BS EN 61526:2013

BSI Standards Publication

Radiation protection instrumentation — Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations — Direct reading personal dose equivalent meters

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National foreword

This British Standard is the UK implementation of EN 61526:2013. It is derived from IEC 61526:2010. It supersedes BS EN 61526:2007 which is withdrawn.

The CENELEC 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 [C〉 〈C].

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English version

Radiation protection instrumentation - Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations - Direct reading personal dose equivalent meters

(IEC 61526:2010, modified)

Instrumentation pour la radioprotection - Mesure des équivalents de dose individuels Hp(10) et Hp(0,07) pour les rayonnements X, gamma, neutron et bêta - Appareils de mesure à lecture directe de l'équivalent de dose individuel (CEI 61526:2010, modifiée)

Strahlenschutz-Messgeräte - Messung der Tiefen- und der Oberflächen-Personendosis Hp(10) und Hp(0,07) für Röntgen-, Gamma-, Neutronen- und Betastrahlung - Direkt ablesbare Personendosimeter (IEC 61526:2010, modifiziert)

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

This document (EN 61526:2013) consists of the text of IEC 61526:2010 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:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-12-24
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2015-12-24

This document supersedes EN 61526:2007.

EN 61526:2013 includes the following significant technical changes with regard to the previous edition:

– inclusion of terms and definitions of ISO/IEC Guide 99:2007 (VIM:2008);

– full consistency with IEC/TR 62461:2006 “*Radiation protection instrumentation – Determination of uncertainty in measurement*”;

– improved determination of constancy of the dose response and statistical fluctuations;

– abolition of classes of personal doses equivalent meters in relation to retention of stored information;

– inclusion of usage categories of personal dosemeters in Annex C.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 61526:2010 are prefixed “Z”.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61526:2010 was approved by CENELEC as a European Standard with agreed common modifications.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-393	2003	International Electrotechnology Vocabulary - Part 393: Nuclear instrumentation - Physical phenomena and basic concepts	-	-
IEC 60050-394	2007	International Electrotechnical Vocabulary - Part 394: Nuclear instrumentation - Instruments, systems, equipment and detectors	-	-
IEC 60068-2-31	2008	Environmental testing - Part 2-31: Tests - Test Ec: Rough handling shocks, primarily for equipment-type specimens	EN 60068-2-31	2008
IEC 60086-1	2006	Primary batteries - Part 1: General	EN 60086-1[1)]	2007
IEC 60086-2 + corr. April	2006 2007	Primary batteries - Part 2: Physical and electrical specifications	EN 60086-2[2)]	2007
IEC 60359	2001	Electrical and electronic measurement equipment - Expression of performance	EN 60359	2002
IEC 60529 + A1	1989 1999	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May + A1	1991 1993 2000
IEC 61000-4-2	2008	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009
IEC 61000-4-3 + A1	2006 2007	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3 + A1	2006 2008
IEC 61000-4-4 + corr. June	2004 2007	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2004

1) EN 60086-1 is superseded by EN 60086-1:2011, which is based on IEC 60086-1:2011.

2) EN 60086-2 is superseded by EN 60086-2:2011, which is based on IEC 60086-2:2011.

IEC 61000-4-5 + corr. October	2005 2009	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
IEC 61000-4-6	2008	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	2009
IEC 61000-4-8	2009	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	2010
IEC 61000-4-11	2004	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	2004
IEC 61000-6-2	2005	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments	EN 61000-6-2 + corr. September	2005 2005
IEC 61187 (mod)	1993	Electrical and electronic measuring equipment - Documentation	EN 61187 + corr. March	1994 1995
IEC/TR 62461	2006	Radiation protection instrumentation - Determination of uncertainty in measurement	-	-
ISO/IEC Guide 98-3	2008	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-
ISO/IEC Guide 98-3 Suppl.1	2008 2008	Propagation of distributions using a Monte Carlo method and Corr.1 (2009)	-	-
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 from 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	-	-
ISO 12789-1	2008	Reference radiation fields - Simulated workplace neutron fields - Part 1: Characteristics and methods of production	-	-
ISO 12789-2	2008	Reference radiation fields - Simulated workplace neutron fields - Part 2: Calibration fundamentals related to the basic quantities	-	-
ICRU Report 51	1993	Quantities and units in radiation protection dosimetry	-	-

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INTRODUCTION

This International Standard applies to active, direct reading personal dose equivalent meters and monitors used for measuring the personal dose equivalents $H_p(10)$ and $H_p(0,07)$ for X, gamma, neutron and beta radiations.

For the personal dose equivalent $H_p(10)$ or the personal dose equivalent rate $\dot{H}_p(10)$ and for X and gamma radiations, two minimum rated ranges for the photon energy are given. The first from 20 keV to 150 keV is for workplaces where low energy X-rays are used, e.g., in medical diagnostic, the second from 80 keV to 1,5 MeV is for workplaces where high energy X-rays and/or gamma sources are used, e.g., in industry. For neutron radiation the minimum rated range of neutron energy is from 0,025 eV (thermal neutrons) to 5 MeV. The rated ranges can be extended to all energies covered by the respective standards for reference radiation fields.

For the personal dose equivalent $H_p(0,07)$ and for X and gamma radiations, a minimum rated range for the photon energy from 20 keV to 150 keV is given and for beta radiation, the minimal rated range is from 0,2 MeV to 0,8 MeV 〚C〛mean beta particle energy〚C〛. The rated ranges can be extended to all energies covered by the respective standards for reference radiation fields.

Examples of extended rated ranges are given in Annex C.

In some applications, for example, at a nuclear reactor installation where 6 MeV photon radiation is present, measurement of personal dose equivalent (rate) $H_p(10)$ for photon energies up to 10 MeV should be required. In some other applications, measurement of $H_p(10)$ down to 10 keV should be required.

For personal dose equivalent meters, requirements for measuring the dose quantities $H_p(10)$ and $H_p(0,07)$ and for monitoring of the dose rate quantities $\dot{H}_p(10)$ and $\dot{H}_p(0,07)$ are given. The measurement of these dose rate quantities is an option for personal dose equivalent meters.

Establishments in some countries may wish to use this type of personal dose equivalent meter as the dosemeter to provide the dose of record by an approved dosimetry service.

RADIATION PROTECTION INSTRUMENTATION – MEASUREMENT OF PERSONAL DOSE EQUIVALENTS $H_p(10)$ AND $H_p(0,07)$ for X, GAMMA, NEUTRON AND BETA RADIATIONS – DIRECT READING PERSONAL DOSE EQUIVALENT METERS

1 Scope and object

This International Standard applies to personal dose equivalent meters with the following characteristics:

a) They are worn on the trunk or the extremities of the body.

b) They measure the personal dose equivalents $H_p(10)$ and $H_p(0,07)$ from external X and gamma, neutron and beta radiations, and may measure the personal dose equivalent rates $\dot{H}_p(10)$ and $\dot{H}_p(0,07)$ [C] for the same radiations (for alarming purposes). [C]

c) They have a digital indication.

d) They may have alarm functions for the personal dose equivalents or personal dose equivalent rates.

This standard is therefore applicable to the measurement of the following combinations of dose quantities (including the respective dose rates) and radiation

1) $H_p(10)$ and $H_p(0,07)$ from X and gamma radiations;

2) $H_p(10)$ and $H_p(0,07)$ from X, gamma and beta radiations;

3) $H_p(10)$ from X and gamma radiations;

4) $H_p(10)$ from neutron radiations;

5) $H_p(10)$ from X, gamma and neutron radiations;

6) $H_p(0,07)$ from X, gamma and beta radiations.

NOTE 1 When reference is made in this standard to ”dose”, this is meant to indicate personal dose equivalent, unless otherwise stated.

NOTE 2 When reference is made in this standard to ”dosemeter”, this is meant to include all personal dose equivalent meters, unless otherwise stated.

This standard specifies requirements for the dosemeter and, if supplied, for its associated readout system.

This standard specifies, for the dosemeters described above, general characteristics, general test procedures, radiation characteristics as well as electrical, mechanical, safety and environmental characteristics. The only requirements specified for associated readout systems are those which affect its accuracy of readout of the personal dose equivalent and alarm settings and those which concern the influence of the reader on the dosemeter.

This standard also specifies in Annex C usage categories with respect to different measuring capabilities.

This standard does not cover special requirements for accident or emergency dosimetry although the dosemeters may be used for this purpose. The standard does not apply to dosemeters used for measurement of pulsed radiation, such as radiation emanating from most medical diagnostic X-ray facilities, linear accelerators or similar equipment.

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

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60086-1:2006, *Primary batteries – Part 1: General*

IEC 60086-2:2006, *Primary batteries – Part 2: Physical and electrical specifications*

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
Amendment 1 (1999) [1]

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2008, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61187:1993, *Electrical and electronic measuring equipment – Documentation*

IEC/TR 62461:2006, *Radiation protection instrumentation – Determination of uncertainty in measurement*

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1 There exists a consolidated edition (2.1) which includes IEC 60529 (1989) and its Amendment 1 (1999).

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

ISO/IEC Guide 98-3:2008/Suppl.1:2008, *Propagation of distributions using a Monte Carlo method and Corr.1 (2009)*

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 from 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: Method 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 dosemeters and determination of response as a function of energy and angle of incidence*

ISO 12789-1:2008, *Reference radiation fields – Simulated workplace neutron fields – Part 1: Characteristics and methods of production*

ISO 12789-2:2008, *Reference radiation fields – Simulated workplace neutron fields – Part 2: Calibration fundamentals related to the basic quantities*

ICRU report 51:1993, *Quantities and units in radiation protection dosimetry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-393, IEC 60050-394, IEC 60359 and ICRU Report 51, as well as the following terms and definitions, apply.

3.1
acceptance test
contractual test to prove to the customer that the device meets certain conditions of its specification

[IEV 394-20-09; IEV 151-16-23; IEV 394-40-05]

3.2
calibration (for the purpose of this standard)
quantitative determination of the reference calibration factor, N_0, and the correction for non-constant response, r_n, under a controlled set of standard test conditions for which all the m relative response values, r_q, are unity and all the l deviations, D_p, are zero

3.3
calibration factor
N
quotient of the conventional true value of a quantity, H_r, and the indicated value, G_r, at the point of test for a specified reference radiation under specified reference conditions. It is expressed as

$$N = \frac{H_r}{G_r}$$

NOTE 1 (See ISO 4037-3) The calibration factor N is dimensionless when the instrument indicates the quantity to be measured. A dosemeter indicating the conventional quantity value correctly has the calibration factor of one.

NOTE 2 (See ISO 4037-3) 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 condition prevailing at the time of measurement.

NOTE 3 (See ISO 4037-3) The value of the calibration factor may vary with the magnitude of the quantity to be measured. In such cases, a dosemeter is said to have a non-constant response.

3.4
coefficient of variation
ratio of the standard deviation s to the arithmetic mean $\bar{x}$ of a set of n measurements x_i given by the following formula:

$$v = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

[IEV 394-40-14]

3.5
combined standard measurement uncertainty
combined standard uncertainty
u_c
standard measurement uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model

NOTE In case of correlations of input quantities in a measurement model, covariances must also be taken into account when calculating the combined standard measurement uncertainty; see also ISO/IEC Guide 98-3:2008,2.3.4.

[ISO/IEC Guide 98-3:2008, 2.31]

3.6
conventional quantity value
conventional value of a quantity
conventional value
quantity value attributed by agreement to a quantity for a given purpose

NOTE 1 The term “conventional true quantity value” is sometimes used for this concept, but its use is discouraged.

NOTE 2 Sometimes a conventional quantity value is an estimate of a true quantity value.

NOTE 3 A conventional quantity value is generally accepted as being associated with a suitably small measurement uncertainty, which might be zero.

[ISO/IEC Guide 98-3:2008, 2.12]

NOTE 4 In this standard the quantity is the dose equivalent (rate).

3.7
correction for non-constant response
***r*n**
quotient of the response, R, under specified conditions where only the quantity to be measured is varied and the reference response, R_0. It is expressed as

$$r_{\mathrm{n}} = \frac{R}{R_0}$$

NOTE For an instrument with constant response, r_{n} is equal to one.

3.8
detector assembly
assembly of a radiation detector and the associated components needed for the calibration or the determination of the response

NOTE The calibration result is only valid for this detector assembly.

EXAMPLE A personal dosemeter is to be calibrated using a phantom. The combination of personal dosemeter and phantom and possibly further reading instruments and cables comprise one detector assembly.

[ISO/DIS 29661, 3.1.10]

3.9
deviation
D
difference between the indicated values for the same value of the measurand of a dose equivalent (rate) meter, when an influence quantity assumes, successively, two different values

[IEV 311-07-03, modified]

$$D = G - G_{\mathrm{r}}$$

where G is the indicated value under the effect of an influence quantity and
G_{r} is the indicated value under reference conditions.

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

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

NOTE 3 The deviation is of special importance for influence quantities of type S.

3.10
effective range of measurement
range of values of the quantity to be measured over which the performance of a dosemeter meets the requirements of this standard

[IEV 394-20-16, modified]

3.11
expanded measurement uncertainty
expanded uncertainty
U
product of a combined standard measurement uncertainty and a factor larger than the number one

NOTE 1 The factor depends upon the type of probability distribution of the output quantity in a measurement model and on the selected coverage probability.

NOTE 2 The term “factor” in this definition refers to a coverage factor.

NOTE 3 Expanded measurement uncertainty is termed “overall uncertainty” in paragraph 5 of Recommendation INC-1 (1980) (see the GUM) and simply “uncertainty” in IEC documents.

[ISO/IEC Guide 98-3:2008, 2.35]

3.12
indicated value (for the purpose of this standard)
G
value given by the digital indication of the dosemeter

3.13
influence quantity
quantity that is not the measurand but that effects the result of the measurement

NOTE 1 For example, temperature of a micrometer used to measure length.

[IEV 394-20-27; GUM B.2.10]

NOTE 2 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 the influence quantities “radiation energy and angle of radiation incidence”.

3.14
influence quantity of type F
influence quantity whose effect on the indicated value is a change in response

NOTE 1 Examples are radiation energy and angle of radiation incidence (see 9.4 to 9.6) and dose rate when measuring the dose.

NOTE 2 “F” stands for factor: The indication due to radiation is multiplied by a factor due to the influence quantity.

3.15
influence quantity of type S
influence quantity whose effect on the indicated value is a deviation independent of the indicated value

NOTE 1 Examples are electromagnetic disturbance (see Clause 11) and microphonics (see 12.4).

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

NOTE 3 “S” stands for sum: The indication is the sum of the indication due to radiation and due to the influence quantity, e.g., electromagnetic disturbance.

3.16
lower limit of effective range of measurement
H_0
lowest dose(rate) value included in the effective range of measurement

3.17
maximum possible measuring time
t_{max}
longest measuring time within which all requirements of this standard are fulfilled

NOTE The time can be given by the battery life or by other requirements, see note to 9.3.6.

3.18
measured value (using response)
M
value that can be obtained from the indicated value G by applying the model function for the measurement

NOTE 1 The model function is necessary to evaluate the uncertainty according to the GUM (see GUM 3.1.6, 3.4.1 and 4.1).

NOTE 2 An example of a model function is given here. It combines the indicated value G with the reference calibration factor N_0, the correction for non-constant response 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:

$$M = \frac{N_0}{r_n \prod_{q=1}^{m} r_q} \left[G - \sum_{p=1}^{l} D_p \right].$$

NOTE 3 The calculations according to such model function are usually not performed, only in the case that specific influence quantities are well known and an appropriate correction is applied.

NOTE 4 With the calibration controls adjusted according to the manufacturer's instructions, the reference calibration factor, the correction for non-constant response and all relative response values are set to one and the deviations are set to zero, these settings cause an uncertainty of measurement which can be determined from the measured variation of the response values and the measured deviations. For a dosemeter tested according to this standard, all these data are available.

3.19
minimum rated range
smallest range being specified of an influence quantity or instrument parameter over which the dose equivalent meter will operate within the respective variation of the relative response in order to comply with this standard

3.20
non-constant response
variation of the value of the (relative) response with the magnitude of the quantity to be measured

3.21
personal dose equivalent
$H_p(d)$
dose equivalent in soft tissue at a specified point in the human body at a depth d

NOTE The recommended depths are 10 mm for penetrating radiation and 0,07 mm for superficial radiation.

[IEV 393-14-97]

3.22
personal dose equivalent meter
assembly intended to measure the personal dose equivalent with a digital dose indication

3.23
personal dose equivalent rate
$\dot{H}_p(d)$
quotient of $dH_p(d)$ by dt, where $dH_p(d)$ is the increment of personal dose equivalent in the time interval dt

$$\dot{H}_p(d) = \frac{dH_p(d)}{dt}$$

Units of personal dose equivalent rate are a quotient of the sievert or its decimal multiples or submultiples by a suitable unit of time (for example, mSv h^{-1})

3.24
point of test
point at which the conventional quantity value is determined and at which the reference point of the detector assembly is placed for calibration and test purposes

3.25
qualification tests
tests which are performed in order to verify that the requirements of a specification are fulfilled. Qualification tests are subdivided into type tests and routine tests

3.26
rated range
range of a quantity to be measured, observed, supplied, or set assigned to the instrument

3.27
rated range of use
range of values of an influence quantity giving the limits of operation within the stated limits of the relative response or the deviation

3.28
reference calibration factor
calibration factor, N_0, for a reference value, $H_{r,0}$, of the quantity to be measured. With $G_{r,0}$ being the respective indicated value, it is expressed as

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

NOTE For the value of $H_{r,0}$ see Table 3.

3.29
reference operating condition
reference condition
operating condition prescribed for evaluating the performance of a measuring instrument or measuring system or for comparison of measurement results

NOTE 1 Reference operating conditions specify intervals of values of the measurand and of the influence quantities.

NOTE 2 In IEC 60050-300, 311-06-02, the term “reference condition” refers to an operating condition under which the specified instrumental measurement uncertainty is the smallest possible.

[ISO/IEC Guide 98-3:2008, 4.11]

NOTE 3 The reference conditions given in Table 3 include also a reference value for the quantity to be measured. For an instrument with non-constant response these values are mandatory, e.g., the indicated value G during testing should be equal to $H_{r,0}/N_0$ (see 3.28). For an instrument with constant response, $H_{r,0}$, can be any value within the range given by the standard test conditions, see Table 3.

3.30
reference orientation
orientation of the detector assembly with respect to the direction of the incident radiation stated by the manufacturer

NOTE The detector assembly is positioned in the reference orientation during calibration.

3.31
reference point of an assembly
mark on the equipment by which the ▌C〉 detector 〈C▐ assembly is positioned for the purpose of calibration

NOTE The point from which the distance to the source is measured.

[IEV 394-40-15, modified]

3.32
reference response
R_0
response of the assembly under reference conditions:

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

where $H_{r,0}$ is a reference (conventional) quantity value of the quantity to be measured for a specified reference radiation under specified reference conditions and $G_{r,0}$ is the respective indicated value.

NOTE The reference response is the reciprocal of the reference calibration factor.

3.33
relative expanded uncertainty
U_{rel}
expanded uncertainty divided by the result of the measurement

3.34
relative response
r
ratio of the response, R, and the reference response, R_0, at the point of test under specified conditions:

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

NOTE The reference response R_0 is always measured at 0° radiation incidence at the reference energy, see 3.30.

3.35
response (of a radiation measuring assembly)
R
ratio, under specified conditions, given by the relation:

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

where G is the value of the quantity measured by the equipment or assembly under test and

H is the conventional quantity value of this quantity

[IEV 394-40-21, modified]

NOTE 1 For an instrument with non-constant response, the value of the response varies when the conventional quantity value is changed.

NOTE 2 For the specified reference conditions, the response is the reciprocal of the calibration factor.

3.36
routine test
conformity test made on each individual item during or after manufacture

[IEV 151-16-17, IEV 394-40-03]

3.37
standard test conditions
a value, values, or range of values of an influence quantity or instrument parameter, which are permitted when carrying out calibrations or tests on another influence quantity or instrument parameter (see column 3 of Table 3)

3.38
standard measurement uncertainty
standard uncertainty of measurement
standard uncertainty
u_i
measurement uncertainty expressed as a standard deviation

[ISO/IEC Guide 98-3:2008, 2.30]

3.39
supplementary tests
tests intended to provide supplementary information on certain characteristics of the dosemeters

3.40
type test
conformity test made on one or more items representative of the production

[IEV 394-40-02; IEV 151-16-16]

3.41
measurement uncertainty
uncertainty of measurement
uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand**,** based on the information used

NOTE 1 Measurement uncertainty includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of measurement standards, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for but, instead, associated measurement uncertainty components are incorporated.

NOTE 2 The parameter may be, for example, a standard deviation (or a specified multiple of it), or the half-width of an interval having a stated coverage probability.

NOTE 3 Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

NOTE 4 In general, for a given set of information, it is understood that the measurement uncertainty is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty

[ISO/IEC Guide 98-3:2008, 2.26]

4 Units and list of symbols

4.1 Units

In the present standard, the units of the International System (SI) are used. The definition of radiation quantities and dosimetric terms is given in IEC 60050-393, IEC 60050-394 and ICRU report 51. In addition, the following units are accepted:

– For energy: electron-volt (symbol eV). 1 eV = 1,602 · 10^{-19} J.

– For time: year, day (symbol d), hour (symbol h), minute (symbol min).

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

The SI unit of dose equivalent is the sievert (symbol Sv). 1 Sv = 1 J kg^{-1}.

4.2 List of symbols

Table 1 gives a list of the symbols (and abbreviated terms) used.

Table 1 – Symbols (and abbreviated terms)

Symbol	Meaning	Unit
α	Angle of radiation incidence	deg
α_{max}	Maximum value of α within rated range of use	deg
D	Deviation	Sv
d	Depth in soft tissue. Recommended depths are 10 mm and 0,07 mm	m
D_p	Deviation due to influence quantity no. p of type S	Sv
$\overline{E}$	Mean radiation energy	eV
G	Indicated dose(rate) value	Sv (Sv h^{-1})
G_a	Indicated dose value at which the alarm occurs	Sv
$\dot{G}_{high}$	Stabilized dose rate reading after an increase in dose rate	Sv h^{-1}
G_K	Indicated dose value due to a single irradiation with the conventional quantity value H_K	Sv
G_{K+L}	Indicated dose value due to a (simultaneously) combined irradiation with the conventional quantity value H_K + H_L	Sv
G_L	Indicated dose value due to a single irradiation with the conventional quantity value H_L	Sv
$G_{low,1}$	Indication of the dosemeter under the same conditions as given for G_{nom}, but when the battery voltage is low, for example, the dosemeter indicates “Low battery” for the first time.	Sv
Δg_{mix}	Relative change in indication caused by subsequent and mixed (simultaneously) exposure, see Clause 8	—
G_{nom}	Indication of the dosemeter under given conditions when the battery voltage has its nominal value.	Sv
G_{nat}	Accumulated dose in the environment	Sv
G_r	Indicated dose(rate) value under specified reference conditions	Sv (Sv h^{-1})
$G_{r,0}$	Reference value of the indicated dose(rate) due to exposure to $H_{r,0}$	Sv (Sv h^{-1})
H	Conventional quantity value of the dose (rate)	Sv (Sv h^{-1})
H_0	Lower dose(rate) limit of the effective range of measurement	Sv (Sv h^{-1})

Symbol	Meaning	Unit
H_a	Dose value to which the alarm is set	Sv
$H_{a,c}$	Conventional quantity value of the dose at which the alarm occurs	Sv
$\dot{H}_a$	Dose rate value to which the alarm is set	Sv h^{-1}
$H_p(0,07)$	Personal dose equivalent at a depth 0,07 mm	Sv
$H_p(10)$	Personal dose equivalent at a depth 10 mm	Sv
$\dot{H}_p(0,07)$	Personal dose equivalent rate at a depth 0,07 mm	Sv h^{-1}
$\dot{H}_p(10)$	Personal dose equivalent rate at a depth 10 mm	Sv h^{-1}
$H_p(d)$	Dose equivalent in soft tissue at a specified point in the human body at a depth d	Sv
H_r	Conventional quantity value of the dose(rate) under specified reference conditions	Sv (Sv h^{-1})
$H_{r,0}$	Reference dose(rate) value of the quantity to be measured	Sv (Sv h^{-1})
$H_{true,nat}$	Expected personal dose equivalent due to natural environmental radiation	Sv
$\dot{H}_{true,nat}$	Known personal dose equivalent rate due to natural environmental radiation	Sv h^{-1}
$I_{low,1}$	Supply current of the dosemeter when the indication is $M_{low,1}$	A
$I_{low,2}$	Supply current of the dosemeter when the alarm sounds and the visual alarm is displayed after the alarm is set on its lowest range	A
K	Symbol of radiation condition K, for example, 3 mSv and N-80	—
k	Coverage factor (see GUM)	—
L	Symbol of radiation condition L, for example, 4 mSv and S-Co	—
l	Number of influence quantities of type S	—
M	Measured dose(rate) value	Sv (Sv h^{-1})
m	Number of influence quantities of type F	—
N	Calibration factor	—
n	Number of indicated values for one dose value used for the test of constancy of dose response and coefficient of variation	—
N_0	Reference calibration factor	—
Q_{nom}	Nominal capacity of the batteries	A h
R	Response	—
r	Relative response	—
R_0	Reference response	—
r_n	Correction for non-constant response	—
r_q	Relative response due to influence quantity no. q of type F	—
S_K	Symbol of radiation quality of condition K, for example, N-80	—
S_L	Symbol of radiation quality of condition L, for example, S-Co	—
t_{env}	Measuring time in the environment	h
t_{max}	Maximum possible measuring time	h
t_{min}	Minimal time required for continuous operation of the dosemeter, 100 h for primary batteries and 24 h for secondary batteries	h
U	Expanded uncertainty	As quantity
u_c	Combined standard uncertainty	As quantity
u_i	Standard uncertainty due to component no. i	As quantity

Symbol	Meaning	Unit
$U_{low,1}$	Battery voltage under conditions prevailing for the determination of $G_{low,1}$	V
$U_{low,2}$	Battery voltage under the same conditions as given for G_{nom}, but when the battery voltage is lowered until the indication of the dosemeter is 0,9 G_{nom}	V
U_{nom}	Nominal value of the battery voltage	V
U_{rel}	Relative expanded uncertainty	—
v	Coefficient of variation	—
v_{max}	Maximum permitted coefficient of variation at the dose rate to which the alarm is set	—
w	Number of dose values used for the test of constancy of the dose response and coefficient of variation	—

5 Mechanical characteristics

5.1 Size

The dimensions shall not exceed 15 cm in length, 3 cm in depth, 8 cm in width, excluding any clip or retaining device. In addition, the volume, excluding the clip or other fixing arrangement, shall not exceed 300 cm^3 for personal dose equivalent meters for mixed neutron/photon fields and 250 cm^3 for all other dosemeters.

5.2 Mass

The mass shall not exceed 350 g for personal dose equivalent meters for mixed neutron/photon fields, 300 g for personal dose equivalent meters for neutron fields and 200 g for all other personal dose equivalent meters.

5.3 Case

The case should be smooth, rigid, shock resistant, dust-proof and water spray-proof. Means shall be provided for fixing the dosemeter to clothing, for example, a strong clip, ring or a lanyard. The design of the dosemeter should assist the wearing in a position that ensures the necessary orientation of the detector and of the alarm indicators.

5.4 Switches

If external switches are provided, these shall be adequately protected from accidental or unauthorized operation. Operation of such switches shall not interfere with the integrating function of the dosemeter. Switches shall be operable beneath a plastic bag and with gloved hands.

6 General characteristics

6.1 Storage of dose information

The personal dose equivalent meter shall retain the stored dose information under all normal circumstances.

6.2 Indication

Any dose indication for personal dose equivalent meters shall be digital and shall be shown in units of dose equivalent, namely sieverts and its submultiples, for example, microsieverts

(μSv). The display shall be clearly visible and be easy to read by the wearer. The display shall clearly indicate the unit of the quantity being measured.

6.3 Dosemeter markings

The reference point for calibration and test purposes shall be indicated on the outside of the dosemeter. The reference orientation with respect to the wearer shall also be marked on the dosemeter.

6.4 Retention of radioactive contamination

The dosemeter shall be designed to minimize the retention of contamination and to ease its removal. A dosemeter may be provided with an additional protective cover; if fitted, the dosemeter shall still conform to the requirements of this standard.

6.5 Ranges for dose equivalent and dose equivalent rate

The dose equivalents to be measured are within the range 1 μSv to 10 Sv. For most applications, the dose equivalent rates are within the range from 1 μSv h^{-1} to 1 Sv h^{-1}.

6.6 Effective range of measurement

For personal dose equivalent meters, the effective range of measurement shall cover at least the range from 100 μSv to 1 Sv for the measurement quantity $H_p(10)$ and [C⟩ at least ⟨C] from 1 mSv to 10 Sv for the measurement quantity $H_p(0,07)$ and start from the first non-zero indication in the second least significant digit in the lowest range up to the maximum indication.

Where more than one detector is used for measurements over the complete range, the results shall be derived and displayed automatically. Where the dosemeter has range change facilities, these shall be automatic.

NOTE As an example, for a display with a maximum indication of 9999,9 the effective range of measurement should start in the lowest range from 1,0 and go to 9999,9 in the highest range.

6.7 Rated range of an influence quantity

The rated range of any influence quantity has to be stated by the manufacturer in the documentation, it shall cover at least the minimum rated range given in the third column of Tables 4 to 9. All requirements of this standard shall be fulfilled within the whole rated range.

NOTE Personal dosemeters are designed for specific applications (see Table C.1) so the manufacturers should specify the types of radiation, the measuring range, the energy ranges and the ranges of all other influence quantities their dosimeters are designed for (see 14.2). The purchasers may make reference to Table C.1 to determine which categories apply to their requirements.

6.8 Use of more than one dosemeter

If dosemeters are intended to be used in radiation fields for which they are not specified, for example, a neutron and a photon dosemeter together in a mixed neutron/photon field, the effect of radiation not intended to be measured shall be considered as an influence quantity. For the mentioned example, it follows that photon radiation is an influence quantity for the dosemeter only designed and specified for neutrons and vice versa. For each dosimeter designed for the measurement of a specific radiation, the manufacturer shall specify the deviation of this dosimeter if exposed to other radiation types. From this information, in the case of use of more than one dosemeter, the user can estimate the total dose value and the associated uncertainties.

6.9 Indication due to the intrinsic background of the instrument

For a personal dose meter for $H_p(10)$ and $H_p(0,07)$ from X and gamma radiations the indication due to instrument artefacts shall be given by the manufacturer for an integrating period equivalent to the maximum possible measuring time t_{max}, for test see 9.3.5.

NOTE This value is required if measured values of dose equivalents accumulated during several days, for example, one month, and measured using different dosemeters are compared.

6.10 Dose or dose rate alarms

6.10.1 General

For personal dose equivalent meters, it shall not be possible to set alarm levels by external switches on the dosemeter. The alarm levels shall either be set by the associated readout system or it shall be possible to inhibit unauthorized change of alarm levels by an electronic or mechanical access-limiting system.

6.10.2 Dose equivalent alarms

It shall be possible to set this alarm to at least one value in each order of magnitude over the complete effective range of measurement of the dosemeter (for example, 30 μSv, 0,3 mSv, 3 mSv and 30 mSv).

6.10.3 Dose equivalent rate alarms

It shall be possible to set this alarm to at least one value in each order of magnitude over the complete effective range of measurement of the dosemeter (for example, 30 μSv h^{-1}, 0,3 mSv h^{-1}, 3 mSv h^{-1} and 30 mSv h^{-1}).

6.10.4 Alarm output

a) Location

The audible and/or visual alarm shall be located so that when the dosemeter is worn on the body, the audible alarm can be heard and the visual alarm seen by the wearer.

b) Audible alarm

The frequency shall be within the 1 kHz to 5 kHz range. Where an intermittent alarm is provided, the signal interval shall not exceed 2 s. The A-weighted sound level (impulse level for intermittent alarm) shall exceed 80 dBA and not exceed 100 dBA at 30 cm from the alarm source. A visual signal or earphones capability should be available for high noise environments.

6.11 Indication of malfunction

Indication shall be given of operation conditions in which the accumulation of dose equivalent is not accurate (within the specifications of this standard), for example, low battery supply, detector failure, electronic failure, or when used in high dose equivalent rate fields.

7 General test procedures

7.1 Nature of tests

Unless otherwise specified in the individual clauses, all the tests enumerated in this standard are to be considered as type tests. Certain tests may be considered as acceptance tests by agreement between the purchaser and the manufacturer or supplier.

7.2 Reference conditions and standard test conditions

Reference conditions are given in the second column of Table 3. Except where otherwise specified, the tests in this standard shall be carried out under standard test conditions given in the third column of Table 3. For those tests carried out under standard test conditions, the values of temperature, pressure, and relative humidity at the time of test shall be stated and the appropriate corrections made to give the response under reference conditions. The values of any corrections shall be stated.

For those tests intended to determine the effects of variations in the influence quantities given in Table 3, all other influence quantities shall be maintained within the limits for standard test conditions given in Table 3, unless otherwise specified in the test procedure concerned.

7.3 Tests for influence quantities of type F

These tests may be performed at any value of the quantity to be measured above 10 H_0. From the result of each test, the respective variation of the relative response r can be determined.

It is accepted that some small part of the effects of the influence quantities classified as Type F could be regarded as the effects produced by Type S influence quantities. If these effects are small they shall be ignored in relation to the use of this standard. If during testing larger effects of Type S are observed, then the respective test shall be performed at a dose value of 10 H_0 and these findings shall be reported in the type test report.

7.4 Tests for influence quantities of type S

These tests shall be performed at a conventional quantity value of the dose equivalent H of not more than 10 times the lower limit H_0 of the effective range of measurement. The result of each test is a deviation D_p.

It is accepted that some small part of the effects of the influence quantities classified as Type S could be regarded as the effects produced by Type F influence quantities. If these effects are small they should be ignored in relation to the use of this standard. If during testing larger effects of Type F or significant negative effects are observed, then the respective test shall be performed at a dose value of 10 H_0 and these findings shall be reported in the type test report.

Due to the generally lower indicated value when compared to tests according to 7.3, the necessary number of measurements may be increased.

7.5 Phantom for testing

For all tests involving the use of a phantom, the ISO water slab phantom given in ISO 4037-3 shall be used. For beta radiation this phantom can be replaced by a polymethylmethacrylate (PMMA) slab, 100 mm × 100 mm × 10 mm (see ISO 6980-3, subclause 6.31).

The required irradiation geometry is specified in the appropriate ISO reference standard (ISO 4037-3, ISO 6980-3 or ISO 8529-3).

NOTE The combination of dosemeter, phantom and further parts, for example, clip, is called “detector assembly”, see 3.8. In principle, all response values according to this standard are valid only for this detector assembly and should consequently be called “detector assembly response”. But it is common practice to use the term “dosemeter response” for that purpose. This is also followed in this standard.

7.6 Position of detector assembly for the purpose of testing

For all tests involving the use of radiation, the reference point of the detector assembly shall be placed at the point of test and it shall be oriented with respect to the direction of the radiation field as given by the reference orientation, except for tests with variations of the angle of radiation incidence.

7.7 Position of dosemeter during use

If the dosemeter design permits the user to wear the dosemeter in two orientations, one with the reference orientation pointing to the body of the user and one pointing away from the body – for example, a credit card size dosemeter – then the dosemeter shall fulfil the requirements of this standard for both orientations or it shall clearly be stated that wearing in the wrong orientation can cause erroneous results.

7.8 Minimum rated range of influence quantity

The minimum rated range of any specified influence quantity is given in the third column of Tables 4 to 9.

7.9 Low dose equivalent rates

For the measurement of low dose equivalent rates of photon and beta radiation, it is necessary to take into account the contribution of natural background radiation to the dose equivalent rate at the point of test. The indication due to natural background radiation shall be subtracted from the indicated value during irradiation.

7.10 Statistical fluctuations

For any test involving the use of radiation, if the magnitude of the statistical fluctuations of the indication arising from the random nature of radiation alone, is a significant fraction of the variation of the indication permitted in the test, then sufficient readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient accuracy to determine whether the requirements for the characteristic under test are met.

The interval between such readings shall be sufficient to ensure that the readings are statistically independent.

The number of readings required to settle the true difference between two sets of fluctuating dose equivalent meter readings on the same instruments under unchanged conditions is given in Table A.1.

7.11 Production of reference radiation

Unless otherwise specified in the individual methods of test, all tests involving the use of X, gamma, neutron or beta radiations shall be carried out with the relevant specified type of radiation (see Table 3). The nature, construction and conditions of use of the radiation sources shall be in accordance with the following recommendations

a) ISO 4037-1/ISO 4037-2/ISO 4037-3/ISO 4037-4;

b) ISO 6980-1/ISO 6980-2/ISO 6980-3;

c) ISO 8529-1/ISO 8529-2/ISO 8529-3.

8 Additivity of indicated value

8.1 Requirements

The indicated value shall be additive with respect to simultaneous irradiation with different types of radiation (for example, X and gamma or gamma and beta) and with different energies and angles of radiation incidence.

If the dosemeter uses only one signal (measured with one detector) to evaluate the indicated value, then this requirement is fulfilled.

If a dosemeter uses more than one signal (measured either with several detectors or with one detector using, for example, pulse height analysis) to evaluate the indicated value, then this

requirement is not automatically fulfilled. In that case it shall be ensured that the relative change in indication, Δg_{mix}, caused by the mix of radiation, shall not exceed ±0,1.

NOTE If the algorithm used to evaluate the indicated value is either a linear combination of the signals or a linear optimization of them, then this requirement is fulfilled and no tests are required.

8.2 Method of test

Perform two irradiations under the two different irradiation conditions K and L (different energies, different angles of incidence or even different types of radiations) with the conventional quantity values H_{K} and H_{L}. Determine the indicated values G_{K} and G_{L} for the two irradiations. Also perform a third simultaneous irradiation under the two irradiation conditions K and L with the conventional quantity value $H_{\text{K+L}} = H_{\text{K}} + H_{\text{L}}$ and determine the indicated value $G_{\text{K+L}}$ for this simultaneously mixed irradiation.

The relative change in indication is then given by:

$$\Delta g_{\text{mix}} = \frac{G_{\text{K}} + G_{\text{L}} - G_{\text{K+L}}}{G_{\text{K+L}}}$$

Δg_{mix} shall be determined for any value of H_{K} and H_{L} and any simultaneous combination of radiation fields. As simultaneous irradiations may be difficult to perform, the use of calculations as a replacement for the simultaneous irradiations is permitted and recommended for this test. A prerequisite of the use of calculations is the knowledge of measured response values of each signal to all the irradiation conditions K and L and of the evaluation procedure to determine the indicated value from these signals. The calculation of the response of the entire dosemeter with the aid of radiation transport simulations to determine the response values of each signal to all the irradiation conditions is not permitted.

The non-linearity of the signals is treated in 9.3. Therefore, when no calculation is performed, the signals shall be corrected for non-linearity for this test. When different dosemeters are used to determine G_{K}, G_{L} and $G_{\text{K+L}}$, any difference in the reference calibration factor shall be corrected.

8.3 Interpretation of the results

The relative change in indication, Δg_{mix}, shall not exceed ±0,1. In this case, the requirements of 8.1 can be considered to be met.

NOTE For neutron dosemeters, this requirement cannot always be fulfilled. In such cases, special agreements between customer and supplier are necessary together with a warning in the documentation.

9 Radiation performance requirements and tests

9.1 General

All influence quantities dealt with in this Clause are regarded as of type F. One possible method to determine the variation of the relative response for radiation energy and angle of radiation incidence is given in Annex B.

NOTE 1 The requirements for the influence quantity *radiation energy and angle of radiation incidence* are given with respect to the reference response R_0 under reference conditions (reference radiation and 0° radiation incidence, reference dose and/or dose rate and all the other reference conditions as given in Table 3). The possible reference radiations can be found for photon radiation in Table 1 of ISO 4037-1, for beta radiation in Table 1 of ISO 6980-1 and for neutron radiation in Table 1 of ISO 8529-1. The most used reference radiations are given in Table 3, but especially for neutron dosemeters it can be necessary to choose other radiations as reference radiation to comply with the requirements for this influence quantity, even an energy value can be chosen as reference condition for which no physical radiation is available. In that case this (virtual) reference radiation is realized by an available reference radiation and the deviation of the response to the (virtual) reference radiation.

NOTE 2 For details regarding the reasons for the non-symmetric limits for the relative response due to radiation energy and angle of radiation incidence see IEC/TR 62461.

9.2 Consideration of the uncertainty of the conventional quantity value

The expanded (k = 2) relative uncertainty, U_{rel}, of the conventional quantity value of the dose equivalent or dose equivalent rate shall be less than 10 % = 0,1 and shall be taken into account. Any requirement needing the use of radiation is considered to be given for U_{rel} = 0. For $U_{\text{rel}} > 0$, the allowed variation of the relative response shall be enlarged by U_{rel}. If several tests are to be performed with the same radiation quality, for example, the test for the constancy of the response, only the uncertainty of the ratio of the actual value and the reference value of the dose equivalent (rate) shall be considered. In case of other requirements, the consideration is mentioned in the respective method of test.

9.3 Constancy of the dose response, dose rate dependence and statistical fluctuations

9.3.1 General

The tests for constancy of dose response, dose rate dependence and statistical fluctuations are performed using the same measurement data.

If the method of detection is different for photon, beta and neutron radiation or for specific energy ranges of these radiations, this requirement shall be tested separately for all types of radiation.

If the manufacturer can show that the technical design of the dosemeter ensures the fulfilment of the requirements on constancy of the dose response for a large range of dose values, then the number of tests can be reduced. Only tests with different dose rates are then required.

9.3.2 Requirements

a) Under standard test conditions, with the calibration controls adjusted according to the manufacturer's instructions, the variation of the relative response due to the non-constancy of the dose response shall not exceed –17 % to +25 % over the whole of the effective range of measurement for either X, gamma, neutron or beta reference radiations chosen. The dose rate shall be varied over the whole range of dose rate specified by the manufacturer for dose measurements. If the maximum dose rate specified by the manufacturer for dose measurements is less than 1 Sv h^{-1}, this should be indicated on the dosemeter.

b) The statistical fluctuations of the indication measured as coefficient of variation shall fulfil the requirements given in Tables 4 to 6.

c) For photon dosemeters to measure $H_{\text{p}}(10)$ from X and gamma radiations the difference between the indicated background dose, G_{nat} , and the conventional quantity value of the background dose, $H_{\text{true,nat}}$, shall not exceed H_0 for the stated measuring time t_{max}.

9.3.3 Method of test using sources

a) Source to be used

For the purpose of this test, the conventional quantity value of the personal dose equivalent (rate) at the point of test shall be known. The tests shall be performed with reference sources as given in Table 3 of appropriate activity, for example, ^{137}Cs for photon radiation, ^{241}Am-Be for neutron radiation and ^{90}Sr/^{90}Y for beta radiation, irradiating the dosemeter on the required phantom (see 7.5) in the reference direction. The dose rate shall be varied over the whole range of dose rates specified by the manufacturer for dose measurements.

If this test cannot be performed on the required phantom (see 7.5), for example, because the required high dose rate cannot be produced at a distance where the entire phantom is illuminated, then the test can also be performed free in air at shorter distances if the correction factor for irradiating free in air instead of on the phantom is applied. This

correction factor is specific for the dosemeter under test and the radiation quality used and shall therefore be determined specifically.

b) Tests to be performed

The tests shall be performed separately with photon radiation (for example, ^{137}Cs), with neutron radiation (for example, ^{241}Am-Be) and with beta radiation (for example, ^{90}Sr/^{90}Y).

The response shall be measured for at least three dose values in each order of magnitude of the effective range of measurement of dose. These shall be at approximately 20 %, 40 % and 80 % of each full order of magnitude. At the different dose values, different dose rate values covered by the rated range of dose rate shall be applied as well. In total, n repeated measurements at each of the w dose values shall be performed, depending on the effective range of measurement of dose. From these measurements the w response values the variation of the relative response due to the non-constancy of the response may be determined.

9.3.4 Interpretation of the results of the test using sources

Determine the mean value and the coefficient of variation of the n values of the indication for each of the w dose values.

Using the w mean values, the variation of the relative response due to the non-constancy of the response shall not exceed the range from –17 % to +25 %. Also, using the w values of the coefficients of variation and the values of c_1 and c_2 given in Table 2, show that

- for w – 2 dose values the coefficients of variation are less than c_1 times the limits given in Tables 4 to 6 and
- for the remaining two dose (rate) values – which shall not be adjacent – the coefficients of variation are less than c_2 times the limits given in Tables 4 to 6.

In that case, the requirements a) and b) of 9.3.2 can be considered to be met.

NOTE 1 The value of c_1 is always smaller than that of c_2.

NOTE 2 This method ensures that the probability of passing the test is independent of the number w of dose values at which the test is performed. Without applying the factors c_1 and c_2 the probability of passing the test decreases with increasing number w of dose values at which the tests are performed.

NOTE 3 The reasons for the test procedure are given in the paper of Brunzendorf and Behrens, see Bibliography.

9.3.5 Method of test for photon dosemeters using natural radiation

a) Simple test: Place the dosemeter on the ISO water slab phantom for at least one week (t_{env}) in a normal laboratory environment and assume as a first estimate a background dose rate $\dot{H}_{true,nat}$ of 2 µSv d^{-1}, if no other information is available. Determine the instrument's accumulated dose $G_{i,nat}$ for the time t_{env} (see also 6.9). Calculate the expected dose value from the assumed dose rate due to natural environmental radiation $H_{true,nat}$ = 2 µSv d^{-1} × t_{env}.

b) Refined test: This refined test is only necessary if the simple test does not show compliance with the requirements, see 9.3.6. Place the dosemeter on the ISO water slab phantom for at least one week (t_{env}) in an environment where the 〚C〛mean〚C〛 background dose rate $\dot{H}_{true,nat}$ is known 〚C〛*text deleted*〚C〛. This shall be at a standard field station where the dose rates have been measured with reference instruments which are traceable to national standards. Determine the accumulated dose G_{nat} for time t_{env} (see also 6.9). Calculate the expected dose value from the known dose rate due to natural environmental radiation: $H_{true,nat} = \dot{H}_{true,nat} \times t_{env}$.

9.3.6 Interpretation of the results of the test using natural radiation

If the 〚C〛 inequality 〚C〛

$$\frac{\left|G_{\text{nat}} - H_{\text{true, nat}}\right|}{t_{\text{env}}} \times t_{\text{max}} \leq H_0$$

is valid, the requirements of 9.3.2 c) can be considered to be met.

NOTE This [C] inequality [C] can also be used to fix (new) values for H_0 and t_{max}.

9.4 Variation of the response due to photon radiation energy and angle of incidence

9.4.1 Measurement quantity $H_p(0,07)$ or $\dot{H}_p(0,07)$

9.4.1.1 Requirements

The relative response due to radiation energy and angle of radiation incidence for photon radiation within the rated range of use shall be within the interval from 0,71 to 1,67 (see Table 4). The minimum rated range of use covers energies between 20 keV and 150 keV and angles of radiation incidence between 0° and 60°. For energies below 50 keV a variation within the interval from 0,67 to 2,0 is permitted.

If the methods of detection are different for specific dose (rate) ranges, this requirement shall be tested separately for all these ranges.

All indicated dose values shall be corrected for non-constant response and for the effect of the influence quantity dose rate on dose measurements.

9.4.1.2 Method of test

For this test, the dosemeter shall be placed on the ISO water slab phantom . The photon radiation qualities specified in ISO 4037-1, ISO 4037-2, ISO 4037-3, ISO 4037-4 shall be used. The narrow spectrum series is preferred. The selection of the radiation qualities should be done in accordance with Annex B.

The response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{\text{max}}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter.

NOTE 1 Details of the reference radiations and the calibration procedure are given in ISO 4037-1, ISO 4037-3 and ISO 4037-4.

NOTE 2 According to ISO 4037-1 and ISO 4037-3, typical $\dot{H}_p(0,07)$ dose rates of 1 mSv h^{-1} to 10 mSv h^{-1} can be produced for the narrow spectrum series at a distance of 1 m from the focal spot of the X-ray tube operating at 1 mA.

9.4.1.3 Interpretation of the results

All the relative response values due to photon radiation energy and angle of incidence shall be within the interval from 0,71 to 1,67 for all energies above or equal to 50 keV and within the interval from 0,67 to 2,0 for energies below 50 keV. In that case, the requirements of 9.4.1.1 can be considered to be met.

9.4.2 Measurement quantity $H_p(10)$ or $\dot{H}_p(10)$

9.4.2.1 Requirements

The relative response due to radiation energy and angle of radiation incidence for photon radiation within the rated range of use shall be within the interval from 0,71 to 1,67 (see Table 5). The minimum rated range of use covers energies between 80 keV and 1,5 MeV or between 20 keV and 150 keV and angles of radiation incidence between 0° and 60°.

All indicated dose values shall be corrected for non-constant response and, if necessary, for the effect of the influence quantity dose rate on dose measurements.

NOTE The two minimum rated ranges reflect the two main workplace conditions. The minimum rated range of use from 80 keV to 1,5 MeV is for workplaces where gamma sources are used, e.g., in industry, and the minimum rated range of use from 20 keV to 150 keV is for workplaces where X-rays are used, e.g., in medical diagnostic. Both ranges can be extended until in the extreme case the rated range of use covers all energies from 10 keV to 10 MeV.

9.4.2.2 Method of test

For this test the dosemeter shall be placed on the ISO water slab phantom. The photon radiation qualities specified in ISO 4037-1, ISO 4037-2, ISO 4037-3, ISO 4037-4 shall be used. The narrow spectrum series is preferred. Their mean energy should be chosen in accordance with Annex B.

The response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{max}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter.

NOTE 1 Details of the reference radiations and the calibration procedure are given in ISO 4037-1, ISO 4037-3 and ISO 4037-4.

NOTE 2 According to ISO 4037-1 and ISO 4037-3, typical $\dot{H}_p(10)$ dose rates of 0,1 mSv h^{-1} to 1 mSv h^{-1} can be produced for the narrow spectrum series at a distance of 2,5 m from the focal spot of the X-ray tube operating at 1 mA.

9.4.2.3 Interpretation of the results

All the relative response values due to photon radiation energy and angle of incidence shall be within the interval from 0,71 to 1,67. In this case, the requirements of 9.4.2.1 can be considered to be met.

9.5 Variation of the response due to neutron radiation energy and angle of incidence

9.5.1 Measurement quantity $H_p(10)$ or $\dot{H}_p(10)$

9.5.1.1 Requirements

The relative response due to radiation energy and angle of radiation incidence for neutron radiation shall be within the interval from 0,65 to 4,0 for the energy range between the minimum energy of the rated range and 100 keV, shall be from 0,65 to 2,22 for the energy range between 100 keV and 10 MeV and shall be from 0,65 to 4,0 for the energy range between 10 MeV and the maximum energy of the rated range (see Table 6). The minimum rated range of use covers energies between 0,025 eV and 5 MeV and angles of radiation incidence between 0° and 60° (see Table 6).

If the methods of detection are different for specific dose (rate) ranges, this requirement shall be tested separately for all these ranges.

All indicated dose values shall be corrected for non-constant response and, if necessary, for the effect of the influence quantity dose rate on dose measurements.

9.5.1.2 Method of test

For this test, the dosemeter shall be placed on the ISO water slab phantom. The neutron radiation qualities specified in ISO 8529-1, ISO 8529-2, ISO 8529-3 and ISO 12789-1, ISO 12789-2 shall be used.

For the range from the minimum energy of the rated range to 100 keV, at least one mainly thermal field with contribution of thermal neutrons to personal dose equivalent greater than 50 % and one nearly mono energetic neutron field between about 10 keV and 100 keV shall be used. For the range from 100 keV to 1 MeV, at least 3 mono energetic neutron fields shall be used. For the range from 1 MeV to 10 MeV at least 3 mono energetic neutron fields or 2 mono energetic neutron fields and a broad source (^{252}Cf or ^{241}Am-Be) shall be used. For the range of 10 MeV to 15 MeV, at least the mono energetic 14,8 MeV neutron field shall be used. If the rated range extends above 15 MeV, additional appropriate energies shall be used.

In case the 〚C〛*text deleted*〚C〛 requirements cannot be met, 〚C〛with the above mentioned reference radiations〚C〛 the following alleviations are admitted:

a) If the 〚C〛 relative 〚C〛 response for the mainly thermal field is out of the limits given in 9.5.1.1, then a simulated workplace field with contribution of thermal neutrons to personal dose equivalent of at least 10 % shall be used instead of the mainly thermal field.

b) If the 〚C〛relative〚C〛 response for the mono energetic neutron field in the energy range from 10 keV to 100 keV is out of the limits given in 9.5.1.1, then a simulated work place field with contribution of intermediate neutrons (0,4 eV to 100 keV) to personal dose equivalent greater than 10 % shall be used instead.

c) If the 〚C〛relative〚C〛 response for up to two mono energetic neutron fields in the energy range from 100 keV to 10 MeV is out of the limits given in 9.5.1.1, then simulated work place fields or broad sources shall be used instead. The mean energy (dose equivalent weighted) of the mono energetic and the replacement neutron fields shall be within a factor of 1/1,5 to 1,5.

In addition, it is recommended to state the response to standardized simulated work place neutron field sources. By agreement between the manufacturer and the customer, simulated work place neutron fields shall be selected in accordance with the field encountered at the work place where the device will be used.

The response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{max}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter.

NOTE Details of the reference radiations and the calibration procedure are given in ISO 8529-1, ISO 8529-2 and ISO 8529-3. For simulated realistic work place neutron field sources, see ISO 12789-1 and ISO 12789-2.

9.5.1.3 Interpretation of the results

All the relative response values due to neutron radiation energy and angle of incidence shall be within the interval from 0,65 to 4,0 for the energy range between the minimum energy of the rated range and 100 keV, shall be within the interval from 0,65 to 2,22 for the energy range between 100 keV and 10 MeV and shall be within the interval from 0,65 to 4,0 for the energy range between 10 MeV and the maximum energy of the rated range. Where one or more alleviations are used, the manufacturer shall indicate precisely the characteristics of the simulated neutron field or broad source used for the test and shall indicate the response to the replaced mono energetic field. In that case, the requirements of 9.5.1.1 can be considered to be met.

9.6 Variation of the response due to beta radiation energy and angle of incidence

9.6.1 Measurement quantity $H_p(0,07)$ or $\dot{H}_p(0,07)$

9.6.1.1 Requirements

The relative response due to radiation energy and angle of radiation incidence for beta radiation within the rated range of use shall be within the interval from 0,71 to 1,67 (see Table 4). The minimum rated range of use covers mean energies between 0,2 MeV and 0,8 MeV and angles of radiation incidence between 0° and 60°. If the rated range of use does not cover 0,06 MeV, then in addition the maximum value of the variation of the relative response due to

beta radiation energy and angle of incidence shall be stated by the manufacturer for 0,06 MeV (see Table 4).

If the methods of detection are different for specific dose (rate) ranges, this requirement shall be tested separately for all these ranges.

All indicated dose values shall be corrected for non-constant response and for the effect of the influence quantity dose rate on dose measurements.

9.6.1.2 Method of test

For this test, the dosemeter shall be placed on the PMMA slab phantom (see 7.5). The following reference radiation qualities selected from the list of beta reference radiations specified in ISO 6980-1 shall be used:

^{147}Pm ($\overline{E} \approx$ 0,06 MeV);

^{204}Tl or ^{85}Kr ($\overline{E} \approx$ 0,24 MeV);

^{90}Sr/^{90}Y ($\overline{E} \approx$ 0,8 MeV).

The response values are measured for angles of incidence of α = 0°, α = ±45° and α = ±60° and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm\alpha_{max}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter.

NOTE Details of the reference radiations and the calibration procedure are given in ISO 6980-1 and ISO 6980-3.

9.6.1.3 Interpretation of the results

All the relative response values due to beta radiation energy and angle of incidence shall be within the interval from 0,71 to 1,67. In this case, the requirements of 9.6.1.1 can be considered to be met.

9.6.2 Measurement quantity $H_p(10)$ or $\dot{H}_p(10)$

9.6.2.1 Requirements

The dosemeter shall be as insensitive as possible to beta radiation because the effective dose equivalent, for which $H_p(10)$ is a conservative estimate, is not a suitable quantity for beta radiation.

9.6.2.2 Method of test

For this test, the dosemeter shall be placed on the PMMA slab phantom (see 7.5). Expose the dosemeter at 0° angle of radiation incidence to beta reference radiation specified in the ISO 6980 series of the following quality:

^{90}Sr/^{90}Y ($\overline{E} \approx$ 0,8 MeV).

The indicated $H_p(10)$ dose value shall be less than 10 % of the $H_p(0,07)$ dose received.

NOTE Details of the reference radiations and the calibration procedure are given in the ISO 6980 series.

9.7 Retention of dose equivalent reading

9.7.1 General

These requirements shall be tested separately for both $H_p(10)$ and $H_p(0,07)$.

9.7.2 Requirements

a) At the end of any exposure period, the reading of the dosemeter and that indicated by any associated readout system, if supplied, shall not change by more than ±2 % or a single change in the least significant digit, whichever is the greatest, over the next 8 h.

   The change of the indicated value due to background radiation shall be excluded.

b) After 24 h from the loss or interruption of the principal voltage supply, the integrated dose equivalent measured by the dosemeter, and from any associated readout system, prior to this loss or interruption, shall not change by more than ±5 %, or a change in the least significant digit, whichever is greater, upon replacement of the principal voltage supply.

9.7.3 Method of test and interpretation of the results

a) Expose the dosemeter to a source of radiation giving a dose equivalent sufficiently high so that any subsequent accumulation due to background radiation can be neglected. Stop the irradiation immediately when the integration period is completed and note the displayed reading. Every hour up to 8 h after the end of the integration period, read the display. None of these eight readings shall differ by more than a least significant digit or by more than ±2 % compared with the initial reading, whichever is the greatest.

b) Expose the dosemeter to a source of radiation giving a dose equivalent sufficiently high so that any subsequent accumulation due to background radiation can be neglected. Note the displayed reading. The principal batteries shall then be removed from the dosemeter. (When the principal battery fails or is removed, the reading may disappear or be replaced by some instruction.) After 24 h, the principal batteries of the dosemeter shall be replaced or recharged. The reading of the dose equivalent obtained shall not differ by more than ±5 % from the last value obtained before the principal batteries were removed, or there shall only be a change in the least significant digit.

9.8 Overload characteristics

9.8.1 General

If the method of detection is different for photon, beta and neutron radiation or for specific energy ranges of these radiations, then this requirement shall be tested separately for all these types of radiation.

9.8.2 Requirements

For dose equivalent (rates) greater than that corresponding to the maximum value of the upper order of magnitude of the effective range of measurement and up to ten times the maximum indication, the dosemeter shall be “off-scale” at the higher end of the scale and shall remain so whilst in that radiation field. The manufacturer shall state the time taken for dosemeters that indicate dose equivalent rate to return to the appropriate “on-scale” dose equivalent rate reading following their irradiation to this overexposure.

For the dose equivalent irradiation, the indication shall remain “off-scale” upon removal from the radiation field. For dose equivalent dosemeters where the dose equivalent rate during integration exceeds the measurable rate, an overload condition shall then be indicated and remain until reset. The measurable rates are those for which the requirements of 9.3 are met; the manufacturer shall state the upper limits of such rates. The dosemeter shall continue to fulfil all requirements of this standard.

9.8.3 Method of test and interpretation of the results

9.8.3.1 General

This test shall be performed using an appropriate source. If for some types of radiation, for example, neutrons or betas, the required high dose rate fields are not available, this shall be

reported. Electrical test methods shall be applied and a theoretical performance analysis shall be performed.

9.8.3.2 Dose equivalent meters

The dosemeter shall be irradiated to a dose equivalent of 10 times the maximum range value, but no more than 10 Sv. The indication of the dosemeter shall remain at the maximum of the range and an overload indication shall be displayed.

9.8.3.3 Dose equivalent rate meters

The dosemeter shall be irradiated, for about 10 min, to a dose equivalent rate of 10 times the maximum range value, but not more than 10 Sv h^{-1}. The indication of the dosemeter shall remain at the maximum of the range and an overload indication shall be displayed.

Upon removal of this “off-scale” dose equivalent rate, the time shall be measured for the indication of the dosemeter to return to an “on-scale” dose equivalent rate and recorded in the type test report. This time shall be less than 10 s.

9.9 Alarm

9.9.1 General

These tests shall be 〚C〛 performed for $H_p(10)$, $\dot{H}$ (10), $H_p(0,07)$ and $\dot{H}$ (0,07) 〚C〛 and for photon, neutron and beta radiation, as appropriate for the dosemeter 〚C〛 *text deleted* 〚C〛. All dose equivalent (rate) values shall be corrected for non-constant response. If for some types of radiation, for example, neutrons or betas, the required high dose rate fields are not available, this shall be reported, and an electrical test method shall be applied.

9.9.2 Response time for dose equivalent rate indication and alarm

9.9.2.1 Requirements

When the dosemeter is subjected to a step or slow increase or decrease in dose equivalent rate of one order of magnitude within the effective range of the dosemeter, the readout shall indicate the new dose equivalent rate with an error of less than –17 % to +25 % of the upper dose equivalent rate value within 10 s after the dosemeter is subjected to the final dose equivalent rate. In case of a step increase or decrease the alarm, if set to one half of the upper dose equivalent rate value, shall respond within 2 s. These requirements shall apply for changes from background dose equivalent rates to upper case dose equivalent rate values, which are greater than 1 mSv h^{-1} for $\dot{H}_p(10)$ from X and gamma radiation and 10 mSv h^{-1} for $\dot{H}_p(0{,}07)$ from X, gamma and beta radiation and 10 mSv h^{-1} for $\dot{H}_p(10)$ from neutron radiation. Alternatively, any delay of more than 2 s in the alarm responding or 10 s in the indication shall not result in the receipt of a dose in excess of 10 µSv for $\dot{H}_p(10)$ from X and gamma radiation and 100 µSv for $\dot{H}_p(0{,}07)$ from X, gamma and beta radiation and 500 µSv for $\dot{H}_p(10)$ from neutron radiation.

9.9.2.2 Method of test and interpretation of the results

For this test the dosemeter shall be placed in the irradiation facility in non-irradiating conditions and allowed to stabilize. The irradiation facility shall then rapidly or slowly be set to irradiating conditions and readings recorded continuously until the dosemeter stabilizes at the new upper dose equivalent rate giving the reading $\dot{G}_{high}$. The change of the indication to 83 % of this high reading $\dot{G}_{high}$ shall take less than 10 s after the dosemeter is subjected to the final dose equivalent rate. In case of a step increase or decrease the alarm, if set to one half

of the dose equivalent rate reading, 0,5 $\dot{G}_{high}$, shall respond within 2 s. Next the irradiation facility shall rapidly or slowly be set to non-irradiating conditions. The dosemeter reading shall be below 25 % of the reading $\dot{G}_{high}$ within 10 s after the dosemeter is subjected to the final dose equivalent rate. In case of a step increase or decrease the alarm, if set to one half of the dose equivalent rate reading, 0,5 $\dot{G}_{high}$, shall stop within 2 s. The dose accrued during the delay in the alarm responding shall be measured. When, in any case where the delay is greater than 2 s, the dose is less than 10 μSv for $\dot{H}_p(10)$ from X and gamma radiation and 100 μSv for $\dot{H}_p(0{,}07)$ from X, gamma and beta radiation and 500 μSv for $\dot{H}_p(10)$ from neutron radiation, the requirements of 9.9.2.1 can be considered to be met. This test shall be performed for one $\dot{G}_{high}$ value for each order of magnitude of the effective range of the dosemeter.

9.9.3 Accuracy of dose equivalent alarm

9.9.3.1 Requirements

When the dosemeter is subjected to a dose of 13 % less than the dose equivalent alarm set point, no alarm shall be given and when the dosemeter is subjected to a dose equivalent of 18 % greater than the dose equivalent alarm set point, the alarm shall be given.

At least two tests shall be carried out, one for an alarm set point near the maximum range of the dosemeter and one near the maximum value of the second least significant order of magnitude of the effective range of measurement.

9.9.3.2 Method of test and interpretation of the results

For this test, the dosemeter shall be placed on the required phantom (see 7.5) and the dose alarm set to H_a. The dosemeter shall be reset and then subjected to a dose equivalent rate of the appropriate reference radiation type such that the alarm will not occur for at least 100 s. The time of exposure of the dosemeter until the alarm occurs is to be measured and the corresponding conventional quantity value of the dose, $H_{a,c}$, shall be calculated. The quotient $H_a/H_{a,c}$ shall be within the range 0,87 (1 – U_{rel}) to 1,18 (1 + U_{rel}), see 9.2 for U_{rel}.

NOTE If this test cannot be performed on the required phantom (see 7.5), for example because the required dose rate cannot be produced, then the test can also be performed free in air if appropriate correction factors are applied.

9.9.4 Accuracy of dose equivalent rate alarm

9.9.4.1 Requirements

Let v_{max} be the maximum permitted coefficient of variation at the dose rate to which the dose equivalent rate alarm is set (see line 3 in Tables 4 to 6). When the dosemeter is subjected from a reference source to a dose equivalent rate of (1 – 2 v_{max}) times the dose equivalent rate alarm set point for 10 min, the alarm shall be active for not more than 5 % of the time. Similarly, at a dose equivalent rate of (1 + 2 v_{max}) times the set alarm level, this alarm shall be active for at least 95 % of the time. This requirement shall not be a second test for the response time, therefore, the dosemeter shall be given sufficient time to achieve a stable condition.

At least two tests shall be carried out, one with the alarm set to near the maximum effective range of measurement and one with the alarm set to near the maximum value of the second least significant order of magnitude of the effective range of measurement.

9.9.4.2 Method of test and interpretation of the results

For this test, the dosemeter shall be placed on the required phantom (see 7.5). The set alarm levels shall be corrected for non-constancy of the dose rate response.

Expose the dosemeter to a reference source for 15 min to a dose equivalent rate ($1 - U_{rel} - 2\ v_{max}$) times the set alarm level. For the last 10 min the alarm shall be active not more than 5 % of this time. For U_{rel} , see 9.2.

Expose the dosemeter for 15 min to the upper dose equivalent rate, ($1 + U_{rel} + 2\ v_{max}$) times the set alarm level. For the last 10 min the the alarm shall be active for at least 95 % of this time. For U_{rel} , see 9.2.

NOTE If there are problems to perform the irradiations of this test on the required phantom (see 7.5), for example because the required high dose rate cannot be produced at a distance where the entire phantom is illuminated, then the test can also be performed free in air at shorter distances if appropriate correction factors are applied.

9.10 Model function

The manufacturer shall state the general form of the model function for the measurement with the dosemeter. The example given in 3.18 or other functions can be used. Any interdependencies between the variables of the model function shall be stated. The actual values of the variables will be determined during the type test according to this standard.

10 Electrical and environmental performance requirements and tests

10.1 General

All influence quantities dealt with in this clause are regarded as of type F, although some of them can be partly also of type S, see 7.3.

10.2 Power supplies

10.2.1 General requirements

Facilities shall be provided for testing the battery under maximum load during use. In addition, an indication shall be provided when the remaining operational life is going to end. At the first time this indication appears, the remaining operational life shall be at least 8 h at dose rates of about 0,1 mSv h^{-1} under normal conditions, including 1 min of alarm operation. Also, provision shall be made for indicating when the battery condition is no longer adequate for the dosemeter to meet the performance requirements of this standard. Batteries may be connected in any desired manner; if required, the correct polarity shall be clearly indicated on the dosemeter by the manufacturer. It is recommended that primary or secondary batteries of physical dimensions as specified in IEC 60086-1 or IEC 60086-2 be used.

After the first appearance of the indication that the operational life is going to end, e.g., “low battery”, this indication shall be permanent until the battery is replaced or re-charged.

It shall not be possible to remove batteries without the use of a special tool.

Below –10 °C, the capacity of most types of batteries strongly decreases with temperature. If the rated range of temperature is extended below –10 °C, this shall be considered.

10.2.2 Specific primary batteries requirements

The manufacturer shall state the makers (manufactures) and types of primary batteries with which the requirements of this standard are met.

a) When power is supplied by primary batteries, the capacity of these shall be such that, after 100 h of continuous operation under standard test conditions the variation of the relative response due to power supply shall not exceed –0,09 to +0,11, other functions remaining within their specifications. The dosemeter shall meet this specification in fields of 0,01 mSv h^{-1} to 0,1 mSv h^{-1}.

b) Immediately after new batteries are fitted, the dosemeter shall be capable of operating for at least 15 min with the alarm sounding and with the visual alarm displayed.

10.2.3 Specific secondary batteries requirements

a) When power is supplied by secondary batteries, the capacity of these shall be such that after at least 24 h of continuous use under standard test conditions, the variation of the relative response due to power supply shall not exceed –0,09 to +0,11, other functions remaining within their specifications. The dosemeter shall meet this specification in fields of 0,01 mSv h^{-1} to 0,1 mSv h^{-1}.

b) Immediately upon re-charge, the dosemeter shall be capable of operating for at least 15 min with the alarm sounding and with the visual alarm displayed.

It shall be possible to fully re-charge the batteries from the main supply within 12 h.

10.2.4 Method of test and interpretation of the results (primary and secondary batteries)

10.2.4.1 General

The evaluation of the remaining battery capacity of the dosemeter can be done either by measuring the actual voltage of the internal batteries or, especially for secondary batteries, by performing charge measurements during use and recharging.

Two test methods are provided. The first method uses batteries and shall be chosen if the remaining battery capacity is determined by performing charge measurements during use and recharging, the second method uses a power supply and may be chosen if the remaining battery capacity is determined by measuring the actual voltage of the internal batteries.

10.2.4.2 Test using batteries

New primary batteries or fully charged secondary batteries of the type indicated by the manufacturer shall be fitted before commencing these tests.

a) Expose the dosemeter to a dose equivalent rate of between 0,01 mSv h^{-1} and 0,1 mSv h^{-1}. Leave the dosemeter working in this field for a period of 100 h for primary batteries or 24 h for secondary batteries and note the reading at the end of the period. The corresponding variation of the relative response shall not exceed −0,09 to +0,11.

b) Set the dosemeter to alarm on its lowest dose equivalent and/or dose equivalent rate setting. Expose the dosemeter to a dose equivalent rate of between 0,01 mSv h^{-1} and 0,1 mSv h^{-1} until the alarm sounds and the visual alarm is displayed, then after 15 min further exposure ensure that the alarm still sounds and the visual alarm is still displayed.

c) Test for general requirement of 8 h operation (see 10.2.1).

   Expose the dosemeter to a source of radiation until the indication that the operational life is going to end, e.g., “low battery”, appears. The dosemeter shall then be set to zero using the appropriate device (for example, a readout system) and further exposed for 7 h 59 min to a dose equivalent rate of about 0,1 mSv h^{-1}. After that time-period, the dose equivalent (rate) alarm is set to operate (either by adjusting the alarm value or the dose rate) and the alarm shall continue to sound for a further minute. Determine from the conventional true dose value and the reading the variation of the relative response due to power supply. It shall not exceed −0,09 to +0,11. Check that the indication that the operational life is going to end, e.g., “low battery”, has been continuously indicated during the 8 h period.

10.2.4.3 Test using power supply

The internal batteries shall be removed and the instrument connected to an external power supply with a suitable series resistor to simulate the battery impedance near the end of its life. The power supply shall be set to the nominal battery voltage U_{nom}. Expose the dosemeter to a dose equivalent rate of between 0,01 mSv h^{-1} and 0,1 mSv h^{-1}. The instrument shall be switched on and allowed to stabilize.

The dosemeter indication G_{nom} shall then be recorded. The supply voltage shall then be reduced until the instrument indicates that the battery voltage is low, for example, "low battery". This voltage $U_{\text{low,1}}$ and the corresponding supply current $I_{\text{low,1}}$ shall be noted together with the instrument indication $G_{\text{low,1}}$. It shall be checked that all other functions are operating correctly. $G_{\text{low,1}}$ shall be between 0,91 G_{nom} and 1,11 G_{nom}, otherwise the test is failed. Then the dosemeter shall be set to alarm on its lowest range and the supply current $I_{\text{low,2}}$ be measured when the alarm sounds and the visual alarm is displayed. The supply voltage shall then be further reduced until the dosemeter indicates for the first time the dose value 0,91 G_{nom} or 1,11 G_{nom} and the corresponding voltage $U_{\text{low,2}}$ shall be noted.

Change the voltage to a value slightly larger than $U_{\text{low,1}}$ but much lower than the nominal voltage. Check that the indication “operational life is going to end” has been permanently indicated during the whole test.

The test is passed if the following requirements are met:

– $0{,}91 \le \dfrac{G_{\text{low,1}}}{G_{\text{nom}}} \le 1{,}11$ and all other functions are operating correctly,

– $\dfrac{Q_{\text{nom}}}{I_{\text{low,1}}} \ge t_{\text{min}}$,

– $\dfrac{Q_{\text{nom}}}{I_{\text{low,2}}} \ge 15\ \text{min}$,

– $$\frac{(479\ \text{min} \times I_{\text{low,1}} + 1\ \text{min} \times I_{\text{low,2}}) / (U_{\text{low,1}} - U_{\text{low,2}})}{Q_{\text{nom}} / (U_{\text{nom}} - U_{\text{low,1}})} \ge \frac{8\ \text{h}}{t_{\text{min}}}$$

Q_{nom} is the nominal capacity of the batteries (given for example, in mA h) for the appropriate discharge conditions and considering the rated range of temperature (see 10.2.1); t_{min} is the minimal time required for continuous operation, 100 h for primary batteries and 24 h for secondary batteries.

This calculation assumes that near the end of its life the battery voltage decreases linearly with remaining capacity. If this is not true under operational conditions the test should be carried out using batteries as described in 10.2.4.2.

10.3 Ambient temperature

10.3.1 Requirements

This test shall be performed separately for all different detectors, this may require different types of radiation.

a) Stable temperature

   Over the rated range of temperature, the variation of the relative response due to stable temperature shall not exceed –0,13 to +0,18. The minimum rated ranges of temperature are +5 °C to +40 °C for indoor use and –10 °C to +40 °C for outdoor use.

b) Temperature shock

The variation of the relative response due to temperature shock shall not exceed –0,13 to +0,18 in the rated range of temperatures. Each temperature shock shall be performed in less than 5 min.

c) Low temperature start-up

The instrument shall be capable of starting operation at the lowest temperature of the rated range.

10.3.2 Method of test and interpretation of the results

For this test, the dosemeter shall be exposed to a reference source providing a sufficient indication under standard tests conditions for the test to be carried out.

a) Stable temperature

The temperature shall be maintained at each of the extreme values of the rated range for at least 4 h, and the indication of the dosemeter measured during the last 30 min of this period. The variation of the relative response shall be less than –0,13 to +0,18.

b) Temperature shock

The dosemeter and the source shall be placed in a temperature of 20 °C ± 5 °C (room temperature) and allowed to stabilize for a minimum of 60 min. Then the response shall be measured.

The dosemeter and the source shall be removed from this environment and placed directly into an environmental chamber such that the same exposure geometry is established and the temperature near the dosemeter is maintained at the maximum value of the rated range. This procedure shall be performed in less than 5 min. The response shall be measured immediately and then every 15 min for 2 h. If the dosemeter does not fail the test within the first hour, data does not need to be taken during the second hour. However, the dosemeter shall remain in this environment during the period required to reach temperature stabilization.

The dosemeter and source shall be removed from the environmental chamber and returned to the first environment such that the same exposure geometry is established and the temperature near the dosemeter is 20 °C ± 5 °C (room temperature). This procedure shall be performed in less than 5 min. The response shall be measured immediately and then every 15 min for 2 h. If the dosemeter does not fail the test within the first hour, data does not need to be taken during the second hour. However, the dosemeter shall remain in this environment during the period required to reach temperature stabilization.

The test shall be repeated with the temperature inside the environmental chamber near the dosemeter maintained at the minimum value of the rated range.

The variation of the relative response shall not exceed –0,13 to +0,18.

c) Low temperature start-up test

The dosemeter with the batteries fitted shall be placed for at least 4 h inside the environmental chamber with the temperature at the minimum value of the rated range. Then the dosemeter shall be switched on and shall operate as normally.

10.4 Relative humidity

10.4.1 Requirements

This test shall be performed separately for all different detectors, this may require different types of radiation, as appropriate for the dosemeter category, see Annex C.

The variation of the relative response due to humidity shall not exceed –0,09 to +0,11 in the rated range of use. The minimum range of use of relative humidity is from 40 % to 90 %.

10.4.2 Method of test and interpretation of the results

For this test, the dosemeter shall be exposed to a suitable source in contact with the dosemeter (the test is performed first for photon radiation and then for other radiation) and providing a sufficient indication. The test shall be carried out at a single temperature of +35 °C using an environmental chamber. Therefore, the reference response for this test shall be determined at +35 °C and not at +20 °C.

The humidity shall be maintained at 65 % and at each of its extreme values for at least 24 h and the indication of the dosemeter noted during the last 30 min of this period. The permitted variation of the relative response (calculated using response at 65 % relative humidity at +35 °C as reference) of –0,09 to +0,11 as specified in Table 7 is additional to the permitted variation of the relative response due to temperature alone.

10.5 Atmospheric pressure

The influence of atmospheric pressure is, in general, only significant for an unsealed detector using air as the detecting medium. In this case, the atmospheric pressure at which all tests are performed shall be stated, and the variation of the relative response due to atmospheric pressure within the range of 86,0 kPa to 106,6 kPa shall not exceed –0,09 to +0,11.

Representative tests at other values of atmospheric pressure shall be performed if required.

A test of this influence quantity is only required if the manufacturer cannot prove that the instrument is insensitive to atmospheric pressure.

10.6 Sealing

The manufacturer shall state the precautions that have been taken to prevent the ingress of moisture and describe the tests and results used to demonstrate the effectiveness of the sealing. The IP classification according to IEC 60529 shall be stated by the manufacturer, at least IP 53 shall be fulfilled.

10.7 Storage

All dosemeters for use in temperate regions shall be designed to operate within the specification of this standard following storage or transport (which may be without batteries) for a period of at least three months in the manufacturer's packaging and at any temperature between –25 °C and +50 °C. In certain circumstances, more severe specifications may be required such as capability of withstanding air transport at low ambient pressure.

11 Electromagnetic performance requirements and tests

11.1 General

Electromagnetic disturbances are regarded as influence quantities of type S. Special precautions shall be taken in the design of a dosemeter to ensure proper operation in the presence of electromagnetic disturbances, particularly radio-frequency fields (see IEC 61000-4-3). If no other specifications are given, all tests shall be performed with the dosemeter and the associated readout systems.

The duration of the electromagnetic disturbance shall be such that it is equivalent to 1 h of operation according to the frequency data given in Table 8.

The test shall be done in accordance with the standards of the IEC 61000-4 series as given in Table 8. For all tests, the minimum rated ranges are taken from IEC 61000-6-2 and given in Table 8 together with the frequency of the disturbance, the respective maximum value of the deviation and the performance criteria, A, B or C, according to IEC 61000-6-2. Only the criteria A or B are permitted. If criterion B is permitted then the requirements given in Table 8

apply to the values of the personal dose equivalents indicated before and after the test. Before each test, the dosemeter indication shall be reset to zero.

NOTE 1 If the duration of the electromagnetic disturbance is different from the equivalent to 1 h operation, the effect of the electromagnetic disturbance shall be calculated for 1 h operation.

NOTE 2 For specific applications the electromagnetic performance requirements can be reduced, if the workplace environment ensures proper operation. For example, if dosemeters are only used in a reactor area, where mobile phones are prohibited, the requirements of 11.3 may be restricted to frequencies below 1 GHz. In such cases, special agreements between customer and supplier are necessary together with a warning in the documentation.

11.2 Electrostatic discharge

11.2.1 Requirements

The deviation due to electrostatic discharge shall not exceed 0,7 H_0 after 10 discharges (see Table 8).

11.2.2 Test method and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test with the dosemeter set to the most sensitive range.

The discharging shall be done using a suitable test generator as described in IEC 61000-4-2 at least five times to those various external parts of the dosemeter which may be touched by the operator during a normal measurement, when the dosemeter is on and, if the ranges are selectable, set to its most sensitive range. The electrostatic discharge shall be performed as described in IEC 61000-4-2 with a voltage of 4 kV. When dosemeters with insulated surfaces are tested, the air discharge method with a voltage of 8 kV shall be used.

11.3 Radiated electromagnetic fields

11.3.1 Requirements

The deviation due to electromagnetic fields shall not exceed 0,7 H_0 after 6 min (10 % of 1 h) of exposure to the electromagnetic field (see Notes to 11.1 and Table 8).

11.3.2 Test method and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display with the dosemeter set to the most sensitive range.

The electromagnetic field strength shall be 30 V/m in the frequency range of 80 MHz to 2,7 GHz in steps of 1 % (see IEC 61000-4-3).

To reduce the amount of measurements needed to show compliance with the above requirement the following method is suggested:

Perform tests at radiation frequencies 80, 90, 100, 110, 120, 130, 140, 150, 160, 180, 200, 220, 240, 260, 290, 320, 350, 380, 420, 460, 510, 560, 620, 680, 750, 820, 900, 1 000 MHz, 1,4; 1,5; 1,6; 1,8; 2,0; 2,2; 2,4, 2,7 GHz with a field strength of 60 Vm^{-1} in one orientation only. At each frequency, the test shall be performed for 6 min or the result corrected for a 6 min measuring time. If any deviation greater than one-third of the limits given in Table 8 is observed at one of these given radiation frequencies, additional tests in the range of ±5 % around this frequency in steps of 1 % and with a field strength of 30 Vm^{-1} shall be carried out with the dosemeter oriented as described in IEC 61000-4-3.

11.4 Conducted disturbances induced by fast transients or bursts

11.4.1 Requirements

This requirement shall apply only for associated readout systems supplied from the mains. The deviation due to conducted disturbances induced by fast transients or bursts shall not exceed 0,7 H_0 after 10 fast transients or bursts (see Table 8).

11.4.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test with the dosemeter set to the most sensitive range.

Fast transients or bursts shall be applied to the mains supply terminals via a coupling/ decoupling network, or equivalent equipment. The repetition rate shall not exceed once per minute. The tests shall be performed as described in IEC 61000-4-4 with a peak voltage of ±2 kV.

11.5 Conducted disturbances induced by surges

11.5.1 Requirements

This requirement shall apply only for associated readout systems supplied from the mains. The deviation due to conducted disturbances induced by surges shall not exceed 0,7 H_0 after 10 surges (see Table 8).

11.5.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test with the dosemeter set to the most sensitive range.

Pulses shall be applied to the mains supply terminals via a coupling/decoupling network, or equivalent equipment. The repetition rate shall not exceed once per minute. The tests shall be performed as described in IEC 61000-4-5 with a voltage of ±2 kV or ±1 kV as given in Table 8.

11.6 Conducted disturbances induced by radio-frequencies

11.6.1 Requirements

This requirement shall apply only for dosemeters that have at least one conducting cable (for example, signal line) and for associated readout systems supplied from the mains. The deviation due to conducted disturbances induced by radio-frequencies shall not exceed 0,7 H_0 after 6 min (10 % of 1 h) of exposure to the electromagnetic field (see Notes to 11.1 and Table 8).

11.6.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test with the dosemeter set to the most sensitive range.

The disturbances shall be induced according to IEC 61000-4-6 and the voltage shall be 10 V in the frequency range of 150 kHz to 80 MHz in steps of 1 %, see Table 8.

To reduce the amount of measurements needed to show compliance with the above requirement, methods similar to those given in 11.3 and 11.4 may be used.

11.7 50 Hz/60 Hz magnetic field

11.7.1 Requirements

The deviation due to 50 Hz (or 60 Hz as appropriate) magnetic field shall not exceed 0,7 H_0 after 6 min (10 % of 1 h) of exposure to the magnetic field (see Notes to 11.1 and Table 8).

11.7.2 Method of test and interpretation of the results

Compliance shall be checked by observing and recording the indications of the display while measurements are performed with the dosemeter set to the most sensitive range.

The dosemeter shall be exposed to a continuous fields of 30 A m^{-1} at a frequency of 50 Hz (or 60 Hz as appropriate) The dose equivalent(rate) meter shall be exposed in a minimum of two orientations (0° and 90°) relative to the field lines.

11.8 Voltage dips and short interruptions

11.8.1 Requirements

This requirement is valid only for associated readout systems supplied from the mains. The deviation due to voltage dips and short interruptions shall not exceed 0,7 H_0 after 10 voltage dips and short interruptions (see Table 8).

11.8.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test with the dosemeter set to the most sensitive range.

The tests shall be performed as described in IEC 61000-4-11 with a 30 % reduction for 10 ms and a 60 % reduction for 100 ms as given in Table 8.

12 Mechanical performance, requirements and tests

12.1 General

Mechanical disturbance are regarded as influence quantities of type S.

After all mechanical disturbances, the dosemeter shall be working properly.

12.2 Drop test

12.2.1 Requirements

The deviation due to 6 drops from heights of 1,0 m onto a concrete surface (IEC 60068-2-31) shall not exceed 0,7 H_0 (see Table 9). These tests shall be made on each face of the dosemeter. The stored dose information shall not be lost by these drops. The physical condition of dosemeters shall not be affected by these drops (for example, solder joints shall hold, nuts and bolts shall not come loose).

12.2.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test.

The dosemeter shall be subjected to drop tests on each of the 6 faces of the dosemeter.

After the test, the dosemeter shall be inspected, the physical condition documented and it shall be working properly.

12.3 Vibration test

12.3.1 Requirements

The deviation due to vibration shall not exceed 0,7 H_0 (see Table 9) for harmonic loadings of 20 m s^{-2} applied for 15 min in the frequency range of 10 Hz to 33 Hz. The stored dose information shall not be lost by the vibration. The physical condition of dosemeters shall not be affected by this vibration (for example, solder joints shall hold, nuts and bolts shall not come loose).

12.3.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test.

The dosemeter shall be subjected to harmonic loadings of 20 m s^{-2} for 15 min in each of three orthogonal directions at one frequency in each of the following ranges: 10 Hz to 21 Hz and 22 Hz to 33 Hz. After each 15 min vibration interval, the dosemeter reading shall be determined.

After the test, the dosemeter shall be inspected and the physical condition documented and it shall be working properly.

12.4 Microphonics test

12.4.1 Requirements

The deviation due to microphonics shall not exceed 0,7 H_0 (see Table 9), if the dosemeter is subjected to 60 repeated shocks, each shock corresponding to a drop from a height of 10 cm, on to a hard steel surface. The stored dose information shall not be lost by the drops. The physical condition of dosemeters shall not be affected by these drops (for example, solder joints shall hold, nuts and bolts shall not come loose).

12.4.2 Method of test and interpretation of the results

Compliance with this performance requirement shall be checked by observing and recording the indications of the display before and after the test.

The dosemeter shall be dropped 60 times on a hard steel surface (IEC 60068-2-31), from a height of 10 cm, so that 10 shocks occur on each of the six main faces.

After the test, the dosemeter shall be inspected and the physical condition documented.

13 Uncertainty

The uncertainty of a dose value measured with a dosemeter in compliance with this standard can be calculated without further test measurements, see IEC/TR 62461. The uncertainty depends on the workplace conditions and the knowledge about them. The largest uncertainty is obtained if the only knowledge of the workplace conditions is that they are within the rated ranges of all influence quantities. A further necessary assumption is, that the calibration conditions (for example, on the ISO water slab phantom) are representative for the conditions of use. In that case, the model function given by the manufacturer (see 9.10) together with the obtained values for the variation of the relative response and the deviations will directly lead to the uncertainty.

All uncertainty calculations shall be performed according to the *Guide to the Expression of Uncertainty in Measurement* (ISO/IEC Guide 98-3) and IEC/TR 62461.

NOTE If there is some knowledge of the workplace conditions, this knowledge can then be used to determine actual values of the responses and to correct the indicated dose value. This will reduce the uncertainty of the dose value.

14 Documentation

14.1 Type test report

At the request of the customer, the manufacturer shall provide the report on the type tests performed to the requirements of this standard.

14.2 Certificate

A certificate shall be provided with each dosemeter with at least the following information in accordance with IEC 61187:

– manufacturer's name or registered trade mark; type of dosemeter and serial number;
– statement that this equipment is tested in accordance with this standard and that the requirements are fulfilled;
– detector type or types;
– measurement quantity;
– types of radiation the dosemeter is intended to measure;
– effective dose range of measurement;
– reference point of the dosemeter and the calibration direction for calibration purposes and reference orientation relative to radiation sources and reference orientation with respect to the wearer;
– location and dimensions of the sensitive volumes of the detectors;
– specified reference conditions for determining the reference calibration factor and its reciprocal, the reference response;
– rated ranges of use for all influence quantities (for example, radiation energy and angle of incidence, temperature) together with the corresponding results of the type test (for example, response as a function of radiation energy and angle of incidence for all types of radiation intended to be measured);
– maximum possible measuring time, t_{max} (see 9.4.2);
– indication due to zero effect and natural environmental radiation and the method to determine it (see 6.9 and 9.3.2);
– maximum dose rate for dose measurements, if lower than 1 Sv h^{-1} this should also be indicated in the dosemeter (see 9.3.2);
– mass and dimensions of dosemeter;
– power supply requirements;
– model function for the measured value of the dosemeter, see 9.10;
– the usage category according to Annex C may be indicated.

15 Operation and maintenance manual

An operation and maintenance manual containing at least the following information shall be supplied:

– schematic electrical diagrams including spare parts list;
– operational details, maintenance and calibration procedures;

– method of retention of stored dose information.

Table 2 – Values of c_1 and c_2 for w different dose values and n indications for each dose value

w	Value of c_1 for n equal							Value of c_2 for n equal						
	4	7	10	15	20	25	∞	4	7	10	15	20	25	∞
5	1,000	1,007	1,009	1,009	1,009	1,009	1	1,499	1,400	1,344	1,290	1,255	1,231	1
6	1,058	1,051	1,046	1,039	1,035	1,032	1	1,572	1,454	1,389	1,326	1,287	1,261	1
8	1,147	1,117	1,100	1,084	1,074	1,067	1	1,687	1,536	1,458	1,383	1,336	1,304	1
10	1,215	1,166	1,141	1,117	1,102	1,092	1	1,772	1,597	1,508	1,423	1,372	1,335	1
12	1,269	1,205	1,173	1,143	1,124	1,112	1	1,840	1,645	1,548	1,455	1,399	1,360	1
14	1,315	1,238	1,200	1,164	1,142	1,128	1	1,895	1,684	1,578	1,480	1,421	1,379	1
16	1,351	1,265	1,222	1,182	1,158	1,142	1	1,940	1,716	1,605	1,502	1,440	1,396	1
18	1,388	1,289	1,242	1,211	1,171	1,153	1	1,980	1,743	1,628	1,409	1,453	1,409	1
20	1,418	1,311	1,259	1,233	1,183	1,164	1	2,015	1,767	1,646	1,394	1,466	1,421	1
25	1,483	1,355	1,295	1,240	1,210	1,186	1	2,081	1,812	1,683	1,563	1,445	1,444	1
50	1,683	1,494	1,407	1,328	1,283	1,252	1	2,275	1,945	1,789	1,646	1,561	1,504	1

Table 3 – Reference conditions and standard test conditions

Influence quantity	Reference conditions (unless otherwise indicated by the manufacturer)	Standard test conditions (unless otherwise indicated by the manufacturer)
Photon radiation energy for:		
$H_p(10)$	S-Cs or S-Co (ISO 4037-3)	S-Cs or S-Co (ISO 4037-3)
$H_p(0,07)$	N-80 or S-Am (ISO 4037-3)	N-80 or S-Am (ISO 4037-3)
Beta radiation energy, $H_p(0,07)$	$^{90}Sr/^{90}Y$	$^{90}Sr/^{90}Y$
Neutron radiation energy, $H_p(10)$	^{241}Am-Be or ^{252}Cf a)	^{241}Am-Be or ^{252}Cf a)
Angle of incidence of radiation	Reference direction given by the manufacturer	Direction given ±5°
Dose for:		
$H_p(10)$	0,3 mSv	0,1 mSv to 10 mSv b)
$H_p(0,07)$	3 mSv	0,5 mSv to 50 mSv b)
Dose rate for:		
$H_p(10)$	0,3 mSv h^{-1}	0,1 mSv h^{-1} to 10 mSv h^{-1} b)
$H_p(0,07)$	3 mSv h^{-1}	0,5 mSv h^{-1} to 50 mSv h^{-1} b)
Stabilization time	15 min	≥15 min
Ambient temperature	20 °C	18 °C to 22 °C c)
Relative humidity	65 %	50 % to 75 % c)
Atmospheric pressure	101,3 kPa	86,0 kPa to 106,6 kPa c)
Battery voltage	Nominal voltage	Battery used up to half of its useful life
Electromagnetic field of external origin	Negligible	Less than the lowest value that causes interference
Magnetic induction of external origin	Negligible	Less than twice the induction due to the earth's magnetic field
Orientation of dosemeter (geotropism)	To be stated by the manufacturer	Stated orientation ±5°
Dosemeter controls	Set up for normal operation	Set up for normal operation
Natural radiation background	Ambient dose equivalent rate of 2 μSv d^{-1}	Less than ambient dose equivalent rate of 0,25 μSv h^{-1}
Contamination by radioactive elements	Negligible	Negligible

a) Other sources may be used if necessary.

b) The actual value of the dose (rate) at the time of test shall be stated.

c) The actual values of these quantities at the time of test shall be stated. These values are applicable for temperate climates. In hotter or colder climates, the actual values of the quantities at the time of test shall be stated. Similarly, a lower limit of pressure of 70 kPa may be permitted at high altitudes.

Table 4 – Radiation characteristics of $H_p(0,07)$ dosemeters for X, gamma and beta radiation

Line	Characteristic under test or influence quantity	Minimum rated range of influence quantity	Limit of variation of instrument parameter or relative response for whole rated range	Sub-clause
1	Variation of the relative response due to dose and dose rate	1 mSv to 10 Sv and 5 μSv h^{-1} to 1 Sv h^{-1} a) for personal dose equivalent	–17 % to +25 % b) dose equivalent meter	9.3
2	Statistical fluctuation, v: dose equivalent $H_p(0,07)$ for X, gamma and beta radiation	$H_0 \le H < 11\ H_0$ $H \ge 11\ H_0$	$(16 - H/(H_0))$ % 5 %	9.3
3	Statistical fluctuation, v: dose equivalent rate $\dot{H}_p(0,07)$ for X, gamma and beta radiation	$\dot{H}$ < 100 μSv h^{-1} 100 μSv $h^{-1} \le \dot{H}$ < 600 μSv h^{-1} $\dot{H} \ge$ 600 μSv h^{-1}	20 % $(21 - \dot{H}/(100\ \mu Sv\ h^{-1}))$ % 15 %	9.3
4	X and gamma radiation energy and angle of incidence	20 keV to 150 keV and 0° to 60° from reference direction	–29 % to +67 % c) E < 50 keV: –33 % to +100 % c)	9.4.1
5	Mean beta radiation energy and angle of incidence	0,2 MeV to 0,8 MeV and 0° to 60° from reference direction	–29 % to +67 % c)	9.6.1
6	Mean beta radiation energy and angle of incidence	0,06 MeV (^{147}Pm) and 0° to 60° from reference direction	To be stated by the manufacturer	9.6.1
7	As in line 4 to 6 but new reference direction opposite to that one used	See line 4 to 6, if no statement concerning wrong orientation is given by the manufacturer	See line 4 to 6, if no statement concerning wrong orientation is given by the manufacturer	7.7
8	Overload	10 times maximum range, but for dose rate not more than 10 Sv h^{-1}	Indication to be off-scale on the high side or dose equivalent(rate) meter to indicate overload (for 10 min)	9.8
9	Response time for dose equivalent rate indication and alarm functions	$\dot{H}_p(0,07) \ge$ 10 mSv h^{-1}	–17 % to +25 % for the indication and any delay of more than 2 s in the alarm responding shall not result in the receipt of a dose in excess of 100 μSv	9.9.2
10	Accuracy of alarm set to H_a or $\dot{H}_a$	$H_a \ge$ maximum value of the second least significant order of magnitude $\dot{H}_a \ge$ maximum value of the second least significant order of magnitude	$0,87\ (1 - U_{rel}) \le H_a / H_{a,c} \le 1,18\ (1 + U_{rel})$ d) $\dot{H} \le (1 - 2\ v_{max})\ \dot{H}_a$: Alarm active not more than 5 % of time $\dot{H} \ge (1 + 2\ v_{max})\ \dot{H}_a$: Alarm active for at least 95 % of time	9.9.3
11	Effects of radiation not intended to be measured	—	Response to be stated by the manufacturer	6.8

a) Minimum dose rate value as low as reasonably achievable. If the maximum dose rate specified by the manufacturer for dose measurements is less than 1 Sv h^{-1}, this should be indicated on the dosemeter.

b) This variation of the relative response is additional to the uncertainty in the determination of the ratio of the actual value and the reference value of the conventional quantity value of the dose equivalent (rate).

c) This variation of the relative response is additional to the uncertainty in the determination of the conventional quantity value of the dose equivalent (rate).

d) $H_{a,c}$ is the conventional quantity value of the dose at which the alarm occurs.

Table 5 – Radiation characteristics of $H_p(10)$ dosemeters for X and gamma radiation

Line	Characteristic under test or influence quantity	Minimum rated range of influence quantity	Limit of variation of instrument parameter or relative response for whole rated range	Sub-clause
1	Variation of the response due to dose and dose rate	100 µSv to 1 Sv and 0,5 µSv h^{-1} to 1 Sv h^{-1} a) for personal dose equivalent	–17 % to +25 % b) dose equivalent meter	9.3
2	Statistical fluctuation, v: dose equivalent $H_p(10)$	$H_0 \leq H < 11\ H_0$ $H \geq 11\ H_0$	$(16 - H / (H_0))$ % 5 %	9.3
3	Statistical fluctuation, v: dose equivalent rate $\dot{H}_p(10)$	$\dot{H}$ < 10 µSv h^{-1} 10 µSv $h^{-1} \leq \dot{H}$ < 60 µSv h^{-1} $\dot{H} \geq$ 60 µSv h^{-1}	20 % $(21 - \dot{H} / (10$ µSv $h^{-1}))$ % 15 %	9.3
4	Radiation energy and angle of incidence	80 keV to 1,5 MeV or 20 keV to 150 keV and 0° to 60° from reference direction under consideration	–29 % to +67 % c)	9.4.2
5	As in line 4 and 5 but new reference direction opposite to that one used	See line 4 and 5, if no statement concerning wrong orientation is given by the manufacturer	See line 4 and 5, if no statement concerning wrong orientation is given by the manufacturer	7.7
6	Overload	10 times maximum range, but for dose rate not more than 10 Sv h^{-1}	Indication to be off-scale on the high side or dose equivalent(rate) meter to indicate overload (for 10 min)	9.8
7	Response time for dose equivalent rate indication and alarm functions	$\dot{H}_p(10) \geq$ 1 mSv h^{-1} and 10 s maximum waiting time	–17 % to +25 % for the indication and any delay of more than 2 s in the alarm responding shall not result in the receipt of a dose in excess of 10 µSv	9.9.2
8	Accuracy of alarm set to H_a or $\dot{H}_a$	$H_a \geq$ maximum value of the second least significant order of magnitude $\dot{H}_a \geq$ maximum value of the second least significant order of magnitude	$0{,}87\ (1 - U_{rel}) \leq H_a / H_{a,c} \leq 1{,}18\ (1 + U_{rel})$ d) $\dot{H} \leq (1 - 2\ v_{max})\ \dot{H}_a$: Alarm active not more than 5 % of time $\dot{H} \geq (1 + 2\ v_{max})\ \dot{H}_a$: Alarm active for at least 95 % of time	9.9.3
9	Effects of radiation not intended to be measured	—	Response to be stated by the manufacturer	6.8
10	Response due to natural background radiation	—	Deviation of the indication during t_{max} from the natural background less than H_0	9.3.5

a) Minimum dose rate value as low as reasonably achievable. If the maximum dose rate specified by the manufacturer for dose measurements is less than 1 Sv h^{-1}, this should be indicated on the dosemeter.

b) This variation of the relative response is additional to the uncertainty in the determination of the ratio of the actual value and the reference value of the conventional quantity value of the dose equivalent (rate).

c) This variation of the relative response is additional to the uncertainty in the determination of the conventional quantity value of the dose equivalent (rate).

d) $H_{a,c}$ is the conventional quantity value of the dose at which the alarm occurs.

Table 6 – Radiation characteristics of $H_p(10)$ dosemeters for neutron radiation

Line	Characteristic under test or influence quantity	Minimum rated range of influence quantity	Limit of variation of instrument parameter or relative response for whole rated range	Sub-clause
1	Variation of the response due to dose and dose rate	100 µSv to 1 Sv and 5 µSv h^{-1} to 1 Sv h^{-1} a) for personal dose equivalent	–17 % to +25 % b) dose equivalent meter	9.3
2	Statistical fluctuation, v: dose equivalent	$H_0 \leq H < 51\ H_0$ $H \geq 51\ H_0$	$(25{,}4 - H / (2{,}5\ H_0))$ % 5 %	9.3
3	Statistical fluctuation, v: dose equivalent rate for alarm functions	$\dot{H}$ < 1 mSv h^{-1} 1 mSv $h^{-1} \leq \dot{H}$ < 6 mSv h^{-1} $\dot{H} \geq 6$ mSv h^{-1}	20 % $(21 - \dot{H} / (100\ \mu Sv\ h^{-1}))$ % 15 %	9.3
4	Radiation energy and angle of incidence	0,025 eV to 100 keV plus 100 keV to 5 MeV Range extension: 5 MeV to 10 MeV above 10 MeV and 0° to 60° from reference direction under consideration	–35 % to +300 % c) d) –35 % to +122 % c) d) –35 % to +122 % c) d) –35 % to +300 % c) d)	9.5.1
5	As in line 4 and 5 but new reference direction opposite to that one used	See line 4 and 5, if no statement concerning wrong orientation is given by the manufacturer	See line 4 and 5, if no statement concerning wrong orientation is given by the manufacturer	7.7
6	Overload	10 times maximum range, but for dose rate, not more than 10 Sv h^{-1}	Indication to be off-scale on the high side or dose equivalent(rate) meter to indicate overload (for 10 min)	9.8
7	Response time for dose equivalent rate indication and alarm functions	$\dot{H}_p(10) \geq 10$ mSv h^{-1}	–17 % to +25 % for the indication and any delay of more than 2 s in the alarm responding shall not result in the receipt of a dose in excess of 500 µSv	9.9.2
8	Accuracy of alarm set to H_a or $\dot{H}_a$	$H_a \geq$ maximum value of the second least significant order of magnitude $\dot{H}_a \geq$ maximum value of the second least significant order of magnitude	$0{,}87\ (1 - U_{rel}) \leq H_a / H_{a,c} \leq 1{,}18\ (1 + U_{rel})$ e) $\dot{H} \leq (1 - 2\ v_{max})\ \dot{H}_a$: Alarm active not more than 5 % of time $\dot{H} \geq (1 + 2\ v_{max})\ \dot{H}_a$: Alarm active for at least 95 % of time	9.9.3
9	Effects of radiation not intended to be measured	—	Response to be stated by the manufacturer	6.8

a) Minimum dose rate value as low as reasonably achievable. If the maximum dose rate specified by the manufacturer for dose measurements is less than 1 Sv h^{-1}, this should be indicated on the dosemeter.

b) This variation of the relative response is additional to the uncertainty in the determination of the ratio of the actual value and the reference value of the conventional quantity value of the dose equivalent (rate).

c) This variation of the relative response is additional to the uncertainty in the determination of the conventional quantity value of the dose equivalent(rate).

d) Some alleviations are admitted to use simulated workplace field, see 9.5.1.

e) $H_{a,c}$ is the conventional quantity value of the dose at which the alarm occurs.

Table 7 – Electrical and environmental characteristics of dosemeters

Line	Characteristic under test or influence quantity	Minimum rated range of influence quantity	Limit of variation of instrument parameter or relative response for whole rated range	Sub-clause
1	Power supplies	100 h continuous use for primary batteries [a] or 24 h continuous use for secondary batteries [a]	–9 % to +11 %	10.2
2	Ambient temperature	a) Indoor use +5 °C to +40 °C b) Outdoor use –10 °C to +40 °C	–13 % to + 18 % [b]	10.3
3	Relative humidity	40 % to 90 % relative humidity at 35 °C	–9 % to +11 % [c]	10.4
4	Atmospheric pressure	86,0 kPa to 106,6 kPa [d]	–9 % to +11 %	10.5
5	Sealing	IP classification IP-53	IP classification to be stated	10.6
6	Storage	–25 °C to +50 °C for three months	To operate within specification	10.7

[a] Additional 8 h measurement after the instrument indicates that the battery voltage is low, for example, "low battery".

[b] The display of the dosemeter may be frozen, read out at room temperature shall be possible.

[c] The reference response for this test (at 65 % relative humidity) shall be determined at +35 °C and not at +20 °C.

[d] A lower limit of pressure of 70 kPa may be required at high altitudes.

Table 8 – Electromagnetic disturbance characteristics of dosemeters

Line	Influence quantity or instrument parameter	Minimum rated range of influence quantity	Test according to	Frequency	Maximum permitted value for deviation, D_p, for whole rated range [a]	Criterion [b]	Subclause
1	Electrostatic discharge, charging voltage	0 kV to ±8 kV air discharge 0 kV to ±4 kV contact discharge	IEC 61000-4-2	10 disturbances per hour	0,7 H_0	B	11.2
2	Radiated electromagnetic fields, field strength and modulation	80 MHz to 2,7 GHz 0 V/m to 30 V/m (r.m.s., unmodulated) 80 % AM (1 kHz)	IEC 61000-4-3	10 % of time	0,7 H_0	A	11.3
3	Conducted disturbances induced by fast transients/burst, peak voltage	0 kV to ±2 kV 5/50 ns (t_r/t_h)	IEC 61000-4-4	10 disturbances per hour	0,7 H_0	B	11.4
4	Conducted disturbances induced by surges, peak voltage and rise time	0 kV to ±2 kV non-sym. 0 kV to ±1 kV sym. 1,2/50 (8/20) µs (t_r/t_h)	IEC 61000-4-5	10 disturbances per hour	0,7 H_0	B	11.5
5	Conducted disturbances induced by radio-frequencies, frequency and voltage	150 kHz to 80 MHz 0 V to 10 V (r.m.s., unmodulated) 80 % AM (1 kHz)	IEC 61000-4-6	10 % of time	0,7 H_0	A	11.6
6	50 Hz (or 60 Hz as appropriate) magnetic field, field strength	0 A m^{-1} to 30 A m^{-1}	IEC 61000-4-8	10 % of time	0,7 H_0	A	11.7
7	Voltage dips/short interruptions, duration	10 ms (30 % reduction) 100 ms (60 % reduction)	IEC 61000-4-11	10 disturbances per hour	0,7 H_0	B	11.8

[a] H_0 is the lower limit of the effective range of measurement.

[b] See IEC 61000-6-2.

Table 9 – Mechanical disturbances characteristics of dosemeters

Line	Influence quantity or instrument parameter	Minimum rated range of influence quantity	Maximum permitted value for deviation, D_p, for whole rated range [a]	Subclause
1	Drop on surface	1,0 m onto concrete surface (IEC 60068-2-31)	0,7 H_0	12.2
2	Vibration	20 m s^{-2} over frequencies 10 Hz to 33 Hz	0,7 H_0	12.3
3	Microphonics	60 times 0,1 m onto steel surface (IEC 60068-2-31)	0,7 H_0	12.4

[a] H_0 is the lower limit of the effective range of measurement.

Annex A
(normative)

Statistical fluctuations

For any test involving the use of radiation, the magnitude of the statistical fluctuations of the reading arising from the random nature of radiation alone may be a significant fraction of the variation of the mean reading permitted in the test. A sufficient number of readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to demonstrate compliance or non-compliance with the test requirement. Table A.1 provides guidance on the number of monitor readings required to determine true differences between two sets of monitor readings at the 95 % confidence level. Listed are the percentage difference between the means, the coefficient of variation of the sets of readings (assumed to be equal for each set), and the number of monitor readings required.

Whenever possible during testing, dose equivalent rates shall be used such that the effect of the statistical fluctuation of the monitor readings is minimized. It may be necessary to take monitor readings mid-scale on the second or third most sensitive scale or in the middle of the second or third most sensitive order of magnitude of the effective range of measurement in order to accomplish this.

The interval between monitor readings shall be large enough to ensure that the readings are statistically independent. The manufacturer shall provide the necessary information.

Table A.1 – Number of instrument readings required to detect true differences (95 % confidence level) between two sets of instrument readings on the same instrument[2]

Percentage difference between true value and obtained values	Coefficient of variation specified by manufacturer %	Number of readings required to get percentage difference
5	0,5	1
5	1,0	1
5	2,0	4
5	3,0	9
5	4,0	16
5	5,0	25
5	7,5	56
5	10,0	99
5	12,5	154
5	15,0	223
5	20,0	396
10	0,5	1
10	1,0	1
10	2,0	1
10	3,0	3
10	4,0	4
10	5,0	6
10	7,5	14
10	10,0	24
10	12,5	37
10	15,0	53
10	20,0	94
15	0,5	1
15	1,0	1
15	2,0	1
15	3,0	1
15	4,0	2
15	5,0	3
15	7,5	6
15	10,0	10
15	12,5	16
15	15,0	23
15	20,0	40
20	0,5	1
20	1,0	1
20	2,0	1
20	3,0	1
20	4,0	1
20	5,0	2
20	7,5	3
20	10,0	6
20	12,5	9
20	15,0	12
20	20,0	21

NOTE This table is derived under the assumption that the probability of saying that there is a difference when there is no true difference and the probability of saying that there is no difference when there is a true difference are both equal to 0,05.

2 Information taken from the American standard ANSI N42.17A.D8.

Annex B
(informative)

Procedure to determine the variation of the relative response due to radiation energy and angle of radiation incidence

The easiest way to determine the rated range of radiation energy is to measure the (absolute) response values for all energies and angles of incidence for all radiation qualities within the anticipated rated range. Special care shall be taken at large polar angles of incidence, because the response might also depend on the azimuth angle. Then the relative response values are determined by dividing all these (absolute) response values by the value of the (absolute) response for the reference energy and 0° radiation incidence. If all relative response values are within the allowed limits (for example, 0,71 – U_{rel} and 1,67 + U_{rel} for photon radiation) then the anticipated rated range can be stated as rated range of the dosemeter. This rated range may not be the maximum possible rated range, because even lower or higher energies may fulfil the requirements and thus larger rated ranges may be possible. In addition, especially for neutron dosemeters, a change of the reference energy may lead to a larger rated range. A better and more direct way to determine the maximum rated range, especially for photon radiation, is given in the following.

For dosemeters where the design gives no reason to expect a non-monotonic dependence of the relative response versus angle of radiation incidence, the following four step procedure may be used to minimise the number of measurements. In the first step, the energy dependence of relative response at 0° radiation incidence is measured. In the second step, the minimum energy of the rated range is determined where the requirements on radiation energy *and* angle of radiation incidence are met. In the third step, the respective maximum energy of the rated range is determined and in the fourth step, it is verified that the requirements are also met in the energy range in between.

a) The energy dependence of relative response at 0° radiation incidence is measured at all energies given in the respective subclause in the anticipated rated range of energy and plotted versus the (mean) energy.

b) The energy on the low energy side of the plot measured in a) is determined where the relative response leaves (the first time) the allowed interval (for example, from 0,71 – U_{rel} to 1,67 + U_{rel} for photon radiation). For the radiation quality with the next higher (mean) energy, the relative response values are measured for angles of incidence of $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{max}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter. If, for this radiation quality, all relative response values are in the allowed interval (for example, from 0,71 – U_{rel} to 1,67 + U_{rel} for photon radiation), the procedure has to be repeated with the radiation exhibiting the next lower (mean) energy. Otherwise, the radiation quality with the next higher mean energy shall be used.

For both radiation qualities used in the test, all measured relative response values are plotted as a function of (mean) energy. Each two relative response values belonging together shall be connected by a straight line. The minimum rated energy is that energy above which all straight lines are between the allowed limits (for example, 0,71 – U_{rel} and 1,67 + U_{rel} for photon radiation).

c) The energy on the high energy side of the plot measured in a) is determined where the relative response leaves (the first time) the allowed interval (for example, from 0,71 – U_{rel} to 1,67 + U_{rel} for photon radiation). For the radiation quality with the next lower (mean) energy, the relative response values are measured for angles of incidence of $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{max}$. These measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter. If, for this radiation quality, all relative response values are in the allowed interval (for example, from 0,71 – U_{rel} to

1,67 + U_{rel} for photon radiation), the procedure has to be repeated with the radiation exhibiting the next higher (mean) energy. Otherwise, the radiation quality with the next lower mean energy shall be used. With a procedure similar to that given in b), the maximum rated energy is determined.

d) For at least one radiation quality within the rated range determined above, it shall be shown that all relative response values for angles of incidence of $\alpha = \pm 45°$ and $\alpha = \pm 60°$ and if the rated range of use exceeds 0° to ±60°, $\alpha = \pm \alpha_{max}$, are within the allowed interval (for example, from 0,71 – U_{rel} to 1,67 + U_{rel} for photon radiation). If the relative response values measured in a) have extreme values in the rated range, then the corresponding radiation qualities have to be used for this step.

Annex C
(informative)

Usage categories of personal dosemeters

The usage categories given in Table C.1 can be used to categorize personal dosemeters for approval purposes.

Table C.1 – Usage categories of personal dosemeters

Category	Sym-bol	Minimum required range of use	Optional extensions		
			for influence quantity energy	for dose range	for influence quantity dose rate
$H_p(10)$ Gamma radiation	**G**	80 keV to 1,5 MeV [a] 100 µSv to 10 Sv [b] 0,5 µSv h^{-1} to 1 Sv h^{-1} [c]	**m** (mid): lower limit 60 keV **l** (low): lower limit 20 keV **h** (high): includes 6 MeV	**f**: lower limit 10 µSv	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,05 µSv h^{-1}
$H_p(10)$ X radiation	**X**	20 keV to 150 keV [a] 100 µSv to 10 Sv [b] 0,5 µSv h^{-1} to 1 Sv h^{-1} [c]	**l** (low): lower limit 10 keV **h** (high): includes 300 keV	**f**: lower limit 10 µSv	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,05 µSv h^{-1}
$H_p(10)$ Neutron radiation	**N**	0,025 eV to 5 MeV [a] 100 µSv to 1 Sv [b] 5 µSv h^{-1} to 1 Sv h^{-1} [c]	—	**f**: lower limit 10 µSv	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,5 µSv h^{-1}
$H_p(0,07)$ X, gamma radiation	**S** skin	20 keV to 150 keV [a] 1 mSv to 10 Sv [b] 5 µSv h^{-1} to 1 Sv h^{-1} [c]	**l**: lower limit 15 keV **n**: lower limit 10 keV	**g**: lower limit 100 µSv	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,5 µSv h^{-1}
$H_p(0,07)$ Beta radiation	**B**	200 keV to 800 keV (E_{mean}) [a] 1 mSv to 10 Sv [b] 5 µSv h^{-1} to 1 Sv h^{-1} [c]	**l**: lower limit 60 keV (E_{mean})	**g**: lower limit 100 µSv	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,5 µSv h^{-1}

[a] Minimal rated energy range.

[b] Minimal effective range of measurement.

[c] Minimal rated range of use for influence quantity dose rate.

Example: A personal gamma neutron dosemeter for a nuclear plant may be classified as **Gmh-N**.

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