



SLOVENSKI STANDARD
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Water quality - Determination of tritium activity concentration - Liquid scintillation counting method

Qualité de l'eau - Détermination de l'activité volumique du tritium - Méthode par comptage des scintillations en milieu liquide

Ta slovenski standard je istoveten z: ISO 9698:1989

ICS:

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**Water quality — Determination of tritium activity
concentration — Liquid scintillation counting method**

*Qualité de l'eau — Détermination de l'activité volumique du tritium —
Méthode par comptage des scintillations en milieu liquide*



Reference number
ISO 9698:1989(E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 9698 was prepared by Technical Committee ISO/TC 147, *Water quality*.

Annex A of this International Standard is for information only.

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Introduction

The tritium present in the environment is of natural origin and man made. As a result of nuclear weapon testing in the atmosphere, emissions from nuclear engineering installations, and the application and processing of isotopes, relatively large amounts of tritium are reaching the environment. Despite the low toxicity of tritium, monitoring of tritium activity concentrations in the environment is necessary in order to follow its circulation in the hydrosphere and biosphere.

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Water quality — Determination of tritium activity concentration — Liquid scintillation counting method

1 Scope

This International Standard specifies a method for the determination of tritiated water ($[^3\text{H}]\text{H}_2\text{O}$) activity concentration in water by liquid scintillation counting.

The method is applicable to all types of water including seawater with tritium activity concentrations of up to 10^6 Bq/m³ when using 20 ml counting vials.

NOTES

1 Below tritium activity concentrations of about 5×10^4 Bq/m³^[8], a prior enrichment step and/or the measurement of larger sample volumes can significantly improve the accuracy of the determination and lower the limit of detection (see clause 9 for calculation of the minimum detectable activity concentration).

However, enrichment means an extra step in the analytical procedure and thus an extra source of error, quite apart from the greater analytical effort involved. A scatter of about 1 % occurs as a result of the inherent variability of the enrichment cells. Direct scintillation counting with commonly used liquid scintillation counters^[5] is therefore preferable for tritium activity concentrations higher than about $5 \cdot 10^4$ Bq/m³, and, depending on the required accuracy of the measurements, is also applicable to much lower activity concentrations.

2 Tritium activity concentrations higher than 10^6 Bq/m³ may be determined after appropriate dilution with distilled water of proven low tritium content. An alternative method for the determination of these higher activities involves increasing the tritium activity concentrations of the internal standard solution (4.4).

3 The method is not applicable to the analysis of organically bound tritium; its determination requires an oxidative digestion.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All stand-

ards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5667-1:1980, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes*.

ISO 5667-2:1982, *Water quality — Sampling — Part 2: Guidance on sampling techniques*.

3 Principle

Addition of thiosulfate to a water sample which is then made alkaline and distilled. Mixing of an aliquot of the distillate with the scintillation solution in a counting vial. Partial conversion of the kinetic energy of the tritium beta particles in the resulting mixture (usually an emulsion) into photons. Counting of these photons as pulses. The counting rate is a measure of the tritium activity concentration.

NOTES

4 Tritium decays to helium by emitting beta radiation with a maximum energy of 18,6 keV. Its half-life is 4540 days (12,43 years)^[7].

5 The majority of the interfering compounds which act, for example, by quenching of the scintillation process, remain in the residue of the distillation together with any radioactive iodide and bicarbonate that might be present.

6 For counting, certain boundary conditions should be satisfied, e.g. simultaneous detection by two or more photomultiplier tubes connected in series; discrimination of pulses by preset measurement channels.

4 Reagents

During the analysis use only reagents of recognized analytical grade.

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4.1 Sodium carbonate, anhydrous (Na_2CO_3) .

4.2 Sodium thiosulfate, anhydrous ($\text{Na}_2\text{S}_2\text{O}_3$) .

4.3 Blank water, with a tritium activity concentration $c_o(t)$, in becquerels per cubic metre, at the time t at which the samples are measured.

Obtain water with a tritium activity concentration as low as possible, e.g. (deep) subterranean water. Distil the water according to 7.1. Keep the distillate in a well-stoppered borosilicate glass bottle in the dark at a temperature as constant as possible. Determine (see note 8) the tritium activity concentration $c_o(t=0)$, in becquerels per cubic metre, of this water and note the date ($t=0$) of this determination.

NOTES

7 It is advisable to keep an adequate quantity of blank water in stock and to make small working amounts from it for immediate use as required. Contamination with tritium (e.g. from water vapour in the air and from tritium sources such as luminous watches and gas chromatographs) or other radioactive species should be avoided.

8 The tritium activity concentration in the blank water can be determined by enrichment, followed by, for example, liquid scintillation counting.

When the stock of blank water is sufficiently large, e.g. 10 litres to 20 litres, and well sealed, it will remain stable for years, although it is advisable to redetermine the tritium activity concentration at predetermined intervals, e.g. every year.

9 Preferably use blank water with a tritium activity concentration of less than 500 Bq/m^3 . In case the tritium activity concentration of the blank water is greater than 500 Bq/m^3 , a correction must be made using the calculation procedure given in 8.1.2. The tritium activity concentration at the time t at which the samples are measured (7.3), corrected for radioactive decay, is given by the equation

$$c_o(t) = c_o(t=0)e^{-\lambda t} \quad \dots (1)$$

where

$c_o(t)$ is the tritium activity concentration, in becquerels per cubic metre, of the blank water at the time t at which the samples are measured;

$c_o(t=0)$ is the tritium activity concentration, in becquerels per cubic metre, of the blank water at the time of its preparation;

λ is the decay constant, in reciprocal years ($\lambda = 0,05576$);

t is the time, in years, between the preparation of the blank water and the measurement of the samples.

For blank water with a tritium activity concentration of up to 500 Bq/m^3 , correction for radioactive decay is not necessary.

4.4 Internal standard solution, tritium activity concentration $c_s(t)$.

In a location which is remote from the area where the tritium analyses are to be carried out, weigh and pour into a weighed 100 ml volumetric flask the requisite quantity of a concentrated tritium ($[^3\text{H}]\text{H}_2\text{O}$) standard solution (tritium activity concentration 10^{10} Bq/m^3 to 10^{11} Bq/m^3 , total inaccuracy less than about 1 %), so that the tritium activity concentration will be about 170 Bq/m^3 after making up to the mark with blank water (4.3) and mixing. Calculate the tritium activity concentration of the resulting internal standard solution $c_s(t=0)$ in becquerels per cubic metre. Note the date at which the standard solution was made up ($t=0$).

NOTES

10 The tritium activity concentration of the internal standard solution at time t at which the samples are measured (7.3), corrected for radioactive decay, is given by the equation

$$c_s(t) = c_s(t=0)e^{-\lambda t} \quad \dots (2)$$

where

$c_s(t)$ is the tritium activity concentration, in becquerels per cubic metre, of the internal standard solution at the time t at which the samples are measured;

$c_s(t=0)$ is the tritium activity concentration, in becquerels per cubic metre, of the internal standard solution at the time of its preparation;

λ is the decay constant, in reciprocal years ($\lambda = 0,05576$);

t is the time, in years, between the preparation of the internal standard solution and the measurement of the samples.

11 Instead of a concentrated tritium ($[^3\text{H}]\text{H}_2\text{O}$) standard solution, alternatively soluble aqueous tritium standard capsules may be used. However, commercially available standard capsules have a total inaccuracy much greater than 1 %.

4.5 Scintillation solution.

Scintillation solutions with one or more emulsifiers in which relatively large quantities of water samples can be incorporated, usually in an emulsion or gel, are commonly used. Commercially available cocktails are found to be the most satisfactory in practice (see also 9.1).

Pseudocoumene (1,2,4-trimethylbenzene) based cocktails are preferable because of their lower toxicity, higher flash point, better stability and lack