IEC 60846-2

Edition 2.0 2015-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

IEC 60846-2:2015-12(en-fr)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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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.

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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
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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

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*

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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.

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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.

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- –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).

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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.

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