BS EN 60846-1:2014

BSI Standards Publication

Radiation protection instrumentation — Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation

Part 1: Portable workplace and environmental meters and monitors

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National foreword

This British Standard is the UK implementation of EN 60846-1:2014. It is derived from IEC 60846-1:2009. It supersedes BS EN 60846:2004 which is withdrawn.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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Radiation protection instrumentation - Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation - Part 1: Portable workplace and environmental meters and monitors (IEC 60846-1:2009 , modified)

Instrumentation pour la radioprotection - Instruments pour la mesure et/ou la surveillance de l'équivalent de dose (ou du débit d'équivalent de dose) ambiant et/ou directionnel pour les rayonnements bêta, X et gamma - Partie 1: Instruments de mesure et de surveillance portables pour les postes de travail et l'environnement (CEI 60846-1:2009 , modifiée)

Strahlenschutz-Messgeräte - Umgebungs- und/oder Richtungs-Äquivalentdosis(leistungs)-Messgeräte und/oder Monitore für Beta-, Röntgen- und Gammastrahlung - Teil 1: Tragbare Messgeräte und Monitore für den Arbeitsplatz und die Umgebung (IEC 60846-1:2009 , modifiziert)

This European Standard was approved by CENELEC on 2014-07-28. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

This document (EN 60846-1:2014) consists of the text of IEC 60846-1:2009 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) 2015-07-28
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2017-07-28

This document supersedes EN 60846:2004.

Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 60846-1:2009 are prefixed “Z”.

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.

Endorsement notice

The text of the international Standard IEC 60846-1:2009 was approved by CENELEC as a European Standard with common modifications.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60325:2002	NOTE Harmonized as EN 60325:2004 (modified).
IEC 61005:2003	NOTE Harmonized as EN 61005:2004 (modified).

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 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60050-151	2001	International Electrotechnical Vocabulary (IEV) Part 151: Electrical and magnetic devices	-	-
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 + A1 + A2	1995 1998 2000	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2 + A1 + A2 [3)]	1995 1998 2001
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 61000-4-6	2008	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6 [4)]	2009
IEC 61000-4-8 + A1	1993 2000	Electromagnetic compatibility (EMC) Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8 + A1 [5)]	1993 2001

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.
3) EN 61000-4-2 is superseded by EN 61000-4-2:2009, which is based on IEC 61000-4-2:2008.
4) EN 61000-4-6 is superseded by EN 61000-4-6:2014, which is based on IEC 61000-4-6:2013.
5) EN 61000-4-8 is superseded by EN 61000-4-8:2010, which is based on IEC 61000-4-8:2009.

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 99	2007	International vocabulary of metrology - Basic and general concepts and associated terms (VIM)	-	-
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	-	-

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CONTENTS

RADIATION PROTECTION INSTRUMENTATION – AMBIENT AND/OR DIRECTIONAL DOSE EQUIVALENT (RATE) METERS AND/OR MONITORS FOR BETA, X AND GAMMA RADIATION –

Part 1: Portable workplace and environmental meters and monitors

1 Scope and object

This part of the IEC 60846 series applies to dose equivalent (rate) meters and/or monitors for the measurement of ambient dose equivalent (rate) and/or directional dose equivalent (rate) from external beta, X and gamma radiation, as recommended in ICRU, Report 47.

NOTE 1 If both quantities, ambient dose equivalent and directional dose equivalent are meant, the term dose equivalent may be used as an abbreviation.

This part of IEC 60846 series applies only to portable meters and monitors which are intended to be used in both the workplace and the environment. It applies to devices that measure the dose equivalent or dose equivalent rate from external beta and/or X and gamma radiation in the dose range between 0,01 μSv and 10 Sv and the dose rate range between 0,01 μSv h^{-1} and 10 Sv h^{-1} and in the energy ranges given in the following Table. All the energy values are mean energies with respect to the prevailing dose quantity.

Table 1 – Measuring quantities and energy ranges covered by the standard

Measuring quantity	Energy range for Photon radiation	Energy range for Beta-particle radiation
$H^*(10)$	12 keV to 10 MeV	—
$H'(0,07)$	8 keV to 250 keV	0,07 MeV[a] to 1,2 MeV almost equivalent to E_{max} from 225 keV to 3,54 MeV

[a] For beta-particle radiation, an energy of 0,07 MeV is required to penetrate the dead layer of skin of 0,07 mm (almost equivalent to 0,07 mm of ICRU tissue) nominal depth.

NOTE 2 Where a dose rate meter or monitor may be attached to a supplementary probe used to monitor contamination, the relevant standard for that probe is IEC 60325.

If national legislation requires the use of different measuring quantities, for example, air kerma or exposure, the standard may be used with the respective adjustments.

In this document, the expression "dose equivalent (rate)" is used when the provisions apply to both the measurement of dose equivalent and the measurement of dose equivalent rate.

NOTE 3 It does not apply to medical radiology which is within the scope of technical committee 62, where the conditions of radiation exposure may be extremely inhomogeneous, but precisely known.

NOTE 4 It does not apply to instruments intended to be worn by an individual for the purpose of estimating the radiation dose received by that individual.

The object of this standard is to specify the design requirements and the performance characteristics of dose equivalent (rate) meters intended for the determination of ambient dose equivalent (rate) and directional dose equivalent (rate) as defined in ICRU Report 47.

Accordingly, this standard specifies:

a) general characteristics, the functions and performance characteristics of dose equivalent (rate) meters;

b) the methods of test to be used to determine compliance with the requirements of this standard.

Some countries may wish to use this type of dose equivalent (rate) meter for measurements in the framework of legal metrology.

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 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

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 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*
Amendment 1 (1998)
Amendment 2 (2000) [2]

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1 (2007) [3]

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 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*
Amendment 1 (2000) [4]

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

2 There exists a consolidated edition (1.2) which includes IEC 61000-4-2 (1995), its Amendment 1 (1998) and its Amendment 2 (2000).

3 There exists a consolidated edition (3.1) which includes IEC 61000-4-3 (2006) and its Amendment 1 (2007).

4 There exists a consolidated edition (1.1) which includes IEC 61000-4-8 (1993) and its Amendment 1 (2000).

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*

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

ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

ISO 4037-1:1996, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 1: Radiation characteristics and production methods*

ISO 4037-2:1997, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 2: Dosimetry for radiation protection over the energy ranges 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

ISO 4037-3:1999, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence*

ISO 4037-4:2004, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 4: Calibration of area and personal dosemeters in low energy X reference radiation fields*

ISO 6980-1:2006, *Nuclear energy – Reference beta-particle radiation – Part 1: Methods of production*

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

ISO 6980-3:2006, *Nuclear energy – Reference beta-particle radiation – Part 3: Calibration of area and personal dosemeters and determination of their response as a function of beta radiation energy and angle of incidence*

3 Terms and definitions

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

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

3.2
ambient dose equivalent
***H**(10)**
dose equivalent at a point in a radiation field that would be produced by the corresponding expanded and aligned field in the ICRU sphere at a depth of 10 mm on the radius opposing the direction of the aligned field

NOTE 1 The SI unit of ambient dose equivalent is the sievert (Sv) or its decimal multiples or submultiples (e.g. mSv).

NOTE 2 The ambient dose equivalent (rate), used for the monitoring of strongly penetrating radiation, is not an appropriate quantity for any beta radiation even that which is nominally penetrating (ICRU Report 47, 1992).

NOTE 3 When the term dose equivalent alone is used in this standard, the quantities ambient dose equivalent and directional dose equivalent are implied.

3.3
ambient dose equivalent rate
$\dot{H}^*(10)$
ratio of d$H^*(10)$ by dt, where d$H^*(10)$ is the increment of ambient dose equivalent in the time interval dt

$$\dot{H}^*(10) = \frac{\mathrm{d}H^*(10)}{\mathrm{d}t}$$

NOTE The SI unit of ambient dose equivalent rate is the sievert per second (Sv s^{-1}). Units of ambient dose equivalent rate are any quotient of the sievert or its decimal multiples or submultiples by a suitable unit of time (e.g. mSv h^{-1}).

3.4
coefficient of variation
v
ratio of the estimate of standard deviation s to the arithmetic mean $\bar{x}$ of a set of n measurements

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

3.5
(complete) result of a measurement
set of values attributed to a measurand, including a value, the corresponding uncertainty and the unit of the measurand

NOTE 1 The central value of the whole (set of values) can be selected as measured value M and a parameter characterizing the dispersion as uncertainty.

NOTE 2 The result of a measurement is related to the indicated value given by the instrument G and to the values of correction obtained by calibration and by the use of a model.

NOTE 3 The estimation of M can be based on one or more indicated values.

[IEV 311-01-01, modified]

3.6
conventional quantity value
H
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.

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

[VIM 2.12]

3.7
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]

$$D = G - G_r$$

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.

3.8
directional dose equivalent
***H′*(0,07)**
dose equivalent at a point in a radiation field that would be produced by the corresponding expanded field in the ICRU sphere at a depth of 0,07 mm, on a radius in a specified direction

NOTE The SI unit of directional dose equivalent is the sievert (Sv) or its decimal multiples or submultiples (e.g. mSv).

3.9
directional dose equivalent rate
$\dot{H}'(0{,}07)$
ratio of dH'(0,07) by dt, where dH'(0,07) is the increment of directional dose equivalent in the time interval dt

$$\dot{H}'(0{,}07) = \frac{\mathrm{d}H'(0{,}07)}{\mathrm{d}t}$$

NOTE The SI unit of directional dose equivalent rate is the sievert per second (Sv s^{-1}). Units of directional dose equivalent rate are any quotient of the sievert or its decimal multiples or submultiples by a suitable unit of time (e.g. mSv h^{-1}).

3.10
dose equivalent (rate) meter
assembly intended to measure or evaluate the dose equivalent (rate)

3.11
effective range of measurement (of a dose equivalent (rate) meter)
range of values of the quantity to be measured over which the performance of a dose equivalent (rate) meter meets the requirements of this standard

3.12
indicated value (for the purpose of this standard)
G
value given by the (digital) indication of the dosemeter in units of dose equivalent or dose equivalent rate

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.

[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 An example is radiation energy and angle of radiation incidence.

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 An example is the electromagnetic disturbance.

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 dose equivalent rate (for dosemeters)
$\dot{H}_{\max}$
doserate, specified by the manufacturer, below which the effect of the dose rate on the dose reading is within specified limits

3.18
measured value
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 of the measured value 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-linear 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:

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

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 If necessary another model function closer to the design of a certain dosemeter may be used.

NOTE 5 With the calibration controls adjusted according to the manufacture’s instructions, the reference calibretion factor, the correction for non-linear 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
minimal rated range (of use)
smallest range being specified for an influence quantity or instrument parameter over which the dose equivalent (rate) meter shall operate within the specified limits of variation in order to comply with this standard

NOTE The minimal rated ranges of the influence quantities dealt with in this standard are given in the second column of ⟨C⟩ Tables 5 to 9 ⟨C⟩.

3.20
non-linearity
variation of the value of the (relative) response with the dose (rate) being measured

3.21
point of test (of a dose equivalent (rate) meter)
point at which the conventional quantity value is determined and at which the reference point of the dose equivalent (rate) meter is placed for calibration and test purposes

3.22
qualification tests
tests which are performed in order to verify that the requirements of a specification are fulfilled. Qualification tests are sub-divided into type tests and routine tests as defined below

3.23
rated range (of use) (of a dose equivalent (rate) meter)
range of values of an influence quantity or instrument parameter over which the dose equivalent (rate) meter will operate within the specified limits of variation. Its limits are the maximum and minimum rated values

3.24
reference orientation (of a dose equivalent (rate) meter)
orientation of the dose equivalent (rate) meter with respect to the direction of the incident radiation during calibration

3.25
reference point (of a dose equivalent (rate) meter)
physical mark or marks on the outside of the dose equivalent (rate) meter used to position it at the point of measurement or the point of test

3.26
reference response
R_0
response for a reference value $H_{r,0}$ of the quantity to be measured under reference conditions

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

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

NOTE 1 The reference response is the reciprocal of the reference calibration factor.

NOTE 2 The reference values for the dose (rate) are given in Table 4.

3.27
relative response
r
quotient of the response R and the reference response R_0

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

3.28
response (of a radiation measuring assembly)
R
ratio, under specified conditions, given by the relation

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

where G is the indicated value of the quantity measured by the equipment or assembly under test (dosemeter) and

H is the conventional quantity value of this quantity

3.29
routine test
a test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.30
standard test conditions
conditions representing the range of values of a set of influence quantities under which a calibration or a determination of response is carried out

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

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

[ISO 4037-3, 3.2.3, modified]

3.31
standard test values
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

NOTE Under standard test conditions, influence quantities and instrument parameters have their standard test values.

3.32
supplementary tests
tests intended to provide supplementary information on certain characteristics of the dose equivalent (rate) meters

3.33
type test
conformity testing on the basis of one or more specimens of a product representative of the production

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 are given in IEC 60050-393, IEC 60050-394 and ICRU report 51. Nevertheless, the following units may be acceptable in common usage:

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

– for time: year, day, 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 2 gives a list of the symbols (and abbreviated terms) used.

Table 2 – Symbols (and abbreviated terms)

Symbol	Meaning	Unit
α	Angle of radiation incidence	°
α_{max}	Maximum value of α within rated range of use	°
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 value	Sv
$\dot{G}$	Indicated doserate value	Sv h^{-1}
$\dot{G}_0$	Indicated doserate value arising from any internal radioactive contamination or from the electronic noise of the instrument	Sv h^{-1}
$\dot{G}_{0,s}$	Indicated background doserate value in the calibration laboratory	Sv h^{-1}
G_e	Indicated dose (rate) value produced by the electrical signal q_e	Sv
$\dot{G}_f$	Final dose rate indication after a step increase in dose equivalent rate	Sv
$\dot{G}_i$	Initial dose rate indication before a step increase in dose equivalent rate	Sv
G_K	Indicated dose value due to a single irradiation with the conventional true dose value H_K	Sv
G_{K+L}	Indicated dose value due to a combined (simultaneous) irradiation with the conventional true dose value H_K + H_L	Sv
G_{nat}	Indicated dose value after exposure to natural background radiation for the time t_{env}	Sv
G_L	Indicated dose value due to a single irradiation with the conventional true dose value H_L	Sv
G_{low}	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
G_{nom}	Indication of the dosemeter under given conditions when the battery voltage has its nominal value.	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})
$\dot{G}_s$	Indicated doserate due to exposure to a source including background radiation indication	Sv h^{-1}
Δg_{mix}	Relative change in indication caused by subsequent and mixed exposure, see Clause 6	—
H_0	Lower dose limit of the effective range of measurement	Sv
$\dot{H}_0$	Lower doserate limit of the effective range of measurement	Sv h^{-1}
H_a	Dose value which produces the indication to which the alarm is set	Sv
$\dot{H}_a$	Doserate value which produces the indication to which to the alarm is set	Sv h^{-1}

Symbol	Meaning	Unit
$\dot{H}_{max}$	Maximum dose equivalent rate (for dosemeters)	Sv h^{-1}
$H'(0,07)$	Directional dose equivalent at a depth 0,07 mm	Sv
$H^*(10)$	Ambient dose equivalent at a depth 10 mm	Sv
H_{nat}	Expected ambient dose equivalent due to natural environmental radiation	Sv
$\dot{H}'(0,07)$	Directional dose equivalent rate at a depth 0,07 mm	Sv h^{-1}
$\dot{H}^*(10)$	Ambient dose equivalent rate at a depth 10 mm	Sv h^{-1}
$\dot{H}^*(10)_c$	Ambient dose equivalent rate due to the cosmic component of the background radiation in the calibration room	Sv h^{-1}
$\dot{H}^*(10)_t$	Ambient dose equivalent rate due to the terrestrial gamma component of the background radiation in the calibration room	Sv h^{-1}
$\dot{H}^*(10)_s$	Ambient dose equivalent rate due to a calibration source	Sv h^{-1}
$\dot{H}_{nat}$	Known ambient dose equivalent rate due to natural environmental radiation	Sv h^{-1}
H	Conventional quantity value of the dose(rate)	Sv (Sv h^{-1})
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})
I_{low}	Supply current of the dosemeter when the indication is G_{low}	A
k	Coverage factor (see GUM)	—
K	Symbol for the first of two exposure conditions, for example 3 mSv and N-80 and 60° of radiation incidence	—
l	Total number of influence quantities of type S	—
L	Symbol for the second of two exposure conditions, for example 4 mSv and S-Co and 0° of radiation incidence	—
M	Measured dose(rate) value	Sv (Sv h^{-1})
m	Total number of influence quantities of type F	—
n	Number of indicated values for one dose (rate) value	—
N	Calibration factor	—
N_0	Reference calibration factor	—
p	Index giving the number of an influence quantities of type S	—
q	Index giving the number of an influence quantities of type F	—
q_e	Strength of electrical signal to simulate the detector signal	dependent
$q_{r,0}$	Strength of electrical signal to produce the indication $G_{r,0}$	dependent
Q_{nom}	Nominal capacity of the batteries	A h
r	Relative response	—
R	Response	—
R_0	Reference response	—
R_c	Response to the cosmic component of the background radiation	—
R_t	Response to the terrestrial gamma component of the background radiation	—
R_s	Response to the radiation of a calibration source	—
r_n	Correction for non-linearity	—
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

Symbol	Meaning	Unit
	〖C〗 *text deleted* 〖C〗	
U	Expanded uncertainty	As quantity
u_c	Combined standard uncertainty	As quantity
u_i	Standard uncertainty due to component no. i	As quantity
U_{low}	Battery voltage under conditions prevailing for the determination of G_{low}	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 (rate) values used for test of linearity and coefficient of variation	—

5 General characteristics of ambient and directional dose equivalent (rate) meters

5.1 Indication

Any dose (rate) indication of the dose equivalent (rate) meter shall be in units of dose equivalent or dose equivalent rate, for example millisieverts or millisieverts per hour, respectively.

5.2 Read-out

The changing of measuring range and read-out scale shall be simultaneous and shall be clearly displayed. All scales shall be readable under normal lighting conditions.

5.3 Dose equivalent rate range

The implementation of the ICRP recommendations requires the determination of dose equivalent rate over a wide range of values. Under some circumstances, dose equivalent rates as high as 10 Sv h^{-1} require measurement. At the other extreme, dose equivalent rates as low as 0,1 μSv h^{-1} could be obtained. For many applications, the dose equivalent rates of interest are within the range from approximately 1 μSv h^{-1} to 10 mSv h^{-1}.

5.4 Effective range of measurement

The effective range of measurement, starting at $\dot{H}_0$ or H_0, shall be not less than the following:

a) for dose equivalent (rate) meters with an analogue type of display (e.g. linear or logarithmic) and one range per order of magnitude from 10 % to 100 % of the scale maximum angular deflection on each scale range and for dose equivalent (rate) meters with two ranges per order of magnitude from 30 % to 100 % of the scale maximum angular deflection on each scale range;

NOTE The requirement on the coefficient of variation is 5 % for any dose(rate) value greater than 11 times the lower limit of the effective range of measurement. To achieve this the scale resolution should be of the order of half of this, for example 3 %. At 10 % of the scale maximum angular deflection this is for a linear scale equivalent to about 30 divisions. Therefore, the linear scale requires about 300 divisions in total. An alternative is to limit the effective range of measurement to 30 % to 100 % of the scale maximum angular deflection on each scale range. In that case a linear scale with 100 divisions is sufficient to measure the required coefficient of variation of 5 %. For a linear scale this requires at least two ranges per order of magnitude, e. g. with the scale maximum 1, 3, 10 etc.

b) for dose equivalent (rate) meters with a digital display, from an indication in the second least significant digit up to the maximum indication on each range. As an example, for a display with a maximum indication of 9 999,9, the effective range can extend from 1,0 to

9 999,9 - i.e. four orders of magnitude – or from 3,0 to 9 999,9 - i.e. three and a half orders of magnitude;

c) for dose equivalent (rate) meters with a digital and scientific display (e.g. x,yz E ± ab) the mantissa shall have three digits at least (for instance 1,00 to 9,99). The manufacturer shall define the effective range of measurement (for instance 1,00 E–7 to 9,99 E–2 with the unit Sv h^{-1}).

For dose equivalent (rate) meters with more than one scale, the effective range of measurement shall be from 10 % of the lowest scale range to 100 % of the highest scale and all scales shall be arranged to make the total range covered by the effective range of measurement.

When the test methods do not extend over the whole of the effective range of measurement and any of the observed variations are near the permitted limit, further tests to demonstrate compliance with the requirement in question over the whole effective range of measurement may be necessary. Supplementary tests shall be agreed between the purchaser and the manufacturer.

5.5 Minimum range of measurement

The minimum effective range of measurement of dose equivalent rate shall cover at least three orders of magnitude and shall include 10 μSv h^{-1} for the measuring quantity $\dot{H}^*(10)$ and 0,1 mSv h^{-1} for the measuring quantity $\dot{H}'(0{,}07)$. The minimum effective range of dose equivalent shall cover at least three orders of magnitude and shall include 0,1 mSv.

5.6 Rated range of an influence quantity

The rated range of any influence quantity has to be stated in the documentation. In addition, some rated ranges have to be stated on the instrument, see 5.12.

5.7 Minimum rated range of influence quantity

The minimum rated range of the specified influence quantity is given in the second column of 〚C〛 Tables 5 to 9 〚C〛.

5.8 Alarm levels

The visual and/or audible alarms (if provided) for dose equivalent rate and/or dose equivalent should be pre-settable.

When any alarm is set, it must not be possible to deactivate all available alarms (silence the audible alarm, deactivate the visual alarm, deactivate the vibration alarm and others) simultaneously.

It shall be possible to set the dose equivalent alarm either to any value over the effective range of measurement or at least one value in each order of magnitude of this range, for example 3 μSv, 30 μSv, 300 μSv, 3 mSv, 30 mSv, and 300 mSv.

It shall be possible to set the dose equivalent rate alarm either to any value over the effective range of measurement or at least one value in each order of magnitude of this range, for example 3 μSv h^{-1}, 30 μSv h^{-1}, 300 μSv h^{-1}, 3 mSv h^{-1}, 30 mSv h^{-1} and 300 mSv h^{-1}.

The frequency of the audible alarm should be within the range of 1 000 Hz to 3 000 Hz. Where an intermittent alarm is provided, the signal interval shall not exceed 2 s. The A-weighted sound level should not exceed 100 dBA at 30 cm from the alarm source and shall be at least 75 dBA at that point.

NOTE The manufacturer should indicate whether the setting of the alarm point is to be done with the aid of a tool, by software interface or manually.

5.9 Additional indication

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, detector failure or dose equivalent rate overload.

5.10 Failure operation of indication

A provision to test for failure of the display shall be installed.

5.11 Ease of decontamination

The dose equivalent (rate) meter should be designed and constructed in such a manner as to facilitate decontamination.

5.12 Information given on the instruments

The following information shall be clearly visible on the dose equivalent (rate) meter:

a) the quantity that is measured;
b) the effective range of measurement;
c) the type of radiation (for example photon and/or beta) the dosemeter is suitable for;
d) the rated range of particle energy;
e) reference point and reference orientation (or in the manual);
f) usage category according to Annex B.

NOTE An example is: 0,1 µSv ≤ $H^*(10)$ ≤ 1 Sv; 55 keV ≤ E_{ph} ≤ [C] 1,33 MeV [C]; IEC 60846-1 series category: Gm.

5.13 Algorithm to evaluate the indicated value

For the type test according to this standard, the manufacturer shall deliver the evaluation algorithm of the indicated value starting from the signal(s) of the detector(s) and ending at the indicated value. This shall include all the calculations and/or the decision tree.

If more than one signal is used to evaluate the indicated value, the manufacturer has to supply a possibility to read out the separate signals of the detector(s) for the type test.

NOTE This algorithm may be confidential and only be used by the testing laboratory for the purpose of type testing.

5.14 Classification of the dosemeters

The different types of dose equivalent (rate) meters may be classified according to the type of radiation, the dose (rate) range and the rated range of radiation energy and direction of radiation incidence. The classification scheme is given in Annex B.

If a dose equivalent (rate) meter has been designed to carry out the functions of both an ambient and directional dose equivalent (rate) meter, it shall comply with the requirements pertaining to both of these functions.

6 General test procedures

6.1 Instructions for use

The instructions for use of the dose equivalent (rate) meter have to be unambiguously given in the manual, see 14.3. These instructions have to be the same for all parts of the type test and for the routine use as well.

6.2 Nature of tests

Unless otherwise specified in the individual clauses, all the tests enumerated in this standard are to be considered as type tests (see 3.33). Certain tests may be considered as acceptance tests by agreement between the purchaser and the manufacturer.

6.3 Reference conditions and standard test conditions

Reference conditions are given in the second column of Table 4. Except where otherwise specified, the tests in this standard shall be carried out under the standard test conditions given in the third column of Table 4. 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.

For those tests intended to determine the effects of variations in the influence quantities given in Table 4, all other influence quantities should be maintained within the limits for standard test conditions given in Table 4, unless otherwise specified in the test procedure concerned.

6.4 Tests for influence quantities of type F

These tests may be performed at any value of the quantity to be measured above or equal 10 $\dot{H}_0$ or 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 classed 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 $\dot{H}_0$ or 10 H_0 and these findings shall be reported in the type test report.

6.5 Tests for influence quantities of type S

These tests shall be performed at a value of the quantity to be measured of less or equal than 10 times the lower limit $\dot{H}_0$ or H_0 of the effective range of measurement, even zero dose (rate) is possible if no other specification is given in the respective subclause and a negative deviation can be excluded. The result of each test is a deviation D_p.

It is accepted that some small part of the effects of the influence quantities classed 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 $\dot{H}_0$ or 10 H_0 and these findings shall be reported in the type test report.

NOTE Due to the generally lower indicated value when compared to tests according to 6.4 the necessary number of measurements may be increased.

6.6 Consideration of non-linearity

The effect of a non-constant response shall be regarded.

Testing should be undertaken in a dose (rate) region where non-linearity is not significant. A practical method is to undertake the linearity test first, in order to identify the region of non-linearity, then to perform the other tests in a dose (rate) region where non-linearity is negligible (1 % to 2 %).

6.7 Consideration of several detectors or signals in a dosemeter

If more than one signal or detector is used to evaluate the indicated value, each signal or detector shall be tested separately. Separate tests are necessary when the different signals

are used to evaluate the indicated value in different regions of the measuring range or in different regions of an influence quantity.

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

NOTE 2 Examples:

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

6.8 Position of dose equivalent (rate) meter for test purposes

For all tests involving the use of radiation, the reference point of the dose equivalent (rate) meter shall be placed at the point of test, and in the orientation indicated by the manufacturer (except for the tests of combined energy and angular dependence, see 8.4 and 8.5).

6.9 Low dose equivalent rates

For the measurement of low dose equivalent rates, it is necessary to take account of the contribution of background radiation to the dose equivalent rate at the point of test. See Annex C for details.

6.10 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 time 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 (rate) meter readings on the same instruments under unchanged conditions is given in Table A.1.

6.11 Production of reference radiation

Unless otherwise specified in the individual test methods, all tests involving the use of beta or X and gamma radiation should be carried out with a specified type of radiation (see Table 4). 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.

6.12 Reference photon radiation

The reference photon radiation shall be that provided by the nuclide ^{137}Cs for the ambient dose equivalent (N-100 filtered X-radiation of the narrow series spectrum if the minimum rated range is 30 keV to 150 keV), and by N-80 filtered X-radiation for the directional dose equivalent (see ISO 4037-1, ISO 4037-3 and ISO 4037-4).

6.13 Reference beta radiation

The reference beta radiation shall be that provided by the nuclide $^{90}Sr/^{90}Y$ for the directional dose equivalent (see ISO 6980-1 and ISO 6980-3).

6.14 Determination of dose equivalent (rate) response

Although the question of whether the radiation being measured is photon or beta radiation is not relevant for ambient and directional dose equivalent (rate) measurements, it is nevertheless necessary to perform the calibration of such dose equivalent (rate) meters with beta and photon radiation separately and also to establish both the beta radiation characteristics and the photon radiation characteristics of such dose equivalent (rate) meters.

The method for determining the ambient and directional dose equivalent (rate) response at the point of test is given in ISO 4037-3, ISO 4037-4 and ISO 6980-3.

Guidance on the features which should be considered when determining the conventional quantity value of the dose equivalent (rate) is given in ISO 4037-2, ISO 4037-4 and ISO 6980-2.

7 Additivity of indicated value

7.1 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 assured that the relative change in indication, Δg_{mix}, caused by the mix of radiation shall not exceed $\pm$ 0,1.

NOTE If the algorithm used to evaluate the indicated value, see 5.13, is either a linear combination of the signals or a linear optimization of them, then this requirement is fulfilled and no tests are required.

7.2 Method of test

Perform subsequently 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. Then 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 S_{K} and S_{L}. As simultaneous irradiations are very 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.

NOTE The non-linearity of the signals is treated in 8.7. 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_{K+L}, any difference in the reference calibration factor shall be corrected.

7.3 Interpretation of the results

The relative change in indication, Δg_{mix}, shall not exceed ± 0,1. In this case, the requirements of 7.1 can be considered to be met.

8 Radiation performance requirements and tests

8.1 General

All influence quantities dealt with in this clause are regarded as of type F.

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 4). The possible reference radiations are given in Table 4.

NOTE 2 Reasons for the non symmetric limits for the relative response due to radiation energy and angle of radiation incidence are given in IEC 62461.

When a dose equivalent (rate) meter utilises more than one radiation detector to cover the full range of dose equivalent (rates) indicated by the dose equivalent (rate) meter, these requirements apply to the relevant ranges for each detector separately.

8.2 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 considered. Any requirement needing the use of radiation is considered to be given for U_{rel} = 0. For $U_{rel} \neq 0$, 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 linearity of the response, only the uncertainty of the ratio of the actual value and the reference value of the conventional quantity value of the dose equivalent (rate) shall be considered when enlarging the allowed variation. In case of other requirements, the consideration is mentioned in the respective method of test.

8.3 Model function

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

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

8.4.1 Measuring quantity $H'(0,07)$ or $\dot{H}'(0,07)$

8.4.1.1 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 5). The minimum rated range of use covers energies between 10 keV and 250 keV and angles of radiation incidence between 0° and 45°. For angles of radiation incidence outside the rated range up to ± 90° the relative response shall be stated by the manufacturer for all radiation energies of the rated range.

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

8.4.1.2 Method of test

For this test, the reference point of the dosemeter shall be placed at a point of test where the dose (rate) is known. The photon radiation qualities of the narrow spectrum series of ISO shall be used if possible, otherwise low air kerma rate series or K-fluorescence reference radiations of ISO shall be used.

In principle, the relative response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 30°$, $\alpha = \pm 45°$, $\alpha = \pm 60°$, $\alpha = \pm 75°$, $\alpha = \pm 90°$ (and $\alpha = \pm \alpha_{max}$ if α_{max} is not in this list). Measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter. In practice, several angles of incidence can be omitted, if

– the response values for different angles of incidence are similar, e.g., at higher energies, and
– the design of the dosemeter and especially of the energy compensating filters gives no reason for the angular dependence of the response to be non-monotonous.

In principle, it is desirable that this test be performed at the same indicated dose equivalent (rate) for each radiation quality. In practice, this may not be possible, in which case the indicated dose equivalent (rate) for each radiation quality shall be corrected for the relative response at the indicated dose equivalent (rate) (see 8.7).

NOTE 1 Details of the reference radiations and the calibration procedure are given in ISO 4037-1, ISO 4037-2, ISO 4037-3 and ISO 4037-4.

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

8.4.1.3 Interpretation of the results

All the relative response values of the rated range of use due to photon radiation energy and angle of incidence shall be within the interval from 0,71 to 1,67. In that case, the requirements of 8.4.1.1 can be considered to be met. To achieve this, the rated range of use shall be fixed accordingly using the determined relative response values. If necessary, the limits of the rated range of use can be determined by linear interpolation.

8.4.2 Measuring quantity $H^*(10)$ or $\dot{H}^*(10)$

8.4.2.1 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 6). The minimum rated range of use covers energies between 80 keV and [C] 1,33 MeV [C] or between 20 keV and 150 keV and angles of radiation incidence between 0° and 45°. For angles of radiation incidence outside the rated range up to ± 90° the relative response shall be stated by the manufacturer for all radiation energies of the rated range.

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

If the ambient dose meter is to be used in the vicinity of nuclear power installations, the response up to 10 MeV shall to be stated by the manufacturer. The relative response at high energies in the reference direction shall be determined and should be within the interval from 0,71 to 1,67.

NOTE The two minimum rated ranges reflect the two main workplace conditions. The minimum rated range of use from 80 keV to [C] 1,33 MeV [C] 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.

8.4.2.2 Method of test

For this test, the reference point of the dosemeter shall be placed at a point of test where the dose (rate) is known. The photon radiation qualities of the narrow spectrum series and the gamma sources ^{60}Co, ^{137}Cs and ^{241}Am specified by ISO shall be used if possible.

In principle, the relative response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 30°$, $\alpha = \pm 45°$, $\alpha = \pm 60°$, $\alpha = \pm 75°$, $\alpha = \pm 90°$ (and $\alpha = \pm \alpha_{max}$ if α_{max} is not in this list). Measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter. In practice, several angles of incidence can be omitted, if

– the response values for different angles of incidence are similar, e.g., at higher energies, and
– the design of the dosemeter and especially of the energy compensating filters gives no reason for the angular dependence of the response to be non-monotonous.

In principle, it is desirable that this test be performed at the same indicated dose equivalent (rate) for each radiation quality. In practice, this may not be possible, in which case the indicated dose equivalent (rate) for each radiation quality shall be corrected for the relative response at the indicated dose equivalent (rate) (see 8.7).

NOTE 1 Details of the reference radiations and the calibration procedure are given in ISO 4037-1, ISO 4037-2, ISO 4037-3 and ISO 4037-4.

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

8.4.2.3 Interpretation of the results

All the relative response values of the rated range of use 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 8.4.2.1 can be considered to be met. To achieve this, the rated range of use shall be fixed accordingly using the determined relative response values. If necessary, the limits of the rated range of use can be determined by linear interpolation.

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

8.5.1 Measuring quantity $H'(0,07)$ or $\dot{H}'(0,07)$

8.5.1.1 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 5). 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 45°. For angles of radiation incidence outside the rated range up to ± 60°, the relative response shall be stated by the manufacturer for all radiation energies of the rated range. In addition, if the rated range of use does not cover 0,06 MeV, then the variation of the relative response due to beta radiation energy and angle of incidence shall be stated for that energy by the manufacturer (see Table 5).

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

8.5.1.2 Method of test

For this test, the reference point of the dosemeter shall be placed at a point of test where the dose (rate) is known. The following reference radiation qualities selected from the list of beta reference radiations specified by ISO 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).

In principle, the relative response values shall be measured for angles of incidence of $\alpha = 0°$, $\alpha = \pm 30°$, $\alpha = \pm 45°$, $\alpha = \pm 60°$ (and $\alpha = \pm \alpha_{max}$ if α_{max} is not in this list). Measurements shall be performed in two perpendicular planes containing the reference direction through the reference point of the dosemeter. In practice, several angles of incidence can be omitted, if

– the response values for different angles of incidence are similar, e.g., at higher energies, and
– the design of the dosemeter and especially of the energy compensating filters gives no reason for the angular dependence of the response to be non-monotonous.

In principle, it is desirable that this test be performed at the same indicated dose equivalent (rate) for each radiation quality. In practice, this may not be possible, in which case the indicated dose equivalent (rate) for each radiation quality shall be corrected for the relative response at the indicated dose equivalent (rate) (see 8.7).

NOTE Details of the reference radiations and the calibration procedure are given in ISO 6980-1, ISO 6980-2 and ISO 6980-3.

8.5.1.3 Interpretation of the results

All the relative response values of the rated range of use 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 8.5.1.1 can be considered to be met. To achieve this, the rated range of use shall be fixed accordingly using the determined relative response values.

8.5.2 Measuring quantity $H^*(10)$ or $\dot{H}^*(10)$

8.5.2.1 Requirements

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

8.5.2.2 Method of test

For this test, the reference point of the dosemeter shall be placed at a point of test where the $H'(0{,}07)$ or $\dot{H}'(0{,}07)$ dose (rate) is known. Expose the dosemeter at 0° angle of radiation incidence to beta reference radiation specified by ISO of the following quality:

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

NOTE Details of the reference radiations and the calibration procedure are given in ISO 6980-1, ISO 6980-2 and ISO 6980-3.

8.5.2.3 Interpretation of the results

The indicated dose (rate) value G shall be less than 10 % of the exposed $H'(0{,}07)$ or $\dot{H}'(0{,}07)$ dose (rate) value.

8.6 Response to neutron radiation

8.6.1 Requirements

If the dose equivalent (rate) meter is intended to be used in the presence of neutron radiation, then the response to this radiation shall be stated. A test for neutron response is not mandatory and needs only be carried out if this requirement is specified.

In any case, dose equivalent (rate) meters shall be designed in such a way as to limit as far as possible the influence of neutron radiation on their photon and beta indication.

8.6.2 Test method

The method of test shall be subject to agreement between the purchaser and the manufacturer.

NOTE Details of test procedures for neutron dose (rate) meters are given in IEC 61005. Some of these can also be applied for the dose (rate) meters considered here.

8.7 Linearity and statistical fluctuations

8.7.1 General

The tests for linearity (constancy of the dose (rate) response) and statistical fluctuations are performed using the same measurement data.

NOTE Details of test procedures are explained in the paper of Brunzendorf and Behrens, see Bibliography.

If the methods of detection are different for photon and beta radiation, this requirement shall be tested separately for all types of radiation.

For instruments intended to measure the dose (rate) due to natural environmental radiation see Annex C.

8.7.2 Requirements

Under standard test conditions, with the calibration controls adjusted according to the manufacture's instructions, the variation of the relative dose (rate) response due to the non-linearity shall not exceed the range from – 15 % to + 22 % over the whole of the effective range of measurement for either the X, the gamma or the beta reference radiation chosen.

The coefficient of variation of the dose (rate) indication shall not exceed the limits given in Tables 5 and 6.

8.7.3 Method of test

a) Sources to be used

The tests shall be performed with appropriate reference sources. For the ambient dose equivalent (rate) ^{137}Cs or ^{60}Co shall be used and for the directional dose equivalent (rate) N-80 or S-Am for photon radiation and ^{90}Sr/^{90}Y for beta radiation. All irradiations of the dosemeter shall be performed in the reference direction. For tests where the consideration of the background radiation is required, see Annex C for further information.

Although the required reference photon radiation for the directional dose equivalent is the N-80 filtered X-radiation or S-Am, it may not be practical to produce these at all the dose equivalent (rates) required for this test. If the full range of dose equivalent (rates) required for this test cannot be provided by the X-radiation, it is permissible to substitute the reference radiation of ^{137}Cs in order to determine the variation of the relative response at the dose equivalent (rates) which cannot be provided by the X-radiation. In this case, it is necessary to ensure that the variation of the relative response is determined at a minimum of one common dose equivalent (rate) for both the X-radiation and the ^{137}Cs reference

radiation. This will enable the appropriate correction to be applied for any difference in the response of the detector at the ^{137}Cs energy compared to the X-radiation energy.

In the case of the gamma reference radiation, secondary electron equilibrium conditions shall be established at the detector of the dose equivalent (rate) meter under test, see ISO 4037-3.

b) Tests to be performed

The test shall be carried out on one or more dose equivalent (rate) meters of the series. The time interval between dosemeter readings shall be large enough to ensure that the readings are statistically independent. The manufacturer shall provide the necessary information. For dose equivalent (rate) meters provided with substantially linear analogue scales, the test shall consist of measurements of the variation of the relative response carried out on all the scale ranges of the dose equivalent (rate) meter, and on at least three values of each order of magnitude. It is recommended that these points be at approximately 20 %, 40 % and 80 % of the scale maximum on each range. If the range covers less than one order of magnitude, then the test at 20 % shall be omitted.

For dose equivalent (rate) meters with a substantially logarithmic graduation or with digital presentation the test shall be performed for at least three values in each order of magnitude of dose equivalent (rate) indicated. It is recommended that these values be at approximately 20 %, 40 % and 80 % of each order of magnitude. If the range starts at values greater than 20 % of the scale maximum, then the test at this value shall be omitted.

If the same detector is used for both the beta and gamma reference radiations, it is not necessary to perform the measurements on all ranges with both reference radiations, but measurements on at least one range (or order of magnitude) shall be performed with both the beta and gamma reference radiations.

NOTE 1 The direct use of the reference radiation sources for these tests may require the use of an inconveniently large number of sources of reference radiation, or, at the higher dose equivalent (rates), sources of inconveniently high activity. In this case, some other source of radiation (e.g. a suitable X-ray generator) may be used provided that suitable corrections are made for any difference in the response of the dose equivalent (rate) meter to such radiation and to the reference radiation, caused by the difference in the energy of the radiation used. In determining these corrections, it is essential that the response of the dose equivalent (rate) meter to the reference radiation and the radiation source used be compared for at least one point, at dose equivalent (rates) that give the same indication on the dose equivalent (rate) meter scale.

NOTE 2 See also the note to 5.4.

8.7.4 Interpretation of the results

Determine the mean value and the coefficient of variation of the n values of the indication for each of the w dose (rate) 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 – 15 % to + 22 %. And, using the w values of the coefficients of variation and the values of c_1 and c_2 given in Table 3, show that

– for $w - 2$ dose (rate) values the coefficients of variation are less than c_1 times the limits given in Tables 5 and 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 5 and 6.

In that case, the requirements of 8.7.2 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 assures, that the probability of passing the test is independent of the number w of dose (rate) 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 (rate) values at which the tests are performed.

8.8 Overload characteristics

8.8.1 Dose equivalent meters

8.8.1.1 Requirements

1) The dose equivalent meter shall read off-scale on the high side or shall indicate overload when exposed to doses greater than the maximum of its measuring range. This requirement shall apply to all ranges.
2) When subjected to dose rates high enough to cause wrong dose indication, there shall be indication that the equipment is not able to provide correct dose indication.

8.8.1.2 Test method

1) Subject the dosemeter to a dose in excess of 100 times the maximum dose that can be indicated, at most 50 Sv, at least 1 Sv. The doserate during the exposure shall be less than the maximum doserate capability as specified by the manufacturer. The equipment shall not be reset or switched off for at least 30 min after the equipment has been subjected to the test dose.
2) Subject the dose equivalent meter to a doserate 10 % in excess of that specified as the doserate limit by the manufacturer for a period of 100 s. In case, no error of the dose value (due to doserate overload) is indicated, subject the dose equivalent meter to further increased dose rates in steps of 10 % for 100 s until the error indication of the dose value (due to doserate overload) is displayed.

8.8.1.3 Interpretation of the results

1) The indication shall be off-scale on the high side or overload shall be indicated and shall remain so until the dose indication is reset or the equipment is switched off.
2) Ensure that either the dose indication has increased appropriately or indication is given that the reading of dose (due to doserate overload) is in error. Prior to the error indication the dose indication shall increase as appropriate.

8.8.2 Dose equivalent ratemeters

8.8.2.1 Requirements

The dose equivalent ratemeter shall read off-scale on the high side or shall indicate overload when exposed to dose rates greater than the maximum of its measuring range. This requirement shall apply to all ranges.

8.8.2.2 Test method

The dose equivalent ratemeter shall be submitted to the following dose equivalent rates for a period of 5 min

– 100 times the range maximum for range maxima up to and including 0,1 Sv h^{-1};
– 10 times the range maximum, or 10 Sv h^{-1}, whichever is the greater, for range maxima in excess of 0,1 Sv h^{-1} up to and including 5 Sv h^{-1};
– 2 times the range maximum for dose rates in excess of 5 Sv h^{-1}.

8.8.2.3 Interpretation of the results

The indication of the dose equivalent rate shall read off-scale on the high side or indicate overload throughout this period and the dose equivalent ratemeter shall function within the specification 5 min after completion of this test. If the device is not in a position to do so, a warning must be displayed. Assignment of this warning to the cause of its release must be unambiguous. The warning may extinguish only when the device meets again the specifications without restrictions. This test is applicable to each range.

8.9 Response time

8.9.1 Dose equivalent meters

8.9.1.1 Requirements

When subjected to a dose rate the dose equivalent meter shall within 10 s indicate at least 91 % but not more than 111 % of the appropriate increase in dose.

8.9.1.2 Test method

Subject the dose equivalent meter for 10 s to a doserate $\dot{H}$ in the range of measurement, for which the dose increment can be read with sufficient accuracy, for instance of 360 µSv h^{-1}. The dose reading shall have increased by 9,1 s$\times \dot{H}$ to 11,1 s$\times \dot{H}$ at the end of this 10 s period, for the example by 0,91 µSv to 1,11 µSv.

Subject the dose equivalent meter for 10 s to the doserate limit of the instrument as specified by the manufacturer. At the end of the 10 s period the dose, indication shall have increased by 0,002 5 $\{\dot{H}_{\text{lim}}\}$ µSv to 0,003 1 $\{\dot{H}_{\text{lim}}\}$ µSv, where $\{\dot{H}_{\text{lim}}\}$ is the doserate limit defined by the manufacturer in µSv h^{-1}.

NOTE An exposure of 10 s at a doserate of 1 µSv h^{-1} results in a dose of 0,002 8 µSv.

8.9.2 Dose equivalent ratemeters

8.9.2.1 Requirements

When the dose equivalent ratemeter is subjected to a step or slow increase or decrease in dose equivalent rate, the indication shall reach the following value in less than 10 s after the dose equivalent ratemeter is subjected to the final dose equivalent rate:

$$\dot{G}_{\text{i}} + \frac{90}{100}(\dot{G}_{\text{f}} - \dot{G}_{\text{i}})$$

where

$\dot{G}_{\text{i}}$ is the initial indication, and

$\dot{G}_{\text{f}}$ is the final indication.

The response time shall be stated by the manufacturer.

The time of 10 s applies to values of $\dot{G}_{\text{f}}$ of more than 1 µSv h^{-1} but less than 10 mSv h^{-1}. For values of $\dot{G}_{\text{f}}$ above this, the time shall be 2 s or less.

In addition, after 60 s the indication shall reach $(1 \pm 0{,}1)\,\dot{G}_{\text{f}}$ for all values of $\dot{G}_{\text{f}}$.

8.9.2.2 Test method

The test may be carried out either with a suitable source of radiation or by the injection of a suitable electrical signal into the input of the measuring dose equivalent ratemeter.

〚C〉 The initial and final dose equivalent rates shall differ by a factor of 10 or more up to the factor for the change from background dose rate to the maximum dose rate of the rated range. The measurements shall be carried out for both an increase and a decrease in the dose equivalent rate by this factor. The initial or the final dose equivalent rate shall be the background dose rate. 〈C〛

Measurements shall be made over each order of magnitude of dose equivalent rate indication for dose equivalent ratemeters provided with a digital or a logarithmic display, and on each scale range for dose equivalent ratemeters provided with a linear display.

If the electrical method of test is employed, this shall be stated in the accompanying documents; the injected signals shall correspond to the above requirements.

For the increasing dose equivalent rate test, the dose equivalent ratemeter shall be subjected first to the higher dose equivalent rate and the indication $\dot{G}_f$ noted.

The dose equivalent ratemeter shall then be subjected to the lower dose equivalent rate for a time sufficient for the indication $\dot{G}_i$ to reach a steady value and this indication noted.

The dose equivalent rate shall then be changed both as quickly as possible (< 1 s) and, if possible, slowly (> 10 s) to that corresponding to the indication $\dot{G}_f$, and the time taken from subjecting the final dose equivalent rate to reach the value given by the formula in 8.9.2.1 be measured.

The decreasing dose equivalent rate test shall be performed in the same way with the values of dose equivalent rates corresponding to $\dot{G}_i$ and $\dot{G}_f$ interchanged.

8.10 Interrelation between response time and statistical fluctuations

The response time and coefficient of variation of the statistical fluctuations are interdependent characteristics, acceptable limits for which are given above.

For high dose equivalent rates, it is recommended that, whenever possible, the response time be reduced, while conforming to the limits laid down for the statistical fluctuations.

If, however, the limits in 8.9 can be met with a response time of not more than 1 s, it is preferable to reduce the statistical fluctuations rather than to reduce the response time below 1 s.

If a dose equivalent (rate) meter has provision for a number of different, pre-selected statistical fluctuations and/or response times, then at least one pre-selected value shall conform to the requirements of both 8.9.1 and 8.9.2.

8.11 Variation of the response due to dose rate dependence of dose measurements

8.11.1 General

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

If the manufacturer can show that the technical design of the dose equivalent meter assures the fulfilment of the requirements for a large range of dose rate values, then the number of tests can be reduced.

For instruments intended to measure the dose due to natural environmental radiation, see Annex C.

8.11.2 Requirements

The variation of the relative response due to dose rate dependence shall not exceed the range from –13 % to +18 % for all dose rates of the rated range of use. The minimum rated range of use for dose rate dependence is given in Tables 5 and 6. If this requirement cannot be met up to 1 Sv h^{-1}, it shall be met up to at least the maximum value of the measuring range of doserate and the maximum value of the rated range of use shall be indicated on the dosemeter.

In addition, the variation of the relative response due to low dose rates down to natural environmental radiation shall be stated by the manufacturer.

8.11.3 Method of test using radiation sources

Determine the response values at 80 % of each order of magnitude of the effective range of dose measurement when the dose equivalent meter is exposed to a reference source. Perform the test for each dose value at one dose rate of each order of magnitude of the rated range of use for dose rate dependence.

Since at the lower dose values, the exposure times is too short for the higher rates, whilst at high dose values, the exposure times are too long for the lower rates, these tests shall exclude any exposure involving times of less than 10 s or exceeding 10 h.

If the integration of the dose equivalent meter is done digitally by a counter, one test of about 100 s per dose rate is sufficient.

The variation of the response is determined from the measured response values.

8.11.4 Method of test using natural radiation

Place the dose equivalent meter for at least one week (t_{env}) in a normal laboratory environment and assume a background dose rate $\dot{H}_{nat}$ of 2 µSv d^{-1}, if no other information is available. Determine the instrument's accumulated dose, G_{nat}, for time t_{env}. Calculate the expected dose value from the known or assumed dose rate due to natural environmental radiation, H_{nat} = 2 µSv $d^{-1} \times t_{env}$.

8.11.5 Interpretation of the results

The variation of the relative response due to dose rate dependence determined in 8.11.3 shall not exceed the range from –13 % to +18 %. In that case, the requirements of 8.11.2 can be considered to be met.

State the response to natural environmental radiation as $\frac{G_{nat}}{H_{nat}}$.

8.12 Response to pulsed ionizing radiation fields

8.12.1 Requirements

Some types of dose equivalent (rate) meters may give spuriously low indications in pulsed ionizing radiation fields, particularly if the duration of the pulse of radiation is small compared with the interval between pulses. The manufacturers shall give an appropriate warning if a dose equivalent (rate) meter may give a reduced indication in pulsed radiation fields. A test for the response of the dose equivalent (rate) meter in pulsed radiation fields is not mandatory.

8.12.2 Test method

The test method shall be subject to agreement between the purchaser and the manufacturer.

8.13 Requirements on the accuracy of alarm of dose equivalent (rate) monitors

8.13.1 Dose equivalent alarm

8.13.1.1 Requirement

Let H_a be the dose equivalent value which produces the indication to which the alarm is set. Under standard test conditions, when the dose equivalent meter or monitor is subject to a dose equivalent of 0,8 H_a, no alarm shall be given, and when the dose equivalent meter or monitor is subject to a dose equivalent rate of 1,2 H_a, the alarm shall be actuated.

When a dose equivalent (rate) meter utilizes more than one radiation detector to cover the full range of dose equivalent indicated by the dose equivalent (rate) meter, these requirements apply to the relevant ranges for each detector separately.

8.13.1.2 Method of test

At least two tests shall be carried out, one with H_a near to the maximum effective range and one with H_a near to the maximum of the second least significant order of magnitude. The alarm shall be reset, the dose indication shall be set to zero and then the dose equivalent meter or monitor shall be subjected to a conventional true dose equivalent rate so that the alarm will not occur for at least 100 s. The time of exposure until the alarm of the dose equivalent monitor occurs shall be measured.

8.13.1.3 Interpretation of the results

If the ratio of H_a and the product of the dose equivalent rate used and the measured time is within the range 0,8 $(1 - U_{rel})$ to 1,2 $(1 + U_{rel})$, where U_{rel} is the expanded (k = 2) relative uncertainty of the conventional true dose equivalent, then the requirements of 8.13.1.1 can be considered to be met.

8.13.2 Dose equivalent rate alarm

8.13.2.1 Requirement

Let $\dot{H}_a$ be the dose equivalent rate value which produces the indication to which the alarm is set. Under standard test conditions, when the dose equivalent (rate) meter or monitor is subject to a dose equivalent rate of 0,8 $\dot{H}_a$ for 10 min, the alarm shall not be activated for more than 10 % of the period of test. Similarly at a dose equivalent rate of 1,2 $\dot{H}_a$ for 10 min, the alarm shall be activated for 90 % of the test period and the alarm should actuate the first time within 10 s or within a time so that the product of this time and the dose equivalent rate of the alarm point is less than 10 µSv.

When a dose equivalent (rate) meter utilizes more than one radiation detector to cover the full range of dose equivalent rates indicated by the dose equivalent (rate) meter, these requirements apply to the relevant ranges for each detector separately.

8.13.2.2 Method of test

At least two tests shall be carried out, one with $\dot{H}_a$ near to the maximum effective range and one with $\dot{H}_a$ near to the maximum of the second least significant order of magnitude. Expose the dose equivalent (rate) meter for both $\dot{H}_a$ values for 10 min each to a dose equivalent rate of $(0,8 - U_{rel})$ $\dot{H}_a$ and record the time period for which the alarm is activated. Repeat the tests with a dose equivalent rate of $(1,2 + U_{rel})$ $\dot{H}_a$ and record again the time period for which the alarm is activated and the time for the alarm to be actuated the first time.

8.13.2.3 Interpretation of the results

If all the on-times of the alarm for $(0,8 - U_{rel}) \times \dot{H}_a$ are less than 60 s and all the on-times for $(1,2 + U_{rel}) \times \dot{H}_a$ are greater than 540 s and in addition the alarm actuates the first time within 10 s or within a time so that the product of this time and the dose equivalent rate $\dot{H}_a$ is less than 10 µSv, than the requirements of 8.13.2.1 can be considered to be met. U_{rel} is the expanded (k = 2) relative uncertainty of the conventional true dose equivalent rate.

9 Electrical characteristics of directional and ambient dose equivalent (rate) meters

9.1 Stability of zero indication with time

9.1.1 Requirements

The indication of a dose equivalent (rate) meter with a zero setting switch that has been set to zero after the dose equivalent (rate) meter has been in operation for 30 min under standard test conditions shall not differ from the indication after zero setting by more than $\pm$ 0,2 H_0 or $\pm$ 0,2 $\dot{H}_0$ during the next 4 h.

For dose equivalent (rate) meters without a zero-set control, the same requirements and test method apply except the step of setting to zero.

9.1.2 Test method

Switch on the dose equivalent (rate) meter and leave it for a period of 30 min. If a zero-set control is available to the operator, this shall then be adjusted to bring the indication to a point stated by the manufacturer. For some dose equivalent (rate) meters with a non-linear scale, such a control is used to bring the indication to some reference point rather than to zero. If this is the case, the control shall be set to bring the indication to the appropriate reference point.

The dose equivalent (rate) meter shall be left in this condition and the reading noted every 30 min for a further 4 h period.

9.1.3 Interpretation of the results

If the noted readings are proved to be within the limits of 9.1.1, then the requirements are met.

9.2 Warm-up time

9.2.1 Requirements

The time taken for a dose equivalent (rate) meter, after switching on while it is exposed to the reference radiation, to give an indication which does not differ by more than 5 % from the final value obtained under standard test conditions shall be stated by the manufacturer for each range.

9.2.2 Test method

With the dose equivalent (rate) meter switched off, expose it to an appropriate radiation source that will provide an indication of at least half of the scale maximum on the most sensitive range or order of magnitude. Switch on the instrument and note the readings every 15 s during a period of 6 min after switching on.

30 min after switching on, take a sufficient number of readings and use the mean value as the final value of the indication.

9.2.3 Interpretation of the results

From the graph of readings as a function of time note the warm-up time, where the reading should be within 5 % of the final reading.

9.3 Power supplies

9.3.1 General

Battery power shall be provided for portable dose equivalent (rate) meters. Facilities shall be provided for testing the battery under maximum load. Also, provision shall be made for indicating when the battery condition is no longer adequate for the performance of the dose equivalent (rate) meter to meet the requirements of this standard. Batteries may be connected in any desired manner but shall be individually replaceable; the correct polarity shall be clearly indicated on the dose equivalent (rate) meter by the manufacturer. Only primary or secondary batteries of physical dimensions as specified in IEC 60086-1 or IEC 60086-2 should be used.

Below –10 °C, the capacity of most types of batteries strongly decreases with decreasing temperature. This shall be considered.

9.3.2 Requirements

The manufacturer shall state the makers (manufacturers) and types of batteries with which the requirements of this standard are fulfilled.

If the methods of detection are different for photon and beta radiation, then these requirements shall be tested separately for all types of radiation.

The capacity of the batteries should be such that, after 40 h of intermittent use[5] during operation under standard test conditions, the indication of the dose equivalent (rate) meter shall remain within ±5 %, other functions remaining within specification.

For secondary batteries the manufacturer shall indicate the charging time.

9.3.3 Test method

9.3.3.1 General

The evaluation of the remaining battery capacity of the dose equivalent (rate) meter 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.

9.3.3.2 Test using batteries

New primary batteries or fully charged secondary batteries of the type indicated by the manufacturer shall be used for this test.

Expose the dose equivalent (rate) meter to a dose equivalent rate of between 10 μSv h^{-1} and 1 mSv h^{-1}.

Leave the dose equivalent (rate) meter working in this field for a period of 8 h followed by 16 h with the dose equivalent (rate) meter switched off. Perform this test for 5 consecutive days and note the reading at the end of the period.

The corresponding variation of the relative response shall not exceed ± 0,05 and no indication that the battery voltage is low, for example "low battery", shall be given.

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[5] 40 h intermittent use means 8 h continuous use followed by 16 h with the dose equivalent (rate) meter switched off, for 5 consecutive days.

9.3.3.3 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. The power supply shall be set to the nominal battery voltage U_{nom}. Expose the dosemeter to a dose equivalent rate of between 10 μSv h^{-1} and 1 mSv h^{-1}. The instrument shall be switched on and allowed to stabilise.

The dosemeter indication $\dot{G}_{nom}$ 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". The corresponding supply current I_{low} shall be noted together with the instrument indication $\dot{G}_{low}$.

The test is passed if the following requirements are met:

– $0{,}95 \leq \frac{\dot{G}_{low}}{\dot{G}_{nom}} \leq 1{,}05$,

– all auxiliary functions operating as selected and

– $\frac{Q_{nom}}{I_{low}} \geq 40\ h$,

where Q_{nom} is the nominal capacity of the batteries (given e.g. in mA h) for the appropriate discharge conditions and considering the rated range of temperature (see 11.2).

10 Mechanical characteristics of directional and ambient dose equivalent (rate) meters

10.1 Shock during operation (microphonics)

10.1.1 General

This influence quantity is considered to be of type S.

10.1.2 Requirements

For portable dose equivalent (rate) meters, the additional indication due to microphonics shall not exceed $\pm$ 0,7 H_0, if the dose equivalent (rate) meter is subjected to 60 repeated shocks, each shock corresponding to a drop from a height of at least 0,1 m, on to a hard steel surface (see Table 9). 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).

10.1.3 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 while the dose equivalent (rate) meter is in operation.

The dose equivalent (rate) meter shall be dropped 60 times on a hard steel surface (IEC 60068-2-31), from a given height, so that 10 shocks occur on each of the six main faces. The minimal height is 0,1 m.

After the test, the dose equivalent (rate) meter shall be inspected and the physical condition documented.

If the deviation due to microphonics does not exceed $\pm$ 0,7 H_0, then the requirements of 10.1.2 can be considered to be met.

10.2 Drop test during transport

10.2.1 Requirements

When packaged for transport, portable dose equivalent (rate) meters shall be able to withstand, without damage, 6 falls on orthogonal directions from a given height on concrete surface. The minimal height is 1 m.

In order to meet the above requirements, a (directional) dose equivalent (rate) meter normally requires some form of protective cover or case. The nature of the protection provided shall be stated. The requirements are not applicable to (directional) dose equivalent (rate) meters when they are in operation.

10.2.2 Test method

Perform the test as given in IEC 60068-2-31.

10.2.3 Interpretation of the results

After the tests, the dose equivalent (rate) meter shall be checked for mechanical damage or loose fittings. After maintaining normal conditions for the time specified in the certificate, the dose equivalent (rate) meter shall be switched on and the technical characteristics checked as specified for this type test.

10.3 Orientation of dose equivalent (rate) meter (geotropism)

10.3.1 General

This influence quantity is considered to be of type F.

10.3.2 Requirements

When exposed to the reference beta or gamma radiation, the indication of a portable dose equivalent (rate) meter shall not vary by more than ± 2 % of the full scale maximum angular deflection from that indicated in the reference orientation of use for any orientation of the dose equivalent (rate) meter.

The reference orientation shall be stated by the manufacturer.

10.3.3 Test method

Although, in principle, this test should be performed with the dose equivalent (rate) meter in any orientation, in general, only the indicating meter itself is influenced by differences in orientation. The orientations tested may therefore be confined to those that may be assumed by the meter with the dose equivalent (rate) meter held in the hand, and in which the reading scale would be visible to the operator.

During this test, the angle of incidence of radiation with respect to the dose equivalent (rate) meter should be constant. This may conveniently be done by attaching a suitable small test source to the dose equivalent (rate) meter.

NOTE If appropriate, the battery test function together with a power supply to generate an indication may be used for this test.

〈C〉 10.Z1 Drop test during operation

10.Z1.1 Requirements

Portable dose equivalent (rate) meters shall be able to withstand without damage, a drop from a height of 0,3 m onto a hard steel or concrete surface. 〈C〉

〈C〉 10.Z1.2 Test method

The dose equivalent (rate) meter shall withstand at least one single drop from 0,3 m to each surface of dose equivalent (rate) meter so that the unit is still operable after the drop. The test may be performed either with one or more test units in such a way that one drop onto each surface of the dose equivalent (rate) meter is tested. The instrument passes the test if the instrument response does not deviate after the 6 drop tests from the original response by more than - 17 % to + 25 %. The drop can make the instrument switch off but the user shall be able to switch the unit back on. The physical condition of the instrument shall not be affected by these drops (for example solder joints shall hold, nuts and bolts shall not come loose). 〈C〉

11 Environmental characteristics, performance requirements and tests

11.1 General

The influence quantity of 11.2 is considered to be of both types F and S, the influence quantities of 11.3 and 11.4 are considered to be of type F and the influence quantity of 11.7 is considered to be of type S.

11.2 Ambient temperature

11.2.1 Requirements

Over the rated range of temperature, the indication shall remain within –13 % to +18 % of that obtained under standard test conditions. Minimum rated range of temperature for dose equivalent (rate) meters is from –10 °C to +40 °C. For instruments designed for indoor use only the minimum rated range is from +5 °C to +40 °C. Such instruments shall be labelled “for indoor use only”. If the detector is an unsealed ionisation chamber, it is permissible for the indicated value to be corrected for air density, either by manual calculation or automatically by the dose equivalent (rate) meter, before the requirement is met.

NOTE For dose equivalent (rate) meters intended to operate at temperatures below –10 °C, some means of maintaining the batteries at a higher temperature may be required.

11.2.2 Test method

This test normally needs to be carried out in an environmental chamber. It is not, in general, necessary to control the humidity of the air in the box unless the dose equivalent (rate) meter is particularly sensitive to changes of humidity.

Expose the dose equivalent (rate) meter to a source of radiation suitable to give a dose equivalent or dose equivalent rate of 10 H_0 or 10 $\dot{H}_0$ and note the reading under standard test conditions (see Table 4).

The temperature shall then be maintained at each of its extreme values for at least 4 h, and the dose equivalent (rate) meter exposed as before. The indication of the dose equivalent (rate) meter shall be measured during the last 30 min of this period.

11.2.3 Interpretation of the results

If the measured indications are proved to be within the limits of 11.2.1, then the requirements are met.

11.3 Relative humidity

11.3.1 Requirements

The indication of the dose equivalent (rate) meter shall not vary by more than –9 % to +11 % from that obtained under standard test conditions, with the exception of 35 °C ambient temperature, for all relative humidities within the rated range. The minimal rated range covers all relative humidity levels up to 85 % at a temperature of 35 °C.

11.3.2 Test method

The test shall be carried out at a single temperature of 35 °C, using an environmental chamber. Each humidity value shall be maintained for at least 4 hours and the indication measured at the end of the period. The permitted variation of –9 % to +11 % in the indication is additional to the permitted variation due to temperature alone.

11.3.3 Interpretation of the results

If the measured indications are proved to be within the limits of 11.3.1, then the requirements are met.

11.4 Atmospheric pressure

11.4.1 Requirements

Over the range of atmospheric pressure from 70 kPa to 106 kPa, the response of the dose equivalent (rate) meter shall not vary by more than –9 % and +11 % from that under reference conditions. If the detector is an unsealed ionisation chamber it is permissible for the indicated value to be corrected for air density, either by manual calculation or automatically by the dose equivalent (rate) meter, before the requirement is met.

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

11.4.2 Test method

The response shall be measured at an air pressure of 70 kPa and at 106 kPa and be compared with the measurement result for the reference atmospheric pressure of 101,3 kPa. ▌C〉 The differences shall be within - 9 % to + 11 %. 〈C▐

11.5 Sealing against moisture

For dose equivalent (rate) meters intended for outdoor use, the manufacturer shall state the precautions that shall be taken to prevent the ingress of moisture. The IP classification according to IEC 60529 shall be stated by the manufacturer, at least IP 53 shall be fulfilled.

11.6 Storage and transport

All apparatus designed for use in temperate climates shall be designed to operate within the specifications of this standard after sufficient time has been allowed to reach ambient temperature following storage (or transport), without batteries, for a period of at least three months in the manufacturer's packaging at any temperature between –25 °C and +50 °C.

In certain circumstances, more severe specifications may be required, such as capability for withstanding air transport at low ambient pressure.

11.7 Electromagnetic compatibility

11.7.1 General

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). All EMC tests cause deviations of the dose equivalent (rate) meter. Therefore, all requirements are given with respect to the lower limit H_0 or $\dot{H}_0$ of the effective range of measurement. For each of the EMC tests given in 11.7.3 to 11.7.6, the dose equivalent (rate) meter shall be set to the most sensitive range and the dose value set to zero and any deviations due to the tests shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$. The duration of the electromagnetic disturbance shall be such that it is equivalent to 1 h operation according to the frequency data given in Table 8. All tests shall be done in accordance with IEC 61000-4 series.

For all tests, the rated ranges are taken from IEC 61000-6-2 together with performance criteria A, B or C, see Table 8. Only criteria A or B are permitted. If criterion B is permitted, then the requirements given in Table 8 apply to the values of the dose equivalents indicated before and after the test. The electric field strength at 800 MHz to 960 MHz and 1,4 GHz to 2,7 GHz are orientated to the field strength in the vicinity of cellular phones.

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

11.7.2 Emission of electromagnetic radiation

The relevant IEC standards are applicable.

11.7.3 Electrostatic discharge

a) Requirements

The maximum spurious deviations (both transient and permanent) at the display or data output due to electrostatic discharge shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$ after 10 discharges (see Table 8).

b) Test method

Compliance with this performance requirement shall be checked by observing and recording the indications at the display and any data output terminals while discharging a suitable test generator as described in IEC 61000-4-2 at least five times to those various external parts of the complete equipment which may be touched by the operator during a normal measurement, when the dose equivalent (rate) meter 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 dose equivalent (rate) meters with insulated surfaces are tested, the air discharge method with a voltage of 8 kV (severity level 3) shall be used.

11.7.4 Radiated electromagnetic fields

11.7.4.1 General radiated electromagnetic fields

a) Requirements

The maximum spurious deviations (both transient and permanent) of the display or data output due to electromagnetic fields of 10 V m^{-1} in the frequency range of 80 MHz to 800 MHz and 960 MHz to 1,4 GHz shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$. For a dose equivalent meter, this deviation shall not be exceeded after 6 min (10 % of 1 h) of exposure to the electromagnetic field (see Table 8).

b) Test method

Compliance with this performance requirement shall be checked by observing and recording the indications of the display and any data output terminals with the dose equivalent (rate) meter set to the most sensitive range. During the tests, the device shall be exposed to a dose rate of about 7 $\dot{H}_0$.

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

Perform tests at frequencies of (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) MHz and (1,0; 1,1; 1,2 and 1,3) GHz with a field strength of 20 V m^{-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 frequencies, additional tests in the range of $\pm$ 5 % around this frequency in steps of 1 %

and with a field strength of 10 V m^{-1} shall be carried out with the dose equivalent (rate) meter in all three orientations as described in IEC 61000-4-3.

11.7.4.2 Radiated electromagnetic fields of mobile phones and wireless LAN

a) Requirements

The maximum spurious deviations (both transient and permanent) of the display or data output due to electromagnetic fields of 30 V m^{-1} in the frequency range of of 800 MHz to 960 MHz and 1,4 GHz to 2,7 GHz shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$. For a dose equivalent meter this deviation shall not be exceeded after 6 min (10 % of 1 h) of exposure to the electromagnetic field (see Table 8).

b) Method of test

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. During the tests, the device shall be exposed to a dose rate of about 7 $\dot{H}_0$.

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

Perform tests at frequencies of (820; 900) MHz and (1,4; 1,5; 1,6; 1,8; 2,0; 2,2; 2,4 and 2,7) GHz with a field strength of 60 V m^{-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 frequencies, additional tests in the range of $\pm$ 5 % around this frequency in steps of 1 % and with a field strength of 30 V m^{-1} shall be carried out with the dose equivalent (rate) meter in all three orientations as described in IEC 61000-4-3.

11.7.5 Conducted disturbances induced by radio-frequencies

a) Requirements

The maximum spurious deviation (both transient and permanent) of the display or data output due to conducted disturbances induced by radio-frequencies shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$. For a dose equivalent meter, this indication shall not be exceeded after 6 min (10 % of 1 h) of exposure to the electromagnetic field (see Table 8). Dose equivalent (rate) meters that do not have at least one conducting cable (e.g. signal line) are excluded from this test.

b) Test method

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 voltage shall be 10 V in the frequency range of 150 kHz to 80 MHz in steps of 1 % and the disturbances shall be induced according to IEC 61000-4-6. To reduce the amount of measurements needed to show compliance with the above requirement, methods similar to those given in 11.7.4 may be used.

11.7.6 50 Hz/60 Hz magnetic field

a) Requirements

The additional spurious deviation (both transient and permanent) of the display or data output due to 50 Hz or 60 Hz magnetic field shall not exceed $\pm$ 0,7 H_0 or $\pm$ 0,7 $\dot{H}_0$. For a dose equivalent meter, this indication shall not be exceeded after 6 min (10 % of 1 h) of exposure to the magnetic field (see Table 8).

b) Test method

Compliance shall be checked by observing and recording the indications of the display and any data output terminals while measurements are performed on the most sensitive range. The dose equivalent (rate) meter shall be exposed to continuous fields of 30 A m^{-1} at a frequency of 50 Hz or 60 Hz. The dose equivalent (rate) meter should be exposed in a minimum of two orientations (0° and 90°) relative to the field lines.

12 Software

12.1 General

The final version of the software shall be available at the beginning of the type test, as a great part of the software test is indirectly covered by the metrological test. The manufacturer shall be aware of the fact that any change of the “data relevant part” of the software may question the validity of the type test.

NOTE In modern instruments, the software has increasing importance for the generation of the measured value. Therefore, the type test automatically includes the performance of the software running in the device under test. This is considered by the given requirements.

The requirements given are guided by the WELMEC software guide 7.2, see Bibliography. The requirements are based on the requirements for instruments with embedded software in a built-for-purpose measuring instruments (Type P) and a risk class B (low level).

12.2 Requirements

12.2.1 General requirements

The requirements set shall prevent any unintended modification of the software of the data. In addition, any intended modification of the software shall be prevented unless done in the foreseen way by authorized personnel.

12.2.2 Design and structure of the software

The software shall be designed in such a way that the part relevant for the indicated value is not affected by other software unless the effect is required for the correct use of the dose equivalent (rate) meter.

NOTE One possible technical solution is to separate the software into two parts. One part contains all the functions necessary to evaluate, store and display the indicated values. This part is the “data relevant part”. The other parts of the software, the “non data relevant part”, contain for example value, date and time of a maximum of the indication. The data relevant part has well defined functions (software interface) that are used to communicate with the non data relevant software parts. This technical concept of software separation has the advantage, that the “non data relevant part” may be modified without influencing the “data relevant part”. The concept of software separation is state of the art in software engineering.

12.2.3 Protection of the software and data

12.2.3.1 Identification

The “data relevant part” of the software (see note to 12.2.2) shall have an identification. It shall be possible to display this identification while the software is running. This identification can be compared with the identification given in the test record or in the user instructions.

NOTE If the identification automatically changes in case the software is changed – in that case a simple version number is not sufficient – an additional benefit is given. Any change of a bit in the stored software of the dose equivalent (rate) meter, e.g. due to radiation, is recognized. One possible technical solution is a check sum, at least CRC-16, built over the software. The reference value of the checksum is stored. During start up of the instrument, the checksum is calculated again and compared with the stored reference value. In case a change occurred, the software stops and supplies an appropriate error message.

12.2.3.2 Alarm under abnormal operating conditions

When abnormal operating conditions occur in components of the dose equivalent (rate) meter, this shall be indicated. These abnormal operating conditions include those that lead to a faulty indication or loss of dose information, for example high voltage failure in a photomultiplier tube.

12.2.3.3 Control of input data

All values used for the determination of the indicated value, for example, calibration factors and high voltage of a GM tube, shall be secured against unauthorised modification.

NOTE One possible technical solution is to require a password before any change of such data.

12.2.3.4 User interfaces, hardware interfaces and software interfaces

All entered commands or values received via interfaces (for example, user interfaces as keyboard, software interfaces) shall influence the instrument's data and functions in an admissible way only. All commands or values have to be defined, i.e., they shall either have a meaning and processing by the instrument shall be possible, or the instrument shall identify them as being invalid. Invalid commands shall not have any effect whatsoever on the data and functions of the instrument.

NOTE In principle, it is possible to circumvent a software interface. This can usually be excluded by software separation, see note to 12.2.2, when the data relevant part of the software is realized in a separate binary file.

12.2.4 Documentation

12.2.4.1 Documentation in the instruction manual

The whole functionality and all menus and submenus of the software shall be described in the instruction manual, see Clause 14.

12.2.4.2 Documentation for the type test

Beside the documentation listed in Clause 14, the following information shall be given by the manufacturer for the purpose of type testing:

– a description of the structure of the software according to 12.2.2;
– the method to evaluate and display the identification and to prevent measurements with changed software, see 12.2.3.1;
– the measures to recognize abnormal operation conditions, see 12.2.3.2;
– a complete list of all relevant parameters, their ranges and nominal values, the method to make sure that they are in allowed ranges, where they are stored, how they may be viewed, and how they can be changed, see 12.2.3.3;
– a complete list of all commands (e.g. menu items) and values that can be received via the interfaces, including their effect, see 12.2.3.4.

12.3 Method of test

12.3.1 General

Testing of software can be a very complex item, however, it shall not dominate the testing-time. Therefore, no specific test is given and a large amount of responsibility is handed over to the manufacturer. The only test is done indirectly by performing the type test with the final version of the software and using the manufacturer's documentation, see 12.2.4, to perform the tests. The only test is on the documentation.

12.3.2 Testing the documentation

By using the software during the type test a lot of menus will be used. All of them shall be documented in the instruction manual. The rest of the menus shall be checked by “playing” with the running software and comparing the corresponding parts of the instruction manual. If not all of the menus found in the software and in the instruction manual fit together, the requirement is not met. This should also be done for additional software and for the interfaces. In addition, the identification (see 12.2.3.1) shall be displayed and given in the certificate.

13 Summary of characteristics

The requirements of the various performance characteristics are summarized, for convenience, in Tables 4 to 9. These tables also give the number of the relevant clauses in which the requirements for each particular characteristic are described.

14 Documentation

14.1 Information on the instrument

Each dose equivalent (rate) meter shall give the following information on its housing:

– manufacturer's name or registered trade mark;
– type of the dose equivalent (rate) meter and serial number;
– type of radiation the dose equivalent (rate) meter is intended to measure;
– measuring quantity;
– effective range of measurement;
– rated range of the combined influence quantity radiation energy and angle of radiation incidence;
– rated range of ambient temperature;
– reference point of the dose equivalent (rate) meter;
– reference direction.

14.2 Certificate

A certificate shall accompany each dose equivalent (rate) meter, giving at least the following information (IEC 61187):

– manufacturer's name or registered trade mark;
– type of the dose equivalent (rate) meter and serial number;
– type of radiation the dose equivalent (rate) meter is intended to measure;
– scale limits for each measuring range;
– measuring quantity;
– measuring range and variation of the response due to non-linear response;
– coefficient of variation as a function of the dose equivalent;
– relative response as a function of radiation energy and angle of incidence (for both beta and photon radiation);
– rated ranges of all other influence quantities and the corresponding variation of the response or deviation;
– reference point of the dose equivalent (rate) meter for calibration purposes and reference orientation relative to the calibration source;
– reference direction;

– identification of the software.

14.3 Operation and maintenance manual

Each dose equivalent (rate) meter shall be supplied with an appropriate instruction manual in accordance with IEC 61187.

14.4 Type test report

On request by the customer, the manufacturer shall provide the type test report according to this standard.

Table 3 – Values of c_1 and c_2 for w different dose (rate) values and n indications for each dose (rate) 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

NOTE Values taken from Brunzendorf and Behrens, see Bibliography.

EXAMPLE For 12 different dose rates and 10 indications taken at every dose rate value, the c_1 value becomes c_1 = 1,173 and the c_2 value becomes c_2 = 1,548.

Table 4 – 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: 1) Ambient dose equivalent, $H^*(10)$ 2) Directional dose equivalent, $H'(0,07)$	Gamma radiation from ^{137}Cs or N-100 (ISO 4037-3) N-80 or S-Am (ISO 4037-3)	Gamma radiation from ^{137}Cs or N-100 (ISO 4037-3) N-80 or S-Am (ISO 4037-3)
Beta radiation energy 2) Directional dose equivalent, $H'(0,07)$	^{90}Sr/^{90}Y (ISO 6980-1)	^{90}Sr/^{90}Y (ISO 6980-1)
Dose for: $H^*(10)$ $H'(0,07)$	 100 µSv 100 µSv	 10 µSv to 1 mSv [a] 10 µSv to 1 mSv [a]
Dose rate for: $\dot{H}^*(10)$ $\dot{H}'(0,07)$	 10 µSv h^{-1} 100 µSv h^{-1}	 3 µSv h^{-1} to 100 µSv h^{-1} [a] 10 µSv h^{-1} to 1 mSv h^{-1} [a]
Stabilization time	15 min	≥15 min
Ambient temperature	20 °C	18 °C to 22 °C [a]
Relative humidity	65 %	55 % to 75 % [a]
Atmospheric pressure	101,3 kPa	86,0 kPa to 106,6 kPa [a]
Power supply voltage	Nominal power supply voltage	Nominal power supply voltage ± 1 %
Angle of incidence of radiation	Calibration direction given by manufacturer	Direction given ± 5°
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 dose equivalent (rate) meter and/or monitor	To be stated by the manufacturer	Stated orientation ± 5°
Dose equivalent (rate) meter and/or monitor controls	Set up for normal operation	Set up for normal operation
Radiation background	0,1 µSv h^{-1} or less if practical	Less than 0,25 µSv h^{-1}
Contamination by radioactive elements	Negligible	Negligible
[a] The actual values at the time of test shall be stated.		

Table 5 – Radiation characteristics of directional dose equivalent (rate) meters

Characteristics under test or influence quantity	(Minimum) rated range of influence quantity	Limits of variation of the relative response	Subclause
Linearity	Three orders of magnitude including 100 µSv h^{-1} and 100 µSv	– 15 % to + 22 %	5.5 and 8.7
Statistical fluctuation: dose equivalent	$H = H_0$ [a] $H_0 < H < 11\ H_0$ $H \geq 11\ H_0$	15 % (16 – H / H_0) % 5 %	8.7
Statistical fluctuation: dose equivalent rate	$\dot{H} = \dot{H}_0$ [a] $\dot{H}_0 < \dot{H} < 11\ \dot{H}_0$ $\dot{H} \geq 11\ \dot{H}_0$	15 % (16 – $\dot{H} / \dot{H}_0$) % 5 %	8.7
Beta radiation energy and angle of incidence	E_{mean} of beta radiation 200 keV to 800 keV and 0° to ± 45° from reference direction	– 29 % to + 67 %	8.5.1
X and gamma radiation energy and angle of incidence	10 keV to 250 keV and 0° to ± 45° from reference direction	– 29 % to + 67 %	8.4.1
Angle of incidence – beta radiation	0° to ± 60° from reference direction	To be stated by the manufacturer	8.5.1
Angle of incidence – X and gamma radiation	0° to ± 90° from reference direction	To be stated by the manufacturer	8.4.1
Dose rate for dose measurements	5 µSv h^{-1} to 1 Sv h^{-1} [b]	–13 % to +18 %	8.11
Overload	100 times the range maximum for range maxima up to and including 0,1 Sv h^{-1} 10 times the range maximum, or 10 Sv h^{-1}, whichever is the greater, for range maxima more than 0,1 Sv h^{-1}	Indication to be off-scale on the high side or dose equivalent (rate) meter to indicate overload (for 5 min)	8.8
Effects of neutron radiation	Not applicable	Response to be stated by the manufacturer	8.6.1

[a] H_0 and $\dot{H}_0$ are the lower limits of the measuring range of dose equivalent and dose equivalent rate.

[b] At least maximum value of measuring range of dose rate.

Table 6 – Radiation characteristics of ambient dose equivalent (rate) meters

Characteristic under test or influence quantity	(Minimum) rated range of influence quantity	Limits of variation of the relative response	Subclause
Linearity	Three orders of magnitude including 10 µSv h^{-1} and 100 µSv	– 15 % to + 22 %	5.5 and 8.7
Statistical fluctuation: dose equivalent	$H = H_0$ [a] $H_0 < H < 11\ H_0$ $H \geq 11\ H_0$	15 % (16 – H / H_0) % 5 %	8.7
Statistical fluctuation: dose equivalent rate	$\dot{H} < \dot{H}_0$ [a] $\dot{H}_0 \leq \dot{H} < 11\ \dot{H}_0$ $\dot{H} \geq 11\ \dot{H}_0$	15 % (16 – $\dot{H}$ / $\dot{H}_0$) % 5 %	8.7
Beta radiation energy and angle of incidence	E_{mean} of beta radiation 800 keV and 0° from reference direction	Indication less than 10 % of the exposed $H'(0{,}07)$ or $\dot{H}'(0{,}07)$ dose (rate) value	8.5.1
X and gamma radiation energy and angle of incidence	80 keV to [C] 1,33 MeV [C] or 20 keV to 150 keV and 0° to ± 45° from reference direction	– 29 % to + 67 %	8.4.2
Angle of incidence – X and gamma radiation	0° to 90° from reference direction	To be stated by the manufacturer	8.4.2
Dose rate for dose measurements	5 µSv h^{-1} to 1 Sv h^{-1} [b]	–13 % to +18 %	8.11
Overload	100 times the range maximum for range maxima up to and including 0,1 Sv h^{-1} 10 times the range maximum, or 10 Sv h^{-1}, whichever is the greater, for range maxima more than 0,1 Sv h^{-1}	Indication to be off-scale on the high side or dose equivalent (rate) meter to indicate overload (for 5 min)	8.8
Effects of neutron radiation	Not applicable	Response to be stated by the manufacturer	8.6.1
Response time	Not applicable	$\dot{G}_f$ < 10 mSv h^{-1}: < 10 s to indicate 90 % of change $\dot{G}_f$ > 10 mSv h^{-1}: 2 s After 60 s: indicate $(1 \pm 0{,}1)\dot{G}_f$	8.9

[a] H_0 and $\dot{H}_0$ are the lower limits of the measuring range of dose equivalent and dose equivalent rate.

[b] At least maximum value of measuring range of dose rate.

Table 7 – Electrical, mechanical and environmental characteristics of directional and ambient dose equivalent (rate) meters

Characteristic under test or influence quantity	(Minimum) rated range of influence quantity	Limits of variation of the relative response or of the deviation	Sub-clause
Zero drift	Period of 4 h	± 0,2 H_0 or ± 0,2 $\dot{H}_0$ respectively	9.1
Warm-up time	Not applicable	Time to read within ± 5 % of final value under reference conditions to be stated	9.2
Power supplies Primary and secondary batteries	For 40 h intermittent use	± 5 %	9.3
Orientation of dose equivalent (rate) meter	Any	± 2 % of full scale maximum angular deflection	10.3
Ambient temperature	–10 °C to +40 °C Instruments labelled "for indoor use only": +5 °C to +40 °C	–13 % to +18 % for a dose of 10 H_0 or a dose rate of 10 $\dot{H}_0$	11.2
Relative humidity	up 85 % relative humidity at 35 °C	–9 % to +11 % [a]	11.3
Atmospheric pressure	70 kPa to 106 kPa	–9 % to +11 %	11.4
Sealing	IP 53 according to IEC 60529	Precautions to be stated	11.5
Storage	–25 °C to +50 °C for three months	To operate within specification after unpacking	11.6

[a] Limit of variation from the indication at 35 °C and reference humidity.

Table 8 – Maximum values of deviation due to electromagnetic disturbances

Influence quantity or instrument parameter	Minimum rated range of influence quantity	Test according to	Frequency	Maximum value of deviation [a]	Criterion [b]	Subclause
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 or ± 0,7 $\dot{H}_0$	B	11.7.3
General radiated electromagnetic fields, field strength and modulation	80 MHz to 800 MHz and 960 MHz to 1,4 GHz 0 V m^{-1} to 10 V m^{-1} (r.m.s., unmodulated) 80 % AM (1 kHz)	IEC 61000-4-3	10 % of time	± 0,7 H_0 or ± 0,7 $\dot{H}_0$	A	11.7.4.1
Radiated electromagnetic fields of mobile phones and wireless LAN, field strength and modulation	800 MHz to 960 MHz and 1,4 GHz to 2,7 GHz 0 V m^{-1} to 30 V m^{-1} (r.m.s., unmodulated) 80 % AM (1 kHz)	IEC 61000-4-3	10 % of time	± 0,7 H_0 or ± 0,7 $\dot{H}_0$	A	11.7.4.2
Conducted disturbances induced by radio-frequencies, frequency and voltage	150 kHz to 80 MHz 0 to 10 V (r.m.s., unmodulated) 80 % AM (1 kHz)	IEC 61000-4-6	10 % of time	± 0,7 H_0 or ± 0,7 $\dot{H}_0$	A	11.7.5
50 Hz/60 Hz magnetic field, field strength	0 A m^{-1} to 30 A m^{-1}	IEC 61000-4-8	10 % of time	± 0,7 H_0 or ± 0,7 $\dot{H}_0$	A	11.7.6

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

[b] See IEC 61000-6-2.

Table 9 – Mechanical performance under test conditions

Influence quantity	Minimum rated range of influence quantity	Test conditions	Subclause
Microphonics	0,1 m	60 drops from a given height onto steel surface (IEC 60068-2-31)	10.1
Drop during transport	1 m	6 falls on orthogonal directions from a given height on concrete surface	10.2
Drop during operation	0,3 m	6 drops from a given height onto steel or concrete surface	10.Z1

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 dosemeter readings required to determine true differences between two sets of dosemeter 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 dosemeter readings required.

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

The interval between dosemeter 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 [6]

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

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.

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

Annex B
(informative)

Usage categories of ambient/directional dose (rate) meters

The usage categories, given in Table B.1 can be used to categorize ambient or directional dose (rate) equivalent meters for approval purposes.

Table B.1 – Usage categories of ambient or directional dose (rate) meters

Main Category	Symbol	Minimum required range of use	Optional extensions			
			for energy range	for angle range	for dose rate range	for dose range
$H^*(10)$ gamma radiation	**G**	energy: 80 keV to [C] 1,33 MeV [C] angle: – 45° to + 45° dose rate: 3 orders of magnitude, including 10 μSv h^{-1} dose (if provided): 3 orders of magnitude, including 0,1 mSv	**m** (mid): lower limit 60 keV **l** (low): lower limit 20 keV **h** (high): includes 6 MeV	**w** (wide): – 90° to + 90°	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,03 μSv h^{-1}	**a** (accident): upper limit 2 Sv **f**: lower limit 10 μSv **k**: lower limit 0,1 μSv
$H^*(10)$ X radiation	**X**	energy: 20 keV to 150 keV angle: – 45° to + 45° dose rate: 3 orders of magnitude, including 10 μSv h^{-1} dose (if provided): 3 orders of magnitude, including 0,1 mSv	**l** (low): lower limit 10 keV **h** (high): includes 300 keV	**w** (wide): – 90° to + 90°	**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,03 μSv h^{-1}	**a** (accident): upper limit 2 Sv **f**: lower limit 10 μSv **k**: lower limit 0,1 μSv
$H'(0,07)$ X, gamma radiation	**S** (skin)	energy: 10 keV to 250 keV dose rate: 3 orders of magnitude, including 0,1 mSv h^{-1} dose (if provided): 3 orders of magnitude, including 0,1 mSv	**h**:(high) includes 300 keV **u**:(ultra) includes 1,3 MeV		**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,5 μSv h^{-1}	**a** (accident): upper limit 2 Sv **f**: lower limit 10 μSv
$H'(0,07)$ Beta radiation	**B**	mean-energy (E_{mean}): 200 keV to 800 keV dose rate: 3 orders of magnitude, including 0,1 mSv h^{-1} dose (if provided): 3 orders of magnitude, including 0,1 mSv	**l**: low limit 60 keV (E_{mean})		**a** (accident): upper limit 10 Sv h^{-1} **e** (environmental): lower limit 0,5 μSv h^{-1}	**a** (accident): upper limit 2 Sv **f**: lower limit 10 μSv
EXAMPLE A gamma dosemeter for a nuclear plant to measure in accidental conditions may be classified as **Gha**. A fixed installed dosemeter for environmental monitoring of dose rate may be classified as **Gmhwe** and for dose as **Gmhwk.**						

Annex C
(informative)

Calibration of ambient dose equivalent (rate) meters for environmental monitoring

For the measurement of low ambient dose equivalent rates, it is necessary to take into account the contribution of background radiation to the ambient dose equivalent rate at the point of test. This requires a detailed knowledge of the detector's response to the different components of the background. These problems are discussed in this annex. The cosmic radiation response and the internal background of each assembly should be determined.

The indication $\dot{G}$ of an assembly that is irradiated by a calibration source may be represented by:

$$\dot{G} = R_{\mathrm{c}}\,\dot{H}^{*}(10)_{\mathrm{c}} + R_{\mathrm{t}}\,\dot{H}^{*}(10)_{\mathrm{t}} + R_{\mathrm{s}}\,\dot{H}^{*}(10)_{\mathrm{s}} + \dot{G}_{0}$$

where

$\dot{G}$ is the dose rate indication in terms of $H^{*}(10)$, e.g. in units of nSv h^{-1};

$\dot{H}^{*}(10)_{\mathrm{c}}$ is the ambient dose equivalent rate due to the cosmic component of the background radiation in the calibration room;

$\dot{H}^{*}(10)_{\mathrm{t}}$ is the ambient dose equivalent rate due to the terrestrial gamma component of the background radiation in the calibration room;

$\dot{H}^{*}(10)_{\mathrm{s}}$ is the ambient dose equivalent rate due to the calibration source;

R_{c} is the response to the cosmic component of the background radiation;

R_{t} is the response to the terrestrial gamma component of the background radiation;

R_{s} is the response to the radiation of the calibration source;

$\dot{G}_{0}$ is the contribution to the reading arising from any internal radioactive contamination or from the electronic noise of the instrument.

For many detectors, R_{c}, R_{t} and R_{s} are usually not equal and the factor R_{s} depends on the photon energy so that the value R_{s} derived from a laboratory calibration with point sources or beams will not be equal to R_{t} and cannot be directly used for field measurements. To determine R_{c}, R_{t}, R_{s} and $\dot{G}_{0}$ it is necessary to measure each response separately by elimination of the other three influence quantities. This can be done in the following way.

a) By determining how R_{s} varies with energy and weighting the appropriate R_{s} values by the environmental energy spectrum, a value of R_{t} applicable to the field use of the assembly can be calculated.

b) The indication $\dot{G}_{0}$ due to the internal background of any instrument can be estimated, for example, by observing the instrument reading when it is taken to large depths below ground. At a depth of 100 m, cosmic radiation is effectively eliminated and by placing the detector within a 10 cm thick lead shield its response to the radiation from the local rocks can also be virtually eliminated.

   For ionization chambers, $\dot{G}_{0}$ can normally be considered as due to intrinsic alpha radioactivity in the chamber. It can be estimated by placing the chamber in a shielded low background facility and monitoring the electrometer output with a short time constant recorder. Alpha pulses can be identified by large spikes produced in the recorder output. Periodic checks for leakage current and for insulator stresses should also be made. The unidirec-

tional currents arising from stress within the insulator can be determined by making measurements with both positive and negative polarizing voltages.

The internal background of any instrument should not change significantly during its life because the radio nuclides present have long half-lives. Nevertheless, occasional checks are advisable since the instrument may become contaminated by external sources itself.

c) The determination of the cosmic response R_c can be made either experimentally or from a theoretical calculation of the interaction of the cosmic rays in the detector. The experimental measurement of the cosmic ray response can be made on a boat or on a swimming platform, constructed from material of low radioactivity, on a fresh water lake or reservoir or at sea at least 100 m to 1 km from the shore.

The X or gamma ray calibration of the instrument R_s may be accomplished as follows:

1) the background reading, $\dot{G}_{0,s}$, of the instrument is first taken before exposure to the calibration source;

2) the assembly is then exposed to the source and the reading $\dot{G}_s$ noted;

3) $R_s = \dfrac{\dot{G}_s - \dot{G}_{0,s}}{\dot{H}^*(10)_s}$.

This method eliminates the effects of the response due to cosmic radiation, that due to the calibration laboratory background dose and from the $\dot{G}_0$ contribution. It should be noted, however, that it is only applicable if the scattered radiation from the source is negligible. Where significant scattered radiation is present, these two measurements shall be replaced by one with the source present and by a second with a 5 cm deep lead shadow shield placed between the detector and the source, whose shape is just sufficient to shield the detector from the direct radiation from the calibration source. Subtraction of the lead shield reading allows the response to the source primary radiation to be determined.

Alternatively, in a low background environment, e. g. 100 m or more below ground, use at least three different ambient dose equivalent rates for calibration. The lowest dose rate should be close to but significantly above internal background of the environment.

4) Determine the contribution to the reading, $\dot{G}_0$, arising from any internal radioactive contamination or from the electronic noise of the instrument by extrapolating the indication to zero ambient dose equivalent rate.

5) Determine the response R_s from the slope of the linear dependence of the instrument reading $\dot{G}_s$ versus ambient dose equivalent rate $\dot{H}^*(10)_s$ of the calibration source.

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