IEC 62694

Edition 1.0 2014-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Radiation protection instrumentation – Backpack-type radiation detector (BRD) for the detection of illicit trafficking of radioactive material

Instrumentation pour la radioprotection – Détecteur de rayonnement de type sac-à-dos (BRD) pour la détection du trafic illicite des matières radioactives

IEC 62694:2014-03(en-fr)

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CONTENTS

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RADIATION PROTECTION INSTRUMENTATION – BACKPACK-TYPE RADIATION DETECTOR (BRD) FOR THE DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL

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International Standard 62694 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/781/FDIS	45B/790/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- withdrawn,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.

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RADIATION PROTECTION INSTRUMENTATION – BACKPACK-TYPE RADIATION DETECTOR (BRD) FOR THE DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL

1 Scope

This International Standard applies to backpack-type radiation detectors (BRDs) that are used for the detection of illicit trafficking of radioactive material. This standard establishes the operational and performance requirements for BRDs. BRDs are portable instruments designed to be worn during use. They may also be used as temporary area monitors in a stand-alone mode.

BRDs detect gamma radiation and may include neutron detection and/or the identification of gamma-ray emitting radionuclides. This standard establishes performance and testing requirements associated with radiation measurements and the expected electrical, mechanical, and environmental conditions while in use.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts): *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 60050-393:2003, *International Electrotechnical Vocabulary – 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 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, abbreviations, quantities and units

3.1 Terms and definitions

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

3.1.1
accuracy
closeness of the agreement between the result of a measurement and the conventionally true value of the measurand

3.1.2
alarm
audible, visual, or other signal activated when the instrument reading exceeds a preset value, falls outside of a preset range, or when the instrument detects the presence of the source of radiation according to a preset condition

[SOURCE: IEC 60050-393:2003, 393-18-03, modified]

3.1.3
background level
radiation field in which there are no external sources present other than those in the natural background at the location of the measurements

3.1.4
backpack-type radiation detector
instrument composed of several radiation detection components that are placed inside a backpack or other similar enclosure with an external user interface or control device

3.1.5
centre line
horizontal or vertical line that describes the geometrical centre of an object

3.1.6
coefficient of variation
V
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:

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

[SOURCE: IEC 60050-394:2007, 394-40-14]

3.1.7
energy window
part of the energy spectrum within an upper and lower energy limit

[SOURCE: IEC 60050-394:2007, 394-38-70]

3.1.8
keyhole markup language
KML
is a file format used to display geographic data

Note 1 to entry: For example, see http://www.opengeospatial.org/standards/kml/.

3.1.9
fluence
Φ
the quotient of dN by da, where dN is the number of particles incident on a sphere of cross-sectional area da: Φ = dN/da

[SOURCE: IEC 60050-881:1983, 881-04-18]

3.1.10
fluence rate
the *fluence rate*, $\dot{\phi}$, is the quotient of dΦ by dt, where dΦ is the increment of the fluence in the time interval dt, thus $\dot{\phi} = \frac{d\phi}{dt}$. The unit of fluence rate is $m^{-2}s^{-1}$

[SOURCE: ICRU Report 60:1998]

3.1.11
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-394:2007, 394-40-02]

3.1.12
user interface
software and/or hardware that manages interactions between a user and equipment

3.1.13
variance
σ^2
measure of dispersion, which is the sum of the squared deviation of observations from their mean divided by one less than the number of observations

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

3.2 Abbreviations

AC	alternating current
BRD	backpack-type radiation detector
cps	counts per second
DC	direct current
DU	depleted uranium
ESD	electrostatic discharge
FIFO	first in first out
GPS	global positioning system
HDPE	high density polyethylene
HEU	highly enriched uranium
HPGe	high purity germanium
KML	keyhole markup language
NORM	naturally occurring radioactive material
PMMA	polymethyl methacrylate
RGPu	reactor grade plutonium
WGPu	weapons grade plutonium
XML	eXtensible Markup Language

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 and IEC 60050-394.

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);

– for distance: centimetre (symbol: cm), millimetre (symbol: mm), kilometre (symbol: km);

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

4 General test procedure

4.1 Nature of test

The tests in this standard are to be considered type tests, unless otherwise stated.

4.2 Standard test conditions

Except where otherwise specified, the tests in this standard shall be performed under the standard test conditions given in Table 1.

4.3 Tests performed under standard test conditions

For these tests, the value of temperature, pressure, relative humidity and gamma and neutron background at the time of the test shall be recorded. Values should be within the standard test conditions given in Table 1.

4.4 Test performed with variation of influence quantities

For those tests intended to determine the effects of variations in an influence quantity (e.g., temperature, humidity), all other influence quantities should be maintained at the standard test conditions given in Table 1 unless otherwise specified in the applicable test method.

4.5 Statistical fluctuations

For tests involving the use of radioactive sources to verify susceptibility to an environmental, electromagnetic, or mechanical condition the ambient dose equivalent rate produced by the sources to verify the BRD response shall be adjusted to reduce the magnitude of the statistical fluctuations.

If the magnitude of the statistical fluctuations of the BRD indication arising from the random nature of radiation alone is a significant fraction of the variation of the indication permitted in the test, then the ambient dose equivalent rate 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.

It is recommended that the coefficient of variation (*V*, expressed in percentage) for each nominal mean reading be less than or equal to 12 %. For neutron or photon background measurements, attaining a coefficient of variation to meet this requirement may not be possible. Therefore, testing with neutrons or photons at background levels (i.e., testing

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

without radioactive source present) can be performed even when the coefficient of variation is larger than 12 %.

12 % is from statistical analysis techniques for dosimeter testing and has proven to be a simple way of determining when a group of readings are acceptable for compliance testing. The time interval between readings needs be sufficiently long (i.e., larger than the integration time of the instrument) to ensure that the readings are statistically independent.

4.6 Uncertainties in the measurements

Unless otherwise stated for a specific quantity, the uncertainties for any measurable quantity (e.g., radiation field) should not exceed 15 % with a coverage factor of k = 1.

4.7 Background radiation during testing

Testing shall be performed in an area with a nominal natural radiation background that has only natural variation as defined in Table 1.

The gamma-ray background intensity shall be measured using a pressurized ion chamber or similar environmental radiation measurement device that is calibrated to provide the gamma-ray ambient dose equivalent rate, $\dot{H}^*(10)$. When testing spectrometric BRDs the gamma-ray background shall be characterized using a high resolution gamma-ray spectrometer (e.g., high purity germanium (HPGe) detector). The measured spectra shall be recorded. If the BRD is equipped with neutron detectors, the neutron background should be the natural background and should not be artificially modified during testing. The neutron background at the test location shall be measured and recorded.

The evaluation of the BRD shall be performed without the benefit of any radiation shielding against the natural background, except for that shielding that is part of the instrument.

4.8 BRD set up

The BRD shall be set up based on the manufacturer's specifications including background update mode, if applicable. Once set up for testing, no changes shall be made that could affect the overall response of the BRD. If more than one background update mode is available, testing should be performed in all modes when indicated in the specific clauses under the radiological tests.

When performing the radiological tests in Clause 6, the BRD shall be configured and oriented as it would be used. This may be achieved by using a phantom that would represent the human upper torso. The phantom shall be made of polymethyl methacrylate (PMMA).The phantom dimensions shall be 40 cm wide, 60 cm high and 15 cm thick.

The BRD shall be mounted on a stand or fixture made out of a material that does not have a large hydrogen content (e.g., foam, plastic). It is recommended to use materials such as aluminium for mounting the BRD to prevent possible additional moderation of the neutron source.

The reference point of the BRD should be marked by the manufacturer. If marking is not provided by the manufacturer, the reference point is defined as the imaginary point where the three mutually orthogonal lines that go through the center of the length, width and thickness of the BRD intersect (see Figure 2).

For static and dynamic tests described in Clause 6, the reference point of the BRD shall be positioned 1,5 m from the floor or ground surface. The centreline of the source shall be at the same height as the reference point of the BRD, 1,5 m from the floor or ground surface.

For static tests, the distance between the source and the centreline of the BRD shall be between 1 m and 3 m unless otherwise stated.

For dynamic tests, the line of source movement and detector centreline shall be kept parallel, the distance of closest approach between the source and the reference point of the BRD shall be between 1 m and 3 m unless otherwise stated, see Figure 1.

The phantom is not used when the BRD is evaluated for use as a stand-alone area radiation monitor. Testing as an area radiation monitor is performed if such claim is made by the manufacturer.

When performing the tests in Clauses 7, 8, and 9, the BRD shall not be mounted on a phantom. The BRD-to-source distance and the relative orientation and position between the BRD and the radiation source shall be adjusted to reduce the statistical fluctuations as discussed in 4.5. The testing distance, orientation and position of the BRD with respect to source shall be recorded for these tests. Due to the nature of the tests, there is no need for this standard to specify the BRD-to-source distance, and relative orientation and position between the BRD and the source.

4.9 Speed of moving sources and integration time for radionuclide identification

For static tests, the integration time required to perform a radionuclide identification shall be as specified by the manufacturer or a maximum of 1 min (whichever is the shortest).

During the static tests, the source shall be removed and placed back in the same location between trials. There shall be a 10 s minimum delay between each trial with the source either positioned at a distance where it does not affect the background surrounding the BRD or shielded during the delay.

For dynamic tests, the source or BRD shall be moved in a configuration that provides no shielding around the source other than that required for the specific test. The source speed shall be 1,2 m·s^{-1} (average walking speed) when tested at a distance of closest approach of 1,5 m, unless otherwise required in a test. If the distance of closest approach, *d* (expressed in m), is adjusted within 1 m and 3 m then the passage speed, *v* (expressed in m·s^{-1}), shall be adjusted to $v = v_0 \times d/d_0$,

where v_0 = 1,2 m·s^{-1} and d_0 = 1,5 m.

During the dynamic tests, there shall be a 10 s minimum delay between each trial with the source either positioned at a distance where it does not affect the background surrounding the BRD or shielded during the delay.

NOTE For all dynamic tests, the source or the BRD can be moved relative to each other.

4.10 Radiation sources

Unless otherwise stated, tests involving the use of gamma radiation shall be carried out using ^{137}Cs for gross count measurements and ^{241}Am together with ^{60}Co for radionuclide identification (see Table 1).

The reference source for neutron radiation is ^{252}Cf. The neutron emission rate of the ^{252}Cf source shall be 20 000 s^{-1} (± 20 %) (see Table 1). The unmoderated reference neutron source shall be encapsulated in 1 cm of steel and shielded with 0,5 cm-thick lead in order to attenuate the possible gamma-ray emission from the ^{252}Cf source. The lead shall be placed outside the steel encapsulation. The moderation of the ^{252}Cf is achieved by surrounding the source in the presence of the 1 cm of steel encapsulation and 0,5 cm-thick lead shielding with 4 cm-thick high density polyethylene (HDPE) container (e.g., sphere, cylinder, box).

The sources shall be mounted on a stand or fixture made out of a material that does not have a large hydrogen content (e.g., foam, plastic). It is recommended to use materials such as aluminium for mounting the sources to prevent possible additional scattering and moderation of the neutron source.