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**Radiation protection instrumentation -
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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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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- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2008-04-01
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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.

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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.Z2**lowest level of detection**

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

3.Z3**lowest limit of detection**

limit of detection associated to the lowest level of detection. ☐

4 Classification of assemblies

Assemblies are classified as follows.

4.1 According to type of radiation to be measured

- ☐ 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). ☐

4.2 According to type of surface

- ☐ 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. ☐

4.3 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.Z1 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. ☐

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

C

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 cm × 20 cm \square if not otherwise agreed between manufacturer and user for existing equipment. \square

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 \square 15 cm × 35 cm \square .

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.

5.10 Detectors used

The type of detector used will be determined by the manufacturer to meet the classification (Clause 4) and radiation characteristics (Clause 7) for which the equipment is designed.

Where gas flow detectors are used, all tests shall be undertaken with the gas flow rate equal to or just above the flow rate specified by the manufacturer for units using continuous flow. Where the flow is not continuous, the manufacturer shall be able to demonstrate that equipment will operate satisfactorily with a mean flow rate as specified by the manufacturer.

6 Performance requirements and test procedures

6.1 General test procedure

6.1.1 Nature of tests

Except where otherwise specified, these tests are to be considered as type tests, although any or all may be considered as acceptance tests by agreement between the manufacturer and purchaser. The stated requirements are minimum requirements and may be extended for any particular equipment or function.

NOTE Other test methods may be agreed between manufacturer and purchaser to be regarded as additional acceptance tests. Examples may be published as informative annexes to this standard in future.

Standard test conditions with allowable tolerances are defined in Table 1.

Test procedures applicable to the assemblies listed in 4.2 are shown in Clause 7.

6.1.2 Tests performed under standard test conditions

Tests which are performed under standard test conditions are listed in Table 2 which indicates, for each characteristic, the limits of variation and the Subclause where the corresponding test method is described.

6.1.3 Tests performed with variation of influence quantities

These tests are intended to determine the effects of variation in influence quantities, and are given in Table 3, with the range of variation of each influence quantity and limits of consequent variation in the effective alarm point.

The range of variation of influence quantities indicated in Table 3 defines a nominal operating range within which the variation in indication shall remain within the limits stated by the manufacturer. These limits shall in no case exceed those laid down in Table 3.

In order to test the effect of variation in any one of the influence quantities listed in Table 3, all other quantities shall be maintained within the limits for the standard test conditions given in Table 1, unless otherwise specified in the test procedure concerned.

In order to simplify these tests, for each individual influence quantity, only the routine test of the variation of the effective alarm point need be performed.

Other aspects of the performance of the assembly need be tested with variation of influence quantities only if it is considered that the routine test specified will not give a representative indication.

6.2 Statistical fluctuations

For any test involving the use of radiation, if the magnitude of the statistical fluctuations, arising from the random nature of the radiation being detected 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 demonstrate compliance with the test in question.

The interval between such readings shall be at least three times the response time in order to ensure that the readings are statistically independent.

6.3 Reference sources

The reference sources used in tests involved with measurement of radiation shall be sources of Caesium 137 for gamma measurement (Iodine 129 for low energy gamma), Chlorine 36 or Thallium 204 for beta measurement and Americium 241 or Plutonium 239 for alpha measurement.

For assemblies for the monitoring of hands, sources of active area 15 cm × 10 cm should be used except where tests of the uniformity of the detector responses are being made.

For assemblies for the monitoring of feet, sources of active area 30 cm × 10 cm or 15 cm × 10 cm should be used except where tests of the uniformity of the detector responses are being made.

The distribution of the surface emission rate of the above two reference sources shall be uniform, such that the surface emission rate per unit area taken over any 10 cm² shall not differ from the mean surface emission rate per unit area of the total area by more than 6 % to a measurement confidence limit of 1 σ (See ISO 8769 and 3.12 of this standard).

Where sources of the areas quoted above are not available, tests shall be carried out using small sources or other large area sources of dimensions less than that quoted above. In this case the measured value shall be the average of a number of readings with the source moved over an equivalent area. The number of source positions used shall be as quoted in 7.1.2 and 7.1.3.

6.4 Nature of tests

All tests in this document are regarded as type tests except the tests of 7.6 which are also routine tests.

6.5 Use of gas flow detectors

Where detectors rely on a continuous or semi-continuous supply of gas for the detection of radioactive particles, the manufacturer shall state the gas to be used, and its purity.

An indication of the flow of gas into the equipment shall be provided.

7 Radiation characteristics

7.1 Variation of response with source position

7.1.1 For clothing or the body

7.1.1.1 Requirement

Tests shall be made to determine the variation of response with source position.

The variation of response around the body of the user shall be stated by the manufacturer.

☐ In order to improve the performance and meet the requirements of this standard, the manufacturer may in the case of beta and/or gamma monitoring additionally sum the response of any number of adjacent detectors. ☐

7.1.1.2 Method of test

7.1.1.2.1 Alpha monitoring systems

It is not possible to define the actual performance for the detection of contamination on the body. Where the equipment is intended to measure alpha on the body, tests similar to those of 7.1.2 and 7.1.3 shall be carried out on the whole area of each type of detector used. The manufacturer shall publish the results obtained specifying the nuclide used. The detector shall be operated such that the background is less than 0,2 counts per second, otherwise background subtraction shall be introduced.

☐ NOTE For a possible further test (for further characterization of the sensitive volume) see ZA.2. ☐

7.1.1.2.2 Beta monitoring systems

a) Effect of the vertical position of the source of radiation

Where there is more than one vertical array of detectors and there is a difference between these arrays, a test shall be carried out for each form of array.

The small beta source of Chlorine 36, as defined in 3.6, shall be moved in steps in a vertical line 5 cm from the detector. Each step shall be 2 cm or less and the response of the equipment shall be measured for each step as indicated above. For the first reading, the source shall be centred at or below a point 5 cm above the surface of the soles of the feet and the last shall be between the height of the tallest person which the equipment is designed for and 2 cm higher.

The value of response taken for each position of the source shall be the response of that detector in the array which gives the highest response.

Where it has been necessary to take more than one set of readings, these readings shall be summed with relation to the vertical position and the position of the maximum response shall be noted and used in b) below.

The highest reading of the response shall be stated (see Figure 1).

b) Around the body

For this test, a phantom of the trunk of the human torso is required. This shall be an ellipse in section, of circumference 95 cm and major axis 35 cm. Since these tests are to be carried out with beta sources, this phantom may be hollow providing materials of the wall have a thickness equivalent to at least $0,5 \text{ g cm}^{-2}$.

The central axis of this phantom is to be placed where the centre of the user would normally be during the monitoring period. Where the user is not specifically positioned, the phantom shall be positioned such that the closest it is to the outermost part of the detector protection is 5 cm. Some metering or scaling device shall be connected to each monitoring channel.

A small source of Chlorine 36 as defined in 3.6 shall be moved right around the phantom every 10° as illustrated in Figure 2. This shall be carried out at the vertical position of maximum response found in a) above. The response of each measuring channel shall be plotted on a single graph as illustrated in Figure 2. The maximum to minimum value of response shall be stated. When plotting the response, the response to ambient background radiation must be taken into account, and this effect must be subtracted.

Where the monitoring equipment is designed to monitor the body, clothed or not, with the user in more than one position, the response curve shall be the composite of the results taken in each position.

NOTE 1 This test does not determine the performance of the equipment for some areas of the body, for example parts shielded from the detector by other parts of the body. The manufacturer must state precautions made to minimise such areas and where applicable indicate performance for these areas.

NOTE 2 For a possible further test (for further characterization of the sensitive volume) see ZA.2.

7.1.1.2.3 Gamma monitoring systems

a) The effect of the vertical position of the source of radiation

This shall be carried out in the same way as for beta in 7.1.1.2.2 a) above except that the source of radiation shall be Caesium 137 (Iodine 129 for the low energy version) and the steps can be 5 cm.

b) Around the body

As in 7.1.1.2.2 b) above, except that the source, wherever possible shall be placed half-way up a solid phantom at least 25 cm high and of density of about 1 g cm^{-3} . The source used shall be Caesium 137 (Iodine 129 for low energy version) and the steps can be 20° .

NOTE For a possible further test (for further characterization of the sensitive volume) see ZA.1.

7.1.2 For hand monitoring

7.1.2.1 Requirement

The variation of response from the mean value with the position of the source to be monitored shall be stated by the manufacturer over the area of a hand for the reference nuclide of Caesium 137 shielded with $>0,6 \text{ mm}$ of aluminium (or Iodine 129 for low energy monitors) for gamma monitoring, Chlorine 36 for beta monitoring and Americium 241 for alpha monitoring and shall not exceed a factor of 2.

7.1.2.2 Method of test

For this test an area 15 cm × 10 cm of the hand detector shall be considered, as defined by the manufacturer. The response of the detector shall be measured using a small reference source in each of the 24 positions shown in Figure 3 on the outermost part of the detector protection. The effect of background shall be subtracted from each calculation of response. The greatest difference from the mean value shall not exceed a factor of two.

7.1.3 For foot monitoring

7.1.3.1 Requirement

The variation of response with the position of the source to be monitored shall not exceed a factor of 2 over the area of a foot for the reference nuclide of Caesium 137 shielded with >0,6 mm of Aluminium (or Iodine 129 for low energy monitors) for gamma monitoring, Chlorine 36 for beta monitoring and Americium 241 for alpha monitoring.

7.1.3.2 Method of test

For this test, an area 30 cm × 10 cm of the foot detector shall be considered, as defined by the manufacturer. The response of the detector shall be measured using a small source in each of the 44 positions shown in Figure 4 on the outermost part of the detector protection. The effect of ambient background shall be subtracted from each calculation of response.

The greatest difference from the mean value shall not exceed a factor of 2.

7.2 Background

All measurements of radiation are affected by ambient background radiation and the effects may be dealt with in different ways dependent on the design of the equipment.

7.2.1 No background compensation

Where no background compensation is included, the range of ambient background radiation in which the equipment is designed to work without adjustment shall be specified by the manufacturer.

7.2.2 Simultaneous compensation

The method where background compensation is achieved by having a number of detectors measuring the ambient background radiation simultaneously with the measurement of the contamination. Such detectors will not give exact compensation since they are not in the same position as the monitoring detectors.

The manufacturer shall state the magnitude of the variation of the ambient background signal which is used in calculating the decision threshold (see 7.3). He shall also provide the magnitude of the changes necessary to create that signal change.

Changes in value.

Changes in energy.

Changes in direction.

The effects of changes in direction shall be due to movements of sources placed more than 10 m from the equipment.

When calculating the decision threshold (minimum detectable surface emission rate), the effect of changes in the indicated background magnitude shall be taken into account.

7.2.3 Consecutive compensation

When not in use, the equipment monitors the background from each monitoring channel and stores the information for later subtraction from the measurement signal.

In this case, the manufacturer shall state the period over which the background is averaged for subtraction for a range of reference background count rates or the number of background counts. Where this is adjustable, he shall state the value he has taken for achieving his published minimum detectable surface emission rate.

The manufacturer shall also state any precautions taken for the possibility of continuous use of the equipment.

In calculating the minimum detectable surface emission rate in relation to this standard, the manufacturer shall determine two values, one taking into account a 5 % change in the background value between storage and measurement and subtracting this from the response due to reference activity and the other taking no account of background change (see 7.3).

7.3 C Minimum detectable surface emission rate C

For clarity, reference should be made to Annex A.

C Since the minimum detectable surface emission rate depends on the response of the equipment and this is going to depend on where on the body the activity is to be measured, the minimum detectable surface emission rate is dependent on where the activity is. In order to provide some indication of performance an average minimum detectable activity shall be determined from the average efficiency. Since also the signal from the background can be large by comparison to the signal from the activity being measured, and this background will be far from constant both in terms of time and position, allowance in determining the minimum detectable surface emission rate shall take account of this. The user also has a significant effect on the background. In this document the minimum detectable surface emission rate has a special meaning and includes arbitrary factors not used in the more precise decision threshold defined in ISO 11929. C

For the purposes of this document, and to avoid any unnecessary mistrust of the equipment, a decision value α shall be chosen such that there is a theoretical false alarm of one per cent, or better, for the whole assembly for a complete measurement cycle with no contamination present. Since, in general, detectors used in this equipment will produce pulses which are subsequently counted by some means, the requirements of the following Subclauses are defined in terms of count rates obtained from the detectors.

7.3.1 For clothing or body

C For the purposes of this document, the minimum detectable surface emission rate shall relate to the 4π body average efficiency to clothing (body). This shall be determined as below, or the manufacturer shall undertake similar methods of determining an average efficiency. In the latter case the manufacturer shall provide the purchaser with a full description of the phantom used, all measurements taken, the assumptions made in calculating the average efficiency and the calculations made to determine this “average”. The 4π efficiency shall be determined from both the vertical response characteristic shown in Figure 1 and the polar response given in Figure 2. C

The average polar response is determined from the radius of a circle whose area is equal to the area enclosed by the polar response diagram shown in Figure 2.

The 4π average overall efficiency is determined from product of the average polar response at the plane of maximum vertical response and the ratio of the average overall vertical response to the maximum vertical response as shown in Figure 1. C *Text deleted* C The average vertical response for an array is determined in a similar way to that of the polar response. In the case where all the arrays are identical, the overall vertical response is the average vertical response for an array.

From this, the 4π body average efficiency (overall response) can be determined as follows:

$$\frac{\text{Counts per second for average response}}{\text{Surface emission rate of the source in determining the response}} = \text{Overall response} \quad [3]$$

This efficiency equation shall be used in determining the minimum detectable surface emission rate (*MDSER*) as described in Annex A. (Unless otherwise agreed between the manufacturer and purchaser.)

In all cases, the minimum detectable surface emission rate in a background level agreed upon between the purchaser and manufacturer shall not be greater than 200 s^{-1} for beta emission and a photon emission of $2\,000 \text{ s}^{-1}$ rate for gamma for a total monitoring time of 10 s or shall be a time agreed between the purchaser and manufacturer. \square Where monitoring is undertaken by two or more steps, the sum of the times taken for each monitoring step shall not exceed the time specified above or a time agreed between the manufacturer and purchaser \square .

NOTE Although nominally 200 s^{-1} is equivalent to 400 Bq, the user should refer to ISO 7503-1 for corrections to allow for self-absorption on clothing or other surfaces actually to be measured.

7.3.2 For hand monitoring

a) Alpha

The \square minimum detectable surface emission rate \square shall relate to the response of the hand detector to a source of uniform activity of area $15 \text{ cm} \times 10 \text{ cm}$.

The \square minimum detectable surface emission rate \square shall be the emission rate which in the monitoring time of the equipment gives at least 5 counts from the detectors associated with each hand (unless the operating environment is such that a lower number of counts would not create a significant false alarm rate, as agreed between the manufacturer and user). It shall be less than 10 s^{-1} for a monitoring time of 10 s or shall be agreed upon between manufacturer and purchaser.

NOTE Nominally 20 Bq, but refer to note in 7.3.1.

b) Beta

The limit of detection shall relate to the response of the hand detector to a source of uniform surface emission rate of area $15 \text{ cm} \times 10 \text{ cm}$.

The minimum detectable surface emission rate shall be determined in the same way as that for clothing and shall be less than 100 s^{-1} for a monitoring time of 10 s or shall be agreed upon between the purchaser and manufacturer (see note to 7.3.1).

c) Gamma

The \square minimum detectable surface emission rate \square shall relate to the response of the hand detector to a source of area $15 \text{ cm} \times 10 \text{ cm}$.

The minimum detectable surface emission rate shall be determined in the same way as for clothing and shall be less than a photon emission rate of $2\,000 \text{ s}^{-1}$ for a monitoring time of 10 s, or shall be determined by agreement between the purchaser and the manufacturer.

7.3.3 For foot monitoring

a) Alpha

The limit of detectable surface emission rate shall relate to the response of the foot detector to a source of uniform activity of area $30 \text{ cm} \times 10 \text{ cm}$. A source of $15 \text{ cm} \times 10 \text{ cm}$ may be used in two places to simulate the $10 \text{ cm} \times 30 \text{ cm}$ source.

The limit of detectable surface emission rate shall be the surface emission rate which in the monitoring time of the equipment gives at least five counts from the detector. It shall be less than 20 s^{-1} for a monitoring time of 10 s or shall be agreed upon between manufacturer and purchaser (see note to item a) of 7.3.2).

b) Beta

The limit of detectable surface emission rate shall relate to the response of the foot detector to a source of uniform surface emission rate of area 30 cm × 10 cm. A source of 15 cm × 10 cm may be used in two places to simulate the 10 cm × 30 cm source.

The minimum detectable surface emission rate shall be determined in the same way as that for clothing and shall be less than 200 s⁻¹ for a monitoring time of 10 s or shall be agreed upon between manufacturer and purchaser (see note to 7.3.1).

c) Gamma

The limit of detectable surface emission rate shall relate to the response of the foot detector to a source of uniform surface emission rate of area 30 cm × 10 cm. A source of 15 cm × 10 cm may be used in two places to simulate the 30 cm × 10 cm source.

The minimum detectable surface emission rate shall be determined in the same way as that for clothing and shall be less than 1 000 s⁻¹ for a monitoring time of 10 s, or shall be determined by agreement between the purchaser and the manufacturer.

7.4 Variation of response with energy

7.4.1 Beta

7.4.1.1 Requirements

The equipment shall be capable of detecting beta emitters with E_{\max} greater than 150 keV. Measurements of the response shall be made with at least three beta emitters.

- one < 0,2 MeV,
- one between 0,2 MeV and 0,5 MeV,
- one > 0,5 MeV.

By way of information, a list of suitable radionuclides is given below.

¹⁴ C	(maximum energy 0,155 MeV).
¹⁴⁷ Pm	(maximum energy 0,225 MeV). Precautions shall be taken to ensure that the content of ¹⁴⁶ Pm is low enough not to disturb the calibration.
⁶⁰ Co	(maximum energy 0,314 MeV). Precautions shall be taken when using this radionuclide in order to identify and correct for the effects of the gamma emission on the response of the equipment.
¹⁸⁵ W	(maximum energy 0,432 MeV).
³⁶ Cl	(maximum energy 0,714 MeV).
²⁰⁴ Tl	(maximum energy 0,766 MeV).
²¹⁰ Bi	(maximum energy 1,161 MeV).
\square ⁹⁰ Sr/ ⁹⁰ Y \square	(maximum energy of short lived daughter ⁹⁰ Y 2,274 MeV).

7.4.1.2 Method of test

a) The body

For this test, the phantom used in test 7.1.1.2.2 shall be used as specified in that test.

A point source of the nuclide of interest shall be moved in the vertical plane at 2 cm steps and right around the phantom every 10° in the plane where the response in the vertical plane is a maximum and the response of each monitoring channel shall be plotted on a single graph as illustrated in Figure 2 and as described in test 7.1.1.2.2.

The 4π body average efficiency shall be calculated for each nuclide of interest and compared to that of the reference source (See 7.3.1).

b) Hands

This may be undertaken either by use of large area sources of uniform activity or point sources. Where large area sources are used, they shall be 15 cm × 10 cm \square or by default 10 cm x 10 cm (performing two measurements without overlap in order to cover the whole detector area and using the mean response for further reference) \square and the ratio of the response to that of the reference source can be measured directly. The sources shall be centred about the reference point of the detector.

Where point sources are used, the following procedure should be adopted.

The response of the detector shall be measured using the point source of the nuclide of interest in each of the 24 positions shown in Figure 3. The effect of the background shall be subtracted from each calculation of response. The average of the responses shall be calculated and these shall be taken as the response using the large area sources.

c) Feet

The requirement shall be met in the same way as for hands above except that when large area sources are used, these shall be 30 cm × 10 cm \square or by default 10 cm x 10 cm (performing three measurements without overlap in order to cover the whole detector area and using the mean response for further reference) \square and where point sources are used 44 positions shall be used as in Figure 4.

7.4.2 Alpha**7.4.2.1 General**

Since the alpha radiation emitted from alpha contamination may be degraded significantly by self-absorption within the contamination, measurements of response shall be made with an alpha emitter of energy lower than that of the reference nuclide. A source of natural or depleted uranium should be used.

Depleted Uranium will be predominately uranium 238 emitting 4,2 MeV alphas with traces of uranium 234 and uranium 235 and natural uranium will be uranium 238 in near equilibrium with uranium 234 emitting 4,8 MeV alphas with traces of uranium 235.

7.4.2.2 Requirements

The manufacturer should state, for the detectors used to monitor the hands and the feet, the ratio of the response to natural or depleted uranium to the response to the reference radionuclide.

7.4.2.3 Method of test

The method of test for the hand and foot detectors is identical to that for beta radiation.

7.4.3 Gamma**7.4.3.1 General**

The equipment shall be capable of detecting gamma or X-ray emitters with energy greater than 50 keV (5 keV for low energy systems). Measurements shall be made with at least 3 gamma emitters for equipment designed to measure high energy emitters and 2 for equipment designed to measure low energy emitters.

- one between 5 keV and 20 keV (low energy system),
- one between 50 keV and 150 keV (low and high energy systems),
- one between 150 keV and 500 keV (high energy system),
- one above 500 keV (high energy system).

By way of information, a list of suitable radionuclides is given below

⁵⁵ Fe	major emission 5,9 keV	half life 2,7 years
¹²⁹ I	major emission 29 keV	half life $1,6 \times 10^7$ years
²⁴¹ Am	major emission 59,5 keV	half life 432 years with a sufficiently thick window to eliminate electron and alpha particle penetration
⁵⁷ Co	major emission 122 keV	half life 270 days
¹³⁷ Cs	major emission 661 keV	half life 30 years with sufficiently thick window to eliminate electron penetration
⁶⁰ Co	major emissions 1173 keV and 1332 keV	half live 5,271 years with sufficiently thick window to eliminate electron penetration

7.4.3.2 Requirements

The manufacturer shall specify for the detectors used to monitor the body, hands and feet, the ratio of the response of the named nuclides used in the test to the response of the reference nuclide. One set of results is obtainable from using the test methods described in 7.1

7.4.3.3 Method of test

a) The body

For this test, the phantom used in test 7.1.1.2.3 shall be used as specified in that test. A small source [C] of the nuclide [C] of interest shall be moved in the vertical plane every 5 cm and right around the phantom every 20° . The response of each monitoring channel shall be plotted on a single graph as illustrated in Figure 2.

The 4π body average efficiency around the phantom shall be calculated for each nuclide of interest and compared to that of the reference source (see 7.3.1).

b) Hands

This may be undertaken either by the use of large area sources of uniform activity or point sources. Where large area sources are used, they shall be $15 \text{ cm} \times 10 \text{ cm}$ [C] or by default $10 \text{ cm} \times 10 \text{ cm}$ (performing two measurements without overlap in order to cover the whole detector area and using the mean response for further reference) [C] and the ratio of the response to that of the reference source can be measured directly. The sources shall be centred about the reference point of the [C] detector [C] .

Where point sources are used, the following procedure should be adopted.

The response of the detector shall be measured using the point source of the nuclide of interest in each of the 24 positions shown in Figure 3. The effect of background noise shall be subtracted from each calculation of response. The average of the responses shall be calculated and these shall be taken as the response using the large area sources.

c) Feet

The requirement shall be met in the same way as for hands above, except where large area sources are used, these shall be $30 \text{ cm} \times 10 \text{ cm}$ [C] or by default $10 \text{ cm} \times 10 \text{ cm}$ (performing three measurements without overlap in order to cover the whole detector area and using the mean response for further reference) [C] and where point sources are used, 44 positions shall be used as in Figure 4.

7.5 Response to other ionising radiations

Assemblies shall be designed so as to limit as far as possible the influence of other ionising radiations.

7.5.1 Gamma radiation

7.5.1.1 Requirements for alpha contamination monitors or warning assemblies

When the detector is subjected to an air kerma rate of $10 \mu\text{Gy/h}$ [C] from a Caesium-137 source [C], there shall be no measurable effect on the measurement or set alarm level. The effective centre of the source shall be at least 3 m from the equipment under test.

7.5.1.2 Requirements for beta contamination monitors or warning assemblies

The effects of gamma radiation shall be determined by exposure of the equipment to the gamma radiation due to Caesium 137. The effective centre of this source of radiation shall be at least 3 m from the equipment under test. The dose rate and the limits of indication shall be specified by the manufacturer. The equipment shall be operated as defined by the manufacturer.

7.5.2 Alpha radiation (for beta and gamma contamination assemblies)

7.5.2.1 Requirements

Since in general the hazard of alpha emitters is very much higher than that due to beta or gamma emitters, there is no specific requirement. The response of the measuring assembly to the reference alpha radiation shall be stated by the manufacturer if the detector has an equivalent window thickness of less than 6 mg/cm^2 .

For simultaneous alpha/beta and/or gamma contamination monitoring assemblies with separate indication of alpha, beta gamma contamination, the response of the beta channel to alpha radiation shall be less than that of the alpha channel. This relates to measured counts or current prior to any signal processing which makes allowance for the differences in hazard.

7.5.2.2 Method of test

Insert the hand or foot alpha radiation reference source in the assembly and using a scaler or similar equipment determine the ratio of the response in terms of count rate per unit surface emission rate of the alpha source to the similar response to the beta reference source.

7.5.3 Beta or gamma radiation (for alpha contamination monitoring assemblies)

7.5.3.1 Requirements

The response of alpha contamination monitoring assemblies to Strontium 90/Yttrium 90 radiation or reference gamma radiation shall be stated (see 6.3).

For both alpha and simultaneous alpha/beta, alpha/gamma or alpha/beta/gamma contamination monitoring assemblies, the response of the alpha channel to beta or gamma radiation shall be less than 1 % of that due to alpha in this channel. This relates to measured counts or current prior to any signal processing which makes allowance for the difference in hazard.

7.5.3.2 Method of test

[C] Add the foot or hand beta radiation reference source in the assembly and using a scaler or similar equipment determine the ratio of the response in terms of count rate per unit surface emission rate of the beta source to the similar response to the alpha reference source. [C]

7.6 Type and routine tests of performance

In order to confirm the operation of an assembly, the following tests shall be made.

7.6.1 For the detectors

The detection efficiency of each detector shall be determined by measurement of a radioactive source. The position and type of source used shall be stated by the manufacturer. The counting efficiency obtained shall be such that the minimum detectable surface emission rate performance specified by the manufacturer can be achieved. It shall be verified that the detector is operating at its specified operating point.

7.6.2 For the alarm threshold

The manufacturer shall check that the alarm threshold of each monitoring channel is correct by the use of sources or injection of a suitable train of pulses.

7.7 Linearity of indication

7.7.1 Requirements

In the case of monitoring assemblies where the indication of the level of contamination detected is given in any form (becquerels, becquerels per square centimetre, derived working levels etc.) the manufacturer shall undertake tests to verify that the response is linear to better than 20 % over the range specified by the manufacturer.

7.7.2 Method of test

The method of test for linearity of indication shall be by agreement between the manufacturer and purchaser.

8 Overload protection

8.1 Requirements

For radiation intensities greater than that corresponding to full scale on any indicating device or greater than the alarm set point, the equipment shall indicate a level higher than the maximum indication and the alarm shall always operate.

8.2 Method of test

Compliance with this requirement shall be confirmed by placing a source of 10^6 Bq of Caesium 137 for gamma detecting equipments, 10^5 Bq of Strontium 90 in equilibrium with its daughter on the normally fitted protection to the sensitive area of the detector for beta detecting equipments and 10^4 Bq of Americium 241 on the normally fitted protection of the sensitive area of the detector for alpha detecting equipments. The contamination alarm shall operate and indication shall be given that the particular detector exposed to the source of radiation is providing the alarm information.

9 Availability

9.1 Warm-up time

Assemblies using a special gas supply would require this gas supply to be connected for a long period of time (several hours) after installation before they are operational. As a consequence of this, the gas supply should not be switched off and so a test of warm-up time is unnecessary. The manufacturer shall advise the purchaser of the minimum time between connection of the gas supply and operation, which shall be longer than the time required for the connection of the electrical supply. Where assemblies do not use a special gas supply, the equipment shall be operational within 30 min of the connection of the electrical supply.

9.2 Power failure

In the event of a failure of the electrical power supply of less than 1 h, the equipment shall be operational within 5 min of the restoration of the supply without any intervention apart from resetting any alarm condition. A return of the equipment to the operational condition shall be indicated.

10 Environmental conditions

10.1 Temperature

10.1.1 Requirements

The change of performance of the equipment shall be less than 30 % of nominal performance under standard test conditions for a change of temperature from +5 °C to +40 °C [C] (see also IEC 60068 series) [C].

Testing outside this range may be agreed between manufacturer and purchaser.

10.1.2 Method of test

Since the equipments to which this standard applies include warning assemblies and are larger than the majority of environmental test chambers, compliance with the requirements may be met by the testing of parts of the equipment.

a) Detector channels

This includes the detector, associated amplifiers, discriminators and pulse shaping circuits which together produce regular shaped pulses the frequency of which is dependent on the radiation being measured. Where gas flow counters are used, precaution should be taken to ensure that the gas used is at the test temperature.

The detectors shall be subjected to beta radiation from the reference radiation such that the pulse rate from the detectors lies between 100 and 1 000 per second under standard test conditions. The count rate shall be noted over a period of 100 s. The temperature shall be reduced to +5 °C and the count rate again taken after 4 h with the equipment at this temperature. The temperature shall then be increased to +40 °C at 10 °C per hour the count rate again taken after 4 h at this temperature. The equipment must be operational for at least 30 min before each count rate is measured. The count rate shall be noted and shall not differ from that under standard test conditions by more than 30 %.

Where identical detector channels are used, it is only necessary to test one channel, but detectors must be identical in shape and size, for example it is necessary to check both hand and foot channels, even though the difference is only the sensitive area of the detector.

b) Signal processing

All parts of the electronic circuitry other than the detector channels shall be tested, if necessary by the injection of pulses from a pulse generator, over the temperature range 5 °C to 40 °C. Where changes are detected or where the signal is transformed into analogue form for meter display these changes or the change in analogue reading shall be such that the equivalent change into counts into this circuit when added to the maximum error obtained in any of the detector channels shall be still less than 30 %.

10.2 Relative humidity

10.2.1 Requirements

The change of performance of the equipment shall be less than 10 % of the performance under standard test conditions but with the temperature held at 35 °C where the relative humidity is changed from 40 % to 85 %.

10.2.2 Method of test

This will be similar to that for temperature variation in that sub-components may be tested individually but keeping the relative humidity at the limit values for 24 h.

10.3 Atmospheric pressure

Most assemblies are not affected by normal changes of atmospheric pressure, so there is no test for this effect. Where assemblies use open-air detectors, the test of the effect of atmospheric pressure shall be by agreement between the manufacturer and purchaser.

11 Power supply

11.1 Voltage and frequency

If assemblies are designed to operate from a.c. power supplies, this shall be from single-phase a.c. supply voltage in one of the following categories **[C]** (in accordance with IEC 60038) **[C]**:

- Series I: 230 V;
- Series II: 120 and/or 240 V;

In some countries, nominal single-phase power is 117 V and/or 234 V, 60 Hz; nominal single-phase power of 110 V, 50 Hz is an alternative supply in other countries.

By agreement between manufacturer and purchaser, the equipment may be provided with the possibility of operating from a low voltage standby supply in the case of a power failure. In such cases, it would be desirable for the equipment not to malfunction or trigger an alarm as a result of the supply changeover.

11.2 Electromagnetic compatibility

11.2.1 Electrostatic discharge

Based on IEC 61000-4-2.

11.2.1.1 Requirements

The tests to evaluate the immunity to electrostatic discharge (ESD) shall use the “contact discharge” technique for conductive surfaces and coupling planes and the “air discharge” technique for insulating surfaces. Discharge points shall be based on user accessibility.

11.2.1.2 Method of test

The following tests shall be performed; guidance can be obtained from the reference document.

- a) 10 discharges per discharge point with a minimum of 1 s recovery time between each discharge.
- b) The maximum intensity of each discharge is based on the technique used: 6 kV for contact, and 8 kV for air discharge. These levels are based on Tables 1 and A.1 of IEC 61000-4-2, level 3.
- c) Response effects shall not exceed ± 10 % of the response without discharge. No alarms or other outputs shall be activated when the equipment is exposed to the discharge.

11.2.2 Radiofrequency (RF)

Based on IEC 61000-4-3.

The requirements related to radiofrequency shall be by agreement between the manufacturer and purchaser.

11.2.3 Surge Immunity

Based on IEC 61000-4-5 and 61000-4-12.

11.2.3.1 Requirements

The tests shall be based on and meet the requirements of the Class 3 requirements stated in Annex B of IEC 61000-4-5 and level 3, Table 1, requirements of IEC 61000-4-12. Pulses shall be applied to the main supply terminals via a coupling/decoupling network, or equivalent equipment. The repetition rate shall not exceed 1 per min.

11.2.3.2 Method of test

The following tests shall be performed. Guidance can be found in IEC 61000-4-5 and IEC 61000-4-12.

- a) 10 pulses shall be applied to the equipment with a minimum time between surges of 1 min.
- b) Each pulse should consist of a combination wave (1,2/50 μ s to 8/20 μ s) at an intensity of 2 kV.
- c) Ring wave pulses should be not more than 2 kV.

Response effects shall not exceed ± 10 % of the response without the pulse. No alarms or other outputs should be activated when the equipment is exposed to the pulse.

11.2.4 Conducted immunity

Based on IEC 61000-4-6.

11.2.4.1 Requirements

The test applies to equipment used in the presence of RF transmitters in the frequency range of 150 kHz to 80 MHz. Equipments which do not have at least one conducting cable (mains supply, signal line, or earth connection) are excluded. The protocol is based on the class 3 requirements stated in Annex C of IEC 61000-4-6.

11.2.4.2 Method of test

The following tests shall be performed. Guidance can be obtained from IEC 61000-4-6.

- a) Frequency range of 150 kHz to 80 MHz at an intensity of 140 dB (μV).
- b) The signal shall be 80 % amplitude modulated with a 1 kHz sine wave.
- c) The test should be performed using an automated sweep at a rate not greater than $1,5 \times 10^{-3}$ decades per second, or 1 % of the fundamental.
- d) Response effects shall not exceed ± 10 % of the response without the field present. No alarms or other outputs shall be activated when the equipment is exposed to the field. Note some level of susceptibility may be acceptable, this shall be specified by the purchaser.

11.2.5 Magnetic fields

Based on IEC 61000-4-8.

Tests related to this effect shall be by agreement between the purchaser and manufacturer.

12 Storage

All assemblies designed for use in temperate regions shall be designed to operate within the specifications of this standard following storage for three months in the manufacturer's packing at any temperature between -25 °C and $+50$ °C.

13 Documentation

13.1 Certificate

A certificate shall accompany each assembly, giving at least the following information:

- manufacturer's name or registered trade mark;
- type of assembly and serial number;
- type of detectors used;
- for hand monitors, range of indication;
- for foot monitors, range of indication;
- limit of detection for body, clothed or not (if applicable);
- limit of detection for hands (if applicable);
- limit of detection for feet (if applicable);
- range of alarm settings for the body, clothed or not (if applicable);
- range of alarm settings for the hands (if applicable);
- range of alarm settings for the feet (if applicable);
- total sensitive area of detectors for clothing monitoring (if applicable);
- total sensitive area of detectors for hand monitoring (if applicable);
- total sensitive area of detectors for foot monitoring (if applicable);
- effective mass per unit area of the protective windows on each type of detector;
- body size limits for which the equipment is designed;
- the variations of the response with source position unless it is within the requirements of the specification;

- response as a function of beta radiation energy for beta detectors;
- the method and limitation of background compensation;
- gas type and minimum flow rate, where applicable;
- size and shape of sources used in the type tests;
- declaration whether the EN 61098:2007 standard test and, if necessary, the tests of Annex ZA are met.

13.2 Operation and maintenance manual

An operation and maintenance manual in accordance with IEC 61187 and including the following information shall be supplied:

- schematic electrical diagrams, including spare parts list;
- operational details, maintenance and calibration procedures.

13.3 Operational instructions

Instructions for personnel monitoring themselves in the equipment. These can either be verbal or written.

13.4 Type test report

At the request of the purchaser, the manufacturer shall make available the report on the type tests performed to the requirements of this standard.

Table 1 – Reference and standard test conditions

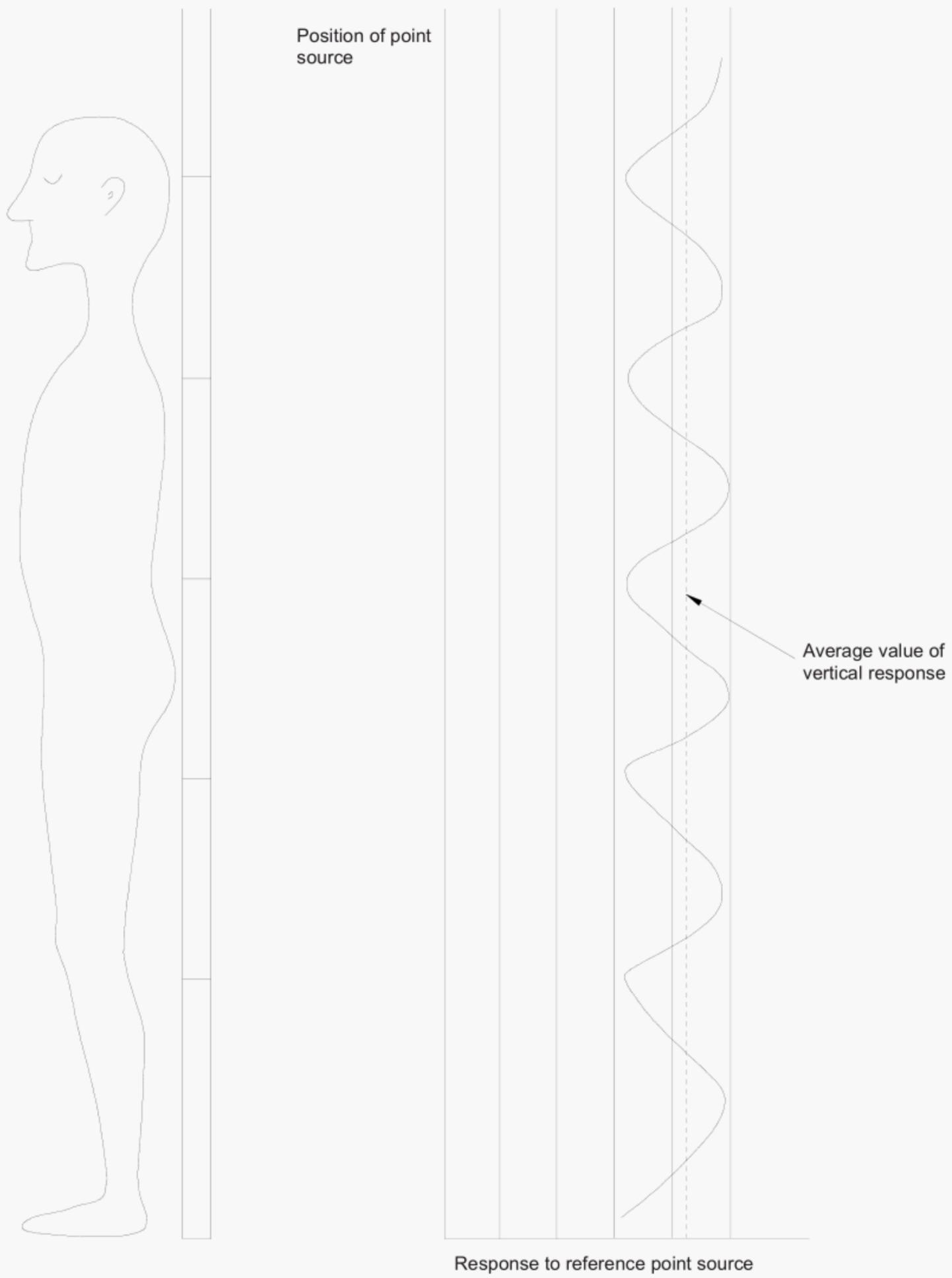
Influence quantities	Reference conditions (unless otherwise indicated by manufacturer)	Standard test conditions (unless otherwise indicated by manufacturer)
Warm-up time (gas purging)	See Clause 9	See Clause 9
Ambient temperature	20 °C	18 °C to 22 °C
Relative humidity	65 %	55 % to 75 %
Atmospheric pressure	101,3 kPa	86 kPa to 106 kPa ^{a)}
Power supply voltage	Nominal supply voltage U_N	Nominal power supply $U_N \pm 1 \%$
Power supply frequency	Nominal frequency	Nominal frequency $\pm 2 \%$
Power supply waveform	Sinusoidal	Sinusoidal with total harmonic distortion lower than 5 %
Ambient gamma radiation at the level of the detector	Less than an air kerma rate of $0,2 \mu\text{Gy}\cdot\text{h}^{-1}$	Less than an air kerma rate of $0,25 \mu\text{Gy}\cdot\text{h}^{-1}$
Electromagnetic field of external origin	Negligible	Less than the lowest value that caused interference
Magnetic induction of external origin	Negligible	Less than twice the induction due to the earth's magnetic field
Setting of the assembly control	Set up for normal operation	Set up for normal operation
Contamination by radioactive elements	Negligible	Less than the lowest value that can be detected by the assembly
NOTE The standard test conditions represent the permitted tolerances on the reference conditions. See IEC 60359.		
^{a)} Where due to geographical location it is not possible to meet this requirement, the manufacturer shall clearly identify that tests have not been carried out at this pressure and shall specify the range of pressure existing at the time of routine and type testing of any equipment.		

Table 2 – Tests performed under standard test conditions

Influence quantity	Range of values of influence quantity	Limits of variation of indication	Relevant Subclause
Variation of response with source position:			
<u>Alpha</u>			
Body or clothing		To be specified by the manufacturer	7.1.1.2.1
Hands		Less than a factor two	7.1.2
Feet		Less than a factor two	7.1.3
<u>Beta</u>			
Body or clothing vertical plane	Every 2 cm	To be specified by the manufacturer	7.1.1.2.2 a)
Body or clothing horizontal plane	Every 10° around the torso		7.1.1.2.2 b)
Hands	Over area of hand	Less than a factor two	7.1.2
Feet	Over area of foot	Less than a factor two	7.1.3
<u>Gamma</u>			
Body or clothing vertical plane	Every 5 cm	To be specified by the manufacturer	7.1.1.2.3 a)
Body or clothing horizontal plane	Every 20° around the torso		7.1.1.2.3 b)
Hands	Over area of hand	Less than a factor two	7.1.2
Feet	Over area of foot	Less than a factor two	7.1.3
Limit of detection:		At specified background	
Body or clothing - beta		200 s ⁻¹ (note 1)	7.3.1
- gamma		2 000 s ⁻¹	7.3.1
Hands - alpha		10 s ⁻¹ (note 2)	7.3.2 a)
- beta		100 s ⁻¹ (note 3)	7.3.2 b)
- gamma		2 000 s ⁻¹	7.3.2 c)
Feet - alpha		20 s ⁻¹ (note 4)	7.3.3 a)
- beta		200 s ⁻¹ (note 1)	7.3.3 b)
- gamma		2 000 s ⁻¹	7.3.3 c)
Variation with energy			
Beta energy:	150 keV upwards	To be specified by the manufacturer	
- body or clothing			7.4.1.2 a)
- hands			7.4.1.2 b)
- feet			7.4.1.2 c)
Alpha energy:	Uranium		7.4.2
Gamma energy:	50 (10) keV upwards		
- body or clothing			7.4.3.2 a)
- hands			7.4.3.2 b)
- feet			7.4.3.2 c)
Overload	> 10 ⁶ Bq of ¹³⁷ Cs > 10 ⁵ Bq of ⁹⁰ Sr/ ⁹⁰ Y > 10 ⁴ Bq of ²⁴¹ Am	Alarm of full scale	8
<p>NOTE 1 Although nominally this is equivalent to 400 Bq, the user should make reference to ISO 7503-1 for corrections to allow for self-absorption on clothing or other surfaces actually to be measured.</p> <p>NOTE 2 Nominally 20 Bq, but refer to note 1.</p> <p>NOTE 3 Nominally 200 Bq, but refer to note 1.</p> <p>NOTE 4 Nominally 40 Bq, but refer to note 1.</p>			

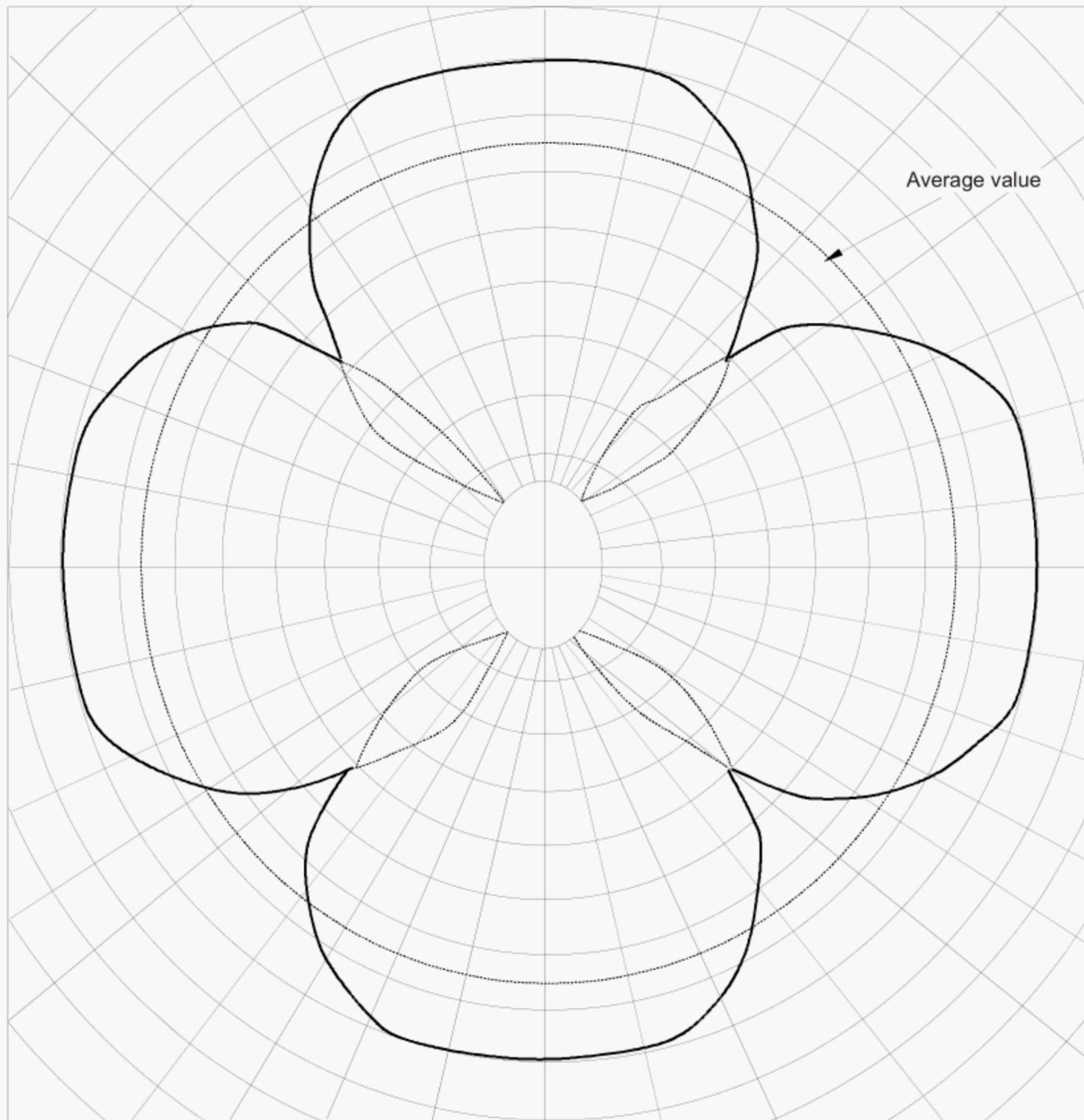
Table 3 – Tests performed with variation of influence quantities

Influence quantity	Range of values of influence quantity	Limits of variation of indication	Relevant subclause
Response to other ionising radiations			
Gamma radiation			
Alpha assemblies	10 $\mu\text{Gy}\cdot\text{h}^{-1}$	No effect	7.5.1.1
Beta assemblies	Specified by the manufacturer	As specified by the manufacturer	7.5.1.2
Alpha radiation			
Beta and gamma assemblies	Specified by the manufacturer	As specified by the manufacturer	7.5.2.2
Beta and gamma radiation			
Alpha assemblies	Specified by the manufacturer	1 % of the equivalent response	7.5.3.2
Warm-up time		30 min	9.1
Power failure	1 h	5 min	9.2
Temperature	+5 °C to +40 °C (see note)	± 30 %	10.1.2
Relative humidity	40 % to 85 % at 35 °C	± 10 %	10.2.2
Electromagnetic compatibility			11.2
NOTE For equipment intended for temperate conditions. In hotter or colder conditions, other limits may be specified. These shall be by agreement between the manufacturer and purchaser.			



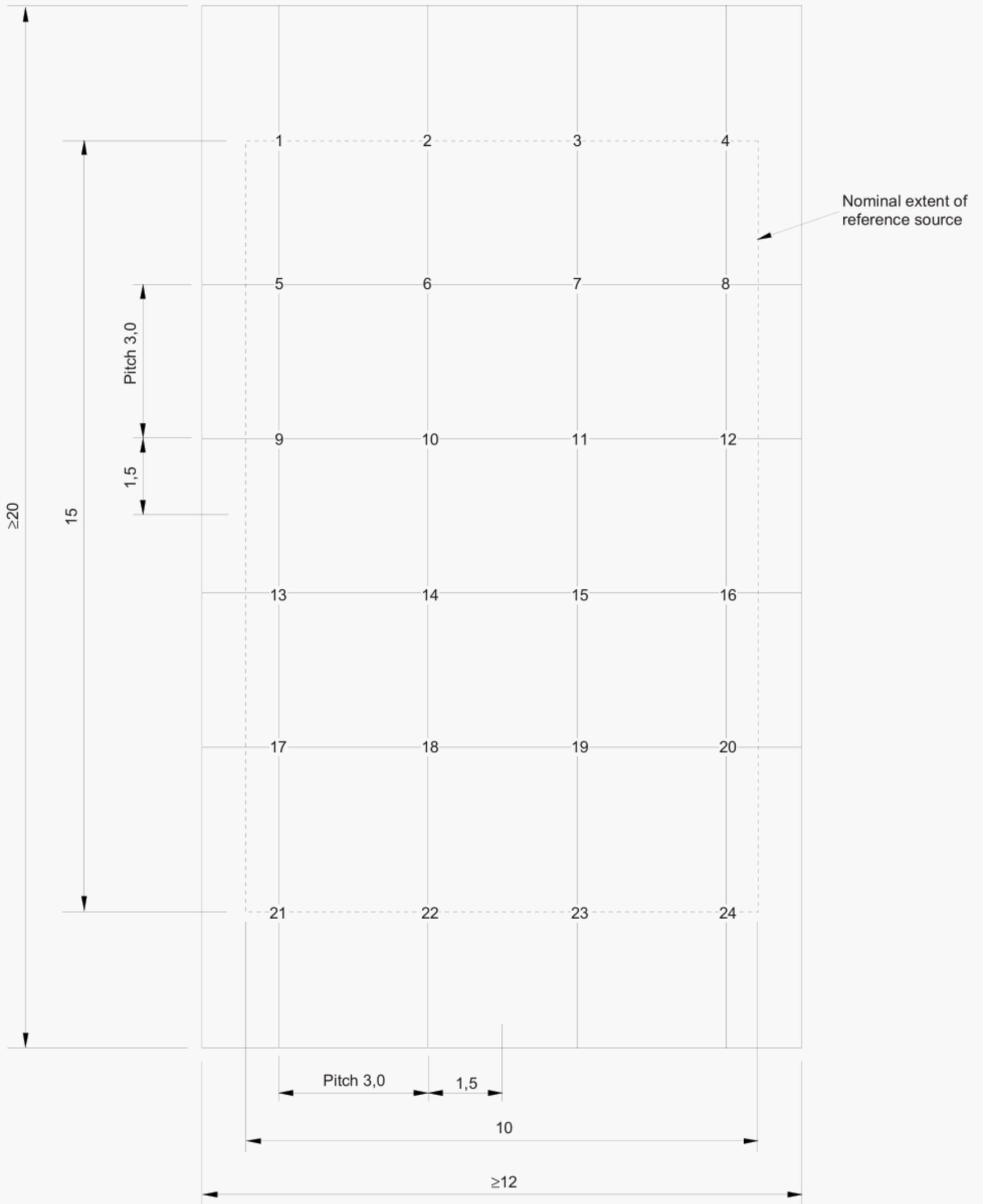
IEC 2656/03

Figure 1 – Response to the reference point source depending on its vertical position



IEC 2657/03

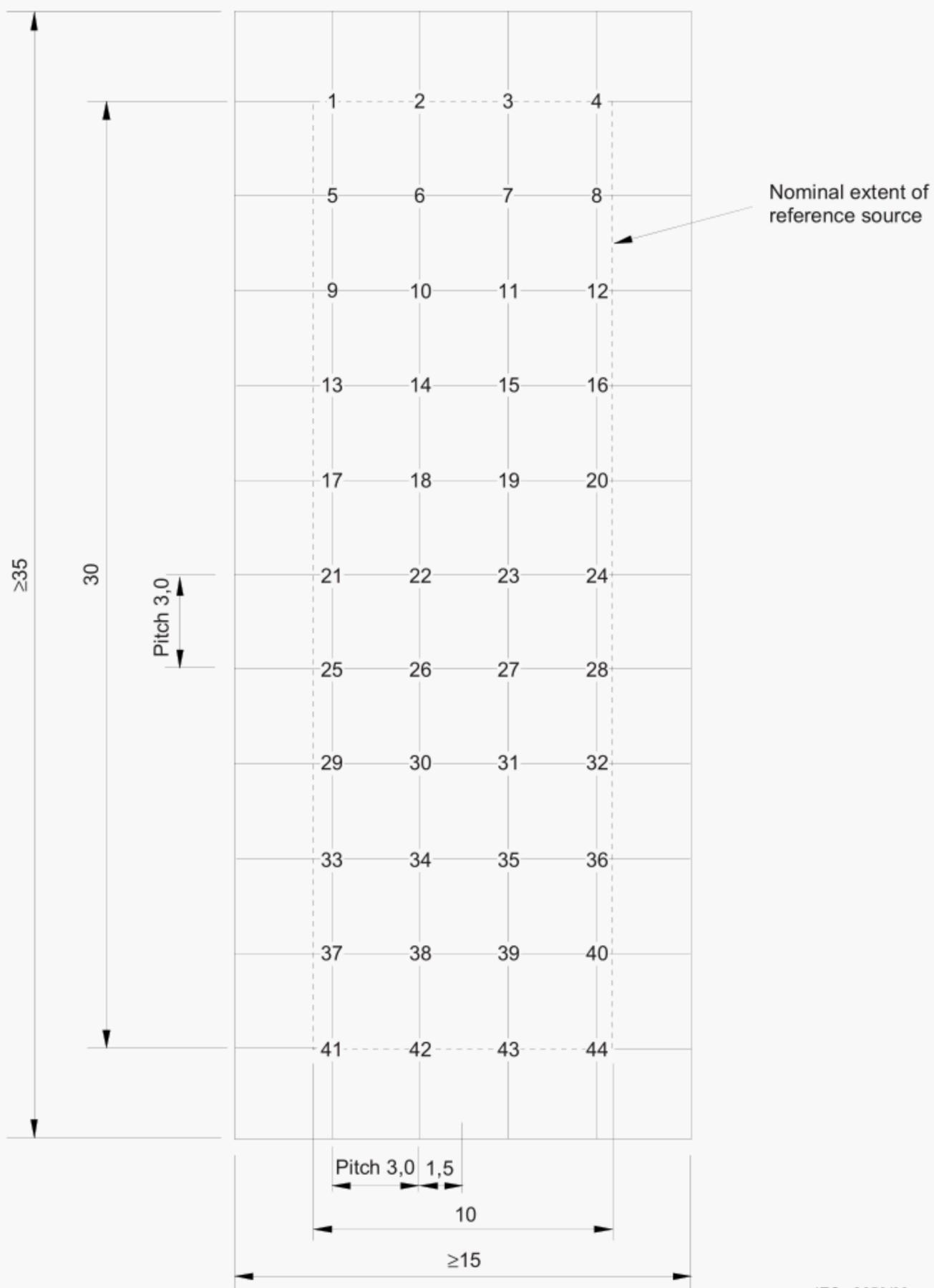
Figure 2 – Example of the polar response to the reference point source



IEC 2658/03

Ⓢ Dimensions in cm Ⓢ

Figure 3 – Detector for hand monitoring



IEC 2659/03

Ⓢ Dimensions in cm Ⓢ

Ⓢ Figure 4 – Detector for foot monitoring Ⓢ

Annex A (informative)

Explanation of the derivation of minimum detectable surface emission rate formula

A.1 Assemblies with no automatic compensation of background radiation

If the manufacturer specifies a minimum background noise under certain specified conditions in which the equipment will work, this can be related to a count rate from the detector or group of detectors, and this count rate can be accounted for electronically. C The manufacturer shall state the maximum operational background, which can also be related to a count rate. The count rate from the activity must therefore be greater than the difference between the real operational background and this maximum background to be significant. It should be noted that the background signal will be reduced by the presence of the user. This reduction will depend on the size and the shape of the user. The manufacturer shall use a background count rate less than the reduced background due to the largest user specified by the manufacturer as the minimum background, and a background count rate greater than the reduced background due to the smallest user specified by the manufacturer as the maximum background. The manufacturer shall specify the height and mass of the smallest and largest user specified above.

There however will also be a random deviation on the count, which, when no contamination is present will be the square root of the count in the measurement time for a one standard deviation.

So the minimum count to be sure that there is activity measured is given by: C

$$(B_2T - B_1T) + P (B_2T)^{0,5} \quad \text{[A.1]}$$

where

B_2 is the count rate due to the maximum background specified;

B_1 is the count rate due to the minimum background specified C (Zero if not specified) C;

T is the monitoring time;

P is the number of standard deviations required to give the required false alarm rate C (at the maximum background; 3,1 for one in a thousand for each detector) C.

C Text deleted. C

C This count rate from the detector will determine the minimum detectable surface emission rate $(MDSER) \times (Eff)$, where the Eff is the detection efficiency for the particular nuclide specified C.

Therefore $(MDSER) \times (Eff) \times T = \text{Count in time } T$ [A.2]

and $(MDSER) \times (Eff) \times T = (B_2T - B_1T) + P(B_2T)^{0,5}$ [A.3]

So
$$MDSER = \frac{B_2 - B_1 + P \left(\frac{B_2}{T} \right)^{0,5}}{Eff}$$
 [A.4]

This formula shall be used in verifying the performance requirements of 7.3.1.

C NOTE The sizes of the users used for the above should not be taken as a physical limit on the size of users of the assemblies. The background count rate shall be determined from the count rates taken in naturally occurring omni-directional background conditions. C

A.2 Assemblies with simultaneous subtraction of background radiation

Where simultaneous subtraction is used, there will be a small error in the background counts from the two detectors used (measurement and background). The manufacturer shall determine this in terms of count-rate.

☐ In determining this, the manufacturer shall take into account that both background count rates will be effected by the presence of the user. The manufacturer shall specify the mass and height of the largest and smallest users for which the minimum detectable surface emission rate is specified. ☐

There will also be a random deviation on the background count, which with no contamination present, will have the value of the square root of this background count as the standard uncertainty.

The maximum signal error in the counting channel with no contamination present will then be:

$$B_x T + P(B_{2M} T)^{0,5} + P(B_{2B} T)^{0,5} \quad [A.5]$$

since the measuring detector and background detector will have individual random deviations, where

B_x is the difference of count rate between detectors;

B_{2M} is the count rate from the measuring detector in maximum background;

B_{2B} is the count rate from the background detector in maximum background;

T monitoring time;

P is the number of standard deviations required to give the required false alarm rate from each channel.

B_{2M} and B_{2B} should be nearly the same and by adding the random uncertainties, equation A.5 becomes:

$$B_x T + P(2B_{2B} T)^{0,5} \quad [A.6]$$

The minimum alarm threshold must be set to this count.

So the counts from contamination must be equivalent to this value, where they are due to the minimum detectable emission rate.

The count rate from the detector will be the minimum detectable surface emission rate ($MDSER$) \times (Eff), where the Eff is the counting efficiency of the detector for the particular nuclide specified (Chlorine 36).

Therefore $(MDSER) \times (Eff) \times T = \text{count in time } T \quad [A.7]$

and $(MDSER) \times (Eff) \times T = B_x T + P(2B_{2B} T)^{0,5} \quad [A.8]$

So $MDSER = \frac{B_x + P \left(\frac{2B_{2B}}{T} \right)^{0,5}}{Eff} \quad [A.9]$

This formula shall be used in verifying the performance requirements of 7.3.1.

☐ NOTE The sizes of the users used for the above should not be taken as a physical limit on the size of users of the assemblies. The background count rate shall be determined from the count rates taken in naturally occurring omni-directional background conditions. ☐

A.3 Assemblies with sequential background subtraction

The standard uncertainty in the stored background information will be:

$$u(Bt) = (Bt)^{0,5} \quad [A.10]$$

where

t is the background monitoring time;

P is the number of standard deviations required to give the required false alarm rate from each channel;

B is the maximum background count rate.

In unit time, standard uncertainty becomes

$$\boxed{C} u(Bt) = \frac{(Bt)^{0,5}}{t} \boxed{C} \quad [A.11]$$

and in the monitoring time T , it becomes

$$\boxed{C} u(BT) = T \frac{(B)^{0,5}}{t} \boxed{C} \quad [A.12]$$

The count during the monitoring period without contamination present will be BT with a standard deviation of $(BT)^{0,5}$. Adding these uncertainties with the rate of false alarm required we have:

$$\left(\frac{P^2 BT^2}{t} + P^2 BT \right)^{0,5} \quad [A.13]$$

which becomes:

$$P \left(\frac{BT^2}{t} + BT \right)^{0,5} \quad [A.14]$$

There could however be an error due to changes in background noise between the mean measurement under background conditions and under operational conditions and a notional 5 % is included to account for this in determining the quality of the *MDSER*. (It is not intended that the manufacturer should take any such error into account in automatic corrections the equipment makes).

This error would cause a count change of $0,05BT$.

The total change could therefore be:

$$P \left(\frac{BT^2}{t} + BT \right)^{0,5} + 0,05 BT \quad [A.15]$$

The minimum alarm threshold must be set to this count. So the counts from contamination must be set to this count value or at this value where they are due to the minimum detectable surface emission rate.

The count rate from the detector will be the minimum detectable surface emission rate ($MDSER$) \times (Eff), where the Eff is the counting efficiency of the detector for the particular nuclide specified (Chlorine 36).

Therefore $(MDSER) \times (Eff) \times T = \text{count in time } T$ [A.16]

so $(MDSER) \times (Eff) \times T = P \left(\frac{BT^2}{t} \right)^{0,5} + 0,05 BT$ [A.17]

and $MDSER = \frac{P \left(\frac{B}{t} + \frac{B}{T} \right)^{0,5} + 0,05 B}{Eff}$ [A.18]

This formula shall be used in verifying the performance requirements of 7.3.1.

Ⓒ The major variation between background count rate during the monitoring cycle and background cycle is due to the absorption of the radiation by the user. The manufacturer shall determine the reduction in background due to the largest user as specified by the manufacturer. If the change is greater than 5 %, this percentage change shall be used in place of 5 % unless compensation is included for the presence of the user. Half the difference between this value and that due to the largest person may be used in place of 5 % unless this value is less than 5 %.

NOTE The sizes of the users used for the above should not be taken as a physical limit on the size of users of the assemblies. The background count rate shall be determined from the count rates taken in naturally occurring omni-directional background conditions. Ⓒ

Annex ZA (informative)

Examples of possible additional tests for further characterization of the sensitive volume

To take account of different interaction distances for gamma rays and alpha or beta particles, two possible additional test procedures with specific source locations are described below. The examples are given for an assembly of $x = 60$ cm wide, $z = 200$ cm high and $y = 60$ cm depth.

ZA.1 Complete window pattern (CWP) method for gamma rays

A set of vertical (x,z) planes grid, with a pitch of 30 cm x 50 cm is located inside the assembly, distance of each other of 30 cm in the y direction, starting from the inlet gate up to the outlet gate.

In these conditions, for $x = 60$ cm, $z = 200$ cm, $y = 60$ cm, we obtain a $3 \times 5 \times 3 = 45$ points location matrix.

The CWP method consists in testing the response of the whole assembly with respect of each 45 small gamma source locations.

To take account of different shape of assembly, it is allowed to replace the orthogonal pattern by a cylindrical coordinate one composed of two vertical planes shifted from a $\pi/2$ angle.

This disposition allows five test source locations, including the center point, for each of the nine horizontal levels spaced by 25 cm from bottom to top. This provides 45 measurement test locations.

For gamma radiation the assembly meets the requirements for this test if, for a $4,5 (\pm 5 \%)$ kBq of ^{60}Co gamma equivalent source, and an alarm threshold set at 3 kBq:

The test is performed three times. The acceptance criteria are that the following requirements are both met:

- in one of the three tests at least 44 of the test source points trigger an alarm in less than 5 seconds and
- none of the source locations which don't trigger alarm in the three tests appears twice.

ZA.2 Thin Frame Window pattern (TFW) method for alpha and beta particles

Use the location matrix as in ZA.1 but replace the internal parallelepipedic volume by one delimited by a 10 cm band thickness starting from the vertical active walls of the assembly, and move the source in the middle vertical plane at 1 cm for alpha, 2,5 cm for beta particles, starting from the vertical active walls.

In these conditions, for $x = 60$ cm, $z = 200$ cm, $y = 60$ cm, we obtain a $2 \times 5 \times 2 = 20$ points location matrix for two active walls.

The TFW method consists in testing the response of the whole assembly with respect of each 20 small alpha or beta source locations.

It may be completed by a test of the top and a test of the bottom central locations.

For alpha and beta radiation the information received from this test is of an informative character only.

Annex ZB (informative)

Summation of information from adjacent detectors

The body is such a large area that to reduce the effect of background it is necessary to have a number of individual detector channels. It is inevitable that there will be gaps between these detectors and the detection capability of the contamination on the body adjacent to these gaps will be much lower than for activity adjacent to the centre of the detectors.

The effects of these gaps on performance can be reduced by summing the signals from adjacent detectors. However under these circumstances there is an increased background signal and this must be taken into account when determining any improvement in the minimum detectable activity. In the simplest case where the detectors are identical the effective limit of detection is increased by approximately $\sqrt{2}$. In the case where the detectors are not identical the resulting limit will be approximately the root of the sum of the squares of the effective limit of detection of each of the two detectors involved.

Figure ZB.1 illustrates the effect of summation on the response in the case of six vertical detectors. The response values which should be taken in determining the body average efficiency have been shown very slightly greater than the true value to clearly show how they have been determined.

Figure ZB.2 similarly illustrates the effect on the polar response where effectively four detector arrays forming a square (two actual detectors with the user making a second monitoring procedure having turned through 180°) are used.

The detector configurations used in these illustrations are not to be taken as the best configurations to be used but provide one of the better configurations to illustrate the principle.

The line of effective response is shown in these figures can be used in place of responses illustrated in Figures 1 and 2 of the main text and used in the determination of the 4π average overall efficiency as used in 7.3.1.

In the diagrams the line is the efficiency of a single detector to a point source.

..... is the sum of the efficiencies of two adjacent detectors to a point source:

$$E_m + E_n$$

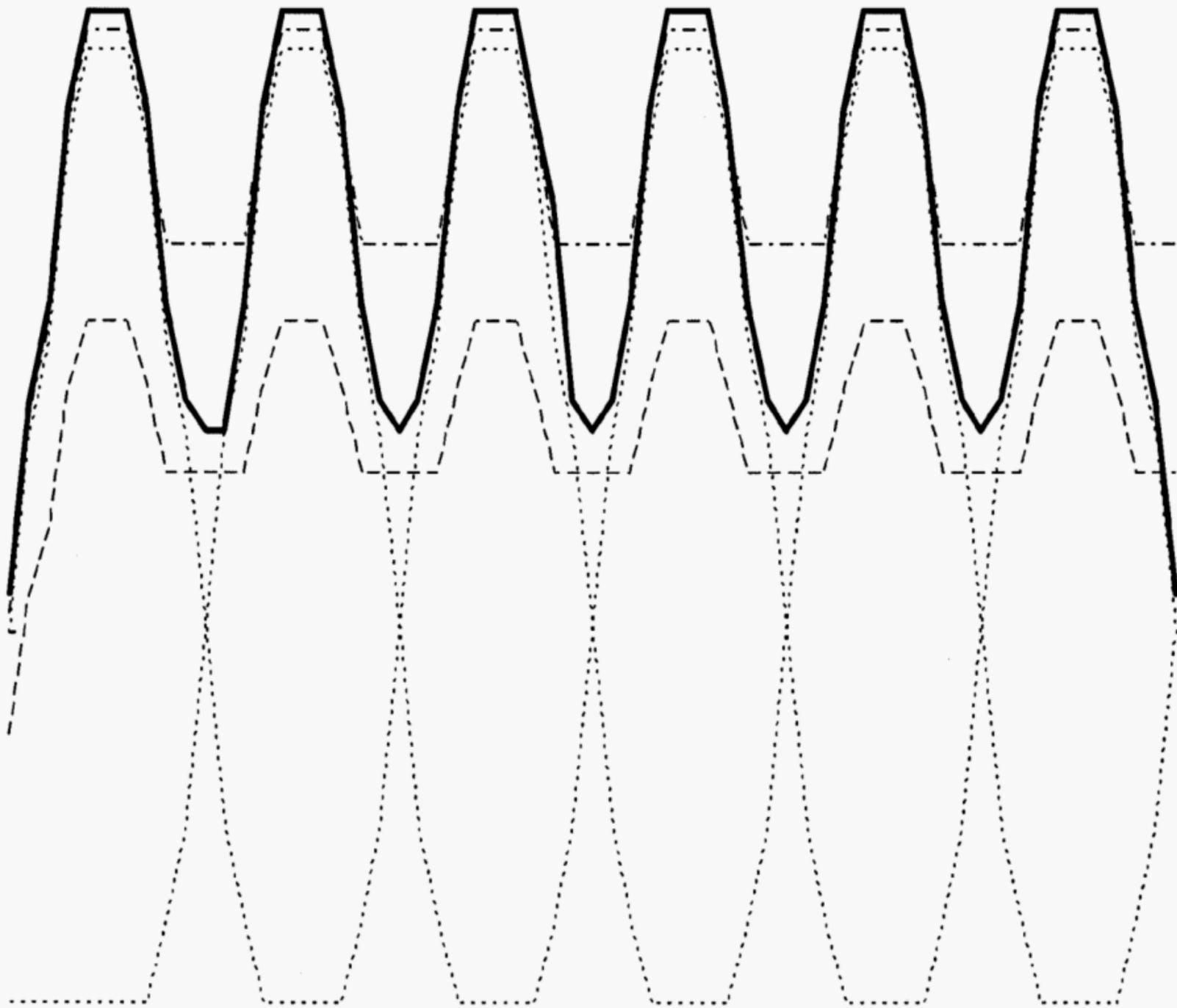
----- is the weighted efficiency of two adjacent detectors, for the purpose of this standard:

$$\frac{(E_m + E_n) \cdot (B_m^2 + B_n^2)^{0.5}}{B_m + B_n}$$

B_m and B_n the background count in the monitoring period from detectors m and n respectively. Where detectors are the same ($B_m = B_n$) and the weighted efficiency is:

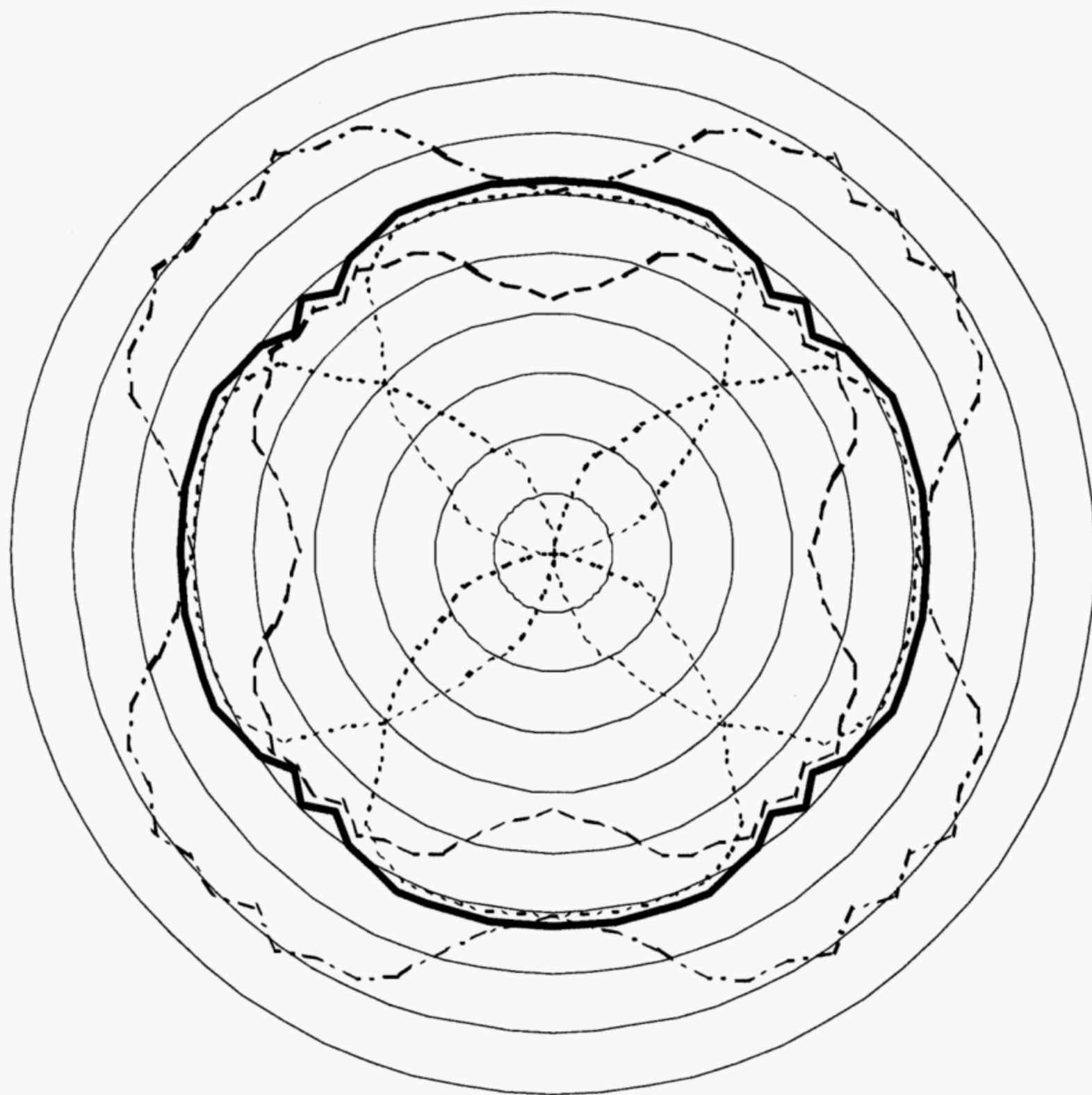
$$\frac{E_m + E_n}{\sqrt{2}}$$

———— is the efficiency from a single detector or the weighted efficiency from two adjacent detectors from a point source, whichever is the greater and is the efficiency to be taken in determining the 4π average efficiency and hence the minimum detection surface emission rates (in the illustrations the values are shown very slightly greater than actual value for clarity of interpretation).



Key
..... Single detector
- . - . Summation of adjacent detectors
- - - - Weighted summation
_____ Efficiency for MDA

Figure ZB.1 – Example of effect of summation on efficiencies in vertical plane



Key
..... Single detector
----- Summation of adjacent detectors
- . - . - . Weighted summation
————— Efficiency for MDA

Figure ZB.2 – Example of effect of summation on efficiencies in horizontal plane (polar response)

Annex ZC
(normative)

**Normative references to international publications
with their corresponding European publications**

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.

NOTE Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60038 (mod)	1983	IEC standard voltages ¹⁾	HD 472 S1	1989
-	-		+ corr. February	2002
-	-		A1	1995
A1	1994			
A2	1997			
IEC 60050-151	2001	International Electrotechnical Vocabulary (IEV) - Part 151: Electrical and magnetic devices	-	-
IEC 60050-393	2003	International Electrotechnology Vocabulary (IEV) - Part 393: Nuclear instrumentation - Physical phenomena and basic concepts	-	-
IEC 60050-394	1995	International Electrotechnical Vocabulary (IEV) -	-	-
A1	1996	Chapter 394: Nuclear instrumentation:	-	-
A2	2000	Instruments	-	-
IEC 60068	Series	Environmental testing	EN 60068	Series
IEC 60359	2001	Electrical and electronic measurement equipment - Expression of performance	EN 60359	2002
IEC 60777	1983	Terminology, quantities and units concerning radiation protection	-	-
IEC 61000-4-2	1995	Electromagnetic compatibility (EMC) -	EN 61000-4-2	1995
A1	1998	Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	A1	1998
A2	2000		A2	2001
IEC 61000-4-3	2002	Electromagnetic compatibility (EMC) -	EN 61000-4-3 ²⁾	2002
A1	2002	Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	A1	2002
IEC 61000-4-5	1995	Electromagnetic compatibility (EMC) -	EN 61000-4-5 ³⁾	1995
+ corr. October	1995	Part 4-5: Testing and measurement techniques - Surge immunity test		
A1	2000		A1	2001

¹⁾ The title of HD 472 S1 is: Nominal voltages for low voltage public electricity supply systems.

²⁾ EN 61000-4-3 is superseded by EN 61000-4-3:2006, which is based on IEC 61000-4-3:2006.

³⁾ EN 61000-4-5 is superseded by EN 61000-4-5:2006, which is based on IEC 61000-4-5:2005.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61000-4-6 A1	2003 2004	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	-	-
IEC 61000-4-8 A1	1993 2000	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8 A1	1993 2001
IEC 61000-4-12 A1	1995 2000	Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Oscillatory waves immunity test	EN 61000-4-12 ⁴⁾ A1	1995 2001
IEC 61187 (mod)	1993	Electrical and electronic measuring equipment - Documentation	EN 61187 + corr. March	1994 1995
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	1988	Reference sources for the calibration of surface contamination monitors - 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	-	-

⁴⁾ EN 61000-4-12 is superseded by EN 61000-4-12:2006, which is based on IEC 61000-4-12:2006.