INTERNATIONAL STANDARD

ISO 18589-2

Third edition
2022-12

Measurement of radioactivity in the environment — Soil —

Part 2: Guidance for the selection of the sampling strategy, sampling and pre-treatment of samples

Mesurage de la radioactivité dans l'environnement — Sol —

Partie 2: Lignes directrices pour la sélection de la stratégie d'échantillonnage, l'échantillonnage et le prétraitement des échantillons

Reference number
ISO 18589-2:2022(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 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.

The committee responsible for this document is 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 18589-2:2015), which has been technically revised.

The main change is as follows:

— the review of the introduction according 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, 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 crew during air travel. The average level of occupational exposures is generally similar to 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, and

— 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 samples. 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 ^{201}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), ^{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 conformity 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 should 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 and 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.

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

Measurement of radioactivity in the environment — Soil —

Part 2: Guidance for the selection of the sampling strategy, sampling and pre-treatment of samples

1 Scope

This document specifies the general requirements, based on ISO 11074 and ISO/IEC 17025, for all steps in the planning (desk study and area reconnaissance) of the sampling and the preparation of samples for testing. It includes the selection of the sampling strategy, the outline of the sampling plan, the presentation of general sampling methods and equipment, as well as the methodology of the pre-treatment of samples adapted to the measurements of the activity of radionuclides in soil including granular materials of mineral origin which contain NORM or artificial radionuclides, such as sludge, sediment, construction debris, solid waste of different type and materials from technologically enhanced naturally occurring radioactive materials (mining, coal combustion, phosphate fertilizer production etc.).

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

This document is addressed to the people responsible for determining the radioactivity present in soil for the purpose of radiation protection. It is applicable to soil from gardens, 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 range of the testing performed. When a laboratory does not undertake one or more of the activities covered by this document, such as planning, sampling, test or calibration, the corresponding requirements do not apply.

NOTE The term "laboratory" is applicable to all identified entities (individuals, organizations, etc.) performing planning, sampling, test and calibration.

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 18589-1, *Measurement of radioactivity in the environment — Soil — Part 1: General guidelines and definitions*

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

3 Terms and definitions

For the purposes of this document, the terms, definitions, and symbols given in ISO 80000-10, ISO 18589-1, ISO 11074, 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/

4 Symbols

e	thickness of the layer sampled
m_{ss}	wet mass of the sorted sample
m'_{ss}	wet mass of a subsample of the sorted sample
m_{ts}	dry mass of the test sample
a	activity per unit of mass of the test sample
A_S	activity per unit area
S	surface area sampled

5 Principle

The purpose of the measurement of soil radioactivity is to monitor the environmental impact of radioactive substances[2] and/or to assess the radiological impact on the population[3][4][5][6].

The main objectives of the measurement of radionuclides in soil (see ISO 18589-1) are the following:

— characterization of radioactivity in the environment;

— routine surveillance of the impact of radioactivity released from nuclear installations or of the general evolution of the radioactivity in a region;

— investigations of accidents and incidents;

— planning and surveillance of remedial action;

— decommissioning of installations or the disposal of materials.

Consequently, measurements of soil radioactivity are performed in a variety of situations, but a generic approach can be described, with the following steps as outlined in this document:

a) Planning process — Selection of the sampling strategy

The selection of the sampling strategy depends on the main objectives and on the results of the initial investigation of the area. The sampling strategy shall lead to the knowledge of the nature, activity concentrations, spatial distribution of the radionuclides, as well as their temporal evolution, taking into account changes caused by migration, atmospheric conditions, and land/soil use.

An initial investigation of the area shall be carried out to determine the sampling strategy.

ISO 18400-104 gives general guidance on sampling strategies and ISO 18400-202 on preliminary investigations. ISO 18400-205 gives specific guidance for the investigation of natural, near-natural, and cultivated areas; and ISO 18400-203 deals with the investigation of potentially contaminated sites.

Details are given in Clause 6 and a scheme for the selection of the sampling strategy is given in Annex A.

b) Planning process — Sampling plan

The sampling plan shall be developed according to the sampling strategy selected. It shall specify the selection of sampling areas and units, the sampling pattern, the sampling points, the types

of samples, the sampling procedures and equipment, as well as the safety requirements for the personnel.

ISO 18400-107 gives general guidance on the framework for the preparation and application of a sampling plan.

Details, such as the selection of sampling areas and the sampling units that result from the type of grid applied to these areas, are given in Clause 7. Definitions of the types of samples are given in ISO 18589-1. The relationship between samples types is given in Annex B.

c) Sampling process — Collection of samples

The collection of any soil samples in the field shall conform to the established sampling plan.

— For sampling of the top layer, a *single sample* or *n increments* of a defined thickness are taken from each of the selected sampling units.

— For vertical sampling of several soil layers, samples are taken at increasing depth vertically below the surface sampling point. A *single sample* or *n increments* are collected from the various soil layers with different thicknesses according to the sampling depth. Special care should be exercised in order not to mix samples from different soil layers.

Reference [12] gives guidance on recording and reporting of the samples.

Details are given in Clauses 7 and 8.

d) Sampling process — Preparation of the sorted sample

The preparation of *sorted samples* is carried out by the reduction of single or composite samples. A sorted sample should be representative of the average value of one or more given soil characteristics. The identification, labelling, packaging, and transport procedures of sorted samples to the laboratory shall guarantee the preservation of their characteristics.

Details are given in 8.3, 8.4, and 8.5.

e) Laboratory process — Handling of the laboratory sample

After arrival at the laboratory, the sorted samples are considered as *laboratory samples* for storage and further pre-treatment before their analysis.

Details are given in Clause 9.

f) Laboratory process — Preparation of the test sample

Before any testing, the laboratory samples are pre-treated by drying, crushing, sieving, and homogenizing to produce test samples in the form of a fine, homogeneous powder. Pre-treatment shall guarantee that the physical and chemical characteristics of the test sample are constant over time, thus rendering the results easier to interpret. Representative subsamples with masses determined by the specifications of the different radioactivity measurements shall be isolated from the test sample as test portions.

Details are given in Clause 9.

If some material is stored for future investigations or for the purpose of settling a potential dispute, subsamples shall be taken from the laboratory sample or the test sample in an acceptable and documented manner.

6 Sampling strategy

6.1 General

During the planning process, the sampling strategy for the site under investigation is determined according to the objectives described in Clause 5 item a), resulting in the definition of a sampling plan [2][3][5][7][8][9].

6.2 Initial investigation

Whatever the objective of the work being carried out is, certain preliminaries shall be undertaken during the initial investigation phase to help define the sampling strategy, such as the following:

— analysis of historical and administrative data, company archives, previous studies, and interviews with former employees, which help identify potential sources of radioactive contamination;

— collection of information on geological, hydrological, and pedological characteristics and on the main climatic parameters, in order to characterize the spatial and temporal development of the characteristics of the radioactivity of an area;

— survey of the site under investigation to identify its topography, the nature of the vegetation cover, and any peculiarities that can affect the techniques and the sampling plan;

— for farmland, collection of information from the farmers on the nature and depth of works (sub-soiling or drainage, ploughing and harrowing ditches, etc.) and on chemical fertilizers and additives that can lead to excessive natural radioactivity (nature and quantity of products applied).

When data on radioactive soil contamination are not available or in case of suspicion of contamination, *in situ* analytical investigation using portable detectors or some preliminary sampling and subsequent laboratory analysis can be necessary in order to select the sampling areas and strategy.

6.3 Types of sampling strategies

Sampling strategies are either orientated or probabilistic depending upon the objectives and the initial knowledge of radioactivity distribution over the area under investigation.

Orientated strategies are based on a priori constraints that lead to a selection of sampling units in a specific area under special scrutiny because of particular interest or level of contamination.

Probabilistic strategies are based on a selection of sampling units without any a priori constraints.

The selection of sampling units and points is described in 7.2.

6.4 Selection of the sampling strategy

The approach or sampling strategy shall be selected depending on the objective pursued and the relevant end points, for example the protection of humans and the environment, taking into account social and economic constraints. The sampling strategy selected should ensure that the radioactivity of the samples is representative of the distribution of radionuclides in the soil of the area under investigation (see ISO 18400-101 and References [2][3][5][7]).

Although the strategy can only be defined on a case-by-case basis, the selection of the sampling strategy should follow these stages:

— analysis of the records, which enables an historic study of the sampling site, in particular of its previous use (identification of the source);

— evaluation of preferential migration pathways and/or accumulation areas;

— site reconnaissance with respect to the boundaries of the sampling areas and sampling undertaken;