INTERNATIONAL STANDARD

ISO 7503-1

Second edition
2016-01-15

Corrected version
2018-02-15

Measurement of radioactivity — Measurement and evaluation of surface contamination —

Part 1: General principles

Mesurage de la radioactivité — Mesurage et évaluation de la contamination de surface —

Partie 1: Principes généraux

Reference number
ISO 7503-1:2016(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

The committee responsible for this document is ISO/TC 85, *Nuclear energy nuclear technologies and radiological protection*, Subcommittee SC 2, *Radiation protection*.

This second edition cancels and replaces the first edition (ISO 7503-1:1988), which has been technically revised.

ISO 7503 consists of the following parts, under the general title *Measurement of radioactivity — Measurement and evaluation of surface contamination*:

— *Part 1: General principles*

— *Part 2: Test method using wipe-test samples*

— *Part 3: Apparatus calibration*

This corrected version of ISO 7503-1:2016 incorporates the following corrections:

— In 3.2, for I*(A)*, replace "$(Bq \cdot cm^{-2})/s^{-1}$" by "$s^{-1}/(Bq \cdot cm^{-2})$";

— In Clause 9, replace the first paragraph which has been rephrased.

Introduction

ISO 7503 gives guidance on the measurement of surface contamination. This International Standard is applicable to many situations where radioactive contamination can occur. Contamination arises from the release of radioactivity into the local environment. In most circumstances, the release is inadvertent but, on occasion, may be deliberate. Although the purpose and scope of the investigation may differ, the approaches taken to measure the levels and extent of the contamination are essentially similar.

Radioactive contamination can arise from a number of activities or events such as the following:

— routine laboratory use of radio-chemicals;

— medical treatments;

— industrial applications;

— transport accidents;

— equipment malfunctions;

— malevolent incidents;

— nuclear accidents.

Without process knowledge or documentation, it is not always possible to identify or distinguish the different radionuclides constituting a surface contamination, and the evaluation of such a contamination cannot be made on a quantitative basis. Instead of using instruments with nuclide specific calibrations, it may be necessary to use other instruments which are fit for such a purpose.

However, there may be cases (e.g. a contaminated fuel material transport container) where the radionuclide or the radionuclide mixture can be clearly characterized. A surface contamination evaluation exceeding a pure qualitative assessment of fixed and removable surface contamination may then be needed. Moreover, following requirements laid down in national regulations and in international conventions, a measured surface contamination activity per unit area has to be compared with surface contamination guideline values or surface contamination limits.

Surface contamination guideline values are radionuclide-specific and thus require complex radionuclide-specific calibrations of measurement equipment. Calibration quality assurance is crucial in order to avoid non-detection (i.e. type II decision errors) leading to incorrectly assuming compliance with given surface contamination guideline values or limits. Evaluation of surfaces contaminated by a mixture of radionuclides with known ratios requires respectively proportionated calibration factors.

ISO 7503 is concerned with the measurement and estimation of radioactivity levels. It does not provide advice on decommissioning, planning and surveillance techniques.

Surface contamination is specified in terms of activity per unit area and the limits are based on the recommendations by the International Commission on Radiological Protection (ICRP 103).

This part of ISO 7503 deals with the evaluation of surface contamination by direct measurement using a surface contamination instrument, and in the case of the indirect method, using wipe tests. This part of ISO 7503 is primarily concerned with direct monitoring, practical guidance on measurements, it describes principles to keep an instrument in a fitness-for-purpose state. This part of ISO 7503 also presents instrument calibration principles and compiles the basic uncertainties of both surface contamination evaluation methods.

Measurement of radioactivity — Measurement and evaluation of surface contamination —

Part 1: General principles

1 Scope

ISO 7503 (all parts) and ISO 8769 are addressed to the people responsible for determining the radioactivity present on solid surfaces. ISO 7503 is published in three parts and can be used jointly or separately according to needs.

This part of ISO 7503 relates to the assessment of surface contamination by direct and indirect measurements and the calibration of the associated instrumentation.

The standard applies to alpha-, beta- and photon emitters and is intended for use by hospitals, universities, police, or industrial establishments. The standard also can be used in the assessment of activity on trucks, containers, parcels, equipment and is applicable in any organization which handles radioactive materials. Generally, it is applicable to well defined flat surfaces where direct methods are applicable, however, it can also be used for surfaces which are not flat and where indirect wipe tests would be appropriate. These investigations may be carried out on containers, inaccessible areas, non-flat areas where wipe tests can be used. This part of ISO 7503 may be useful in emergency situations, i.e. in nuclear accidents where health physics professionals would be involved.

This part of ISO 7503 does not apply to the evaluation of contamination of the skin, of clothing and of loose material such as gravel.

NOTE The test method using wipe-test samples for the evaluation of radioactive surface contaminations is dealt with in ISO 7503-2. The calibration of instruments for the evaluation of radioactive surface contaminations is dealt with in ISO 7503-3.

2 Normative references

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

ISO 8769, *Reference sources — Calibration of surface contamination monitors — Alpha-, beta- and photon emitters*

ISO 11929, *Determination of the characteristic limits (decision threshold, detection limit, and limits of the confidence interval) for measurements of ionizing radiation — Fundamentals and application*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
activity per unit area
ratio between the activity of the radionuclides present on a surface and the area of that surface, expressed in becquerels per square centimetre

3.1.2
surface contamination
radioactive substances deposited on defined surfaces

3.1.3
fixed surface contamination
surface contamination which cannot be removed or transferred by non-destructive means

3.1.4
removable surface contamination
radioactive material that can be removed from surfaces by non-destructive means, including casual contact, wiping, or washing

Note 1 to entry: It should be noted that under the influence of moisture, chemicals, etc., or as a result of corrosion or diffusion, fixed contamination may become removable or *vice versa* without any human action. Furthermore, surface contaminations may decrease due to evaporation and volatilization.

Note 2 to entry: It should be emphasized that the ratio between fixed and removable contamination can vary over time, and that some decisions, such as those related to clearance, should be based on total activity with the potential to become removable over time, not just the amount that is removable at the time of a survey.

3.1.5
direct measurement of surface contamination
measurement of surface contamination by means of a contamination meter or monitor

3.1.6
indirect evaluation of surface contamination
evaluation of the removable surface contamination by means of a wipe test

3.1.7
wipe test
test to determine if removable contamination is present through wiping the surface with a dry or wet material, followed by evaluation of the wipe material for removable contamination

3.1.8
wiping efficiency
ratio of the activity of the radionuclides removed from the surface by one wipe sample to the activity of the radionuclides of the removable surface contamination prior to this sampling

Note 1 to entry: In practice, it is almost impossible to measure the total amount of removable activity on the surface, and in most cases, a value for the wiping efficiency cannot be assessed but can only be estimated.

3.1.9
surface emission rate of a source
number of particles of a given type above a given energy or of photons emerging from the front face of the source per unit time

3.1.10
instrument efficiency
ratio between the instrument net reading and the surface emission rate of a source under given geometrical conditions

3.1.11
emission instrument response
instrument efficiency times detector window area, equals the observed net count rate per surface emission rate per unit area of a calibration source

3.1.12
activity instrument response
instrument efficiency times detector window area times the probability of a particle or photon leaving the source surface, equals the observed net count rate per Bq per unit area of a calibration source

3.1.13
emission calibration factor
reciprocal of instrument efficiency times window area

3.1.14
activity calibration factor
reciprocal of instrument efficiency times window area times probability of a particle leaving the source surface

3.1.15
calibration

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

3.1.16
guideline value
value which corresponds to scientific, legal or other requirements for which the measuring procedure is intended to assess

3.2 Symbols and abbreviated terms

For the purposes of this part of ISO 7503, the following symbols apply:

$I(E)$	emission instrument response in $s^{-1}/(s^{-1}\cdot cm^{-2})$
ρ_c	observed count rate from the calibration source in s^{-1}
ρ_0	background count rate in s^{-1}
R_c	emission rate of the calibration source in s^{-1}
S_c	area of the calibration source in cm^2
$I(A)$	activity instrument response in $s^{-1}/(Bq\cdot cm^{-2})$
A_c	activity of the calibration source in Bq
P	inverse of probability of a particle emerging from the surface, equal ratio of the particle or photon generation rate (activity) and the emission rate from the surface in Bq^{-1}/s^{-1}
S_p	effective detector or probe area in cm^2
$C(E)$	emission calibration factor in $(s^{-1}\cdot cm^{-2})/s^{-1}$

$C(A)$ activity calibration factor in $(Bq \cdot cm^{-2})/s^{-1}$

ε instrument efficiency in s^{-1}/s^{-1}

A_s activity per unit area of fixed and removable contamination in $Bq \cdot cm^{-2}$

ρ_g measured total (gross) count rate in s^{-1}

4 Objectives of surface contamination measurements

4.1 General

Initial investigations into possible surface contamination need to assume a worst case scenario. The area, environment or premises need to be approached assuming that there may be significant dose-rates. If the initial investigation establishes that the dose rates do not present a radiological hazard where shielding may be necessary, the issue of contamination needs to be addressed.

If the investigation is routine, then the initial investigation into possible high dose rates does not need to be undertaken. The investigation only needs to proceed into possible surface contamination.

Having established the presence of surface contamination, the question of contamination instrumentation needs to be considered. Factors such as the instrument response to the likely radionuclide contamination and other aspects shall be assessed. The area to be monitored may determine the size of the most suitable detectors.

The bibliography contains publications which provide guidance on suitable instrumentation.

4.2 National and international regulations

It is necessary to comply with current national and international regulations or existing standards and guidance in addition to the customer requirements. National and international regulations provide guidance on averaging areas. In particular, it is essential to establish the areas over which measurements may be averaged for the purposes of demarcating areas on the basis of contamination levels.

4.3 Definition of the measuring programme

The objectives of a surface contamination measurement programme are

— the detection of ionizing particles or photons emitted from a surface contaminated with radioactive material, and

— the evaluation of the instrument readings which can be used to provide an estimate of the quantities and characteristics radioactive contaminants.

In order to achieve these objectives with a reasonable degree of confidence, it is necessary to plan the monitoring procedure. In many organizations, there are standard procedures that state how routine radiation protection monitoring should be done. The monitoring takes place in familiar areas, carried out by an organization's own staff, using its own monitoring equipment and reporting system.

In some circumstances, there may be no standard procedures in place to develop a suitable measurement programme. In these circumstances, information needs to be gathered, which might include the collection and documentation of the following details:

a) identification of the operator;

b) defining the areas or items to be monitored;

c) history of the areas to be monitored to include

    1) radionuclides used in the area and at what times and in what quantities,

2) refurbishment, repair and maintenance histories, and

3) previous survey results and possibly trend analysis;

d) the level of detail and levels of accuracy required by the operator;

e) the sampling strategy;

f) the need to distinguish between fixed and removable contamination;

g) the need for any direct or indirect measurements;

h) types and quantities of equipment required for specific measurements and available including status of calibration;

i) details of current dose rate levels around and within the areas to be surveyed;

j) limitations on access;

k) need for personal protective equipment (overalls, breathing apparatus, rubber gloves);

l) facilities for disposal of radioactive waste;

m) liaison with other organizations (e.g. police, national regulatory agencies);

n) environmental conditions (e.g. temperature, humidity);

o) types of surfaces to be monitored (e.g. rough concrete, painted contaminated surfaces).

Having gathered the relevant information listed above, an appropriate measurement programme should be developed and documented. The measurement programme should include the calculations and assumptions used in establishing the action levels. It is recommended that the measurement programme expresses where possible, the action levels in the same units that are displayed on the specified instruments. The measurement programme should include the steps to be taken whenever those levels are exceeded and the designation of those personnel who can authorize the resumption of the measurement programme if action levels have been exceeded.

5 Direct and indirect methods of assessing surface contamination

5.1 General

Contamination on a surface can be assessed either directly or indirectly.

The initial investigation into the contamination of premises should assume the worst case. The premises should be approached assuming that there may be a significant dose rate. This may be applicable to only one laboratory or maybe the whole building. If the initial investigation establishes that the dose rate does not present a shielding problem or radiological hazard, then the issue of contamination can then be addressed.

The applicability and the reliability of direct measurement or indirect evaluation of surface contamination are strongly dependent on the particular circumstances, i.e. the physical and chemical form of the contamination, the adherence of contamination on the surface (fixed or removable), the accessibility of the surface for measurement or the presence of interfering radiation fields.

Direct measurement is used when the surface is readily accessible without

— interfering inactive liquid or solid deposits that cannot be taken into account, or

— interfering radiation fields that cannot be taken into account.

Indirect evaluation of surface contamination is generally more applicable when the surfaces are not readily accessible because of difficult location or configuration, or where interfering radiation fields adversely affect contamination monitors, or when methods of direct measurement with standard instrumentation are not available. An indirect method cannot assess fixed contamination, and because of the great uncertainty usually related to the wiping efficiency, application of the indirect method usually results in conservative estimations of removable contamination.

Due to the inherent shortcomings of both the direct measurement and the indirect evaluation of surface contamination, in many cases, the use of both methods in tandem can help ensure results which best meet the aims of the evaluation.

5.2 Direct method

The direct method is the best approach whenever possible. In the direct method, the monitor probe is moved over a surface, with the face of the probe at a minimal distance of approximately 3 mm from the surface. The probe shall be kept stationary for a minimum to obtain sufficient accuracy. This measurement can then be used to determine the radiation emitted from the surface.

There are many circumstances where the above measurement might not be possible. A surface may be so convoluted that it is not possible to monitor it directly, or the background radiation may be so high that it is impossible to obtain meaningful results from the measurements; however, these results should be recorded because a calibration could be provided later. In these instances, an indirect measurement has to be made using a wipe test.

5.3 Indirect method (wipe tests)

A test procedure is often carried out using a filter paper or other wipe, typically 20 mm to 60 mm in diameter, which can be placed in commercial holder for measurement. The filter paper should be wiped over the area, usually at least 100 cm^2, or whatever area is locally defined for the surface that may be contaminated with radionuclides. The filter paper can either be placed in a lab counter drawer to assess the level and type of activity, or sent to a radiochemistry laboratory for a full assessment of nuclide type and activity. In both instances, all measurements should be traceable to national standards or governed by local requirements.

Wipe tests can be either "dry wipe" or "wet wipe". In general, it is a senior health physics professional who makes the decision on which to use.

The indirect surface evaluation contamination method is described in detail in ISO 7503-2.

5.4 Wipe test uncertainties

A brief discussion on uncertainties is given in 10.3.

6 Radionuclide identification and spectral analysis

Normally, the radionuclides are known. If not, they need to be identified. Radionuclide identification of contaminants using hand-held instruments is only practicable where the contaminants are gamma emitting nuclides with energies in the range of 50 keV to 1500 keV. If the contaminant does not emit photons in this range, it may not be possible to identify the radionuclide with hand-held instruments. In cases such as an accident or where only one radionuclide is in use, it may not be necessary for it to be determined as the contamination is known. Otherwise, more sophisticated techniques such as beta and alpha spectroscopy are required and these techniques are usually only available in a well-equipped laboratory where samples from the contaminated site can be prepared and analysed.

Small hand-held instruments exist that permit spectroscopic analysis of gamma radiation. In general, the instruments use a small, approximately 40 mm × 40 mm, NaI crystal as the principle detector. The sensitivity of a NaI crystal to gamma radiation makes these instruments particularly useful as "search and locate" devices particularly for finding and identifying lost or hidden gamma sources. However, it is not possible to make an accurate assessment of contamination levels using this type of instrument. A small NaI crystal connected to a multichannel analyser (MCA) permits spectral analysis of the

