ISO/FDIS 4723:2023(E)

ISO TC 147/SC 3~~/WG 16~~

Secretariat: AFNOR

Date: 2023-~~05-29~~xx

Water quality — Actinium-227 —Test method using alpha spectrometry

Qualité de l'eau — Actinium-227 —Méthode d'essai par spectrométrie alpha

First edition

Style Definition: Heading 1: Indent: Left: 0 pt, First line: 0 pt, Tab stops: Not at 21.6 pt

Style Definition: Heading 2: Font: Bold, Tab stops: Not at 18 pt

Style Definition: Heading 3: Font: Bold

Style Definition: Heading 4: Font: Bold

Style Definition: Heading 5: Font: Bold

Style Definition: Heading 6: Font: Bold

Style Definition: ANNEX

Style Definition: AMEND Terms Heading: Font: Bold

Style Definition: AMEND Heading 1 Unnumbered: Font: Bold

Commented [eXtyles1]: The reference is to a withdrawn standard which has been replaced

ISO 20344, Personal protective equipment — Test methods for footwear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Commented [eXtyles2]: URL Validation failed: https://www.iso.org/ returns an unknown connection failure. (connection error "Error 12031: ERROR_INTERNET_CONNECTION_RESET").

Table of contents

Contents

Foreword

~~ISO (the International Organization for Standardization) is a worldwide federation of national~~ 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.

Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

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~~document 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~~www.iso.org/directives).

~~Attention is drawn~~ISO draws attention to the possibility that ~~some of~~ the ~~elements~~implementation of this document may ~~be~~involve the ~~subject~~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/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. ~~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 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~~www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 3, *Radioactivity measurements*.

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~~www.iso.org/members.html.

Introduction

Radionuclides are present throughout the environment; thus, water bodies (e.g. surface waters, ground waters, sea waters) contain radionuclides which can be of either natural, or anthropogenic origin:

— naturally-occurring radionuclides, including, ^{3}H, ^{14}C, ^{40}K and those originating from the thorium and uranium decay series, in particular ^{210}Pb, ^{210}Po, ^{222}Rn, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{231}Pa, ^{234}U and ^{238}U, can be found in water bodies due to either natural processes (e.g. desorption from the soil and runoff by rain water) or released from technological processes involving naturally-occurring radioactive materials (e.g. mining, mineral processing, oil, gas, and coal production, water treatment and the production and use of phosphate fertilisers);

— anthropogenic radionuclides such as ^{55}Fe, ^{59}Ni, ^{63}Ni, ^{90}Sr, ^{99}Tc, transuranic elements (Np, Pu, Am, and Cm) and some gamma emitting radionuclides such as ^{60}Co and ^{137}Cs can also be found in natural waters. Small quantities of anthropogenic radionuclides can be discharged from nuclear facilities to the environment as a result of authorized routine releases. The radionuclides present in liquid effluents are usually controlled before being discharged to the environment[1] and water bodies. Anthropogenic radionuclides used for medical and industrial applications can be released to the environment after use. Anthropogenic radionuclides are also found in waters due to contamination from fallout resulting from above-ground nuclear detonations and accidents such as those that have occurred at the Chornobyl and Fukushima nuclear facilities.

Radionuclide activity concentrations in water bodies can vary according to local geological characteristics and climatic conditions and can be locally and temporally enhanced by releases from nuclear installations during planned, existing, and emergency exposure situations[2][3]. Some drinking-water sources can thus contain radionuclides at activity concentrations that could present a human health risk. The World Health Organization (WHO) recommends to routinely monitor radioactivity in drinking waters[4] and to take proper actions when needed to minimize the health risk.

National regulations usually specify the activity concentration limits that are authorized in drinking waters, water bodies, and liquid effluents to be discharged to the environment. These limits can vary for planned, existing, and emergency exposure situations. As an example, during either a planned or existing situation, the WHO guidance level for ^{227}Ac in drinking water is 0,1 Bq·l^{-1}, see Notes 1 and 2. Compliance with these limits is assessed by measuring radioactivity in water samples and by comparing the results obtained with their associated uncertainties as specified by ISO/IEC Guide 98-3[5] and ISO 5667-20[6].

NOTE 1 If the value is not specified in Annex 6 of reference [4], the value has been calculated using the formula provided in reference [4] and the dose coefficient data from references [7] and [8].

NOTE 2 The guidance level calculated in Reference [4] is the activity concentration with an intake of 2 l·d^{-1} of drinking water for one year, results in an effective dose of 0,1 mSv·a^{-1} to members of the public. This is an effective dose that represents a very low level of risk to human health and which is not expected to give rise to any detectable adverse health effects[4].

This document contains method(s) to support laboratories, which need to determine ^{227}Ac in water samples. The method(s) described in this document can be used for various types of waters (see Scope). Minor modifications such as sample volume and counting time can be made if needed to ensure that the characteristic limit, decision threshold, detection limit and uncertainties are below the required limits. This can be done for several reasons such as emergency situations, lower national guidance limits, and operational requirements.

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Commented [eXtyles3]: The in-text citation "5" is not in the reference list. Please correct the citation, add the reference to the list, or delete the citation.

Commented [eXtyles4]: An apparent in-text citation "5" is not in the reference list, and has not been converted. Please check the citation, and if necessary correct it and run eXtyles Citation Style Conversion again.

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Commented [eXtyles5]: No appendix matches the in-text citation "Annex 6". Please supply the missing appendix or delete the citation.

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Water quality — Actinium-227— Test method using alpha spectrometry

WARNING — Persons using this document should be familiar with normal laboratory practices. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of any other restrictions.

IMPORTANT — It is essential that tests conducted according to this document be carried out by suitably trained staff.

1 Scope

This document specifies a test method to determine the activity concentration of ^{227}Ac in all types of waters by alpha spectrometry.

The test method is applicable to test samples of supply/drinking water, rainwater, surface and ground water, marine water, as well as cooling water, industrial water, domestic, and industrial wastewater after proper sampling and handling and test sample preparation (see ISO 5667-1, ISO 5667-3, ISO 5667-10). Filtration of the test sample is necessary.

Commented [eXtyles6]: ISO 5667-3: current stage is 40.60

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

The detection limit depends on the sample volume, the instrument used, the background count rate, the detection efficiency, the counting time, the chemical yield, and the progeny ingrowth. The method described in this document, using currently available alpha spectrometry apparatus, has a detection limit of approximately 0,03 Bq·l^{-1}, when directly measuring the alpha peak of ^{227}Ac. This detection limit is lower than the WHO criteria for safe consumption of drinking water for any actinide alpha emitter (0,1 Bq·l^{-1}).[4] This value can be achieved with a counting time of 48 h for a sample volume of 1 l.

Only a small fraction of ^{227}Ac decays through alpha emissions (~1,42 %). An option to lower the detection limit of the method is to wait, let the progenies of ^{227}Ac grow in, and measure an alpha progeny peak of ^{227}Ac (e.g.,. ^{215}Po). This is a longer technique, but a lower detection limit of approximately 0,000 2 Bq·l^{-1} can be obtained by re-counting the sample approximately 90 days after purification. The sample can be re-counted before 90 days, but with a higher detection limit.

The test method(s) described in this document can be used during planned, existing and emergency exposure situations as well as for wastewaters and liquid effluents with specific modifications that can increase the overall uncertainty, detection limit and threshold. For an emergency situation, it is preferable to reduce the counting time rather than the sample volume.

The analysis of ^{227}Ac adsorbed to suspended matter is not covered by this document.

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.

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

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

<std>ISO 3696, *Water for analytical laboratory use — Specification and test methods*</std>

<std>ISO 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques*</std>

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

<std>ISO 5667-10, *Water quality — Sampling — Part 10: Guidance on sampling of waste water*</std>

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

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

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

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 5667-10, *Water quality — Sampling — Part 10: Guidance on sampling of waste water*

ISO 11929 (all parts), *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application*</std>

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

<std>ISO 80000-10, *Quantities and units — Part 10: Atomic and nuclear physics*</std>

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

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

3 Terms, definitions and symbols

3.1 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

3.2 Symbols

For the purposes of this document, the symbols and designations given in ISO/IEC Guide 98-3, ISO/IEC Guide 99, ISO 11929 (all parts),), ISO 80000-10 and the following shall apply.

Commented [eXtyles7]: ISO 5667-3: current stage is 40.60

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Commented [eXtyles8]: The reference is to a withdrawn standard which has been replaced

ISO 11929-4, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 4: Guidelines to applications

ISO 11929-1, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 1: Elementary applications

ISO 11929-2, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 2: Advanced applications

ISO 11929-3, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 3: Applications to unfolding methods

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Commented [eXtyles9]: The reference is to a withdrawn standard which has been replaced

ISO 11929-4, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 4: Guidelines to applications

ISO 11929-1, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 1: Elementary applications

ISO 11929-2, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 2: Advanced applications

ISO 11929-3, Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation — Fundamentals and application — Part 3: Applications to unfolding methods

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Formatted: Pattern: Clear

Symbol	Definition	Unit
A	Activity of ^{225}Ac tracer added	Bq
α	Probability of the false positive decision	
β	Probability of the false negative decision	
C_A	Activity concentration of ^{227}Ac measured in the sample	Bq·l^{-1}
C_A^*	Decision threshold of the measurand	Bq·l^{-1}
$C_A^\#$	Detection limit of the measurand	Bq·l^{-1}
$C_A^\triangleleft, C_A^\triangleright$	Lower and upper limits of the probabilistically symmetric coverage interval of the measurand, respectively	Bq·l^{-1}
$C_A^<, C_A^>$	Lower and upper limits of the shortest coverage interval of the measurand, respectively	Bq·l^{-1}
$\tilde{C}_A$	Possible or assumed true quantity values of the measurand	Bq·l^{-1}
$C_{A\mathrm{T}}$	Activity concentration of ^{225}Ac tracer solution at the moment of separation	Bq·l^{-1}
ε	Counting efficiency	
ε_1	Counting efficiency for the first measurement of the indirect method	
ε_2	Counting efficiency for the second measurement of the indirect method	
F	Bias correction factor for the losses of ^{219}Rn	
Φ	Distribution function of the standardized normal distribution; $\Phi(k\ p) = p$ applies	
$1-\gamma$	Probability for the coverage interval of the measurand	
k_p	Quantiles of the standardized normal distribution for the probabilities p (for instance $p = 1-\alpha$, $1-\beta$ or $1-\gamma/2$)	
k_q	Quantiles of the standardized normal distribution for the probabilities q (for instance $q = 1-\alpha$, $1-\beta$ or $1-\gamma/2$)	
p, q	Probability for the coverage interval	
λ	Decay constant of the isotope (ex: $\lambda_{^{215}\mathrm{Po}}$ is the decay constant of ^{215}Po)	
m	Sample mass	kg
m_{ST}	Mass of tracer solution	g
N_0	Number of counts measured of the background on the alpha spectrum for a given time in the region of interest of ^{227}Ac, the measurand.	
$N_{0\mathrm{T}}$	Number of counts measured of the background on the alpha spectrum for a given time in the region of interest of ^{225}Ac, the tracer.	
N_g	Number of counts measured on the alpha spectrum for a given time in the region of interest of ^{227}Ac, the measurand.	
N_{T}	Number of counts measured on the alpha spectrum for a given time in the region of interest of ^{225}Ac, the tracer.	
p, q	Probability for the coverage interval	
P_α	Probability of the isotope to decay through alpha particle emission (branching ratio)	
r_0	Background count rate in the region of interest of the measurand (^{227}Ac)	s^{-1}