Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure

REAFFIRMED

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ANSI/ANS-16.1-2019 (R2024)

ANSI/ANS-16.1-2019

An American National Standard

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American National Standard
Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure

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American Nuclear Society

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American National Standard

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Foreword

(This foreword is not a part of American National Standard "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure," ANSI/ANS-16.1-2019, but is included for informational purposes.)

Contact of solid radioactive wastes with water is the initial step of a potentially major pathway for radionuclide release and migration off-site. The release of radionuclides from a waste form through contact with water, referred to as leaching, must occur before they migrate through groundwater and off the disposal site. It follows that the resistance of a waste form to leaching is of fundamental interest in low-level radioactive waste disposal and that the measurement of the leach resistance of potential waste forms is important in low-level radioactive waste management. The low-level radioactive wastes addressed in this standard are those defined in Title 10, Code of Federal Regulations, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste."[1)]

This standard provides a simple method for the quantitative comparison of the leach resistance of different radionuclides from different materials. The method is not intended to provide information suitable for assessing waste form performance or qualification for disposal. Rather, it provides a rapid and economical means for screening optional materials, formulations, and processing methods to develop and select waste forms for more extensive testing. Although the test results might provide basic insights regarding the leaching mechanism and performance, those insights should be evaluated using process-specific test methods and site-specific test conditions (e.g., by following the approach recommended in ASTM C1174-17[2)]). Other methods appropriate for evaluating release mechanisms and long-term performance of low-level waste forms have been developed (e.g., ASTM C1308-08[3)] and EPA SW-846 Methods 1311 and 1312[4),5)]). EPA SW-846 Methods 1313 and 1315[6),7)] may be used to determine additional information. EPA SW-846 Method 1315 has been used with prepared glass coupons and at multiple controlled temperatures to evaluate dissolution and leaching kinetics.[8)] EPA Methods 1313 and 1315 have also been used to understand the susceptibility of cement mortars and low-activity nuclear waste forms to carbonation and carbonation front ingress rates and to understand the impact of carbonation on the leaching of material constituents.[9),10),11)]

[1)] *Code of Federal Regulations*, Title 10, "Energy," Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," U.S. Nuclear Regulatory Commission, Washington, D.C.

[2)] ASTM C1174-17, "Standard Practice for Evaluation of the Long-Term Behavior of Materials Used in Engineered Barrier Systems (EBS) for Geological Disposal of High-Level Radioactive Waste," ASTM International (2017).

[3)] ASTM C1308-08(2017), "Standard Test Method for Accelerated Leach Test for Diffusive Releases from Solidified Waste and a Computer Program to Model Diffusive, Fractional Leaching from Cylindrical Waste Forms," ASTM International (2008).

[4)] EPA SW-846, "Test Method 1311: Toxicity Characteristic Leaching Procedure," part of Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Environmental Protection Agency (1992); available at https://www.epa.gov/hw-sw846/sw-846-test-method-1311-toxicity-characteristic-leaching-procedure (current as of March 14, 2019).

[5)] EPA SW-846, "Test Method 1312: Synthetic Precipitation Leaching Procedure," part of Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Environmental Protection Agency (1994); available at https://www.epa.gov/hw-sw846/sw-846-test-method-1312-synthetic-precipitation-leaching-procedure (current as of March 14, 2019).

[6)] EPA SW-846, "Validated Test Method 1313: Liquid-Solid Partitioning as a Function of Extract pH Using a Parallel Batch Extraction Procedure," Environmental Protection Agency (2017); available at https://www.epa.gov/hw-sw846/validated-test-method-1313-liquid-solid-partitioning-function-extract-ph-using-parallel (current as of March 14, 2019).

[7)] EPA SW-846, "Validated Test Method 1315: Mass Transfer Rates of Constituents in Monolothic or Compacted Granular Materials Using a Semi-Dynamic Tank Leaching Procedure," Environmental Protection Agency (2017); available at https://www.epa.gov/hw-sw846/validated-test-method-1315-mass-transfer-rates-constituents-monolithic-or-compacted (current as of March 14, 2019).

[8)] C. CORKHILL et al., "Evaluation of Novel Leaching Assessment for Nuclear Waste Glasses," *Proc. Waste Management 2018*, Phoenix, Arizona, March 18–22, 2018, paper 18314 (2018).

[9)] J. L. BRANCH et al., "The Impact of Carbonation on the Microstructure and Solubility of Major Constituents in Microconcrete Materials with Varying Alkalinities due to Fly Ash Replacement of Ordinary Portland Cement," *Cem. Concr. Res.*, **89**, 297 (2016); https://doi.org/10.1016/j.cemconres.2016.08.019.

[10)] O. KLEIN-BENDAVID et al., "Retention of Cr in Metakaolin-Based Geopolymeric Materials Under Oxidation and Carbonation," *Proc. Waste Management 2017*, Phoenix, Arizona, March 5–7, 2017, paper 17453 (2017).

[11)] J. L. BRANCH et al., "Evaluating the Impacts of Reactive Gas (Carbon Dioxide and Oxygen) Ingress on Leaching from Cementitious Waste Forms," *Proc. Waste Management 2017*, Phoenix, Arizona, March 5–7, 2017, paper 17482 (2017).

Low-level radioactive wastes are generated as combustible, non-combustible, compactible, and non-compactible solids (e.g., cloth, metal, paper, wood), liquids (e.g., evaporator bottoms, decontamination solutions), slurries (e.g., filter sludges, ion-exchange resins), and powders (e.g., incinerator ash, salts). This standard was designed principally for comparisons of solid monolithic low-level radioactive waste forms generated from non-self-heating radioactive fluid (e.g., liquids, slurries, free-flowing powders) waste streams.

An accepted method for managing these liquids, slurries, and powders is solidification, packaging, and subsequent shipment for disposal by shallow land burial. Solidification restricts dispersal during handling and transportation and provides a non-changing volume during the residence time of the waste in the burial trench.

At present, generators of low-level radioactive wastes (e.g., nuclear power plants, U.S. Department of Energy reservations and national laboratories, research and development laboratories, and hospitals) need a common basis for comparing the alternatives for packaging, handling, storing, and shipping their radioactive wastes. Vendors and developers of solidification systems need a common basis for comparing the leachability of the waste forms made by their solidification processes. The test presented in this standard provides a relative measure of leach resistance within a reasonable time period to provide comparative results for alternative low-level waste forms.

Although leach testing has been recognized as a primary technique for the comparison of solidified waste forms, the determination of release rates from different waste form materials remains complex for the following reasons:

(1) Leaching can proceed by several concurrent mechanisms, such as diffusion, dissolution, and erosion. The relative importance of each process can be different for each radionuclide of interest, matrix material, and set of processing conditions and can change with time, temperature, pH, substances dissolved in the water, and other environmental variables.

(2) Actual leaching conditions that might occur during the sound life of a solidified waste form (i.e., the time over which the waste form meets the specifications for all applicable performance parameters) are imprecisely known, and postulated conditions can vary widely over time.

The test method described in this standard cannot be used for performance assessment of waste forms because it does not address the radionuclide release mechanisms or effects of environmental conditions on the test response. Instead, it provides an economical and rapid method for comparing the leachability of alternative waste forms.

This standard was originally published as ANS-16.1-1986, which was informed by a method published by the International Atomic Energy Agency in 1971[12)] and ISO 6961:1982(E), published in 1982.[13)] ANS-16.1-2003 (R2017) was reaffirmed in 2017 with the understanding that it would be revised to update its technical content and clarify its purpose and application. While the leach test procedure and definition of the leachability index remain consistent with previous versions, this revision provides specific instructions regarding test variables, execution, presentation and analysis of test data, and interpretation of the test results. The most significant changes are that the revised procedure requires constant 1-day replacement

[12)] "Leach Testing of Immobilized Radioactive Waste Solids, A Proposal for a Standard Method," E. D. HESPE, Ed., International Atomic Energy Agency, *At. Energy Rev.*, **9**, *1*, 195 (1971).
[13)] ISO 6961:1982(E), "Long-Term Leach Testing of Solidified Radioactive Waste Forms," International Organization for Standardization (1982).

intervals, eliminates the option for long-term test intervals, and quantifies the uncertainty in the leachability index to objectively compare values for different materials.

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