BS IEC 60846-2:2015

BSI Standards Publication

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

Part 2: High range beta and photon dose and dose rate portable instrumentation for emergency radiation protection purposes

National foreword

This British Standard is the UK implementation of IEC 60846-2:2015.

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 2: High range beta and photon dose and dose rate portable instruments for emergency radiation protection purposes

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 2: Instruments portables de grande étendue, pour la mesure de la dose et du débit de dose des rayonnements photoniques et bêta dans des situations d'urgence de radioprotection

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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 2: High range beta and photon dose and dose rate portable instruments for emergency radiation protection purposes

FOREWORD

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International Standard IEC 60846-2 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition of IEC 60846-2, issued in 2007, as well as IEC 61018, issued in 1991; it constitutes a technical revision.

The main technical change with regard to the previous edition consists of an update to the revised edition of IEC 60846-1:2009.

This International Standard IEC 60846-2 is to be used in conjunction with IEC 60846-1:2009. For the purposes of this standard, clauses/subclauses of IEC 60846-1:2009 apply, without modifications, except when stated. The modified clauses/subclauses are identified by the same number as in IEC 60846-1:2009 or, for new clauses/subclauses, by a higher number not used in IEC 60846-1:2009.

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

FDIS	Report on voting
45B/822/FDIS	45B/834/RVD

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

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

A list of all parts of the IEC 60846 series, under the general title *Radiation protection instrumentation – Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation*, can be found on the IEC website.

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

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

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

Part 2: High range beta and photon dose and dose rate portable instruments for emergency radiation protection purposes

1 Scope and object

This part of IEC 60846 applies to portable or transportable dose equivalent (rate) meters and/or monitors for the measurement of ambient and/or directional dose equivalent (rate) from external beta, X and gamma radiation for energies up to 10 MeV during emergency situations.

The object of this International Standard is to specify the design requirements and the performance characteristics of dose equivalent (rate) meters intended for the determination of ambient and/or directional dose equivalent (rate) as defined in ICRU Report 47 under emergency conditions. With the exception of modified or new clauses listed below, all clauses in IEC 60846-1:2009 are applicable for instruments used for emergency purposes.

This International Standard does not specify which instruments are required nor does it consider the numbers or specific locations of such instruments. This International Standard does not identify instrumentation for specific types of accidents. It is essential that the rated ranges of the instruments and the radiological and non-radiological conditions for which the instruments are designed adequately cover the accident and post-accident conditions as determined by accident analysis and/or specified by appropriate regulatory authorities or qualified individuals. It is expected that accidents will involve both dose equivalent (rate) and environmental extremes (e.g. temperature and humidity). Specifications for instruments for measuring dose equivalent rates less than the minimum detectable dose rate level specified in this International Standard are contained in IEC 60846-1:2009. Where such instruments are also used for emergency measurements, the requirements of this International Standard apply.

Although this International Standard specifies the requirements for instruments primarily for emergency use, such instruments may also be used for on-site measurements at other times. If the instrument has a remote detector and if an additional detector is provided in the measuring assembly to measure dose equivalent rate at the location of the operator, the requirements apply to both of the detectors.

2 Normative references

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

This clause of IEC 60846-1:2009 applies, with the following additional references:

IEC 60325:2002, *Radiation protection instrumentation – Alpha, beta and alpha/beta (beta energy > 60 keV) contamination meters and monitors*

IEC 60846-1:2009, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 3.1 to 3.33 of IEC 60846-1:2009 and the following apply:

3.34
extracameral response
response to radiation of all the parts of the instrument except the detector itself

3.35
emergency situation
situation in which the dose equivalent (rates) of interest and one or more of the influence quantities are not covered in IEC 60846-1

4 Units and list of symbols

For the purposes of this standard, the units and list of symbols given in 4.1 to 4.2 of IEC 60846-1:2009 apply, without modifications.

5 General characteristics of ambient dose equivalent (rate) meters for emergency purposes

For the purposes of this standard, 5.1 to 5.14 of IEC 60846-1:2009 apply, without modifications, except as stated in the following subclauses. The changed subclauses are identified by the same number as in IEC 60846-1:2009 or, for new subclauses, by a higher number not used in IEC 60846-1:2009.

5.2 Read-out

Single scale is preferred. If multiple scales are used, 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 and dose equivalent rate range

The implementation of 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. For application as an emergency instrument, the dose equivalent rates of interest are within the range from approximately 1 mSv h^{-1} to 10 Sv h^{-1}. If integrating capability is provided, the range between 1 mSv to 10 Sv usually is of interest.

5.5 Minimum range of measurement

The minimum effective range of measurement of dose equivalent rate shall cover at least four orders of magnitude and shall include the range from 1 mSv h^{-1} to 10 Sv h^{-1}. The minimum effective range of dose equivalent shall cover at least four orders of magnitude and shall include 10 Sv.

5.15 Portability

In the case of survey meters, the complete instrument should not exceed 4 kg in weight and shall be equipped with handles, straps or other means to facilitate operation while being carried. It is recognized that an extension probe or some other means may be required to reduce the dose to the operator.

5.16 Protection of switches

Switches and other controls shall be protected to prevent inadvertent de-activation or mal-operation of the instrument.

5.17 Use of extension probe

If an extension probe is to be used, the instrument including the probe and all associated equipment necessary for measurements including the extension device extended to the worst case configuration shall be tested. Details of the test method shall be made available along with the results.

5.18 Contamination probe

Emergency dose rate monitors are frequently provided with a surface contamination probe. This probe shall meet the requirements of IEC 60325.

6 General test procedures

For the purposes of this standard, 6.1 to 6.14 of IEC 60846-1:2009 apply, without modifications.

7 Additivity of indicated value

For the purposes of this standard, 7.1 to 7.3 of IEC 60846-1:2009 apply, without modifications.

8 Radiation performance requirements and tests

For the purposes of this standard, 8.1 to 8.13 of IEC 60846-1:2009 apply, without modifications, except as stated in the following subclauses. The changed subclauses are identified by the same number as in IEC 60846-1:2009 or, for new subclauses, by a higher number not used in IEC 60846-1:2009.

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

8.4.3 Measuring quantity H'(0,07), $\dot{H}'$(0,07), H^*(10) or $\dot{H}^*$(10) for telescopic or remote cylindrical probes

8.4.3.1 General

Where telescopic or remote cylindrical probes with their calibration direction perpendicular to the axis of symmetry are used for emergency instrumentation, this subclause 8.4.3 replaces 8.4.1 and 8.4.2 of IEC 60846-1:2009. In all other cases, subclauses 8.4.1 and 8.4.2 of IEC 60846-1:2009 apply, without modification.

8.4.3.2 Requirements

The variation of the relative response due to a change of the photon radiation energy and angle of photon radiation incidence shall not exceed the following values:

- –29 % to 67 % for photon radiation energies of 80 keV to 1,5 MeV and angle of photon radiation incidence of 0° to ±60° and 180° to (180° ± 60°).
- –37,5 % to 150 % for photon radiation energies of 80 keV to 1,5 MeV and angle of photon radiation incidence of ±60° to ±120°; however, at angle of photon radiation incidence of 90°±10° a lower response of –50 % is allowed.

- –37,5 % to 150 % for photon radiation energies of 1,5 MeV to 7 MeV and angle of photon radiation incidence of 0° to ±60° and 180° to (180° ± 60°).

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

Where more than one detector is utilized, then these requirements shall apply to each detector.

NOTE The range of the response –29 % to +67 % corresponds to the range of the correction factor 1,00 ± 0,40. The range of the response –37,5 % to 150 % corresponds to the range of the correction factor 1,00 ± 0,60.

8.4.3.3 Method of test

The tests with X-rays should be performed using the narrow-spectrum series of radiation qualities of ISO 4037-1, however if very high dose rates are required, the wide-spectrum series or high air kerma rate series may be required.

In order to minimize the number of measurements, in a first step the minimum rated photon energy is determined where both requirements on energy and angular dependence of response are met:

- The energy dependence of response for angles of incidence of $\alpha = 0°$ normalized to its value at ^{137}Cs gamma energy, $R(E_i, 0°)$, is measured and plotted versus the photon energy at the points of the mean energies (fluence weighted) of the used X-ray spectra, E_i.
- The photon energy where the variation of the relative response falls outside –29 % to +67 % (for 80 keV up to 1,5 MeV) or outside –37,5 % to +150 % (for 1,5 MeV up to 7 MeV) is determined.
- For the radiation quality with the mean energy above the lower photon energy thus determined, the relative response is measured for all angles between 0° and 180° at 15° intervals in two perpendicular planes containing the reference direction through the reference point of the dose equivalent (rate) meter.
  - If for this radiation quality, all variations of the relative response are between –29 % to +67 % (for 80 keV up to 1,5 MeV and 0° to ±60° and 180° to {180°±60°}) and between –37,5 % to +150 % (for 80 keV up to 1,5 MeV and ±60° to ±120°; however at 90° the variation of the relative response is allowed to be as low as –50 %) and between –37,5 % to 150 % (for 1,5 MeV up to 7 MeV and 0° to ±60° and 180° to {180°±60°}, the procedure shall be repeated with the radiation quality with the next lower mean photon energy.
  - Otherwise, the radiation quality with the higher mean energy shall be chosen.

For both radiation qualities used in the test, all measured responses are plotted as a function of photon energy in a lin-log graph. Each two responses belonging together shall be connected by a straight line. The minimum and maximum rated photon energy is obtained by the intersection of the straight line with the specified limits at the highest photon energy.

In a second step, further radiation qualities in the rated range of use shall be chosen to prove that all normalized responses $R(E,\alpha)$ are within its specified limits. One radiation quality is determined by the maximum energy of the rated range of use. If the normalized responses $R(E_i, 0°)$ determined before have extreme values in the rated range, then the corresponding radiation qualities are further values for these tests concerning the angle of incidence, otherwise at least one quality shall be chosen within the rated range.

In principle, it is desirable that this test be performed at the same 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 6.10 of IEC 60846-1:2009).

8.4.3.4 Interpretation of the results

If all the variations of the relative response of the rated range of use due to photon radiation energy and angle of incidence are within the limits given in 8.4.3.2, then the requirements can be considered to be met.

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 variation of the relative response of the directional dose equivalent (rate) meter to beta radiation produced by the reference radiation of $^{90}Sr/^{90}Y$ in the calibration direction, i.e., 0° radiation incidence, shall be between –33 % to +100 %. In addition, the response to the reference radiation of ^{85}Kr or ^{204}Tl shall be given by the manufacturer.

8.5.1.2 Method of test

For the beta radiation of $^{90}Sr/^{90}Y$, the response shall only be measured for zero angle of radiation incidence.

8.5.1.3 Interpretation of the results

If all the variations of the relative response of the rated range of use due to beta radiation energy at 0° angle of incidence are within –33 % to +100 %, then the requirements can be considered to be met.

8.7 Linearity and statistical fluctuations

8.7.2 Requirements

The requirements of IEC 60846-1:2009 apply, with the exception that Tables 5 and 6 of IEC 60846-1:2009 are replaced by Tables 5 and 6 given in this standard.

8.14 Extracameral response

8.14.1 Requirements

The instrument shall not exhibit an extracameral response greater than or equal to 2 % of scale reading when exposed to a dose rate greater than or equal to 1 Sv h^{-1} with photon energy of 1,25 MeV and beta radiation from $^{90}Sr/^{90}Y$.

8.14.2 Method of test

With the detector and its surrounding housing shielded or not in the radiation field, expose the rest of the instrument, including cable, electronics (not contained in the housing in which the detector is contained), and the indicating device, to a dose rate of 1 Sv h^{-1} with a photon energy of 1,25 MeV and betas from $^{90}Sr/^{90}Y$ (one after the other) for at least 10 min. The scale reading (indicated value) shall be less than 2 % of the irradiated dose rate: that is less than 20 mSv h^{-1}.

8.15 Response of instrument with extended probe

8.15.1 Requirements

The instrument with an extended probe shall exhibit no change in radiation characteristics defined above when tested up to the maximum extension (or cable length) specified by the manufacturer. Where multiple detectors are utilized to cover the entire range, they shall be tested separately.

8.15.2 Method of test

The instrument shall be tested as required in 8.1 through 8.14 with the detector located at the minimum and maximum distances (or cable length) specified by the manufacturer. The response shall be the same, within 5 %, for both distances (or cable length).

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

For the purposes of this standard, 9.1 to 9.3 of IEC 60846-1:2009 apply, without modifications, except as stated in the following subclauses. The changed subclauses are identified by the same number as in IEC 60846-1:2009 or, for new subclauses, by a higher number not used in IEC 60846-1:2009.

9.2 Warm-up time

9.2.1 Requirements

The instrument shall be capable of starting operation at the lowest temperature of the rated range and operate as normally. One (1) minute after instrument switched on, the indication shall not differ by more than 10 % from the value obtained after 60 min.

9.2.2 Test method

The dose equivalent meter with the batteries fitted shall be placed for at least 4 h inside the environmental chamber with the temperature at –25 °C. With the dose equivalent (rate) meter switched off, expose it to an appropriate radiation source that will provide an indication in the second most sensitive range. Switch on the instrument and note the readings every 15 s during a period of 2 min after switching on.

60 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 determine the reading after 1 min. If this value does not differ by more than 10 % from the value obtained after 60 min then the requirements of 9.2.1 are met.

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

For the purposes of this standard, 10.1 to 10.3 of IEC 60846-1:2009 apply, without modifications, except as stated in the following subclauses. The changed subclauses are identified by the same number as in IEC 60846-1:2009 or, for new subclauses, by a higher number not used in IEC 60846-1:2009.

10.4 Drop test

10.4.1 Requirements

Portable dose equivalent (rate) meters used for emergency purposes shall be able to withstand without damage, a drop from a height of 1 m (distance from ground point to surface of dose equivalent (rate) meter) onto a concrete floor. The instrument passes the test if the instrument response after the tests does not deviate from the original response by more than –17 % to +25 %.

10.4.2 Method of test

The dose equivalent (rate) meter shall be subjected to at least one single drop from 1 m to each surface of dose equivalent (rate) meter. 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 response of the instrument shall be determined before and after the test. If the dose equivalent recorded is important to measurement, then the data recorded before drop shall be maintained and shall not be increased by more than 0,7 H_0 (H_0 is the lower limit of the effective range of measurement). The drop can make the instrument switch off but the user shall be able to switch the unit back on. The dose equivalent (rate) meter shall be inspected and the physical condition be documented.

10.4.3 Interpretation of the results

If the instrument response does not deviate from the original response by more than –17 % to +25 % and the instrument is in good physical condition then the requirements are met.

11 Environmental characteristics, performance requirements and tests

For the purposes of this standard, 11.1 to 11.7 of IEC 60846-1:2009 apply, without modifications, except as stated in the following subclauses. The changed subclauses are identified by the same number as in IEC 60846-1:2009 or, for new subclauses, by a higher number not used in IEC 60846-1:2009.

11.2 Ambient temperature

11.2.1 Requirements

The indicated values of the portable dose equivalent (rate) meters used for emergency purposes shall remain within the following ranges of the indicated values obtained at +20 °C over the following temperature ranges:

a) Assemblies for extended temperature range: over the range of temperature from –25 °C to +50 °C, the indicated value shall not deviate by more than –17 % to +25 % from that obtained under standard test conditions. It is recommended that portable assemblies be designed to meet these requirements for outdoor use.

b) Assemblies for extreme temperature range: where the assembly is to be used in hotter conditions, the indicated value shall not deviate by more than –23 % to +43 % from that obtained under standard test conditions over the temperature range of –25 °C to +70 °C.

c) Assemblies for all temperature ranges: where the assembly is to be used in hotter conditions (e.g. fire), the indicated value shall not deviate by more than –23 % to +43 % from that obtained under standard test conditions over the temperature range specified by the manufacturer.

The manufacturer shall state the maximum temperature the instrument can withstand.

NOTE Some means of maintaining the batteries at a temperature within the nominal operation range may be required when assemblies are operated at temperatures below –10 °C.

11.2.2 Test method

For this test, the dose (rate) meter shall be exposed to a photon radiation source of sufficient intensity providing an indication in the second most sensitive range. The dose (rate) meter and the photon source shall be arranged in a reproducible geometry for the test.

The dose (rate) meter shall be held at a temperature of +20 °C ± 2 °C and allowed to stabilize for a minimum of 60 min. The indication of the dose (rate) meter shall be determined. The dose (rate) meter and the source shall be removed from this environment and placed directly in an environmental chamber such that the same exposure geometry is established and the

temperature near the meter is maintained within 5 °C for each maximum and minimum temperature identified in the three temperature ranges given in 11.2.1. This procedure shall be performed in less than 5 min. The temperature shall then be maintained at each of its extreme values for at least 4 h, and the indication of the dose (rate) meter measured during the last 30 min of the period. The dose (rate) meter shall be removed from the environmental chamber and returned to the first environment such that the same exposure environment is established and the temperature near the meter is +20 °C ±2 °C. This procedure shall be performed in less than 5 min. The indication shall then be determined during the last 30 min of a 2 h period.

It is not, in general, necessary to control the humidity of the air in the chamber unless the meter is particularly sensitive to changes of humidity. Humidity levels should be low enough to prevent condensation (<75 %).

11.2.3 Interpretation of the results

The requirements of IEC 60846-1:2009 apply.

11.3 Relative humidity

11.3.1 Requirements

The requirements of IEC 60846-1:2009 apply, with the exception that the minimal rated range covers all relative humidity levels up to 95 % at a temperature of +35 °C.

11.8 Temperature shock

11.8.1 Requirements

The indicated value of the dose (rate) meter shall not vary by more than –17 % to +25 % from the indicated value taken at a temperature of +20 °C when the temperature is raised from +20 °C to +50 °C or lowered from +20 °C to –10 °C in less than 5 min.

The indicated value of the dose (rate) meter shall not vary by more than –17 % to +25 % from the indicated value taken at a temperature of +50 °C or –10 °C when the temperature changes from either one of the above temperatures to +20 °C.

11.8.2 Method of test

For this test, the dose (rate) meter shall be exposed to a photon radiation source of sufficient intensity to provide an indication in the second most sensitive range. The dose (rate) meter and the photon source shall be arranged in a reproducible geometry for the test.

The dose (rate) meter shall be held at a temperature of +20 °C ± 5 °C and allowed to stabilize for a minimum of 60 min. The indication of the dose (rate) meter shall be determined. The dose (rate) meter and the source shall be removed from this environment and placed directly in an environmental chamber such that the same exposure geometry is established and the temperature near the meter is maintained between +45 °C and +50 °C. This procedure shall be performed in less than 5 min. The indication shall then be determined every 15 min over a period of 2 h. The meter shall remain in this environment during the period to reach a stable temperature.

The dose (rate) meter shall be removed from the environmental chamber and returned to the first environment such that the same exposure environment is established and the temperature near the meter is +20 °C ± 5 °C. This procedure shall be performed in less than 5 min. The indication shall then be determined every 15 min over a period of 2 h. The meter shall remain in this environment during the period necessary to reach a stable temperature.

The test shall be repeated inside the environmental chamber with a temperature near the meter maintained between –10 °C and –5 °C.

11.8.3 Interpretation of the results

If the instrument indication does not deviate from the indication at +20 °C by more than –17 % to +25 % then the requirements are met.

12 Software

For the purposes of this standard, 12.1 to 12.3 of IEC 60846-1:2009 apply, without modifications.

13 Summary of characteristics

For the purposes of this standard, Clause 13 of IEC 60846-1:2009 applies, without modifications.

14 Documentation

For the purposes of this standard, 14.1 to 14.4 of IEC 60846-1:2009 apply, without modifications.

Tables

For the purposes of this standard, all Tables 1 to 9 of IEC 60846-1:2009 apply, without modifications, except as stated in the following Tables. The changed Tables are identified by the same number as in IEC 60846-1:2009. The changed rows are marked by underlining the respective element for “Characteristics under test or influence quantity” in each Table.

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	Four orders of magnitude, including 1 mSv h^{-1} to 10 Sv h^{-1} and 10 Sv	–17 % to +25 %	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 800 keV and 0° from reference direction	–33 % to +100 %	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
In case of telescopic or remote cylindrical probes: photon radiation energy and angle of incidence	80 keV to 1,5 MeV and at 0° to ±60° and 180° to (180°±60°), at ±60° to ±120°, at 90°±10°, and 1,5 MeV to 7 MeV and at 0° to ±60° and 180° to (180°±60°), from reference direction	–29 % to +67 % –37,5 % to +150 % –50 % to +150 % –37,5 % to +150 %	8.4.3
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} 2 times the range maximum for dose rates in excess of 5 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
Extracameral response	Dose rate ≥ 1 Sv h^{-1} for 1,25 MeV photons or $^{90}Sr/^{90}Y$	< 2 % of scale reading	8.14
Response of instrument with extended probe	Repeat tests 8.1 through 8.14 with detector at minimum and maximum distances (or cable length) specified by the manufacturer	Within ±5 % at both distances	8.15

[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.

NOTE Underlined items indicate additions or changes to IEC 60846-1:2009.

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	Four orders of magnitude including 1 mSv h^{-1} to 10 Sv h^{-1}	–17 % to +25 %	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 1,5 MeV 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
In case of telescopic or remote cylindrical probes: X and gamma radiation energy and angle of incidence	80 keV to 1,5 MeV and at 0° to ±60° and 180° to (180°±60°), at ±60° to ±120°, at 90°±10°, and 1,5 MeV to 7 MeV and at 0° to ±60° and 180° to (180°±60°), from reference direction	–29 % to +67 % –37,5 % to +150 % –50 % to +150 % –37,5 % to +150 %	8.4.3
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} 2 times the range maximum for dose rates in excess of 5 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
Extracameral response	Dose rate ≥ 1 Sv h^{-1} 1,25 MeV photons or $^{90}Sr/^{90}Y$	< 2 % of scale reading	8.14

Characteristic under test or influence quantity	(Minimum) rated range of influence quantity	Limits of variation of the relative response	Subclause
Response of instrument with extended probe	Repeat tests 8.1 through 8.14 with detector at minimum and maximum distances (or cable length) specified by the manufacturer	Within 5 % of both distances	8.15

[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.

NOTE Underlined items indicate additions or changes to IEC 60846-1:2009.

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	Subclause
Zero drift	Period of 4 h	± 0,2 H_0 or ± 0,2 $\dot{H}_0$ respectively	9.1
Warm-up time	less than or equal to 1 min	±10 % of value after 60 min	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
Drop test	Drop from 1 m onto a concrete floor	–17 % to +25 %	10.4
Ambient temperature	a) –25 °C to +50 °C b) –25 °C to +70 °C c) larger range than b)	–17 % to +25 % –23 % to +43 % –23 % to +43 % for a dose of 10 H_0 or a dose rate of 10 $\dot{H}_0$	11.2
Temperature shock	Change from +20 °C to –10 °C or to +50 °C within 5 min; Change from –10 °C or +50 °C to +20 °C within 5 min;	–17 % to +25 %	11.8
Relative humidity	up 95 % 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.

NOTE Underlined items indicate additions or changes to IEC 60846-1:2009.

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