standard specifies general characteristics, general test procedures and performance requirements, radiation characteristics as well as environmental, electrical, mechanical, software and safety characteristics.

The absolute calibration of the dosimetry system is not checked during a type test according to this standard as only system properties are of interest. The absolute calibration is checked during a routine test.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-300:2001, *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation: Physical phenomena and basic concepts*

IEC 60050-394:1995, *International Electrotechnical Vocabulary (IEV) – Chapter 394: Nuclear instrumentation: Instruments*
Amendment 1 (1996)
Amendment 2 (2000)

IEC 60068-2-32, *Environmental testing – Part 2: Tests. Test Ed: Free fall*

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 61000-4-11, *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 4037-1:1996, *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 4037-2:1997, *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 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

ISO 4037-3:1999, *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 4037-4:2004, *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 6980-1:2006, *Nuclear energy – Reference beta-particle radiation – Part 1: Methods of production*

ISO 6980-2:2004, *Nuclear energy – Reference beta-particle radiation – Part 2: Calibration fundamentals related to basic quantities characterizing the radiation field*

ISO 6980-3:2006, *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 8529-1:2001, *Reference neutron radiations – Part 1: Characteristics and methods of production*

ISO 8529-2:2000, *Reference neutron radiations – Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field*

ISO 8529-3:1998, *Reference neutron radiations – Part 3: Calibration of area and personal dosimeters and determination of response as a function of energy and angle of incidence*

3 Terms and definitions

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

For definitions related to measurements in general, definitions were taken from IEC 60050-300, Part 311, from IEC 60050-393 and from IEC 60050-394. A very limited number of definitions was taken from ISO 4037-3 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The references are given in brackets [ ]. The information following the brackets is specific to this standard and is not originating from the given source.

A word between parentheses ( ) in the title of a definition is a qualifier that may be skipped if there is no danger of confusion with a similar term.

The terms are listed in alphabetical order.

3.1
ambient dose equivalent
H*(d)
at a point in a radiation field, dose equivalent that would be 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

[ICRU 51]

NOTE The recommended depth, d, for environmental monitoring in terms of $H^*(d)$ is 10 mm, and $H^*(d)$ may be written as $H^*(10)$. [IEV 393-14-95]

3.2
calibration factor
N_0
quotient of the conventional true value of a quantity $C_{r,0}$ and the indicated value $G_{r,0}$ at the point of test for a reference radiation under reference conditions. It is expressed as

$$N_0 = \frac{C_{r,0}}{G_{r,0}}$$

NOTE 1 The reciprocal of the calibration factor is equal to the response under reference conditions. In contrast to the calibration factor, which refers to the reference conditions only, the response refers to any conditions prevailing at the time of measurement.

[ISO 4037-3, Definition 3.2.12, modified]

NOTE 2 This definition is of special importance for non-linear dosemeters.

NOTE 3 The reference value $C_{r,0}$ for the dose is given in Table 2.

3.3
coefficient of variation
v
ratio of the standard deviation s to the arithmetic mean $\overline{G}$ of a set of n indicated values G_j (indicated value) given by the following formula:

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

[IEV 394-20-14, modified]

3.4
conventional true value (of a quantity)
C
value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose

NOTE "Conventional true value" is sometimes called “assigned value”, “best estimate of the value”, “conventional value” or “reference value”.

[IEV 311-01-06; GUM B.2.4]