IEC 61563

Edition 2.0 2019-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Equipment for measuring the activity concentration of gamma-emitting radionuclides in foodstuffs

Instrumentation pour la radioprotection – Équipement de mesure de la concentration d'activité des radionucléides émetteurs gamma dans les aliments

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RADIATION PROTECTION INSTRUMENTATION – EQUIPMENT FOR MEASURING THE ACTIVITY CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN FOODSTUFFS

FOREWORD

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International Standard 61563 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 published in 2001. This edition constitutes a technical revision.

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

a) The previous edition applied to handheld-type and portable-type instruments. This edition applies to transportable-type and installed-type instruments, as well as the scope of the previous edition. The handheld-type and portable-type instruments are mainly used in case of a post accidental situation, however, the transportable-type and installed-type instruments can be used through recovery phase.
b) Uncertainty of measurement according to GUM is introduced.
c) Detection limit defined in ISO 11929 is introduced to specify a minimum detectable activity.

d) Environmental requirements, mechanical requirements and electromagnetic requirements are updated according to IEC 62706.

e) Sample format of measuring report is introduced as Annex C (informative).

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

FDIS	Report on voting
45B/931/FDIS	45B/936/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.

RADIATION PROTECTION INSTRUMENTATION – EQUIPMENT FOR MEASURING THE ACTIVITY CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN FOODSTUFFS

1 Scope

This document applies to instruments used to measure the activity and/or activity concentration of gamma-emitting radionuclides in food and/or foodstuffs. This document applies to instruments used both as gross count type instruments and pulse height analysing type instruments used in field conditions and in measurement facilities. This document does not apply to high-resolution spectrometers that use germanium detectors.

The instruments to which this document applies can be used to measure the activity and activity concentration of gamma-emitting radionuclides for a wide variety of samples, such as soil, sewage, plant, and animal life.

The object of this document is to establish performance requirements, to provide test methods and to specify general characteristics, general test conditions, and radiological, environmental, mechanical and electromagnetic characteristics to be used to determine whether an instrument meets the requirements of this document. The test results provide information to end-users and manufacturers regarding the capability of instrument for reliable measurement of the activity and/or activity concentration of gamma-emitting radionuclides.

This document does not apply to sample preparation.

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 (IEV) – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60086-2, *Primary batteries – Part 2: Physical and electrical specifications*

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

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

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

ISO 11929, *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation – Fundamentals and application*

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

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 Terms and definitions

3.1.1
activity concentration
activity per unit mass (Bq kg^{-1}) or activity per unit volume (Bq m^{-3}) of a given radionuclide.

[SOURCE: IEC 60050-395:2014, 395-01-09, modified: Activity per unit mass mentioned in IEV 395-01-08 is added to a meaning of activity concentration defined as activity per unit volume in IEV 395-01-09.]

3.1.2
blank sample
dummy sample that contains the same substance that is to be measured in the sample but does not contain radioactive material other than Naturally Occurring Radioactive Materials (NORMs)

3.1.3
coefficient of variation
V

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

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

3.1.4
conventional true value
value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose

[SOURCE: IEC 60050-311:2001, 311-01-06]

3.1.5
decade
range of values of a certain quantity for which the common logarithms of the ratio of maximum and minimum value is unity

3.1.6
non-linearity
deviation from a straight line of the curve representing an output quantity as a function of an input quantity

Note 1 to entry: The reference straight line is determined by the radionuclide activity conversion factor described in 6.2.

3.1.7
effective range of measurement
absolute value of the difference between the two limits of a nominal range

3.1.8
upper limit of effective range of measurement
maximum activity or activity concentration to be measured at which the performance of an instrument meets the requirements of its specifications

3.1.9
lower limit of effective range of measurement
A_0
minimum activity or activity concentration to be measured over which the performance of an instrument meets the requirement of its specifications

3.1.10
decision threshold
y^*
value of the estimator of the measurand, which, when exceeded by the result of an actual measurement using a given measurement procedure of a measurand quantifying a physical effect, is used to decide that the physical effect is present.

Note 1 to entry: The decision threshold is defined such that in cases where the measurement result, y, exceeds the decision threshold, y*, the probability of a wrong decision, namely that the true value of the measurand is not zero if in fact it is zero, is less or equal to a chosen probability α.

Note 2 to entry: If the result, y, is below the decision threshold, y*, it is decided to conclude that the result cannot be attributed to the physical effect; nevertheless, it cannot be concluded that it is absent.

[SOURCE: ISO 11929:2019, 3.12]

3.1.11
detection limit
$y^\#$
smallest true value of the measurand which ensures a specified probability of being detectable by the measurement procedure.

Note 1 to entry: With the decision threshold according to 3.1.10, the detection limit is the smallest true value of the measurand for which the probability of wrongly deciding that the true value of the measurand is zero is equal to a specified value, β, when, in fact, the true value of the measurand is not zero. The probability of being detectable is consequently $(1-\beta)$.

Note 2 to entry: The terms detection limit and decision threshold are used in an ambiguous way in different standards (e.g. standards related to chemical analysis or quality assurance). If these terms are referred to one has to state according to which standard they are used.

[SOURCE: ISO 11929:2019, 3.13]

3.1.12
radionuclide activity conversion factor
C
quotient of the conventional true value of the activity (A) and an indication of the instrument in count rate (I), which is given by the following formula:

$$C = \frac{A}{I}$$

Note 1 to entry: Radionuclide activity conversion factor is inverse of the counting efficiency.

3.1.13
reference source
radioactive source calibrated by using the standard source for use in a calibration of the measuring instrument

3.1.14
standard source
radioactive source that has been calibrated by a laboratory recognized as a country's national standardizing laboratory for radioactivity measurements and that has been so certified by the aforementioned laboratory

[SOURCE: IEC 60050-395:2014, 395-02-03]

3.1.15
check source
radioactive source which is used for the instrument operability check, as well as for performing tests for stability and the influences of ambient factors

3.1.16
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.1.17
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.1.18
acceptance test
contractual test to prove to the customer that the item meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151-16-23]

3.1.19
uncertainty of measurement
parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

Note 1 to entry: This formal definition of the term “uncertainty of measurement” was developed for use in ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM 1995)*, and ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*.

[SOURCE: IEC 60050-815:2015, 815-17-19]

3.1.20
standard uncertainty
standard deviation associated with the measurement result or an input quantity

Note 1 to entry: See GUM 2.3.4.

Note 2 to entry: The standard uncertainty of the measurement result is sometimes called “combined standard uncertainty”.

Note 3 to entry: The quotient of the standard uncertainty and a measurement result is called “relative standard uncertainty” and sometimes given as percentage.

3.1.21
expanded uncertainty
U
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

Note 1 to entry: The expanded uncertainty can be obtained by multiplying the (combined) standard uncertainty times a coverage factor.

[SOURCE: ISO/IEC Guide 98-3:2008, GUM 2.2.5]

3.2 Quantities and units

In the present document, the 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: 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.

– SI unit of absorbed dose, kerma and specific energy imparted

$$1\ \text{Gy} = 1\ \text{J kg}^{-1}$$

– SI unit of activity of an amount of radionuclide equal to a second to the power minus one

$$1\ \text{Bq} = 1\ \text{s}^{-1}$$

3.3 Symbols

Table 1 gives a list of symbols used.

Table 1 – Symbols

Symbol	Meaning	Unit
y^*	decision threshold	---
$y^\#$	detection limit	---
$\tilde{u}(0)$	standard uncertainty of a measurand when its true value equals zero	Bq, Bq kg^{-1}, Bq m^{-3}
$\tilde{u}(y^\#)$	standard uncertainty of a measurand when its true value equals $y^\#$	Bq, Bq kg^{-1}, Bq m^{-3}
$k_{1-\alpha}$	quantile of a standardized normal distribution for the probabilities $1-\alpha$.	---
$k_{1-\beta}$	quantile of a standardized normal distribution for the probabilities $1-\beta$.	---
A	conventional true value of the activity or activity concentration	Bq
A_{DL}	detection limit expressed in units of activity or activity concentration	Bq, Bq kg^{-1}, Bq m^{-3}
I	indication of instrument	s^{-1}, Bq, Bq kg^{-1}, Bq m^{-3}

[1] International Bureau of Weights and Measures: The International System of Units (SI) 8th edition, 2006; updated in 2014.

Symbol	Meaning	Unit
u	relative standard uncertainty of measurement	---
U	relative expanded uncertainty of measurement	---
U_{rel}	relative expanded uncertainty of a ratio of an actual value to the reference value of the conventional true value of the activity and/or activity concentration	---
C	radionuclide activity conversion factor	Bq s
A_0	lower limit bound of effective range of measurement	Bq, Bq kg^{-1}, Bq m^{-3}
M	measurand of the instrument	Bq, Bq kg^{-1}, Bq m^{-3}

4 General test procedure

4.1 Nature of tests

Tests in this document are to be considered as type tests unless otherwise specified. A user may employ certain tests in this document as acceptance tests. The required specifications are evaluated by the tests given in the appropriate clauses. All tests in this document shall be performed using the same instrument setup with any accessories included with the instruments under test. Type tests shall be performed by using one or more instruments in order to verify the design of the instrument model. Where no test is specified, it is understood to mean that the characteristics can be verified by observation or consultation of the manufacturer's specifications.

4.2 Reference conditions and standard test conditions

4.2.1 General

The tests should be carried out under reference conditions ideally, however, since it is not always possible to maintain these conditions, standard test conditions, which have small intervals around the reference values, may be used.

The reference and standard test conditions are given in Table A.1. The reference conditions are the conditions under which the performances of the instrument are valid and the standard test conditions indicate the necessary tolerances in practical testing.

The tests in this document shall be performed under the standard test conditions given in the third column of Table A.1 unless otherwise specified.

The temperature, pressure and relative humidity at the time of the test shall be stated, as well as measuring time and date of the tests.

4.2.2 Tests performed under standard test conditions

Tests that are performed under the standard test conditions are listed in Table B.1 which indicates, for each characteristic under test, the requirements according to the clause in which the corresponding test method is described.

4.2.3 Tests performed with variation of influence quantities

For tests intended to determine the effects of variations in the influence quantities given in Table A.1, all of the other influence quantities should be maintained within the limits for the standard test conditions unless otherwise specified in the relevant test procedure.

4.3 Instrument set-up during tests

All tests, including those involving the use of the radioactive sources, should be performed in accordance with the manufacturer's instructions.

4.4 Statistical fluctuations

If the magnitude of the statistical fluctuations of the indication arising from the random nature of radiation alone is a significant fraction of the variation of the indication permitted in the test, then sufficient readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to determine whether the requirements for the characteristic being tested are met. The interval between such readings shall be longer than a measuring time for accumulating type instruments and longer than the three times the time constant for rate meter type instruments, which are sufficient to ensure that the readings are statistically independent.

4.5 Standard sources and reference sources

The following types of sources or their combinations are used for instrument testing and adjustment of response:

– standard sources,
– reference sources.

Standard sources and reference sources should contain radionuclides that the instrument is intended to measure, existing either as a single radionuclide or some appropriate combination. The activity(ies) of the standard sources and reference sources to be used shall be traceable to national or international standards. The conventionally true value of activity of standard sources shall be determined with a relative expanded uncertainty (k = 2) of less than 10 %. If necessary, half-life corrections should be made for these standard sources.

The standard sources and reference sources may be produced by using various substitutes, including polymeric compounds, activated aluminium powder or natural matrix. The standard sources and reference sources may also be radioactive solutions. The sources should be equivalent to the sample to be measured in terms of radionuclide composition and the total mass attenuation coefficient. The sources should be the same shape as the sample and should be uniform. It should be noted that proper detection efficiency cannot be obtained due to the different self-absorption if the density of the source is different from that of a sample.

4.6 Check sources

Check sources are used for the instrument operability check, as well as for performing tests for stability and the influences of ambient factors. Solid sealed gamma-sources of appropriate sizes and activities may be used for these purposes. The instrument should hold the source at a fixed position relative to the detector.

The check source reading shall be taken after each response calibration using standard sources and reference sources. When a check source is used to perform type tests, the ratio of the response from the check source to the response from the standard sources and/or reference sources shall be determined for each radionuclide used in the test (see 6.3).

4.7 Functionality tests

4.7.1 General

Functionality tests are performed before, during or after performance testing to assess potential changes in the instruments response. Instead of being used as an independent test, they are always combined with an environmental, mechanical, or electromagnetic test from IEC 62706, hereinafter referred to as performance tests. A response to photons or variation of indication is verified by the functionality test.