IEC 61017

Edition 1.0 2016-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Transportable, mobile or installed equipment to measure photon radiation for environmental monitoring

Instrumentation pour la radioprotection – Equipement transportable, mobile ou installé pour mesurer le rayonnement de photons pour la surveillance de l'environnement

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RADIATION PROTECTION INSTRUMENTATION – TRANSPORTABLE, MOBILE OR INSTALLED EQUIPMENT TO MEASURE PHOTON RADIATION FOR ENVIRONMENTAL MONITORING

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International Standard 61017 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This first edition of IEC 61017 cancels and replaces the first edition of IEC 61017-1, published in 1991, and the first edition of IEC 61017-2, published in 1994. It constitutes a technical revision.

The main technical changes with the previous editions are as follows:

– this standard explicitly describes air absorbed dose and dose rate, ambient dose equivalent dose and dose rate, in addition to air kerma and kerma rate;

– this standard includes the description of the typical detector types for use in environmental monitoring.

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

FDIS	Report on voting
45B/825/FDIS	45B/837/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.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.

INTRODUCTION

Exposure of members of the public to ionizing radiation produced by nuclear and other facilities is subject to control. An essential part of control is the measurement of the environmental radiation levels in the neighborhood of these facilities .

The evaluation of the environmental radiation dose from photons is difficult. The composition of the background radiation is complex and includes contributions from natural sources such as cosmic radiation and terrestrial radioactivity in addition to man-made radioactivity arising from the operation of nuclear facilities and fall-out from nuclear weapon tests. This, if further complicated by the variation in the natural background radiation dose, varies in time due to variation in ambient radon concentrations and space due to spatial heterogeneity of the natural environmental background.

The requirements specified in this standard relate to normal operations of the assembly. Should an assembly be required for emergency conditions on-site at nuclear facilities then the requirements of IEC 60846-2 should also be applied to the assembly, particularly with regard to overload characteristics. The requirements for portable work place monitors to measure ambient and/or directional dose equivalent (rate) are specified in IEC 60846-1.

RADIATION PROTECTION INSTRUMENTATION – TRANSPORTABLE, MOBILE OR INSTALLED EQUIPMENT TO MEASURE PHOTON RADIATION FOR ENVIRONMENTAL MONITORING

1 Scope

This International Standard is applicable to transportable, mobile or installed assemblies intended to measure environmental air kerma rates or air absorbed dose rates from 30 nGy·h^{-1} to 30 μGy·h^{-1} or ambient dose equivalent rates from 30 nSv·h^{-1} to 30 μSv·h^{-1}, or air kerma or air absorbed dose from 10 nGy to 10 mGy, or ambient dose equivalent from 10 nSv to 10 mSv, due to photon radiation of energy between 50 keV and 7 MeV. The measurable range of dose and dose rate can be extended by agreement between the purchaser and the manufacturer. This extension may be realized by combining more than one detector, for example NaI(Tl) scintillator and ionization chamber. For most environmental applications, instruments may measure over a more limited energy range of 80 keV to 3 MeV.

NOTE 1 80 keV to 3 MeV has been chosen to cover the energies of the chief environmental and man-made radio-nuclides that contribute to the environmental dose. The term "dose" used in this standard means the quantity, air kerma, air absorbed dose, and ambient dose equivalent, that the instrument is intended to measure.

If the assembly is to be used to measure these quantities in the area surrounding a nuclear reactor producing 6 MeV radiation from the ^{16}N isotope, it will be necessary to determine the response at this energy. An absorbed dose in air, which uses the same unit, Gy, as air kerma can be taken to have the same numerical value as air kerma under the condition of electron equilibrium.

Passive devices such as Thermo-Luminescence Dosemeter (TLD), Optically Stimulated Luminescence (OSL) Dosemeter or Glass Radio-Photo Luminescence (RPL) Dosemeter are not covered by this standard.

Installed assemblies should be capable of operating continuously.

This standard does not provide for the measurement of beta and neutron radiation.

The equipment covered by this standard comprises a detector assembly and processing circuits, which may be connected together either rigidly or by means of a flexible cable, or incorporated into a single assembly. The equipment assembly may also include circuits for displaying readings, alarms and communication.

This equipment should meet the environmental conditions of use.

Examples of instruments include (detailed information is described in Annex A):

a) Ionization chamber

This is suitable for the measurement of air kerma and air absorbed dose and dose rate. In the environment, the correction due to temperature and atmospheric pressure may be required.

NOTE 2 For the measurement of ambient dose equivalent and dose equivalent rate the energy response may be compensated.

b) Geiger-Muller (GM) counter

The energy response should be corrected. GM counters may overestimate the readings due to the dose (rate) from cosmic radiation.

c) Scintillation detector

The energy response should be corrected. Detailed information is described in Annex A and Annex B.

d) Semiconductor detector

The energy response should be corrected.

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.

IEC 60038, *IEC standard voltages*

IEC 60050-395:2014, *International Electrotechnical Vocabulary – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

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

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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

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

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

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

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

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

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

IEC 61000-4-12, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

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

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

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

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 dose rate meters and for determining their response as a function of photon energy – Part 2: Dosimetry for radiation protection over the energy range 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 dose rate 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 dose rate 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*

3 Terms, definitions, abbreviations, symbols, quantities and units

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE General terminology concerning detection and measurement of ionizing radiation and nuclear instrumentation is given in IEC 60050-395 and IEC 60050-151.

3.1.1
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

3.1.2
alarm
audible, visual, or other signal activated when the instrument reading exceeds a preset value, falls outside of a preset range, or when the instrument detects the presence of the source of radiation according to a preset condition

3.1.3
background level
radiation field in which the instrument is intended to operate which includes background produced by naturally occurring radioactive material

3.1.4
manufacturer
designer and seller of the equipment

3.1.5
monitor type

3.1.5.1
installed
radiation instruments that may be permanently mounted at a location for use.

Note 1 to entry: By agreement between manufacturer and purchaser, these assemblies should be provided with appropriate facilities for indicating readings.

3.1.5.2
transportable
radiation instruments not intended to be used whilst transported

3.1.5.3
mobile
radiation instruments that are mounted to moving platforms and that operate while in motion

3.1.6
conventionally true value of quantity
conventionally true dose or dose rate
best estimate of the value of that quantity used for calibration of equipment; this value and its uncertainty shall be determined from a primary or secondary standard or by a reference instrument which has been calibrated against a primary or secondary standard

3.1.7
error of indication
difference between the indicated value of a quantity D_I and the conventionally true value of that quantity at the point of measurement D_T

3.1.8
response
response R of an assembly is the ratio of the assembly's indicated value to the conventionally true value

$$R = \frac{\dot{D}_I}{\dot{D}_T}$$

3.1.9
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:

$$I(\%) = \frac{\dot{D}_I - \dot{D}_T}{\dot{D}_T} \times 100$$

3.1.10
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

3.1.11
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:

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

3.1.12
effective range of measurement
range of values of the quantity to be measured over which the performance of an equipment meets the requirements of this standard

3.2 Test nomenclature

3.2.1
calibration direction
direction of the incident radiation during calibration stated by the manufacturer

3.2.2
reference point of an assembly
physical mark on the assembly indicating a center of a sensitive part of an assembly's detector and to be used to calculate an effective reference point of the assembly

Note 1 to entry: Effective reference point of an assembly is located at a distance, stated by the manufacturer for specified energy, from a reference point of the assembly to be used in order to position the assembly at a point where the conventionally true value of a quantity to be measured is known.

3.2.3
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), air absorbed dose (rate) or ambient dose equivalent (rate) is known

Note 1 to entry: For all tests involving the use of radiation, the reference point of the assembly shall be placed at the point of test and, apart from the test for variation in response with angle of incidence, in the orientation indicated by the manufacturer, i.e. with the radiation field incident from the manufacturer's stated calibration condition.

3.2.4
qualification tests
tests performed on a representative sample of equipment to verify the adequacy of the design and that the equipment meets the specifications agreed upon between manufacturer and user under normal operational conditions and anticipated operation occurrences

Note 1 to entry: Qualification tests are performed in order to verify that the requirements of a specification are fulfilled.

Note 2 to entry: Qualification tests are subdivided into type tests and routine tests.

3.2.5
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.2.6
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.2.7
acceptance test
contractual test to prove to the purchaser that the device fulfils certain specifications

[SOURCE: IEC 60050-151:2001, 151-16-23]

3.2.8
supplementary tests
tests intended to provide supplementary information on certain specifications

Note 1 to entry: The term “dose” used in this standard means the quantity, air kerma, air absorbed dose, and ambient dose equivalent, that the instrument is intended to measure. The radiation tests are defined by the manufacturer in terms of this quantity.

3.3 Abbreviations and symbols

EMC electromagnetic compatibility

3.4 Quantities and units

In this standard, units of the International System (SI) are used [1]. The definitions of radiation quantities are given in IEC 60050-395. The corresponding old units (non SI) are indicated in brackets.

Nevertheless, the following units may also be used:

– for energy: electron-volt (symbol: eV), 1 eV = 1,602 × 10^{-19} J;
– for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min).

Multiples and submultiples of SI units will be used, when practicable, according to the SI system.

4 General test procedure

4.1 Nature of tests

Unless otherwise specified in the individual clauses, all tests enumerated in this standard are to be considered as "type tests". Nevertheless, by agreement between the manufacturer and the purchaser, some of them may be considered as acceptance tests.

4.2 Reference conditions and standard test conditions

Reference and standard test conditions are given in Table 1. Reference conditions are those conditions to which the performance of the instrument is referred and standard test conditions indicate the necessary tolerances in practical testing. Except where otherwise specified, the tests in this standard shall be performed under the standard test conditions given in the third column of Table 1.

4.3 Radiation performance tests

The radiation performance tests are listed in Table 2, which indicates, for each characteristic under test, the requirements according to the clause where the corresponding test method is described. The tests shall be performed under test conditions detailed in Table 1, except for the quantity being tested.

4.4 Tests performed with variation of influence quantities

The classification of electrical, mechanical and environmental characteristics tests is shown in Table 3. Those tests are intended to determine the effects of variations in the influence

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[1] International Bureau of Weights and Measures: The International System of Units, 8th edition, 2006.