
**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*

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[ISO 8690:2020](https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020)

<https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020>



iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 8690:2020

<https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normatives references.....	1
3 Terms, definitions and symbols.....	2
3.1 Terms and definitions.....	2
3.2 Symbols.....	3
4 Principle.....	4
5 Apparatus.....	4
6 Contamination and decontamination agents.....	6
6.1 Contaminant solutions.....	6
6.1.1 Composition of contaminant solutions.....	6
6.1.2 Preparation of the contaminant solutions.....	6
6.1.3 Preparation of contaminant solution using neutron activation.....	7
6.1.4 Storage of the contaminant solution.....	8
6.2 Decontaminant solution.....	8
7 Test specimens.....	8
7.1 Preparation and preliminary testing.....	8
7.1.1 Resistance to cleaning solution.....	8
7.1.2 Test specimens of non-metallic materials.....	8
7.1.3 Test specimens of metallic materials.....	9
7.2 Number and dimensions.....	9
7.3 Conditioning and cleaning.....	9
8 Procedure.....	10
8.1 Determining the specific pulse rate of each contaminant solution.....	10
8.2 Contamination.....	10
8.3 Decontamination.....	12
8.4 Determining the residual pulse rate.....	13
9 Calculation of results and assessment of ease of decontamination.....	14
10 Test report.....	15
Annex A (informative) Holder for contamination of test specimen.....	16
Annex B (normative) Cage-stirrer apparatus for decontamination.....	18
Annex C (informative) Formulae for preparation of the ¹³⁷Cs and ⁶⁰Co contaminant solutions.....	27
Annex D (informative) Calculations for the production of the contaminant solution using neutron activation.....	30
Annex E (informative) Example of a test report.....	32
Bibliography.....	34

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 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. (standards.iteh.ai)

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:

- title was changed and adapted to measurement of radioactivity (or gamma ray and beta emitting radionuclides);
- opening to further applications;
- adding of symbols of the used measurands;
- improvement in readability;
- adaption to current standards;
- insert preparation of contaminant solution using neutron activation;
- adding a new annex with calculations using neutron activation.

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.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[ISO 8690:2020](https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020)

<https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020>

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 8690:2020

<https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020>

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 series).

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

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 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 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:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://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

[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* (3.1.2)

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

3.1.5

mean residual pulse rate

\bar{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)
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	Molar mass ($\text{kg}\cdot\text{mol}^{-1}$)
H	Abundance
σ	Cross l (cm^{-2})
\emptyset	Neutron flux ($\text{cm}^{-2}\cdot\text{s}^{-1}$)
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: $10^{-5} \text{ mol l}^{-1}$; 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 test material specimens was accomplished 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 means of a classification that has been empirically compiled.

iteh STANDARD PREVIEW
(standards.iteh.ai)

5 Apparatus

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

<https://standards.iteh.ai/catalog/standards/sist/ea7d8048-42a1-4016-9f11-9a07c5157af0/iso-8690-2020>

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 $\frac{D_{\min} - 12,5}{h}$ shall not be less than 3,

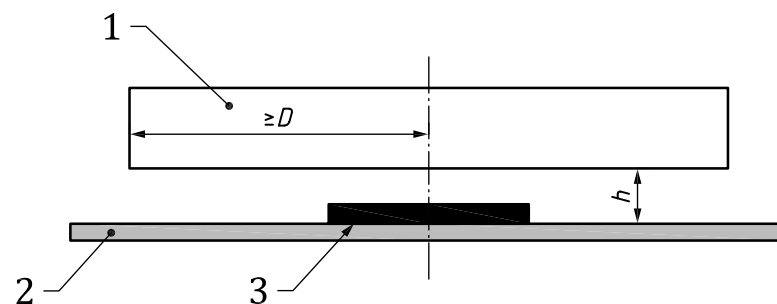
where

- 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

- 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;
- 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

- detector
- test specimen
- contamination

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 8690:2020

Figure 1 — Geometrical requirements (cross-section)
<https://standards.iteh.ai/catalog/standards/sist/7580-06-2020/iso-8690-2020>
9a07c5157af0/iso-8690-2020

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), perfluoroalkoxy 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 Ten 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 $(1 \pm 0,1) \cdot 10^{-5} \text{ mol} \cdot \text{l}^{-1}$ in a solution of nitric acid with a pH-value of $(4,0 \pm 0,2)$. 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(NO₃)₂] or caesium nitrate (CsNO₃) solutions respectively, which need to be added to establish a carrier concentration of $(1 \pm 0,1) \cdot 10^{-5} \text{ mol} \cdot \text{l}^{-1}$ in the individual solutions.

6.1.2.4 Place these quantities of carrier solutions in polytetrafluoroethylene vessels of sufficient size to allow dilution of the solutions to their final volumes. In order to enhance the displacement of chloride ions which may be present in the radionuclide stock solutions, add 5 ml of nitric acid solution (high purity grade) [HNO₃ = 1 mol·l⁻¹] per 90 ml of final volume of contaminant solution.

6.1.2.5 Finally, add the calculated quantities of ⁶⁰Co, ¹³⁴Cs or ¹³⁷Cs stock solutions to the carrier solution.

6.1.2.6 Evaporate the mixtures to dryness using infrared lamps until fume evolution stops.

6.1.2.7 Then heat the vessels for another 2 h with the infrared lamps being moved to double the initial distance.

6.1.2.8 After cooling, top the vessels up to the respective final volume by adding nitric acid with a pH-value of 4.

NOTE Nitric acid with a pH value 4 is produced by diluting 7 µl of nitric acid ($\rho = 1,4 \text{ g} \cdot \text{ml}^{-1}$) to 1 l water using double distilled water.

6.1.2.9 Check the specific pulse rates of the thoroughly homogenized solutions in accordance with [8.1](#) and the pH value.

6.1.3 Preparation of contaminant solution using neutron activation

Stable Co(NO₃)₂ or CsNO₃ solutions are used as stock solutions.

Chloride solutions are inappropriate, because the activation of chlorine produces unwanted radionuclides such as ³⁵S, ³⁶Cl and ³⁸Cl.

The specific activity of the ⁶⁰Co- and ¹³⁴Cs-solution produced by neutron activation can be calculated from concentration of the Co- and Cs-stock solutions. The ideal carrier concentration should be $1,0 \cdot 10^{-5} \text{ mol} \cdot \text{l}^{-1}$.

By means of concentration of the inactive Co- and Cs-stock solutions the amount of these solutions can be calculated, which are required for the desired volumes of the contaminant solutions with the carrier concentration of $1,0 \cdot 10^{-5} \text{ mol} \cdot \text{l}^{-1}$.

Co- and Cs-stock solutions are loaded in a polytetrafluoroethylene (PTFE) or quartz ampoule and dried by maximum 40 °C. Subsequently the ampoules are sealed and activated in the reactor.

The irradiation time can be calculated using the formulae in [Annex D](#). The irradiation time depends on the radionuclide, the neutron flux, and the starting stock solution concentration.

After activation the ampoules are unsealed and the activated material are transferred to sealable bottles for storage using nitric acid (pH = 4) solution. Continue rinsing until the desired volume of stock solution is achieved.

For opening ampoules following operation, it is recommended that the ampoule is positioned in the centre of a closable polyethylene tube (PE) and broken carefully in a vice. To be sure that all the