



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 Forms¹

This standard is issued under the fixed designation C 1308; 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 method for accelerating the leach rate of solidified waste and determining if the release is diffusion-controlled. This test method is applicable to any material that does not degrade, deform, or change leaching mechanism during the test.

1.1.1 If diffusion is the dominant leaching mechanism, then results of this test can be used to model long-term releases from waste forms. Diffusion can be confirmed as the leaching mechanism through the use of a computerized mathematical model for diffusion from the finite cylinder (Note 1).

1.1.2 The leaching mechanism should be verified as diffusion-controlled by a means other than analysis of the leach test data. For this purpose, analysis of post-leaching concentration profiles within the solid waste form is recommended.

NOTE 1—The computer program and the models are briefly described in Annex A1 and in the Accelerated Leach Test Method and User's Guide for the "ALT" Computer Program (1).

1.2 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 632 Standard Practice for Developing Accelerated Tests to Aid Prediction of the Service Life of Building Components and Materials²

D 1193 Standard Specification for Reagent Water³

2.2 ANSI/ANS Standard:

ANSI 16.1 Measurement of the Leachability of Solidified

Low-Level Radioactive Wastes by a Short-Term Test Procedure⁴

3. Terminology

3.1 *cumulative fraction leached*—the sum of the fractions of a species leached during all sampling intervals calculated as $CFL = \sum a_n / A_0$ and assuming no radioactive decay, where a_n is the quantity of a species in the leachate during any interval and A_0 is the quantity of that species originally present in the sample.

3.2 *diffusion coefficient (diffusivity)*—based on Fick's Laws for diffusion, the diffusion coefficient is the ratio of the rate of transfer of a diffusing substance through the unit area of a section to the concentration gradient measured normal to the section.

3.3 *effective diffusion coefficient (effective diffusivity)*—the diffusion coefficient that results from diffusion as it is modified by other processes (for example, adsorption) or physical constraints (for example, tortuosity and constrictivity).

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

3.5 *incremental fraction leached*—the fraction leached of a species of interest during a single sampling interval calculated as $IFL = a_n / A_0$ and assuming no radioactive decay.

3.6 *leachant*—the liquid that contacts the specimen during a leach test or contacts a waste form in the disposal environment.

3.7 *leachate*—the leachant after contacting the specimen or the waste form.

3.8 *leaching*—the process (or processes) by which mass transport from a solid to a liquid takes place.

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

3.10 *leaching mechanism*—the process that controls the rate of mass transport out of a specimen during leaching.

3.11 *reference leach test*—a leach test conducted under defined conditions, the results of which are used as a standard against which the results of other leach tests (for example, accelerated) are compared. In this test method a reference leach

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² Annual Book of ASTM Standards, Vol 14.02.

³ Annual Book of ASTM Standards, Vol 11.01.

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

test is one that is conducted at 20°C.

3.12 *semi-dynamic leach test*—a leach test method that exposes the specimen to fresh leachant on a periodic schedule.

3.13 *semi-infinite medium*—a body used in diffusion theory whose outer boundary is effectively at an infinite distance from the inner region.

3.14 *source term*—the original concentration, prior to leaching, of a species of interest in a specimen or a waste form.

3.15 *surface area*—for purposes of this test method, surface area is defined as the geometric surface area of a specimen calculated from macroscopic measurements of its dimensions.

3.16 *volume*—for purposes of this test method, volume is defined as the volume of a specimen calculated from macroscopic measurements of its dimensions.

3.17 *waste form*—a stable, solid body composed of the waste and a solidification agent.

4. Summary of Test Method

4.1 This test method is a semi-dynamic leach test, that is, the leachant is sampled and replaced periodically. It is based on earlier semi-dynamic tests such as the IAEA test (2) and the ANS 16.1 Leach Test.⁴ Elevated temperatures, large volumes of leachant, frequent leachant changes, and small specimen size are used to obtain accelerated releases. This is a short-term test, requiring sampling on each of eleven or more successive days. Tests must be performed to demonstrate that the leaching mechanism does not change at the elevated test temperature. This may be done by performing leach tests at a minimum of three temperatures to ascertain that the mechanisms and structural controls of leaching do not change with increasing temperature. If the test is to be used only for making comparisons among specimens, then testing at a single temperature is adequate.

4.2 The results of this accelerated test can be extrapolated to long times if the data from tests run at elevated temperatures and the tests run at the reference temperature (20°C), and can be modeled by diffusion. A computer program that plots the experimental data and a curve calculated from an effective diffusion coefficient for diffusion from a finite cylinder (Fig. 1) is available from ASTM. If the data from the accelerated tests, the reference test, and the modeled curve fit within defined

criteria, the leaching mechanism is taken to be diffusion. In this case, the model can be used to project releases from full-scale waste forms and to long times. The accelerated test provides a measure of the maximum fractional release to which the modeled data can be extrapolated. By generating data over a specified temperature range, an Arrhenius plot can be produced allowing projections to be made at temperatures other than those tested. If the diffusion model cannot fit the data, other models (for example, diffusion plus partitioning and solubility limited leaching) contained in the computer program can be used to indicate the leaching mechanism that controls releases. No extrapolations are allowed with these models. If no model fits the data, then an alternative graphical comparison of the data is recommended. A linear plot of modeled CFL plotted against experimental CFL verifies that the accelerated data is comparable to the reference data, showing that the accelerated test is appropriate. With this technique, no extrapolation of data can be made.

5. Significance and Use

5.1 This test method measures mass transport from a cylindrical solidified waste form into water under conditions that accelerate leaching. Test parameters, such as the volume of leachant and the frequency at which the leachant is changed, have been optimized to eliminate experimental effects (for example, saturation effects that can complicate modeling of the net forward diffusion rate).

5.2 This test method can be used to:

5.2.1 Provide diffusion coefficients for waste forms;

5.2.2 Obtain higher fraction releases than can be achieved with expected service conditions for greater confidence in waste form properties;

5.2.3 Obtain measurable leachate concentrations from materials that have very low release rates under service conditions; and

5.2.4 Compare releases from various types of solidification agents and formulations.

5.3 Modeling the experimental observations obtained in the test allows the extrapolation of leaching results to long times and to full-scale waste forms under the following constraints:

5.3.1 Results of this test method cannot be taken to apply to releases in specific disposal environments unless tests are conducted to determine the leaching mechanism under those conditions.

5.3.2 Projections of releases require the long-term stability of the waste form, which may or may not be indicated adequately by short-term tests.

5.3.3 Extrapolations are limited to the maximum CFL obtained with the accelerated test.

5.3.4 The leaching mechanisms observed in tests conducted at elevated temperatures must be the same as the mechanisms observed in the tests run at the reference temperature.

6. Apparatus

6.1 A forced-air environmental chamber or a circulating water bath capable of controlling leachant temperatures to $\pm 1^\circ\text{C}$ shall be used.

6.2 *Balance*—The balance shall be accurate to 0.1 % of the test load.

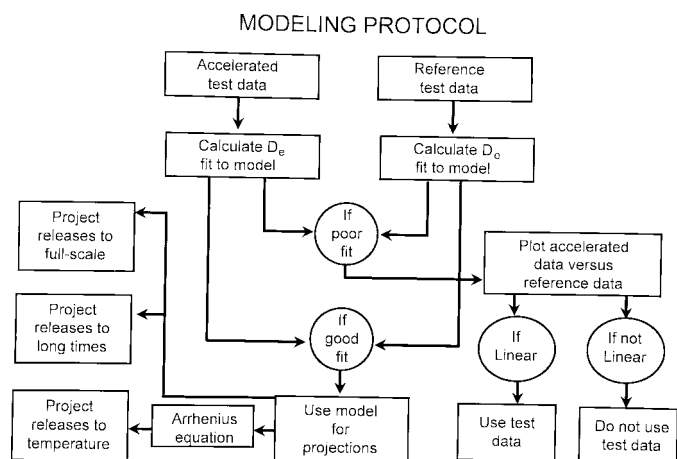


FIG. 1 A Schematic of the Concepts Used in This Test Method to Combine Experimental and Modeling Approaches

7. Reagents and Materials

7.1 *Leachant*—The leachant shall be distilled or deionized water meeting or exceeding standards for types II or III reagent water as specified in Specification D 1193.

7.2 *Containers*—Leaching containers shall be made of a material that does not react with the leachant/leachate and the specimen. It is particularly important to select materials that allow very little plate-out of radionuclides from solution. High density polyethylene has been found to be a suitable container material. The top of the container shall fit tightly to minimize evaporation. This fit must be checked at test temperatures to ensure that evaporative losses are less than 1 % over 24 hours.

7.3 *Specimen Supports*—Supports for the specimens shall be made of a material that does not react with the leachant/leachate or the specimen and does not allow plate-out onto the support. The method of support should not impede leaching by obstructing the surface area of the specimen by more than 1 %. Moreover, it should not interfere with replacement of the leachate. It is often convenient to suspend the waste form from the cover of the leaching container using monofilament string.

7.4 *Sample Containers*—Containers to hold aliquots of leachate for storage prior to analysis should not allow any plate-out of radionuclides. The containers should be checked to ascertain that evaporation over long times is acceptably small.

7.5 *Stirrers*—Stirrers that are long enough to reach the bottom of the leaching containers are required. Wood or plastic tongue depressors are adequate.

7.6 *Filtration Equipment*—If particulates are present in the leachate, filtration is necessary. Tests must be conducted to ensure that the filter and the filtration apparatus do not adsorb the species of interest. The filter medium should be capable of removing particulates that are 0.45 μm in diameter. Disposable syringe filters are recommended.

8. Specimens

8.1 Right circular cylindrical specimens shall be used with a diameter-to-height ratio between 1:1 and 1:2. A convenient size is 2.5 cm diameter by 2.5 cm height. Smaller sizes should be avoided to preclude problems of mixing and producing non-homogeneous samples.

8.2 Specimens shall be representative of the full-scale solidified waste form. Particular attention should be paid to ensuring that the laboratory specimen is homogeneous. The specimens should be prepared using the same techniques as those used to produce full-scale waste forms. Curing conditions, especially the temperatures experienced by the large waste forms, should be duplicated for laboratory-scale specimens. Care should be taken to ensure that surfaces of the laboratory specimens reflect the structure of surfaces of large waste forms. This refers to surfaces that are cast against container walls as opposed to free or cut surfaces.

8.3 A minimum of three specimens should be tested at any given temperature.

8.4 The dimensions, weight, composition, and curing history shall be recorded for each specimen. Accurate determination of the source term (A_0), that is, the amount of the species of interest in the specimen at the start of the leach test, shall be made and recorded.

9. Procedure

9.1 *Removal of Specimen from Mold*—After removing the specimen from its container or mold, any excess material should be removed prior to weighing the specimen. The mold should be rinsed in a volume of water equal to the volume of the specimen. If the quantity of the species of interest contained in this rinse water represents more than 0.5 % of the total quantity in the specimen, the value should be subtracted from the source term (A_0).

9.2 *Leachant Volume*—The leachant volume used for each interval is $100 \times$ the surface area of the specimen as calculated below:

$$\frac{\text{Leachant volume (cm}^3\text{)}}{\text{Specimen surface area (cm}^2\text{)}} = 100 \text{ cm} \pm 2 \% \quad (1)$$

This ratio requires a large volume of water, for example, a 2.5 cm × 2.5 cm specimen has a surface area of approximately 30 cm², giving a leachant volume of 3000 mL. Specimens that are much larger than this will require volumes of water that need more sophisticated means of wastewater handling (such as peristaltic pumps for draining the containers), since large volumes are too unwieldy for pouring.

NOTE 2—Some waste form materials, such as glass, have such low leach rates that a volume-to-surface area ratio of 100 cm is not necessary. In some cases, such a large volume of leachant can make analysis challenging, even for major constituents of the specimen. Under these circumstances, the volume-to-surface area ratio may be reduced to 10 cm.

9.3 *Temperature*—For materials and formulations that have not been tested previously, leach tests shall be conducted at a minimum of three temperatures to establish that leaching increases systematically with higher temperatures. One temperature must be 20°C. The recommended maximum temperature is 50°C, which is below the threshold of anomalous releases observed so far (3). Temperatures above 50°C can be used if it is demonstrated that releases follow the trend observed at low temperatures, that is, that the leaching mechanism has not changed.

9.4 *Leachant Replacement*—Leachant replacements shall take place at the time intervals shown in Table 1. The time at which the specimen is first placed in the leachant should be noted. The leachant shall be brought to the test temperature before the specimen is placed in it.

9.4.1 If the specimen is suspended from the top of the

TABLE 1 Replacement Intervals for the Accelerated Test Leachant

Interval	Incremental Time (t)	Cumulative Time (Σt)
1	2 h	2 h
2	5 h	7 h
3	17 h	1 day
4	1 day	2 days
5	1 day	3 days
6	1 day	4 days
7	1 day	5 days
8	1 day	6 days
9	1 day	7 days
10	1 day	8 days
11	1 day	9 days
12	1 day	10 days
13	1 day	11 days

container, the most convenient method of changing the leachant is to lift off the cover (with the specimen attached) and place it on a new container full of fresh leachant that is at the test temperature. This can be replaced in the temperature-controlled environment while the leachate in the other container is being sampled. During leachant changes, the specimen should be exposed to air for as short a time as possible.

9.5 *Leachate Sampling*—Immediately after the specimen has been moved to fresh water, the old leachate should be stirred thoroughly and sampled to minimize any artifacts caused by cooling (for example, precipitation). These samples will be used to determine quantities of the species of interest that have leached from the specimen during each interval and should be preserved in a way appropriate for the analytical techniques. This may require that several aliquots be taken during each sampling. If particulates are present in the leachate, it is necessary to account for the quantity of the species of interest associated with them. Two approaches can be used. One requires filtration of the leachate and subsequent analysis of both the filtrate and the particulate material on the filter. The other is to acidify the leachate to dissolve the particulates and thereby include the associated species of interest in the leachate.

9.6 *Analysis and Standards*—Analysis of species in the leachate will be conducted by standard methods. Appropriate standards will be used for analysis. If necessary, standards will be prepared to match the matrix elements in the samples. For radioactive specimens, the preferred method of analysis includes use of a standard prepared from an aliquot of the original solution (or waste) used to make the specimens. From this aliquot, dilutions are made from which the standard is taken. With this method, leachate samples can be counted relative to standards without the need for absolute standards, detector efficiencies, or decay corrections.

10. Calculations

10.1 *Incremental Fraction Leached*—Several parameters shall be calculated from the data obtained. The incremental fraction leached (IFL) is calculated by the following equation:

$$IFL = \frac{a_n}{A_0} \tag{2}$$

where:

a_n = the quantity of species *i* observed in the leachate at any given time interval. This value is corrected for radioactive decay to the time of the beginning of the test.

A_0 = the source term, the total original quantity contained in the leaching specimen at the beginning of the test.

10.1.1 The rate of release for any interval can be calculated by dividing IFL by the elapsed time of the interval. The rate can then be divided by the surface area of the specimen to obtain the fraction released per square cm per s.

10.2 *Cumulative Fraction Leached*—Another parameter is cumulative fraction leached, which is calculated as:

$$CFL = \frac{\sum_i a_n}{A_0} \tag{3}$$

which is the sum of the fractions of a species of interest leached during the test. This value for each interval, plotted against cumulative time, provides a useful means of graphically comparing data to other test results and to modeling results. An example of this type of plot is shown in Fig. 2.

10.3 *Diffusion Coefficient*—This test method has an associated computer program that calculates a best fit effective diffusion coefficient based on the solution to diffusion from the finite cylinder (4, 5). The computer program calculates D_e from the test data so that the curve $\sum a_n/A_0$ calculated from D_e can be plotted against time and readily compared to the data itself. This should be done for data from the accelerated test and from the reference test. If the curves of the data and the model all fall within a designated value describing “goodness of fit,” then it can be concluded that diffusion is the dominant leaching mechanism. In this case, the model can be used to project releases to long times. This projection requires the assumption that the waste form remains intact and the leaching mechanism does not change with time.

10.3.1 The computer program that accompanies this test method contains two models in addition to the two diffusion models. One model partitions the source term into a leachable component and an unleachable component. It then uses the diffusion models to determine releases from the leachable portion of the source term. The other model is used to determine if solubility constraints are limiting leaching. This model produces a graph of incremental fraction leached plotted as a function of time. Although the partition model allows extrapolation of releases based on the leachable fraction of the source term, neither the partitioning model nor the solubility model should be used to make projections. Rather, these models are intended to indicate if mechanisms other than simple diffusion are controlling releases.

10.3.2 The “goodness of fit” of the model to the data is determined by calculating the sum of the residuals between the optimized model curve and the experimental data. The sum of

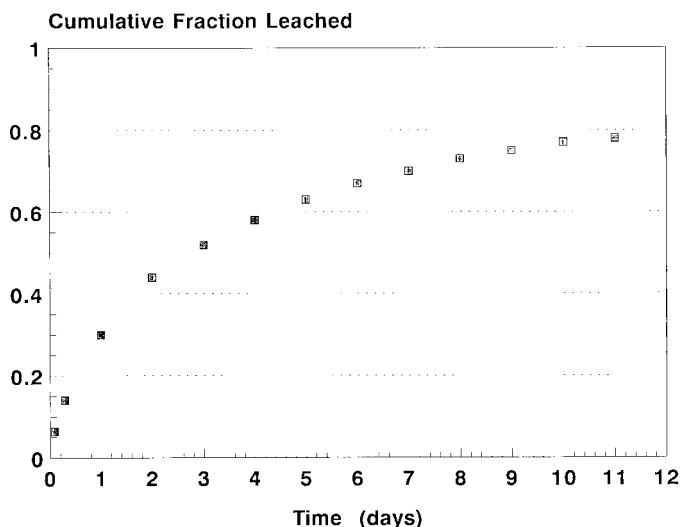


FIG. 2 The Cumulative Fraction Leached Plotted Versus Time. The Top of the Plot (CFL = 1) Represents 100 % Release

the residuals is expressed as E_R , which is a percentage of the final CFL value of the experimental data. With a perfect fit of the model to the data, E_R will be zero. A value of E_R equal to or less than 0.5 % is taken to mean that the diffusion model accurately represents the data. Projections using the diffusion model should be limited to the maximum achieved in the leach test. This maximum CFL must be taken from data that fit the model being used to make the projections.

10.4 *Relationship of Temperature to Leaching*—The accelerated leach test relies on elevated temperature as the primary means of increasing mass transport from specimens, consequently the leach rate must show a positive relationship to increasing temperature. Theoretically, the temperature dependence of a chemical process, in this case leaching as expressed by the diffusion coefficient D_e , depends on the Arrhenius equation; however, knowledge of the temperature dependence of leaching in some materials may not be adequate to strictly apply the Arrhenius equation. Consequently the following equation can be applied:

$$D_e = A \exp(k/T) \tag{4}$$

where:

- D_e = effective diffusion coefficient at T,
- A = constant,
- k = derived constant, and
- T = temperature in degrees kelvin.

10.4.1 From this equation, the log of the diffusion coefficients determined from experiments conducted at several temperatures are plotted against $1/T$, as shown in Fig. 3. A linear plot indicates that the increase in leaching is proportional to the increase in temperature. This linear relationship means that:

(1) The leaching mechanism, as well as the structural controls on leaching (for example, tortuosity, porosity) are unchanged by increasing temperature; and

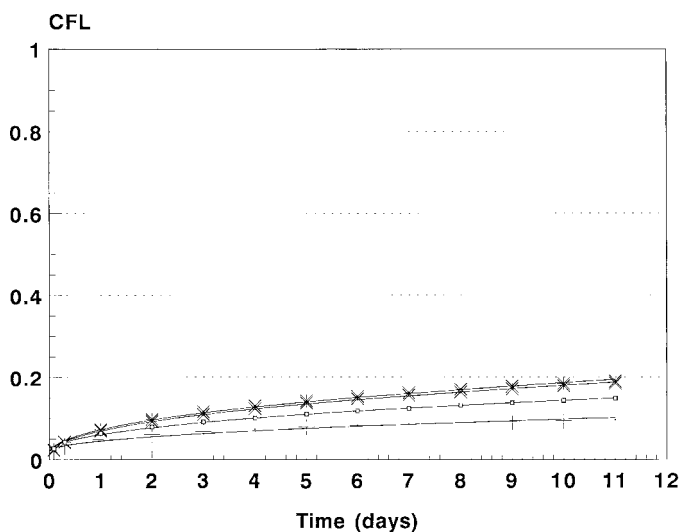


FIG. 3 An Example of a Plot of the Temperature Dependence of Leaching With Y-Axis as the Logarithm of the Effective Diffusion Coefficient, D_e , and the X-Axis as the Reciprocal of Absolute Temperature. This Figure is for Sr-85 Leaching from a Cement Waste Form and Indicates That There is a Linear Relationship Between the Data and Temperature to 65°C ($X = 2.95$)

(2) Effective diffusion coefficients can be calculated for temperatures other than those tested.

10.4.2 For this test method it must be demonstrated that a linear relationship exists on the plot for every material tested under accelerating conditions. In some cases the plot may not be linear at elevated temperatures. This effect can limit the maximum test temperature. For all materials, the relationship of leaching to elevated temperature must be determined for at least five temperatures to ascertain that the maximum temperature to be used is mechanistically acceptable. A convenient maximum test temperature is 50°C, although in some cases a lower temperature is required to conserve the leaching mechanism.

10.5 *Empirical Correlation*—If the data and the model do not provide a good fit, indicating that diffusion is not the leaching mechanism, an empirical approach can be taken to compare releases from the accelerated test with releases from the reference test. This is done by plotting CFL from the accelerated test on the y-axis of a graph and CFL from the reference test on the x-axis. The points are matched according to interval. If this scatter plot results in a linear graph, the data from the two tests can be compared and the results of the accelerated test can be said to accurately reflect the data from the reference test. However, this method of correlation cannot be used to extrapolate the data to long times.

11. Precision and Bias

11.1 The precision of this test method will vary depending on the solid waste being tested and on the species of interest being leached.

11.2 Determining the accuracy of this test method is not possible, as no standard reference material exists.

11.3 Results of tests of four replicate solid waste forms are shown in Fig. 4, for polyethylene waste forms containing fifty and seventy weight percent sodium nitrate. Diffusion coefficients of sodium, fractional releases, and values of E_R , indicating “goodness of fit” of the model to the experimental data (see 10.3), are shown in Table 2. The data shown in Fig. 4 is for 50 Wt % loading leached at 20°C. Other data and modeling results are available (3, 6, 7).

12. Keywords

12.1 accelerated; diffusion; leach; waste

TABLE 2 Fractional Releases and Diffusion Coefficients of Sodium from Sets of Four Replicate Polyethylene Samples Containing 50 % and 70 % NaNO₃ Leached at 20°C

Sample	Cumulative Fraction Released (%)	E_R (%)	Diffusion Coefficient (cm ² /s)
50 % A	14.8	0.25	2.32×10^{-9}
50 % B	18.9	0.43	4.67×10^{-9}
50 % C	18.5	0.27	4.37×10^{-9}
50 % D	9.6	2.52	8.84×10^{-10}
50 % Mean	15.5	0.87	3.05×10^{-9}
70 % A	50.2	0.41	4.74×10^{-8}
70 % B	54.4	0.39	6.10×10^{-8}
70 % C	47.6	0.92	4.82×10^{-8}
70 % D	57.3	0.77	6.60×10^{-8}
70 % Mean	52.4	0.62	5.57×10^{-8}

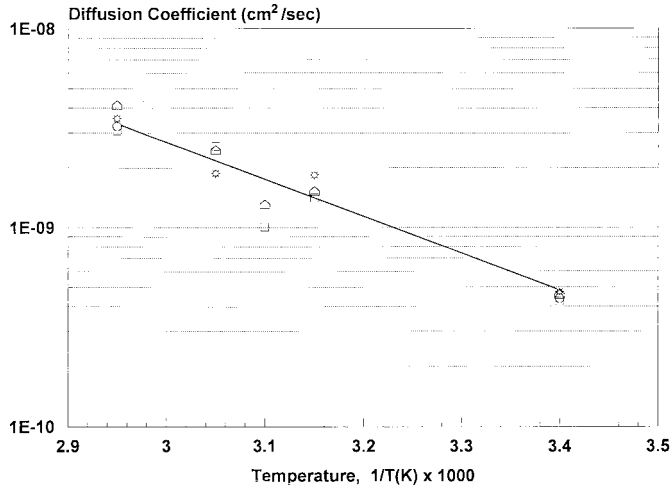


FIG. 4 CFL of Sodium at 20°C from Four Replicates of Polyethylene Containing 50 Wt % NaNO₃

ANNEX

(Mandatory Information)

A1. COMPUTER PROGRAM FOR THE ACCELERATED LEACH TEST

A1.1 Scope

A1.1.1 This Annex contains a brief outline of the ALT computer program that was developed to accompany the accelerated leach test. The program serves a variety of functions including:

A1.1.1.1 Comparing experimental data to curves generated by four models,

A1.1.1.2 Calculating incremental and cumulative fractional releases, and

A1.1.1.3 Storing data in a form compatible with Lotus 1-2-3.

A1.1.2 The Accelerated Leach Test computer program and a detailed Users' Guide (1) are available from: ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

A1.2 Equipment

A1.2.1 The computer program that is available for this test method is a compiled version and runs on IBM or IBM compatible personal computers. A math co-processor is desirable to decrease the computation time. A graphics board is required to generate plots and can be a CGA, EGA, VGA, or a Hercules color or monochrome board. Without a compatible graphics board, the program will do all calculations and list the results.

A1.3 Approach

A1.3.1 The ALT program contains four mathematical models that can be used to represent the data. The leaching mechanisms described by these models are:

A1.3.1.1 Diffusion through a semi-infinite medium (for low CFL),

A1.3.1.2 Diffusion through a finite cylinder (for high CFL),

A1.3.1.3 Diffusion plus partitioning of the source term, and

A1.3.1.4 Solubility limited leaching.

A1.3.2 These mechanisms were observed in studies with various materials during development of the test method (3, 8). Theoretical background for each mechanism is given in Appendix A of the Users' Guide (1).

A1.3.3 For models containing the diffusion mechanism, the computer program plots both the experimental data and a curve calculated from the selected model that best fits the data. This is done through an iterative method that optimizes the fit to the entire data curve (Fig. A1.1). The solution to the finite cylinder equation that is used in the program was developed by Pescatore (9, 10). This method is particularly attractive because it becomes asymptotic at high fraction releases while using relatively little computer time, a failure of some other solutions. If the "goodness of fit" between the data curve and the model gives an E_R value that is less than 0.5 %, then the model is taken to represent the leaching mechanism of that material. In this case the model can be used to project releases to long times. In the case of diffusion, projections also can be made for full size cylinders. If the value of E_R is greater than 0.5 %, then the model cannot be used to make projections.

A1.3.4 The solubility limited leaching model is based on the concept that the concentration of the species of interest in the leachate (and therefore the incremental fraction leached) should be the same at the end of each sampling interval. The mean of the IFL, the standard deviation, and the coefficient of variation about the mean are calculated. If the coefficient of variation is less than 10 %, then the dissolution model is taken to be appropriate.

A1.3.5 The results of the ALT program are presented in several forms. Tables of data and associated parameters (for example, diffusion coefficient and E_R) are displayed on the

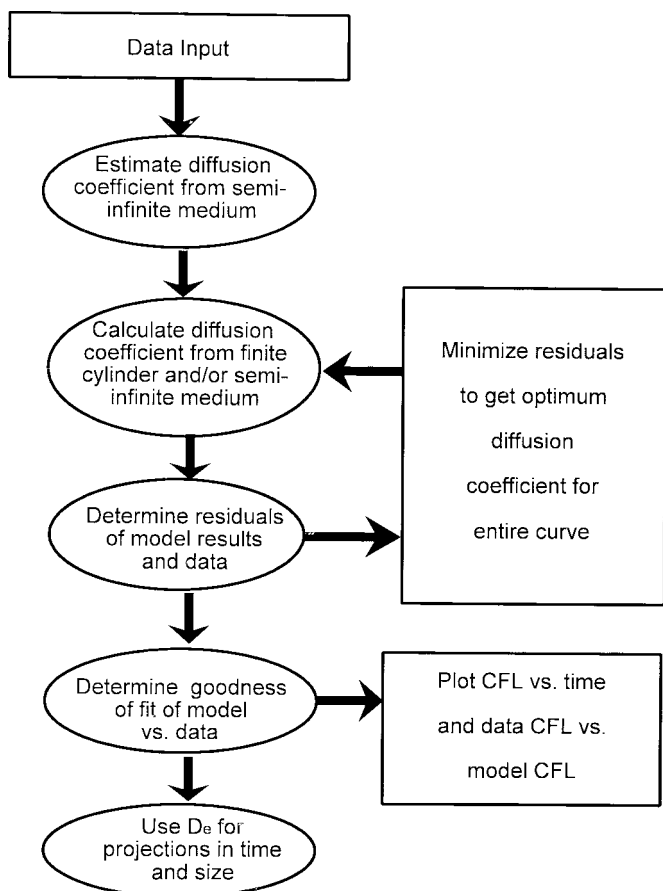


FIG. A1.1 A Flow Chart of the Major Functions of the Accelerated Leach Test Computer Program

screen and can be printed if desired. Graphs of CFL plotted as a function of time are generated on screen and contain both experimental data points and the curve produced by the model. In addition, graphs are available in which the experimental data is plotted on the x-axis and model-generated values are plotted on the y-axis. This type of plot allows easy comparison of the relationship between the data and the model results. If the test has been run at three or more temperatures, the activation energy can be determined by the program. Projections of future releases and for full-scale waste forms can be made if the leaching mechanism is found to be diffusion.

A1.4 Running the Program

A1.4.1 The program starts by giving the user eight options, including entering new (raw) data, entering data in the form of CFL, retrieving data from files, or editing data. Key F1

provides explanations of these choices.

A1.4.1.1 Some prompts in this program have default answers that appear in brackets. Pressing “ENTER” will select the default choice.

A1.4.2 Inputs required by various portions of the program are explained in A1.4.2.1-A1.4.2.10.

A1.4.2.1 *Multiple Source Term Data*—Some data require a new value for the source term for each interval. This would be necessary for a very short half-life radionuclide. The source term value that is input here is the number of counts from a standard. Corrections for dilutions are made automatically. The standard counts are separated by a comma from the leachate counts.

A1.4.2.2 *Single Source Term Data*—Some data require only a single value for the source term throughout the entire experiment. This can be in the form of counts per minute (CPM) or as concentration (for stable elements). For some specimens that are radioactive, liquid standards may not be available. In this case, the activity in the specimen should be calculated. This value can be input as “concentration” in the single source term option.

A1.4.2.3 *Number of Sampling Increments*—This is the number of samplings in the experiment. The default value is 13.

A1.4.2.4 *Number of Species*—This input is the number of elements or radionuclides analyzed in each set of leachate samples that need to be addressed by the program. A maximum of eight species is allowed in each data file.

A1.4.2.5 *Leachate Volume (litres)*—This is the volume of leachate used during each sampling interval. The test method recommends 3 litres.

A1.4.2.6 *Default Times (standard ALT)*—The default time intervals (in days) are 0.083, 0.208, 0.708, 1.00, 1.00, 1.00, etc. to a total of 11 days.

A1.4.2.7 *Sample Diameter (cm)*—Diameter of the specimen that was leached.

A1.4.2.8 *Sample Height (cm)*—Height of the specimen that was leached.

A1.4.2.9 *Counting Sample Volume (mL)*—The volume of the aliquot used for radionuclide counting.

A1.4.2.10 *Source Term Multiplication Factor*—The factor by which the original source solution was diluted to make the counting standard. For example, 3 mL of tracer were added to a specimen when it was made and 1 mL of that solution was diluted 1000-fold to produce the standard that was counted. The multiplication factor would be 3000.

A1.4.2.11 Detailed instructions, in a screen-by-screen format, are given in the Users’ Guide (1).

REFERENCES

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