INTERNATIONAL STANDARD

ISO 11932

First edition
1996-12-15

Activity measurements of solid materials considered for recycling, re-use, or disposal as non-radioactive waste

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Mesures d'activité de matériaux solides considérés comme déchets non radioactifs destinés à un recyclage, une réutilisation, ou une mise au rebut

ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

Reference number
ISO 11932:1996(E)

Contents

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

© ISO 1996

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 the publisher.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

International Standard ISO 11932 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Working Group WG2, *Radioactivity measurements*.

ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

Introduction

During the TC 85 Plenary Meeting in Paris (1988-10-13), it was decided to set up a new ad hoc working group "*Radioactivity Measurements*" to deal with, among other topics, the task to investigate in which areas measurements, in particular regarding low-level radioactivity, can be carried out and to what extent international standardization in this area is desirable. In view of the topics treated in other Technical Committees, for example radioactivity measurements in soil and water, a need exists for a standard on "Determination of the Decision Threshold and the Detection Limit for Ionizing Radiation Measurements". Moreover, a need for an International Standard directly related to the field of nuclear energy and, in particular, to the problem of recycling, re-use or disposal of materials from the dismantling of nuclear installations as inactive materials, was identified. Primarily, major nuclear installations for electricity production and to a lesser extent, installations like particle accelerators and reprocessing plants may be over thirty years old and therefore reaching the end of their scheduled lifetime. It is estimated that 51 commercial nuclear power plants were decommissioned in OECD countries between 1981 and 1995 and another 237 should be decommissioned during the following 15 years (reference [1] in annex C). Of the contaminated and activated metals arising from decommissioning, it has been calculated (reference [2] in annex C) that about 4 800 t of steel from a 1 000 MW(e) pressurized water reactor (PWR) would have a specific activity at, or below, 1 $Bq \cdot g^{-1}$. This specific activity limit is proposed as a possible limit for unrestricted recycling of steel scrap in the CEC. Consequently, in view of the quantities of scrap concerned and the fact that material released in one country for unrestricted use may enter other countries as ordinary scrap, international standardization of the radioactivity measurement procedures used to show compliance with release criteria is urgently needed.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Until now, the recycling or re-use of materials from nuclear installations is handled in individual countries using ad hoc criteria based on existing national legislations. However, international criteria for release of materials have been developed and are waiting to be adopted formally. For instance, a CEC Group of Experts recommended the following clearance levels for recycling of contaminated or activated steel (reference [2] in annex C) as mentioned above, and they are given here only as an example.

For beta/gamma activity:

- a specific activity limit of 1 Bq · g^{-1} averaged over a maximum mass of 1 tonne with no single piece exceeding 10 Bq · g^{-1};
- a surface activity limit of 0,4 Bq · cm^{-2} for non-fixed contamination on accessible surfaces, averaged over 300 cm^2 or over the whole area if it is less than 300 cm^2;
- for fixed contamination, the specific activity limit is assumed to be applied.

For alpha emitters:

- a surface activity limit of 0,04 Bq · cm^{-2} averaged over an area of 300 cm^2.

Other examples may be found in references [3] and [4] in annex C. In addition, release criteria are sometimes based on total activity.

This International Standard concerns radioactivity measurements in materials, to show compliance with release criteria as mentioned above or criteria of similar magnitude, as defined by national or international authorities. A review of experience in this field is given in reference [5] in annex C.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

This page intentionally left blank

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

Activity measurements of solid materials considered for recycling, re-use, or disposal as non-radioactive waste

1 Scope

This International Standard specifies basic guidance and methods for activity measurements of materials to be released for recycling, re-use or disposal as non-radioactive waste arising from the operation and decommissioning of nuclear facilities, in order to show compliance with established criteria for unrestricted release. It does not apply to ordinary radioactive waste.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/69ca2ff1-4076-42dc-86e4-d631fe6663e5/iso-11932-1996

ISO 4037:1979, *X and γ reference radiations for calibrating dosemeters and doseratemeters and for determining their response as a function of photon energy.*

ISO 6980:1984, *Reference beta radiations for calibrating dosemeters and doseratemeters and for determining their response as a function of beta radiation energy.*

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

ISO 7503-2:1988, *Evaluation of surface contamination — Part 2: Tritium surface contamination.*

ISO 7503-3:1996, *Evaluation of surface contamination — Part 3: Isomeric transition and electron capture emitters, low energy beta emitters (maximum beta energy less than 0,15 MeV).*

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

ISO 11929-1:1996, *Determination of the lower limits of detection and decision for ionizing radiation measurements — Part 1: Fundamentals and applications to counting measurements without the influence of sample treatment.*

 © ISO

ISO 11929-2:—[1], *Determination of the lower limits of detection and decision for ionizing radiation measurements — Part 2: Fundamentals and applications to counting measurements with the influence of sample treatment.*

ISO 11929-3:—[1], *Determination of the lower limits of detection and decision for ionizing radiation measurements — Part 3: Fundamentals and applications to counting measurements by high-resolution gamma spectrometry without the influence of sample treatment.*

IEC 325:1981, *Alpha, beta and alpha-beta contamination meters and monitors.*

IEC 846:1989, *Beta, X and gamma radiation dose equivalent and dose equivalent rate meters for use in radiation protection.*

IEC 1017-1:1991, *Portable, transportable or installed X or gamma radiation ratemeters for environmental monitoring — Part 1: Ratemeters.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 activity (of an amount of a radionuclide in a particular energy state at a given time)**:** Quotient of the expectation value of the number of spontaneous nuclear transitions, dN, from that energy state and the time interval, dt.

The special name for the SI unit of activity is the becquerel (Bq) (1 Bq = 1 s^{-1}).

iTeh STANDARD PREVIEW
(standards.iteh.ai)

3.2 specific activity: Activity of a specified material divided by its mass.

It is expressed in becquerels grams to the power of minus one (Bq · g^{-1}).

ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42de-86e4-1631bf6665e5/iso-11932-1996

NOTE — The term "mass activity concentration" is used sometimes in other publications (see reference [2] in annex C) but ISO terminology is used throughout this International Standard.

3.3 surface contamination: Contamination of surfaces with radioactive substances.

3.4 surface activity: Ratio between the activity of the radionuclides present on a surface and the area of that surface.

It is expressed in becquerels centimetres to the power of minus two (Bq · cm^{-2}).

3.5 directly measurable surface contamination: Fraction of the surface contamination available for direct measurement.

3.6 removable surface contamination: Fraction of surface contamination which is removable or transferable under normal working conditions.

3.7 indirect evaluation of removable surface contamination: Evaluation of the removable activity on a surface by means of a smear sample.

3.8 smear test: Taking of a sample of removable activity by wiping the surface with dry or wet material and the subsequent evaluation of the activity transferred to the material used to wipe the surface.

3.9 removal factor, F**:** Ratio of the activity removed from the surface by one smear sample to the activity of the removable surface contamination prior to the sampling.

---

1) To be published.

3.10 instrument efficiency, ε_i**:** Ratio between the instrument net reading (counts per unit time) and the surface emission rate of the source (particles or photons emitted per unit time) in a specified geometry relative to the source.

NOTE — The instrument efficiency depends on the energy of the radiations emitted by the source.

3.11 contamination source efficiency, ε_s**:** Ratio between the surface emission rate and the number of particles or photons of the same type created or released within the source per unit time.

NOTE — According to this definition, the efficiency of a source would be expected to be less than 0,5, since emission occurs from the front face only; however, a contribution due to back-scattered particles may enhance this value.

3.12 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 unit time.

4 Requirements for activity measurements related to unrestricted release

4.1 General

Radioactivity measurements related to unrestricted release of solid materials to be treated in this standard deal with

— surface contamination measurements;

— specific activity measurements;

— dose-rate measurements;

— total activity estimates.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665e5/iso-11932-1996

These release criteria could be, for instance:

surface contamination: between 0,4 $Bq \cdot cm^{-2}$ and 4,0 $Bq \cdot cm^{-2}$ for beta/gamma emitters or between 0,04 $Bq \cdot cm^{-2}$ and 0,4 $Bq \cdot cm^{-2}$ for alpha emitters (averaged over areas between 100 cm^2 and 1 m^2);

specific activity: range from 0,1 $Bq \cdot g^{-1}$ to 10^4 $Bq \cdot g^{-1}$ (limitations set also to local and average values);

dose rate: from 0,05 $\mu Gy \cdot h^{-1}$ to 1 $\mu Gy \cdot h^{-1}$(above local background, dose rate near surface).

Criteria for unrestricted use of solids to be released for recycling, re-use or disposal and the combination rules in their applicabilities are set by national authorities.

4.2 Surface contamination measurements

4.2.1 Radionuclides to be considered

The radionuclides of concern encountered during operation and decommissioning will depend strongly on the type of nuclear installation (e.g. power reactor, enrichment plant, accelerator, fuel fabrication plant) and will differ from one nuclear installation to another. Whatever the installation, the radionuclide mixture must be known before starting a large-scale programme of surface contamination monitoring, since the response of the survey instrument depends on the radionuclide mixture. Therefore, the mixture of contaminating radionuclides shall be determined for each part of the plant, unless it concerns an installation with one known single contaminant [e.g. natural uranium oxide (UO_2)]. Such laboratory measurements are an essential precursor to provide "fingerprint" information for field measurements.

4.2.1.1 Determination of radionuclide mixture

The composition of the radionuclide mixture can be determined by one or both of the following methods:

— High-resolution gamma and X-ray spectrometry using, for example, Ge(Li) or high-purity germanium detectors for gamma radiation and Si(Li) or high-purity planar germanium detectors for X and soft gamma radiations for the energy range of 5 keV to 50 keV.

— Radioanalysis for low-activity samples using methods such as fixation on "carriers", radiochemical separation to isolate, in particular, radionuclides which cannot be measured by gamma-ray spectrometry (see annex B).

Calculations may be used to supplement the measurements, but only when the accuracy of the calculation has been confirmed by spot measurements and only in situations where activity from bulk activation dominates the activity inventory. They cannot be used whenever contamination is important.

4.2.2 Methods to determine surface contamination

4.2.2.1 General

Surface contamination can be determined by direct or indirect measurements (see also ISO 7503-1, ISO 7503-2 and ISO 7503-3). Direct measurements are carried out with contamination meters and monitors. These detectors measure both fixed and removable surface contamination. Indirect measurements are carried out using smear tests to determine the removable surface contamination.

Direct measurements may sometimes be difficult, or impossible, if inactive solid or liquid deposits are present on the surface, or if the measurements are influenced by high background-radiation levels due to, for example, activation of the objects to be checked, or if the surface to be checked is not accessible for an instrument.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Indirect methods (smear tests) can only be used to determine the non-fixed contamination level with an uncertainty in the removal fraction. Certain exemption-criteria proposals (reference [2] in annex C) recommend, however, clearance levels for non-fixed contamination only on accessible surfaces. In this case, direct measurements may result in an overestimation and smear tests are therefore more appropriate. In many cases, a combination of both methods will lead to the most reliable results. Smear tests may be ineffective for the determination of tritium (see also 4.2.2.5).

ISO 11932:1996

4.2.2.2 Direct measurements of surface contamination

4.2.2.2.1 Measuring instruments

The characteristics and performance of the measuring instruments shall be in accordance with IEC 325. The instruments shall be capable of detecting activities below the level of the surface-contamination release criteria as defined by international or national regulations. Guidance on the detection limit may be obtained from ISO 11929-1, ISO 11929-2 and ISO 11929-3.

4.2.2.2.2 Detection procedure

The detector is moved as close as practicable over a surface. Once a contaminated area is detected, the detector shall be positioned over this area and held stationary for a sufficient length of time to confirm the measured value of the contamination. The speed of movement shall be commensurate with the contamination limit and the performance characteristics of the detector.

4.2.2.2.3 Measurement procedure

When making a measurement, the operating instructions relating to the measuring instrument used and the following requirements shall be complied with.

a) The background count rate shall be determined at a place representative of the area to be surveyed.

b) The background count rate shall be checked regularly.

c) The correct functioning of the instrument should be verified using a suitable check source (daily for instruments used frequently). Deviations of more than 25 % from the agreed value shall give rise to a recalibration of the instrument.

d) Removable spacers may be required to keep the distance between the detector and surface as small as possible.

e) The detector shall be kept in position for at least three times the response time of the instrument (indication 95 %).

f) The instrument efficiency for the radionuclides to be measured shall be known over the anticipated range of environmental conditions.

g) The effect of the shape of the surface of the objects to be checked on the instrument efficiency shall be evaluated, in case the surface is not flat (examples can be found in reference [6] in annex C).

h) The effect on the contamination source efficiency, ε_S, of visible layers of dirt and/or oxidation on the surface of the objects to be checked shall be taken into account, in case these layers cannot be removed. Correction factors are given in annex A for various radionuclides, as a function of surface density of the absorbent layer.

According to ISO 7503-1 the surface activity, alpha or beta, A_S, of the fixed and non-fixed contamination in $Bq \cdot cm^{-2}$ is given by the following equation:

$$A_S = \frac{(n - n_B)}{\varepsilon_i \times \varepsilon_S \times W} \quad \ldots (1)$$

where

n is the total count rate, in reciprocal seconds;

n_B is the background count rate, in reciprocal seconds;

ε_i is the instrument efficiency for alpha or beta radiation;

W is the surface of the detector window, in square centimetres;

ε_S is the efficiency of the contamination source.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
ISO 11932:1996
https://standards.iteh.ai/catalog/standards/sist/b9ca2ff1-4076-42dc-86e4-d631fe6665a5/iso-11932-1996

In the absence of known values, ε_S can be taken as

$\varepsilon_S =$ 0,5 [beta emitters ($E_\beta \geqslant$ 0,4 MeV)]

$\varepsilon_S =$ 0,25 [beta emitters (0,15 MeV $< E_\beta <$ 0,4 MeV) and alpha emitters]

where E_β is the maximum beta particle energy.

The possibility of underestimating the alpha contamination is discussed in ISO 7503-1.

4.2.2.3 Indirect measurements of surface contamination

4.2.2.3.1 Measuring instruments

Smear samples should preferably be measured with well-shielded fixed counting equipment, such as alpha/beta proportional counters, gamma spectroscopy systems and liquid scintillation counting systems. If portable contamination monitors and meters are used, they shall be in agreement with IEC 325. The instruments shall be able to determine the activity removed, such that surface activity can be easily determined as being below the clearance criteria for surface activity concentration, as defined by national or international regulations.

NOTE — Most instruments are capable of detecting less than 0,4 Bq for alpha contamination and less than 4 Bq for beta contamination. This implies that for a smear sample covering 100 cm^2, and assuming a removal factor F = 0,1, it is possible to measure a non-fixed contamination of less than 0,04 $Bq \cdot cm^{-2}$ for alpha emitters and of less than 0,4 $Bq \cdot cm^{-2}$ for beta emitters, these being, for example, the CEC proposed clearance levels for surface activity concentrations.