IEC 62534

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Highly sensitive hand-held instruments for neutron detection of radioactive material

Instrumentation pour la radioprotection – Instruments portables de haute sensibilité pour la détection neutronique de matières radioactives

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RADIATION PROTECTION INSTRUMENTATION – HIGHLY SENSITIVE HAND-HELD INSTRUMENTS FOR NEUTRON DETECTION OF RADIOACTIVE MATERIAL

FOREWORD

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International Standard IEC 62534 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/639/FDIS	45B/653/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 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- withdrawn,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 – HIGHLY SENSITIVE HAND-HELD INSTRUMENTS FOR NEUTRON DETECTION OF RADIOACTIVE MATERIAL

1 Scope and object

This International Standard applies to hand-held instruments used for the detection and localization of neutron emitting radioactive material. These instruments are highly sensitive meaning that they are designed to detect slight variations in the range of usual background that may be caused by illicit trafficking or inadvertent movement of radioactive material. This high sensitivity allows scanning of larger volume items such as vehicles and containers. These instruments may also be used in fixed or temporally fixed unattended mode to monitor check points or critical areas. Instruments addressed by this standard will also provide a means to detect photon radiation for personal protection.

This standard does not apply to the performance of radiation protection instrumentation which is covered in IEC 61005 and in IEC 61526.

The object of this standard is to establish performance requirements, provide examples of acceptable test methods, and to specify general characteristics, general test conditions, radiation characteristics, electrical safety, and environmental characteristics, that are used to determine if an instrument meets the requirements of this standard.

The results of tests performed provide information to government agencies and other users on the capability of radiation detection instruments for reliably detecting neutron sources.

Obtaining operating performance that meets or exceeds the specifications as stated in this standard depends upon properly establishing appropriate operating parameters, maintaining calibration, implementing a suitable response testing and maintenance program, auditing compliance with quality requirements, and providing proper training for operating personnel.

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 60050-394:2007, *International Electrotechnical Vocabulary – Part 394: Nuclear instrumentation – Instruments, systems, equipment, and detectors*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

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

IEC 61005:2003, *Radiation protection instrumentation – Neutron ambient dose equivalent (rate) meters*

IEC 61526:2005, *Radiation protection instrumentation – Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations – Direct reading personal dose equivalent meters and monitors*

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

3 Terms and definitions

3.1 General

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

NOTE Radiation quantities and dosimetric terms are from IEC 60050-393 and IEC 60050-394.

3.2 Definitions

3.2.1
acceptance test
contractual test to prove to the customer that the instrument fulfils certain specifications

[IEV 151-16-23, modified]

[IEV 394-40-05, modified]

3.2.2
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]

3.2.3
background level
radiation field in which the instrument is intended to operate which includes background produced by naturally occurring radioactive material

3.2.4
conventionally true value
value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose

NOTE Conventionally true value of a quantity is sometimes called assigned value, best estimate of the value, conventional value or reference value.

[IEV 394-40-10]

3.2.5
false alarm
alarm not caused by an increase in radiation level over background conditions

3.2.6
functionality test
test performed to verify that alarms activate and that radiation detection is acceptable

3.2.7
influence quantity
quantity that may have a bearing on the result of a measurement without being the subject of the measurement

3.2.8
manufacturer
includes the designer of the equipment

3.2.9
point of measurement
place at which the conventionally true values are determined and at which the reference point of the instrument is placed for calibration or test purposes

3.2.10
purchaser
includes the user of the equipment

3.2.11
radioactive material
in this standard, radioactive material includes special nuclear material, unless otherwise specifically noted

3.2.12
reference point of an instrument
mark on the equipment at which the instrument is positioned for the purpose of calibration and testing

NOTE The point from which the distance to the source is measured.

[IEV 394-40-15, modified]

3.2.13
type test
conformity test made on one or more items representative of the production

[IEV 151-16-16]

[IEV 394-40-02]

3.3 Quantities and units

In the present standard, units of the International System (SI) are used[1]. The definitions of radiation quantities are given in IEC 60050-393, IEC 60050-394.

The following units may also be used:

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

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

4 General requirements

4.1 General characteristics

Instruments addressed by this standard are used for the detection of neutron emitting radioactive material. These instruments are hand-held and battery-powered. They have a significantly higher detection capability than pocket-sized devices which allows them to be used to search around larger volume items such as vehicles and containers.

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1 The International System of Units, 8th edition, 2006.

4.2 Physical configuration

The instrument case design shall meet the requirements stated for IP code 53 (see IEC 60529).

Controls and adjustments that may affect the operation of the instrument including setting of alarms shall be designed so that access to them is limited to authorized persons.

Provisions shall be made to permit testing of visual and/or sound warning indicators without the use of radiation sources.

Alarm threshold values shall be calculated by the instrument automatically using background measurements and user definable alarm factors.

4.3 Basic information

4.3.1 Documentation supplied

The manufacturer shall provide instrument performance specifications and instructions for operation. See Clause 8 for details.

4.3.2 Radiation detector

Manufacturer provided information shall describe the radiation detector types used for neutron detection and the personal protection alarm (e.g., ^{3}He, GM). For gas-filled counter tubes the internal pressure shall be stated by the manufacturer.

The instrument's fluence response to bare and moderated ^{252}Cf shall be stated by the manufacturer.

4.3.3 Size

The dimensions of the instrument shall be specified by the manufacturer with maximum dimensions of 350 mm × 200 mm × 150 mm excluding the handle.

4.3.4 Weight

The weight or mass of the instrument shall be specified by the manufacturer and should be less than 5 kg.

4.4 Operating modes

4.4.1 Monitor mode

The instrument shall have the ability to monitor the area surrounding the instrument for changes in radiation levels that may be caused by a source passing through the area. This shall be done without actions by the user and shall work autonomously. The user shall have the ability to select whether the alarm will be silent or audible, and visual or not.

4.4.2 Search mode

The instrument shall have a search function that is activated by the user. The instrument shall provide an audible and visual indication when operated in search mode. Audible and visual indications shall be related to the magnitude of the radiation field (e.g., increasing frequency or pitch of beep tone with increasing radiation signal) for eyes-free searching and localization.

4.4.3 Integration mode

The instrument shall have the ability to integrate counts for an extended period of time. The start and end of the integration time shall be user activated with the accumulated counts

displayed as the measurement proceeds. An alarm shall be provided based on the accumulated counts. The integrated mode alarm method shall be described by the manufacturer.

4.5 Maintenance/Calibration

The instrument shall have an access-controlled, menu-driven mode that will allow personnel to check and perform adjustments as needed to calibrate the instrument as well as make adjustments to factors that can control the response of the instrument.

4.6 Communication interface

The instrument shall have the ability to transfer data to another device such as a personal computer. The manufacturer shall provide a full description of the transfer data format. “XML” format based on ANSI N42.42 is recommended.

4.7 User interface

The following are considered essential or desirable:

a) the following shall be provided:
   - simple to use for non-expert users and user-friendly controls for routine operation,
   - neutron radiation alarms with visual and audible alarms,
   - display that provides a method to track radiation levels when operating in the “search” mode,
   - display that provides a real-time radiation level indication that can be viewed when operating in the “monitor” mode,
   - audible and/or visual indication that is related to the magnitude of the radiation field (e.g., increasing frequency or pitch of beep tone with increasing radiation signal) for eyes-free searching and localization,
   - readable display in all lighting conditions including darkness,
   - protection of the setting of all operational parameters, if available,
   - controls and switches that are designed in a way to minimize accidental operation,
   - diagnostic capabilities,
   - indication of battery status, and
   - the capability to operate if the user is wearing gloves.

b) the following should be provided:
   - silent alarms for covert operation such as vibration alarm and/or earphone connection with an adjustable volume to cope with the large variations in human hearing sensitivity and noise level.

4.8 Markings

4.8.1 General

All external instrument controls, displays, and adjustments shall be identified as to function. Internal controls needed for operation shall be identified through markings and identification in technical manuals. External markings shall be easily readable and permanently fixed under normal conditions of use.

4.8.2 Exterior markings

The following markings shall appear on the exterior of the instrument or each major assembly (e.g., detector probe) as appropriate:

- manufacturer and model number,

- unique serial number,
- location of the reference point, and
- function designation for controls, switches, and adjustments that are not menu or software driven.

Markings shall be easily readable and permanently fixed under normal conditions of use (including use of normal decontamination procedures).

4.9 Power supply

4.9.1 Requirements

Instruments shall be equipped with a test circuit or other visible direct indicator of battery condition for each battery circuit.

The manufacturer shall state the expected continuous operating time using the recommended batteries and the conditions (functional and environmental) used to determine this time.

The instrument shall be fully operational for a minimum of 8 h after warm-up under standard test conditions. The low-battery indication shall be no lower than the minimum voltage required for proper operation.

If operated using consumable batteries, the batteries shall be widely available, not unique to the instrument, and be field replaceable (e.g., AA) with no special tools. Battery chargers shall meet appropriate electrical standards.

4.9.2 External DC or AC power

The instrument should be capable of operating from an external DC or AC source. Adequate protection from reverse polarity, over-voltage, and electrical noise shall be provided. AC or DC power sources may include:

a) 12 V DC as would be obtained from a 12-volt vehicle electrical system.

b) A portable battery pack, such as one that can be worn, that supplies 4 V DC to 28 V DC.

c) A regulated 12 V DC power supply operating from mains power.

d) A single phase 100 V AC to 240 V AC 50 Hz – 60 Hz power supply.

Requirements are verified by observation of the instrument and review of manufacturer-provided information.

4.10 Protection of switches

Switches and other controls should be protected to minimize or prevent inadvertent deactivation or improper operation of the instrument.

4.11 Display units

Neutron indication shall be in counts per second.

4.12 Effective range of measurement

The neutron energy range shall be from thermal to fast neutrons with tests performed using moderated and unmoderated ^{252}Cf.

The manufacturer shall also state the range for neutron count rate indication.

4.13 Alarms

4.13.1 Source indication alarm

A source indication alarm shall be provided when the measured neutron field (count rate) is above the source indication alarm threshold. This alarm threshold shall be calculated by the instrument from the background measurement by adding a user-defined count rate increment or number of standard deviations (depending on instrument operating mode). The alarm shall be both audible and visual, and not be affected by slowly increasing radiation fields that could cause a slow change in the alarm threshold. It shall not be possible to switch off all alarm indications at the same time.

4.13.2 Personal protection alarm

Alarms shall be provided to alert the user when the measured neutron field (counts per second) or the photon radiation field intensity are above a user-selected threshold level (typically 100 $\mu Sv.h^{-1}$). Each alarm shall be audible and visual, be different from the neutron source indication alarm, and adjustable through the restricted mode. For the personal protection photon radiation alarm, the alarm value shall be based on ^{137}Cs. For neutron, the alarm value shall be based on the spectrum from ^{252}Cf.

The personal protection alarm shall be functional over the stated range of the instrument.

4.14 Explosive atmospheres

The manufacturer shall state as to whether the instrument is certified for use in explosive atmospheres and its category. Proof of certification shall be provided when claimed.

4.15 Indication features

The instrument shall provide an indication of its operational status and alarm condition. The user shall have the ability to select the visibility of the status indication.

All alarm indicators shall automatically or manually reset as defined by the user.

5 General test procedure

5.1 Nature of test

Unless otherwise specified in the individual steps, all tests enumerated in this standard are to be considered type tests. Certain tests may be considered acceptance tests by agreement between the purchaser and the manufacturer.

When performing radiation tests as described in this standard, the reference point of the instrument shall be placed at the point of measurement and the instrument shall be oriented with respect to the direction of the radiation source as indicated by the manufacturer.

5.2 Reference conditions and standard test conditions

Reference conditions are given in Table 1. Except where otherwise specified, tests shall be carried out under the standard test conditions in accordance with Table 1. For those tests carried out under standard test conditions, the values of temperature, pressure, and relative humidity shall be stated and the appropriate corrections made to give the response under reference conditions. The values of any corrections should be stated.

5.3 Statistical fluctuations

For any test involving the use of radiation, if the magnitude of the statistical fluctuations of the indication arising from the random nature of radiation alone is a significant fraction of the