INTERNATIONAL STANDARD

ISO 18589-2

Second edition
2015-02-01

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 18589-2:2015(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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is 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 18589-2:2007), which has been technically revised.

ISO 18589 consists of the following parts, under the general title *Measurement of radioactivity in the environment — Soil*:

— *Part 1: General guidelines and definitions*

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

— *Part 3: Test method for gamma-emitting radionuclides using gamma ray spectrometry*

— *Part 4: Measurement of plutonium isotopes (plutonium 238 and plutonium 239+240) by alpha spectrometry*

— *Part 5: Measurement of strontium 90*

— *Part 6: Measurement of gross alpha and gross beta activities*

— *Part 7: In situ measurement of gamma-emitting radionuclides*

Introduction

This International Standard is published in several parts to be used jointly or separately according to needs. ISO 18589-1 to ISO 18589-6 concerning the measurements of radioactivity in the soil, have been prepared simultaneously. These parts are complementary and are addressed to those responsible for determining the radioactivity present in soils. The first two parts are general in nature. ISO 18589-3 to ISO 18589-5 deal with radionuclide-specific measurements and ISO 18589-6 deals with non-specific measurements of gross alpha or gross beta activities. ISO 18589-7 deals with the measurement of gamma emitters radionuclides using *in situ* spectrometry.

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

1 Scope

This part of ISO 18589 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.

This part of ISO 18589 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 part of ISO 18589 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 part of ISO 18589, such as planning, sampling, or testing, the corresponding requirements do not apply.

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 31-9, *Quantities and units — Part 9: Atomic and nuclear physics*

ISO 11074, *Soil quality — Vocabulary*

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

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

3 Terms, definitions, and symbols

For the purposes of this document, the terms, definitions, and symbols given in ISO 31-9, ISO 18589-1, ISO 11074, and the following apply.

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

4 Principle

The purpose of the measurement of soil radioactivity is to monitor the environmental impact of radioactive substances[1] and/or to assess the radiological impact on the population.[2],[3],[4],[5]

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 part of ISO 18589:

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, as well as temporal evolution of the radionuclides, 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 10381-1[6] gives general guidance on the selection of the sampling strategy; ISO 10381-4[7] gives specific guidance for the investigation of natural, near-natural, and cultivated areas; and ISO 10381-5[8] deals with the investigation of soil contamination at urban and industrial sites.

Details are given in Clause 5 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.

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 6. Definitions of the types of sample are given in ISO 18589-1. The relationship between sample 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.

Details are given in Clauses 6 and 7.

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 7.3, 7.4, and 7.5.

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 8.

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 8.

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.

5 Sampling strategy

5.1 General

During the planning process, the sampling strategy for the site under investigation is determined according to the objectives described in Clause 4 item a), resulting in the definition of a sampling plan. [1],[2],[4],[9],[11],[12]

5.2 Initial investigation

Whatever the objective of the work being carried out, 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.

5.3 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 6.2.

5.4 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. [1],[2],[4],[6],[9]

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;

— site reconnaissance: a rapid analytical investigation using portable radioactivity detectors can be used to characterize the distribution of the radioactivity of the areas to be studied.

This step in the planning process determines a large number of choices and can generate important and costly activities. It also includes the definition of the objectives of the data quality according to the parameters to be analysed.

Annex A gives a flow diagram that helps in the selection of a sampling strategy according to the objectives of the investigation.

The choice of the strategy determines the sampling density, the temporal and spatial distribution of the units from which samples are collected and the timing of the sampling, taking into account the following:

— potential distribution of radionuclide: homogeneous or heterogeneous (“hot” spots);

— characteristics of the environment;

— minimum mass of soil necessary to carry out all the laboratory tests; and

— maximum number of tests that can be performed by the laboratory for the study.

In many cases, a prediction of the possible presence of soil contamination and its distribution (homogeneous or heterogeneous) can be drawn up. It is then necessary to verify these hypotheses by an orientated sampling strategy. One variant of this strategy, which is systematic with selected representative sampling points, is adapted for the routine monitoring of sites whose radioactive origins and distribution patterns are known. This allows a more accurate definition of the number and location of the sampling points than a purely probabilistic sampling strategy. This subjective selection of the sampling points can be combined with a statistical approach to meet the quality requirements for the

interpretation. When the spatial radioactivity distribution is unknown, it is necessary to adopt an orientated spatially random strategy.

Probabilistic strategies with random sampling (random distribution of sampling points) are suitable only if the distribution of the radioactivity on the site is considered homogeneous. For a site with occasional heterogeneities (point sources), the implementation of a systematic sampling strategy that is dependent upon the degree of knowledge of the distribution of these heterogeneities in the different sampling areas is recommended.

When the objective of the investigation is the characterization of a recent deposit on the soil surface, such as in the case of fallout following a routine, authorized gaseous release, or an accident, the collection of the top layer is recommended.

When the objective is the study of a polluted site, where it is necessary to know the vertical migration of radionuclides with depth (in order to predict the potential contamination of the groundwater), samples from layers at various depths shall be collected. Layers can be defined either with the same thickness or as representative of the different soil horizons.

The sampling strategy leads to a set of technical options that are detailed in Clause 6.

6 Sampling plan

6.1 General

The sampling plan is a precise procedure that, depending on the application of the principles of the strategy adopted, defines all actions to be realized in the field. The plan also defines the human resources needed for the sampling operation. The plan is directly linked to the purposes of the study, the characteristics of the environment of the site, the capacity of the laboratory testing facilities, and the objectives for the data quality requisite for the interpretation of the results of the measurements.

The sampling plan shall be set up on a case-by-case basis. The plan shall contain all information needed to perform the sampling, i.e. sampling areas, sampling units, location of sampling points in the sampling units, types of samples, single or composite, number of increments for composite samples, periodicity, required mass of a sample considering the planned tests, requirement for archiving the material, vertical distribution, etc.

6.2 Selection of sampling areas, units, and points

6.2.1 General

After deciding on the sampling strategy, sampling areas and units are defined based on the results of the initial investigation. In some cases, the boundaries of sampling areas and the location of sampling units for routine surveillance/monitoring can be fixed by legal requirements, for example as in the operation of a new nuclear installation. They are defined as a result of the reference radiological study performed for the project. For accident investigations, the size of the sampling area and location of the sampling units can also be determined by the environmental conditions (wind strength and direction, topography, etc.) at the time of accident, as well as the variation of the source characteristics (radionuclides, activity, release duration, etc.).

For a probabilistic strategy, the sampling units can be selected either by systematic or random approaches whereas it cannot be done by a random approach for an orientated strategy.

For both strategies, the sampling points can be selected either by a systematic or a random approach.

On the same site, depending on the heterogeneity of the radioactivity distribution, a combination of these strategies can be applied to the different sampling areas.

6.2.2 Sampling for use with a probabilistic strategy

For a probabilistic strategy, the sampling areas, following their identification, are covered with a grid that defines the sampling units. The size of the grid mesh should take into account the surface area of the site and is also governed by the analytical capacity of the laboratory and the financial constraints that restrict the number of samples that can be analysed. The surface area of the grid units can range from a few square metres to several square kilometres depending on the site under investigation.

If a radioactivity map is available as a result of a preliminary *in situ* radiological inspection (see ISO 18589-7[24]), the grid mesh imposed on the sampling area can correspond to the grid adopted for the radioactive cartography. The radioactivity map can be denser where contaminated areas are suspected, or less dense in the presumed absence of contamination.

For systematic sampling, a sampling point is selected in each knot or centre of the sampling unit. The final number of sampling units that are eventually sampled depends on the heterogeneity of the environmental characteristics and on the access restrictions imposed by the topographical complexity of the area.

For random sampling, the sampling units are referenced and a number chosen at random.

When the purpose of the study is to investigate the impact on the environment of the contribution of a specific source of radioactivity, it shall be compared to the background activity level. The latter can be determined in an area assumed to be uncontaminated by the source under investigation (for example, not influenced by any effluent discharges from the plant under study) and is considered as the reference area.

6.2.3 Sampling for use with an orientated strategy

For an orientated sampling strategy, the sampling area is defined by the constraints imposed by the objectives of the investigation on the basis of the environmental data and the cartography results.

The sampling plan is based on a subjective selection of sampling units as a result of prior knowledge of the area and/or initial *in situ* radioactivity investigations.

When the objective is to collect the samples with the highest activity level and there are no radioactivity data available, a preliminary radiological investigation with a portable detector allows the creation of a map of the site that highlights the contaminated area(s) and helps to define the sampling plan with the precise location of the sampling unit (see ISO 18589-7[24]).

NOTE One of the aspects of this initial investigation is also to assess the risks of exposure of workers in charge of the sampling operation and, therefore, to define radiation protection measures, in particular, those to be implemented on-site relating to the protection of personnel against radiation.

In routine surveillance of a nuclear installation, the sampling unit can be chosen as the point of maximum concentration of the predicted fallout of gaseous discharges from the plant.

When the radioactivity of the soil and other components of the environment (air, water, bio-indicators, elements of the human food chain) is investigated simultaneously, then the selection of the sampling unit should take into account the presence of the other indicators.

6.2.4 Selection criteria of sampling areas and sampling units

Using the data of past environmental studies and visual reconnaissance of the site, sampling areas with homogeneous topological configuration and vegetation cover are identified. This requires the separation of elevated zones from sloping zones, herbaceous areas from bushy ones, forested areas from cultivated and ploughed areas, etc.

If possible, sampling units with a soil layer that has not been disturbed by human activity, and with a well-kept herbaceous cover, should be selected. The surface of the sampling unit shall be at least several square metres. Any disturbance shall be noted, indicating the scale, nature, and origin on the sample sheet.

The radioactive surveillance of disturbed soils may be carried out in addition to radioactivity investigation of plants in the field. For agricultural land, the upper layer with a thickness equal to the ploughed depth

