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Edition 3.0 2023-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Radiation protection instrumentation – Installed personnel surface contamination monitors

Instrumentation pour la radioprotection – Moniteurs fixes pour la surveillance de la contamination de surface du personnel



IEC 61098:2023-02(en-fr)



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Instrumentation pour la radioprotection – Moniteurs fixes pour la surveillance de la contamination de surface du personnel

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CONTENTS

FOREWORD 6
1 Scope 8
2 Normative references 8
3 Terms, definitions, units and symbols 9
3.1 Terms and definitions 9
3.2 Units 14
3.3 Symbols (see Table 1) 15
4 Classification of monitors 16
4.1 According to type of radiation to be measured 16
4.2 According to body surface being monitored 16
4.3 According to background compensation method 16
5 Design characteristics 16
5.1 Positioning of the person being monitored 16
5.2 Size of the person being monitored 16
5.3 Hand monitoring facilities 17
5.4 Foot monitoring facilities 17
5.5 Body monitoring facilities 17
5.6 Frisker 17
5.7 Visual display 18
5.7.1 For the user 18
5.7.2 For maintenance purposes 18
5.8 Audible indicators 18
5.9 Monitoring period 18
5.10 Ease of decontamination 18
5.11 Detectors used 19
5.12 Seismic consideration 19
6 Performance requirements and test procedures 19
6.1 General test procedure 19
6.1.1 Nature of tests 19
6.1.2 Tests performed under standard test conditions 19
6.1.3 Tests performed with variation of influence quantities 19
6.1.4 Type F influence test 20
6.1.5 Type S influence test 20
6.2 Functionality test 20
6.2.1 General 20
6.2.2 Pre-test 20
6.2.3 Post-test 21
6.3 Statistical fluctuations 21
6.4 Reference sources 21
6.5 Requirements for use of gas flow detectors 22
7 Radiation measurement characteristics 22
7.1 Variation of response with source position 22
7.1.1 General 22
7.1.2 For clothing or the body 22
7.1.3 For hand monitoring 27
7.1.4 For foot monitoring 28

7.1.5 Contamination measurement of cloth or body by friskers 30
7.2 Background 33
7.2.1 General 33
7.2.2 Subtraction of pre-determined background 33
7.2.3 Simultaneous subtraction of determined background 33
7.2.4 No background subtraction 33
7.2.5 Gamma monitoring systems 34
7.3 Detection limit (DL) 34
7.3.1 General 34
7.3.2 For clothing or body 36
7.3.3 The effective instrument efficiency at the specific operating point 36
7.3.4 For hand monitoring 37
7.3.5 For foot monitoring 37
7.3.6 For frisker monitoring 38
7.4 Variation of response with energy 38
7.4.1 General 38
7.4.2 Beta 38
7.4.3 Alpha 40
7.4.4 Gamma 40
7.5 Response to other ionising radiations 41
7.5.1 General 41
7.5.2 Gamma radiation 42
7.5.3 Alpha radiation (for beta and gamma contamination monitoring assemblies) 42
7.5.4 Beta or gamma radiation (for alpha contamination monitoring assemblies) 42
7.6 Linearity of indication 42
7.6.1 Requirements 42
7.6.2 Method of test 43
7.7 Alarm threshold 43
7.7.1 General 43
7.7.2 Requirements 43
7.7.3 Method of test 43
8 Overload protection 43
8.1 Requirements 43
8.2 Method of test 43
9 Availability 44
9.1 Warm-up time 44
9.2 Power failure 44
10 Environmental requirements 44
10.1 General 44
10.2 Ambient temperature 44
10.2.1 Requirements 44
10.2.2 Method of test 44
10.3 Relative humidity 45
10.3.1 Requirements 45
10.3.2 Method of test 45
10.4 Atmospheric pressure 45
11 Mechanical requirements 45

11.1 General 45
11.2 Vibration test 45
11.2.1 Requirements 45
11.2.2 Method of test 46
11.3 Mechanical shock 46
11.3.1 Requirements 46
11.3.2 Method of test 46
12 Power and electromagnetic compatibility 46
12.1 Voltage and frequency 46
12.2 Electromagnetic compatibility 47
12.2.1 General 47
12.2.2 Electrostatic discharge 47
12.2.3 Radio-frequency (RF) Immunity 47
12.2.4 Radiated emissions 48
12.2.5 AC line powered monitor requirements 48
12.2.6 Immunity from conducted RF 49
12.2.7 Surges and ring waves 49
12.2.8 Magnetic fields 50
13 Storage 50
14 Documentation 50
14.1 Certificate 50
14.2 Operation and maintenance manual 51
14.3 Operational instructions 51
14.4 Type test report 51
Annex A (informative) Explanation of the derivation of detection limit formula 56
A.1 General 56
A.2 In a case of taking into account a change in the background value between the background measurement and the contamination measurement 59
A.3 In a case of achieving background compensation simultaneously 61
Annex B (informative) Phantoms for testing the body effect for gamma contamination body monitors 63
B.1 General 63
B.2 Phantoms building blocks 63
B.3 Range of phantoms 64
Annex C (informative) Characterization of the error due to the background attenuation by the body 65
C.1 General 65
C.2 Standard background case 65
C.2.1 Test procedure 65
C.2.2 Result interpretation 65
C.2.3 Acceptance criteria 66
C.2.4 Important note 66
C.3 Increased background case 66
C.3.1 General 66
C.3.2 Polar response characterization 67
C.3.3 Test procedure of body attenuation effect 67
C.3.4 Result interpretation and acceptance criteria 67
Annex D (informative) Characterization of the response to a carried gamma source 68
D.1 General 68

D.2 Test procedure 68
Bibliography 70

Figure 1 – Vertical position of radiation source 24
Figure 2 – Response curve composition by source position 25
Figure 3 – Centre planes of the detection volume 26
Figure 4 – Detector for hand monitoring 28
Figure 5 – Detector for foot monitoring 30
Figure 6 – Frisker (clothes)/Overhead detector 32
Figure B.1 – Size of slices 63
Figure B.2 – Assembled phantoms 64
Figure D.1 – Source positions for the head 68
Figure D.2 – Source positions for the body 69
Figure D.3 – Source positions for the legs 69

Table 1 – Symbols and abbreviate terms 15
Table 2 – Emission frequency range 48
Table 3 – Reference and standard test conditions 52
Table 4 – Tests performed under standard test conditions 52
Table 5 – Tests performed with variation of influence quantities 54
Table 6 – Test and sources 55
Table B.1 – Sizes of the set of phantoms 64

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RADIATION PROTECTION INSTRUMENTATION – INSTALLED PERSONNEL SURFACE CONTAMINATION MONITORS

FOREWORD

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IEC 61098 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2003. This edition constitutes a technical revision.

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

a) Title is modified.
b) As an alternative of small area sources, area sources are added to be used for methods of test with respect to the variation of response with source position, effective instrument efficiency, detection limit (DL), and variation of response with energy.
c) Detection limit (DL) complies with the ISO 11929 series.
d) Descriptions of influence quantities of type F and type S are added.
e) Consistency with IEC 62706 is promoted for environmental requirements, mechanical requirements, electromagnetic compatibility and methods of test.
f) Descriptions of overhead detectors are added.

g) Descriptions of friskers are added with respect to the hand and foot monitoring.

h) Figures are made easier to understand the relation between the detector position and the response, and the positional relation between the detector surface and the source.

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

Draft	Report on voting
45B/1020/FDIS	45B/1026/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.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, ISO/IEC Directives and 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/standardsdev/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,
- replaced by a revised edition, or
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RADIATION PROTECTION INSTRUMENTATION – INSTALLED PERSONNEL SURFACE CONTAMINATION MONITORS

1 Scope

This document applies to contamination monitors that include warning assembles and meters used for the monitoring of radioactive contamination on the surface of personnel whether they be clothed or not. The document is applicable only to that type of equipment where the user stays at the monitor. It is not applicable to the user passes quickly through the monitor. It is also not applicable to any peripheral equipment which can be associated with a particular type of equipment such as small article monitors. Probes (friskers) for measuring clothes or body by the person under monitoring or someone else are included in this document. The probes (friskers) are always connected to the monitor.

This document is applicable to the monitoring of the whole body (including the head), hands and feet, but parts of this document can be used for monitors designed for the monitoring of radioactive contamination on the hands and/or feet only. This document does not include tritium measurement.

This document is applicable to:

– installed personnel monitor (all clauses applicable);
– transportable personnel monitor (all clauses applicable);
– monitor for monitoring the hands (see the following clauses and subclauses: 2, 3, 4, 5, 6, 7.1.3, 7.2, 7.3.4, 7.4.2.2 b), 7.4.3, 7.4.4.1, 7.4.4.2, 7.4.4.3 b), 7.5, 7.6, 7.7, 8, 9, 10, 11, 12, 13 and 14);
– monitor for monitoring the feet (see the following clauses and subclauses: 2, 3, 4, 5, 6, 7.1.4, 7.2, 7.3.5, 7.4.2.2 c), 7.4.3, 7.4.4.1, 7.4.4.2, 7.4.4.3 c), 7.5, 7.6, 7.7, 8, 9, 10, 11, 12, 13 and 14); and
– monitor for monitoring the hands and feet (including probe (frisker) for whole body measurement) (see the following clauses and subclauses: 2, 3, 4, 5, 6, 7.1.3, 7.1.4, 7.1.5, 7.2, 7.3.4, 7.3.5, 7.3.6, 7.4.2.2 b), 7.4.2.2 c), 7.4.2.2 d), 7.4.3, 7.4.4.1, 7.4.4.2, 7.4.4.3 b), 7.4.4.3 c), 7.4.4.3 d),7.5, 7.6, 7.7, 8, 9, 10, 11, 12, 13 and 14).

The object of this document is to define mechanical and operational characteristics, minimum performance characteristics and general test procedures for personnel monitors.

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*, available at www.electropedia.org

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

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

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

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

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measuring techniques – Power frequency magnetic field immunity test*

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

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

ISO 8769:2020, *Measurement of radioactivity – Alpha-, beta- and photon emitting radionuclides – Reference measurement standard specifications for the calibration of surface contamination monitors*

3 Terms, definitions, units and symbols

3.1 Terms and definitions

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

3.1.1
surface emission rate
<of a source> number of particles or photons of a given type above a given energy emerging from the face of the source or its window per time in a mass-free environment

[SOURCE: ISO 8769:2020, 3.1, modified – Word "second" replaced with "time" in the definition.]

3.1.2
source efficiency
ε_S
ratio between the number of particles of a given type above a given energy emerging from the face of the source or its window per unit time (surface emission rate) and the number of particles of the same type created or released within the source (for a thin source) or its saturation layer thickness (for a thick source) per unit time

3.1.3
small area source
source whose active surface area has a maximum linear dimension not exceeding 2,5 cm

3.1.4
surface emission rate response
<instrument efficiency> under stated conditions specified by the manufacturer (sensitive area of the detector, active area of the source and the distance between source and detector), ratio of the number of detected particles (for instance counts per unit time, corrected for background) to the number of particles of the same type emitted by the radiation source in the same interval of time (conventionally true surface emission rate)

3.1.5
sensitive area of the detector
area of the detector, defined by the manufacturer, where the efficiency for a small area source is greater than 50 % of the maximum efficiency

3.1.6
total equivalent thickness
thickness, generally expressed in mass per unit area, that a particle (alpha or beta) emitted normally from the contaminated surface crosses in order to reach the sensitive volume of the detector

Note 1 to entry: This thickness includes the distance in the air plus the detector window thickness and, sometimes, the thickness of any screen fitted over the detector window which protects it from contamination.

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

3.1.8
response
R
ratio of the indicated value of a monitor M_{i} to the conventional true value M_{t}

$$R = \frac{M_{\mathrm{i}}}{M_{\mathrm{t}}}$$

3.1.9
relative error of indication
I
quotient of the error of indication of a measured quantity $M_{\mathrm{i}} - M_{\mathrm{t}}$ by the conventional true value M_{t} of the quantity

Note 1 to entry: It may be expressed as a percentage.

$$I = \frac{M_{\mathrm{i}} - M_{\mathrm{t}}}{M_{\mathrm{t}}} \times 100$$

3.1.10
relative intrinsic error
relative error of indication of an assembly with respect to a quantity when subjected to a specified reference radiation under specified reference conditions

3.1.11
coefficient of variation
V
ratio V of the standard deviation s to the value of the arithmetic mean $\bar{x}$ of a set of n measurements x_i given by the following formula:

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

3.1.12
deviation
D
difference between the indicated values for the same value of the measured quantity, when made under reference conditions and when subject to an influence quantity

$$D = M_{\mathrm{i}} - M_{\mathrm{t}}$$

where

M_{i} is the indicated value of a monitor;

M_{t} is the conventional true value

Note 1 to entry: The deviation can be positive or negative resulting in an increase or a decrease of the indicated value, respectively.

Note 2 to entry: The deviation is of special importance for influence quantities of type S.

3.1.13
lower limit of effective range of measurement
A_0
minimum activity or activity concentration to be measured over which the performance of a monitor meets the requirement of its specifications

3.1.14
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 that the true value of the measurand 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^*, the result cannot be attributed to the physical effect; nevertheless, it cannot be concluded that it is absent.

[SOURCE: ISO 11929-1:2019, 3.12, modified – Notes to entry rephrased.]

3.1.15
detection limit
DL
$y^{\#}$
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 3.1.15, 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.

[SOURCE: ISO 11929-1:2019, 3.13, modified – Last sentence of Note 1 to entry removed, and Note 2 to entry deleted.]

3.1.16
conventional true value
best estimate of the value of that quantity

Note 1 to entry: This is usually the value determined by, or traceable to, a secondary or primary standard or by a reference instrument which has been calibrated against a secondary or primary standard.

3.1.17
frisker
probes for whole body monitoring attached to hand and/or foot contamination monitors

3.1.18
influence quantity of type F
influence quantity whose effect on the indicated value is a change in response

Note 1 to entry: An example is radiation energy and angle of radiation incidence.

Note 2 to entry: "F" stands for factor: The indication due to radiation is multiplied by a factor due to the influence quantity.

3.1.19
influence quantity of type S
influence quantity whose effect on the indicated value is a deviation independent of the indicated value

Note 1 to entry: An example is the electromagnetic disturbance.

Note 2 to entry: All requirements for influence quantities of type S are given with respect to the value of the deviation D.

Note 3 to entry: "S" stands for sum. The indication is the sum of the indication due to radiation and due to the influence quantity.

3.1.20
ambient background
gamma radiation field in which the monitor is intended to operate which includes natural background and radiation due to radioactive sources and/or plants adjacent to the monitor

3.1.21
reference background
artificial background created to simulate the maximum ambient background for which the monitor is designed

Note 1 to entry: This background includes the naturally occurring background and additional radiation provided by a source of ^{137}Cs (or other radionuclide by agreement between the purchaser and manufacturer) placed at least 3 m from the detector of interest of the monitor under test.

3.1.22
uniformity of surface emission rate of sources
uniformity of a surface in respect to the surface emission rate in relation to the average surface emission rate

Note 1 to entry: For further information on area radioactive sources, refer to ISO 8769.

3.1.23
monitoring channel
system of assemblies or parts of assemblies enabling the signals from one or more detectors to show whether contamination is present or not on specific parts of the body, feet or hands

3.1.24
emission probability
probability of the emission of the particle or photon of interest per disintegration

3.1.25
effective instrument efficiency
E_{ff}
mean value of the instrument efficiency over the whole of the detector, used when the detection limit (DL) is determined

Note 1 to entry: In a case of using the detector for the body surface monitoring, the effective instrument efficiency is the mean value of the instrument efficiency distribution measured using a phantom.

3.1.26
qualification test
sets of tests performed in order to verify that the requirements of a specification are fulfilled

3.1.27
type test
conformity test made on one or more items representative of the production

Note 1 to entry: Type tests are qualification tests which are performed on one assembly or on a small number of assemblies considered to be representative of a standard production assembly, and which, in principle, are not repeated on each assembly.

[SOURCE: IEC 60050-151:2001, 151-16-16, modified – Note to entry added.]

3.1.28
routine test
conformity test made on each individual item during or after manufacture

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

3.1.29
acceptance test
contractual test to prove to the customer that the item meets certain conditions of its specification

Note 1 to entry: Acceptance tests are, in general, selected from the qualification tests specified, but this selection is a contractual matter and does not form any part of this document.

[SOURCE: IEC 60050-151:2001, 151-16-23, modified – Note to entry added.]

3.2 Units

In this document, units of the International System (SI) are used[1]. The definitions of radiation quantities are given in IEC 60050-395. 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; and
– for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min).

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

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

3.3 Symbols (see Table 1)

Table 1 – Symbols and abbreviate terms

Symbol	Meaning	Unit
α	probability of the error of the first kind	N/A
β	probability of the error of the second kind	N/A
A_0	lower limit of effective range of measurement	s^{-1}
D	deviation	s^{-1}
E_{ff}	effective instrument efficiency	N/A
I	relative error of indication	%
$k_{1-\alpha}$	quantile of the standardized normal distribution for the probability $1-\alpha$	N/A
$k_{1-\beta}$	quantile of the standardized normal distribution for the probability $1-\beta$	N/A
M_i	indicated value of a monitor	s^{-1}
M_t	conventional true value	s^{-1}
R	response	N/A
r_0	estimate of the background count rate	s^{-1}
r	counts per second average response	s^{-1}
r_x	difference of count rate between the detector for measurement and the detector for background	s^{-1}
s	standard deviation	s^{-1}
S_{DL}	detection limit (DL) of the surface emission rate	s^{-1}
t_g	measurement duration of the measurement of the gross effect	s
t_0	measurement duration of the measurement of the background effect	s
$\tilde{u}(0)$	uncertainty of the measurand when its true value equals zero	N/A
$\tilde{u}(y^{\#})$	uncertainty of the measurand when its true value equals $y^{\#}$	N/A
V	coefficient of variation	N/A
$\bar{x}$	value of the arithmetic mean of a set of n measurements	s^{-1}
x_i	value of i th measurement	s^{-1}
y^*	decision threshold of the measurand	s^{-1}
$y^{\#}$	detection limit of the measurand	s^{-1}
y	measurement result of the measurand	s^{-1}
ϕ	surface emission rate of the source in determining the response	N/A
ε_s	source efficiency	N/A

4 Classification of monitors

4.1 According to type of radiation to be measured

– Alpha contamination monitors

– Beta contamination monitors

– Gamma contamination monitors

– Alpha-Beta contamination monitors (where the alpha and beta contaminations are indicated separately)

– Beta-Gamma contamination monitors (where the beta and gamma contaminations are indicated together)

– Alpha-Beta-Gamma contamination monitors (where the alpha contamination is indicated separately, the beta and gamma contaminations are indicated together)

4.2 According to body surface being monitored

– For the monitoring of the whole body (including the head and the overhead)

– For the monitoring of hands only

– For the monitoring of feet only

– For the monitoring of both hands and feet

4.3 According to background compensation method

a) Subtraction of predetermined background

Monitors whose background compensation is achieved by measuring background with each detector constantly while measured persons are not using monitors.

b) Simultaneous subtraction of determined background

Monitors whose background compensation is achieved by having a number of detectors measuring the ambient background radiation simultaneously with the measurement of the contamination.

c) No background subtraction

Monitors without background subtraction.

5 Design characteristics

5.1 Positioning of the person being monitored

Sensors shall be included for alpha and beta monitoring to ensure that the feet, hands and body of the person being monitored are correctly positioned. The hands shall be open so that the palms and both sides of the fingers are properly monitored. Such sensors shall indicate to the person being monitored that he/she has positioned himself/herself correctly and remains in the correct position for the full monitoring period. Both audible and visual indication shall be given if the person being monitored moves from the correct position and the monitoring procedure shall cease until the correct position is regained. The monitoring time may either be the total time the person being monitored in the correct monitoring positions and monitoring is taking place or a single continuous monitoring time; in the latter case, the information collected prior to the person being monitored moving shall be ignored.

5.2 Size of the person being monitored

It is impossible to define dimensions of the detecting system and location of detectors in a standard because of the great variation between nations of the average size of persons.

However, the manufacturer shall state the relevant body size limits for which the monitor has been designed.