

Radiation protection instrumentation — Installed personnel surface contamination monitoring assemblies

The European Standard EN 61098:2007 has the status of a
British Standard

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National foreword

This British Standard is the UK implementation of EN 61098:2007. It was derived by CENELEC from IEC 61098:2003.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by tags **[C]** **[C]**.

The UK participation in its preparation was entrusted to Technical Committee NCE/2, Radiation protection and measurement.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Installed personnel surface contamination monitoring assemblies
(IEC 61098:2003, modified)**

Instrumentation pour la radioprotection -
Ensembles fixes pour la surveillance
de la contamination de surface
du personnel
(CEI 61098:2003, modifiée)

Strahlenschutz-Messgeräte -
Festinstallierte
Personenkontaminationsmonitore
(IEC 61098:2003, modifiziert)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 61098:2003, prepared by SC 45B, Radiation protection instrumentation, of IEC TC 45, Nuclear instrumentation, together with the common modifications prepared by the CENELEC BTTF 111-3, Nuclear instrumentation and radiation protection instrumentation, was submitted to the formal vote and was approved by CENELEC as EN 61098 on 2007-04-01.

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Clauses, subclauses, notes, tables and figures which are additional to those in IEC 61098:2003 are prefixed “Z”.

Annexes ZA, ZB and ZC have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61098:2003 was approved by CENELEC as a European Standard with agreed common modifications.

CONTENTS

1	Scope and object.....	5
2	Normative references	5
3	Terms and definitions	6
4	Classification of assemblies	9
4.1	According to type of radiation to be measured	10
4.2	According to type of surface.....	10
4.3	According to type.....	10
5	Design characteristics	11
5.1	Positioning of user.....	11
5.2	Size of user	12
5.3	Hand monitoring facilities.....	12
5.4	Foot monitoring facilities	12
5.5	Body monitoring facilities	12
5.6	Visual display	13
5.7	Audible indicators	13
5.8	Monitoring period.....	13
5.9	Ease of decontamination.....	13
5.10	Detectors used	14
6	Performance requirements and test procedures.....	14
6.1	General test procedure	14
6.2	Statistical fluctuations	15
6.3	Reference sources.....	15
6.4	Nature of tests.....	15
6.5	Use of gas flow detectors.....	15
7	Radiation characteristics.....	16
7.1	Variation of response with source position.....	16
7.2	Background	18
7.3	Decision threshold (minimum detectable surface emission rate).....	19
7.4	Variation of response with energy	21
7.5	Response to other ionising radiations.....	24
7.6	Type and routine tests of performance	25
7.7	Linearity of indication.....	25
8	Overload protection	25
8.1	Requirements	25
8.2	Method of test	25
9	Availability.....	26
9.1	Warm-up time	26
9.2	Power failure	26
10	Environmental conditions	26
10.1	Temperature.....	26
10.2	Relative humidity	27
10.3	Atmospheric pressure	27

11	Power supply.....	27
11.1	Voltage and frequency	27
11.2	Electromagnetic compatibility	27
12	Storage	29
13	Documentation	29
13.1	Certificate.....	29
13.2	Operation and maintenance manual	30
13.3	Operational instructions	30
13.4	Type test report.....	30
Annex A (informative) Explanation of the derivation of minimum detectable surface emission rate formula.....		37
Annex ZA (informative) Examples of possible additional tests for further characterization of the sensitive volume		41
Annex ZB (informative) Summation of information from adjacent detectors.....		42
Annex ZC (normative) Normative references to international publications with their corresponding European publications		45
Figure 1 – Vertical position of the source of radiation.....		33
Figure 2 – Position of the source of the radiation around the body		34
Figure 3 – Detector for hand monitoring		35
Figure 4 – Foot monitor.....		36
Table 1 – Reference and standard test conditions		30
Table 2 – Tests performed under standard test conditions		31
Table 3 – Tests performed with variation of influence quantities.....		32

RADIATION PROTECTION INSTRUMENTATION –

Installed personnel surface contamination monitoring assemblies

1 Scope and object

☐ This International Standard applies to contamination warning assemblies and monitors used for the monitoring of radioactive contamination on the surface of personnel whether they be clothed or not ☐. The standard is applicable only to that type of equipment where the user takes no action other than to present himself and/or his hands and feet to the detectors. It is not applicable to equipment where the user or someone else moves detectors over the area to be monitored or the user passes quickly through the monitor. It is also not applicable to any peripheral equipment which may be associated with a particular type of equipment such as small article monitors.

This standard is applicable to the monitoring of the whole body (including the ☐ head ☐), hands and feet but parts of this standard may be used for equipment designed for the monitoring of radioactive contamination on the hands and/or feet only.

This standard is applicable to:

- installed personnel monitoring equipment (all Clauses applicable);
- equipment for monitoring the hands (see the following Clauses and Subclauses: 2, 3, 4, 5, 6, 7.1.2, 7.2, 7.3.2, 7.4.1.2 b), 7.4.2, 7.4.3.1, 7.4.3.2, 7.4.3.3 b), 7.5, 7.6, 7.7, 8, 9, 10, 11 and 12);
- equipment for monitoring the feet (see the following Clauses and Subclauses: 2, 3, 4, 5, 6, 7.1.3, 7.2, 7.3.3, 7.4.1.2 c), 7.4.2, 7.4.3.1, 7.4.3.2, 7.4.3.3 c), 7.5, 7.6, 7.7, 8, 9, 10, 11, 12 and 13);
- equipment for monitoring the hands and feet (see the following Clauses and Subclauses 2, 3, 4, 5, 6, 7.1.2, 7.1.3, 7.2, 7.3.2, 7.3.3, 7.4.1.2 b), 7.4.1.2 c), 7.4.2, 7.4.3.1, 7.4.3.2, 7.4.3.3 b), 7.4.3.3 c), 7.5, 7.6, 7.7, 8, 9, 10, 11 and 12).

The object of this International Standard is to define mechanical and operational characteristics, minimum performance characteristics and general test procedures for personnel monitoring equipment.

2 Normative references

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

☐ IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts* ☐

IEC 60050-394:1995 + A1:1996 + A2:2000 , *International Electrotechnical Vocabulary (IEV) – Chapter 394: Nuclear instrumentation: Instruments*

IEC 60777:1983, *Terminology, quantities and units concerning radiation protection*

IEC 61000-4-2:1995 + A1:1998 + A2:2000, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electronic discharge immunity test*. Basic EMC publication

IEC 61000-4-3:2002 + A1:2002, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radiofrequency, electromagnetic field immunity test*

IEC 61000-4-5:1995 + Corr. 1995 + A1:2000, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-6:2003 + A1:2004, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:1993 + A1:2000, *Electromagnetic compatibility (EMC) – Part 4: Testing and measuring techniques – Section 8: Power frequency magnetic field immunity test*

IEC 61000-4-12:1995 + A1:2000, *Electromagnetic compatibility (EMC) – Part 4: Testing and measuring techniques – Section 12: Oscillatory waves immunity test*

IEC 60038:1983 + A1:1994 + A2:1997, *IEC standard voltages*

IEC 60068 series, *Environmental testing*

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance* 

IEC 61187:1993, *Electrical and electronic measuring equipment – Documentation*

ISO 8769:1988, *Reference sources for the calibration of surface contamination monitors – Beta-emitters (maximum beta energy greater than 0,15 MeV) and alpha-emitters*

ISO 7503-1:1988, *Evaluation of surface contamination – Part 1: Beta-emitters (maximum beta energy greater than 0,15 MeV) and alpha-emitters*

ISO 8769-2:1996, *Reference sources for the calibration of surface contamination monitors – Part 2: Electrons of energy less than 0,15 MeV and photons of energy less than 1,5 MeV*

ISO 11929 series, *Determination of the detection limit and decision threshold for ionizing radiation measurements* 

3 Terms and definitions

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

NOTE In this standard, the word "shall" signifies a mandatory requirement, the word "should" signifies a mandatory requirement except under certain circumstances which must be specified, and the word "may" signifies an acceptable method or example of good practice.

3.1

warning assembly

equipment designed to indicate either visually or audibly or both that some quantity exceeds a certain value. In this standard, it means primarily radioactive contamination on hands, feet, body or clothing.

3.2

surface emission rate of a source

number of particles or photons of a given type above a given energy emerging per unit time from the source or its window

☐ (according to ISO 8769 definition) ☐

3.3

response

R

ratio of the indicated value (ν) to the quantity being measured (or its conventionally true value) (ν_c)

$$R = \nu/\nu_c \quad [1]$$

3.4

source efficiency (for alpha and beta emitters)¹

ratio between the surface emission rate and the number of particles of the same type created or released within the source or its saturation layer thickness per unit time

NOTE 1 Under this definition, the efficiency of a source would be expected to be not more than 0,5. However a contribution due to backscattered particles can enhance this value considerably).

NOTE 2 This definition applies to alpha sources and beta sources with maximum energy > 150 keV.

3.5

high efficiency source

one in which the efficiency for particles with energy greater than ☐ 0,59 keV ☐ is greater than 25 %, including backscattered particles

3.6

small source

high efficiency source whose maximum active ☐ surface ☐ dimension does not exceed 1 cm

3.7

coefficient of variation

ratio 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:

$$\text{coefficient of variation } V = \frac{s}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{i=1}^{i=n} (x_i - \bar{x})^2} \quad [2]$$

3.8

conventionally true value of a quantity

best appropriate estimate of that quantity. This value and its uncertainty shall be determined from a secondary or primary standard, or by a reference instrument which has been calibrated against a secondary or primary standard.

3.9

error of indication

difference between the indicated emission rate and the conventionally true emission rate at the point of measurement

¹ See ISO 8769.

3.10**ambient background**

that gamma radiation field in which the equipment is intended to operate which includes natural background and radiation due to radioactive sources and/or plants adjacent to the instrument

3.11**reference background**

artificial background created to simulate the maximum ambient background for which the equipment is designed

NOTE This background includes the naturally occurring background and additional radiation provided by a source of Caesium 137 (or other radionuclide by agreement between the purchaser and manufacturer) placed at least 3 m from the detector of interest of the equipment under test.

3.12**uniformity of surface emission rate of sources²**

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

For the purpose of specifying the uniformity of a source in respect to surface emission rate per unit area, the source shall be considered as being made up of a number of portions of equal area. The uniformity shall then be specified as the estimated coefficient of variation of measurements of the individual portions about the mean value for the whole surface. The area of the portions shall be 10 cm² or less.

Uniformity may be measured by inserting a masking plate between the source and the counter. The masking plate should have an aperture of appropriate size and should be of a thickness sufficient to absorb particles of the maximum energy emitted in the case of alpha and beta emitters and shall in the case of gamma radiation be such that no count shall be greater than twice that expected if the absorber were perfect (i.e. more than the half thickness for the energy being used). The uniformity shall be expressed as a percentage (knowledge of uniformity will make it possible to use smaller areas of the source while maintaining traceability)

3.13**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

3.14

 NOTE Not used in EN 61098, see 3.Z1. 

3.15

 NOTE Not used in this document. 

3.16**body average efficiency**

average efficiency of the complete equipment, to the activity on the surface of the body assuming there is no self-absorption or backscatter. For the purpose of inter-comparison, this standard specifies a solid of elliptical cross-section of specific dimensions as a simulation of the body.

² For further information on large area radioactive sources, reference should be made to ISO 8769.

3.17

qualification tests

sets of tests performed in order to verify that the requirements of a specification are fulfilled.

Qualification tests are subdivided into type tests and routine tests and are identified as such in this standard.

3.18

type tests

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

Those 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

[IEV 151-04-15, modified]

3.19

routine tests

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

[IEV 151-04-16]

3.20

acceptance tests

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

[IEV 151-04-20, modified]

3.21

units

in this document, the Units of the International System (SI)³ are used. The definition of radiation quantities and dosimetric terms⁴ are given in IEC 60050(393) and IEC 60050(394) and in IEC 60777. The corresponding non-SI Units are indicated in brackets.

Nevertheless the following units could be used:

- for energy: the electron-volt (symbol eV).

$$1 \text{ eV} = 1,602 \times 10^{-19} \text{ J}$$

- for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min).

Multiples and sub-multiples of SI units will be used, when practical according to the SI system.

3.21

minimum detectable surface emission rate

specific performance criteria taking account both the statistical fluctuation in the background count rates and nominal factors of the background to take account of short term spatial and temporal changes in background as well as changes due to the operator mass.

NOTE This definition is specific for this standard only. 

³ International Bureau of Weights and Measures (BIPM): *Le Système International d'Unités (SI)*, 7th edition (1998).

⁴ ICRU Report 33:1980 and Publication 26 of the International Commission on Radiological Protection (ICRP).

3.22**lowest level of detection**

minimum count rate above background that will not trigger a false alarm due to statistical fluctuations.

3.23**lowest limit of detection**

limit of detection associated to the lowest level of detection. **3.23**

4 Classification of assemblies

Assemblies are classified as follows.

4.1 According to type of radiation to be measured

- **4.1.1** Alpha contamination monitors and warning assemblies.
- Beta contamination monitors and warning assemblies.
- Gamma only contamination monitors and warning assemblies.
- Alpha-Beta contamination monitors and warning assemblies (where the alpha and beta contaminations are indicated separately).
- Beta-Gamma contamination monitors and warning assemblies (where the beta and gamma contaminations are indicated separately).
- Alpha-Beta-Gamma contamination monitors and warning assemblies (where the alpha, beta and gamma contaminations are indicated separately). **4.1.2**

4.2 According to type of surface

- **4.2.1** Assemblies for the monitoring of the whole body (including the head).
- Assemblies for the monitoring of hands only.
- Assemblies for the monitoring of feet only.
- Assemblies for the monitoring of both hands and feet. **4.2.2**

4.3 According to type

- Assemblies with ambient background subtraction.
- Assemblies without ambient background subtraction.
- Assemblies where in order to provide an improved detection capability for both beta and gamma emissions there are, in addition to beta detectors, gamma only detectors. These assemblies include background subtraction.
- Assemblies where in order to provide improved detection capability for both beta and gamma emissions there are, in addition to beta detectors, gamma only detectors. These assemblies do not include background subtraction.

4.21 Compressed overall classification

The equipment may also be supported with a compressed overall classification based on the intended field of use, as shown in Table Z1 below. **4.21**

Table Z1 – Classification according to the intended field of use

Common			Options		
Category	Abbreviation	Energy range	Energy extension	Ambient background compensation	Control type
Alpha	A	3 MeV to 6 MeV	–	O: Without any compensation CP: Post compensation CPA: Alpha natural compensation CPB: Beta high energy compensation CS: Simultaneous compensation CSA: Alpha natural dynamic compensation CSB: Beta high energy dynamic compensation	Hands, Feet, Whole body
Beta	B	$E_{\max}$ of 150 keV to 3 MeV	–	O: Without any compensation CP: Post compensation CPA: Alpha natural compensation CPB: Beta ambient compensation CPGX: Gamma and X-ray ambient compensation CS: Simultaneous compensation CSA: Alpha natural dynamic compensation CSB: Beta ambient dynamic compensation CSGX: Gamma and X-ray ambient dynamic compensation	Hands, Feet, Whole body
Gamma	G	500 keV to 1,5 MeV	L1: Low limit 1 at 50 keV L2: Low limit 2 at 150 keV	O: Without any compensation CP: Post compensation CPB: Beta ambient compensation CPGX: Gamma and X-ray ambient compensation CS: Simultaneous compensation CSB: Beta ambient dynamic compensation CSGX: Gamma and X-ray ambient dynamic compensation	Hands, Feet, Whole body
X-rays	X	5 keV to 20 keV	H: High limit at 50 keV	O: Without any compensation CP: Post compensation CPB: Beta ambient compensation CPGX: Gamma and X-ray ambient compensation CS: Simultaneous compensation CSB: Beta ambient dynamic compensation CSGX: Gamma and X-ray ambient dynamic compensation	Hands, Feet, Whole body



5 Design characteristics

5.1 Positioning of user

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 must be open so that the palms and both sides of the fingers are properly monitored. Such sensors shall indicate to the user that he has positioned himself correctly and remains in the correct position for the full monitoring period. Both audible and visual indication shall be given if the user 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 user is 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 user moving shall be ignored.

5.2 Size of user

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 equipment has been designed.

5.3 Hand monitoring facilities

The design shall be such that both hands shall be monitored with both sides of a hand being monitored simultaneously, or the design shall be such that both sides of both hands must be monitored. The design shall be such that both hands must be open to be monitored.

Where the detecting system is intended to monitor for alpha contamination, at least one part of both sides of the hands shall be in contact with the protective grille of the detector.

The size of the sensitive area of the detector for each side of each hand shall be at least $12\text{ cm} \times 20\text{ cm}$ [C] if not otherwise agreed between manufacturer and user for existing equipment. [C]

Protective and other grilles over the sensitive area of the detector shall not obscure more than 40 % of that sensitive area. This level of obscurity shall include any collimation effect at distances of up to 10 mm from the outer surface of the grille. In the un-obscured area, the total density thickness of material between the sensitive volume of the detector and outer edge of the protective grille shall not exceed $6\text{ mg}\cdot\text{cm}^{-2}$ ($2\text{ mg}\cdot\text{cm}^{-2}$ for detectors intended to measure alpha or low energy beta contamination). Thicker material may be used by agreement between the manufacturer and user subject to conformity with the performance requirements of 7.4.

5.4 Foot monitoring facilities

The equipment should monitor each foot independently. Where a single detector is used it shall have twice the area specified below.

The sensitive area of the detector for each foot shall be at least [C] $15\text{ cm} \times 35\text{ cm}$ [C].

Protective and other grilles over the sensitive area of each detector shall not obscure more than 60 % of that sensitive area. This level of obscurity shall include any collimation effect at distances of up to 10 mm from the outer surface of the grille. In the un-obscured area, the total density thickness of material between the sensitive volume of the detector and the outer edge of the protective grille shall not exceed $6\text{ mg}\cdot\text{cm}^{-2}$ ($2\text{ mg}\cdot\text{cm}^{-2}$ for detectors intended to measure alpha or low energy beta contamination). Where material is included between the feet and the detector to collect dirt from the feet, it shall be easily removable. Alternatively, it shall be possible to expose the detectors so that their sensitive area can be cleaned.

5.5 Body monitoring facilities

The detectors shall be arranged so that the whole of the body surface, including the head and the external surface of the outermost clothing is monitored.

The detectors shall be arranged in one or more sets such that the response capability is the same for each detector of that set unless otherwise agreed between the manufacturer and user. The maximum height of the person for which equipment is designed shall be specified by the manufacturer.

5.6 Visual display

5.6.1 For the user

The instrument shall display prominently at least the following information:

- a) Instructions for the user, where audible instructions are not available.
- b) Indication of all positions where contamination is sufficient to operate the alarm trip on any measuring channel. For assemblies capable of monitoring two or more types of contamination, the display shall distinguish between them.
- c) Indication at the end of a cycle that no alarm trip has operated during the monitoring cycle.
- d) Equipment operational.
- e) Equipment faulty.
- f) Measurement proceeding.
- g) Body, hands or feet correctly positioned.

5.6.2 For maintenance purposes;

These displays are not necessarily visible to the user:

- a) Capability of displaying the counts or count-rate from any measuring channel.
- b) Flow-rate of the gas supply, if applicable.
- c) The alarm set points for each channel.
- d) The low level alarm settings.
- e) The measuring time.
- f) Background too high for correct operation.
- g) High tension, fault-free operation.

5.7 Audible indicators

Audible indicators shall be clearly distinguishable from one another.

There shall be an audible alarm at the end of the monitoring cycle if contamination above the alarm level is indicated.

An audible indication is desirable if at the satisfactory completion of the monitoring cycle no contamination is indicated.

There shall be an audible indication of an interrupted cycle.

5.8 Monitoring period

Contamination alarms shall only be given at the end of the monitoring period.

5.9 Ease of decontamination

The assembly shall be designed and constructed in such a manner as to minimise the risk of becoming contaminated in use and to facilitate decontamination.