

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Radiation protection instrumentation – Installed personnel surface
contamination monitors**

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



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Radiation protection instrumentation – Installed personnel surface
contamination monitors**

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 13.280; 17.240

ISBN 978-2-8322-6527-7

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

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

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

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

D.2 Test procedure.....	68
Bibliography.....	70
Figure 1 – Vertical position of radiation source	24
Figure 2 – Response curve composition by source position	25
Figure 3 – Centre planes of the detection volume	26
Figure 4 – Detector for hand monitoring	28
Figure 5 – Detector for foot monitoring.....	30
Figure 6 – Frisker (clothes)/Overhead detector	32
Figure B.1 – Size of slices	63
Figure B.2 – Assembled phantoms.....	64
Figure D.1 – Source positions for the head	68
Figure D.2 – Source positions for the body	69
Figure D.3 – Source positions for the legs	69
Table 1 – Symbols and abbreviate terms	15
Table 2 – Emission frequency range	48
Table 3 – Reference and standard test conditions.....	52
Table 4 – Tests performed under standard test conditions	52
Table 5 – Tests performed with variation of influence quantities.....	54
Table 6 – Test and sources.....	55
Table B.1 – Sizes of the set of phantoms	64

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIATION PROTECTION INSTRUMENTATION –
INSTALLED PERSONNEL SURFACE CONTAMINATION MONITORS**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

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

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

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

- g) Descriptions of friskers are added with respect to the hand and foot monitoring.
- h) Figures are made easier to understand the relation between the detector position and the response, and the positional relation between the detector surface and the source.

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

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

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

The language used for the development of this International Standard is English.

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

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

RADIATION PROTECTION INSTRUMENTATION – INSTALLED PERSONNEL SURFACE CONTAMINATION MONITORS

1 Scope

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

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

This document is applicable to:

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

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-395, *International Electrotechnical Vocabulary (IEV) – Part 395: Nuclear instrumentation – Physical phenomena, basic concepts, instruments, systems, equipment and detectors*, available at www.electropedia.org

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

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

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

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

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

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

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

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

3 Terms, definitions, units and symbols

3.1 Terms and definitions

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

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

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

3.1.1

surface emission rate

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

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

3.1.2

source efficiency

ε_s

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

3.1.3

small area source

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

3.1.4**surface emission rate response**

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

3.1.5**sensitive area of the detector**

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

3.1.6**total equivalent thickness**

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

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

3.1.7**effective range of measurement**

absolute value of the difference between the two limits of a nominal range

3.1.8**response**

R

ratio of the indicated value of a monitor M_i to the conventional true value M_t

$$R = \frac{M_i}{M_t}$$

3.1.9**relative error of indication**

I

quotient of the error of indication of a measured quantity $M_i - M_t$ by the conventional true value M_t of the quantity

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

$$I = \frac{M_i - M_t}{M_t} \times 100$$

3.1.10**relative intrinsic error**

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

3.1.11 coefficient of variation

V

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

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

3.1.12 deviation

D

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

$$D = M_i - M_t$$

where

M_i is the indicated value of a monitor;

M_t is the conventional true value

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

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

3.1.13 lower limit of effective range of measurement

A_0

minimum activity or activity concentration to be measured over which the performance of a monitor meets the requirement of its specifications

3.1.14 decision threshold

y^*

value of the estimator of the measurand, which, when exceeded by the result of an actual measurement using a given measurement procedure of a measurand quantifying a physical effect, is used to decide that the physical effect is present

Note 1 to entry: The decision threshold is defined such that in cases where the measurement result y exceeds the decision threshold y^* , the probability that the true value of the measurand is zero is less or equal to a chosen probability α .

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

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

3.1.15 detection limit

DL

$y^{\#}$

smallest true value of the measurand which ensures a specified probability of being detectable by the measurement procedure

Note 1 to entry: With the decision threshold according to 3.1.15, the detection limit is the smallest true value of the measurand for which the probability of wrongly deciding that the true value of the measurand is zero is equal to a specified value β when, in fact, the true value of the measurand is not zero.

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

3.1.16 conventional true value

best estimate of the value of that quantity

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

3.1.17 frisker

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

3.1.18 influence quantity of type F

influence quantity whose effect on the indicated value is a change in response

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

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

3.1.19 influence quantity of type S

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

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

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

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

3.1.20 ambient background

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

3.1.21 reference background

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

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

3.1.22**uniformity of surface emission rate of sources**

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

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

3.1.23**monitoring channel**

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

3.1.24**emission probability**

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

3.1.25**effective instrument efficiency**

E_{ff}

mean value of the instrument efficiency over the whole of the detector, used when the detection limit (DL) is determined

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

3.1.26**qualification test**

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

3.1.27**type test**

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

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

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

3.1.28**routine test**

conformity test made on each individual item during or after manufacture

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

3.1.29**acceptance test**

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

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

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

3.2 Units

In this document, units of the International System (SI) are used¹. The definitions of radiation quantities are given in IEC 60050-395. The corresponding old units (non SI) are indicated in brackets.

Nevertheless, the following units may also be used:

- for energy: electron-volt (symbol: eV), $1 \text{ eV} = 1,602 \times 10^{-19} \text{ J}$; and
- for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min).

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

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

3.3 Symbols (see Table 1)

Table 1 – Symbols and abbreviate terms

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

4 Classification of monitors

4.1 According to type of radiation to be measured

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

4.2 According to body surface being monitored

- For the monitoring of the whole body (including the head and the overhead)
- For the monitoring of hands only
- For the monitoring of feet only
- For the monitoring of both hands and feet

4.3 According to background compensation method

a) Subtraction of predetermined background

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

b) Simultaneous subtraction of determined background

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

c) No background subtraction

Monitors without background subtraction.

5 Design characteristics

5.1 Positioning of the person being monitored

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

5.2 Size of the person being monitored

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

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

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 shall be monitored. The design shall be such that both hands shall be open to be monitored.

The hand detectors should touch both sides of the hands during measurement. The distance between the detector and hands shall be small to allow a reasonable measurement of the potential level of contamination required by regulations. As for sensitive area of the detector, it should be considered not to get contaminated, or to remove contamination easily.

The size of the sensitive area of the detector for each side of each hand shall be at least 12 cm × 20 cm if not otherwise agreed between manufacturer and user for existing monitor.

Protective materials 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-observed 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 mg/cm² (2 mg/cm² 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 facilities 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 15 cm × 30 cm.

Protective materials 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-observed 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 mg/cm² (2 mg/cm² 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 should 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 monitor is designed shall be specified by the manufacturer.

5.6 Frisker

For monitor for monitoring the hands and feet only, frisker for monitoring whole body other than hands and feet may be attached to hand and/or foot contamination monitors.

The detection assembly shall normally have one frisker. The user shall be able to move the frisker over the area to be monitored. The length of a cable connecting the measurement assembly and the frisker shall be appropriate and the frisker shall be sufficiently light so that it can be handled with one hand.

5.7 Visual display

5.7.1 For the user

The monitor 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 detected. For assemblies capable of monitoring two or more types of contamination, the display shall display distinguishing between them;
- c) Indication at the end of a cycle that no alarm trip has operated during the monitoring cycle;
- d) Monitor operational;
- e) Monitor faulty;
- f) Measurement proceeding; and
- g) Body, hands or feet correctly positioned.

5.7.2 For maintenance purposes

Followings are not necessarily visible to the user:

- a) Capability of displaying the counts or count-rate from any measuring channel and if available any related quantity, i.e. total contamination (Bq) or surface contamination (Bq/cm²);
- b) Flow-rate of the gas supply, if applicable;
- c) Alarm set points for each channel;
- d) Low level alarm settings;
- e) Measuring time;
- f) Background too high for correct operation;
- g) High tension (bias voltage); and
- h) Fault diagnosis.

5.8 Audible indicators

Audible indicators shall be clearly distinguishable from one another.

There shall be an audible signal 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.

5.9 Monitoring period

Contamination alarms shall only be given at the end of the monitoring period. There shall be an indication when the monitoring cycle is completed. An audible indication, visual indication or door opening can be used as an indication for this purpose. Other way of indication may be acceptable.

5.10 Ease of decontamination

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

5.11 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 monitor is designed.

Depending on the type of monitoring system, the monitor should use (but not limited to): gas flow detectors, GM counters, semiconductor detectors or plastic scintillation detectors.

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 monitor will operate satisfactorily with a mean flow rate as specified by the manufacturer.

5.12 Seismic consideration

The monitor design, manufacture, and installation should ensure that the person being monitored will not be harmed when exposed to the maximum earthquake strength expected at the user location. Loss of measurement function is acceptable, but following consideration should be taken into account:

- prevent fall of overhead detectors not to harm the person being measured; and
- the doors can be easily open after the event to prevent confinement.

6 Performance requirements and test procedures

6.1 General test procedure

6.1.1 Nature of tests

Tests in this document are to be considered as type tests unless otherwise specified. In acceptance test, the tests of the effective instrument efficiency at the specific operating point (7.3.3) and alarm threshold (7.7) shall be performed, although test items may be extended by agreement between the manufacturer and purchaser. The stated requirements are minimum requirements and may be extended for any particular monitor or function.

Standard test conditions with allowable tolerances are defined in Table 3.

Testing does not necessarily need to be carried out on the whole monitor. Depending on the test item, it is acceptable to select and perform the necessary components.

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 3 which indicates, for each characteristic, the limits of variation and the relevant subclause where the corresponding method of test 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 5, with the range of variation of each influence quantity and limits of consequent variation in the effective alarm point.

The limits of variation of indication in Table 5 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 5.

In order to test the effect of variation in any one of the influence quantities listed in Table 5, all other quantities shall be maintained within the limits for the standard test conditions given in Table 3, 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 needs be performed.

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

6.1.4 Type F influence test

These tests may be performed at any value of the quantity to be measured. From the result of each test, the respective variation of the relative response r can be determined.

It is acceptable that some effects of the influence quantities classified as type F could be regarded as effects produced by type S influence quantities. If these effects are small, they shall be ignored in relation to the use of this document. If, during testing, larger effects of type S are observed, then these findings shall be reported in the type test report.

6.1.5 Type S influence test

These tests shall be performed at a value of the quantity to be measured of less than or equal to 10 times the lower limit of the effective range of measurement, even zero count (rate) is possible only if negative deviation can be measured. The result of each test is a deviation D .

It is acceptable that some small part of the effects of the type S influence could be regarded as the effects produced by type F influence quantities. If these effects are small, they should be ignored in relation to the use of this document. If larger effects of type F or significant negative effects are observed during testing, then these findings shall be reported in the type test report. Due to the generally lower indicated value when compared to tests for influence quantities of type F, the necessary number of measurements may be increased.

6.2 Functionality test

6.2.1 General

The functionality test consists of comparing the monitor functionality before (pre-test) and during or after (post-test) an environmental, mechanical or electromagnetic disturbance described in Clauses 10, 11 and 12.

6.2.2 Pre-test

The pre-test or preparation includes the stabilisation of the monitor in standard test conditions, checking its correct functioning.

A series of operations shall be confirmed in which the monitor makes a determination without contamination in the state of no contamination. In the case, a test is conducted by selecting a part of the monitor, it shall be ensured that no signal leading to contamination detection is output.

Place the source specified in 6.4 at the manufacturer's designated location and it should be confirmed that the monitor detects and displays contamination in accordance with the detection probability associated to the alarm setting.

The number of measurements shall be such that the coefficient of variation of the mean value complies with 6.3. The mean value of the displayed value shall be recorded.

6.2.3 Post-test

A series of operations shall be confirmed in which the monitor makes a determination without contamination in the state of no contamination. In the case, a test is conducted by selecting a part of the arrangement, it shall be ensured that no signal leading to contamination detection is output. It shall be the same result as pre-test.

The number of measurements shall be the same as for the pre-test.

Place a source of the same nuclide, shape, and intensity as used in pre-test at the same location as pre-test and it should be confirmed that the monitor detects and displays contamination.

The false alarm rate and the probability of detection shall comply with the settings. The change of the mean reading shall be lower than 2 times the coefficient of variation (COV) plus 15 %.

There shall be no visible external damage after the environmental, mechanical or electromagnetic disturbance and the monitor shall operate correctly as prior to these tests.

6.3 Statistical fluctuations

Statistical fluctuations shall be considered for following tests: 11.2 Vibration test, 11.3 Mechanical shock and 12.2 Electromagnetic compatibility and others.

The magnitude of the statistical fluctuations of the numerical indication arising from the random nature of radiation alone may be a significant fraction of the variation of the indication permitted in the test. Therefore, the coefficient of variation (COV) of the readings shall be less than or equal to 12 %.

The value of 12 % is chosen to help determine the results of a test as the series of readings and the associated mean are compared to a requirement set in this document. When testing with radioactive sources, a COV of less than or equal to 12 % should be obtained. Processes such as increasing the applied radiation levels will typically reduce the COV to an acceptable level. The number of trials or readings may also be increased to reduce the COV, but this should be secondary to increasing the applied radiation level. When testing without the presence of radioactive sources, the monitor is observed so it does not produce alarms and/or spurious indications. In this case, the COV value is not relevant.

The time interval between each reading shall be long enough to ensure that the readings are independent. The time interval selected is dependent on the integration time of the monitor and the update time of the indicated response.

6.4 Reference sources

The reference sources used in tests involved with measurement of radiation shall be sources of ^{137}Cs or ^{60}Co for gamma measurement (^{129}I or ^{241}Am for low energy gamma), ^{36}Cl or ^{204}Tl for beta measurement and ^{241}Am or ^{239}Pu for alpha measurement. ^{60}Co can be used upon agreement between the purchaser and the manufacturer.

For assemblies for the monitoring of hands, sources of active area 15 cm × 10 cm or 10 cm × 10 cm should be used.

For assemblies for the monitoring of feet, sources of active area 30 cm × 10 cm, 15 cm × 10 cm or 10 cm × 10 cm should be used.

The distribution of the surface emission rate of the above two reference sources shall comply with ISO 8769.

(See ISO 8769 and 3.1.1).

Where sources of the areas quoted above are not available, tests shall be carried out using small area sources or other 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, 7.1.4 and 7.1.5.

6.5 Requirements for 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 monitor shall be provided.

7 Radiation measurement characteristics

7.1 Variation of response with source position

7.1.1 General

All influence quantities dealt with in 7.1 are regarded as of type F. The test contents and the sources used in tests are summarized in Table 6.

7.1.2 For clothing or the body

7.1.2.1 Requirements

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 document, the manufacturer may in the case of beta and/or gamma monitoring additionally sum the response of any number of adjacent detectors.

7.1.2.2 Method of test

7.1.2.2.1 Alpha monitoring systems

It is not possible to define the actual performance for the detection of contamination on the body. Where the monitor is intended to measure alpha on the body, tests similar to those of 7.1.2, 7.1.3, 7.1.4 and 7.1.5 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.

7.1.2.2.2 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 array.

In a case of using a beta small area source of ^{36}Cl or ^{204}Tl , as defined in 3.1.3, the source 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 monitor shall be measured for each step as indicated above. In a case of using a source having a radioactive area 15 cm × 10 cm or 10 cm × 10 cm, the source shall be moved in steps in a vertical line 5 cm from the detector. Each step shall be 15 cm or less for 15 cm × 10 cm source, 10 cm or less for 10 cm × 10 cm source and the response of the monitor shall be measured for each step as indicated above. In either case, the edge of source shall be at 5 cm below from the sole surfaces and for the last reading, the edge of source shall be at 2 cm or more above from the height of the tallest person which the monitor is designed for.

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).

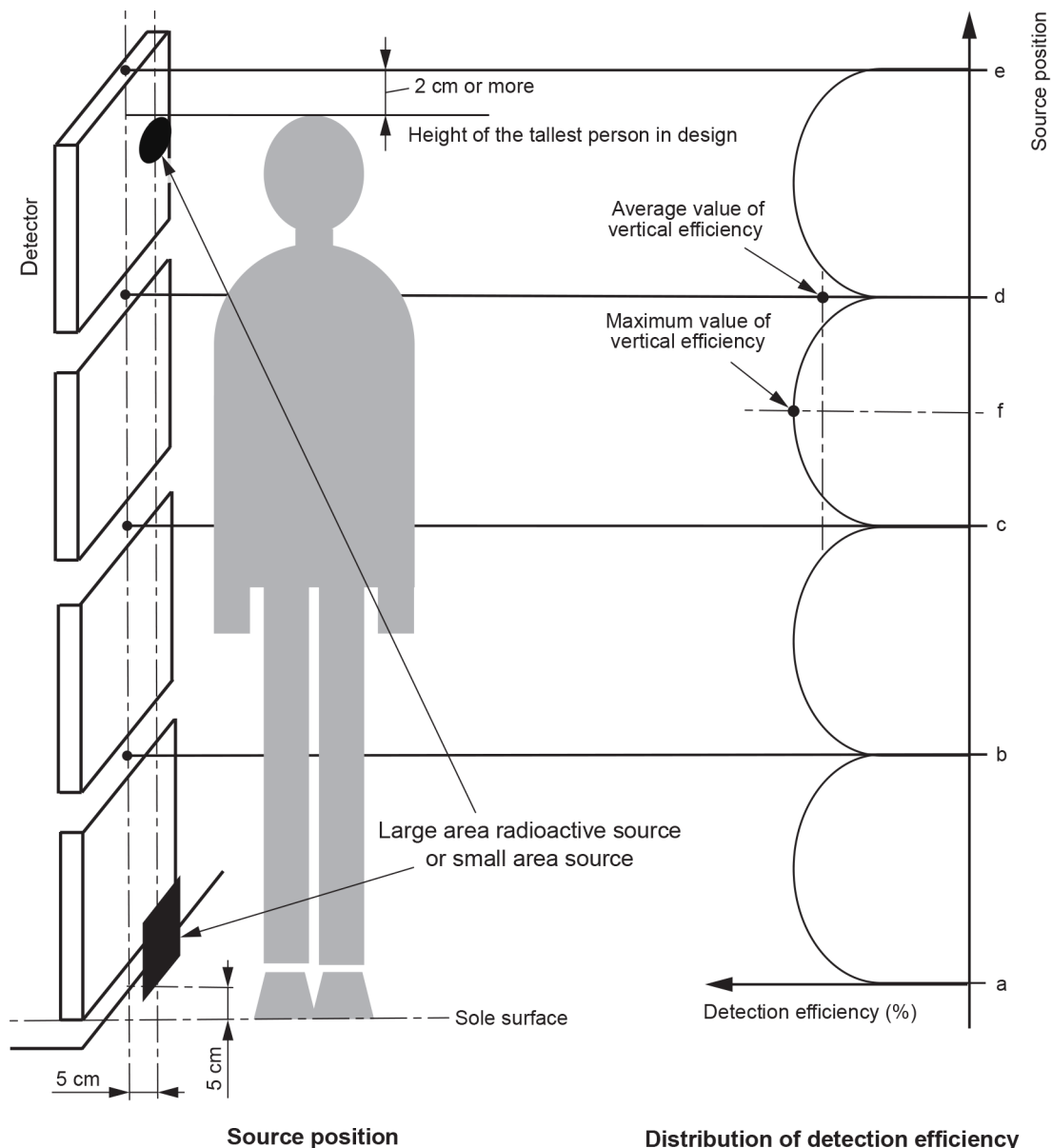


Figure 1 – Vertical position of radiation source

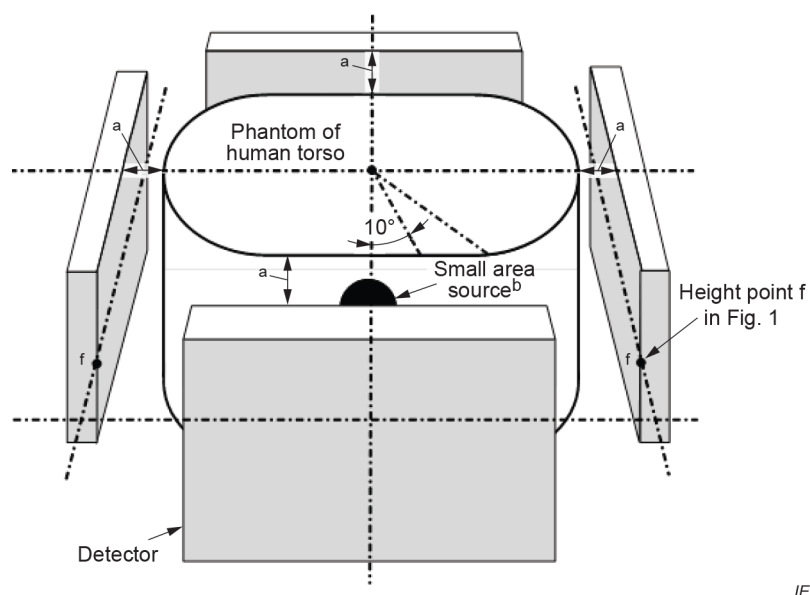
b) Around the body

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 minimum distance between the outermost part of the detector protection and the phantom is 5 cm. Some metering or scaling device shall be connected to each monitoring channel.

In a case of using a small area source of ^{36}Cl or ^{204}Tl as defined in 3.1.5, the source shall be moved right around the phantom every 10° as illustrated in Figure 2 a). The test shall be carried out at the vertical position of maximum response found in Figure 2 a). The response of each measuring channel shall be plotted on a single graph as illustrated in Figure 2 b). The maximum to minimum value of response shall be stated. When plotting the response, the response to ambient background radiation shall be taken into account, and this effect shall be subtracted.

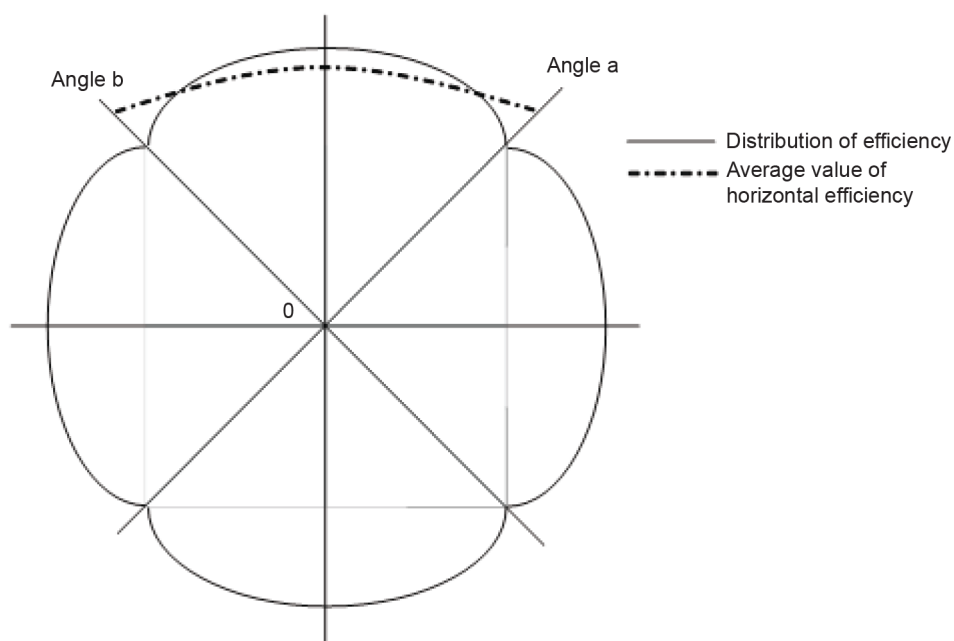
Where the monitor is designed to monitor the body, clothed or not, with the user in more than one position, the response curve shall be the composite of the results taken in each position.



^a 5 cm or more

^b Use suitable jig to hold the source at proper position.

a) Source positions



b) Example of horizontal efficiency measurement

Figure 2 – Response curve composition by source position

7.1.2.2.3 Gamma monitoring systems

The source of radiation shall be ^{137}Cs shielded with more than 0,6 mm of aluminium (^{129}I for the low energy version).

a) Empty homogeneity characterization

- Monitors for which the body position is strongly constrained, typically beta-gamma or alpha-beta-gamma monitors.

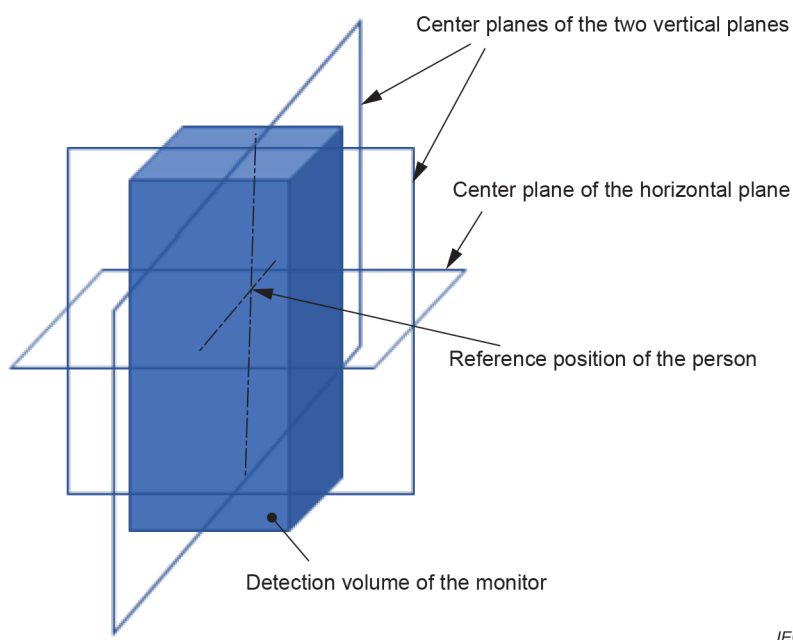
Vertical characterization shall be carried out in the same way as for beta in 7.1.2.2.2 a) except that the steps can be 5 cm for the small area source, and 10 cm for the large area radioactive source.

Around the body, as in 7.1.2.2.2 b), except that the source, wherever possible shall be placed halfway up a solid phantom at least 25 cm high and of density of about 1 g cm^{-3} or placed on a carrier which attenuation and scattering is negligible. The steps can be 45° for the small area source.

- Monitors for which the body position is weakly constrained within a detection volume i.e. typically tunnel monitors.

The homogeneity shall be characterized within the whole detection volume. The grid shall include the centre planes and the planes at 5 cm from the detection volume limits. Intermediary positions shall not be spaced more than 10 cm in the horizontal directions and 20 cm in the vertical direction. The number of measurements made be reduced in case of obvious symmetry (see Figure 1, Figure 2 and Figure 3).

NOTE "Tunnel monitors" are monitors that are constructed such that the monitored person enters on one side, passes or stands in the middle of a detection volume and exits on the other side. This kind of monitor is used in pass-through mode or in standing mode depending of the required sensitivity. When used in standing mode, doors or barriers are generally added.



IEC

Figure 3 – Centre planes of the detection volume

b) Body attenuation effect characterization

This test described in Annex C characterizes the measurement deviation due to the body attenuation of the background, eventually corrected by a morphologic correction function if such a correction is provided.

The measured deviation, reduced by the correction process if provided, is a type S error that shall be reasonably small compared to the low end of the effective measuring range.

This characterization should be made with 5 persons covering the claimed range of weights and heights or using the phantoms set described in Annex B.

If the manufacturer claims that the monitor can be used within a background of higher level than the standard background conditions, then the Annex C characterization shall be done.

c) Carried source response

This test characterizes the response of the monitor in realistic conditions, i.e. with a person present in the monitor. It is of special interest for gamma responses because of the attenuation and scattering due to the person presence.

The characterization should be done according Annex D based on a real person roughly mid weight and mid height or based on a one of the phantoms described in Annex B.

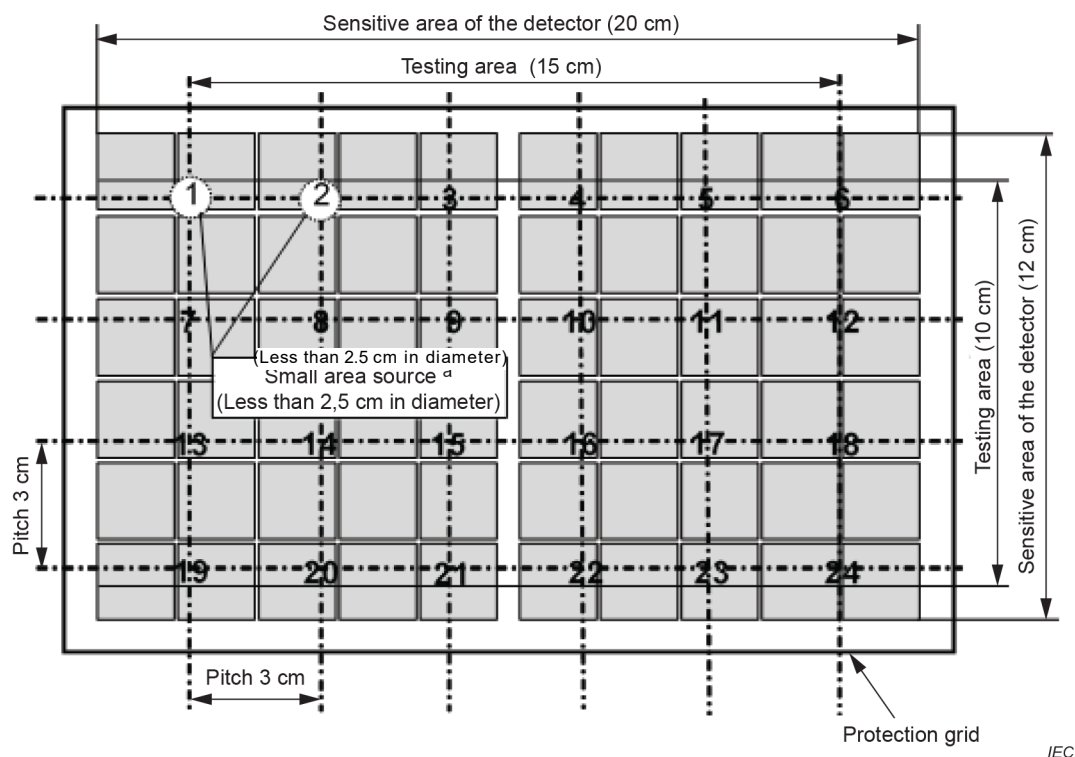
7.1.3 For hand monitoring

7.1.3.1 Requirements

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 ^{137}Cs shielded with more than 0,6 mm of aluminium (or ^{129}I for low energy monitors) for gamma monitoring, ^{36}Cl or ^{204}Tl for beta monitoring and ^{241}Am for alpha monitoring and shall not exceed a factor of 2.

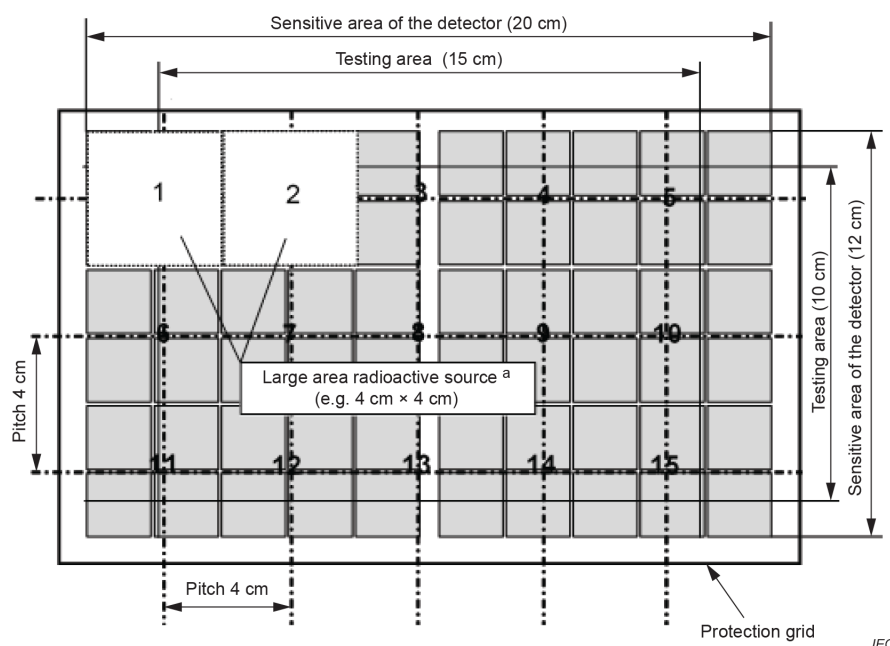
7.1.3.2 Method of test

For this test, the testing area 15 cm × 10 cm of the hand detector shall be considered as defined by the manufacturer. In a case of using a small area source, the response of the detector shall be measured using the source in each of the 24 positions shown in Figure 4 a) on the outermost part of the detector protection. In a case of using a source having a radioactive area of 4 cm × 4 cm, the response of the detector shall be measured in 4 cm pitch in each of the 15 positions shown in Figure 4 b) on the outermost part of the detector protection by 4 cm pitch. However, the sources shall be placed not to exceed the sensitive area of the detector specified by the manufacturer and not to overlap each other. In either case, the effect of background shall be subtracted from each calculation of response.



^a Use suitable jig to hold the source at proper position.

a) Applying small area source



^a Use suitable jig to hold the source at proper position.

b) Applying large area radioactive source

Figure 4 – Detector for hand monitoring

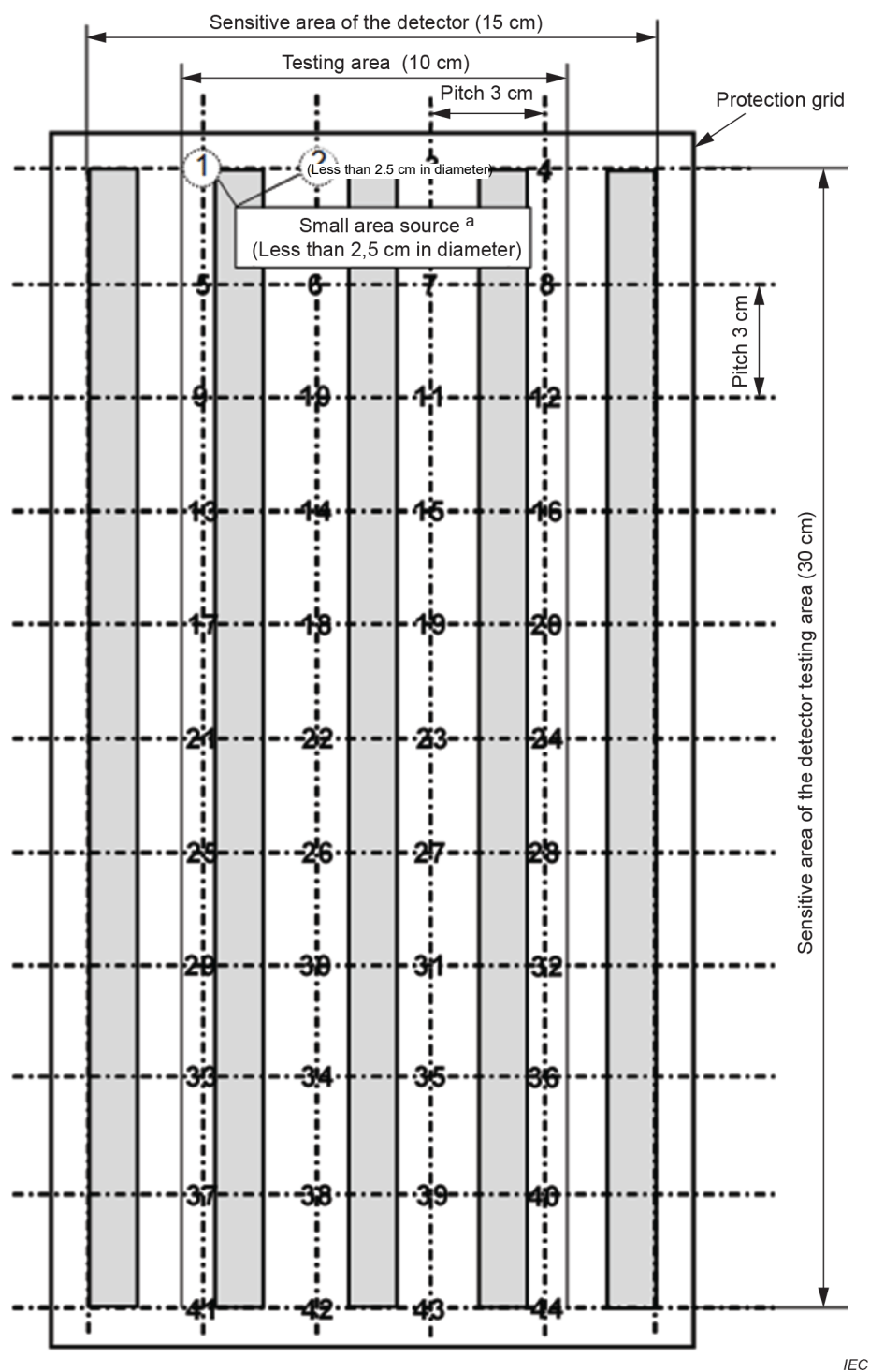
7.1.4 For foot monitoring

7.1.4.1 Requirements

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 ^{137}Cs shielded with more than 0,6 mm of Aluminium (or ^{129}I for low energy monitors) for gamma monitoring, ^{36}Cl or ^{204}Tl for beta monitoring and ^{241}Am for alpha monitoring.

7.1.4.2 Method of test

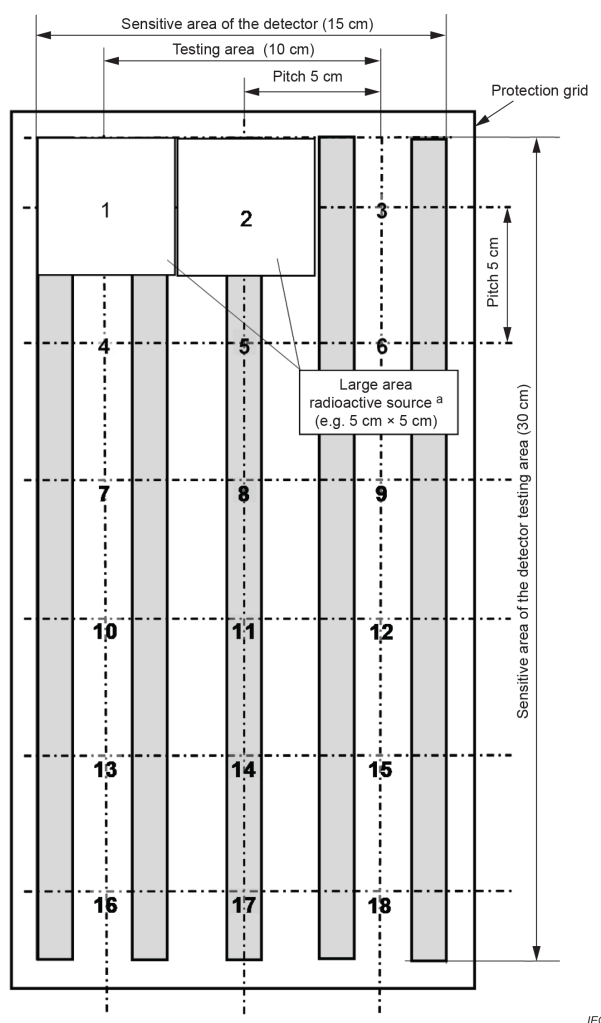
For this test, the testing area 30 cm × 10 cm of the foot detector shall be considered as defined by the manufacturer. In a case of using a small area source, the response of the detector shall be measured using the source in each of the 44 positions shown in Figure 5 a) on the outermost part of the detector protection. In a case of using a source having a radioactive area of 5 cm × 5 cm, the response of the detector shall be measured in 5 cm-pitch in each of the 18 positions shown in Figure 5 b) on the outermost part of the detector protection. However, the sources shall be placed not to exceed the sensitive area of the detector specified by the manufacturer and not to overlap each other. In either case, the effect of ambient background shall be subtracted from each calculation of response.



IEC

^a Use suitable jig to hold the source at proper position.

a) Applying small area source



^a Use suitable jig to hold the source at proper position

b) Applying large area radioactive source

Figure 5 – Detector for foot monitoring

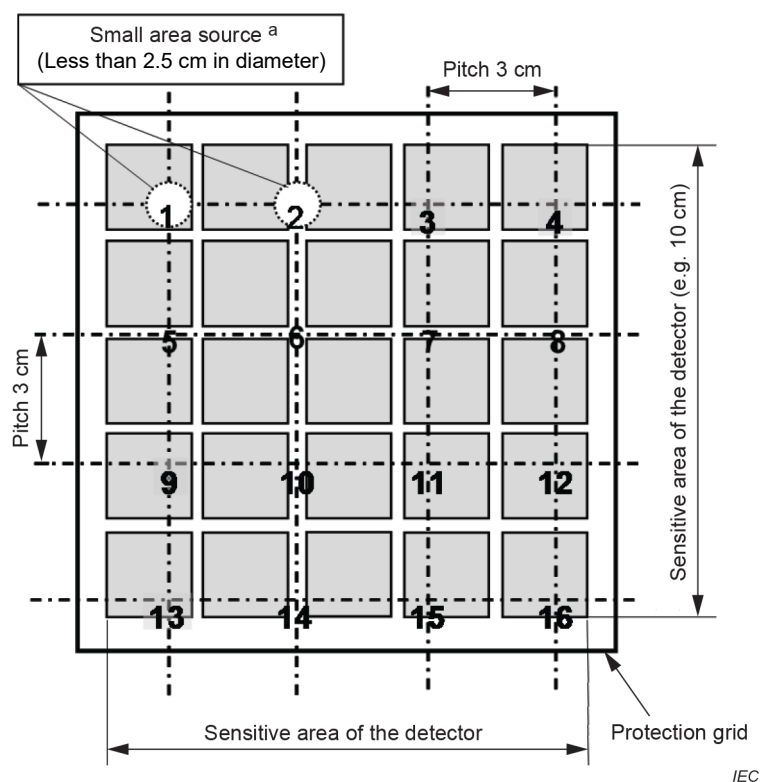
7.1.5 Contamination measurement of cloth or body by friskers

7.1.5.1 Requirements

In a case of a frisker having a sensitive area equal to or more than 10 cm × 10 cm, 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 frisker for the reference nuclide of ¹³⁷Cs shielded with more than 0,6 mm of Aluminium (or ¹²⁹I for low energy monitors) for gamma monitoring, ³⁶Cl or ²⁰⁴Tl for beta monitoring and ²⁴¹Am for alpha monitoring.

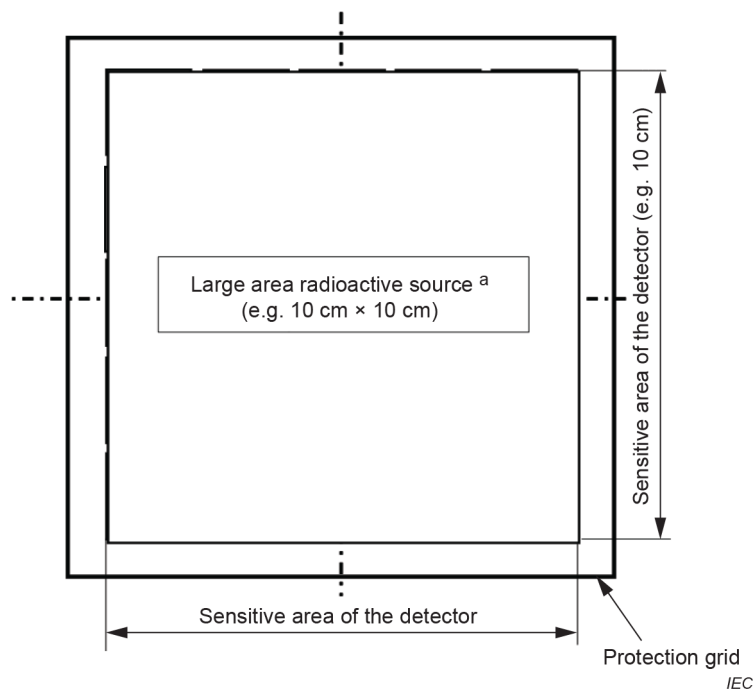
7.1.5.2 Method of test

For this test, a sensitive area equal to or more than 10 cm × 10 cm for a frisker shall be considered. In a case of using a small area source, when a variation of response with source position is required, the response of the detector shall be measured in 3 cm pitch in the outermost part of the detector protection. In a case of using a source having a radioactive area of 10 cm × 10 cm, the response of the detector shall be measured in 10 cm pitch in the outermost part of the detector protection. However, the sources shall be placed not to exceed the sensitive area of the detector specified by the manufacturer and not to overlap each other. In either case, the effect of ambient background shall be subtracted from each calculation of response (see Figure 6).



^a Use suitable jig to hold the source at proper position.

a) Applying small area source



^a Use suitable jig to hold the source at proper position.

b) Applying large area radioactive source

Figure 6 – Frisker (clothes)/Overhead detector

7.2 Background

7.2.1 General

All measurements of radiation are affected by ambient background attenuation due to human body, and the effects may be dealt with in different ways dependent on the design of the monitor.

7.2.2 Subtraction of pre-determined background

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. The manufacturer shall state the background value used to achieve the detection limit (DL) stated by the manufacture.

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

The manufacturer shall calculate the detection limit (DL) according to Formula (3) in 7.3.1 for standard background conditions. If there is agreement between the purchaser and the manufacturer, the manufacturer may calculate the detection limit (DL) according to Formula (4) in 7.3.1. Formula (4) takes into account a 5 % change in the background value between the background measurement and the contamination measurement (see Annex A). By agreement between the purchaser and the manufacturer, $0,05 \cdot \eta_0$ may be replaced another value (e.g. $0,03 \cdot \eta_0$ for a 3 % change in the background value).

7.2.3 Simultaneous subtraction of determined background

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. The compatibility of such detector sets is limited due to the different locations and accordingly different background levels as well as due to statistical uncertainties.

The manufacturer shall state the magnitude of the variation of the difference of count rate between detectors and the ambient background signal which are used in calculating the detection limit (DL) (see Formula (5) in 7.3.1). The manufacturer shall also provide the magnitude of the changes, such as the following, which is necessary to create that signal change:

- changes in value,
- changes in energy, and
- changes in direction.

The effects of changes in direction shall be due to movements of sources placed more than 3 m from the monitor.

When calculating the detection limit (DL), the effect of changes in the indicated background magnitude shall be taken into account.

7.2.4 No background subtraction

Even if no background compensation is included in the monitor, it is necessary to consider the variation of the count rate (background effect) when the background is measured and that of the count rate (gross effect) when the contamination is measured.

The manufacturer shall state the background measurement time and the value used to achieving the manufacturer published detection limit (DL).

The manufacturer shall calculate the detection limit (DL) according to Formula (3) in 7.3.1. If there is agreement between the purchaser and the manufacturer, the manufacturer may calculate the detection limit (DL) according to Formula (4) in 7.3.1. Formula (4) takes into account a 5 % change in the background value between the background measurement and the contamination measurement (see Annex A). By agreement between the purchaser and the manufacturer, the $0,5 \cdot \eta_0$ may be replaced another value (e.g., $0,03 \cdot \eta_0$ for a 3 % change in the background value). A 5 % change includes human body attenuation.

7.2.5 Gamma monitoring systems

The self-shielding effect and the scattering modify the background during measurement. This effect is an S error that leads generally to an underestimation, especially for high background. The correction of this effect may be implemented taking into account, for example, the height and weight of the individuals being measured.

For gamma monitors or for gamma channels of combined monitors, if the manufacturer claims a use in higher background than the standard conditions, the manufacturer has to characterize the body attenuation effect and, if provided, the effectiveness of the correction (see 7.1.2.2.3 and Annex C).

The low end of the effective range of measurements that usually equals the detection limit may have to be increased (see Annex C).

The detection limit is modified and can be calculated using 7.3.1. Formula (4) replacing 5 % with the percentage of deviation found in Annex C at the claimed low end of the effective range of measurement.

7.3 Detection limit (DL)

7.3.1 General

The decision threshold, y^* , and the detection limit (DL), $y^\#$, can be determined using Formula (1) and Formula (2), respectively, which are derived from the procedure described in the ISO 11929 series:

$$y^* = k_{1-\alpha} \tilde{u}(0) \quad (1)$$

where,

y^* is the decision threshold,

$\tilde{u}(0)$ is the uncertainty of the measurand when its true value equals zero, and

$k_{1-\alpha}$ is the quantile of the standardized normal distribution for the probability $1-\alpha$.

NOTE 1 As mentioned in 3.1.17, when the measurand result y exceeds the decision threshold y^* , the probability that the true value of the measurand is zero is less or equal to the chosen probability α .

$$y^\# = y^* + k_{1-\beta} \tilde{u}(y^\#) = k_{1-\alpha} \tilde{u}(0) + k_{1-\beta} \tilde{u}(y^\#) \quad (2)$$

where,

$\tilde{u}(y^\#)$ is the uncertainty of the measured when its true value equals $y^\#$, and

$k_{1-\beta}$ is the quantile of the standardized normal distribution for the probabilities $1-\beta$.

NOTE 2 As mentioned in 3.1.15, with the decision threshold, the detection limit (DL) is the smallest true value of the measurand for which the probability of wrongly deciding that the true value of the measurand is zero is equal to a specified value β , when, in fact, the true value of the measurand is not zero.

If values of 0,05 for both α and β are selected as acceptable, then both $k_{1-\alpha}$ and $k_{1-\beta}$ become 1,65, and Formula (3) can be written as:

$$S_{DL} = \frac{2 \times 1,65 \sqrt{\frac{r_0}{t_g} + \frac{r_0}{t_0}} + \frac{1,65^2}{t_g}}{E_{ff}} = \frac{3,3 \sqrt{\frac{r_0}{t_g} + \frac{r_0}{t_0}} + \frac{2,72}{t_g}}{E_{ff}} \quad (3)$$

where,

S_{DL} is the detection limit (DL) of the surface emission rate (s^{-1}),

r_0 is estimate of the background count rate (s^{-1}),

t_g is measurement duration of the measurement of the gross effect (s),

t_0 is measurement duration of the measurement of the background effect (s), and

E_{ff} is the effective instrument efficiency.

In a case of taking into account a 5 % change in the background value between the background measurement and the contamination measurement, the detection limit (DL) of the surface emission rate (s^{-1}) per unit can be determined using Formula (4):

$$S_{DL} = \frac{3,3 \sqrt{\frac{r_0}{t_g} + \frac{r_0}{t_0} + (0,05r_0)^2} + \frac{2,72}{t_g}}{E_{ff}} \quad (4)$$

In a case of achieving background compensation simultaneously, the detection limit (DL) of the surface emission rate (s^{-1}) per unit can be determined using Formula (5):

$$S_{DL} = \frac{3,3 \sqrt{\frac{2r_0}{t_g} + r_x^2} + \frac{2,72}{t_g}}{E_{ff}} \quad (5)$$

where,

r_0 is estimate of the background count rate (s^{-1}), and

r_x is the difference rate between the detector for measurement and the detector for background.

DL shall be lower than the measurement range.

If background is too large to measure, it may be necessary to stop (or not) the measurement.

NOTE 3 The difference of the count rates cannot be zero with any concurrent corrections.

7.3.2 For clothing or body

For the purposes of this document, the detection limit (DL) shall relate to the effective instrument efficiency to clothing (body). This shall be determined as below, or the manufacturer shall undertake similar methods of determining a instrument efficiency. In the latter case, the manufacturer shall provide the purchaser with the positions of source, all measurements taken, the assumptions made in calculating the average efficiency and the calculations made to determine this "average". The effective instrument efficiency shall be determined from both the vertical response characteristic shown in Figure 1 and the polar response given in Figure 2.

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 effective instrument 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. The overall vertical response is the average of the average vertical responses for each vertical array. In the case where all the arrays are identical, the overall vertical response is the average vertical response for an array.

From this, the effective instrument efficiency E_{ff} can be determined as follows:

$$E_{ff} = \frac{r}{\phi} \quad (6)$$

where,

r is counts per second average response, and

ϕ is surface emission rate of the source in determining the response.

This efficiency equation shall be used in determining the detection limit (DL) as described in Annex A.

In all cases, the detection limit (DL), for standard background conditions or in background level which is agreed upon between the purchaser and manufacturer, shall not be greater than 200 s^{-1} for beta emission and a photon emission of $2\,000 \text{ s}^{-1}$. The total monitoring time shall be 10 s or the time agreed between the purchaser and manufacturer. 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.

NOTE Although nominally 200 s^{-1} is equivalent to 400 Bq (source efficiency is 0,5), the user refers to ISO 7503-1 for corrections to allow for self-absorption on clothing or other surfaces actually to be measured (see Table 4).

7.3.3 The effective instrument efficiency at the specific operating point

Measurement to determine the effective instruments efficiency E_{ff} is described in 7.3.2. The measurement requires many test points, which is generally performed in type test or qualification test. The positions and type of the source used in these measurements are given in 7.1.1.

This test method is not reasonable for acceptance tests or routine tests because it takes a lot of time and effort. Accordingly, for the body detectors, the instrument efficiency E_2 at the specific operating point is measured, and the conversion constant K obtained by the method described in 7.3.2 is calculated. For the acceptance test or the routine test, the method for determining E_{ff} is specified by measuring the instrument efficiency E_2 at the specific operating point. E_{ff} is given by Formula (7):

$$E_{ff} = E_2 \times K \quad (7)$$

The specific operating point and source types are specified by the manufacturer.

This is a simplified method for reasonably performing acceptance tests or routine tests in which the conversion constant K is considered to be approximately constant in a detector of the same model.

7.3.4 For hand monitoring

a) Alpha

The detection limit (DL) shall relate to the response of the hand detector to a source of uniform activity of area 15 cm × 10 cm or 10 cm × 10 cm.

The detection limit (DL) shall be the emission rate which in the monitoring time of the monitor 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). The detection limit (DL) 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 see note in 7.3.2 (see Table 4).

b) Beta

The detection limit (DL) shall relate to the response of the hand detector to a source of uniform surface emission rate of area 15 cm × 10 cm or 10 cm × 10 cm.

The detection limit (DL) 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 in 7.3.2).

c) Gamma

The detection limit (DL) shall relate to the response of the hand detector to a source of area 15 cm × 10 cm.

The detection limit (DL) shall be determined in the same way as for clothing and shall be less than a photon emission rate of 2 000 s⁻¹ for a monitoring time of 10 s, or shall be determined by agreement between the purchaser and the manufacturer.

7.3.5 For foot monitoring

a) Alpha

The detection limit (DL) shall relate to the response of the foot detector to a source of uniform activity of area 30 cm × 10 cm. A source of 15 cm × 10 cm may be used in two places or 10 cm × 10 cm in three places to simulate the 10 cm × 30 cm source.

The detection limit (DL) shall be the surface emission rate which in the monitoring time of the monitor gives at least 5 counts from the detector. The detection limit (DL) 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 7.3.4).

b) Beta

The detection limit (DL) shall relate to the response of the foot detector to a source of uniform surface emission rate 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 or $10\text{ cm} \times 10\text{ cm}$ in three places to simulate the $30\text{ cm} \times 10\text{ cm}$ source.

The detection limit (DL) 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 in 7.3.2).

c) Gamma

The detection limit (DL) shall relate to the response of the foot detector to a source of uniform surface emission rate 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 $30\text{ cm} \times 10\text{ cm}$ source. The detection limit (DL) shall be determined in the same way as that for clothing and shall be less than $1\,000\text{ s}^{-1}$ for a monitoring time of 10 s, or shall be determined by agreement between the purchaser and the manufacturer.

7.3.6 For frisker monitoring

a) Alpha

In a case of a detector having a sensitive area equal to or more than $10\text{ cm} \times 10\text{ cm}$, the detection limit (DL) shall relate to the response of the frisker detector to a source of uniform activity of area which covers the sensitive area.

The detection limit (DL) shall be the emission rate which in the monitoring time of the monitor gives at least 5 counts from the frisker detector (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). The detection limit (DL) 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 see note in 7.3.2.

b) Beta

In a case of a detector having a sensitive area equal to or more than $10\text{ cm} \times 10\text{ cm}$, the detection limit (DL) shall relate to the response of the frisker detector to a source of uniform surface emission rate of area $10\text{ cm} \times 10\text{ cm}$.

The detection limit (DL) 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 in 7.3.2).

c) Gamma

In a case of a detector having a sensitive area equal to or more than $10\text{ cm} \times 10\text{ cm}$, the detection limit (DL) shall relate to the response of the frisker detector to a source of area $10\text{ cm} \times 10\text{ cm}$.

The detection limit (DL) 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.

7.4 Variation of response with energy

7.4.1 General

All influence quantities dealt with in 7.4 are regarded as of type F.

7.4.2 Beta

7.4.2.1 Requirements

The monitor 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, and
- 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 monitor.
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)
⁹⁰ Sr/ ⁹⁰ Y	(maximum energy of short lived daughter ⁹⁰ Y 2,274 MeV)

7.4.2.2 Method of test

a) Body

For this test, the phantom used in test 7.1.2.2.2 b) shall be used as specified in that test.

A small area source of the nuclide of interest shall be moved in the vertical plane at 2 cm steps, in case using area source at 10 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 7.1.2.2.2 b).

The effective instrument efficiency shall be calculated for each nuclide of interest and compared to that of the reference source (see 7.3.2).

Tests using the method shown in 7.1.2.2.2 b) need not be conducted for all nuclides. This test is carried out for one type of nuclide, and the difference in response due to nuclide may be characterized by the detector individually.

b) Hands

This may be undertaken either by use of area sources of uniform activity or small area sources. Where area sources are used, they shall be 15 cm × 10 cm or 10 cm × 10 cm and the ratio of the response to that of the reference source can be measured directly. The source shall be placed at the centre of the detector.

The response of the detector shall be measured using the small area source of the nuclide of interest in positions shown in Figure 4 a). 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 area sources.

This test does not need to be carried out for all nuclides. Differences in response due to nuclides may be characterized by the detector individually.

c) Feet

The requirement shall be met in the same way as for hands above, except that when area sources are used, these shall be 30 cm × 10 cm, 15 cm × 10 cm or 10 cm × 10 cm.

This test does not need to be carried out for all nuclides. Differences in response due to nuclides may be characterized by the detector individually.

d) Frisker

This may be undertaken either by use of area sources of uniform activity or small area sources. Where area sources are used, they shall be 15 cm × 10 cm or 10 cm × 10 cm and the ratio of the response to that of the reference source can be measured directly. The source shall be placed at the centre of the detector.

The response of the detector shall be measured using the source of the nuclide of interest in positions shown in Figure 6. 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 area sources.

This test does not need to be carried out for all nuclides. Differences in response due to nuclides may be characterized by the detector individually.

7.4.3 Alpha**7.4.3.1 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 or ^{241}Am should be used.

Depleted Uranium will be predominately ^{238}U emitting 4,2 MeV alphas with traces of ^{234}U and ^{235}U and natural uranium will be ^{238}U in near equilibrium with ^{234}U emitting 4,8 MeV alphas with traces of ^{235}U . ^{241}Am emits predominantly 5,5 MeV alphas.

7.4.3.2 Requirements

The manufacturer should state, for the detectors used to monitor the hands and the feet, the ratio of the response to natural uranium, depleted uranium or ^{241}Am to the response to the reference radionuclide.

7.4.3.3 Method of test

The methods of test for the hand and foot detectors and frisker are identical to those for beta radiation (see 7.4.2).

7.4.4 Gamma**7.4.4.1 General**

The monitor 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 monitor designed to measure high energy emitters and 2 for monitor designed to measure low energy emitters, as follows:

- one between 5 keV and 50 keV (low energy system);
- one between 50 keV and 150 keV (low energy systems);
- one between 150 keV and 500 keV (high energy system);
- one between 500 keV and 800 keV (high energy system); and
- one over 1 000 keV (high energy system).

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

- ^{55}Fe major emission 5,9 keV;
- ^{129}I major emission 29 keV;
- ^{241}Am major emission 59,5 keV with a sufficiently thick window to eliminate electron and alpha particle penetration;

- ^{57}Co major emission 122 keV;
- ^{133}Ba major emission 356 keV; and
- ^{137}Cs major emission 662 keV;
- ^{60}Co major emission 1 173 keV and 1 333 keV.

7.4.4.2 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 method of tests described in 7.1.

7.4.4.3 Method of test

a) Body

For this test, the phantom used in test 7.1.2.2.2 b) shall be used as specified in that test. A small area source of the nuclide of interest shall be moved in the vertical plane every 5 cm and right around the phantom every 20°. A source having a radioactive area of interest shall be moved in the vertical plane every 10 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 b).

The effective instrument efficiency around the phantom shall be calculated for each nuclide of interest and compared to that of the reference source (see 7.3.2).

b) Hands

This may be undertaken either by the use of area sources of uniform activity or small area sources. Where area sources are used, they shall be 15 cm × 10 cm or 10 cm × 10 cm. The source shall be placed directly on the protection grid. The ratio of the response to that of the reference source can be measured directly. The source shall be placed at the centre of the detector.

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 area sources.

c) Feet

The requirement shall be met in the same way as for hands above, except where area sources are used, these shall be 15 cm × 10 cm or 10 cm × 10 cm. The source shall be placed directly on the protection grid.

d) Frisker

This may be undertaken either by the use of area sources of uniform activity or small area sources. Where area sources are used, they shall be 15 cm × 10 cm or 10 cm × 10 cm. The source shall be placed directly on the protection grid. The ratio of the response to that of the reference source can be measured directly. The source shall be placed at the centre of the detector.

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 area sources.

7.5 Response to other ionising radiations

7.5.1 General

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

All influence quantities dealt with in 7.5 are regarded as of type F.

7.5.2 Gamma radiation

7.5.2.1 Requirements for alpha contamination monitors or warning assemblies

When the detector is subjected to an air kerma rate of 10 $\mu\text{Gy/h}$ by ^{137}Cs , 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 monitor under test.

7.5.2.2 Requirements for beta contamination monitors or warning assemblies

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

7.5.3 Alpha radiation (for beta and gamma contamination monitoring assemblies)

7.5.3.1 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 monitor 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.

7.5.3.2 Method of test

Insert the hand or foot alpha radiation reference source in the monitor and using a scaler or similar monitor 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.

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

7.5.4.1 Requirements

The response of alpha contamination monitors to $^{90}\text{Sr}/^{90}\text{Y}$ radiation or reference gamma radiation shall be stated (see 6.4).

For both alpha and simultaneous alpha/beta, alpha/gamma or alpha/beta/gamma contamination monitor, the response of the alpha channel to beta or gamma radiation shall be less than 1 % of that due to alpha in this channel.

7.5.4.2 Method of test

Add the foot or hand beta radiation reference source in the monitor and using a scaler or similar monitor 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.

7.6 Linearity of indication

7.6.1 Requirements

In the case of monitoring assemblies where the indication of the level of contamination detected is given in any form (Bq, Bq/cm^2 , 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.

7.6.2 Method of test

7.6.2.1 General

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

7.6.2.2 Method of using sources

The response shall be measured at three points or more within the effective range. Further, at least one point among those points shall be measured with the source.

7.6.2.3 Method of equivalent electrical test

In the event that the full measurement range required for the above tests cannot be provided by the sources of radiation available, it is permissible to employ an equivalent electrical test in order to determine the relative error at the contamination level that cannot be provided by the sources of radiation.

The electrical signal shall have a form which simulates as closely as necessary the form of signal delivered by the detector and shall be injected at a point that will test the entire monitor apart from the detector itself or the photomultiplier in the case of a scintillator detector.

7.7 Alarm threshold

7.7.1 General

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.

7.7.2 Requirements

Each monitoring channel activates visual and audible alarm when the output signal from a detector exceeds the predetermined alarm threshold.

7.7.3 Method of test

Alarm verification test is performed by providing the detector with counts above the alarm threshold, which are caused by the exposure to beta radiation (alpha or gamma radiation for alpha or gamma detector, respectively) or by the injection of pulse from pulse generator. This test is carried out for all monitoring channels.

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 monitor 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 ^{137}Cs for gamma detecting monitor and 10^5 Bq of ^{90}Sr in equilibrium with its daughter on the normally fitted protection to the sensitive area of the detector for beta detecting monitor, and 10^4 Bq of ^{241}Am on the normally fitted protection of the sensitive area of the detector for alpha detecting monitor. 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.