

Measurement of radioactivity in the environment - Soil
- Part 5: Strontium 90 - Test method using proportional
counting or liquid scintillation counting (ISO
18589-5:2019)

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN ISO 18589-5:2021 sisaldab Euroopa standardi EN ISO 18589-5:2021 ingliskeelset teksti.	This Estonian standard EVS-EN ISO 18589-5:2021 consists of the English text of the European standard EN ISO 18589-5:2021.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 04.08.2021.	Date of Availability of the European standard is 04.08.2021.
Standard on kättesaadav Eesti Standardimis- ja Akrediteerimiskeskusest.	The standard is available from the Estonian Centre for Standardisation and Accreditation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 13.080.01, 17.240

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardimis- ja Akrediteerimiskeskusele. Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardimis- ja Akrediteerimiskeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardimis- ja Akrediteerimiskeskusega: Koduleht www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation and Accreditation.

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation and Accreditation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation and Accreditation:

Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

English Version

Measurement of radioactivity in the environment - Soil -
Part 5: Strontium 90 - Test method using proportional
counting or liquid scintillation counting (ISO 18589-
5:2019)

Mesurage de la radioactivité dans l'environnement -
Sol - Partie 5: Strontium 90 - Méthode d'essai par
comptage proportionnel ou comptage par scintillation
en milieu liquide (ISO 18589-5:2019)

Ermittlung der Radioaktivität in der Umwelt -
Erdboden - Teil 5: Strontium-90 - Messverfahren mit
Proportional- oder Flüssigszintillationszählung (ISO
18589-5:2019)

This European Standard was approved by CEN on 25 July 2021.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of ISO 18589-5:2019 has been prepared by Technical Committee ISO/TC 85 "Nuclear energy, nuclear technologies, and radiological protection" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 18589-5:2021 by Technical Committee CEN/TC 430 "Nuclear energy, nuclear technologies, and radiological protection" the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2022, and conflicting national standards shall be withdrawn at the latest by February 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 18589-5:2019 has been approved by CEN as EN ISO 18589-5:2021 without any modification.

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

	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

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.

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 , ^3H , ^{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);

- human-made radionuclides, such as transuranium elements (americium, plutonium, neptunium, and curium), ^3H , ^{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.

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) $\text{Bq}\cdot\text{kg}^{-1}$ 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) $\text{Bq}\cdot\text{kg}^{-1}$ 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/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074, ISO 18589-1, ISO 11929 (all parts) and ISO 80000-10 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/>

3.2 Symbols

m	mass of the test portion, in unit of mass
a_i	activity per unit of mass, of radionuclide i , in becquerel per unit of mass
$A_{s,i}$	reference measurement standard activity of radionuclide i , at the calibration time, in becquerel
A_i	sample source activity of radionuclide i , at time $t = 0$, in becquerel
t_g	sample counting time, in seconds
t_0	background counting time, in seconds
t_s	reference measurement standard counting time
r_g	gross count rate, in per second
r_0	background count rate, in per second
r_s	reference measurement standard count rate, in per second
$R_{c,i}$	chemical yield of the extraction of radionuclide i
ε_i	counting efficiency of radionuclide i
λ_i	decay constant of radionuclide i
t_d, t_f	start and stop time respectively of the measurement, referred to $t = 0$, in seconds
r_{gj}	gross count rate, for measurement j , in per second
r_{0j}	background count rate, for measurement j , in per second
r_j	net count rate, for measurement j , in per second
t_j	start time of the measurement j , referred to $t = 0$
$u(X)$	standard uncertainty associated with X
U	expanded uncertainty, calculated by $U = k \cdot u(X)$ with $k = 1, 2, \dots$