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Measurement of radioactivity in urine-^{238}Pu, ^{239}Pu and ^{240}Pu — Test method using alpha spectrometry or ICP-MS

Mesurage de la radioactivité dans les urines-^{238}Pu, ^{239}Pu et ^{240}Pu — Méthode d'essai utilisant la spectrométrie alpha ou l'ICP-MS

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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 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).

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

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

In the course of employment, individuals might work with radioactive materials that, under certain circumstances, could be taken into the body. Minimising the risks to workers from incorporated radionuclides requires the monitoring of potential or actual intakes. This monitoring involves the measurement of the activity of the radionuclides in the body (in vivo measurement) and/or biological samples, e.g. urine or faeces (in vitro measurement).

Analytical methods for plutonium urine bioassay are addressed in this document because of:

— the convenience of urine sampling and relatively easy sample processing. Urine bioassay is the most commonly used in vitro measurement method for accurately assessing the magnitude of internal contamination;

— the high radiotoxicity of Pu isotopes (e.g. ^{238}Pu, ^{239}Pu and ^{240}Pu) due to their long half-lives, highly energetic alpha emission and ability to accumulate into bone and organs;

— the major contribution of Pu isotopes to the internal contamination in many situations, and the relatively low detection limits of Pu isotopes compared to the other highly radiotoxic actinides.

For routine individual monitoring, the detection of all exposures whose sum can lead to an annual dose exceeding 1 mSv should be ensured according to ISO 20553. In emergency situations, the urine bioassay techniques should be sufficiently sensitive to meet the maximum value for reference level of 0,1 Sv recommended by the International Commission on Radiological Protection (ICRP)[1][2][3].

This document offers general requirements for sample processing and measurement of the activity concentration of Pu isotopes in urine samples. Examples of detailed procedures are given in the annexes for different monitoring situations.

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Measurement of radioactivity in urine-^{238}Pu, ^{239}Pu and ^{240}Pu — Test method using alpha spectrometry or ICP-MS

1 Scope

This document specifies approaches for the determination of plutonium isotopes (^{238}Pu, ^{239}Pu and ^{240}Pu) in urine using alpha spectrometry or inductively coupled plasma mass spectrometry (ICP-MS).

It is applicable to the measurement of plutonium isotopes at levels which are appropriate for

— workers handling plutonium in planned exposure situations, where detection limits are sufficiently low to be in accordance with dose limits, and

— workers, members of the public and emergency responders in emergency exposure situations, where required detection limits can be much higher, and results need to be reported in a short timescale.

This document does not provide information on when monitoring is carried out or the interpretation of the results in terms of dose or biological effects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the 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 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*

ISO 13167, *Water quality — Plutonium, americium, curium and neptunium — Test method using alpha spectrometry*

ISO 15189, *Medical laboratories — Requirements for quality and competence*

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

ISO 17294-1, *Water quality — Application of inductively coupled plasma mass spectrometry (ICP-MS) — Part 1: General requirements*

ISO 17294-2, *Water quality — Application of inductively coupled plasma mass spectrometry (ICP-MS) — Part 2: Determination of selected elements including uranium isotopes*

ISO 20553, *Radiation protection — Monitoring of workers occupationally exposed to a risk of internal contamination with radioactive material*

ISO 20899, *Water quality — Plutonium and neptunium — Test method using ICP-MS*

ISO 28218, *Radiation protection — Performance criteria for radiobioassay*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 28218, ISO 20553, ISO 80000-10, ISO 11929 (series), ISO 17924-1, ISO 20899 and the following apply.

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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
reference level
dose criterion used to guide the optimisation process in existing and emergency exposure situations

Note 1 to entry: Generally expressed in terms of individual annual dose ($mSv \cdot year^{-1}$), the value of a reference level should be selected considering the appropriate time frame, individual dose distribution of the affected people, and the tolerability of risk in the circumstances. An objective is to facilitate the identification of people for whom protective efforts should be given priority.

3.2
spot urine sample
urine sample where the collection duration is shorter than 24 h (normally a single voiding)

3.3
sample turn-around time
total time for sample processing and measurement

3.4
sample preparation volume
volume of sample taken from the collected sample for pretreatment and subsequent analysis

4 Symbols

For the purposes of this document, the symbols given in ISO/IEC Guide 98-3, ISO 80000-10, ISO 11929-1 and the following shall apply.

Symbol	Description	Unit
A_0	Activity of the certified calibration source, on the date of the measurement	Bq
A_T	Activity of the tracer added on the measurement date	Bq
α	Probability of the false positive decision	—
β	Probability of the false negative decision	—
c_A	Activity concentration of plutonium isotopes	$Bq \cdot l^{-1}$
c_A^*	Decision threshold of the measurand	$Bq \cdot l^{-1}$
$c_A^\#$	Decision limit of the measurand	$Bq \cdot l^{-1}$
$c_A^\triangleleft$, $c_A^\triangleright$	Lower and upper limits of the probabilistically symmetric coverage interval of the measurand, respectively	$Bq \cdot l^{-1}$
$c_A^<$, $c_A^>$	Lower and upper limits of the shortest coverage interval of the measurand, respectively	$Bq \cdot l^{-1}$
$\tilde{c}_A$	Possible or assumed true quantity values of the measurand	$Bq \cdot l^{-1}$
c_{AT}	Activity concentration of the tracer solution at the moment of separation	$Bq \cdot g^{-1}$
ε	Counting efficiency	—
Φ	Distribution function of the standardized normal distribution	—
$1\text{-}\gamma$	Probability for the coverage interval of the measurand	—
I_α	Summation of alpha emission intensity	—
λ	The probability per unit time that an individual radioactive nucleus will decay, as defined by the exponential decay law (decay constant).	—

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