IEC 62533

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

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

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International Standard IEC 62533 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/640/FDIS	45B/654/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 amendment and the base 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- withdrawn,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 PHOTON DETECTION OF RADIOACTIVE MATERIAL

1 Scope and object

This International Standard applies to hand-held instruments used for the detection and localization of radioactive photon emitting materials. These instruments are highly sensitive meaning that they are designed to detect slight variations in the range of usual photon background caused mainly by illicit trafficking or inadvertent movement of radioactive material. Compared to pocket devices (see IEC 62401), this highly sensitive instrument allows the scanning of larger volume items such as vehicles or containers. They may also be used in fixed or temporarily fixed unattended mode to monitor check points or critical areas.

These instruments also provide an indication of the ambient dose equivalent rate from photon radiation. However, this standard does not apply to the performance of radiation protection instrumentation which is covered in IEC 60846-1 and IEC 61526.

These instruments may provide additional functions as described below without including all features of specialized portable identification devices as defined by IEC 62327:

- rejecting natural background variation encountered when used in movement;
- sorting alarms of interest from naturally occurring radioactive material (NORM) or medical radionuclides originated alarms;
- provide source categorization data (including limited photon spectra) to a remote location.

The object of this standard is to establish performance requirements including physical characteristics, general test conditions, radiation characteristics, electrical safety, and environmental conditions. This standard provides examples of acceptable test methods to determine if an instrument meets the requirements of this standard. The results of tests performed provide information to users on the capability of radiation detection instruments for reliably detecting photon 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, providing proper training for operating personnel and developing operating procedures that address the instrument limitations and capabilities.

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 (IEV) – Part 394: Nuclear Instrumentation – Instruments, systems, equipment and detectors*

IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60529:1989, *Degrees of protection provided by enclosures* (IP Code)

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

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

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields*

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*

International Bureau of Weights and Measures, The International System of Units (SI), 8th edition, 2006

3 Terms, definitions, abbreviations, 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 60050-393 and IEC 60050-394 apply.

3.1.1
A-weighted sound level
the 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
alarm
an 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]

3.1.3
ambient dose equivalent, Hx(10)
dose equivalent at a point in a radiation field, produced by the corresponding aligned and expanded field, in the ICRU sphere at a depth of 10 mm, on the radius opposing the direction of the aligned field

[ICRU Report 39]

NOTE 1 In defining these quantities, it is useful to stipulate certain radiation fields that are derived from the actual radiation field. The terms "expanded" and "aligned" are used to characterise these derived radiation fields. In the expanded field, the fluence and its angular and energy distribution have the same values throughout the

volume of interest as in the actual field at the point of reference. In the aligned and expanded field, the fluence and its energy distribution are the same as in the expanded field but the fluence is unidirectional.

NOTE 2 The ICRU sphere (see ICRU Report 33) is a 30 cm diameter, tissue-equivalent sphere with a density of 1 g/cm^3 and a mass composition of tissue equivalent material (see IEV 393-14-78).

NOTE 3 The recommended depth d, for environmental monitoring in terms of Hx(d) is 10 mm, and Hx(d) may then be written as Hx(10).

NOTE 4 An instrument that has an isotropic response and is calibrated in terms of Hx(d) will measure Hx(d) in radiation fields that are uniform over the dimensions of the instrument.

NOTE 5 The definition of Hx(d) requires the design of the instrument to take account of backscatter.

[IEV 393-14-95]

3.1.4
ambient dose equivalent rate, $\dot{H}x(10)$

the quotient of the ambient dose equivalent at the recommended depth for environmental monitoring of 10 mm $dHx(10)$ by dt, where $dHx(10)$ is the increment of ambient dose equivalent in the time interval dt

$$\dot{H}x(10) = \frac{dHx(10)}{dt}$$

3.1.5
background level

radiation field in which the instrument is intended to operate, including background produced by naturally occurring radioactive material

3.1.6
conventionally true value of a quantity

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

NOTE 1 "Conventionally true value of a quantity" is sometimes called assigned value, best estimate of the value, conventional value or reference value.

NOTE 2 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 394-40-10, modified]

3.1.7
effective range of measurement

absolute value of the difference between the two limits of a nominal range

NOTE In some fields of knowledge, the difference between the greatest and smallest values is called range.

[IEV 394-40-16]

3.1.8
false alarm

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

3.1.9
functionality test

test performed to verify that alarm activation and radiation detection are acceptable

3.1.10
influence quantity

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

3.1.11
manufacturer
includes the designer of the equipment

3.1.12
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

3.1.13
purchaser
includes the user of the equipment

3.1.14
radioactive material
in this standard, radioactive material includes special nuclear material, unless otherwise specifically noted

3.1.15
readout
displayed value, with units, displayed and/or recorded by the instrument as a result of the instrument's response to some influence quantity

3.1.16
reference point of an instrument
mark on the equipment that represents the position of the instrument for the purpose of calibration and testing

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

[IEV 394-40-15, modified]

3.1.17
relative error, ε_{REL}(%)
error of measurement divided by a true value of the measurand

NOTE Since a true value cannot be determined, in practice a conventionally true value is used.

[IEV 394-40-11]

3.1.18
response, *R*
ratio of the instrument reading to the conventionally true value of the measured quantity

3.1.19
restricted (or expert) mode
advanced operating mode used by an expert user to access and control the parameters that can affect the result of a measurement (for example alarm thresholds). Access to this mode should be limited through password protection or other similar methods.

NOTE This mode may also be called "advanced" or "protected" mode.

3.1.20
standard deviation
the positive square root of the variance

3.1.21
type test
conformity test made on one or more items representative of the production

[IEV 394-40-02]

3.1.22
routine test
conformity test made on each individual item during or after manufacture

[IEV 394-40-03]

3.1.23
acceptance test
contractual test to prove to the customer that the device fulfils certain specifications

[IEV 394-40-05]

3.1.24
variance, σ^2
a 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 Abbreviations

3.2.1
HEU
highly enriched uranium

3.2.2
NORM
naturally occurring radioactive material

3.2.3
RF
radio frequency

3.2.4
WGPu
weapons grade plutonium

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 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.

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1 International Bureau of Weights and Measures: *The international System of Units (SI),* 8th edition, 2006.

4 General requirements

4.1 General characteristics

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

4.2 Physical configuration

The instrument case design shall meet the requirements stated for IP code 53 (see IEC 60529), which means that the instrument shall be protected from the ingress of dust and spraying water. For IP53, the ingress of dust is not totally prevented, but dust shall not penetrate the instrument case in such a quantity to interfere with satisfactory operation of the instrument or to impair safety, and water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects.

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

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

4.3 Basic information

4.3.1 Documentation supplied

The manufacturer shall provide instrument performance specifications and instructions for operation.

4.3.2 Type of radiation detector

The manufacturer shall provide information describing the radiation detector types used (e.g., NaI(Tl)).

4.3.3 Size

The dimensions of the instrument shall be specified by the manufacturer.

4.3.4 Weight

The weight or mass of the instrument shall be specified by the manufacturer and should not exceed 3 kg.

4.4 Communication interface

The instrument shall have the ability to transfer data, such as ambient dose equivalent rate indication, count rate, source categorization and possibly limited photon spectra to another device such as a personal computer. The manufacturer shall provide a specification of the transfer data format.

4.5 User interface

The following features are considered essential or desirable:

a) the following features shall be provided:
   - simple to use for non-expert users and user-friendly controls for routine operation;
   - photon radiation alarms, with visual and audible signals;

- source indicator: 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;
- controls and switches that are designed in a way to minimize accidental operation;
- diagnostic capabilities;
- indication of battery status;
- capability to operate if the user is wearing gloves (typically gloves used for thermal protection).

b) the following feature should be provided:

- 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.

4.6 Warm-up time

The manufacturer shall state the time required for the instrument to become fully functional. The maximum time shall be less than 2 min. If the device includes limited spectrometric features, up to 5 min is allowed for stabilization. An indication shall be provided to the user during the period the instrument is not fully ready.

4.7 Markings

4.7.1 General

All external instrument controls, displays, and adjustments shall be identified as to their 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.

4.7.2 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.

4.8 Power supply

4.8.1 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.

4.8.2 External DC or AC power

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

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

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

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

d) A single-phase 100 V to 240 V AC and 50 Hz to 60 Hz.

4.9 Protection of controls

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

4.10 Photon ambient dose equivalent rate indication

The instrument shall provide an indication of the ambient dose equivalent rate.

4.11 Alarms

4.11.1 Source indication alarm

A source indication alarm shall be provided when the measured ambient dose equivalent rate or count rate is above the instrument alarm threshold. This alarm threshold shall be calculated by the instrument automatically from background measurements using techniques such as a user definable dose equivalent rate increment, count rate increment or a multiplier value applied to the standard deviation of the measured background. The alarm shall be visual and/or audible (or by vibration). It shall not be possible to switch off all alarm indicators at the same time.

4.11.2 Personal protection alarm

An alarm shall be provided to alert the user that the indicated ambient dose equivalent rate is above a user-selected threshold level. The alarm shall be both visual and audible (or by vibration), and shall be adjustable through the restricted mode. The alarm shall have an "acknowledge" or other similar control to silence the audible function. It shall not be possible to switch off all alarm indicators at the same time. This alarm shall be different or distinguishable from the source indication alarm.

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

4.12 Effective range of measurement

The effective photon energy response range shall be stated by the manufacturer, and shall include the range from 45 keV to 1,5 MeV.

The manufacturer shall also state the range for photon ambient dose equivalent rate measurement. The range shall be at least from 0,02 $\mu Sv\ h^{-1}$ to 10 $\mu Sv\ h^{-1}$.

4.13 Angular dependence

The manufacturer shall state the angular dependence of the instrument.

4.14 Explosive atmospheres

The manufacturer shall state as to whether the instrument is certified for use in explosive atmospheres. The manufacturer shall provide a certificate to show compliance when certification is 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.