INTERNATIONAL

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Standard Test Method for Accelerated Leach Test for Measuring Contaminant Releases From Solidified Waste[1]

This standard is issued under the fixed designation C1308; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method provides a procedure for measuring the release rates of elements from a solidified matrix material under conditions that mitigate solution feedback effects. Results can be analyzed by using different models to determine if the elemental releases are controlled by mass transport though the matrix (that is, by diffusion), by a surface dissolution process, or by a combination of processes. This test method is applicable to any material that does not deform during the test.

1.1.1 If mass diffusion is the dominant process in the release mechanism, then the results of this test can be used to derive diffusion coefficients for use in diffusion-based mathematical models.

1.1.2 If surface dissolution is the dominant process, then the results of this test can be used to derive the kinetic dissolution rate in the absence of reaction affinity effects for use in dissolution-based mathematical models.

1.1.3 If release is controlled by coupled or combined dissolution and mass transport processes, then the results of this test can be used to derive effective coefficient values for a mechanistic or empirical model.

1.2 Tests at elevated temperatures are used to accelerate the release process to determine the temperature range over which the release mechanism does not change and to generate results that can be used for calculating releases at lower temperatures over long times, provided that the release mechanism does not change with temperature.

1.2.1 Tests conducted at high temperatures can be used to determine the temperature dependence of model coefficients.

1.2.2 The mechanism is considered to remain unchanged over a range of temperatures if the model coefficients show Arrhenius behavior over that range.

1.2.3 Releases at any temperature within that range can be projected in time up to the highest cumulative fractional release value that has been measured for that material.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1220 Test Method for Static Leaching of Monolithic Waste Forms for Disposal of Radioactive Waste

3. Terminology

3.1 *Definitions:*

3.1.1 *cumulative fraction leached*—the sum of the fractions of a species leached during all sampling intervals prior to and including the present interval divided by the amount of that species present in the test specimen before the test.

3.1.2 *diffusion coefficient (diffusivity)*—an intrinsic property of a species that relates *(1)* its concentration gradient to its flux in a given medium (Fick's first law), *(2)* its spatial rate of change in the direction of the concentration gradient to the time rate of change in its concentration in a given medium (Fick's second law), or *(3)* its mean square displacement to time in a given medium (the Einstein equation).

3.1.3 *dissolution*—the transfer of species from the solid test specimen into solution.

[1] This test method is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.13 on Spent Fuel and High Level Waste.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.4 *effective diffusion coefficient (D_e)*—the diffusion coefficient as modified by other processes (for example, adsorption) or physical constraints (for example, tortuosity and constrictivity).

3.1.5 *finite cylinder (finite medium)*—a bounded body for which Fick's diffusion equation can be solved.

3.1.6 *incremental fraction leached*—the amount of a species leached during a single sampling interval divided by the amount of that species in the test specimen before the test.

3.1.7 *leachant*—the initial solution with which a solid is contacted and into which the solid dissolves or is leached.

3.1.8 *leachate*—the final solution resulting from a test in which a solid is contacted by a solution and leaches or dissolves.

3.1.9 *leaching*—the preferential loss of components from a solid material into solution leaving a residual phase that is depleted in those components, but structurally unchanged.

3.1.10 *leaching interval*—the length of time during which a given volume of leachant is in contact with a specimen.

3.1.11 *leaching mechanism*—the set of processes that controls the rate of mass transport of a species out of a specimen during leaching.

3.1.12 *matrix material*—the solid material used to immobilize the waste or species of interest.

3.1.13 *partitioning*—the distribution of a contaminant between phases that may result in different release behaviors.

3.1.14 *reference leach test*—a leach test conducted with the material of interest under defined conditions, the results of which are used as a standard against which the results of other leach tests with that material are compared. In this test method, a reference leach test is one that is conducted at 20 °C using demineralized water.

3.1.15 *semi-dynamic leach test*—a leach test method in which the specimen is exposed to fresh leachant on a periodic schedule.

3.1.16 *semi-infinite medium*—a body having a single planar surface and extending infinitely in the directions parallel to the surface and in one direction normal to the surface.

3.1.17 *source term*—in this test method, the concentration of a species of interest in a specimen prior to leaching.

3.1.18 *specimen surface area*—for purposes of this test method, the geometric surface area of a monolithic specimen that is calculated from macroscopic measurements of its dimensions by assuming a simple geometric shape, such as a right circular cylinder.

3.1.19 *specimen volume*—for purposes of this test method, the volume of a monolithic specimen calculated from macroscopic measurements of its dimensions by assuming a simple geometric shape, such as a right circular cylinder.

3.1.20 *waste form*—the waste material and any encapsulating or stabilizing matrix in which it is incorporated.

4. Summary of Test Method

4.1 This test method is a semi-dynamic leach test in which a specimen of known surface area and volume is immersed in a leachant of known volume that is completely replaced after specified one-day intervals. The concentration of an element of interest in the test solution recovered after each interval is measured. The fraction of a species of interest that is released into solution during each test interval divided by the initial amount of that species in the specimen is referred to as the incremental fraction leached (*IFL*). The accumulated amount of the species of interest released during the intervals prior to and including the interval of interest is referred to as the cumulative fraction leached (*CFL*). Changes in the *IFL* and *CFL* values after each interval are analyzed to determine if the release from the solid can be described using an analytical model.

4.2 The results of tests at a single common temperature may be used to compare the release behaviors of different species from the same or different materials.

4.2.1 The derived model parameter values can be used to calculate releases from waste forms with shapes different than that of the test specimen.

4.2.2 The release model optimized by regression to test results can be used to calculate releases from full-scale waste forms for long times.

4.3 Elevated temperatures are used to accelerate the release of a species of interest, show that release is controlled by the same process over a temperature range, and determine the temperature dependence of the model coefficient values.

4.3.1 Tests must be performed at a minimum of three temperatures to verify that the leaching mechanism does not change over that temperature range.

4.3.2 By conducting tests over a range of temperatures, an Arrhenius plot can be produced to interpolate values of the test parameters within the temperature range that was tested. Values cannot be extrapolated to temperatures that are higher or lower than the temperature range spanned by the tests.

4.4 The *CFL* values of tests conducted at low temperatures can be extrapolated to long times if data from tests run at two or more elevated temperatures and at the reference temperature (20 °C) can all be represented by the same model and if the model coefficient values show Arrhenius behavior.

4.4.1 The results of tests at repository-relevant temperatures can be extrapolated to long times by utilizing results from tests at elevated temperatures if data from tests run at elevated temperatures and data from tests run at the reference temperature (20 °C) can be represented using the same model and the model coefficient values show Arrhenius behavior.

4.4.2 The maximum cumulative fractional release measured represents the maximum extent of reaction for which the consistency of the mechanism has been verified for that material.

4.5 The release model coefficients can be used to calculate releases from waste forms with other shapes and sizes.

4.6 The possibility of a solubility limit to the release of the species of interest shall be addressed. This can be done by evaluating the *IFL* values: constant *IFL* values may indicate either linear release kinetics or solubility limits. The results of additional tests with shorter or longer intervals can be used to discriminate between these possibilities.