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Measurement of radioactivity - Gamma ray and beta emitting radionuclides - Test method to assess the ease of decontamination of surface materials

Décontamination des surfaces contaminées par radioactivité — Méthode d'essai et de détermination de l'aptitude à la décontamination

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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).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html .

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

This second edition cancels and replaces the first edition (ISO 8690:1988), which has been technically revised. The main changes compared to the previous edition are as follows:

Introduction

Wherever radioactivity is used, there is a risk that surfaces can become contaminated through contact with radioactivity in solution or airborne radioactivity. It is normally necessary to remove this surface contamination to reduce the risk to staff from accidental ingestion of the radioactivity on the surface. The ease of decontaminating surface materials is therefore an important parameter to consider when selecting materials to use e.g. for facilities in the nuclear industry, in radionuclide laboratories or nuclear medicine facilities.

This document defines a quantitative method under objective conditions for testing the ease of decontamination of surface materials. The method enables the comparison of different surface materials to support decisions on materials to use for different applications.

For the test, radioactive solutions are deposited onto a sample of the material being studied. The solutions contain radionuclides commonly found in the nuclear industry (^{60}Co, ^{137}Cs or ^{134}Cs) and are in aqueous form. The surface is then cleaned and the residual activity on the surface is measured to give a quantitative measure of the ease of decontamination.

The results of the tests on different materials therefore help the user select the best surface material for the application being considered.

Measurement of radioactivity - Gamma ray and beta emitting radionuclides - Test method to assess the ease of decontamination of surface materials

1 Scope

This document applies to the testing of surfaces which may become contaminated by radioactive materials.

The ease of decontamination is a property of a surface and an important criterion for selecting surface materials used in the nuclear industry, interim storage or disposal facilities from which contamination can be removed easily and rapidly without damaging the surface. The test described in this document is a rapid laboratory-based method to compare the ease of decontamination of different surface materials.

The results from the test may be one parameter to take into account when selecting surface coatings such as varnish or imperious layers such as ceramics and other surfaces. The radionuclides used in this test are those commonly found in the nuclear industry (^{137}Cs, ^{134}Cs and ^{60}Co) in aqueous form. The test can also be adopted for use with other radionuclides and other chemical forms, depending on the customer requirements, if the solutions are chemically stable and do not corrode the test specimen.

The test does not measure the ease of decontamination of the surface materials in practical use, as this depends on the radionuclide(s) present, their chemical form, the duration of exposure to the contaminant and the environmental conditions amongst other factors.

The test method is not intended to describe general decontamination procedures or to assess the efficiency of decontamination procedures (see ISO 7503- series).

In practical applications, it may be important to consider other factors, such as chemical, mechanical and radiation resistance and long-term stability in the selection of the materials to be used. It should be recognized that further decontamination tests under simulated service conditions may be needed.

2 Normatives 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 15, *Rolling bearings — Radial bearings — Boundary dimensions, general plan*

ISO 273, *Fasteners — Clearance holes for bolts and screws*

ISO 2009, *Slotted countersunk flat head screws — Product grade A*

ISO 2010, *Slotted raised countersunk head screws — Product grade A*

ISO 3819, *Laboratory glassware — Beakers*

ISO 4762, *Hexagon socket head cap screws*

ISO 11074, *Soil quality — Vocabulary*

ISO 80000-10, *Quantities and Units — Part 10: Atomic and Nuclear Physics*

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

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the definitions, symbols and abbreviations defined in ISO 11074, ISO 80000-10, ISO/IEC Guide 98-3 and ISO/IEC Guide 99, and the following 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 https://www.iso.org/obp

3.1.1
contamination
radioactive substances deposited on defined surfaces

[SOURCE: ISO 7503-1:2016, 3.1.2]

3.1.2
decontamination
complete or partial removal of radioactive contamination by a deliberate physical, chemical, or biological process

[SOURCE: ISO 12749-3:2015, 3.7.11.2]

Note 1 to entry: It is preferred that decontamination does not significantly change the characteristics of the surface

3.1.3
specific pulse rate I_S
pulse rate caused in the measuring apparatus under given geometrical conditions by 1 ml of a contaminant solution

Note 1 to entry: It is expressed in pulses per minute standardized on 1 ml of the contaminant solution. Pulse rates are derived from count rates applying dead time and background corrections.

3.1.4
residual pulse rate I_r
pulse rate caused in the measuring apparatus under given geometrical conditions by the residual radionuclide on the tested side of the specimen after decontamination

Note 1 to entry: It is expressed in pulses per minute.

3.1.5
mean residual pulse rate $\overline{I_r}$
arithmetic mean of the residual pulse rate values obtained for the five test specimens contaminated by the same radionuclide

Note 1 to entry: It is expressed in pulses per minute.

3.1.6
standardized mean residual pulse rate $\overline{I_{r,n}}$
corrected value of the mean residual pulse rate (3.1.5)

Note 1 to entry: The correction factor is obtained by dividing a reference value of the specific pulse rate by the pulse rate of a contaminant solution used in the test.

Note 2 to entry: It is expressed in pulses per minute.

Note 3 to entry: The purpose of the correction factor is to compensate for variations in specific pulse rates of contaminant solutions used in different test laboratories.

3.1.7
final residual pulse rate
arithmetic mean of the standardized mean residual pulse rate $\overline{I_{r,n}}$ (3.1.6) obtained for ^{60}Co and ^{134}Cs or ^{137}Cs

Note 1 to entry: It is expressed in pulses per minute.

3.2 Symbols

For the purposes of this document, the following apply.

A	Activity of the radionuclide [Bq]
A_S	Specific activity of the radionuclide [Bq · g^{-1}]
A_E	activity of the radionuclide in the contaminant solution
D_{min}	Distance between the center point of the contaminated area and the edge of the sensitive detector cross-section [mm]
h	Distance of the contaminated test surface from the detector surface [mm]
r	Final volume of contaminant solution [ml]
s	Activity concentration of stock solution [MBq ml^{-1}]
q	Carrier concentration [mol l^{-1}]
V	Volume [l]
m	Mass [g]
M	Mol mass [kg·mol^{-1}]
H	Abundance
σ	Cross section [cm^{-2}]
$ø$	Neutron flux [cm^{-2}·s^{-1}]
N_L	Avogadro constant
τ	Carrier concentration of the radionuclide-initial solution [mol l^{-1}]
t	Time [s]
$t_{1/2}$	Half-life [years]
u	Carrier concentration, in moles per litre [mol l^{-1}]

4 Principle

A specimen of the material is contaminated using a solution containing ^{60}Co and ^{137}Cs or ^{134}Cs. The emission from the specimen is measured using a detector. The specimen surface is decontaminated using demineralized water. The emission is measured again and the result is compared to the result of the first measurement to quantify the ease of decontamination.

Separate contaminant solutions containing ^{60}Co and ^{137}Cs or ^{134}Cs (carrier concentration: 10^{-5} molar; pH value: 4) are prepared. 100 µL samples of these solutions are counted using a large area radiation detector. The specific pulse rates of contaminant solutions are calculated using the results from the count.

Contamination of specimens of the material under test over a defined area was first treated with the contaminant solutions and subsequent decontaminated with demineralized water. The residual pulse rate I_r is determined by measuring the contaminated samples.

The standardized mean residual pulse rates $\overline{I_{r,n}}$ for each radionuclide are calculated. The arithmetic mean of the respective values for ^{60}Co and ^{137}Cs or ^{134}Cs (final residual pulse rate) is used to assess the ease of decontamination by means of a classification which has been empirically compiled.

5 Apparatus

In addition to ordinary laboratory apparatus, the following equipment is required for testing the ease of decontamination of surfaces.

5.1 Beakers

Two beakers, of the low-form type, having a capacity of 2 000 ml and complying with requirements laid down in ISO 3819.

5.2 Radiation detector

A detector and associated electronics are required for determining the pulse rate. Suitable detectors include gas-filled proportional counter, scintillation and semi-conductor types.

The minimum size of the sensitive area of the detector shall be a circle having a 30 mm diameter, but in practice, the geometrical requirement specified normally necessitates the use of a larger sensitive area.

To comply with geometrical requirements, the ratio $\frac{D_{\text{min}} - 12{,}5}{h}$ shall not be less than 3,

where

D_{min} is the smallest distance, in millimetres, from the centre point of the contaminated area, as projected onto the detector cross-section, to the edge of the sensitive detection area,

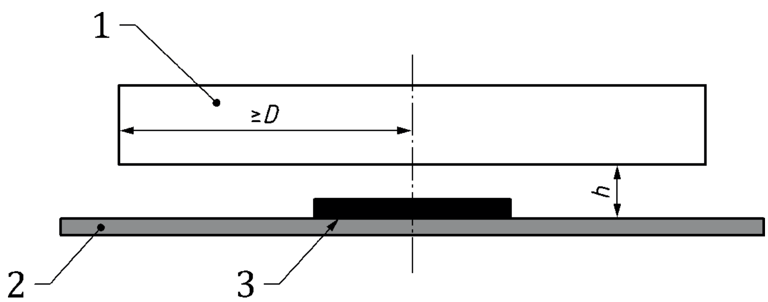
h is the distance, in millimetres, of the contaminated test surface from the detector surface (see Figure 1).

If the geometrical requirement $\frac{D_{min} - 12{,}5}{h} \geq 3$ isn´t met, a detector having a circular sensitive area not less than 30 mm in diameter may be used, provided that

a) for the determination of the specific pulse rate (see 8.1), the 100 µl of contaminant solution is distributed as a series of individual droplets over a circular area 25 mm in diameter, i.e. the area over which the test specimens are contaminated;

b) the net pulse rate of 100 µl of contaminant solution measured under these geometrical conditions is not less than 200 000 pulses per minute (see 8.1).

CAUTION — For the apparatus described in 5.3 to 5.6, separate equipment shall be used for the two or three radionuclides to prevent cross-contamination.



Key

1 Detector

2 Test specimen

3 Contaminated

Figure 1 — Geometrical requirements (cross-section)

5.3 Pipettes

Two pipettes with disposable tips, having a capacity of 100 µl.

Two pipettes with disposable tips, having a capacity of 1 000 µl.

5.4 Two polytetrafluoroethylene (PTFE) or quartz ampoules

Two polytetrafluoroethylene (PTFE) ampoules for preparation of the contamination solution

or

two quartz ampoule for the activation of the inactive stock solution in the neutron reactor are required.

5.5 Storage bottles

Two polytetrafluoroethylene (PTFE) bottles for storage the radioactive stock solution are required.

NOTE Other fluorinated materials of similar chemical resistance are possible alternatives to polytetrafluoroethylene (PTFE), such as polytetrafluoroethylene/perfluoropropylene (PTFE/PFP), perfluoro alkoxyl alkane (PFA) and poly(vinylidene fluoride) (PVDF).

5.6 Mounting

Ten holders for test specimens (5 for each radionuclide), made of poly(methyl methacrylate) (PMMA), serving as positioning aids for the contamination step (see Annex A).

Each holder shall contain a flat silicone rubber ring (45 mm × 25 mm × 2 mm) made of unfilled material having a Shore A hardness value of not more than 60.

NOTE 1 Unfilled, unpigmented, fluorinated silicone rubber has been found particularly suitable for this purpose.

Before using for the first time, the rubber rings shall be clean using the organic solvent mixture (see 7.3) used for cleaning the test specimens. The rings should only be reused after careful decontamination.

NOTE 2 Ten holders, five for each radionuclide, reduce the time needed to carry out the test and help to prevent cross-contamination.

