International Standard

ISO 8690

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

Mesurage de la radioactivité — Radionucléides émetteurs gamma et bêta — Méthode d'essai pour évaluer l'aptitude à la décontamination des matériaux 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).

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For an explanation of 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 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 third edition cancels and replaces the second edition (ISO 8690:2020), of which it constitutes a minor revision.

The main changes are as follows:

— symbols were corrected and clarified;

— principles were rephrased and optimized;

— Table 1 was optimized;

— figures were completed and corrected;

— editorial corrections were made.

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

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 that 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 can be one parameter to take into account when selecting surface coatings such as varnish or impervious 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 7503-1 to ISO 7503-3).

The test method is not suitable for use of radiochemicals if the radionuclide emits low energy gamma rays or beta particles that are readily attenuated in the surface.

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 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 Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *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 terms and definitions given in ISO 11074, ISO 80000-10, ISO/IEC Guide 98-3 and ISO/IEC Guide 99 and the following apply.

ISO and IEC maintain terminology 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/

3.1.1
surface 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

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

[SOURCE: IAEA. IAEA Safety glossary[8]]

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* (3.1.2)

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 symbols 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 centre 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)
I_E	Total pulse rate (counts (pulses) per min or cpm)
I_r	Residual pulse rate (counts (pulses) per min or cpm)
$I_{r,n}$	Standardized residual pulse rate (counts (pulses) per min or cpm)
I_s	Specific pulse rate (counts (pulses) per min or cpm)
r	Final volume of contaminant (radionuclide stock) solution (ml)
s	Activity concentration of stock solution (from manufacturer's data) (MBq·ml^{-1})
q	Carrier concentration (mol·l^{-1})
V	Volume (l)
m	Mass (g)
M	Molar mass (kg·mol^{-1})
H	Abundance
σ	Cross section (cm^{-2})
Φ	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)
T_E	Added amount of carrier unit (mol)
T_S	Required amount of carrier unit (mol)

T_Z Amount of the carrier in the case of decay rate characterization (mol)

u Carrier concentration of the applied carrier solution (mol·l^{-1})

τ Initial radionuclide solution (mol·l^{-1})

V_T Required volume of the carrier solution (l)

4 Principle

A specimen of the material is contaminated using a solution containing ^{60}Co and ^{137}Cs or ^{134}Cs (carrier concentration: 10^{-5} mol·l^{-1}; pH value: 4). 100 µl samples of these solutions on the specimen surface 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 test material specimens was achieved by treating a defined area with the contaminant solutions. Subsequent decontamination was achieved 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 mean of a classification that 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 in accordance with requirements given 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 $\frac{D_{min} - 12{,}5\,mm}{h}$ 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;

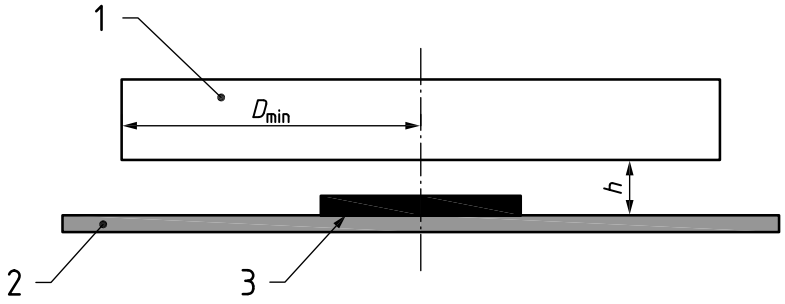
h is the distance, in millimetres, of the contaminated test surface from the detector surface (see Figure 1).

If the geometrical requirement $\frac{D_{min} - 12{,}5\,mm}{h} \geq 3$ is not 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 evenly 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 contamination

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 ampoules for the activation of the inactive stock solution in the neutron reactor are required.

5.5 Storage bottles

Two polytetrafluoroethylene (PTFE) bottles for storage of 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 cleaned 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 10 holders, five for each radionuclide, reduce the time needed to carry out the test and help to prevent cross-contamination.

5.7 Cage-stirrer apparatus

A cage-stirrer apparatus for six test specimens shall be used in accordance with Annex B. The apparatus shall be equipped with a motor allowing the stirrer to be rotated at 100 r/min.

6 Contamination and decontamination agents

6.1 Contaminant solutions

6.1.1 Composition of contaminant solutions

The test specimens shall be contaminated by the radionuclides ^{60}Co and ^{137}Cs or ^{134}Cs, contained in separate solutions.

The use of other radionuclides in aqueous solutions, which may be more suitable in terms of type and chemical behaviour for the envisaged purpose of the surface material, can be adopted, subject to consultation with the testing laboratory.

However, the contaminant solutions shall be chemically stable and shall not corrode the test specimens. The decontaminated samples shall be stable in order to allow the residual contamination to be measured. Special measurement techniques may be required in the case of radionuclides where the emissions are subject to absorption.

The activity concentration of the contaminant solution shall be such that an evaporated 100 µl sample produces a pulse rate of not less than 200 000 pulses per minute in the detector, after correction for dead time and background.

NOTE An activity concentration of 0,2 MBq/ml is usually sufficient to fulfil the requirement.

The radionuclides shall be used with a carrier concentration of $(1 \pm 0{,}1) \cdot 10^{-5}$ mol·l^{-1} in a solution of nitric acid with a pH-value of (4,0 ± 0,2). To make sure that the activity concentration does not change, the pH-value of the contaminant solution is checked monthly or before use. This shall be done using a sample of each contaminant solution.

6.1.2 Preparation of the contaminant solutions

6.1.2.1 Apart from Co^{2+} and Cs^{+} ions and the corresponding nitrate ions, the radionuclide stock solutions shall not contain constituents that remain in the residue when the solutions are evaporated as described in 6.1.2.6.

All reagents used shall be of analytical grade (pro analysis) or better.

6.1.2.2 With the help of the data available for the activity concentrations of the ^{134}Cs or ^{137}Cs and ^{60}Co stock solutions, the quantities of these solutions to be used for preparing the desired quantities of contaminant solutions can be calculated. Formulae for the preparation of the contaminant solutions are given in Annex C.

6.1.2.3 The next step is to calculate from these input quantities the carrier quantities transferred with the radionuclides, and from these in turn calculate the quantities of cobalt(II) nitrate [$Co(NO_3)_2$] or caesium nitrate ($CsNO_3$) solutions respectively, which need to be added to establish a carrier concentration of $(1 \pm 0{,}1) \cdot 10^{-5}$ mol·l^{-1} in the individual solutions.