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ISO TC 147/SC 3~~/WG 15~~

Secretariat: AFNOR

Date: 2023-xx

Water quality — Simultaneous determination of tritium and carbon 14 activities — Test method using liquid scintillation counting

~~**Date: 2023-06-10**~~

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Qualité de l'eau — Détermination simultanée des activités volumiques du tritium et du carbone 14 — Méthode par comptage des scintillations en milieu liquide

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ISO 20344, Personal protective equipment — Test methods for footwear

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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~~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 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 ~~on~~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 the following URL: www.iso.org/iso/foreword.html.~~), see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 13168:2015), which has been technically revised. The main changes compared to the previous edition are as follows:

— Introduction developed;

— Normative references updated;

— Bibliography updated.

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.

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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, runoff by rain water) or released from technological processes involving naturally occurring radioactive materials (e.g. mining, mineral processing, oil, gas and production, water treatment and the production and the 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 in medical and industrial applications can be released to the environment after use. Anthropogenic radionuclides are also found in waters due to the contamination from fallout resulting above-ground nuclear detonations and accidents such as those that 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 facilities 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 is 10 000 Bq·l^{-1}[3] for ^{3}H and 100 Bq·l^{-1} for ^{14}C in drinking water, see NOTE 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 and ISO 5667-20 [5].

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 [6] and [7].

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].

In the event of a nuclear emergency, the WHO Codex Guideline Levels[8] mentioned that the activity concentration might not be greater than 1 000 Bq·l^{-1} for ^{3}H in infant food and 10 000 Bq·l^{-1} for ^{3}H in food, including organically bound tritium, and 10 000 Bq·l^{-1} for ^{14}C in food other than for infant food.

This document contains method to support laboratories which need to determine ^{3}H and ^{14}C in water samples.

The method described in this document can be used for various types of waters (see Clause 1). 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.

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Water quality — Simultaneous determination of tritium and carbon 14 activities — Test method using liquid scintillation counting

WARNING — Persons using this document should be familiar with normal laboratory practice. 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 method for the simultaneous measurement of ^{3}H and ^{14}C in water samples by liquid scintillation counting of a source obtained by mixing the water sample with a hydrophilic scintillation cocktail.

The method presented in this document is considered a screening method because of the potential presence of interfering radionuclides in the test sample. However, if the sample is known to be free of interfering radionuclides then 3H and 14C can be measured quantitatively

The method can be used for any type of environmental study or monitoring.

This 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 having an activity concentration ranging from 5 Bq·l^{-1} to 10^{6} Bq·l^{-1} (upper limit of the liquid scintillation counters for direct counting). For higher activity concentrations, the sample can be diluted to obtain a test sample within this range.

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 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995*~~)</std>~~)

~~<std>ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*</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>~~

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

<std>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*</std>

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

<std>ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

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

ISO 19361, *Measurement of radioactivity — Determination of beta emitters activities — Test method using liquid scintillation counting*</std>

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

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

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 98-3:2008, ISO/IEC Guide 99:2007, ISO 80000-10 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/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 abbreviations given in ISO/IEC Guide 99:2007, ISO/IEC Guide 98-3:2008, ISO 80000-10 and the following shall apply.

Symbol	Description	Unit
V	Sample volume	l
m	Sample mass	kg
ρ	Density of the sample	kg·l^{-1}
C_{AT}	Activity concentration for tritium	Bq·l^{-1}
C_{AC}	Activity concentration for carbon 14	Bq·l^{-1}

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Symbol	Description	Unit
a	Activity per unit of mass	Bq·kg^{-1}
A_T	Activity of the calibration source, in becquerel, for tritium	Bq
A_C	Activity of the calibration source, in becquerel, for carbon 14	Bq
t	Measurement time	s
t_o	Background counting time	s
t_g	Sample counting time	s
t_{sT}	Calibration counting time for tritium	s
t_{sC}	Calibration counting time, for carbon 14	s
r_{oT}	Mean background count rate for tritium	s^{-1}
r_{oC}	Mean background count rate for carbon 14	s^{-1}
r_{gT}	Mean sample count rate for tritium	s^{-1}
r_{gC}	Mean sample count rate for carbon 14	s^{-1}
r_{sT}	Calibration count rate for tritium	s^{-1}
r_{sC}	Calibration count rate for carbon 14	s^{-1}
$r_{sC\rightarrow T}$	Calibration count rate for carbon 14 in the tritium window	s^{-1}
ε	Counting efficiency for the lowest value of the quenching parameter	—
Q	Quenching parameter	—
f_q	Quench factor	—
ε	Counting efficiency in the unquenched vial	—
ε_q ε_Q	Counting efficiency for the quenching parameter, Q	—
ε_T	Detection efficiency for tritium	—
ε_C	Detection efficiency for carbon 14	—
$\varepsilon_{C\rightarrow T}$	Detection efficiency for carbon 14 in the chosen window of the tritium energy range	—
χ	Correcting factor, for the interfering carbon 14 in the chosen window of the tritium energy range	—
f_{qT}	Quench factor for tritium	—
f_{qC}	Quench factor for carbon 14	—
$f_{qC\rightarrow T}$	Quench factor, for the interfering carbon 14 in the chosen window of the tritium energy range	—
$u(c_{AT})$	Standard uncertainty associated with the measurement result for tritium	Bq·l^{-1}
$u(c_{AC})$	Standard uncertainty associated with the measurement result for carbon 14	Bq·l^{-1}
u_{rel}	Relative standard uncertainty	—

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