

Leaching Tests Supported by TestAmerica

Current Methods SW-846 1311 & 1312;

Low-level Radioactive Wastes ANSI/ANS-16.1;

LEAF EPA Methods 1313, 1314, 1315 & 1316

Leaching tests are tools to estimate the potential release of constituents of potential concern (COPC) from waste material after its disposal, or to assess the waste treatment, or to evaluate the material for beneficial use.

Overview of Leaching

In environmental testing, leaching is the process to transfer constituents from a solid (waste, soil, sludge, sediment, combustion residues, coal combustion residue (CCR), stabilized materials, construction materials, or mining wastes) to an aqueous phase or contact liquid. The extent to which constituents in the solid phase will transfer is dependent on site conditions and material specific physical, chemical, and biologic conditions and the length of time involved.

There are a variety of leaching tests and no one leachate test can be used to evaluate the leaching behavior of a wide variety of materials over a broad range of field scenarios. The following describes two current SW-846 leaching methods, ANSI/ANS 16.1 and four newer EPA methods to assess leaching characteristics.



Executive Methods Summary

CURRENT METHODS

Method 1311

Toxicity Characteristic Leachate Procedure (TCLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes in landfills. It is used to classify material as hazardous or non-hazardous for purposes of disposal in a landfill.

Method 1312

Synthetic Precipitation Leachate Procedure (SPLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes into ground and surface waters. SPLP fluid simulates precipitation.

LOW-LEVEL RADIOACTIVE WASTES

ANSI/ANS-16.1

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

This standard was designed for low-level radioactive wastes to determine the leaching characteristics of the solidified material. This standard can be used to measure the leach resistance of any waste solidified into a well-defined geometric shape.

LEAF EPA METHODS

LEAF EPA Method 1313

Liquid-Solid Partitioning as a Function of Extract pH for Constituents in Solid Materials using a Parallel Batch Extraction Procedure

This method is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganics and non-volatile organics in solid materials.

LEAF EPA Method 1314

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using an Up-Flow Percolation Column Procedure

This method is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organics in granular solid material as a function of liquid-to-solid (L/S) ratio under percolation conditions.

LEAF EPA Method 1315

Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials using a Semi-dynamic Tank Leaching Procedure

This method is designed to provide the mass transfer (release rates) of inorganic analytes contained in a monolith or compacted granular material. Under diffusion controlled release conditions, as a function of leaching time.

LEAF EPA Method 1316

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials using a Parallel Batch Extraction Procedure

This method is designed to provide the liquid-solid partitioning (LSP) of inorganic and non-volatile organics at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under conditions that approach liquid-solid chemical equilibrium.

***See Back Cover for the Expanded Methods Summary.**

CURRENT METHODS

Method 1311

Toxicity Characterization Leaching Procedure (TCLP)

TCLP is designed to simulate the leaching a waste will undergo if disposed of in a sanitary landfill.

TCLP has a specific list of regulated compounds with regulatory levels based on health based concentration limits and dilution attenuation factors developed using a subsurface fate and transport model. Federal regulation for the use of TCLP can be found in 40 CFR 261.24. If the TCLP extract contains any one of the TC constituents in an amount equal to or exceeding the concentrations specified in 40 CFR 261.24, the waste possesses the characteristic of toxicity and is a hazardous waste.

TCLP is appropriate for its intended use as a screening test for wastes which may be disposed of in a solid waste landfill or similar conditions. TCLP does not simulate the release of contaminants to non-groundwater pathways.

Method 1312

Synthetic Precipitation Leaching Procedure (SPLP)

SPLP was designed to estimate the mobility/leachability of both organic and inorganic analytes in liquids, soils and wastes in a mono-disposal situation. The extraction fluid is based on the region of the country where the sample is located. The SPLP extraction fluid is intended to simulate precipitation. East of the Mississippi River the extraction fluid is at a pH of 4.2 and west of the river the pH is 5.0. The method indicates that the user compare constituents of concern concentrations in the 1312 extract with levels identified in the appropriate regulations. There are no federal regulations requiring the use of SPLP.

Since the 1990s, there has been concern that TCLP or SPLP would be used outside of their intended use or users may not be familiar with the resulting limitations of the data. TCLP and SPLP are single point batch leachate tests based on pH. Different factors can affect the leaching potential of constituents of concern. They include: pH, redox conditions, liquid-to-solid ratio (L/S), and solubility. Other factors which can affect the leaching potential of organic constituents of concern include: partitioning or solubility, presence of organic carbon, and non-aqueous phase extraction.

ANSI/ANS-16.1-2003 [R2008]

**American National Standards Institute/American Nuclear Society
Measurement of the Leachability of Solidified Low-Level Nuclear
Wastes by a Short-Term Test Procedure.**

This method is the American Nuclear Society's standardization of the International Atomic Energy Agency's 1971 standard leachate test. The goal is to

have a standard leachate test for low level radioactive material to allow for data comparisons. The test provides a leachability index, which quantifies the leaching characteristics of a solidified material and the release of radioisotopes that come in contact with the material. It is a short-term exposure under controlled conditions with a well-defined leachant. This method can also be used to measure the leach resistance of any solidified waste in a well-defined geometric shape.

LEAF METHODS**Leaching Environmental Assessment Framework (LEAF)**

U.S. EPA developed four additional non-regulatory leachate tests to better characterize and model the leachability of wastes. The sources of these methods are from published leaching methods and international standards with additional collaboration between Vanderbilt University and the Energy Research Centre of the Netherlands and DHI in Denmark.

The LEAF Methods are a suite of leaching tests which include batch, column, and tank tests which can be interpreted individually or integrated. They provide information on the leaching behavior of a solid material over a wide range of potential scenarios.

The central mechanism for the leachate tests are either equilibrium or mass transfer control. Equilibrium control release occurs for slow percolation through a

porous or granular material. Mass transfer rate control release occurs when flow is at the external boundary of a monolith or percolation is very rapid relative to mass transfer of constituent release to the percolating waters.

These methods are applicable to a wide range of solid materials including combustion residues, coal combustion residues (CCR), soils, sediments, industrial process residues, and construction materials with the focus on disposal, beneficial use, waste delisting, and the evaluation of treatment effectiveness.

LEAF is a tiered testing approach which increases in detail and complexity depending on the purpose of the testing. Tier 1 testing is for screening purposes and can be a single batch extraction or modified versions of leaching tests. Tier 2 is equilibrium based testing to characterize the liquid solid partitioning over a broad range of scenarios as a function of pH and liquid-to-solid ratio (L/S). The equilibrium testing for Tier 2 includes Methods 1313, 1314 and 1316. Tier 3 is

the mass transfer testing using Method 1315.

LEAF Method 1313

**Liquid-Solid Partitioning as a Function of Extract pH for
Constituents in Solid Materials using a Parallel Batch Extraction**

LEAF Method 1313 is a leaching method which requires particle-size reduced solids material. Using dilute acids and bases at pH values ranging from 2 to 13 and natural conditions, ten eluates are generated from the solid material in parallel extractions. The eluates are then analyzed for the constituents of concern as a function of pH. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid-solid partitioning of the constituents of concern.

LEAF Method 1314

**Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for
Constituents in Solid Materials using an Up-flow Percolation
Column Procedure**

LEAF Method 1314 is a column leaching method which requires particle-size reduction to accommodate the column diameter. It is an equilibrium based up-flow percolation column test. The constituents of concern can be inorganics and non-volatile organics. This leaching test is used to characterize the liquid/solid partitioning between solid phase and the eluate as a function of the liquid to solid ratio. This method provides five options for the generation of the eluate and the subsequent preparation of the analytical samples based on the level of detailed data which is required.

LEAF Method 1315

**Mass Transfer Rates of Constituents in Monolithic or Compacted
Granular Materials using a Semi-dynamic Tank Leaching
Procedure**

LEAF Method 1315 is a flux based leachate method for the analysis of a monolith or compacted granular material. The material is continuously immersed in reagent water at a specified liquid to solid surface area. The constituents of concern are inorganics. This leaching test provides the mass transfer rates of the constituents of concern under diffusion controlled release conditions as a function of leaching time through the material.

LEAF Method 1316

**Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio
for Constituents in Solid Materials using a Parallel Batch
Extraction Procedure**

LEAF Method 1316 is a leaching method which requires particle-size reduced solids material. Using natural pH of the solid material, five eluates are generated from the solid material in parallel extractions over a range of liquid to solid ratios. The eluates are then analyzed for the constituents of concern. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid/solid partitioning of these constituents of concern.

Liquid-Solid Partitioning as a Function of Extract pH *using a Parallel Batch Extraction Procedure*



This method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness and site remediation options.

Scope:

U.S. EPA Method 1313 is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganic constituents, semi-volatile organic constituents and non-volatile organic constituents in solid materials. The LSP curve is evaluated as a function of final extract pH at a liquid-to-solid ratio of 10 mL extractant/g dry sample and conditions that approach liquid-solid equilibrium. This method also yields the acid/base titration and buffering capacity of the tested material.

The method is a leaching characterization method that is used to provide values for intrinsic material parameters that control leaching of inorganic and some organic species under equilibrium conditions. The test is intended as a means for obtaining a series of extracts of a solid material, which may be used to estimate the LSP of constituents as a function of pH.

Summary of Method:

The method consists of nine parallel extractions of a particle-size reduced solid material in dilute acid or base and reagent water. The table below details the leaching

time required based on the particle size of the sample. In addition, the table indicates the minimum dry sample mass required for leaching.

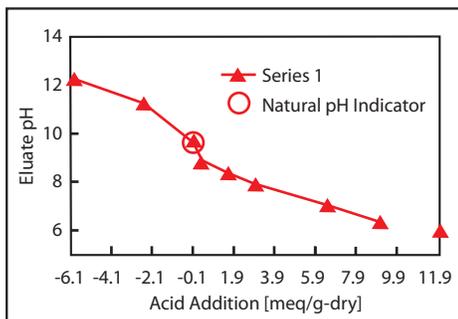
A schedule of acid and base additions is formulated from a pre-test titration curve or prior knowledge indicating the required equivalents/g acid or base to be added to the series of extraction vessels so as to yield a series of eluates having specified pH values in the range of 2-13 (2, 4, 5.5, 7, 8, 9, 12, 13, and natural). The pre-test titration curve is utilized to determine the actual amount of acid or base added to the samples to hit the method specified pH values or client driven pH values.

If the natural pH falls within the method subscribed pH values then a pH value of 10.5 will be performed. In addition to the nine test extractions, three method blanks without solid material are carried through the procedure in order to verify that analyte interferences are not introduced as a consequence of reagent impurities or equipment contamination.

The twelve bottles are tumbled in an end-over-end fashion for a specified contact time, which depends on the particle size of the sample. At the end of the specified contact interval, the liquid and solid phases are separated

Particle Size (85% wt less than) (mm)	US Sieve Size	Minimum Dry Mass (mass g-dry)	Contact Time (hrs)	Suggested Vessel Size (mL)
0.3	50	20 ± 0.02	24 ± 2	250
2	10	40 ± 0.02	48 ± 2	500
5	4	80 ± 0.02	72 ± 2	1,000

Extraction Parameters as Function of Max. Particle Size



Pre-test Titration Curve

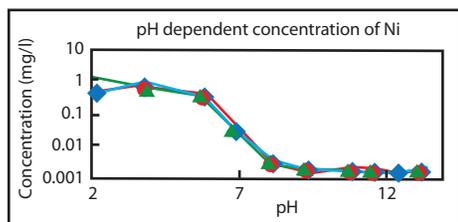
via centrifugation. Extract pH, conductivity, and ORP measurements are then made on an aliquot of the liquid phase and the remaining eluate is filtered thru a 0.45 micron filter. Analytical samples of the filtered eluate are collected and preserved as appropriate for the desired chemical analyses. The eluate concentrations contaminants of potential concern (COPC) are determined and reported. Note: The end user can request specific pH ranges.

Data Results:

An LSP curve can be generated for each COPC following chemical analyses of all extracts by plotting the target analyte concentration in the liquid phase as a function of the measured extract pH for each extract.

The shape of the LSP curve is indicative of the speciation of the COPC in the solid phase with characteristic LSP curve shapes.

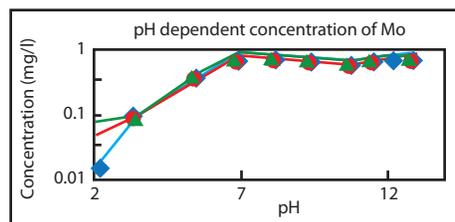
Cationic Species: The LSP curve typically has a maximum concentration in the acidic pH range that decreases to lower values at alkaline pH.



LSP Curve of Cationic Species

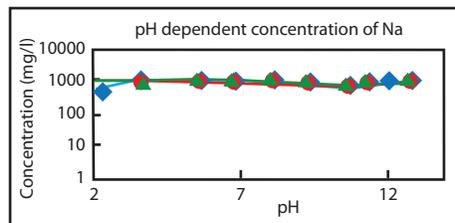
Amphoteric Species: The LSP curves tend to be similar in shape to cationic LSP curves with greater concentrations in the acidic pH range. However, the concentrations pass through a minimum in the near neutral to slightly acidic pH range only to increase again for alkaline pH values.

Oxyanionic Species: The LSP curve often show maximum in the neutral to slightly alkaline range



LSP Curve of Oxyanionic Species

Highly Soluble Species: The LSP curve is only a weak function of pH.



LSP Curve of Highly Soluble Species

In Summary:

The method provides solutions considered indicative of eluate under field conditions, only where the field leaching pH is the same as the final laboratory extract pH and the LSP is

controlled by aqueous phase saturation of the constituent of interest.

The maximum mass of constituent released over the range of method pH conditions ($2 < \text{pH} < 13$) may be considered an estimate of the maximum mass of the constituent leachable under field leaching conditions for intermediate time frames and the domain of the laboratory tests.

References:

U.S. EPA. SW846 Method 1313
July 2017
<https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples:
32-ounce jar

Sample Size: Minimum 800 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time for leachate generation is within 1 month of receipt. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern:
Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 24 to 72 hours for leaching, depending on particles size of the material; 21 days for analysis, for a total of 28-day turnaround.

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio for Constituents in Solid Materials

using an Up-flow Percolation Column Procedure



The method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness, and site remediation options.

Scope:

U.S. EPA Method 1314 is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organic constituents in a granular solid material as a function of liquid-to-solid ratio (L/S) under percolation conditions. The first eluates of the column test may provide insight into the composition of the pore solution either in a granular bed or in the pore space of low-permeability material.

The method is intended as a means for obtaining a series of extracts of a granular solid material which may be used to show eluate concentrations and/or cumulative release as a function of L/S which can be related to a time scale when data on mean infiltration rate, density, and height of application are available.

Summary of Method:

In preparation of solid materials for use in this method, particle-size reduction or exclusion of samples with large grain size is used to enhance approach toward liquid-solid equilibrium over the residence time of eluant in the column. A 30 cm, straight cylindrical column with an inner diameter of 5 cm is currently being used. The

particle size of the material must be $<1/20$ of the column diameter. Based off of this information, the current particle size is 2.5 mm.

Eluant is introduced into a column of moderately-packed granular material in an up-flow pumping mode. The eluate collection performed as a function of the cumulative L/S. Up-flow pumping is used to minimize air entrainment and flow channeling. The default eluant for most material is reagent water. The flow rate is maintained between 0.5-1.0 L/S per day to increase the likelihood of local equilibrium between the solid and liquid phases, due to residence times longer than 1 day.

Eluate volumes are chemically analyzed for a combination of inorganic and non-volatile organic analytes depending on the constituents of potential concern (COPC). The entire eluant volume up to 10mL/g dry sample is collected in nine specific aliquots of varying



Multiple Columns for Method 1314

volume. A limited subset of eluants volumes within the same L/S range may be collected and analyzed for regulatory and compliance purposes. The table below reflects collection times of a sample.

Data Results:

The method provides options for the preparation of analytical samples that provide flexibility based on the level of detail required:

Option A – Complete

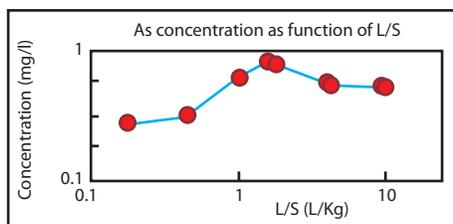
Characterization: Eluate concentrations may be used in conjunction with information regarding environmental management scenarios to estimate anticipated leaching concentrations, release rates, and extent of release for individual material constituents in the management scenarios evaluated. The nine eluate collections are analyzed and reported.

Option B – Limited Analysis:

Under a limited analysis approach, nine eluate collections and analysis of six analytical samples are required. If evaluation is based on eluate concentrations, six eluate fractions are chemically analyzed. If evaluation is based on cumulative release, some eluate fractions are composited by volume-weighted averaging to create a set of six analytical samples. The concentrations of composited analytical samples cannot be interpreted along with eluate fractions on the basis of concentration.

Option C – Index Testing: For the determination of consistency between the subject material and previously characterized materials, nine eluate collections and analysis of three analytical samples are required. If consistency is to be determined by eluate concentrations, three discrete eluate fractions are chemically analyzed. If consistency is to be determined by cumulative release, some eluate fractions are composited by volume-weighted averaging to create a set of three analytical samples. The concentrations of composited analytical samples cannot be interpreted along with eluate fractions on the basis of concentration.

Eluate concentrations of contaminants of concern are then plotted versus the cumulative liquid-to-solid ratio.



Eluate Concentrations versus Cumulative L/S

In Summary:

The method provides eluate solutions considered indicative of leachate under field conditions only where the field leaching pH is controlled by the alkalinity or acidity of the solid material and the field leachate is not subject to dilution or other attenuation mechanisms. The cumulative mass of constituent released over an L/S range may be considered an estimate of the maximum mass of that constituent to be leached under field leaching over intermediate time frames and the domain of the laboratory test pH.

References:

U.S. EPA. SW846 Method 1314
 July 2017
<https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples:
 32-ounce jar

Sample Size: Minimum 1,200 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time for leachate generation is within 1 month of receipt. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern:
 Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 14 days for leaching; 42 total days for leaching and analysis.

Fraction Label	Sum L/S Ratio (mL/g-dry)	Fraction Volume (mL)	Scheduled Collection (date/time)
-	0	10	11/28/12 8:20 AM
T01	0.20	164	11/28/12 2:02 PM
T02	0.50	260	11/28/12 11:05 PM
T03	1.00	434	11/29/12 2:11 PM
T04	1.50	434	11/30/12 5:16 AM
T05	2.00	434	11/30/12 8:22 PM
T06	4.50	2,170	12/3/12 11:50 PM
T07	5.00	434	12/4/12 2:56 PM
T08	9.50	3,906	12/10/12 6:47 AM
T09	10.00	434	12/10/12 9:53 PM

Collection Times of a Sample

Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Material using a Semi-dynamic Tank Leaching Procedure



1315

The leaching characterization method provides intrinsic material parameters for release of inorganic species under mass transfer-controlled leaching conditions. The method is intended as a means for obtaining a series of eluants which may be used to estimate the diffusivity of constituents and physical retention parameter of the solid material under specified laboratory conditions.

Scope:

U.S. EPA Method 1315 is designed to provide the mass transfer rates of inorganic analytes contained in a monolithic or compacted granular material, under diffusion-controlled release conditions, as a function of leaching time.

The geometry of the monolithic samples may be rectangular, cubes, wafers, or cylinders. Samples may also have a variety of faces exposed to the eluant forming anything from 1-dimensional through 3-dimensional mass transfer cases. In all cases, a minimum sample size of 5 cm in the direction of mass transfer must be employed and the liquid-surface-area ratio (L/A) must be maintained at 9 ± 1 mL/cm². **Note:** *The surface area of the sample must be determined by the laboratory or an outside contractor.*

Monolith samples should be suspended or held in the leaching fluid such that at least 98% of the entire sample surface area is exposed to eluant and the bulk of the eluant is in contact with the exposed sample surface.

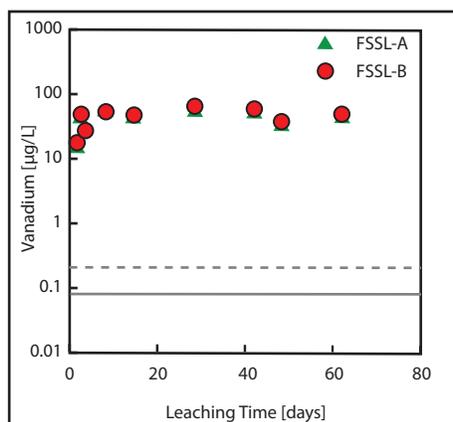
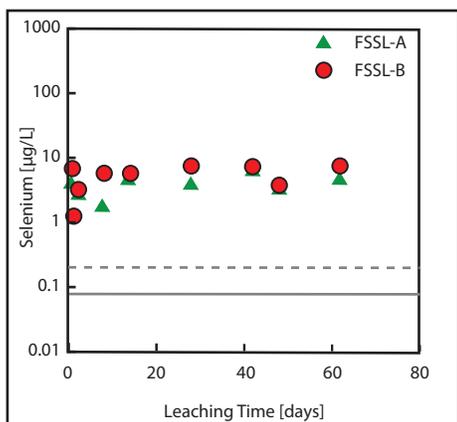
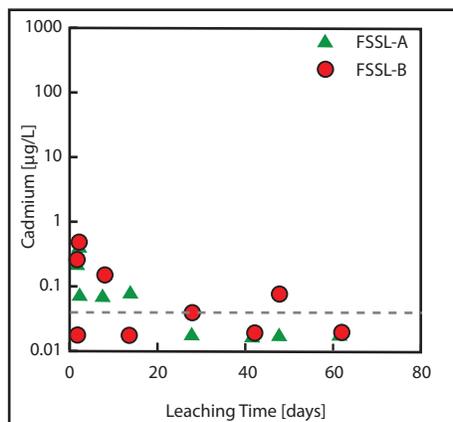
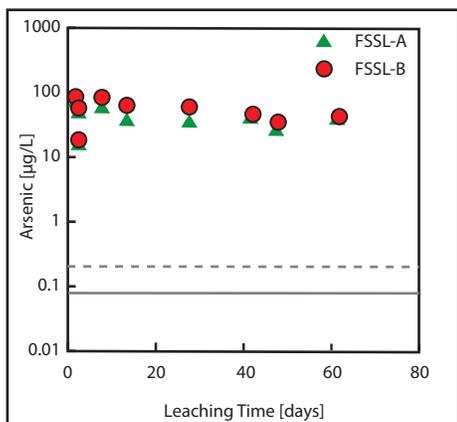
Summary of Method:

The method comprises leaching of continuously water-saturated monolithic or compacted granular material in an eluant-filled tank with periodic renewal of the leaching solution. Samples are contacted with reagent water at the specified L/A. The leaching solution is exchanged with fresh reagent water at nine pre-determined intervals listed below:

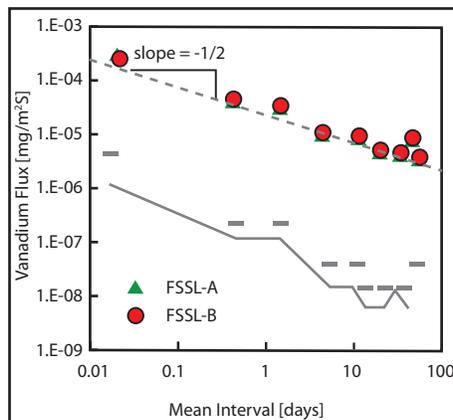
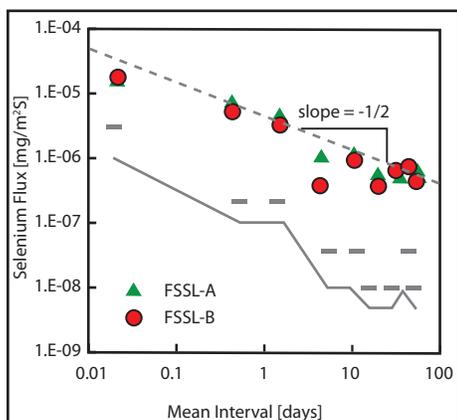
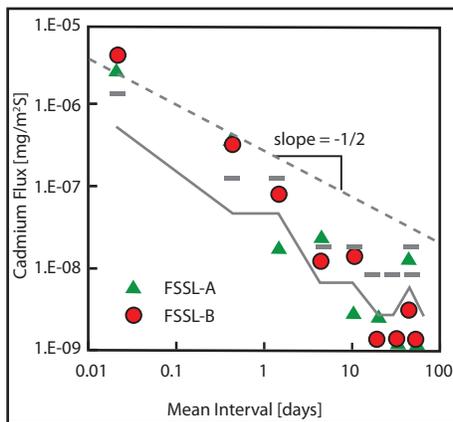
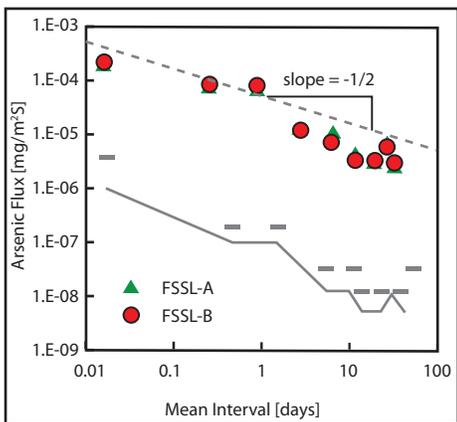
The sample is freely drained and the mass is recorded to monitor the amount of eluant absorbed into the solid matrix at the end of each leaching interval. The eluate pH, specific conductance, and ORP are measured for each time interval. Analytical samples are collected and preserved accordingly based on the determinative methods to be performed on the eluate. **Note:** *Though the method references analyzing for inorganic parameters, TestAmerica is licensed by Vanderbilt University to perform a patented, modified version of the method for analyzing volatiles and semi volatiles.*

Fraction Label	Interval Duration (hrs)	Interval Duration (hrs)	Cumulative Leaching Time (d)
T01	2.0 ± 0.25	–	0.08
T02	23.0 ± 0.5	–	1.0
T03	23.0 ± 0.5	–	2.0
T04	–	5.0 ± 0.1	7.0
T05	–	7.0 ± 0.11	14.0
T06	–	14.0 ± 0.1	28.0
T07	–	14.0 ± 0.1	42.0
T08	–	7.0 ± 0.1	49.0
T09	–	14.0 ± 0.1	63.0

Pre-determined Intervals of Leaching Solution Exchange



Interval Concentration Graphs



Interval Flux Graphs

Data Results:

Eluate concentrations are plotted as a function of time, as a mean interval flux, and as cumulative release as a function of time.

In Summary:

The method is a characterization method and does not provide a solution considered to be representative of eluate under field conditions. This method is similar in structure and use to predecessor methods such as MT001.1, NEN 7345, ANSI 16.1, and ASTM C1308. However, this method differs from previous methods in that: (a) leaching intervals are modified to improve quality control, (b) sample preparation accounts for mass transfer from compacted granular samples, and (c) mass transfer may be interpreted by more complex release models that account for physical retention of the porous medium and chemical retention at the pore wall through geochemical speciation modeling.

References:

U.S. EPA. SW846 Method 1315
 July 2017
<https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>

Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples:

32-ounce jar

Sample Size: Current method allows for varied shapes/sizes as long as the L/Area ratio is $9 \pm 1 \text{ mL/cm}^2$.

Preservation: None

Holding Time: There is no holding time defined to generate the leachate from the monolith. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern:

Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis:

63 days for leaching; 84 days for analysis and leaching turnaround.

Liquid-Solid Partitioning as a Function of Liquid-to-Solid Ratio in Solid Materials

using a Parallel Batch Procedure



1316

The method is intended to be used as part of an environmental leaching assessment for the evaluation of disposal, beneficial use, treatment effectiveness, and site remediation options.

Scope:

U.S. EPA Method 1316 is designed to provide the liquid-solid partitioning (LSP) of inorganic constituents and non-volatile organic constituents at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under the conditions that approach liquid-solid chemical equilibrium.

The eluate concentrations at a low L/S provide insight into pore solution composition either in a granular bed (e.g., soil column) or in the pore space of low-permeability materials (e.g., solidified monolithic or compacted granular fill).

Summary of Method:

This method consists of five parallel extractions of a particle-size reduced solid material in reagent water over a range of L/S values from 0.5 to 10 mL eluant/g dry material. In addition to the five test extractions, a method blank without solid sample is carried through the procedure in order to verify that analyte interferences are not introduced as a consequence of reagent impurities or equipment contamination.

In total, six bottles (i.e., five test positions and one method blank) are tumbled in an end-over-end fashion for a specified contact time based on the maximum particle size of the solid. At the end of the contact interval, the liquid and solid phases are roughly separated via settling or centrifugation. Extract pH, ORP, and specific conductance measurements are then taken on an aliquot of the liquid phase. The bulk of the eluate is clarified by pressure or vacuum filtration in preparation for constituent analysis. Analytical aliquots of the extracts are collected and preserved accordingly based on the determinative methods to be performed. The eluate constituent concentrations are plotted as a function of L/S and compared to QC and assessment limits.

Data Results:

A constituent LSP curve can be generated for each COPC after chemical analysis of all extracts by plotting the constituent concentration in the liquid phase as a function of L/S used for each extraction. The curve indicates the equilibrium concentration of the COPC as a function of L/S at the natural pH.

In Summary:

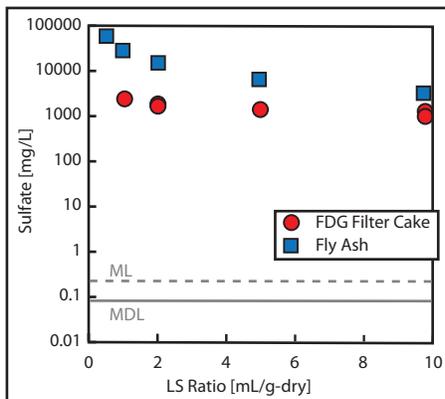
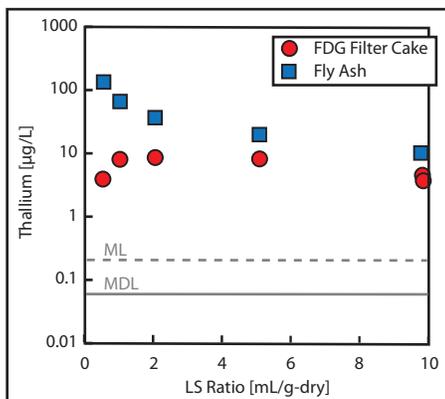
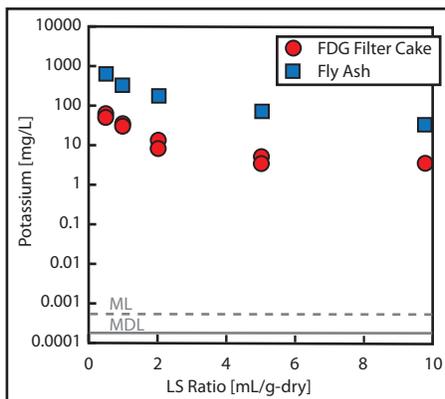
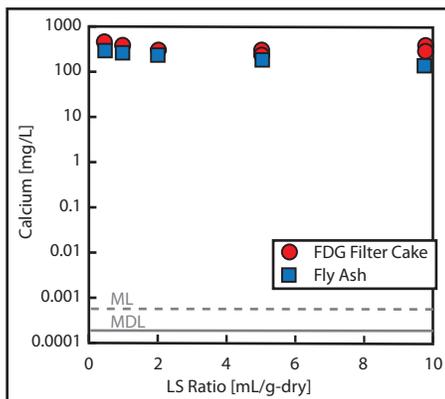
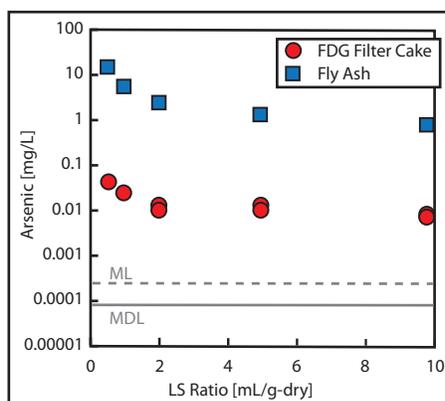
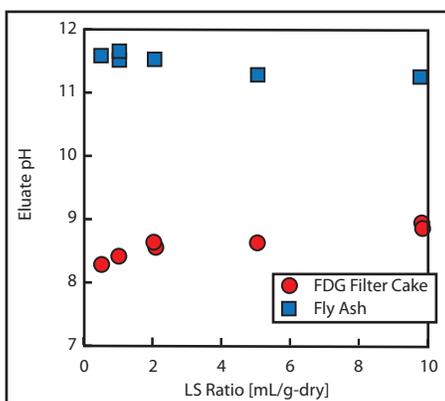
This method is a leaching characterization method used to provide intrinsic material parameters that control leaching of inorganic species under equilibrium conditions. This test method is intended as a means for obtaining an extract (i.e., the eluate) of a solid material which may be used to estimate the solubility and release of inorganic constituents under the laboratory conditions described in

Test Position	Target L/S	Minimum Dry Mass (g-dry)	Moisture "As Tested" Sample (g)	Moisture "As Tested" Sample (g)	Volume Reagent Water (mL)	Recommended Bottle Size (mL)
T01	10.0	20	22.2	2.2	198	250
T02	5.0	40	44.4	4.4	196	250
T03	2.0	100	111.1	11.1	189	500
T04	1.0	200	222.2	22.2	178	500
T05	0.5	400	444.4	44.4	156	1000
B03	QC				200	250
Total			844.4		1120	

Example Schedule for Extraction Setup

Particle Size (85% wt less than) (mm)	US Sieve Size	Min Dry Mass (mass g-dry)	Contact Time (hrs)	Suggested Vessel Size (mL)
0.3	50	20 ± 0.05	24 ± 2	250
2	10	40 ± 0.1	48 ± 2	500
5	4	80 ± 0.1	72 ± 2	1,000

Extraction Parameters as Function of Maximum Particle Size



Equilibrium Concentration as a Function of L/S at the Natural pH

this method. Extract concentrations may be used in conjunction with information regarding environmental management scenarios to estimate anticipated leaching concentrations, release rate and extent for individual material constituents in the management scenarios evaluated. Extract concentrations may also be used along with geochemical speciation modeling to infer the mineral phases that control the LSP in the pore structure of the solid material.

References:

- U.S. EPA. SW846 Method 1316 July 2017
- <https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testing>
- Leaching Environmental Assessment Framework (LEAF) How-To Guide, October 2017

Additional Information:

Recommend bottle type for samples: 32-ounce jar

Sample Size: Minimum 1,000 grams. Sample size will vary based on analysis requested

Preservation: None

Holding Time: Holding time not applicable to the generation of the eluate. The analytical holding times do apply to the environmental samples generated and which are subsequently analyzed for COPCs

Constituents of Potential Concern: Inorganics and non-volatile organics

Approximate Turnaround for Leaching and Subsequent Analysis: 24 to 72 hours for leaching, depending on particle size of the material; 21 days for analysis, for a total of 28-day turnaround.

CURRENT METHODS

Method 1311

Toxicity
Characteristic
Leachate Procedure
(TCLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes in landfills. It is used to classify material as hazardous or non-hazardous for purposes of disposal in a landfill. **Summary Description:** Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1. The sample is then leached with appropriate fluid. A pH 2.9 acetic acid is used for moderately to high alkaline material and pH 4.9 acetate buffer is used for all other materials. The total time for the leachate generation is 18 hours.

Method 1312

Synthetic
Precipitation
Leachate Procedure
(SPLP)

This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes into ground and surface waters. SPLP fluid simulates precipitation. **Summary Description:** Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1 and the samples are then leached with appropriate fluid. The extraction fluid is based on the region of the country where the sample is located. For samples east of the Mississippi River the extraction fluid pH is 4.2 and for materials west the pH is 5.0. The total time for the leachate generation is 18 hours.

LOW-LEVEL RADIOACTIVE WASTES

ANSI/ANS-16.1-2003 [R2008]

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

This standard was designed for low-level radioactive wastes to determine the leaching characteristics of the solidified material. This standard can be used to measure the leach resistance of any waste solidified into a well-defined geometric shape. **Summary Description:** Leaching of continuously water saturated monolithic or compacted granular material in an eluate-filled tank with periodic renewal of the leaching solution. L/S ratio of 10 mL eluate per cm² of surface area. Eluate is collected at predetermined times and analyzed for COPCs. Eluate is centrifuged and filtered for COPCs. Total time of test can be as long as 43 days.

NEW LEAF METHODS

LEAF Method 1313

Liquid-Solid
Partitioning as a
Function of Extract
pH for Constituents
in Solid Materials
using a Parallel
Batch Extraction
Procedure

This method is designed to provide aqueous extracts representing the liquid-solid partitioning (LSP) curve as a function of pH for inorganics and non-volatile organics in solid materials. **Summary Description:** This is a pH dependent batch leaching procedure. Ten parallel extractions of a particle sized reduced solid material in dilute acid or base and reagent water. Series of eluates having pH values ranging from 2-13 as well as natural condition. Liquid solid ratio is 10:1. Eluate is centrifuged and filtered and then analyzed for constituents of concern. Total time to generate the eluate is 5 days for material with 85% or greater solids or 8 days for material with less than 85% solids.

LEAF Method 1314

Liquid-Solid
Partitioning as a
Function of
Liquid-to-Solid Ratio
for Constituents in
Solid Materials using
an Up-Flow
Percolation Column
Procedure

This method is designed to provide the liquid-solid partitioning [LSP] of inorganic constituents and non-volatile organics in granular solid material as a function of liquid to solid (L/S) ratio under percolation conditions. **Summary Description:** This is a dynamic leaching procedure. Eluate is introduced into a column with packed particle sized reduced solid material in an up-flow pumping mode. Flow rate is maintained between 0.5-1.0 L/Day. Eluate is collected at predetermined times, filtered and analyzed for constituents of concern. Total time to generate the eluate is approximately 14 days.

LEAF Method 1315

Mass Transfer Rates
of Constituents in
Monolithic or
Compacted Granular
Materials using a
Semi-dynamic Tank
Leaching Procedure

This method is designed to provide the mass transfer (release rates) of inorganic analytes contained in a monolith or compacted granular material. Under diffusion controlled release conditions, as a function of leaching time. **Summary Description:** This is a hybrid batch and dynamic leaching procedure. Leaching of continuously water saturated monolithic or compacted granular material in an eluate-filled tank with periodic renewal of the leaching solution. L/S ratio of 9 mL eluate per cm² of surface area is used. Eluate is collected at predetermined times and analyzed for constituents of concern. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate is approximately 63 days.

LEAF Method 1316

Liquid-Solid
Partitioning as a
Function of
Liquid-to-Solid Ratio
for Constituents in
Solid Materials using
a Parallel Batch
Extraction Procedure

This method is designed to provide the liquid-solid partitioning (LSP) of inorganic and non-volatile organics at the natural pH of the solid material as a function of liquid-to-solid ratio (L/S) under conditions that approach liquid-solid chemical equilibrium. **Summary Description:** Five parallel extractions of a particle-size reduced solid material in reagent water over a range of L/S values from 0.5 to 10 mL eluate/g dry material. Depending on particle size, sample is tumbled between 24 and 72 hours. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate is between 1 and 3 days..



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