American Nuclear Society

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measurement of the leachability of solidified low-level radioactive wastes by a short-term test procedure

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

Secretariat
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American National Standard

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Foreword

(This Foreword is not part of American National Standard for the Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure, ANSI/ANS-16.1-2003.)

The characteristics of radioactive wastes from the nuclear industry are dependent on many diverse factors, most of which do not lend themselves to simple definition and standardization. In this standard, low-level wastes are considered to be those radioactive wastes that are defined as low-level in Title 10, *Code of Federal Regulations*, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste" (2003). In general, Section 61.2 of Part 61 defines low-level wastes as those containing source, special nuclear, or by-product materials that are not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or uranium or thorium tailings and waste. Resistance to leaching of radionuclides is not specifically mentioned in Part 61 nor is containment of radionuclides called out as an express requirement for low-level radioactive waste packages. Minimization of contact of waste by water is a fundamental concern of Part 61, however, as evidenced by the statement in Section 61.7 that ". . . a cornerstone of the system is stability . . . so that . . . **access of water to the waste can be minimized**. Migration of radionuclides is thus minimized . . ." (bold emphasis added).

In addition, there are several statements in Section 61.57 that address minimization of contact of water with waste. These statements are in recognition of the fact that contact of waste with water is an initial step in a potentially major pathway for radionuclide release and migration off-site. "Leaching," or the release of radionuclides from a waste form through contact with water, is thus a major factor in the subsequent migration of the radionuclides from the waste, through groundwater, and off the site. It follows, therefore, that leaching is a phenomenon that 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 waste management.

Low-level radioactive waste accrues in the form of combustible, noncombustible, compactible, and noncompactible solids (cloth, metal, paper, wood), liquids (evaporator bottoms, decontamination solutions), slurries (filter sludges, ion-exchange resins), and powders (incinerator ash, salts). The ANS-16.1 standard was designed principally for one type of low-level radioactive waste: low-level, non-self-heating, radioactive fluids (liquids, slurries, and free-flowing powders). However, it can be used to measure the leach resistance of any waste solidified into a well-defined geometric shape.

An accepted method for managing these liquids, slurries, and powders is solidification, packaging, and subsequent shipment for disposal by shallow-land burial. Solidification can restrict dispersal during handling and transportation and can provide a nonchanging 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, laboratories, and hospitals) need a common basis for evaluating the alternatives for packaging, handling, storing, and shipping their radioactive wastes. Vendors of solidification systems need a common basis for evaluating the leachability of the waste forms made by their solidification processes. Burial ground operators need leaching information to improve the efficiency of their handling, disposal, and site maintenance operations. The 5-day test provides a measure of leach

resistance performance that can be done in the field in a reasonable time period to provide confidence to generators, vendors, and operators that the material intended for shallow burial meets minimum requirements for leach resistance (for example, the U.S. Nuclear Regulatory Commission requires a minimum leachability index of 6.0 for radioisotopes).

Leaching, which can occur when water contacts a solidified waste form, is an important mechanism for the dispersal of radioactivity. Leach testing has thus been recognized as a primary technique for the evaluation and comparison of solidified waste forms.[1),2)] Even so, the situation remains complex for several reasons:

(1) leaching can proceed by several concurrent mechanisms such as diffusion, dissolution, and erosion, the relative importance of which can change with time, and temperature, substances dissolved in the water, matrix material, the radionuclides of interest, pH, and other variables;

(2) the actual leaching conditions that a solidified waste form will encounter during its sound life (i.e., the time during which the waste form meets the specifications for all applicable parameters) are imprecisely known, with postulated conditions varying widely;

(3) investigators of waste forms have tended to use leach testing procedures unique to their own studies, which makes comparisons difficult.

As a first step toward rectifying the last situation, the International Atomic Energy Agency (IAEA) published a suggested standard leach test in 1971.[1)] This suggested test met with consent in principle but was not put into practice. Instead, much of the leach testing being performed used procedures described as "modified" IAEA tests. The "modifications" were unique to individual laboratories, so that standardization and comparability of results was still lacking. The test presented in the ANSI/ANS-16.1-2003 standard has much in common with the original IAEA test.

Working Group ANS-16.1 of the Standards Committee of the American Nuclear Society had the following membership at the time it approved this standard:

R. D. Spence, Chair, *Oak Ridge National Laboratory*

O. U. Anders, *Individual*
H. W. Godbee, *Individual*
A. Icenhour, *Oak Ridge National Laboratory*
R. M. Neilson, *Idaho National Engineering and Environmental Laboratory*

This standard was processed and approved for submittal to ANSI by the American Nuclear Society's Nuclear Facilities Standards Committee (NFSC) on ANSI/ANS-16.1-2003, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure." Committee approval of the standard does not necessarily imply that all committee members voted for its

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[1)]"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 (1971).

[2)] "Long-Term Leach Testing of Solidified Radioactive Waste Forms," ISO 6961-1982(E), International Organization for Standardization.

approval. At the time it approved this standard, the NFSC committee had the following members:

D. J. Spellman, Chair, *Oak Ridge National Laboratory*
S. Ahmad, Standards Administrator, *American Nuclear Society*

C. K. Brown, *Southern Nuclear Operating Company*
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H. Chander, *U.S. Department of Energy*
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Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure

1 Scope, Purpose, and Application

1.1 Scope

This standard, ANSI/ANS-16.1-2003,[1)] provides a uniform procedure to measure and index the release of radionuclides from waste forms as a result of leaching in demineralized water for 5 days.[2)] The results of this procedure do not apply to any specific environmental situation except through correlative studies of actual disposal site conditions. The test presented in this standard has much in common with the original International Atomic Energy Agency proposal and has by now become familiar to those working in the radioactive waste-form development field. It contains the provisions published in the original version of this standard in 1986.

1.2 Purpose

The quantification of the leaching characteristics of solidified wastes requires a standardized, practical method to measure the ability of the solids to impede the release of radioisotopes when water comes into contact with them. The purpose of this standard is to establish such a test, define a material parameter, and provide a mathematical procedure for calculating a "Leachability Index" value for the test data collected over the time period of the test.

This standard is intended to serve as a basis for indexing radionuclide release from solidified low-level radioactive waste forms in a short-term (5-day) test under controlled conditions in a well-defined leachant. It is not intended to serve as a definition of the long-term (several hundred to thousands of years) leaching behavior of these forms at conditions representing actual disposal conditions.

Under actual leaching conditions, mechanisms other than diffusion (e.g., chemical reaction, surface layers and films, cracking, etc.) are important considerations. Also, the interplay of retardation mechanisms (filtration, ion exchange, coprecipitation, etc.) and enhancement mechanisms (chelation, desorption, dissolution, etc.) for radionuclide migration are important considerations.

1.3 Application

The mechanisms involved in leaching can differ from one type of material to another, from one leachant to another, and from one set of leaching conditions to another. However, if they are known through generic studies, predictions for the release of radioactivity as a function of time can be made. In spite of the differences in materials, leachants, and conditions, a procedure applicable to all products of low-level radioactive waste solidification processes can be devised for purposes of quantitative assessment. The test set forth in this standard is short-term, simple, and emphasizes reproducible conditions that can be readily achieved. The essential test parameters are fixed in detail.

The test consists of a procedure in which the leachant is replaced at designated intervals to generate seven data points over 5 days and ten data points if the test is extended to 90 days. The procedure permits the accumulation of sufficient data in a reasonably short time for quantitative assessment purposes. In its "extended" form, the laboratory leaching can be extended

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[1)] ANSI/ANS-16.1-2003 is hereafter referred to as "this standard."

[2)] Periods of time with the units of days or hours are spelled out since the letters "d" or "h" are used to represent other quantities.