IEC 62401

Edition 2.0 2017-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Alarming personal radiation devices (PRDs) for the 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

IEC 62401:2017-12(en-fr)

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

FOREWORD

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International Standard IEC 62401 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 62401, issued in 2007. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) making the standard consistent with the new standards for detection of illicit trafficking of radioactive material (see the Introduction);
b) changing some requirements:
   – removal of the 2 levels of background levels (high and low) needed for the different tests. Only one background level (laboratory) remains,
   – the gamma alarm is tested using moving sources and not statically (6.2),

  - relative intrinsic error,
  - over-range,
  - detection of neutrons;

c) creating a uniform functionality test for all environmental, electromagnetic and mechanical tests and a requirement for the coefficient of variation of each nominal mean reading;

d) reference to IEC 62706 for the environmental, electromagnetic and mechanical test conditions.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
45B/881/FDIS	45B/888/RVD

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

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

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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Illicit and inadvertent movement of radioactive materials has become a problem of increasing importance. Radioactive sources out of regulatory control, so-called “orphan sources”, have frequently caused serious radiation exposures and widespread contamination. Although illicit trafficking in nuclear and other radioactive materials is not a new phenomenon, concern about a nuclear “black market” has increased in the last few years, particularly in view of its terrorist potential.

In response to the technical policy of the International Atomic Energy Agency (IAEA), the World Customs Organization (WCO) and the International Criminal Police Organization (Interpol) related to the detection and identification of special nuclear materials and security trends, nuclear instrumentation companies are developing and manufacturing radiation instrumentation to assist in the detection of illicit movement of radioactive and special nuclear materials. This type of instrumentation is widely used for security purposes at nuclear facilities, border control checkpoints, and international seaports and airports.

However, to ensure that measurement results made at different locations are consistent, it is imperative that radiation instrumentation be designed to rigorous specifications based upon agreed performance requirements stated in international standards. Several IEC standards have been developed to address body-worn, hand-held and portal instruments, see Table 1.

Table 1 – IEC standards concerning instruments for the detection of illicit trafficking of radioactive material

Type of instrumentation	IEC number	Title of the standard
Body-worn	62401	Radiation protection instrumentation – Alarming Personal Radiation Devices (PRDs) for the detection of illicit trafficking of radioactive material
	62618	Radiation protection instrumentation – Spectroscopy-Based Alarming Personal Radiation Devices (SPRD) for detection of illicit trafficking of radioactive material
	62694	Radiation protection instrumentation – Backpack-type radiation detector (BRD) for detection of illicit trafficking of radioactive material
Portable or hand-held	62327	Radiation protection instrumentation – Hand-held instruments for the detection and identification of radionuclides and for the estimation of ambient dose equivalent rate from photon radiation
	62533	Radiation protection instrumentation – Highly sensitive hand-held instruments for photon detection of radioactive material
	62534	Radiation protection instrumentation – Highly sensitive hand-held instruments for neutron detection of radioactive material
Portal	62244	Radiation protection instrumentation – Installed radiation portal monitors (RPMs) for the detection of illicit trafficking of radioactive and nuclear materials
	62484	Radiation protection instrumentation – Spectroscopy-based portal monitors used for the detection and identification of illicit trafficking of radioactive material
Data format	62755	Radiation protection instrumentation – Data format for radiation instruments used in the detection of illicit trafficking of radioactive materials

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

1 Scope

This document 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 gamma radiation fields. Neutron detection may also be provided.

Personal Radiation Devices (PRDs) 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 the ambient or personal dose equivalent rate.

The object of this document is to describe design and functional criteria along with testing methods for evaluating the performance of the PRDs used for detection of illicit trafficking of radioactive material (e. g., for border radiation monitoring).

This document does not apply to the ambient or personal dose equivalent rate meters which are covered in IEC 60846-1 or IEC 61526, respectively. If the manufacturer states that the PRD can be used for radiation protection purposes, compliance with IEC 60846-1 or IEC 61526 will be needed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-395, *International Electrotechnical Vocabulary – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

IEC 62706:2012, *Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements*

IEC 62755, *Radiation protection instrumentation – Data format for radiation instruments used in the detection of illicit trafficking of radioactive materials*

3 Terms and definitions, abbreviated terms and symbols, quantities and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-395, as well as the following, apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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
quality which characterizes the ability of a measuring instrument to provide an indicated value close to a true value of the measurand

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

3.1.4
background
radiation field in which there are no external sources present other than those in the natural radiation field at the location of the measurements

3.1.5
coefficient of variation
COV
ratio of the standard deviation s to the arithmetic mean $\bar{x}$ of a set of n measurements x_i given by the following formula:

$$COV = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{1}^{n} (x_i - \bar{x})^2}$$

3.1.6
conventionally true value of a quantity
best estimate of the value of a quantity used for a given purpose

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 document

3.1.8
false alarm
alarm not caused by a radioactive source under the specified background conditions

3.1.9
fluence
quotient of dN by da, where dN is the number of particles incident on a sphere of cross-sectional area da (unit: m^{-2})

3.1.10
fluence rate
quotient of $d\Phi$ by dt, where $d\Phi$ is the increment of the fluence in the time interval dt (unit: $m^{-2} \cdot s^{-1}$)

3.1.11
point of measurement
place at which the conventionally true value is determined

3.1.12
reference point
defined position on instrument to be used to position it at a point where the conventionally true value of the quantity to be measured is known

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 when subjected to a specified reference quantity under specified reference conditions

$$\varepsilon_{\mathrm{REL}} = \frac{M - CTV}{CTV}$$

3.1.14
response
reading or indication of the PRD

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

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

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

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

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

Note 1 to entry: 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 2 to entry: 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.

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 Abbreviated terms and symbols

COV coefficient of variation
EMC Electromagnetic Compatibility
ESD electrostatic discharge
IP degree of ingress protection
LED light-emitting diode
PRD personal radiation device
RF radio frequency

3.3 Quantities and units

In the present document, units of the International System (SI) are used[1]. The definitions of radiation quantities are given in IEC 60050-395.

Nevertheless, the following units may also be used:

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

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

4 General characteristics and requirements

4.1 General

PRDs tested using this document are carried on the body and are used to detect and indicate the presence and general magnitude of the gamma radiation fields (e.g., μSv·h^{-1}, counts per second, numerical display without units (1-9), LEDs). PRDs are not intended to provide a measurement of the ambient or personal dose equivalent rate. However, the manufacturer may provide an optional display of the ambient or personal dose equivalent rate from gamma radiation.

The following are important design features:

– quickly alert the user to small increases of radiation levels with a low occurrence of false alarms;
– simple to use for personnel not expert in radiation measurements;
– separate gamma and neutron radiation alarms (if neutron response is provided), with visual and audible alerts;

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1 International Bureau of Weights and Measures: The international System of Units (SI), 8th edition, 2014.

– audible and/or visual indication that corresponds to the magnitude of the radiation field (e.g., increasing frequency or pitch of beep tone with increasing radiation signal);
– the visual display is readable in low light levels (< 150 lx) and high light levels (>10 000 lx);
– small, rugged, shock-resistant, water-resistant and dust resistant;
– protection of the setting of all operational parameters;
– self-diagnostic capabilities (e.g., detector fault);
– indication of battery status;
– vibration alarm and/or earphone with user-adjustable volume;
– personal protection alarm with pre-settable level;
– the operating parameters and the recorded data are not lost if there is a loss of power.

4.2 Mechanical requirements

4.2.1 Size

The overall dimensions of the PRD, excluding any clip, retaining device or external alarm, should not exceed 15 cm in length, 10 cm in width and 5 cm in thickness.

4.2.2 Mass

The mass of the complete instrument including battery, clip, etc., should not exceed 400 g.

4.2.3 Alarm characteristics

a) Indicator – The PRD shall alert the user when an alarm occurs (e.g., visual indicator that enables the operator to view without removal of the device from its wearing position, vibration alarm intensity that can be sensed by the user, etc.).
b) Alarm type – The PRD shall have audible, visual and vibratory alarms. The frequency of an audible alarm should be within the range of 1 kHz to 4 kHz. 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. If the PRD provides neutron detection, the neutron alarm shall be different from the gamma alarm.
c) The personal protection alarm shall be distinguishable from the other alarms.
d) The PRD audible and vibratory alarms shall be capable of being acknowledged and silenced by the PRD user.

4.2.4 Case construction

The PRD 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, holster or ring), with attention given to the necessary orientation of the detector, alarm type and display. See 7.3 for the IP classification.

4.2.5 Reference point marking

The reference point of the PRD shall be marked or described in the manual.

4.2.6 Switches

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

4.3 Data format

If the PRD is capable of transferring data, the data format should meet the IEC 62755 requirements. As a minimum the data shall contain the following information:

– manufacturer name;
– instrument model;
– serial number;
– software version;
– gamma detector kind (e.g., CsI(Tl), NaI(Tl));
– date and time of measurement;
– measured radiation levels (e.g., count rate, dose rate, unit-less level);
– gamma-ray alarm indication;
– personal protection alarm.

If the PRD is equipped with a neutron detector, in addition the data shall contain the following information:

– neutron detector kind (e.g., ^{3}He, Lithium Glass, BF_3);
– neutron level (e.g., count rate);
– neutron alarm indication.

The data transfer protocol shall be fully described by the manufacturer. Consideration should be given to data security when using wireless data transfer techniques.

4.4 Explosive atmospheres

The manufacturer shall state whether or not the PRD is certified for use in explosive atmospheres and its category. Proof of certification shall be provided when claimed. Certification should be based on IEC 60079-11 or equivalent standard (e.g. UL-913).

5 General test procedures

5.1 Nature of tests

The required standard test conditions for environmental quantities, such as temperature and humidity, as well as those for other quantities that may influence the performance of the PRDs, are given in Table 2. Acceptable testing ranges for these quantities shall be met, except where the effect of the condition or quantity itself is being tested.

Table 2 – Standard test conditions

Influence quantities	Standard test conditions (unless otherwise indicated by the manufacturer)
Ambient temperature	18 °C to 25 °C[a]
Relative humidity	≤ 75 %[a]
Atmospheric pressure	96 kPa to 106 kPa[a]
Gamma radiation background	Less than ambient dose equivalent rate of 0,15 $\mu Sv \cdot h^{-1}$
Neutron radiation background	Neutron fluence rate less than 200 $s^{-1} \cdot m^{-2}$

[a] The values are intended for tests performed in temperate climates. In other climates, the actual values of the quantities at the time of test shall be stated. Similarly, a lower limit of pressure of 70 kPa may be permitted at higher altitudes.

The tests in this document are to be considered as type tests, unless otherwise stated. The user may employ parts of the document as acceptance tests.

All tests using this document shall be performed in the configuration of intended use. Functional settings used by the PRD shall not be changed during the different tests if this is not specified in the corresponding method of test.

Where no method of test is described for a requirement, it is understood to mean that either the information for the method of test is contained in the requirement or the characteristic requirement can be verified by observation or by consultation of the manufacturer's specifications.

5.2 Statistical fluctuations

When performing environmental, electromagnetic or mechanical tests, the coefficient of variation (COV) of the readings shall be less than or equal to 12 %. If the COV is larger than 12 %, then the radiation field or the number of readings should be increased to ensure that the mean value of such readings may be estimated with sufficient accuracy to demonstrate compliance with the test in question.

For neutron or gamma background measurements, attaining a COV to meet this requirement may not be possible. Therefore, testing with neutrons or gammas at background levels (i.e., testing without radioactive source present) may be performed even when the COV is larger than 12 %.

The requirement concerning the COV does not apply for the PRDs with unit-less display.

5.3 General test information

The reference point of the PRD shall be placed at the point of measurement. The instrument shall be oriented with respect to the direction of the radiation field as indicated by the manufacturer.

The following radionuclides shall be used for gamma testing: ^{241}Am, ^{137}Cs and ^{60}Co. For neutrons, the test source shall be ^{252}Cf moderated by being surrounded by a spherical shell with 4 cm wall thickness of high density polyethylene or equivalent moderator and inner cavity diameter of not more than 3 cm.

When performing the radiation tests in Clause 6, the PRD shall be mounted on the centre of a phantom to simulate the human torso. The phantom shall be made of polymethyl methacrylate (PMMA).The phantom dimensions shall be 30 cm wide, 30 cm high and 15 cm thick. The reference point of the PRD shall be placed at a height of at least 1 m from the floor.

5.4 Instrument setup

The PRD to be tested shall be placed under standard test conditions, switched on, set up following instructions from the manufacturer, and allowed a stabilisation and background detection period specified by the manufacturer's recommendations. The entire process from the time the PRD is turned on until it is ready for normal operation should not exceed 1 min.