INTERNATIONAL STANDARD

ISO 18589-1

Second edition
2019-11

Measurement of radioactivity in the environment — Soil —

Part 1: General guidelines and definitions

Mesurage de la radioactivité dans l'environnement — Sol —

Partie 1: Lignes directrices générales et définitions

Reference number
ISO 18589-1:2019(E)

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Published in Switzerland

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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 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 second edition cancels and replaces the first edition (ISO 18589-1:2005), which has been technically revised.

The main change compared to the previous edition is 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

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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);

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

ISO 18589 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, ISO 18589-4 and 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[2][3][4][5][22][23].

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

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Measurement of radioactivity in the environment — Soil —

Part 1: General guidelines and definitions

1 Scope

This document specifies the general requirements to carry out radionuclides tests, including sampling of soil including rock from bedrock and ore as well as of construction materials and products, pottery, etc. using NORM or those from technological processes involving Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) e.g. the mining and processing of mineral sands or phosphate fertilizer production and use.

For simplification, the term "soil" used in this document covers the set of elements mentioned above.

This document is addressed to people responsible for determining the radioactivity present in soils for the purpose of radiation protection. This concerns soils from gardens and farmland, urban or industrial sites, as well as soil not affected by human activities.

This document is applicable to all laboratories regardless of the number of personnel or the extent of the scope of testing activities. When a laboratory does not undertake one or more of the activities covered by this document, such as planning, sampling or testing, the requirements of those clauses do not apply.

This document is to be used in conjunction with other parts of ISO 18589 that outline the setting up of programmes and sampling techniques, methods of general processing of samples in the laboratory and also methods for measuring the radioactivity in soil. Its purpose is the following:

— define the main terms relating to soils, sampling, radioactivity and its measurement;

— describe the origins of the radioactivity in soils;

— define the main objectives of the study of radioactivity in soil samples;

— present the principles of studies of soil radioactivity;

— identify the analytical and procedural requirements when measuring radioactivity in soil.

This document is applicable if radionuclide measurements for the purpose of radiation protection are to be made in the following cases:

— initial characterization of radioactivity in the environment;

— routine surveillance of the impact of nuclear installations or of the evolution of the general territory;

— investigations of accident and incident situations;

— planning and surveillance of remedial action;

— decommissioning of installations or clearance of materials.

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.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074 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 General terms

3.1.1
routine surveillance
surveillance carried out periodically and designed to observe the potential changes of the soil's radioactive characteristics

3.1.2
analysis for characterization
set of observations that contribute, at a given time, to the characterization of the radioactive properties of a soil sample with a view to use them later as reference data

Note 1 to entry: The test report may include other data characterizing the site studied.

3.1.3
vertical distribution of the radioactivity
determination of the radioactivity in the layers of the earth's crust sampled at different depths which describe the vertical profile of the distribution by a radionuclide or a group of radionuclides

3.2 Terms relating to soils

3.2.1
soil
upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes and composed of mineral particles, organic matter, water, air, and living organisms organized in generic soil horizons

Note 1 to entry: In a broader civil engineering sense, soil includes topsoil and sub-soil; deposits such as clays, silts, sands, gravels, cobbles, boulders, and organic matter and deposits such as peat; materials of human origin such as wastes; ground gas and moisture; and living organisms.

Note 2 to entry: Mineral materials include earth, sands, clay, slates, stones, etc. that can also be used as construction materials and included in construction products.

[SOURCE: ISO 11074:2015, 2.1.11]

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3.2.2
herbaceous cover
lower stratum of vegetation made up essentially of various herbaceous species found for example in meadows, lawns or fallow fields

3.2.3
soil horizon
basic layer of soil, which is more or less parallel to the surface and is homogeneous in appearance for most morphological characteristics (colour, texture, structure, etc.)

Note 1 to entry: The succession of soil horizons makes up a soil profile and allows, on the basis of certain analytical criteria, the morphogenetic nature of the soil to be defined.

3.3 Terms relating to sampling

3.3.1
sample
portion of material selected from a larger quantity of material, collected and taken away for testing

[SOURCE: ISO 11074:2015, 4.1.17, modified — The word "soil" was removed and the last part of the definition was added.]

3.3.2
sampling
defined procedure whereby a part of the soil is taken for testing

Note 1 to entry: In certain cases, the sample might not be representative but is determined by availability.

Note 2 to entry: Sampling procedures describe all the processes necessary to provide the laboratory with the samples required to reach the objectives of the study of the soil radioactivity. This includes the selection, sampling plan, withdrawal and preparation of the samples from the soil.

3.3.3
sampling strategy
set of technical principles that aim to resolve, depending on the objectives and site considered, the two main issues which are the sampling density and the spatial distribution of the sampling areas

Note 1 to entry: The sampling strategy provides the set of technical options that are required in the sampling plan.

3.3.4
sampling area
area from which the different samples are collected

Note 1 to entry: A site can be divided into several sampling areas.

3.3.5
sampling plan
precise protocol that, depending on the application of the principles of the strategy adopted, defines the spatial and temporal dimensions of sampling, the frequency, the sample number, the quantities sampled, etc., and the human resources to be used for the sampling operation

3.3.6
random sampling
sampling at random in space and time from the sampling area

3.3.7
systematic sampling
sampling by some systematic method in space and time from the sampling area

3.3.8
random systematic sampling
sampling at random from each sampling unit from a set of systematically defined sampling units

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3.3.9
sampling unit
section of the sampling area whose limits can be physical or hypothetical

Note 1 to entry: Sampling units are obtained by dividing the sampling area into grid box units according to the sampling pattern.

3.3.10
sampling pattern
system of sampling locations based on the results of statistical procedures

Note 1 to entry: This leads to a set of predetermined sampling points designed to monitor one or more specified sites. The sampling area is divided into several sampling units or basic grid box units, which are usually square or rectangular (but circular or linear grid boxes are not excluded depending upon the characteristics of the pollution source).

3.3.11
increment
individual portion of material collected by a single operation of a sampling device

[SOURCE: ISO 11074:2015, 4.1.8]

Note 1 to entry: Increments can be grouped to form a composite sample.

3.3.12
sub-sample
sample in which the material of interest is randomly distributed in parts of equal or unequal size

3.3.13
single sample
representative quantity of the material, presumed to be homogeneous, taken from a sampling unit, kept and treated separately from the other samples

3.3.14
composite sample
two or more increments mixed together in appropriate proportions, either discretely or continuously (blended composite sample), from which the average value representative of a desired characteristic can be obtained

[SOURCE: ISO 11074:2015, 4.3.3 modified — the word "subsamples" was removed, "average result" replaced by "average value representative".]

3.3.15
sorted sample
single sample or composite sample taken from the same sampling unit, obtained after the elimination of coarse elements that are larger than 2 cm and before drying

3.3.16
laboratory sample
sorted sample intended for laboratory inspection or testing

Note 1 to entry: When the laboratory sample is further prepared (reduced) by subdividing, mixing, grinding or combinations of these operations, the result is the test sample. When no preparation is required, the initial laboratory sample is considered as the test sample. Depending on the number of analyses to be performed, test portions are isolated from the test sample for analysis

Note 2 to entry: The laboratory sample is the final sample from the point of view of the sample collection step, but it is the initial sample from the point of view of the test step.

[SOURCE: ISO 11074:2015, 4.3.7, modified — Notes have been modified.]

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3.3.17
test sample
sample treated prepared for testing

Note 1 to entry: The test sample is prepared from the laboratory sample. It is a fine dry homogeneous soil in a powder state. It is prepared in accordance with ISO 18589-2 depending of the test method used.

3.3.18
test portion
part of the test sample prepared for specific testing

4 Symbols

Table 1 — Definitions and symbols

Quantity	Common notation	Unit	Definition
Activity	A	becquerel Bq	number of decays per second of a radionuclide
Activity concentration	A_m	becquerel per kilogram $Bq \cdot kg^{-1}$	radionuclide activity per unit dry mass of material
Activity per unit area	A_s	becquerel per square metre $Bq \cdot m^{-2}$	radionuclide activity per unit area used to characterize the activity at the soil surface, at a depth or integrated activity over a soil column
Gross α activity	$A'(\alpha)$	becquerel Bq	number of α decays per second of a mixture of radionuclides determined by non-nuclide-specific measurement techniques whose efficiency is calibrated using a specific radionuclide such as ^{239}Pu, ^{241}Am, …
Gross β activity	$A'(\beta)$	becquerel Bq	number of β decays per second of a mixture of radionuclides determined by non-nuclide-specific measurement techniques whose efficiency is calibrated using a specific radionuclide such as ^{36}Cl, ^{40}K, $^{90}Sr+^{90}Y$, …

5 Origins of the radioactivity in soils

5.1 Natural radioactivity

Soils are naturally radioactive, primarily because of their mineral content. The main natural radionuclides are potassium 40 (^{40}K) and the radioactive nuclides of the uranium 238 (^{238}U) and thorium 232 (^{232}Th) decay series. The natural radioactivity may vary considerably from one type of soil to another. Table 2 gives the order of magnitude of the activity concentrations of these elements in soils of some large regions of the world[24].

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