FINAL
DRAFT

INTERNATIONAL
STANDARD

**ISO/FDIS
24390**

ISO/TC **85**/SC **5**

Secretariat: **BSI**

Voting begins on:
2023-08-25

Voting terminates on:
2023-10-20

Nuclear energy — Nuclear fuel technology — Methodologies for radioactivity characterization of very low-level waste (VLLW) generated by nuclear facilities

Reference number
ISO/FDIS 24390:2023(E)

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

Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 5, *Nuclear installations, processes and technologies*.

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.

Introduction

The activity concentration of very low-level waste (VLLW) is generally below a few becquerels per gram (Bq/g), which is still greater than the allowable limits for clearance waste (often 10 times to 100 times greater). It is generally accepted that due to the low levels of activity associated with this type of waste, VLLW does not require a high level of containment and isolation, as is the case for low and intermediate level waste.

To take full advantage of opportunities for directing waste to alternative waste management routes that are more advantageous, the waste should be appropriately characterized and classified. Accurate waste characterization is also crucial for the protection of people and the environment, given the lower levels of isolation or containment barriers at VLLW disposal sites (generally in ordinary landfills). Additionally, proper characterization may allow waste classification for reuse or recycling.

Although the process for radioactively characterizing waste as low-level waste (LLW), VLLW and clearance generally follows common principles, it is appropriate to establish a specific document to assist in identifying low-level waste against waste acceptance criteria on VLLW.

This document describes the methodologies and procedures for the identification of waste that can be categorized as VLLW.

Nuclear energy — Nuclear fuel technology — Methodologies for radioactivity characterization of very low-level waste (VLLW) generated by nuclear facilities

1 Scope

This document describes methodologies for radioactivity characterization of very low-level waste (VLLW) generated from the operation or decommissioning of nuclear facilities. The purpose is to differentiate VLLW from low-level radioactive solid waste and waste below clearance levels. The aim is to effectively characterize and to demonstrate that it satisfies the criteria for VLLW.

This document focuses specifically on characterization methods of radioactive solid waste. Clearance and exemption monitoring are not covered within this document. Additionally, the characterization of liquid and gaseous wastes is also excluded from 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.

ISO 12749-3, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 3: Nuclear fuel cycle*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12749-3 and the following 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
very low-level waste
VLLW
radioactive waste that does not necessarily meet the criteria of exempt waste, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in landfill type near surface repositories with limited regulatory controlNote 1 to entry: Such landfill type near surface repositories may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer-lived radionuclides in VLLW are generally very limited.

[SOURCE: IAEA Safety Glossary: 2022 edition]

3.2
waste acceptance criteria
WAC
quantitative or qualitative criteria specified for the waste form and waste package to be accepted by the operator of a waste management facility

[SOURCE: IAEA Safety Glossary: 2022 edition, modified — Definition revised.]

3.3
data quality objective
DQO
process used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study

[SOURCE: ISO 18557:2017, 3.8]

3.4
difficult-to-measure radionuclide
DTM radionuclide
radionuclide whose radioactivity is difficult to measure directly from the outside of the waste packages by non-destructive assay means

[SOURCE: ISO 21238:2007, 2.1, modified — Examples removed.]

3.5
key radionuclide
gamma-emitting radionuclide whose radioactivity is correlated with that of *difficult-to-measure radionuclides* (3.4) and can be readily measured directly by non-destructive assay means

Note 1 to entry: Also called "easy-to-measure radionuclide" or "marker radionuclide".

[SOURCE: ISO 21238:2007, 2.2, modified — Example removed.]

3.6
scaling factor
factor or parameter derived from the mathematical relationship used in calculating the radioactivity of *difficult-to-measure radionuclides* (3.4) from that of *key radionuclide* (3.5) determined from sampling and analysis data

[SOURCE: ISO 21238:2007, 2.3]

3.7
nuclide vector
fingerprint
used to infer and quantify the presence of other key nuclides

Note 1 to entry: Applying correlation factors enables estimations of *difficult-to-measure radionuclides* (3.4).

Note 2 to entry: It is a method which involves measurements of *key radionuclides* (3.5) (usually gamma emitters, e.g. 137Cs, 60Co) to quantify difficult-to-measure nuclides.

[SOURCE: ISO 18557:2017, 3.12]

3.8
heterogeneous waste
radioactive waste that does not meet the definition of *homogeneous waste* (3.9), including solid components and mixtures of solid components

EXAMPLE Cartridge filters, contaminated tools or instruments.

[SOURCE: ISO 21238:2007, 2.13, modified — Part of definition used to create EXAMPLES.]

3.9
homogeneous waste
radioactive waste that shows an essentially uniform distribution of activity and physical contents

EXAMPLE Flowable wastes such as concentrates, solidified liquids and spent resins.

[SOURCE: ISO 21238:2007, 2.12, modified — EXAMPLES revised.]

3.10
destructive analysis
analytical techniques of radioactive and chemical materials using methods which involve the destruction of a sample, for example chemical and radiochemical analysis, ICP-MS or alpha spectrometry

[SOURCE: ISO 18557:2017, 3.9, modified — Definition revised.]

3.11
non-destructive analysis
NDA
analytical techniques that allow measurement of specific properties without physical destruction of the media or item

Note 1 to entry: Generally used for in situ measurements.

[SOURCE: ISO 18557:2017, 3.20]

4 Waste acceptance criteria (WAC) for VLLW

Waste acceptance criteria (WAC) are quantitative or qualitative criteria which state the conditions by which waste can be accepted by the operator of facilities that process, store or dispose of VLLW.

WAC specify the radiological, mechanical, physical, chemical and biological characteristics of the waste packages or unpackaged waste which may be accepted into the facility.

WAC are important because they:

— ensure compliance with safety and environmental requirements;

— are designed to assist with the selection of appropriate processing and packaging options;

— prevent technological problems during processing;

— standardize waste management operations;

— ensure waste tracking.

WAC are developed so as to be relevant, concise, measurable and verifiable, provide some flexibility, and be appropriate to each waste stream. WAC ensure that the interfaces between all parties and facilities associated with the management and disposal of VLLW are clearly understood.

Waste characterization requirements are typically developed from disposal safety and/or performance assessment, and the waste acceptance criteria for disposal are derived at the same time.

The radioactivity characterization of VLLW should address the requirements of WAC and should ensure that the requirements for each stage associated with waste management and disposal are considered. It is good practice to develop and justify the requirements of WAC using a robust process, such as data quality objectives (DQO).

The requirements for radioactivity characterization should be interpreted and confirmed, and sufficient characterization should be accomplished to satisfy the requirements of the WAC.

5 Radioactivity characterization

5.1 Principle of radioactivity characterization of VLLW

5.1.1 Requirements and limits

The main purpose of VLLW characterization is to identify conveniently this waste stream from higher-level radioactive waste (LLW) and lower-level radioactive waste (clearance waste). The general

measurement methods used for the characterization of LLW and clearance waste are also applicable to VLLW. The selection of characterization methods for VLLW mainly depends on:

— regulatory requirements, including activity limits or dose rate limits;

— monitoring purpose, such as reused, recycling or landfill disposal;

— limitations on measurement possibilities.

Activity limits can be expressed in terms of surface activity or mass activity and can be fixed for a single radionuclide or a group of radionuclides (e.g. alpha emitters, beta-gamma emitters, pure beta emitters).

The limits of dose rate of gamma emitters can be derived from activity limits and are recommended to identify and determine the classification of radioactive waste (as seen in 5.3).

5.1.2 Measurement methodology

During the radioactivity measurement of VLLW, the following considerations should be taken into account:

— surface activity measurement, i.e. in situ direct measurement, consists mostly of beta and gamma measurement;

— results of in situ direct measurement can be used to show the preliminary distribution of the contamination and confirm “active spots”;

— surface activity measurements can guide targeted sampling and associated gamma spectrometry or destructive analysis;

— alpha particle, soft beta radiation as well as low energy gamma radiation are difficult to detect by in situ direct measurement;

— measurement of alpha particles and soft beta radiation typically requires radio-chemical analysis or spectroscopic analysis to define the composition of mixed radionuclides;

— radio-chemical analysis of low activity requires sufficient samples to facilitate easier measurement and to improve the accuracy of specific activities;

— alpha contamination measurement of VLLW from reactors is usually unnecessary unless cladding ruptures have occurred;

— for mixtures of radionuclides, easily detectable radionuclides (e.g. Co-60) can be used as contamination indicators to determine quickly the activity level of radioactive waste;

— selection of measurement apparatus should be based on the activity limits and characteristics of the apparatus;

— the apparatus should be calibrated following the standards of various energies; the detection thresholds and background levels should be regularly checked to prevent any major error;

— the uncertainty should be carefully considered during the sampling and measurement.

5.2 Process for radioactivity characterization of VLLW

5.2.1 General

The following steps are considered good practice for identification of waste that may be categorized as VLLW:

— investigation of waste properties;

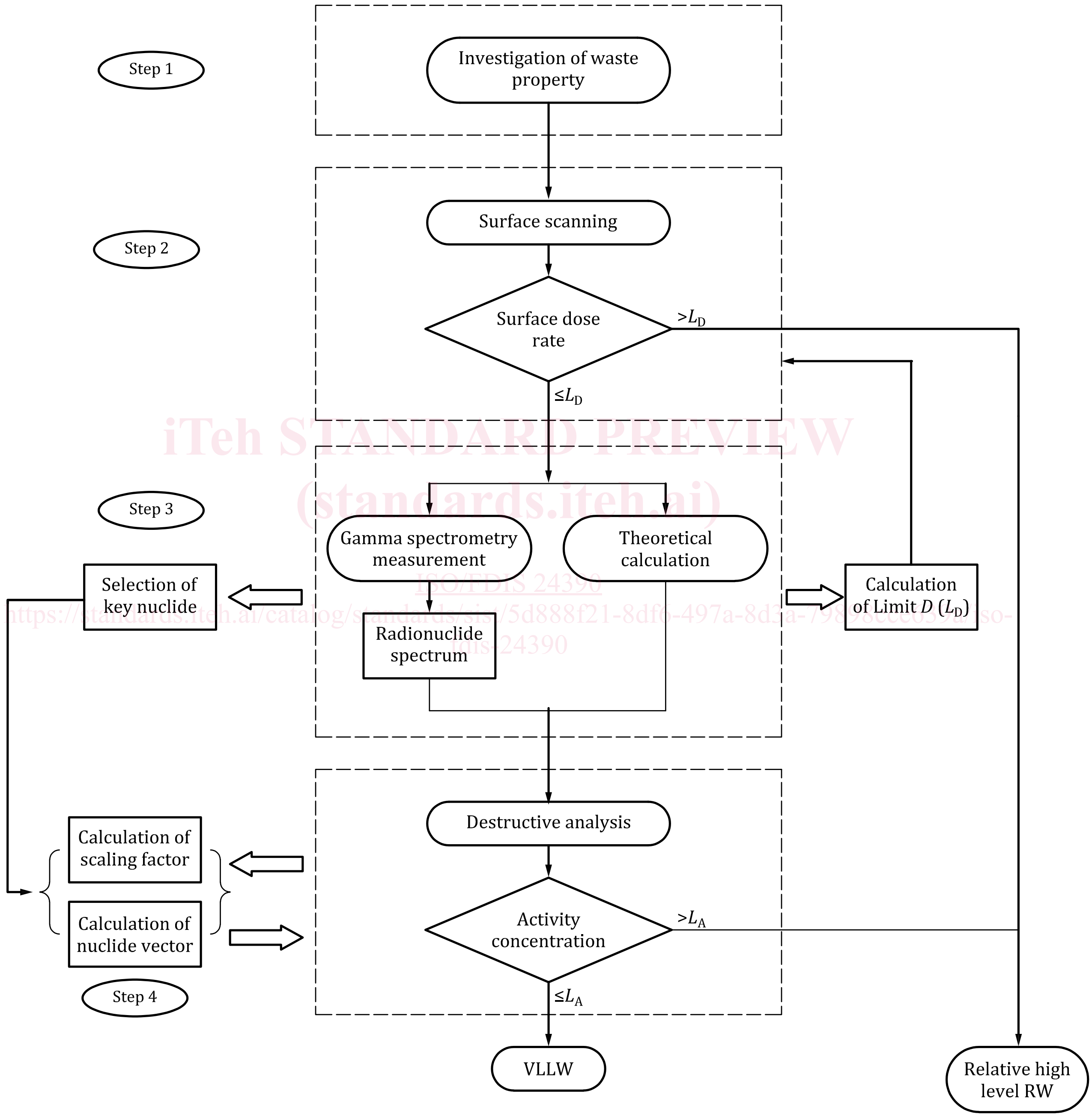
— surface scanning, dose rate assessment;

— theoretical calculation and measurement of waste activity;

— activity measurement by means of destructive analysis.

The process is shown in Figure 1.

The steps in the process are further described in 5.2.2 to 5.2.5.



Key

L_A activity limit, in Bq

L_D dose rate limit, in Gy/h

Figure 1 — VLLW radioactivity characterization process