INTERNATIONAL STANDARD

ISO 18589-5

Second edition
2019-12

Measurement of radioactivity in the environment — Soil —

Part 5: Strontium 90 — Test method using proportional counting or liquid scintillation counting

Mesurage de la radioactivité dans l'environnement — Sol —

Partie 5: Strontium 90 — Méthode d'essai par comptage proportionnel et scintillation liquide

Reference number
ISO 18589-5:2019(E)

© ISO 2019



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

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
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **2**
3.1 Terms and definitions 2
3.2 Symbols 2

4 Principle **3**
4.1 General 3
4.2 Chemical separation 3
4.3 Detection 4
4.3.1 General 4
4.3.2 Source preparation for liquid scintillation counter 4
4.3.3 Source preparation for proportional counter 4
4.3.4 Background determination 4

5 Chemical reagents and equipment **5**

6 Procedure of strontium desorption **5**
6.1 Principles 5
6.2 Technical resources 6
6.2.1 Equipment 6
6.2.2 Chemical reagents 6
6.3 Procedure 6

7 Chemical separation procedure by precipitation **7**
7.1 Principles 7
7.2 Technical resources 7
7.2.1 Equipment 7
7.2.2 Chemical reagents 8
7.3 Procedure 8
7.3.1 Separation of alkaline metals and calcium 8
7.3.2 Separation of barium, radium and lead 9
7.3.3 Separation of fission products and yttrium 9
7.3.4 Strontium purification 9
7.3.5 Yttrium extraction 10
7.3.6 Determination of the chemical yields 11

8 Chemical separation procedure by liquid-liquid extraction **11**
8.1 Principle 11
8.2 Technical resources 12
8.2.1 Equipment 12
8.2.2 Chemical reagents 12
8.3 Procedure 13
8.3.1 General 13
8.3.2 Chemical separation of yttrium 13
8.3.3 Source preparation to be measured by PC 14
8.3.4 Source preparation to be measured by LSC 14
8.3.5 Determination of the chemical yields 14

9 Chemical separation procedure by chromatography (crown ether resin) **15**
9.1 Principles 15
9.2 Technical resources 15
9.2.1 Equipment 15
9.2.2 Chemical reagents 15
9.3 Procedure 16

© ISO 2019 – All rights reserved

9.3.1 General 16
9.3.2 Chemical separation of the strontium 16
9.3.3 Determination of chemical yield 17

10 Measurement 17
10.1 General 17
10.2 Liquid scintillation counter 17
10.3 Gas flow proportional counter 17
10.4 Calculation of counting efficiency 18

11 Expression of results 18
11.1 General 18
11.2 Determination of ^{90}Sr in equilibrium with ^{90}Y 18
11.2.1 Calculation of the activity per unit of mass 18
11.2.2 Standard uncertainty 19
11.2.3 Decision threshold 19
11.2.4 Detection limit 19
11.3 Determination of ^{90}Sr by the ^{90}Y 19
11.3.1 Calculation of the activity per unit of mass 19
11.3.2 Standard uncertainty 20
11.3.3 Decision threshold 20
11.3.4 Detection limit 21
11.4 Determination of ^{90}Sr in presence of ^{89}Sr when ^{90}Sr is in equilibrium with ^{90}Y 21
11.4.1 Calculation of the activity per unit of mass 21
11.4.2 Standard uncertainty 22
11.4.3 Decision threshold 22
11.4.4 Detection limit 23
11.5 Confidence limits 23

12 Test report 23

Annex A (informative) **Examples of evaluation models 25**

Bibliography 32

 © ISO 2019 – All rights reserved

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.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

This second edition cancels and replaces the first edition (ISO 18589-5:2009), which has been technically revised.

The main change compared to the previous edition are as follows:

— The introduction has been reviewed accordingly to the generic introduction adopted for the standards published on the radioactivity measurement in the environment.

A list of all parts in the ISO 18589 series can be found on the ISO website.

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.

© ISO 2019 – All rights reserved

Introduction

Everyone is exposed to natural radiation. The natural sources of radiation are cosmic rays and naturally occurring radioactive substances which exist in the earth and flora and fauna, including the human body. Human activities involving the use of radiation and radioactive substances add to the radiation exposure from this natural exposure. Some of those activities, such as the mining and use of ores containing naturally-occurring radioactive materials (NORM) and the production of energy by burning coal that contains such substances, simply enhance the exposure from natural radiation sources. Nuclear power plants and other nuclear installations use radioactive materials and produce radioactive effluent and waste during operation and decommissioning. The use of radioactive materials in industry, agriculture and research is expanding around the globe.

All these human activities give rise to radiation exposures that are only a small fraction of the global average level of natural exposure. The medical use of radiation is the largest and a growing man-made source of radiation exposure in developed countries. It includes diagnostic radiology, radiotherapy, nuclear medicine and interventional radiology.

Radiation exposure also occurs as a result of occupational activities. It is incurred by workers in industry, medicine and research using radiation or radioactive substances, as well as by passengers and crew during air travel. The average level of occupational exposures is generally below the global average level of natural radiation exposure (see Reference [1]).

As uses of radiation increase, so do the potential health risk and the public's concerns. Thus, all these exposures are regularly assessed in order to:

— improve the understanding of global levels and temporal trends of public and worker exposure;

— evaluate the components of exposure so as to provide a measure of their relative importance;

— identify emerging issues that may warrant more attention and study. While doses to workers are mostly directly measured, doses to the public are usually assessed by indirect methods using the results of radioactivity measurements of waste, effluent and/or environmental samples.

To ensure that the data obtained from radioactivity monitoring programs support their intended use, it is essential that the stakeholders (for example nuclear site operators, regulatory and local authorities) agree on appropriate methods and procedures for obtaining representative samples and for handling, storing, preparing and measuring the test samples. An assessment of the overall measurement uncertainty also needs to be carried out systematically. As reliable, comparable and 'fit for purpose' data are an essential requirement for any public health decision based on radioactivity measurements, international standards of tested and validated radionuclide test methods are an important tool for the production of such measurement results. The application of standards serves also to guarantee comparability of the test results over time and between different testing laboratories. Laboratories apply them to demonstrate their technical competences and to complete proficiency tests successfully during interlaboratory comparisons, two prerequisites for obtaining national accreditation.

Today, over a hundred International Standards are available to testing laboratories for measuring radionuclides in different matrices.

Generic standards help testing laboratories to manage the measurement process by setting out the general requirements and methods to calibrate equipment and validate techniques. These standards underpin specific standards which describe the test methods to be performed by staff, for example, for different types of sample. The specific standards cover test methods for:

— naturally-occurring radionuclides (including ^{40}K, ^{3}H, ^{14}C and those originating from the thorium and uranium decay series, in particular ^{226}Ra, ^{228}Ra, ^{234}U, ^{238}U and ^{210}Pb) which can be found in materials from natural sources or can be released from technological processes involving naturally occurring radioactive materials (e.g. the mining and processing of mineral sands or phosphate fertilizer production and use);

 © ISO 2019 – All rights reserved

— human-made radionuclides, such as transuranium elements (americium, plutonium, neptunium, and curium), ^{3}H, ^{14}C, ^{90}Sr and gamma-ray emitting radionuclides found in waste, liquid and gaseous effluent, in environmental matrices (water, air, soil and biota), in food and in animal feed as a result of authorized releases into the environment, fallout from the explosion in the atmosphere of nuclear devices and fallout from accidents, such as those that occurred in Chernobyl and Fukushima.

The fraction of the background dose rate to man from environmental radiation, mainly gamma radiation, is very variable and depends on factors such as the radioactivity of the local rock and soil, the nature of building materials and the construction of buildings in which people live and work.

A reliable determination of the activity concentration of gamma-ray emitting radionuclides in various matrices is necessary to assess the potential human exposure, to verify compliance with radiation protection and environmental protection regulations or to provide guidance on reducing health risks. Gamma-ray emitting radionuclides are also used as tracers in biology, medicine, physics, chemistry, and engineering. Accurate measurement of the activities of the radionuclides is also needed for homeland security and in connection with the Non-Proliferation Treaty (NPT).

This document describes the requirements to quantify the activity of ^{90}Sr in soil samples after proper sampling, sample handling and test sample preparation in a testing laboratory or in situ.

This document is to be used in the context of a quality assurance management system (ISO/IEC 17025).

This document is published in several parts for use jointly or separately according to needs. These parts are complementary and are addressed to those responsible for determining the radioactivity present in soil, bedrocks and ore (NORM or TENORM). The first two parts are general in nature describe the setting up of programmes and sampling techniques, methods of general processing of samples in the laboratory (ISO 18589-1), the sampling strategy and the soil sampling technique, soil sample handling and preparation (ISO 18589-2). ISO 18589-3 to ISO 18589-5 deal with nuclide-specific test methods to quantify the activity concentration of gamma emitters radionuclides (ISO 18589-3 and ISO 20042), plutonium isotopes (ISO 18589-4) and ^{90}Sr (ISO 18589-5) of soil samples. ISO 18589-6 deals with non-specific measurements to quantify rapidly gross alpha or gross beta activities and ISO 18589-7 describes in situ measurement of gamma-emitting radionuclides.

The test methods described in ISO 18589-3 to ISO 18589-6 can also be used to measure the radionuclides in sludge, sediment, construction material and products following proper sampling procedure.

This document is one of a set of International Standards on measurement of radioactivity in the environment.

Additional parts can be added to ISO 18589 in the future if the standardization of the measurement of other radionuclides becomes necessary.

© ISO 2019 – All rights reserved

Measurement of radioactivity in the environment — Soil —

Part 5: Strontium 90 — Test method using proportional counting or liquid scintillation counting

1 Scope

This document describes the principles for the measurement of the activity of ^{90}Sr in equilibrium with ^{90}Y and ^{89}Sr, pure beta emitting radionuclides, in soil samples. Different chemical separation methods are presented to produce strontium and yttrium sources, the activity of which is determined using proportional counters (PC) or liquid scintillation counters (LSC). ^{90}Sr can be obtained from the test samples when the equilibrium between ^{90}Sr and ^{90}Y is reached or through direct ^{90}Y measurement. The selection of the measuring method depends on the origin of the contamination, the characteristics of the soil to be analysed, the required accuracy of measurement and the resources of the available laboratories.

These methods are used for soil monitoring following discharges, whether past or present, accidental or routine, liquid or gaseous. It also covers the monitoring of contamination caused by global nuclear fallout.

In case of recent fallout immediately following a nuclear accident, the contribution of ^{89}Sr to the total amount of strontium activity will not be negligible. This standard provides the measurement method to determine the activity of ^{90}Sr in presence of ^{89}Sr.

The test methods described in this document can also be used to measure the radionuclides in sludge, sediment, construction material and products by following proper sampling procedure.

Using samples sizes of 20 g and counting times of 1 000 min, detection limits of (0,1 to 0,5) $Bq \cdot kg^{-1}$ can be achievable for ^{90}Sr using conventional and commercially available proportional counter or liquid scintillation counter when the presence of ^{89}Sr can be neglected. If ^{89}Sr is present in the test sample, detection limits of (1 to 2) $Bq \cdot kg^{-1}$ can be obtained for both ^{90}Sr and ^{89}Sr using the same sample size, counting time and proportional counter or liquid scintillation counter as in the previous situation.

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 11074, *Soil quality — Vocabulary*

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

ISO 19361, *Measurement of radioactivity — Determination of beta emitters activities — Test method using liquid scintillation counting*

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

ISO 18589-2, *Measurement of radioactivity in the environment — Soil — Part 2: Guidance for the selection of the sampling strategy, sampling and pre-treatment of samples*

ISO 80000-10, *Quantities and units — Part 10: Atomic and nuclear physics*

© ISO 2019 – All rights reserved