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Measurement of radioactivity — Alpha-, beta- and photon emitting radionuclides — Reference measurement standard specifications for the calibration of surface contamination monitors

Mesurage de la radioactivité — Radionucléides émetteurs alpha, bêta et photoniques — Spécifications des étalons de référence pour l'étalonnage des contrôleurs de contamination de surface

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiological protection*.

This fourth edition cancels and replaces the third edition (ISO 8769:2016), which has been technically revised. The changes compared to the previous edition are as follows:

— In order to maintain consistency with terms described in the International Vocabulary of Metrology or ISO/IEC 17025[16], “reference measurement standard”, “working measurement standard” and “transfer measurement device” were adopted respectively instead of a “reference source”, “working source” and “reference transfer instrument”.

— 5.1 b): “a surface layer of thickness equal to the saturation layer thickness” was modified to “a surface layer of thickness equal to or less than the saturation layer thickness”.

— 5.2.3 and 5.3.3: The statement of “minus its relative standard uncertainty” was removed.

— 5.4.3: Requirement for the re-measurement of uniformity was added as follows; “In case that significant change not due to half-life is found on the re-calibration of surface emission rate, re-measurement of uniformity is required.”

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Radioactive contamination of surfaces can result from spilling, splashing, or leakage from unsealed sources, or breakage or loss of integrity of sealed sources. It can lead to the spread of contamination, loss of quality control and can give rise to the following health hazards:

a) external exposure to parts of the body in proximity to the contaminated surface;

b) internal exposure through incorporation of radioactive material emanating from the surface.

The need for effective monitoring of surface contamination has long been recognized, see Reference [1]. Surface contamination is quantified in terms of activity per unit area, the quantity which is normally used to specify "derived limits", i.e. maximum limits of surface contamination. These limits are based on radiological protection considerations and have been derived from the dose equivalent or intake limits recommended by the International Commission on Radiological Protection (ICRP), see References [2] and [3]. Derived limits are incorporated into numerous national and international regulatory documents which relate specifically to surface contamination monitoring.

The requirement for this document originated from the need for calibration measurement standards in International Standards dealing with the calibration of surface contamination monitors.

While regulatory documents refer to surface contamination in terms of activity per unit area, the response of monitoring instruments is related directly to the radiation emitted from the surface rather than to the activity contained upon or within the surface. Due to variations in the absorptive and scattering properties of real surfaces, it cannot be assumed, in general, that there is a simple, known relationship between surface emission rate and activity. Thus, there emerges a clear need for calibration measurement standards that are specified primarily in terms of surface emission rate, as well as activity. The manner in which these standards are used and the associated calibration protocols vary from country to country[4].

Calibration of an instrument in terms of activity for the types of surfaces that are usually encountered in monitoring situations depends on the following considerations:

— mixture and ratios of radionuclides being monitored;

— their types and abundances of emissions;

— nature of the surface;

— depths and distribution profiles within the surface;

— spectral attenuation dependence of the instrument entrance window;

— distance between the instrument entrance window and the surface.

The derivation of appropriate calibration factors in terms of activity is therefore a highly complex process which is outside the scope of this document. Appropriate guidance on this process is addressed in ISO 7503 (all parts)[5]. However, some estimate of the activity of the calibration measurement standard is required for general radiological safety purposes such as handling, leak testing, shielding, packaging, and transport. This is a generic issue for all radioactive sources regardless of their intended use and is not therefore addressed specifically in this document.

Traceability of calibration measurement standards to International Standards or national standards is established by a system of reference transfer instruments.

Measurement of radioactivity — Alpha-, beta- and photon emitting radionuclides — Reference measurement standard specifications for the calibration of surface contamination monitors

1 Scope

This document specifies the characteristics of reference measurement standards of radioactive surface contamination, traceable to national measurement standards, for the calibration of surface contamination monitors. This document relates to alpha-emitters, beta-emitters, and photon emitters of maximum photon energy not greater than 1,5 MeV.

It does not describe the procedures involved in the use of these reference measurement standards for the calibration of surface contamination monitors. Such procedures are specified in IEC 60325[6], IEC 62363[7], and other documents.

NOTE Since some of the proposed photon standards include filters, the photon standards are to be regarded as reference measurement standards of photons of a particular energy range and not as reference measurement standards of a particular radionuclide. For example, a ^{241}Am source with the recommended filtration does not emit from the surface the alpha particles or characteristic low-energy L X-ray photons associated with the decay of the nuclide. It is designed to be a reference measurement standard that emits photons with an average energy of approximately 60 keV.

This document also specifies preferred reference radiations for the calibration of surface contamination monitors. These reference radiations are realized in the form of adequately characterized large area sources specified, without exception, in terms of surface emission rate and activity which are traceable to national standards.

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.

ISO 12749-2, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 2: Radiological protection*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12749-2, IEC 60050-395, and the following apply.

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

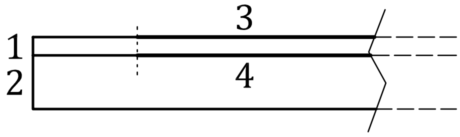
— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
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 second in a mass-free environment

3.2
face
<of a source> vertical projection of the nominal active area onto the front surface of the source

Note 1 to entry: See Figure 1.



Key

1 filter

2 backing

3 face

4 nominal active area

Figure 1 — Cross-sectional drawing of a reference measurement standard with its filter

3.3
saturation layer thickness
<of a source constructed of a homogeneous radioactive material> thickness of the medium equal to the maximum range of the specified particulate radiation

3.4
instrument efficiency
ratio between the instrument net reading (counts per second after background subtraction) and the surface emission rate of the reference measurement standard (particles emitted per second) in a specified geometry relative to a standard

Note 1 to entry: The instrument efficiency depends on the energy of the radiation emitted by the standard, the area of the standard, and the area of the detector entrance window.

3.5
self-absorption
<of a source> absorption of radiation which occurs within the material of the source itself

3.6
uncertainty
standard uncertainty ($k = 1$) unless otherwise stated

Note 1 to entry: The treatment of uncertainties is in accordance with the ISO/IEC Guide 98-3[8] to the expression of uncertainty in measurement.

3.7
uniformity
<of a surface in respect of a given property> indication of the lack of variation of that property over the surface

4 Traceability of reference measurement standards

The following scheme is proposed to ensure that working standards used in the field for the routine calibration of surface contamination monitors shall be related to national measurement standards through a clearly defined traceability chain using reference measurement standards and reference transfer measurement devices.

Reference measurement standards shall be of the following two types:

— **Class 1:** reference measurement standards that have been calibrated directly in terms of activity and surface emission rate at a national or international metrology institute.

— **Class 2**: reference measurement standards that have been calibrated in terms of surface emission rate on a reference transfer instrument, the efficiency of which has been measured by calibration with a Class 1 reference measurement standard of the same radionuclide and of the same general construction using the same geometry, at a laboratory that operates according to ISO/IEC 17025[16] for such measurements.

National metrology institutes shall, at their discretion, provide the means whereby Class 1 reference measurement standards of a specified range of radionuclides may be certified by them. For those countries which are signatories to the Mutual Recognition Arrangement (MRA)[9], a certificate of calibration from another participating institute in a second country is recognized as valid in the first country for the quantities, ranges, and measurement uncertainties specified in Appendix C of Reference [9].

The activity and surface emission rate of Class 1 reference measurement standards shall be measured, using, for example, a windowless gas-flow proportional detector, or by using an instrument that has been calibrated using standards that have been measured absolutely. Calibration procedures for activity determination are discussed for example, in References [10], [11], [12] and [13].

Organizations with a requirement to type test and to calibrate instruments to be used for monitoring radioactive surface contamination need to have access to suitable Class 1 or Class 2 reference measurement standards. The purpose of a working measurement standard is to check the calibration of surface contamination monitors in the field; they are not to be confused with check sources, which are only intended to verify that a monitor is operating.

Organizations with a requirement to provide working measurement standards for the routine confirmation of the calibration of their surface contamination monitoring instruments require access to a reference transfer measurement device with which to calibrate such working measurement standards in terms of surface emission rate against a Class 1 or Class 2 reference measurement standard. Where the working measurement standard is used either in a jig or under a particular geometry, the reference transfer measurement device on which its emission rate is measured shall have been calibrated using a reference measurement standard under identical conditions and geometry. Alternatively, the working measurement standard shall be removable from the jig so that it can be measured in the usual way. Where only a few monitors need calibration or a high degree of accuracy is required, Class 1 or Class 2 reference measurement standards may be used as working measurement standards. In such cases, the frequency of re-calibration shall be that for working measurement standards. National regulations may require more frequent calibrations.

5 Specification of reference measurement standards

5.1 General

Reference measurement standards are of the following kinds:

a) Sources comprising an electrically conducting backing material with a given radionuclide permanently deposited upon or incorporated into one side only; the thickness of the backing material shall be sufficient to prevent emission of the particulate radiation through the back of the source.

or

b) Sources comprising a layer of material within which the radionuclide is uniformly distributed and the thickness of which shall not exceed the thickness of the saturation layer of the particulate radiation. For the purposes of this document, the activity of the source shall be taken as the activity contained within a surface layer of thickness equal to or less than the saturation layer thickness.

Photon-emitting sources shall incorporate filters in accordance with Table 1.

To measure the surface emission rate directly, a threshold corresponding to a minimum energy shall to be set. For beta counting, it shall be set to correspond to a photon energy of 590 eV (0,1 times the energy of the X_K-radiation of Mn following the decay of ^{55}Fe). For alpha counting, the threshold shall be set just above the electronic noise of the system. For photon counting, the threshold shall be set to comprise the photon peak and the whole Compton continuum.

With alpha-emitters and low-energy beta-emitters, self-absorption can be far from negligible. This leads to a degradation of the emission spectrum and might affect measurements with windowed transfer measurement devices.

Reference measurement standards shall be fit for purpose and it shall be the responsibility of the manufacturer to determine and report the radioactive impurities to the extent necessary to ensure that the use of the standard is not compromised by emissions from any impurity. As a minimum, all radioactive impurities with an activity of at least 1 % of the activity of the principal radionuclide shall be determined and reported.

For those standards which might contain radioactive impurities, users of the reference measurement standard shall take into account that the relative activity of the impurity changes with time and could produce a significant effect on the emission rate of the reference measurement standard.

Table 1 — Characteristics and additional filtration of photon-emitting standards

Approximate mean photon energy[a] in keV	Radionuclide	Half-life in days	Filter material[b]	Filter thickness
5,9	^{55}Fe	1,00 × 10^3	none	
16	^{238}Pu	3,20 × 10^4	zirconium	0,05 mm 32,5 mg·cm^{-2}
32	^{129}I	5,88 × 10^9	aluminium	0,3 mm 81 mg·cm^{-2}
60	^{241}Am	1,58 × 10^5	stainless steel	0,25 mm 200 mg·cm^{-2}
124	^{57}Co	272	stainless steel	0,25 mm 200 mg·cm^{-2}
660	^{137}Cs	1,10 × 10^4	stainless steel	1 mm 800 mg·cm^{-2}
1 250	^{60}Co	1,93 × 10^3	aluminium	0,3 mm 81 mg·cm^{-2}

NOTE 1 These are standards of photons of a particular energy range and not standards of a particular radionuclide.

NOTE 2 In most cases, ^{60}Co emits two coincident photons with an angular correlation between them. Great care shall be taken when transferring the calibration to other energies or nuclides.

[a] The approximate mean photon energy is equal to $(\sum n_i \times E_i)/\sum n_i$ where n_i is the number of photons emitted from the standard with energy E_i.

[b] For this document, stainless steel is that which has the composition 72 % Fe, 18 % Cr, 10 % Ni.

5.2 Class 1 reference measurement standards

5.2.1 General requirements

In order to comply with the requirements specified in this document, Class 1 reference measurement standards shall be plane ones comprising an electrically conducting backing material with radioactive material deposited upon or incorporated into one side in such a manner as to minimize source self-absorption and to maintain electrical conductivity across the whole of the face of the source. The active area shall be at least 10^4 mm^2; recommended sizes are 100 mm × 100 mm, 100 mm × 150 mm, and 150 mm × 200 mm.

A Class 1 reference measurement standard is intended to approximate as closely as practicably possible an ideal "thin" source (see IEC 60325[6]) with respect to the activity itself. However, it is acknowledged that with alpha-emitters and low-energy beta-emitters, self-absorption can be far from negligible. Maintenance of electrical conductivity is necessary for the correct operation of windowless proportional counters. The thickness of the backing material should be such as to minimize the contribution from backscattered radiation, both particle and photon. The recommended backing material is aluminium of 3 mm thickness (this thickness is sufficient to eliminate beta-particle emission through the back of the source, with the exception of ^{106}Ru/^{106}Rh sources where the thickness would need to be increased to 4,6 mm). The thickness of the backing material shall be within 10 % of the value detailed in the certificate. The backing material should extend beyond the active area to such an extent that the backscattering effect is uniform over the whole of the active area. It is recommended that the backing material should extend at least 10 mm beyond the active area of the source.

A photon-emitting standard shall include the filtration specified in Table 1. The filter should normally be an integral part of the source, it should not be removable. Their purpose is described in Annex A. The area of the filter should be such that it extends for at least 10 mm beyond the active area of the source. The thickness of the filter shall be within 10 % of the specified value in Table 1.

Standards shall be accompanied by a calibration certificate giving the following information:

a) radionuclide;

NOTE Half-life values and other current nuclear data values are provided by Reference [14].

b) source identification number;

c) surface emission rate and its uncertainty;

d) activity and its uncertainty;

e) impurities of an activity of at least 1 % of the principal radionuclide activity;

f) reference date [shall be identical for c), d) and e)];

g) active area: its location and size;

h) nature, thickness, density, and dimensions of substrate;

i) nature, thickness, density, and dimensions of filter (if any);

j) uniformity and uncertainty (table of relative emission rates of all individual portions relating position and emission rate);

k) class of standard.

Manufacturers may decide to give further information of help to the user, such as the depth of the active layer. Markings on the source itself shall indicate the radionuclide and the source identification number.

5.2.2 Activity and surface emission rate

The activity of a Class 1 reference measurement standard of the preferred size should be such as to give a surface emission rate from about 2 000 s^{-1} to 10 000 s^{-1} in order to optimize between background, statistical uncertainty, and dead-time error. The activity shall be stated with a relative uncertainty not exceeding 10 %. The surface emission rate shall be measured by the national metrology institute with a relative uncertainty not exceeding the following:

a) 3 % for alpha standards;

b) 3 % for beta standards with an end-point energy greater than 150 keV;

c) 5 % for beta standards with an end-point energy less than 150 keV;

d) 10 % for photon standards.

Class 1 reference measurement standards should be re-calibrated in terms of activity, surface emission rate, and uniformity at a frequency of not less than once every four years.

NOTE 1 The frequency of recalibration of a reference measurement standard can be different from country to country, depending on national regulations.

NOTE 2 Overall reference measurement standard activity needs to be related to its size when it is used to calibrate different sized detectors. The reference measurement standard might need sufficient activity/cm^2 to accommodate detectors with a working area of 6,4 cm^2 but not so much activity as to overload a detector with a working area of 200 cm^2.

5.2.3 Uniformity

The uniformity of a reference measurement standard shall be expressed as 1 minus the standard deviation of the surface emission rates (σ_n) of the individual portions of the whole reference measurement standard divided by the mean value of these emission rates (n), as given in Formula (1):

$$\left(1-\frac{\sigma_n}{n}\right)\times 100\,(\%) \tag{1}$$

The uniformity of a Class 1 reference measurement standard shall be greater than 90 %. For the purpose of specifying the uniformity of a reference measurement standard with respect to surface emission rate per area, the reference measurement standard shall be considered as comprising a number of portions of equal area and shape. For rectangular reference measurement standard, the shape of the portions shall be identical to the shape of its active area.

The area of the portions shall be 10 cm^2 or less. For the recommended sizes (see 5.2.1), a reference measurement standard of active area of 100 mm × 100 mm and 100 mm × 150 mm shall be divided into 16 rectangular portions (4×4) and a reference measurement standard of 150 mm × 200 mm shall be divided into 36 rectangular portions (6×6).

The individual emission rates shall be determined with a relative uncertainty that shall be consistent with that specified for the whole reference measurement standard in 5.2.2 and 5.3.2. These uncertainties shall be taken into account when calculating the experimental standard deviation to determine the uniformity resulting in an uncertainty for the uniformity itself (see Reference [10]).

Uniformity may be measured by using the image plate technique, position sensitive measurement systems, or by inserting a masking plate between the reference measurement standard and the detector. The masking device shall have an aperture of appropriate size and provide sufficient shielding of the detector. For the masking plate technique, care should be taken to always use the same portion of the detector to minimize effects due to possible non-uniformity of response to radiation across the surface of the detector. For the other techniques, care should be taken to minimize effects due to possible non-uniformity of the detection efficiency across the whole detector.

In those situations where the detector window area is less than the active area of the reference measurement standard, it is possible to avoid the requirement to have a detailed knowledge of the uniformity by characterizing, in an integral manner, the emission rate from that part of the reference measurement standard that is exposed to the detector window.

5.2.4 Radionuclides

Class 1 reference measurement standards should be prepared, if possible, from any of the radionuclides in Table 1, Table 2, and Table 3. The decay data given in these tables are for indicative information only, the data used for calibrations and calibration certificates shall be taken from Reference [14].

Table 2 and Table 3 have "preferred" and "possible alternative" categories. The preferred radionuclides are chosen for their general availability, suitably long half-lives, high specific activity, and ability to cover the normal range of energies encountered in typical monitoring situations.

The possible alternatives may suffer from concerns such as the need to replace them regularly

— due to their relatively short half-lives,

— due to their low specific activity which makes it difficult to provide sufficient activity in an infinitesimally thin active layer,

— because they emit additional unwanted radiation, and

— due to the difficulty in providing sufficient radioactive purities.

Table 2 — Radionuclides for alpha-emitting standards

Radionuclide	Half-life in days	Maximum energy in keV	Comments
Preferred			
^{241}Am	1,58 × 10^5	5 544	—
^{230}Th	2,75 × 10^7	4 688	—
Possible alternatives			
^{238}Pu	3,20 × 10^4	5 499	—

Table 3 — Radionuclides for beta-emitting standards

Radionuclide	Half-life in days	Maximum energy in keV	Comments
Preferred			
^{14}C	2,08 × 10^6	156	Depending on the nature of the manufacturing process, it might be necessary to re-calibrate more frequently because of possible isotopic exchange with C in atmosphere.
^{99}Tc	7,72 × 10^7	294	—
^{36}Cl	1,10 × 10^8	710	—
^{90}Sr/^{90}Y	1,05 × 10^4(^{90}Sr) 2,67 (^{90}Y)	546 (^{90}Sr) 2 280 (^{90}Y)	If only the higher-energy betas from ^{90}Y are required, a filter of 130 mg·cm^{-2} is needed but this results in significant spectral degradation of the ^{90}Y emission spectrum.
^{106}Ru/^{106}Rh	372 (^{106}Ru) 0,000 35 (^{106}Rh)	39 (^{106}Ru) 3 546 (^{106}Rh)	Relatively short half-life.
Possible alternatives			
^{147}Pm	958	224	Relatively short half-life.

NOTE 1 Most commonly used monitoring instruments cannot detect ^{3}H or ^{63}Ni, with a useful efficiency. Monitoring for these radionuclides normally requires specialized detectors and these radionuclides are not normally included in routine calibrations.

NOTE 2 Many calibration laboratories just use a sub-set of beta-emitting standards which cover the useful energy range that is being monitored for. Typically, the subset comprises ^{14}C, ^{36}Cl and ^{90}Sr/^{90}Y.

Table 3 *(continued)*

Radionuclide	Half-life in days	Maximum energy in keV	Comments
^{204}Tl	$1,38 \times 10^3$	764	Approximately 3 % of decays are by electron capture and produce X-ray emissions of about 70 keV to 90 keV.
^{60}Co	$1,93 \times 10^3$	317	Not a pure beta-emitter. Emits photons at 1,173 MeV and 1,332 MeV.
^{3}H	$4,50 \times 10^3$	19	Depending on the nature of the manufacturing process, it may be necessary to re-calibrate more frequently because of possible isotopic exchange with H in the atmosphere.
^{63}Ni	$3,61 \times 10^4$	67	—
NOTE 1 Most commonly used monitoring instruments cannot detect ^{3}H or ^{63}Ni, with a useful efficiency. Monitoring for these radionuclides normally requires specialized detectors and these radionuclides are not normally included in routine calibrations.			
NOTE 2 Many calibration laboratories just use a sub-set of beta-emitting standards which cover the useful energy range that is being monitored for. Typically, the subset comprises ^{14}C, ^{36}Cl and $^{90}Sr/^{90}Y$.			

5.3 Class 2 reference measurement standards

5.3.1 General requirements

Class 2 reference measurement standards shall comply with the same general requirements as specified for Class 1 reference measurement standards. They shall be marked with the same information as Class 1 reference measurement standards and shall be accompanied by a calibration certificate in accordance with 5.2.1.

5.3.2 Activity and surface emission rate

The emission rate of a Class 2 reference measurement standard of the preferred size should be as required by the user and depends on the type of instrument being calibrated and the particular test being carried out. The activity shall have been determined in a manner which provides traceability to the International System of Units (SI) and shall be stated with a relative uncertainty not exceeding 10 %. The surface emission rate shall be determined by means of a reference transfer measurement device (see Clause 6) with a relative uncertainty not exceeding the following:

a) 5 % for alpha standards;

b) 5 % for beta standards with an end-point energy greater than 150 keV;

c) 10 % for beta standards with an end-point energy less than 150 keV;

d) 15 % for photon standards.

Class 2 reference measurement standards shall be re-calibrated in terms of activity, surface emission rate, and uniformity at a frequency of not less than once every four years (see notes 1 and 2, in 5.2.2).

5.3.3 Uniformity

The uniformity of a Class 2 shall comply with the same requirements as specified for Class 1 (See 5.2.3).

5.3.4 Radionuclides

Class 2 reference measurement standards shall be prepared from among the same radionuclides as provided for Class 1 reference measurement standards in accordance with 5.2.4.

5.4 Working measurement standard

5.4.1 General requirements

The detailed requirements specified for working measurement standards shall be the responsibility of the user. Such standards may often be manufactured in the laboratories and due recognition shall be given to any relevant national regulations. In specifying working measurement standards, the following points need to be considered.

a) Working measurement standards shall be provided in a quantity and variety of sizes to meet the needs of the organization in respect of the routine calibration of its surface contamination monitors.

b) Working measurement standards shall be marked with the surface emission rate at a reference date, the radionuclide and the serial number, and shall be accompanied by a note detailing the geometry for which they have been calibrated and hence should be used. Where the size of the working measurement standard minimizes the space available for marking, the working measurement standard shall bear a unique identifier and shall be accompanied by a calibration certificate which also contains the unique identifier together with details of the radionuclide, surface emission rate, and reference date.

c) Working measurement standards shall be sufficiently robust to withstand day-to-day handling.

d) In the absence of conflicting requirements, working measurement standards should comply with the requirements specified for reference measurement standards in 5.3.

5.4.2 Activity and surface emission rate

The surface emission rate of a working measurement standards should be as agreed upon between the user and the manufacturer. The activity of a working measurement standards shall be stated by the manufacturer and shall be traceable to the SI. The surface emission rate shall have been measured on a transfer measurement device that has been calibrated using a Class 1 or a Class 2 reference measurement standards of the same construction. The surface emission rate of a working measurement standards needs to be known to the uncertainty specified by the appropriate instrument calibration regulations.

Working measurement standards shall be re-calibrated at a frequency of not less than once every two years.

5.4.3 Uniformity

The uniformity of a working measurement standard should preferably be the same as specified for a Class 2 reference measurement standard. In case that significant change not due to half-life is found on the re-calibration of surface emission rate, re-measurement of uniformity is required.

5.4.4 Radionuclides

Working measurement standards shall be prepared from such alpha-emitting, beta-emitting, and photon-emitting radionuclides as might be required by the user.

6 Transfer measurement devices

6.1 Transfer measurement device for alpha-radiation and beta-radiation

A transfer measurement device for alpha-radiation and beta-radiation shall have instrument efficiency greater than 35 % over the range of energies covered by this document. It should be of such size that the variation in spatial response over a measurement area of 100 mm × 150 mm may be ignored. The recommended type of reference transfer instrument for alpha-emitters and beta-emitters is a large-area, windowless, gas-flow proportional counter, together with a regulated gas supply.

6.2 Transfer measurement device for photon-radiation

It is unlikely that a single transfer measurement device would cover the full range of photon energies proposed in this document. The instrument used for a particular energy should have the following characteristics:

a) high detection efficiency;

b) uniformity of response over its surface;

c) stability;

d) low background noise.

Large-area proportional counters with appropriate gas filling are suitable for the measurement of the lower-energy photon emitters. Scintillation detectors such as NaI(Tl) are suitable for the higher-energy photon emitters.

6.3 Calibration

A transfer measurement device shall be calibrated both initially and at regular time intervals during its working life in accordance with regulatory requirements, codes of practice, or other recommendations. It is recommended that the transfer measurement device be re-calibrated at least annually or if less frequently, calibrate before any use as a transfer measurement device. Calibration of a transfer measurement device shall be the responsibility of the organization. Where beta-emitting radionuclides not available as Class 2 reference measurement standards are required as working measurement standards, traceability may be maintained by interpolation of the reference transfer instrument efficiency. However, for beta-emitters of maximum energy less than 0,5 MeV where the efficiency of gas-flow proportional detector changes steeply as a function of energy, interpolation could lead to large errors and every effort should be made to obtain suitable Class 1 or Class 2 reference measurement standards.