International Standard

ISO 19361

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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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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of 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 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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 430, *Nuclear energy, nuclear technologies, and radiological protection,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 19361:2017), which has been technically revised.

The main changes are as follows:

— those driven by the ISO 11929 series evolution for expressing results.

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 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 an average exposure to radiation that represents only a small fraction of the global average level of exposure, taking into account all contributions (natural, medical, radon, etc.). The medical use of radiation is the largest and a growing human-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 by astronauts. The average level of occupational exposures is generally similar to the global average level of natural radiation exposure[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

a) improve the understanding of global levels and temporal trends of public and worker exposure,

b) evaluate the components of exposure so as to provide a measure of their relative importance, and

c) identify emerging issues that may warrant more attention and study.

While doses to workers are mostly directly assessed, doses to the public are usually assessed by indirect methods using radioactivity measurements performed on 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 needs 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 (ISO), 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 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, ^{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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— Anthropogenic 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.

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

1 Scope

This document applies to the determination of beta emitters activity concentration using liquid scintillation counting. The method requires the preparation of a scintillation source, which is 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).

NOTE Planchet are samples, described in 8.5, out of solid material e.g. small metal, plastic or glass pans or support material made of these materials

This document describes the conditions for measuring the activity concentration of beta emitter radionuclides by liquid scintillation counting[2].

The choice of the test method using liquid scintillation counting involves the consideration of the potential presence of other beta-, alpha- and gamma 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 about 1 $Bq \cdot l^{-1}$ to 10^6 $Bq \cdot l^{-1}$. 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[3][[4][5][6][7][8][9][10].

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

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/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

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ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms, definitions

For the purposes of this document, the following term and definition 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/

3.1
quench
anything that interferes with the scintillation process and prevents light from reaching the PMT, results in a loss in the number of recorded counts and in the apparent energy

Note 1 to entry: Physical quench occurs when the radioisotope is physically separated from the solution in which the scintillator is dissolved.

Note 2 to entry: Chemical quench occurs when the energy of the beta particle is absorbed by compounds that will not (or with too low efficiency) re-emit the energy during the transfer to the solvent molecules.

Note 3 to entry: Colour quench occurs when the emitted light is absorbed by colour in the sample.

4 Symbols

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

β_{max}	Maximum energy for the beta emission	keV
V	Volume of test portion	l
m	Mass of test portion	kg
ρ	Density of the sample	$kg \cdot l^{-1}$
ε_p	Preparation efficiency	
a	Activity per unit of mass	$Bq \cdot kg^{-1}$
c_A	Activity concentration	$Bq \cdot l^{-1}$
A	Activity of the calibration source	Bq
t_0	Background counting time	s
t_g	Portion counting time	s
t_s	Calibration counting time	s
r_0	Background count rate	s^{-1}
r_g	Portion count rate	s^{-1}
r_s	Calibration count rate	s^{-1}
ε	Counting efficiency	
ε_q	Quenched efficiency	
f_q	Quench factor	
$u(c_A)$	Standard uncertainty associated with the measurement result	$Bq \cdot l^{-1}$
U	Expanded uncertainty, calculated by $U = k \cdot u(c_A)$ with $k = 1, 2, \ldots$	$Bq \cdot l^{-1}$

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