



DPC: 25/30512405 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 09 April 2025

Origin: International

Latest date for receipt of comments: 30 April 2025

Project No. 2025/01061

Responsible committee: NCE/2 Radiation protection and measurement

Interested committees:

Title: BS EN 61582 Ed.2.0 Draft Radiation protection instrumentation - Portable, transportable or installed equipment for in vivo measurement of photon emitting radionuclides.

Please notify admin.start@bsigroup.com if you are aware of any keywords that might assist in clarifying or identifying the standard or of the content of this standard:

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND 30 April 2025

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <https://standardsdevelopment.bsigroup.com/>.

E-mail: admin.start@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



45B/1086/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 61582 ED2

DATE OF CIRCULATION:

2025-04-04

CLOSING DATE FOR COMMENTS:

2025-05-30

SUPERSEDES DOCUMENTS:

45B/1085/RR

IEC SC 45B : RADIATION PROTECTION INSTRUMENTATION

SECRETARIAT:

France

SECRETARY:

Mr Miroslav Voytchev

OF INTEREST TO THE FOLLOWING COMMITTEES:

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Radiation protection instrumentation - Portable, transportable or installed equipment for in vivo measurement of photon emitting radionuclides

NOTE FROM TC/SC OFFICERS:

Copyright © 2025 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.



Documents

Document Sharing Hub

Link to Committee Draft (CD) online document:

<https://osd.iec.ch/#/editor/archive/315f96e1-6bf2-f86d-e063-6d13000ab0c3/en/CD/1>

How to access

This link leads you to the Online Standards Development (OSD) platform for National Mirror Committee's (NMC) comments. The project draft may be found further down this document.

Resource materials

We recommend NCs to review the available materials to better understand the member commenting on the OSD platform. This includes the:

- OSD NC roles overview: [here](#)
- How to add and submit comments to the IEC: [here](#)

Contact

Should you require any assistance, please contact the IEC IT Helpdesk at helpdesk@iec.ch.

CONTENTS

FOREWORD	8
INTRODUCTION	10
1 Scope and object	12
2 Normative references	12
3 Terms and definitions	13
4 Units	16
5 Classification	16
5.1 General classification	16
5.2 Energy range classification	16
5.2.1 Low energy in vivo monitoring (< 200 keV)	16
5.2.2 High energy in vivo monitoring (> 100 keV)	16
5.3 Specificity of the measurement	16
5.3.1 Type 1 - Nuclide specific, spatially specific with very low background	17
5.3.2 Type 2 - Nuclide specific, spatially specific with low background	17
5.3.3 Type 3 - Nuclide specific	17
5.3.4 Type 4 - Non-nuclide and non-spatial specific	17
6 General	18
6.1 General description of the equipment	18
6.1.1 General	18
6.1.2 Detection assembly	18
6.1.3 Measurement assembly	18
6.1.4 Auxiliary equipment	19
6.1.5 Ease of operation	19
6.1.6 Ease of decontamination	19
6.1.7 Size of subject	19
6.2 Background	19
6.3 Decision threshold	19
6.4 Warm-up time	20
6.5 Upper limit of a measurement time	20
6.6 Nature of tests	20
6.7 Reference conditions and standard test conditions	20
6.7.1 General	20
6.7.2 Tests performed under standard test conditions	20
6.7.3 Tests performed with variation of influence quantities	21
6.8 Equipment set-up during tests	21
6.9 Statistical fluctuations	21
6.10 Reference phantom and sources	21
6.10.1 General	21
6.10.2 Primary phantoms	21
6.10.3 Secondary phantoms and the reference sources	22
6.10.4 Background phantoms	22
6.11 Check sources	22
6.12 Functionality tests	23
6.12.1 General	23

6.12.2	Stability and reproducibility of the source-detector geometry	23
6.12.3	Combination of functionality tests and performance tests	23
6.12.4	Change of Indication	23
6.12.5	Change of photo-peak channel	24
6.12.6	Spurious Count	24
6.12.7	Regular operation behaviour	25
7	Characteristics of equipment for low-energy emitter measuring equipment	25
7.1	Minimum rated range of measurement energy	25
7.2	Decision threshold	25
7.3	Effective range of measurement	25
7.4	Maximum measurable activity	25
7.5	Energy resolution	25
7.6	Integral non-linearity	25
7.7	Natural background level	26
7.8	Reference response	26
8	Characteristics of equipment for high-energy emitter measuring equipment	26
8.1	Minimum rated range of measurement energy	26
8.2	Decision threshold	26
8.3	Effective range of measurement	27
8.4	Maximum measurable activity	27
8.5	Energy resolution	27
8.6	Integral non-linearity	27
8.7	Natural background levels	27
8.8	Reference response	27
8.9	Warm-up time	28
8.10	Upper limit of a measurement time	28
9	Performance requirements and test procedures for radiation measurement characteristics of low-energy emitter measuring equipment	28
9.1	General test procedures	28
9.1.1	Nature of tests	28
9.2	Determination of instrument efficiency for 59,54 keV photon from ^{241}Am	28
9.2.1	Requirements	28
9.2.2	Method of test	28
9.3	Linearity	29
9.3.1	Requirements	29
9.3.2	Method of test	29
9.4	Energy range determination	29
9.4.1	Requirements	29
9.4.2	Method of test	29
9.5	Determination of the integral non-linearity error	30
9.5.1	Requirements	30
9.5.2	Method of test	30
9.6	Background	30
9.6.1	Requirement	30
9.6.2	Method of test	30
9.7	Determination of the decision threshold	30
9.7.1	Requirements	30

9.7.2	Method of test	30
9.8	Determination of the maximum count rate	30
9.8.1	Requirements	30
9.8.2	Method of test	31
9.9	Determination of stability	31
9.9.1	Requirement	31
9.9.2	Method of test	31
9.10	Energy resolution measurement	32
9.10.1	Requirement	32
9.10.2	Method of test	32
10	Performance requirements and test procedures for radiation measurement characteristics of high-energy emitter measuring equipment	33
10.1	General test procedures	33
10.1.1	Nature of tests	33
10.2	Instrument efficiency	33
10.2.1	Requirements	33
10.2.2	Determination of instrument efficiency	34
10.3	Linearity	35
10.3.1	Requirements	35
10.3.2	Method of test	35
10.4	Response to other radio nuclides	35
10.4.1	Requirements	35
10.4.2	Method of test	36
10.5	Energy range determination	36
10.5.1	Requirements	36
10.5.2	Method of test	36
10.6	Determination of the integral non-linearity error	36
10.6.1	Requirements	36
10.6.2	Method of test	36
10.7	Background	36
10.7.1	Requirement	36
10.7.2	Method of test	36
10.8	Determination of the decision threshold	37
10.8.1	Requirements	37
10.8.2	Method of test	37
10.9	Determination of the maximum count rate	37
10.9.1	Requirements	37
10.9.2	Method of test	37
10.10	Determination of stability	38
10.10.1	Requirements	38
10.10.2	Method of test	38
10.11	Energy resolution measurement	39
10.11.1	Requirement	39
10.11.2	Method of test	39
11	Climatic performance characteristics	40
11.1	General	40
11.2	Ambient temperature	40
11.2.1	Requirements	40

11.2.2	Method of test	41
11.3	Relative humidity	42
11.3.1	Requirements	42
11.3.2	Methods of test	42
11.4	Magnetic fields	43
11.4.1	Requirements	43
11.4.2	Method of test	43
11.5	Power supply variations	44
11.5.1	Mains operated equipment	44
11.5.2	Requirements	44
11.5.3	Test methods	44
12	Mechanical performance characteristics	45
12.1	General	45
12.2	Mechanical shock	45
12.2.1	Requirements	45
12.2.2	Test methods	45
12.3	Vibration test	46
12.3.1	Requirements	46
12.3.2	Test methods	46
13	Electromagnetic compatibility	46
13.1	General	46
13.2	Immunity to electrostatic discharge (ESD)	46
13.2.1	Requirements	46
13.2.2	Method of test	47
13.3	Immunity to radiated electromagnetic fields	47
13.3.1	Requirements	47
13.3.2	Method of test	48
13.4	Immunity to Surges and ring waves	48
13.4.1	Requirements	48
13.4.2	Method of test	48
13.5	Immunity to conducted disturbances	49
13.5.1	Requirements	49
13.5.2	Method of test	49
14	Storage	49
15	Documentation	49
15.1	Type test report	49
15.2	Certificate	50
15.3	Operation and maintenance manual	50
15.4	Operational instructions	50
Annex A (informative)	A guide to the number of independent equipment readings required to establish a true difference in indication (relevant for normal distribution)	55
Annex B (informative)	Additional requirements and test procedures for thyroid monitoring	57
Bibliography		58
Table 1 – Reference and standard test conditions		50

Table 2 – Low-energy in vivo counting with scintillation detectors	51
Table 3 – Low-energy in vivo counting with Ge detectors.....	51
Table 4 – High-energy in vivo counting with scintillation detectors	52
Table 5 – High-energy in vivo counting with Ge detectors	52
Table 6 – High-energy in vivo counting without spectroscopy	53
Table 7 – Example of nuclides used in integral non-linearity test	53
Table A.1 – Number of equipment readings required to detect true differences (95 % confidence level) between two sets of equipment readings on the same equipment ...	55

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Radiation protection instrumentation - Portable, transportable or installed equipment for in vivo measurement of photon emitting radionuclides –

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC [had/had not] received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at

<https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61582 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This second edition cancels and replaces the first edition published in 2004. This edition constitutes a technical revision.

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

- a) Measurement traceability to the national standard is required.
- b) Uncertainty of measurement according to GUM is introduced.
- c) Environmental, mechanical and electromagnetic compatibility requirements are up-dated according to IEC 62706.
- d) Relative intrinsic error is replaced by linearity test.

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

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English [change language if necessary].

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

The following items were listed in the bibliography but not cited in the text. Please find a suitable place to cite them to justify their inclusion in the bibliography:

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) - Part 151: Electrical and magnetic devices*[IEC 60050-151 \[1\]](#)

IEC 61000-4-8:2001, *Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test*[IEC 61000-4-8:2001 \[2\]](#)

ICRP Pub 38:1983, *Radionuclide Transformations: Energy and Intensity of Emissions*. Annals of the ICRP 11-13 [\[3\]](#)

ICRP Pub 60:1990, *Recommendations of the International Commission on Radiological Protection*. Annals of the ICRP 21 No. 1-3, 1991 [\[4\]](#)

ICRP Pub 61:1991, *Annual Limits on Intake of Radionuclides by Workers Based on the 1990 - Recommendations*. Annals of the ICRP 21 No. 4. [\[5\]](#)

ICRP Pub 68:1994, *Dose Coefficients for Intakes of Radionuclides by Workers: A Replacement of ICRP 61*. Annals of the ICRP 24 (4). [\[6\]](#)

ICRP 75, *General Principles for the Radiation Protection of Workers* [\[7\]](#)

ICRP, 2007. *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103. Ann. ICRP 37 (2-4). [\[8\]](#)

ICRP, 2015. *Occupational Intakes of Radionuclides: Part 1*. ICRP Publication 130. Ann. ICRP 44(2) [\[9\]](#)

ICRP, 2016. *Occupational Intakes of Radionuclides: Part 2*. ICRP Publication 134. Ann. ICRP 45(3/4), 1-352 [\[10\]](#)

ICRP Publication 137: *Occupational Intakes of Radionuclides: Part 3*. Annals of the ICRP, 01 Dec 2017, 46(3-4):1-486 [\[11\]](#)

ICRP, 2019. *Occupational intakes of radionuclides: Part 4*. ICRP Publication 141. Ann. ICRP 48(2/3) [\[12\]](#)

ICRP, 2022. *Occupational Intakes of Radionuclides: Part 5*. ICRP Publication 151. Ann. ICRP 51 (1-2) [\[13\]](#)

IEC 60068-2-1, *Environmental testing - Part 2-1: Tests - Test A: Cold*[IEC 60068-2-1 \[14\]](#)

IEC 60068-2-2, *Environmental testing - Part 2-2: Tests - Test B: Dry heat*[IEC 60068-2-2 \[15\]](#)

IEC 60068-2-6, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*[IEC 60068-2-6 \[16\]](#)

IEC 60068-2-14, *Environmental testing - Part 2-14: Tests - Test N: Change of temperature*[IEC 60068-2-14 \[17\]](#)

IEC 60068-2-27, *Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock*[IEC 60068-2-27 \[18\]](#)

IEC 60068-2-78, *Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state*[IEC 60068-2-78 \[19\]](#)

IEC 60721-3-5, *Classification of environmental conditions - Part 3-5: Classification of groups of environmental parameters and their severities - Ground vehicle installation*[IEC 60721-3-5 \[20\]](#)

IEC 60721-3-7, *Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 7: Portable and non-stationary use*[IEC 60721-3-7 \[21\]](#)

IEC 61000-4-2, *Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test*[IEC 61000-4-2 \[22\]](#)

IEC 61000-4-5, *Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test*[IEC 61000-4-5 \[23\]](#)

IEC 61000-4-6, *Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields*[IEC 61000-4-6 \[24\]](#)

ISO 11929-2, *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 2: Advanced applications*[ISO 11929-2 \[25\]](#)

ISO 11929-3, *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 3: Applications to unfolding methods*[ISO 11929-3 \[26\]](#)

ISO 11929-4, *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 4: Guidelines to applications*[ISO 11929-4 \[27\]](#)

Radiation protection instrumentation - Portable, transportable or installed equipment for in vivo measurement of photon emitting radionuclides –

1 Scope and object

This document specifies the classification, general design requirements, performance characteristics and test procedures for in vivo counting systems for externally detecting trace amounts of radionuclides in the bodies of persons working in nuclear power plants, laboratories, facilities handling radionuclides and an area contaminated by a nuclear accident, and inhabitants living on territory which may be contaminated by either naturally occurring or artificial radionuclides.

This document applies to equipment for the measurement of the activity of gamma-emitting radionuclides in humans in order to determine the committed dose equivalent due to internal contamination in accordance with the recommendations of the ICRP Pub103, ICRP Pub 130, ICRP Pub 134, ICRP Pub 137, ICRP Pub 141 and ICRP Pub 151.

This document is applicable both to equipment with spectroscopic capabilities, with single-channel pulse height analyser and equipment for rapid screening for gross internal contamination only.

This document is applicable to an equipment for the monitoring of certain critical organs (for example, lungs thyroid gland, etc) as well as an equipment for monitoring the whole body.

The requirements of this document are applicable to the installed apparatus, to vehicle-mounted equipment and to a portable equipment. The general and radiological requirements of all types of in vivo counters are included in this document.

This document specifies general types, specific measuring characteristics, main test procedures, electrical and mechanical characteristics of the in-vivo counter, as well as the requirements related to background radiation of the environment.

NOTE 1 This equipment is not intended for the determination of external contamination of the human body or the clothing of personnel.

NOTE 2 This document is not applicable to equipment such as radiation detectors intended for introduction into the human body.

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 60038, *IEC standard voltages*

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

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

IEC 61000-4-12, *Electromagnetic Compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave immunity test*

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

IEC 62706, *Radiation protection instrumentation - Recommended climatic, electromagnetic and mechanical performance requirements and methods of tests*

ISO 11929:2010, *Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation — Fundamentals and application*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-395 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

conventionally true value of activity

best estimate of activity value and its uncertainty determined from a primary or secondary standard or by means of a reference instrument which has been calibrated against primary or secondary radioactive sources

3.2

indicated (measured) activity

activity indicated by the measuring assembly under test

3.3

coefficient of variation

ratio V of the standard deviation s to the arithmetic mean of set of n measurements x_i given by the following formula

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

3.4

calibration

process of determination of the numerical relationship between the observed indication and the value of the quantity being measured

3.5

instrument efficiency

ϵ

ratio of the net count rate of the equipment, C_{net} , to the photon emission rate of the photon from the reference source, $A_c \mathcal{J}$ obtained under the standard test condition in a specified detector-source geometry. The instrument efficiency is expressed as

$$\epsilon = \frac{C_{\text{net}}}{A_c \mathcal{J}} \quad (2)$$

where,

A_c is the activity of the source at the time of the instrument efficiency determination

$\mathcal{J}$ the abundance of specified photon emission;

3.6 response

R

ratio of the indicated value of a monitor or meter, M_i , to the conventional true value, M_t , expressed as

$$R = \frac{M_i}{M_t} \quad (3)$$

3.7 reference response

R_{ref}

R obtained under standard test conditions (Table 1) to the reference source whose activity gives the indication of the assembly high enough that an effect of variation of the background count is negligible and low enough that a counting loss due to the dead time is also negligible

3.8 relative response

r

ratio of the response at the test point, *R*, to the reference response, expressed as

$$r = \frac{R}{R_{ref}} \quad (4)$$

3.9 dynamic range

quotient of the signal from the maximum measurable indication of a quantity to the signal from the minimum detectable value of that quantity

3.10 error of indication

difference between the indicated activity A_i and the conventionally true activity at the point of measurement A_c

$$\Delta A = A_i - A_c \quad (5)$$

3.11 effective range of measurement

range of values of the quantity to be measured over which the performance of a piece of equipment or assembly meets the requirements of this document

3.12 lower limit of effective range of measurement

A₀

lowest activity or count rate in the effective range of measurement

3.13 measurement time

time delay between the initiation of the measurement and the attainment of the final reading

3.14 energy resolution

full width at half maximum (FWHM)

The full width is measured between the two points on the spectrum situated on either side of the centroid due to the energy of interest where the count rate in the energy channel is half

that of the peak maximum
The relative energy resolution R_e is given by

$$FWHM = \frac{\text{full width in terms of energy (or channel number)}}{\text{the energy (or channel number) of the centroid of the energy of interest}} \% \quad (6)$$

Note 1 to entry: The full width may not be symmetric in relation to the centroid.

3.15

integral non-linearity

integral non-linearity is one of an expression of lack of linearity. It is determined based on the maximum deviation from the approximated straight line as follows. The conversion characteristic is approximated with the straight line:

$$N = \tilde{a} + \tilde{B} \times E_\gamma \quad (7)$$

where,

$\tilde{a}$ is the energy associated with channel 0 of the pulse height analyser;

$\tilde{B} = 1/k$ where k is the energy channel width of the equipment.

For each of the centroid peak positions n_{io} corresponding to the energy $E_{\gamma i}$ the deviation $\Delta E_{\gamma i}$ from the straight-line approximation of the conversion characteristic is calculated. The INL is calculated from the formula

$$\eta(\%) = \frac{\Delta E_{\gamma i \max}}{E_{\gamma \max}} \times 100 \quad (8)$$

where,

$\Delta E_{\gamma i \max}$ is the maximum of the absolute values of $\Delta E_{\gamma i}$;

$E_{\gamma \max}$ is the maximum measure signal pulse height.

3.16

qualification test

test performed in order to verify that the requirements of a specification are fulfilled

Note 1 to entry: Qualification tests are subdivided into type tests and routine tests.

3.17

type testing

conformity testing on the basis of one or more specimens of a product representative of the production

[SOURCE: IEC 394-20-28]

3.18

routine test

test to which an individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 394-20-08]

3.19

acceptance test

contractual test to prove to the customer that the device meets certain conditions of its specification

[SOURCE: IEC 394-20-09]

3.20

minimum rated range

smallest range being specified of an influence quantity over which the instrument will operate within the respective variation of the response in order to comply with this standard

4 Units

Units of the International System (SI) are used. The corresponding non-SI units are indicated in brackets

Activity: the SI unit of radioactivity of any material is the Becquerel (symbol Bq)

1 Bq = 1 nuclear transition (decay) in a second

= 1 decay s⁻¹

The quantity has the unit s⁻¹. In this standard, the units are the multiples and sub multiples of units of the International System of Units (SI)¹. The following non-SI units are also used:

Time: years, days, hours (h), minutes (min)

For energy: electron-volt (eV) (1 eV = 1,602 × 10⁻¹⁹ J)

NOTE Definitions of the radiation quantities are given in IEC 60050-395.

5 Classification

5.1 General classification

Dependent on the type of elements and on the range of energy to be detected in vivo, monitors can be conveniently classified taking account of two considerations:

- the range of energy;
- the specificity of the measurement.

5.2 Energy range classification

5.2.1 Low energy in vivo monitoring (< 200 keV)

These in vivo counters are used for the detection of low-energy emitters (essentially actinides such as Pu, Am, U and electron capture nuclides). Because of their minimal translocation, these radionuclides are normally located in the lung, and measurements are made preferentially in this organ. However, measurements in other organs can also be considered.

5.2.2 High energy in vivo monitoring (> 100 keV)

These in vivo counters are used for the detection of high-energy emitters including activation products and fission product measurements. Because of their rapid translocation, the measurements are generally made on the whole body. However, measurements in other organs can also be considered.

5.3 Specificity of the measurement

The monitors are classified based on the decision threshold and an ability to measure an activity of specific nuclides. The classification is listed below.

a) Classification of low-energy in-vivo monitoring

	Type 1	Type 2
Decision threshold in Bq	20(²⁴¹ Am)	30(²⁴¹ Am)

¹ International Bureau of Weights and Measures: The International System of Units (SI), 9th edition 2019.

Nuclide specification method	spectrometry	spectrometry
Measurement purpose	research and development	routine monitoring

b) Classification of high-energy in-vivo monitoring

	Type 1	Type 2	Type 3	Type 4
Decision threshold in Bq	15(⁶⁰ Co)/30(¹³⁷ Cs)	30(⁶⁰ Co)/60(¹³⁷ Cs)	150(⁶⁰ Co)/300(¹³⁷ Cs)	150(⁶⁰ Co)/300(¹³⁷ Cs)
Nuclide specification method	spectrometry	spectrometry	spectrometry or single channel analysis	not applicable
Measurement purpose	research and development	routine monitoring	screening and monitoring	screening

5.3.1 Type 1 - Nuclide specific, spatially specific with very low background

Type 1 in-vivo counters are used for R&D purposes with nuclide-specific and spatially-specific measurement. This type in-vivo counter will achieve precise low-level radiological monitoring for the measurement of radioactivity as accurately and precisely as possible. It may need longer measuring time and very heavy radiation shield.

NOTE 1 This type in-vivo counters are generally installed in atomic energy research institutions, atomic power plants, emergency treatment centres laboratories, universities and hospitals for research purposes.

NOTE 2 The detector assemblies and driving mechanisms to move the detectors are mounted in a shielded room where special attention is paid to the materials lining the walls and to the air entering the room (radon).

5.3.2 Type 2 - Nuclide specific, spatially specific with low background

Type 2 in-vivo counters are used for routine monitoring with nuclide-specific and spatially-specific measurement. This type in-vivo counter will achieve also precise low-level radiological monitoring, however, it also considers a number of people to be monitored. Then, it may need shorter measuring time and reasonably heavy radiation shield.

NOTE 1 These in vivo counters are used for the estimation of internal dose of individuals and are normally intended for atomic energy research institutions, atomic power plants, emergency treatment centres, etc.

NOTE 2 The structure of this type of in vivo counter is suited to the more rapid monitoring of many subjects; a shadow shield structure (open structure covering only the detectors and their accessories), simpler than the type 1 construction, would meet this requirement.

5.3.3 Type 3 - Nuclide specific

Type 3 in-vivo counters are used for screening purposes with nuclide-specific measurement. This type in-vivo counters will achieve a radiological monitoring of radioactivity with reasonable precision and low-level measurement. It intends to measure activities of a much number of people in a rather short measuring time. It also considers a convenience in transferred from one place to another. The nuclide-specific measurement of this type in-vivo counters will be achieved by gamma photon spectrometry with a multi-channel pulse height analyser and /or counting signals of specific pulse height determined by a window-type single channel pulse height analyser.

NOTE These in vivo counters are general screening counters for radiation workers and for the mass screening of the general public after nuclear accidents. This latter screening may be an initial measurement or a subsequent measurement to determine any changes in condition.

5.3.4 Type 4 - Non-nuclide and non-spatial specific

Type 4 in-vivo counters are used for screening purposes. This type in-vivo counter will achieve the same performance as that achieved by the Type 3 equipment except for not having an ability to identify nuclides in human bodies. It may have quite large detectors.

NOTE Because of the difficulty of measurement and the high background dependency, measurements in the low-energy range need low background equipment. Consequently, the type 3 and type 4 equipment are not used for this range of energy.