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Measurement of radioactivity in the environment — Soil —

Part 6: Gross alpha and gross beta activities — Test method using gas-flow proportional counting

Mesurage de la radioactivité dans l'environnement — Sol —

Partie 6: Mesurage des activités alpha globale et bêta globale — Méthode d'essai utilisant un compteur proportionnel à circulation gazeuse

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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.

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 18589-6:2009), 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 describes the requirements to allow an estimation of gross radioactivity of alpha- and beta-emitters 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.

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Measurement of radioactivity in the environment — Soil —

Part 6: Gross alpha and gross beta activities — Test method using gas-flow proportional counting

1 Scope

This document provides a method that allows an estimation of gross radioactivity of alpha- and beta-emitters present in soil samples. It applies, essentially, to systematic inspections based on comparative measurements or to preliminary site studies to guide the testing staff both in the choice of soil samples for measurement as a priority and in the specific analysis methods for implementation.

The gross α or β radioactivity is generally different from the sum of the effective radioactivities of the radionuclides present since, by convention, the same alpha counting efficiency is assigned for all the alpha emissions and the same beta counting efficiency is assigned for all the beta emissions.

Soil includes rock from bedrock and ore as well as construction materials and products, potery, etc. using naturally occurring radioactive materials (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.

The test methods described in this document can also be used to assess gross radioactivity of alpha- and beta-emitters in sludge, sediment, construction material and products following proper sampling procedure[2][3][4][5][7][8].

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

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/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*

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 18589-4, *Measurement of radioactivity in the environment — Soil — Part 4: Plutonium 238 and plutonium 239 + 240 — Test method using alpha spectrometry*

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

3 Terms and definitions

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

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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

4 Symbols

m	mass of the test portion, expressed in kilograms;
a	activity per unit of mass, expressed in becquerel per kilogram;
A_α, A_β	activity of the standard in the α and β reference measurement standards, expressed in becquerel;
t_g	sample counting time, expressed in seconds;
t_0	background counting time, expressed in seconds;
$t_{s\alpha}$, $t_{s\beta}$	α and β reference measurement standards counting time, expressed in seconds;
$r_{g\alpha}$, $r_{g\beta}$	gross count rate per second, from the α and β windows, respectively
$r_{0\alpha}$, $r_{0\beta}$	background count rate per second, from the α and β windows, respectively;
$r_{s\alpha}$, $r_{s\beta}$	calibration count rate per second, from the α and β windows, respectively;
ε_α, ε_β	counting efficiency for α and β, respectively;
$r_{s\alpha\to\beta}$	count rate in the β window when the α reference measurement standard is measured;
χ	alpha-beta cross-talk, percentage of α count going into β window from the reference measurement standard;
$u(a)$	standard uncertainty associated with the measurement result;
U	expanded uncertainty, calculated by $U = k \cdot u(a)$ with k = 1, 2,..., expressed in becquerel per kilogram;
a^*	decision threshold, expressed in becquerel per kilogram;
$a^\#$	detection limit, expressed in becquerel per kilogram;
$a^\triangleleft$, $a^\triangleright$	lower and upper limits of the confidence interval, expressed in becquerel per kilogram.

5 Principle

Gross α and β radioactivity are determined by using gas-flow proportional counting or solid scintillation counting on a thin layer of fine soil on a planchette[1][9][10]. Gross α and β determinations are not absolute determinations of the radioactivity of the sample, but relative determinations referring to a specific α- or β-emitter that constitutes the reference measurement standard. These types of determinations are also known as the alpha index and beta index.

6 Chemical reagents and equipment

6.1 Degreasing solvent.

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