



BSI Standards Publication

Radiation protection instrumentation — Passive integrating dosimetry systems for individual, workplace and environmental monitoring of photon and beta radiation

National foreword

This British Standard is the UK implementation of EN 62387:2016. It is derived from IEC 62387:2012. It supersedes BS EN 62387-1:2012 which is withdrawn.

The CEN common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **Ⓒ** **Ⓒ**.

The title of this standard has also been modified by CEN.

The UK participation in its preparation was entrusted to Technical Committee NCE/2, Radiation protection and measurement.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Date	Text affected
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English Version

Radiation protection instrumentation - Passive integrating
dosimetry systems for individual, workplace and environmental
monitoring of photon and beta radiation
(IEC 62387:2012 , modified)

Instrumentation pour la radioprotection - Systèmes
dosimétriques intégrés passifs pour la surveillance de
l'individu et de l'environnement des rayonnements
photoniques et bêta
(IEC 62387:2012 , modifiée)

Strahlenschutz-Messgeräte - Passive integrierende
Dosimetriesysteme zur Personen-, Arbeitsplatz- und
Umgebungsüberwachung auf Photonen- und Betastrahlung
(IEC 62387:2012 , modifiziert)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document (EN 62387:2016) consists of the text of IEC 62387:2012 prepared by IEC/SC 45B, "Radiation protection instrumentation", of IEC/TC 45, "Nuclear instrumentation" together with the common modifications prepared by CLC/TC 45B, "Radiation protection instrumentation".

The following dates are fixed:

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- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2019-01-04

This document supersedes EN 62387-1:2012.

Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 62387:2012 are prefixed "Z".

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Endorsement notice

The text of the International Standard IEC 62387:2012 was approved by CENELEC as a European Standard with agreed common modifications.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

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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 standard cancels and replaces IEC 62387-1 published in 2007. This edition constitutes a technical revision.

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

- Extension of the photon energy range for dosimeters to measure $H_p(0,07)$ from the old range of 8 keV to 250 keV to the new range of 8 keV to 10 MeV.
- Addition of performance requirements for dosimeters to measure $H_p(3)$ for both photon and beta radiation. Such dosimeters can be used to monitor the eye lens dose.
- Addition of performance requirements for dosimeters to measure $H'(0,07)$ for both photon and beta radiation.
- Correction and clarification of several subsections to obtain a better applicability

- Alignment of IEC performance requirements on dosimetry systems for measuring personal dose equivalents with the recommendations on accuracy stated in ICRP Publication 75, *General Principles for the Radiation Protection of Workers*. Further information is given in the new informative Annex E.

With these changes it also covers the scope of ISO 12794:2000, *Nuclear energy – Radiation protection – Individual thermoluminescence dosimeters for extremities and eyes*.

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

FDIS	Report on voting
45B/743/FDIS	45B/752/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.

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

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INTRODUCTION

A dosimetry system may consist of the following elements:

- a) a passive device, referred to here 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;
- 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.

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

1 Scope

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

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

 Text deleted 

This standard 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 prevailing dose quantity. The dosimetry systems usually use electronic devices for the data evaluation and thus are often computer controlled.

Table 1 – Mandatory and maximum energy ranges covered by this standard

Measuring quantity	Mandatory energy range for photon radiation	Maximum energy range for testing photon radiation	Mandatory energy range for beta-particle radiation ^a	Maximum energy range for testing beta-particle radiation ^a
$H_p(10)$, $H^*(10)$	80 keV to 1,25 MeV	12 keV to 10 MeV	–	–
$H_p(3)$	30 keV to 250 keV	8 keV to 10 MeV	0,8 MeV almost equivalent to an E_{max} of 2,27 MeV	0,7 MeV ^b to 1,2 MeV almost equivalent to E_{max} from 2,27 MeV to 3,54 MeV
$H_p(0,07)$, $H'(0,07)$	30 keV to 250 keV	8 keV to 10 MeV	0,8 MeV almost equivalent to an E_{max} of 2,27 MeV	0,06 MeV ^c to 1,2 MeV almost equivalent to E_{max} from 0,225 MeV to 3,54 MeV
^a The following beta radiation source 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 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). ^c 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).				

NOTE 2 In this standard, “dose” means dose equivalent, unless otherwise stated.

NOTE 3 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 6980-3.

NOTE 4 The maximum energy ranges are the energy limits within which type tests according to this standard are possible.

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 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 dosimeters.

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

2 Normative references

☐ The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

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

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

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

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

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

ISO 4037-3:1999, *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.

NOTE 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

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 $H^*(10)$. [IEV 393-14-95]¹

[SOURCE: ICRU 51:1993, modified – Note 1 to entry has been added]

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

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

Note 1 to entry: 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.

Note 2 to entry: This definition is of special importance for non-linear dosimeters.

Note 3 to entry: The reference value $C_{r,0}$ for the dose is given in Table 7.

[SOURCE: ISO 4037-3:1999, Definition 3.2.12, modified – The descriptive statement, the symbol as well as the three original notes have been modified and the original example has been removed]

3.3

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)

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

[SOURCE: IEC 60050-394:2007², 394-40-14, modified – “indicated values” has replaced “measurements” and the letters representing quantities in the descriptive statement and in the formula have been modified]

¹ IEC 60050-393 will be replaced by IEC 60050-395.

² IEC 60050-394 will be replaced by IEC 60050-395.

3.4

conventional true value

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 1 to entry: "Conventional true value" is sometimes called "assigned value", "best estimate of the value", "conventional value" or "reference value".

[SOURCE: GUM B.2.4]

3.5

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.

3.6

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, modified – The symbol k has been added]

3.7

detector

radiation detector

apparatus or substance used to convert incident ionizing radiation energy into a signal suitable for indication and/or measurement

Note 1 to entry: The detector usually requires a separate reader to read out the signal. That means the detector usually is not able to provide a signal without any external reading process.

Note 2 to entry: A passive detector does not need an external power supply to collect and store dose information.

Note 3 to entry: In IECV, the term reads "radiation detector".

[SOURCE: IEC 60050-394:2007, 394-24-01, modified – The term "detector" has been added as the first preferred term]

3.8

deviation

D

difference between the indicated values for the same value of the measurand of a dosimetry system, when an influence quantity assumes, successively, two different values

$$D = G - G_r$$

where

G the indicated value under the effect, and

G_r the indicated value under reference conditions

Note 1 to entry: The original term in IEC 311-07-03 reads “variation (due to an influence quantity)”. In order not to mix up variation (of the indicated value) and variation of the response, in this standard, the term is called “deviation”.

Note 2 to entry: The deviation can be positive or negative resulting in an increase or a decrease of the indicated value, respectively.

[SOURCE: IEC 60050-311:2001, 311-07-03, modified – “deviation” has replaced “variation (due to an influence quantity)” and “dosimetry system” has replaced “an indicating measuring instrument, or the values of a material measure” and Notes 1 and 2 to entry have been added]

3.9

directional dose equivalent

$H'(d)$

at a point in a radiation field, dose equivalent that would be produced by the corresponding expanded field, in the ICRU sphere at a depth, d , on the radius in a specified direction

Note 1 to entry: The currently recommended depth, d , for environmental monitoring in terms of $H'(d)$ is 0,07 mm and $H'(d)$ may be written as $H'(0,07)$. [IEV 393-14-96]

[SOURCE: ICRU 51]

3.10

dosemeter

radiation meter designed to measure the quantities absorbed dose or dose equivalent

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 the absorbed dose or dose equivalent.

Note 3 to entry: A dosimeter usually consists of a detector and a badge, for example thermoluminescence detector (TLD) badge with filters.

Note 4 to entry: A dosimeter may contain electronic components (e.g. the direct ion storage (DIS) dosimeter).

3.11

dosimetry system

dosimeter, reader and all associated equipment and procedures used for assessing the indicated value

3.12

expanded uncertainty

U

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

Note 1 to entry: The expanded uncertainty is obtained by multiplying the combined standard uncertainty by a coverage factor.

Note 2 to entry: A confidence level of 95 % is recommended for the use of this standard.

[SOURCE: GUM 2.3.5]

3.13

indicated value

G

value of the measurand given directly by a measuring instrument on the basis of its calibration curve

Note 1 to entry: In this standard, the indicated value is the one given by the dosimetry systems as the final result of the evaluation algorithm (for example, display of the software, print out) in units of dose equivalent (Sv), see 8.2.

Note 2 to entry: The indicated value is equivalent to the evaluated value in ISO 12794:2000, Annex D.

Note 3 to entry: For details, see Annex B of this standard.

[SOURCE: IEC 60050-311:2001, 311-01-08, modified – The original note has been replaced by new Notes 1, 2 and 3 to entry]

3.14

influence quantity

quantity that is not the measurand but that affects the result of the measurement

Note 1 to entry: For example, temperature of a micrometer used to measure length.

Note 2 to entry: If the effect on the result of a measurement of an influence quantity depends on another influence quantity, these influence quantities are treated as a single one. In this standard, this is the case for two pairs of influence quantities:

- a) radiation energy and angle of incidence,
- b) ambient temperature and relative humidity.

[SOURCE: GUM B.2.10, modified – Examples 1, 2 and 3 have been removed and Notes 1 and 2 to entry have been added]

3.15

influence quantity of type F

influence quantity whose effect on the indicated value is a change in response

Note 1 to entry: An example is radiation energy and angle of radiation incidence.

Note 2 to entry: F stands for factor. The indication due to radiation is multiplied by a factor due to the influence quantity.

3.16

influence quantity of type S

influence quantity whose effect on the indicated value is a deviation independent of the indicated value

Note 1 to entry: An example is the electromagnetic disturbance.

Note 2 to entry: All requirements for influence quantities of type S are given with respect to the value of the deviation D .

Note 3 to entry: S stands for sum. The indication is the sum of the indication due to radiation and due to the disturbance.

3.17

lower limit of the measuring range

H_{low}

lowest dose value included in the measuring range

3.18

mandatory range

mandatory range of use

smallest range specified for an influence quantity or instrument parameter over which the dosimetry system must operate to be in compliance with this International Standard

Note 1 to entry: The mandatory ranges of the influence quantities dealt with in this International Standard are given in the second column of Tables 8 to 15.

3.19

maximum rated measurement time

$t_{\max}$

longest continuous period of time over which the dose is accumulated and over which all requirements of this standard are fulfilled

Note 1 to entry: The maximum rated measurement time depends on the lower limit of the measuring range H_{low} , the fading, and other influences.

Note 2 to entry: The beginning of this period of time can for example be erasing the dose by heating (at TLDs) or a dose reset by means of software (at DIS).

3.20

measured value

M

value that can be obtained from the indicated value G by applying the model function for the measurement

Note 1 to entry: For “model function”, see 3.23.

Note 2 to entry: For details, see Annex B.

3.21

measuring range

range defined by two values of the measurand, or quantity to be supplied, within which the limits of uncertainty of the measuring instrument are specified

Note 1 to entry: In this standard, the measuring range is the range of dose equivalent, in which the requirements of this standard are fulfilled and thus the uncertainty is limited.

[SOURCE: IEC 60050-311:2001, 311-03-12, modified – The original note has been replaced by a new Note 1 to entry]

3.22

personal dose equivalent

$H_p(d)$

dose equivalent in soft tissue, at an appropriate depth, d , below a specified point on the body

Note 1 to entry: The recommended depths are 10 mm for penetrating radiation, 3 mm to monitor the eye lens dose, and 0,07 mm for superficial radiation.
[IEV 393-14-97]

Note 2 to entry: Soft tissue means ICRU 4-element tissue, see ICRU Report 39.

[SOURCE: ICRU 51]

3.23

model function

mathematical model of the measurement that transforms the (set of) observation(s) into the result of the measurement

Note 1 to entry: The model function combines the indicated value G with the reference calibration factor N_0 , the correction for non-linearity r_n , the l deviations D_p ($p = 1..l$) for the influence quantities of type S, and the m relative response values r_q ($q = 1..m$) for the influence quantities of type F. An example of a model function is

$$M = \frac{N_0}{r_n \prod_{q=1}^m r_q} \left[G - \sum_{p=1}^l D_p \right]. \text{ A model function is necessary to evaluate the uncertainty of the measured value}$$

according to the GUM (see GUM sections 3.1.6, 3.4.1 and 4.1).

Note 2 to entry: The calculations according to the model function are usually not performed, only in the case that specific influence quantities are well known and an appropriate correction is applied.

Note 3 to entry: For details, see Annex B.

3.24

point of test

point in the radiation field at which the conventional true value of the quantity to be measured is known

[SOURCE: ISO 4037-3, Definition 3.2.6, modified – Between “at which the” and “conventional” the following has been deleted: “reference point of a dosimeter is placed for calibrating or testing purposes and at which the”]

3.25

preparation

normal treatment of dosimeters or detectors before a dose measurement, for example, a procedure to erase stored dose information, reset the dose information by means of software, cleaning, which the dosimeters or detectors are intended to be subjected to in routine use

3.26

rated range

rated range of use

specified range of values which an influence quantity can assume without causing a deviation or variation of the response exceeding specified limits

Note 1 to entry: In IEC 60050-311:2001, 311-07-05, the term reads “nominal range of use”. In this standard, “rated range” is used in order to avoid complicated terms like “the range of use of an influence quantity” but to have terms that are easily readable like “the rated range of an influence quantity”.

Note 2 to entry: Influence quantities can be either of type S or of type F.

[SOURCE: IEC 60050-311:2001, 311-07-05, modified – “rated range” has replaced “nominal range” and “deviation or variation of the response” has replaced “variation”; Notes 1 and 2 to entry have been added]

3.27

reader

dosimeter reader

instrument used to read one or more detectors in a dosimeter

Note 1 to entry: Signal of a passive dosimeter can be amount of light, amount of charge, transparency of film and so on. Each type of passive dosimeter thus has very a different type of reader.

[SOURCE: IEC 60050-394:2007, 394-31-13, modified – The term “dosimeter reader” has been replaced by “reader”, “a dosimeter” has been replaced by “one or more detectors in a dosimeter” and Note 1 to entry has been added]

3.28

readout

process of measuring the stored dose information of a detector in a reader

3.29

reference conditions

set of specified values and/or ranges of values of influence quantities under which the uncertainties admissible for a dosimetry system are the smallest

[SOURCE: IEC 60050-311:2001, 311-06-02, modified – After “uncertainties” the words “, or limits of error,” have been deleted and “dosimetry system” has replaced “measuring instrument”]

3.30

reference direction

direction, in the coordinate system of a dosimeter, with respect to which the angle to the direction of radiation incidence is measured in unidirectional fields

[SOURCE: ISO 4037-3:1999, 3.2.7]

3.31

reference orientation

(dosemeter) orientation for which the direction of the incident radiation coincides with the reference direction of the dosimeter

[SOURCE: ISO 4037-3:1999, 3.2.8]

3.32

reference point of a dosimeter

physical mark or marks on the outside of the dosimeter (possibly described in the manual) to be used in order to position it with respect to the point of test

3.33

reference response

R_0

response for a reference value $C_{r,0}$ of the quantity to be measured under reference conditions

$$R_0 = \frac{G_{r,0}}{C_{r,0}}$$

where $G_{r,0}$ is the corresponding indicated value

Note 1 to entry: The reference response is the reciprocal of the reference calibration factor.

Note 2 to entry: The reference values for the dose are given in Table 7.

3.34

relative expanded uncertainty

U_{rel}

expanded uncertainty divided by the measurement result

3.35

relative response

r

quotient of the response R and the reference response R_0

$$r = \frac{R}{R_0}$$

3.36

response of a radiation measuring assembly

R

ratio, under specified conditions, given by the relation:

$$R = \frac{G}{C}$$

where

G is the indicated value of the quantity measured by the equipment or assembly under test (dosimetry system), and

C is the conventional true value of this quantity

Note 1 to entry: The value of the response may vary with the dose being measured. In such cases, a dosimetry system is said to be non-linear.

[SOURCE: IEC 60050-394: 2007, 394-40-21, modified – The letters representing quantities have been modified, “value” has been replaced by “indicated value of the quantity”, “(dosimetry system)” has been added and the original notes have been replaced by a new Note 1 to entry]

3.37

result of a measurement

set of values attributed to a measurand, including a value, the corresponding uncertainty, and the unit of the measurand

Note 1 to entry: The central value of the whole (set of values) can be selected as *measured value* M (see 3.20) and a parameter characterizing the dispersion as *uncertainty* (see 3.41).

Note 2 to entry: The result of a measurement is related to the *indicated value given by the instrument* G (see 3.13) and to the values of correction obtained by calibration and by the use of a *model* (see 3.23).

Note 3 to entry: The estimation of M can be based on one or more indicated values.

[SOURCE: IEC 60050-311: 2001, 311-01-01, modified – “including a value, the corresponding uncertainty, and the unit of the measurand” has been added, the original Notes 1, 4, and 5 have been deleted, and Notes 1 and 2 to entry have been aligned to terms used in this standard]

3.38

signal

S

quantity obtained in a reader after readout of a detector from which the indicated value of the dose equivalent is evaluated

Note 1 to entry: Examples are the charge measured in a photomultiplier tube due to TL-light; the area of a certain region from a glow curve of a TL detector; a fitting parameter evaluated from a glow curve analysis.

Note 2 to entry: In principle, it is possible to obtain more than one signal from one detector (for example several fitting parameters from a glow curve analysis).

Note 3 to entry: Using more than one detector always means using more than one signal.

Note 4 to entry: The “signal” is similar to the “readout value” in ISO 12794:2000, 3.13.

Note 5 to entry: For details, see Annex B of this standard.

3.39

standard deviation

experimental standard deviation

s

for a series of n measurements of the same measurand, the quantity s characterizing the dispersion of the results

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

where

G_j is the result of the j -th measurement, and

$\bar{G}$ is the arithmetic mean of the n results considered

Note 1 to entry: Considering the series of n values as sample of a distribution, $\bar{G}$ is an unbiased estimate of the mean μ , and s^2 is an unbiased estimate of the variance σ^2 of that distribution.

Note 2 to entry: The expression $s/\sqrt{n}$ is an estimate of the standard deviation of the distribution of $\bar{G}$ and is called the “experimental standard deviation of the mean”.

Note 3 to entry: “Experimental standard deviation of the mean” is sometimes incorrectly called “standard error of the mean”.

[SOURCE: GUM B.2.17, modified – The preferred term “standard deviation” has been added, as well as the symbol s , and the formula has been modified]

3.40

standard test conditions

range of values of a set of influence quantities under which a calibration or a determination of response is carried out

Note 1 to entry: Ideally, calibrations should be carried out under reference conditions. As this is not always achievable (e.g. for ambient air pressure) or convenient (e.g. for ambient temperature), a (small) interval around the reference values may be used. The deviations of the calibration factor from its value under reference conditions caused by these deviations should in principle be corrected for.

Note 2 to entry: During type tests, all values of influence quantities which are not the subject of the test are fixed within the interval of the standard test conditions.

[SOURCE: ISO 4037-3:1999, Definition 3.2.3, modified – One note has been subdivided into two and references to tables have been omitted]

3.41

standard uncertainty

u

uncertainty of the result of a measurement expressed as a standard deviation

Note 1 to entry: Standard uncertainty is a more general term than standard deviation, for example, standard uncertainty may also contain uncertainty contributions evaluated using non statistical methods.

[SOURCE: GUM 2.3.1 modified – Note 1 to entry has been added, as well as the symbol u]

3.42

type test

conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-394:2007, 394-40-02]

3.43

upper limit of the measuring range

H_{up}

highest dose value included in the measuring range

3.Z1

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 performed in terms of $H'(0.07)$ or $H^*(10)$.

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

3.Z2

workplace monitoring

area monitoring using dose (rate) measurements made in the working environment

Note 1 to entry: Usually contrasted with individual monitoring.

Note 2 to entry: Workplace monitoring is performed in terms of $H'(0.07)$ or $H^*(10)$.

3.Z3

environmental monitoring

area monitoring by the measurement of external dose (rate) in the environment

Note 1 to entry: Environmental monitoring is performed in terms of $H'(0.07)$ or $H^*(10)$. 

3.24

individual monitoring

monitoring using dose (rate) measurements by equipment worn by individual workers, or measurements of quantities of radioactive material in or on their bodies

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: IAEA glossary, modified – “dose (rate)” has been added and Note 2 to entry has been added] 

4 Units and symbols

In the present standard, units of the international system (SI) are used. Nevertheless, the following units may be acceptable in common usage:

- for energy: electron-volt (symbol eV). $1 \text{ eV} = 1,602 \times 10^{-19} \text{ J}$
- for time: year, month, day, hour (symbol h), minute (symbol min).

Multiples and submultiples of SI units may be used, according to the SI system.

The SI unit of dose equivalent is 1 J kg^{-1} .

The special name for the unit of the dose equivalent is sievert (symbol Sv). $1 \text{ Sv} = 1 \text{ J kg}^{-1}$.

A list of symbols is given in Table 6 (at the end of the document).

5 General test procedures

5.1 Basic test procedures

5.1.1 Instructions for use

The instructions for use of the dosimetry systems have to be unambiguously given in the manual, see Clause 9. These instructions have to be the same for all parts of the type test and for the routine use as well.

5.1.2 Nature of tests

The tests listed in this standard are considered to be type tests, see Annex C.

5.1.3 Reference conditions and standard test conditions

Reference conditions are given in the second column of Table 7 (at the end of the document). The tests shall be carried out under standard test conditions given in the third column of Table 7 unless otherwise specified.

All influence quantities shall be maintained within the limits set for standard test conditions given in Table 7, except for those influence quantities currently under test, unless otherwise specified in the test procedure.

5.1.4 Production of reference radiation

The nature, construction and conditions for the use of ionizing radiation shall conform to the recommendations in the following documents: a) ISO 4037 series for photon radiation, b) ISO 6980 series for beta radiation, and c) ISO 8529 series for neutron radiation.

5.1.5 Choice of phantom for the purpose of testing

For tests involving the use of a phantom, ISO phantoms as described in ISO 4037-3:1999, 6.3.1, shall be used. The required irradiation geometry is specified in the appropriate ISO reference standard (ISO 4037-3 or ISO 6980-3).

5.1.6 Position of dosimeter for the purpose of testing

For tests involving the use of radiation, the reference point of the dosimeter shall be placed at the point of test and the dosimeter shall be oriented in the reference orientation. This is not applicable for tests to determine the response depending on the angle of incidence.

5.2 Test procedures to be considered for every test

5.2.1 Number of dosimeters used for each test

The number n of dosimeters (or irradiations) used for any test need not be the same for each test but may be determined using Annex A. However, it may be convenient to use, arbitrarily, 4, 5, 8, 10 or 20 dosimeters (or irradiations), in which case the Student's t -value, obtained from Annex A, Table A.1, would be 3,18; 2,78; 2,37; 2,26; or 2,09; respectively.

NOTE Using Annex A, the performance requirements are demonstrated to be met to 95 % confidence.

5.2.2 Consideration of the uncertainty of the conventional true value

The relative expanded uncertainty $U_{C,rel}$ of the conventional true value C of the dose equivalent shall be considered. It shall be less than 8 % at a 95 % coverage interval. The testing laboratory shall determine $U_{C,rel}$ according to the GUM.

NOTE According to 3.12, the confidence level is 95 %.

5.2.3 Consideration of non-linearity

The effect of a non-linearity due to dose dependence shall be taken into account.

A practical method is to start the tests with the non-linearity and perform the other tests in a dose region where the non-linearity is negligible (1 % to 2 %).

5.2.4 Consideration of natural background radiation

For the measurement of low dose equivalents or at low dose equivalent rates, it is necessary to take into account the contribution of natural background radiation to the dose equivalent. This is usually done by taking a significant number of dosimeters (at minimum 10 dosimeters) as background dosimeters. These are treated in the same way as the ones under test, but not irradiated. The mean indicated value of these dosimeters has to be subtracted from the indicated value of the dosimeters under test.

5.2.5 Consideration of several detectors or signals in a dosimeter

If more than one signal (see 3.38) or detector (see 3.7) is used to evaluate the indicated value, each signal or detector shall be tested separately. Separate tests are necessary when the different signals are used to evaluate the indicated value in different regions of the measuring range or in different regions of an influence quantity.

NOTE 1 If this applies, this means that the complete amount of testing according to this standard is multiplied by the number of signals being used in different ranges.

NOTE 2 Examples:

- 1) If a second detector or signal is used to evaluate the dose above a dose equivalent of 200 mSv, for this detector or signal all the requirements according to this standard have to be measured within its operating range, i.e. above a dose equivalent of 200 mSv.
- 2) If a second detector or signal is used to evaluate the dose at very low particle energies (for example a very thin detector for low energy beta radiation), for this detector or signal all the requirements according to this standard have to be measured within its operating range, i.e. at low particle energies.

5.2.6 Performing the tests efficiently

The effect of several influence quantities are tested by irradiating different groups of dosimeters: one or several test groups on which the effect of the influence quantity is measured and one reference group. For limiting the necessary number of irradiations, it is appropriate to combine the tests given in 11.9 to Clause 15 with only two or three reference groups.

A list of actions necessary to perform a type test according to this standard is given in Annex C.

6 Performance requirements: summary

For the following types of dosimeters at least the following quantities shall be measured:

- whole body dosimeter: $H_p(10)$ due to photon radiation,
- extremity dosimeter: $H_p(0,07)$ due to photon and beta radiation,
- eye lens dosimeter used in pure photon radiation fields:
 $H_p(0,07)$ or $H_p(3)$ due to photon radiation,
- eye lens dosimeter used in beta or mixed beta/photon radiation fields:
 $H_p(3)$ due to beta and photon radiation.

National regulations may require that more quantities be measured by specific types of dosimeters.

NOTE 1 Background information regarding the choice of quantities to be measured for eye lens dosimetry can be found in Behrens and Dietze (2010).

NOTE 2 The term “beta radiation” is used as a synonym for both electron and beta radiation in this standard.

The performance requirements for dosimetry systems are given in Tables 8 to 12 depending on the quantity to be measured: $H_p(10)$: Table 8; $H_p(3)$: Table 9; $H_p(0,07)$: Table 10; $H^*(10)$: Table 11; $H'(0,07)$: Table 12.

Details for some of the entries in Tables 8 to 12 (at the end of the document) are given in the further  Tables 13 to 15  (at the end of the document).

In some countries the presence of beta dose has to be indicated by dosimeters worn on the trunk. Such an indication of the presence of beta dose is not a measurement. For that reason, a specific subclause (11.9) deals with the indication of the presence of beta dose.

Usually, a dosimetry system is not able to measure all quantities given above. Thus, the system is only tested with regard to those quantities and types of radiation it is intended to be used for. Annex D gives further guidelines to define specific usage categories.

Full compliance with this standard is given if the requirements for the mandatory ranges given in Tables 8 to 12 are fulfilled. If the customer or manufacturer requires extended ranges then the test should also be performed as specified in this standard, i.e. the requirements given in Tables 8 to 12 apply, too. The range of any influence quantity stated by the manufacturer is called rated range. Thus, dosimetry systems can be classified by stating a set of ranges (for example, for dose, for energy, for temperature) 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.

A dosimetry system may be tested with regard to different quantities at different times. In case the dosimetry system was changed since the previous test, a new test with regard to quantities tested formerly may be necessary.

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.

7 Capability of a dosimetry system

7.1 General

The ranges described in the following subclauses shall be stated by the manufacturer. They shall be larger than the mandatory ranges that are given in Tables 8 to 12. The dosimetry system shall fulfil the requirements for these rated ranges.

The rated ranges shall be given in the documentation of the dosimetry system (instruction manual), so the user of the dosimetry system is aware of the capabilities of the instrument.

7.2 Measuring range and type of radiation

Depending on the dose quantity, the limits of the measuring range shall at least cover the mandatory ranges given in line 7 of Tables 8 to 12.

The type(s) of radiation the dosimetry system is designed for shall be stated.

In case the dosimetry system is not able to measure beta dose (that means it does not fulfil 11.6.2 or 11.7.2 – whichever applies) but is able to indicate the presence of beta dose (that means it does fulfil 11.9) this shall be stated.

7.3 Rated ranges of the influence quantities

The rated range of any influence quantity shall be stated by the manufacturer in the documentation. The mandatory range for each influence quantity is given in the third column of Tables 8 to 15. All requirements of this standard shall be fulfilled over all the rated ranges.

7.4 Maximum rated measurement time $t_{\max}$

The manufacturer shall state the maximum duration of a dose measurement $t_{\max}$ during which the requirements of this standard are fulfilled. Especially, the requirements on the coefficient of variation shall be fulfilled.

This time shall be at least 1 month.

7.5 Reusability

A dosimeter is considered to be reusable as long as its performance meets the requirements of this standard. If the dosimeter cannot be reused indefinitely or if usability depends on the history of the dosimeter, this fact shall be stated by the manufacturer. The manufacturer shall give the limits for repeated uses, e.g. the total number of cycles of use and/or a dose value above which dosimeters cannot be reused. Especially, the requirements relating to the coefficient of variation shall be fulfilled for all dosimeters that are reused.