SLOVENSKI STANDARD
oSIST prEN ISO 19361:2019

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Merjenje radioaktivnosti - Ugotavljanje aktivnosti oddajnikov beta - Preskusna metoda s tekočinskim scintilacijskim štetjem (ISO 19361:2017)

Measurement of radioactivity - Determination of beta emitters activities - Test method using liquid scintillation counting (ISO 19361:2017)

Nachweis der Radioaktivität - Bestimmung der Aktivität von Betastrahlern - Verfahren mit Flüssigszintillationszählung (ISO 19361:2017)

Mesurage de la radioactivité - Détermination de l'activité des radionucléides émetteurs bêta - Méthode d'essai par comptage des scintillations en milieu liquide (ISO 19361:2017)

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Measurement of radioactivity — Determination of beta emitters activities — Test method using liquid scintillation counting

Mesurage de la radioactivité — Détermination de l'activité des radionucléides émetteurs bêta — Méthode d'essai par comptage des scintillations en milieu liquide

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ISO 19361:2017(E)

Contents

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, N*uclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

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 within 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 on their 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 and for astronauts. The average level of occupational exposures is generally below the global average level of natural radiation exposure[13].

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: (1) improve the understanding of global levels and temporal trends of public and worker exposure; (2) to evaluate the components of exposure so as to provide a measure of their relative importance, and; (3) to 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 radioactivity measurements performed on various sources: 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 then handling, storing, preparing and measuring the test samples. An assessment of the overall measurement uncertainty need also 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 over time of the test results and between different testing laboratories. Laboratories apply them to demonstrate their technical qualifications and to successfully complete proficiency tests during interlaboratory comparison, two prerequisites for obtaining national accreditation. Today, over a hundred international standards, prepared by Technical Committees of the International Standardization Organization, including those produced by ISO/TC 85, and the International Electrotechnical Commission (IEC), are available for application by testing laboratories to measure the main radionuclides.

Generic standards help testing laboratories to manage the measurement process by setting out the general requirements and methods to calibrate 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, ^{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);

— Human-made radionuclides, such as transuranium elements (americium, plutonium, neptunium, and curium), ^{3}H, ^{14}C, ^{90}Sr and gamma emitting radionuclides found in waste, liquid and gaseous effluent, in environmental matrices (water, air, soil, biota) and food and feed as a result of authorized releases into the environment and of fallout resulting from the explosion in the atmosphere of nuclear devices and accidents, such as those that occurred in Chernobyl and Fukushima.

Many of these radionuclides are beta emitters that can be measured by liquid scintillation counting, following appropriate sample preparation.

A generic international standard on liquid scintillation counting is justified for test laboratories carrying out beta emitter measurements in fulfilment of national authority requirements. For example, testing laboratories need to obtain a specific accreditation for radionuclide measurement for the monitoring of drinking water, food, the environment or the discharges, as well as for biological samples for medical purpose.

This document describes (after appropriate sampling, sample handling and test sample preparation) the generic requirements to quantify the activity concentration of beta emitters using liquid scintillation counting. In the absence of a specific pre-treatment of the test sample (such as distillation for ^{3}H measurement, or after benzene synthesis for ^{14}C measurement), this document is to be used as a screening method unless the interference of beta emitters, others than those to be quantified, is considered negligible in the test portion.

This document is one of a set of generic International Standards on measurement of radioactivity.

Measurement of radioactivity — Determination of beta emitters activities — Test method using liquid scintillation counting

1 Scope

This document applies to liquid scintillation counters and requires the preparation of a scintillation source obtained by mixing the test sample and a scintillation cocktail. The test sample can be liquid (aqueous or organic), or solid (particles or filter or planchet).

This document describes the conditions for measuring the activity of beta emitter radionuclides by liquid scintillation counting[14][15].

The choice of the test method using liquid scintillation counting involves the consideration of the potential presence of other beta emitter radionuclides in the test sample. In this case, a specific sample treatment by separation or extraction is implemented to isolate the radionuclide of interest in order to avoid any interference with other beta-, alpha- and gamma-emitting radionuclides during the counting phase.

This document is applicable to all types of liquid samples having an activity concentration ranging from a few Bq·l^{-1} to 10^{6} Bq·l^{-1}. For a liquid test sample, it is possible to dilute liquid test samples in order to obtain a solution having an activity compatible with the measuring instrument. For solid samples, the activity of the prepared scintillation source shall be compatible with the measuring instrument.

The measurement range is related to the test method used: nature of test portion, preparation of the scintillator - test portion mixture, measuring assembly as well as to the presence of the co-existing activities due to interfering radionuclides.

Test portion preparations (such as distillation for ^{3}H measurement, or benzene synthesis for ^{14}C measurement, etc.) are outside the scope of this document and are described in specific test methods using liquid scintillation[2][3][4][5][6][7][8][9].

2 Normatives 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 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques*

ISO 5667-3, *Water quality — Sampling — Part 3: Preservation and handling of water samples*

ISO 11929, *Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence 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*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

4 Symbols, abbreviations and units

For the purposes of this document, the symbols and abbreviations defined in ISO 80000-10[10], ISO/IEC Guide 98-3[11], ISO/IEC Guide 99[12] and the following apply.

β_{max}	Maximum energy for the beta emission, in keV
V	Volume of test portion, in litre
m	Mass of test portion, in kilogram
ρ	Density of the sample, in kilogram per litre
ε_p	Preparation efficiency
a	Activity per unit of mass, in becquerel per kilogram
c_A	Activity concentration, in becquerel per litre
A	Activity of the calibration source, in becquerel
t_0	Background counting time, in second
t_g	Portion counting time, in second
t_s	Calibration counting time, in second
r_0	Background count rate, per second
r_g	Portion count rate, per second
r_s	Calibration count rate, per second
ε	Detection efficiency
ε_q	Quenched efficiency
f_q	Quench factor
$u(c_A)$	Standard uncertainty associated with the measurement result; in becquerel per litre
U	Expanded uncertainty, calculated by $U = k \cdot u(c_A)$ with k = 1, 2,..., in becquerel per litre
c_A^*	Decision threshold, in becquerel per litre
$c_A^\#$	Detection limit, in becquerel per litre
$c_A^<$, $c_A^>$	Lower and upper limits of the confidence interval, in becquerel per litre

5 Principle

The aqueous, organic or particles portion is mixed with the scintillation cocktail in a counting vial to obtain a homogeneous medium (scintillation source). Electrons emitted from beta disintegration transfer their energy to the scintillation cocktail molecules that are excited by this process before returning to their ground state by emitting photons that are detected by photoelectron multiplier tubes (phototubes).

The electronic pulses emitted by the phototubes are amplified. The peak pulse amplitude is converted to a digital value by an analogue-to-digital convertor (ADC) and the pulse height stored using a multichannel analyser (MCA). The pulses are analysed (in order to remove random events) by the electronic systems and the data analysis software. The count rate of these photons allows the determination of the activity in the test portion, after correcting for the background count rate and detection efficiency, taking account of the quench correction. The requirements of the specific test

