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Edition 2.0 2017-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Instrumentation pour la radioprotection – Instruments portables pour la détection et l'identification des radionucléides et pour l'estimation du débit d'équivalent de dose ambiant pour le rayonnement de photons

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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

FOREWORD

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International Standard IEC 62327 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 62327, issued in 2006. It constitutes a technical revision.

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

a) addition of detailed methods of test;
b) revised identification test acceptance criteria for environmental tests;
c) changed format to match SC 45B template.

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

FDIS	Report on voting
45B/882/FDIS	45B/887/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- withdrawn,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 in the form of radiation sources and contaminated metallurgical scrap 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 this document. IEC standards have also been developed to address personal radiation detectors, radiation portal monitors, highly sensitive gamma and neutron detection systems, spectrometric personal radiation detectors, and backpack-based radiation detection and identification systems. Table 1 below contains a list of those standards.

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 – HAND-HELD INSTRUMENTS FOR THE DETECTION AND IDENTIFICATION OF RADIONUCLIDES AND FOR THE ESTIMATION OF AMBIENT DOSE EQUIVALENT RATE FROM PHOTON RADIATION

1 Scope

This document applies to hand-held instruments used to detect and identify radionuclides and radioactive material, to estimate ambient dose equivalent rate from photon radiation, and optionally, to detect neutron radiation. They are commonly known as radionuclide identification devices or RIDs.

This document specifies general characteristics, general test procedures, radiation characteristics, as well as electrical, mechanical, safety, and environmental characteristics.

This document does not cover laboratory type, high-resolution photon spectrometers, or instruments covered by IEC 60846-1 (Portable workplace and environmental meters and monitors), IEC 60846-2 (photon dose (rate) meters) or IEC 61005 (neutron dose equivalent (rate) meters).

Table 8 provides a summary of requirements and relevant clauses.

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 60050-395:2014, *International Electrotechnical Vocabulary (IEV) – Part 395: Nuclear instrumentation: physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-18, *Environmental testing – Part 2-18: Tests – Test R and guidance: Water*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

IEC 60068-2-66, *Environmental testing – Part 2-66: Test methods – Test Cx: Damp heat, steady state (unsaturated pressurized vapour)*

IEC 60068-2-68, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

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

IEC 60846-1, *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*

IEC 60846-2, *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*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61005, *Radiation protection instrumentation – Neutron ambient dose equivalent (rate) meters*

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

IEC 62706, *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 following terms and definitions, as well as those given in IEC 60050-395 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
acceptance test
contractual test to prove to the customer that a device meets certain conditions of its specification

3.1.2
alarm
audible, visual, or other signal activated when the reading exceeds a pre-set value or falls outside a pre-set range

3.1.3
ambient dose equivalent (rate)
dose equivalent (rate) at a point in a radiation field, produced by the corresponding aligned and expanded field, in the ICRU sphere at a depth d, on the radius opposing the direction of the aligned field

Note 1 to entry: This definition does not include the notes that are part of definition IEC 60050-395:2014, 395-05-43.

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
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
confidence indicator
typically a numeric value assigned to a radionuclide identification result as to whether the identified radionuclide is present

3.1.7
conventionally true value
best estimate of the true value of a radiation field or source used for testing or calibration of equipment

3.1.8
error of indication
difference between the indicated value v of a quantity and the conventionally true value, CTV, of that quantity at the point of measurement

3.1.9
integration time
length of time used for collection of data to obtain a result

3.1.10
reference point
location marked on the instrument or described in the manual, used to establish radiation source-to-instrument distances and orientation for calibration or test purposes

3.1.11
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 as given by the formula:

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

3.1.12
restricted mode
operating mode used to access spectral data and to control the parameters that can affect the result of a measurement (for example: radionuclide library, routine function control, calibration parameters, alarm thresholds, etc.)

Note 1 to entry: May also be called expert mode.

Note 2 to entry: Access to this mode should be limited through password protection or other similar methods.

3.1.13
routine mode
operating mode that includes detection and identification of radionuclides, and estimation of the ambient dose equivalent rate

Note 1 to entry: May also be called easy mode.

3.1.14
stabilization time
duration, measured from the initial application of power, required for an instrument to indicate that it is operational

3.1.15
type test
conformity test on one or more specimens of a product representative of the production

3.1.16
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.

3.2 Abbreviated terms and symbols

COV	coefficient of variation
ESD	electrostatic discharge
DU	depleted uranium
HEU	highly enriched uranium
ICRU	International Commission on Radiation Units
lx	lux
NORM	naturally occurring radioactive material
RF	radio frequency
RGPu	reactor grade plutonium
RH	relative humidity
RID	radionuclide identification device
WGPu	weapons grade plutonium

3.3 Quantities and units

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

The following units may also be used:

– for energy: electron-volt (symbol: eV), 1 eV = 1,602 x 10^{-19} J;

– for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min);

– for temperature: degrees Celsius (symbol: °C), 0 °C = 273,15 K.

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

4 General characteristics and requirements

4.1 General

RIDs are used for the detection, localization, and identification of radioactive material and for estimation of the ambient dose equivalent rate. They are hand-held, battery-powered instruments most commonly used for the detection and identification of illicit trafficking of radioactive material. They typically measure the photon energy spectrum and identify the radionuclide by comparison with an internal radionuclide library. RIDs may also detect neutrons.

The following are important design features:

– a display that is readable in low light (< 150 lx) and bright light (> 10 000 lx) conditions,

– user friendly controls, a menu structure that is simple and easy to follow, restricted access to critical operating parameters, and switches and other controls that minimize or prevent inadvertent operation.

NOTE During the development of this document, a desire for a RID to provide a simple user display for identification results was noted. The display discussed would provide identification results in the form of, for example, a green or red display to indicate that the radionuclide(s) identified was either not of interest or of possible interest, respectively. At the time of this revision, no specific functional requirements had been established. Requirements for the capability may be part of future revisions of this document.

4.2 Radiation detectors

RIDs may use multiple detectors to detect gamma radiation, identify radionuclides, and detect neutrons.

4.3 Personal protection alarm

4.3.1 Requirements

An alarm shall be provided to alert the user that the ambient gamma dose equivalent rate is above a threshold level. The alarm threshold shall be adjustable through the restricted mode. The alarm shall be both audible and visual with an "acknowledge" or other similar control to silence the audible function. It shall not be possible to deactivate both audible and visual indicators at the same time.

4.3.2 Method of test

a) Following the instructions provided by the manufacturer, set the personal protection alarm to activate at for example, 10 μSv h^{-1}.

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

b) Expose the RID to a gamma source that provides an ambient dose equivalent rate reading 30 % above the alarm setting and verify the RID alarms.

c) While exposed to the radiation field, verify the alarm can be acknowledged. Access the RID menu to verify that it is not possible to disable both the audible and visual alarm indications simultaneously.

4.4 Stabilization time

4.4.1 Requirements

The manufacturer shall state the time required for the RID to become fully functional, i.e., to provide an indication of the ambient dose equivalent rate, be able to perform an identification, and detect neutrons, if applicable. The maximum time shall be less than 5 min from shutdown state or stand-by status (e.g., mechanically cooled detectors).

4.4.2 Method of test

Immediately after the manufacturer-stated stabilization time or within 5 min from switching the RID on either from shutdown state or stand-by status, expose the RID to ^{137}Cs producing an ambient dose equivalent rate of 0,5 μSv h^{-1} (± 30 %) above the background at the reference point of the RID and perform an identification. If the RID can detect neutrons, expose the RID to a neutron source moderated by high density polyethylene having a wall thickness of 4 cm.

The requirement is met if the RID is operational within 5 min of power-on as determined by providing an indication of the ambient dose equivalent rate, being able to perform an identification, and indicating the presence of neutrons, if neutron detection is provided.

4.5 Power supplies – battery

4.5.1 Requirements

The RID shall provide a visible indication of the battery condition, shall be able to detect and identify radionuclides, indicate ambient dose equivalent rate, and indicate the presence of neutrons (when applicable) for a minimum of 5 h under standard test conditions without indicating a low battery condition. The manufacturer shall also state the estimated operating time using the recommended battery(s) at standard test conditions as defined in Table 2 and at –20 °C.

NOTE When operated at low temperatures, the capacity of most types of batteries significantly decreases.

4.5.2 Method of test

Following the manual, verify that the manufacturer provided the expected continuous operating time using the recommended batteries at standard test temperature conditions and at –20 °C, and that the display includes a battery status indication.

Ensure the batteries are new or that rechargeable batteries are fully charged and after allowing the RID to stabilize in standard test conditions, perform a radionuclide identification using ^{137}Cs, and if applicable, expose the RID to a moderated neutron source as defined in 4.4.2. Record the results, including the indicated ambient dose equivalent rate with the source present and the neutron count rate, if provided. Repeat the process each hour for a total of 5 h. At the end of the 5 h period, perform another radionuclide identification and neutron response test, if applicable, with the same sources in the same position, and verify that the low battery indicator is not displayed.

The requirement is met when a low battery condition is not displayed and the RID is able to perform an identification with the same results, indicate the ambient dose equivalent rate with the source present within ± 30 % of the initial value, and if applicable, indicate the presence of neutrons. If a neutron count rate was provided, the count rate shall be within ± 30 % of the initial value.