

Radiation protection instrumentation — Installed, portable or transportable assemblies — Measurement of air kerma direction and air kerma rate

ICS 17.020

National foreword

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The UK participation in its preparation was entrusted to Technical Committee NCE/2, Health physics instrumentation, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**Instrumentation pour la radioprotection –
Appareils à poste fixe, portables ou mobiles –
Mesures de la direction et du débit de kerma
dans l'air**

**Radiation protection instrumentation –
Installed, portable or transportable assemblies –
Measurement of air kerma direction
and air kerma rate**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – INSTALLED, PORTABLE OR TRANSPORTABLE ASSEMBLIES – MEASUREMENT OF AIR KERMA DIRECTION AND AIR KERMA RATE

FOREWORD

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International Standard IEC 61584 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45B/308/FDIS	45B/316/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 3.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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- withdrawn;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

RADIATION PROTECTION INSTRUMENTATION – INSTALLED, PORTABLE OR TRANSPORTABLE ASSEMBLIES – MEASUREMENT OF AIR KERMA DIRECTION AND AIR KERMA RATE

1 General

1.1 Scope and object

1.1.1 This International Standard is applicable to installed, portable or transportable assemblies intended to measure

- the direction of an X or gamma radiation source in terms of azimuth and elevation angles, as shown in the schema of figure 1;
- the X or gamma air kerma rate at the equipment location;
- the attenuation coefficient in a given medium and the related effective energy of the X or gamma beam incident to the equipment location.

The energy range of X or gamma radiation is at least between 50 keV and 1,5 MeV.

1.1.2 The assemblies considered in this standard comprise at least

- a detection sub-assembly which could include several detectors;
- a measuring sub-assembly including a display device, which may be connected together or incorporated into a single assembly or interfaced. This sub-assembly could contain a microprocessor equipped with an algorithm to process the measured data.

1.1.3 This standard is applicable to measuring assemblies designed for special applications: e.g. high air kerma rate measurements and direction of the plume following a nuclear accident or, when mounted on a vehicle, to guide it towards the X or gamma sources and to bring it closer to the intervention place.

1.1.4 National regulation or practice may require the measurement of other quantities than air kerma rate (e.g. ambient dose equivalent rate, other dose rate or exposure rate). This standard may be applied to performance characteristics of equipment to measure any such quantity. For example, the numerical values given for the radiation characteristics apply to any case but the conventionally true values would be expressed in the appropriate quantity.

1.1.5 This publication specifies general characteristics, general test procedures, electrical, safety and environmental characteristics and the identification certificate for assemblies defined in this clause.

1.1.6 This standard does not apply to thermoluminescence dosimetry systems or other passive integrating devices.

1.1.7 This standard does not provide specifications for measurements of beta radiation and neutrons.

1.1.8 This standard is not applicable to the operating characteristics of indicating or recording equipments as such (e.g. indicating meters, recorders, alarms etc.). The characteristics of such equipment should be in conformity with the general requirements appropriate to them.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60038:1983, *IEC standard voltages*

IEC 60050-151:—, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* ¹⁾

IEC 60050(393):1996, *International Electrotechnical Vocabulary (IEV) – Chapter 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050(394):1995, *International Electrotechnical Vocabulary (IEV) – Chapter 394: Nuclear instrumentation – Instruments*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests. Test Ea and guidance: Shock*

IEC 60086-2:1997, *Primary batteries – Part 2: Specification sheets*

IEC 60359:1987, *Expression of the performance of electrical and electronic measuring equipment*

IEC 60532:1992, *Radiation protection instrumentation – Installed dose ratemeters, warning assemblies and monitors – X and gamma radiation of energy between 50 keV and 7 MeV*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61017-1:1991, *Portable, transportable or installed X or gamma radiation ratemeters for environmental monitoring – Part 1: Ratemeters*

IEC 61017-2:1994, *Radiation protection instrumentation – Portable, transportable or installed equipment to measure X or gamma radiation for environmental monitoring – Part 2: Integrating assemblies*

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

ISO 4037-1:1996, *X and gamma reference radiation for calibrating dosimeters and dose rate 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 dosimeters and dose rate 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*

¹⁾ To be published.

1.3 Terms, definitions and units

For the purpose of this standard, the terms defined in IEC 60050(393), IEC 60050(394), IEC 60359, IEC 61017-1 and IEC 61017-2 together with the following apply.

Figure 1 gives a schematic representation of terms defining angles related to beam direction.

1.3.1 portable direction and air kerma rate meter

assembly designed to be easily carried (see 2.1.12) and intended to measure the direction and the air kerma rate, at various places, of X and gamma beams incident to detection sub-assembly including several radiation detectors

NOTE This assembly will also include associated sub-assemblies or basic function units.

1.3.2 installed direction and air kerma rate meter

assembly normally fixed in position. It may be equipped with means of recording and with remote read-out capabilities

1.3.3 transportable direction and air kerma rate meter

rate meter normally installed in a vehicle. Such equipment may be used for example to guide the vehicle closer to the X or gamma source. It may be equipped with means of recording and with remote read-out capabilities

1.3.4 azimuth angle, θ

angle on the horizontal plane between the direction of the beam projection on this plane and the reference direction $\theta = 0$

NOTE The unit of measurement should be degree (or radian).

1.3.5 elevation angle, φ

angle between the direction of the beam and the vertical axis taken as reference direction $\varphi = 0$

NOTE The unit of measurement should be degree (or radian).

1.3.6 attenuation coefficient, μ

1.3.6.1 linear attenuation coefficient is equal to the probability per photon of given energy of undergoing an interaction per unit absorber thickness expressed in cm^{-1}

1.3.6.2 mass attenuation coefficient is obtained by dividing the linear attenuation coefficient by the density of the medium expressed in $\text{cm}^2\cdot\text{g}^{-1}$

NOTE It is assumed in this standard that the dose attenuation, in the detection medium of the detection sub-assembly, is an exponential function of the track length of photons in this medium. If l is the track length (cm) of photons in the medium and μ the attenuation coefficient (cm^{-1}), then $e^{-\mu l}$ is the dose attenuation.

1.3.7 effective energy, $\tilde{E}$

energy deduced from the measurement of the attenuation coefficient using a function relating these two quantities (dose attenuation and attenuation coefficient)

1.3.8 conventionally true value of a quantity

best estimate of the value of that quantity determined by a primary or secondary standard or by a reference equipment that has been calibrated against a primary or secondary standard

1.3.9 error of indication

difference between indicated value of each quantity and the conventionally true value of that quantity at the point of measurement where equipment indicates: azimuth angle θ , elevation angle φ , air kerma rate and attenuation coefficient in a chosen medium and estimates effective energy

1.3.10 responses

1.3.10.1 response of the assembly relative to the azimuth angle θ is expressed by

$$R(\theta) = \frac{\theta_I - \theta_T}{360^\circ}$$

1.3.10.2 response of the assembly relative to the elevation angle φ is expressed by

$$R(\varphi) = \frac{\varphi_I - \varphi_T}{360^\circ}$$

1.3.10.3 for other indicated values, the responses are expressed by the following relations:

$$R(\dot{K}_a) = \frac{(\dot{K}_a)_I}{(\dot{K}_a)_T}$$

$$\text{and } R(\mu) = \frac{\mu_I}{\mu_T}, \quad R(\tilde{E}) = \frac{\tilde{E}_I}{\tilde{E}_T}$$

where

θ_I , φ_I , $(\dot{K}_a)_I$, μ_I and $\tilde{E}_I$ are the indicated values of the conventionally true values θ_T , φ_T , $(\dot{K}_a)_T$, μ_T and $\tilde{E}_T$ respectively

1.3.11 relative error of indication

quotient, expressed as a percentage, of the error of indication of a quantity by the conventionally true value of the measured quantity. It may be expressed as

$$I(\%) = \frac{q_I - q_T}{q_T} \times 100$$

where q_I and q_T are, respectively, the indicated and conventionally true values of each of the following quantities: air kerma rate ($\dot{K}_a$), attenuation coefficient (μ) and effective energy ($\tilde{E}$)

1.3.12 intrinsic error

error of indication of an assembly with respect to a quantity when subjected to a specified reference radiation under specified reference conditions

NOTE This intrinsic error is used to evaluate the performance of the equipment for measuring azimuth and elevation angles.

1.3.13 relative intrinsic error

relative error of indication of an assembly with respect to a quantity when subjected to a specified reference radiation under specified reference conditions

NOTE This parameter is used to specify the performance of the equipment for measuring $\dot{K}_a$, μ and $\tilde{E}$.

1.3.14 coefficient of variation

ratio V of the estimate of the standard deviation, s , to the arithmetic mean $\bar{X}$ of a set of n measurements X_i given by the following formula:

- for air kerma rate and attenuation coefficient measurements:

$$V = \frac{s}{\bar{X}} = \frac{1}{\bar{X}} \times \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2}$$

- for measurements of angles:

$$V = \frac{s}{360^\circ} = \frac{1}{360^\circ} \times \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2}$$

1.3.15 reference point of an assembly

physical mark on the assembly used to position the assembly at a point where the conventionally true value of the quantity to be measured is known

1.3.16 point of test

point at which the reference point of the assembly is placed and at which the conventionally true value of air kerma rate is known

1.3.17 reference orientation of the assembly

direction for which the azimuth angle is equal to 0 and the elevation angle is equal to -90° , the equipment indicating the direction of the incident beam.

The manufacturer must state this reference orientation of the assembly. Generally, this reference orientation and calibration direction shall be on the same axis

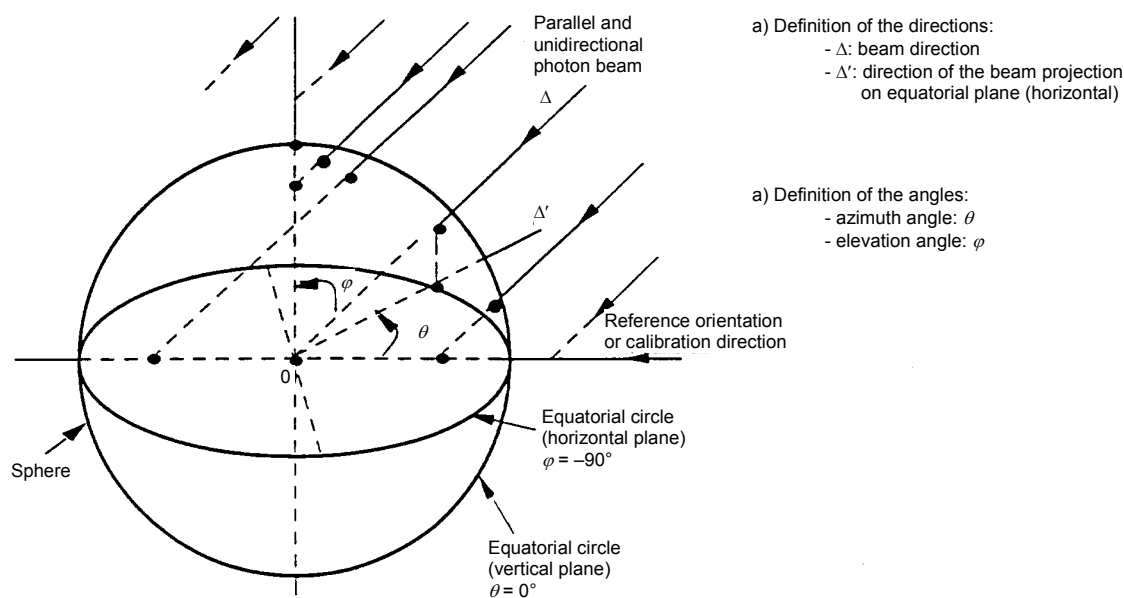


Figure 1 – Schematic of beam direction and definition of angles

1.3.18 qualification tests

tests performed in order to verify that the requirements of a specification are fulfilled. They are subdivided into type tests and routine tests, as defined below:

1.3.18.1 type test

conformity test made on one or more items representative of the production
[IEV 151-16-16]

1.3.18.2 routine test

conformity test made on each individual item during or after manufacture
[IEV 151-16-17]

1.3.18.3 acceptance test

contractual test to prove to the customer that the item meets certain conditions of its specification
[IEV 151-16-23]

1.3.18.4 supplementary tests

tests intended to provide supplementary information on certain characteristics of the assemblies

1.3.19 Units

This standard uses the units of the International System (SI)²⁾. Definitions of radiation quantities and dosimetric terms (see [2] and [3]) are given in IEC 60050(393) and IEC 60050(394). The corresponding old units (not SI) are indicated in parentheses.

²⁾ The figures in square brackets refer to the bibliography.