
**Measurement of radioactivity in the
environment — Soil —**

Part 2:

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

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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*

ISO 18589-2:2007

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 18589-2 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

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: Measurement of gamma-emitting radionuclides*
- *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*

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Introduction

This International Standard is published in several parts to be used jointly or separately according to needs. Parts 1 to 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. Parts 3 to 5 deal with radionuclide-specific measurements and Part 6 with non-specific measurements of gross alpha or gross beta activities.

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

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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 referenced documents are indispensable for the application 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 31-9, *Quantities and units — Part 9: Atomic and nuclear physics*

ISO 10381-2, *Soil quality — Sampling — Part 2: Guidance on sampling techniques*

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 purpose 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 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 gives general guidance on the selection of the sampling strategy; ISO 10381-4 gives specific guidance for the investigation of natural, near-natural and cultivated areas; and ISO 10381-5 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.

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

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 *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 *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 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 7.2, 7.3 and 7.4.

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 homogenization 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

During the planning process, the sampling strategy for the site under investigation is determined according to the objectives described in 4 a), resulting in the definition of a sampling plan [6], [7], [8].

5.1 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.

5.2 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 6.1.

5.3 Selection of the sampling strategy

The approach or sampling strategy shall be selected depending on the objective pursued and the relevant endpoints, 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 may 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 (homogenous 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 may 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 dependant 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 may 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

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.

6.1 Selection of sampling areas and units

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 may be selected either by a systematic or random approach.

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

6.1.1 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, the grid mesh imposed on the sampling area may correspond to the grid adopted for the radioactive cartography. The radioactivity map may be more dense where contaminated areas are suspected, or less dense in the presumed absence of contamination.

For systematic sampling, each knot or centre of the sample unit is sampled. The final number of sampling areas 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.

6.1.2 Sampling for use with an orientated strategy

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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.

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 may 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.

6.1.3 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.