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Radiation protection instrumentation – Alarming personal radiation devices (PRD) for detection of illicit trafficking of radioactive material

Instrumentation pour la radioprotection – Dispositifs individuels d'alarme aux rayonnements pour la détection du trafic illicite des matières radioactives

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – ALARMING PERSONAL RADIATION DEVICES (PRD) FOR DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL

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International Standard IEC 62401 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/540/FDIS	45B/545/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 maintenance result 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- withdrawn,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 – ALARMING PERSONAL RADIATION DEVICES (PRD) FOR DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL

1 Scope and object

This International Standard applies to alarming radiation detection instruments that are pocket-sized, carried on the body and used to detect and indicate the presence and general magnitude of penetrating ionizing radiation, including photons and/or neutrons.

Personal Radiation Devices (PRD) alert the user to the presence of a source of radiation that is distinctly above the measured average local background radiation level. They are not intended to provide a measurement of dose equivalent rate.

The object of this standard is to describe design and functioning criteria along with testing methods for evaluating the performance of instruments for detection of illicit trafficking of radioactive material (for example, for border radiation monitoring). These instruments may be used in extreme environmental conditions.

This standard does not apply to the performance of radiation protection instrumentation covered in IEC 60846, IEC 61526, and IEC 62327.

The performances of the PRD with respect to neutrons may be degraded and not warranted when they are used in other conditions than on the body.

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 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

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

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]

[1] There exists a consolidated edition 2.1 (2001) that includes edition 2.0 and its amendment.

[2] There exists a consolidated edition 1.2 (2001) that includes edition 1.0 and its amendments.

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

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 8529-1:2001, *Reference neutron radiations – Part 1: Characteristics and methods of production*

ISO 8529-2:2000, *Reference neutron radiations – Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field*

ISO 8529-3:1998, *Reference neutron radiations – Part 3: Calibration of area and personal dosimeters and determination of response as a function of neutron energy and angle of incidence*

International Bureau of Weights and Measures: *The International System of Units (SI)*, Seventh edition, 1998

3 Terms, definitions, quantities and units

3.1 Terms and definitions

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

3.1.1
A-weighted sound level
frequency weighting of an acoustic spectrum according to a standardized frequency response curve based on the frequency response of the human ear

3.1.2
accuracy
closeness of the agreement between the result of a measurement and the conventionally true value of the measurand

[IEV 394-20-39, modified]

3.1.3
alarm
audible, visual, or other signal activated when the instrument reading exceeds a preset value or falls outside of a preset range

[IEV 393-18-03, modified]

3.1.4
background level
radiation field in which the instrument is intended to operate

3.1.5
conventionally true value of a quantity
CTV
best estimate of the value of a quantity used for a given purpose

NOTE A conventionally true value is, in general, regarded as sufficiently close to the true value for the difference to be insignificant for the given purpose. For example, a value determined from a primary or secondary standard or by a reference instrument, may be taken as the conventionally true value.

[IEV 394-20-10]

3.1.6
device
radiation detector with its associated electronics

3.1.7
effective range of measurement
range of values of the quantity to be measured over which the performance of a device meets the requirements of this standard

[IEV 394-20-16, modified]

3.1.8
false alarm
alarm not caused by an increase in radiation level over background conditions

3.1.9
influence quantity
quantity that may have a bearing on the result of a measurement without being the subject of the measurement

3.1.10
point of measurement
place at which the conventionally true values are determined and at which the reference point of the instrument is placed for test purposes

3.1.11
readout
value, with units, displayed and/or recorded by the instrument as a result of the instrument's response to some influence quantity

3.1.12
reference point of an assembly
physical mark on a piece of equipment or assembly to be used in order to position it at a point where the conventionally true value of the quantity to be measured is known

[IEV 394-20-15]

3.1.13
relative intrinsic error
ε_{REL}
difference between the instrument's reading, M, and the conventionally true value, CTV, of the quantity being measured divided by the conventionally true value multiplied by 100 % when subjected to a specified reference quantity under specified reference conditions

$$\varepsilon_{REL} = \frac{M - CTV}{CTV} \times 100\ \%$$

[IEV 394-20-12, modified]

3.1.14
response
R
ratio of the instrument reading to the conventionally true value of the measured quantity

3.1.15
standard deviation
positive square root of the variance.

3.1.16
standard test conditions
prescribed range for influence quantities to be used during testing of a measuring instrument

[IEV 394-20-26, modified]

3.1.17
type test
conformity testing on the basis of one or more specimens of a product representative of the production

[IEV 394-20-28]

3.1.18
routine test
test to which an individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[IEV 394-20-08]

3.1.19
acceptance test
contractual test to prove to the customer that the device meets certain conditions of its specification

[IEV 394-20-09]

3.1.20
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[VIM 3.9]

NOTE 1 The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence.

NOTE 2 Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by experimental standard deviations, are evaluated from assumed probability distributions based on experience or other information.

NOTE 3 It is understood that the result of the measurement is the best estimate of the value of the measurand and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

[IEV 394-20-40]

3.1.21
variance
σ^2

measure of dispersion, which is the sum of the squared deviation of observations x_i from their mean $\bar{x}$ divided by one less than the number of observations n

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

3.2 Quantities and units

In the present standard, units of the International System (SI) are used[3]. The definitions of radiation quantities are given in IEC 60050-393 and IEC 60050-394. 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 Design requirements

4.1 General requirements

Instruments tested using this standard are carried on the body and are used to detect and indicate the presence and general magnitude of radiation fields. These devices are not intended to provide a measurement of dose-equivalent rate. However, the manufacturer may provide an optional display of the air kerma rate from photon radiation. Alternative quantities such as ambient dose equivalent rate expressed in Sieverts per hour are acceptable, provided corrections are made by the manufacturer.

The instruments to be tested using this standard shall quickly alert the user to small increases of radiation levels with a low occurrence of false alarms.

The following features are considered essential or desirable for the proper usability of personal radiation detectors:

a) the following features *shall* be provided:
   – simple to use for non-expert users;
   – separate photon and neutron radiation alarms (if neutron response is provided), with visual and acoustical alerts;

3 International Bureau of Weights and Measures: *The international System of Units (SI),* Seventh edition, 1998.

- audible and/or visual indication that corresponds to the magnitude of the radiation field (for example, increasing frequency or pitch of beep tone with increasing radiation signal);
- readable display in all lighting conditions including darkness;
- small, rugged packaging, shock-resistant and water-resistant;
- protection of the setting of all operational parameters, if available;
- diagnostic capabilities;
- indication of battery status;

b) the following features *should* be provided:

- separate indication of the type of radiation detected (photon and/or neutron);
- silent alarms for covert operation such as vibration alarm and/or earphone with user adjustable earphone volume to cope with the large variations in human hearing sensitivity and noise level;
- high air kerma rate alarm with pre-settable level.

4.2 Mechanical requirements

4.2.1 Size

The overall dimensions of the instrument, excluding any clip, retaining device or external alarm, should not exceed 200 mm in length, 100 mm in width and 50 mm in thickness, unless it is incorporated into another device.

4.2.2 Mass

The mass of the complete instrument should not exceed 400 g.

4.2.3 Alarm characteristics

a) *Location* – The device shall be worn on the body in such a manner that the alarm can always alert the wearer.

b) *Alarm type* – The frequency of an audible alarm should be within the range of 1 000 to 4 000 Hz. Where an intermittent alarm is provided, the signal interval shall not exceed 2 s. The alarm volume at a distance of 30 cm from the alarm source shall be at least 85 dB(A). The A-weighted sound level shall not exceed 100 dB(A) at 30 cm from the alarm source. Where ambient noise levels would make the alarm inaudible or when a silent alarm is necessary, a visual, vibratory or other additional signal shall be provided.

4.2.4 Case construction

The instrument case should be smooth, rigid, resistant to mechanical shock, dust-resistant and water-resistant. Means shall be provided to securely affix the instrument to the user (for example, a clip or ring), with attention given to the necessary orientation of the detector, alarm type and display.

4.2.5 Reference point marking

The instrument shall be clearly marked to indicate the position of the reference point for calibration and test purposes.

4.2.6 Switches

Any external switches shall be adequately protected to prevent accidental or unauthorized operation.

4.3 Electromagnetic requirements

Special precautions shall be taken in the design of the instrument to ensure proper operation in the presence of electromagnetic disturbances, particularly radiofrequency fields.

5 Performance tests

5.1 General test conditions

5.1.1 Nature of tests

The required standard test conditions for environmental quantities, such as temperature and pressure, as well as those for other quantities that may influence the performance of instruments, are given in Table 1. Acceptable testing ranges for these quantities shall be met, except where the effect of the condition or quantity itself is being tested. Environmental quantities, such as temperature and humidity are referred to as influence quantities. Measurements or calibrations should be carried out under reference conditions. Since this is not always achievable or convenient, a small interval around the reference values can be used. In this case, corrections to the reference conditions shall be made.

The tests in this standard are to be considered as type tests (see Table 1) unless otherwise stated. The specifications given are evaluated by the tests given in the appropriate subclauses. All tests using this standard shall be performed using the same conditions with any accessories included with the instruments. Where no test is specified, it is understood to mean that the characteristic can be verified by observation or consultation of the manufacturer's specifications. The user may employ certain parts of the standard as acceptance tests.

5.1.2 Reference conditions and standard test conditions

Reference and standard test conditions are given in Table 1. Reference conditions are those conditions to which the performances of the instrument are valid 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.

5.1.3 Tests performed under standard test conditions

Tests, which are performed under standard test conditions, are listed in Table 2 which indicates, for each characteristic under test, the requirements according to the subclause where the corresponding test method is described. For these tests, the value of temperature, pressure and relative humidity at the time of the test shall be stated and the appropriate corrections made to give the response under reference conditions.

5.1.4 Tests performed with variation of influence quantities

For those tests, intended to determine the effects of variations in the influence quantities given in Table 2, all other influence quantities shall be maintained within the limits for the standard test conditions given in Table 1 unless otherwise specified in the test procedure concerned.