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Standard Guide for Sampling Radioactive Tank Waste[1]

This standard is issued under the fixed designation C1751; 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 guide addresses techniques used to obtain grab samples from tanks containing high-level radioactive waste created during the reprocessing of spent nuclear fuels. Guidance on selecting appropriate sampling devices for waste covered by the Resource Conservation and Recovery Act (RCRA) is also provided by the United States Environmental Protection Agency (EPA) (**1**).[2] Vapor sampling of the headspace is not included in this guide because it does not significantly affect slurry retrieval, pipeline transport, plugging, or mixing.

1.2 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.*

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2. Referenced Documents

2.1 *ASTM Standards:*[3]
D1129 Terminology Relating to Water

3. Terminology

3.1 *Definitions*—For definitions of terms used in this method, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *forced evaporation, n*—intentional concentration of a waste solution using heat or vacuum, or both, primarily to remove water or other solvents.

3.2.2 *pH modified, n*—a description of a solution where the pH is adjusted with either an acid or base material to achieve a desired pH level to minimize tank corrosion.

3.2.3 *soft sludge, n*—a sludge with a low viscosity where minimal sampling device pressure could be used to penetrate the sludge layer.

3.2.4 *sparge, n*—a process of delivering a chemically inert gas through fluids to displace materials for the purpose of mixing.

3.3 *Acronyms:*

3.3.1 *EREE*—Extended Reach End-Effector

3.3.2 *HAST*—Highly-Active Storage Tanks

3.3.3 *LDUAs*—Light-Duty Utility Arms

3.3.4 *NPH*—Normal Paraffin Hydrocarbons

3.3.5 *ORNL*—Oak Ridge National Laboratory

3.3.6 *PTFE*—Polytetrafluoroethylene

3.3.7 *PVC*—Polyvinyl Chloride

3.3.8 *RFD*—Reverse-Flow Diverter

4. Significance and Use

4.1 Obtaining samples of high-level waste created during the reprocessing of spent nuclear fuels presents unique challenges. Generally, high-level waste is stored in tanks with limited access to decrease the potential for radiation exposure to personnel. Samples must be obtained remotely because of the high radiation dose from the bulk material and the samples; samples require shielding for handling, transport, and storage. The quantity of sample that can be obtained and transported is small due to the hazardous nature of the samples as well as their high radiation dose.

4.2 Many high-level wastes have been treated to remove strontium (Sr) or cesium (Cs), or both, underwent liquid volume reductions through forced evaporation or have been pH modified, or both, to decrease corrosion of the tanks. These processes, as well as waste streams added from multiple process plant operations, often resulted in precipitation, and produced multiphase wastes that are heterogeneous. Evaporation of water from waste with significant dissolved salts concentrations has occurred in some tanks due to the high heat load associated with the high-level waste and by intentional evaporative processing, resulting in the formation of a saltcake

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[1] This practice 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] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[3] 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.

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or crusts, or both. Organic layers exist in some waste tanks, creating additional heterogeneity in the wastes.

4.3 Due to these extraordinary challenges, substantial effort in research and development has been expended to develop techniques to provide grab samples of the contents of the high-level waste tanks. A summary of the primary techniques used to obtain samples from high-level waste tanks is provided in Table 1. These techniques will be summarized in this guideline with the assumption that the tank headspace is adequately ventilated during sampling.

5. Liquid-Only Sampling Techniques

5.1 Liquid only techniques are not common in tank waste sampling. More common are liquid samples captured by methods used primarily to obtain solid or slurry samples. However, some high-level waste tanks, such as the Highly-Active Storage Tanks (HAST) tanks at Sellafield in the United Kingdom, had sampling systems installed in the tanks before the high-level waste was added. The HAST system uses a needle orifice as part of a Reverse-Flow Diverter (RFD) to obtain samples. The needle orifices are easily plugged by particles; only liquid samples can be obtained by this system. The HAST system design also allows for the agitation of tank contents to help obtain representative liquid samples (**2**).

6. Slurry/Liquid Sampling Techniques

6.1 The simplest of the liquid sampling techniques is dip sampling. At the Hanford Site, this sampling technique is often referred to as "bottle on a string." Only liquid or slurry samples can be taken by this method. Samples can be taken at various depths in the tank to determine whether there is vertical heterogeneity in the tank. If data on the stratification in the tank is not needed, waste in the tank should be sparged or mixed before taking the sample to decrease sampling bias.

6.2 A dip sample is taken by lowering a stoppered and weighted bottle into the waste to the desired depth. After the

TABLE 1 High-Level Waste Tank Sampling Methods

Technique	Material Type Solid	Material Type Slurry	Material Type Liquid	Notes
HAST in-tank needle orifice			X	Orifice as part of Reverse-Flow Diverter (RFD)
Bottle on a String		X	X	Dip sample
Vacuum Pump		X	X	
Auger	X	X		Only high viscosity slurries
Sample Cup	X	X		Manual system used at Savannah River Site to obtain salt-cake samples and hard sludges that don't slump.
Core Drilling — Rotary Mode (Hanford Sampler)	X	X		Hard sludges and salt-cake.
Core Drilling — Push Mode (ORNL Soft Sludge Sampler)		X	X	Liquid or soft sludges.
Cylinder with retractable nose cone		X	X	Used at Savannah River Site for soft sludges and liquids.
Robotic Arm	X	X	X	Material type captured is dependent upon the end-effector.
Hydraulic Mining	X	X	X	
Hydraulic Scoop	X	X	X	
Sample Thief (Bacon Bomb)			X	

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bottle has reached the desired level, the stopper is pulled from the bottle and the liquid or slurry sample flows into the bottle. Ideally, the stopper is then closed and the bottle is pulled from the tank (**3**).

6.3 Dip sampling is limited to lower viscosity liquid and slurry materials and the effectiveness of sampling is highly dependent upon the size of the sample bottle inlet and the presence of saltcake layers which may prevent sampling access to lower tank levels. Further, sampling locations are limited only to vertical columns directly under a tank penetration, or riser. Particulates obtained from this method may be highly biased due to sample location and variations in settling velocity while sampling.

6.4 Liquid samples from radioactive-waste tanks have also been obtained using a vacuum-pump system. Samples were pulled by vacuum from the specified level in the tank through polytetrafluoroethylene (PTFE) tubing into a sample jar; if necessary, the sample jar could be shielded. A stainless-steel pipe nozzle is attached to the bottom of the PTFE tubing to keep it vertical. A diagram of the vacuum-pump sampling system used at Oak Ridge National Laboratory (ORNL) is provided in Fig. 1 (**4**).

7. Solids/Slurry Sampling Techniques

7.1 Early sampling of the solids content of Hanford tank wastes was by the use of an auger. Auger samples were taken only from the surface of the waste and were limited to 6 in. This 6 in. limitation was driven primarily by a desire to reduce radiation dose. Some homogenization of the sample occurs while obtaining auger samples. These samples can only be taken directly beneath a penetration, or riser (**5**).

7.2 Auger samples are taken by encasing an auger in a shroud to contain the sample. The auger is rotated through the sample while the shroud remains stationary. Sample is collected along the flutes of the auger. Liquid is generally not contained in the auger unless it is associated with solids in the form of a sludge or highly viscous slurry.

7.3 Savannah River Site staff developed a manual method of capturing salt-cake samples from waste tanks. This method incorporates a sample cup pinned to a handle that can be driven into the salt cake. The cup has a sharp edge to allow it to cut through the salt cake as the handle is pounded with a hammer. The bore of the cup has a ledge like a fishhook barb that captures the material once it is forced into the cup. The cup design is shown in Fig. 2 (**6**). The applicability of this method is limited to hard materials that will not flow or slump once collected in the sample device.

7.4 Core drilling is the primary mechanism for obtaining samples from the Hanford waste tanks. A core-drilling truck with a shielded handler was specifically designed for this purpose. Two modes, push or rotary, can be used to obtain

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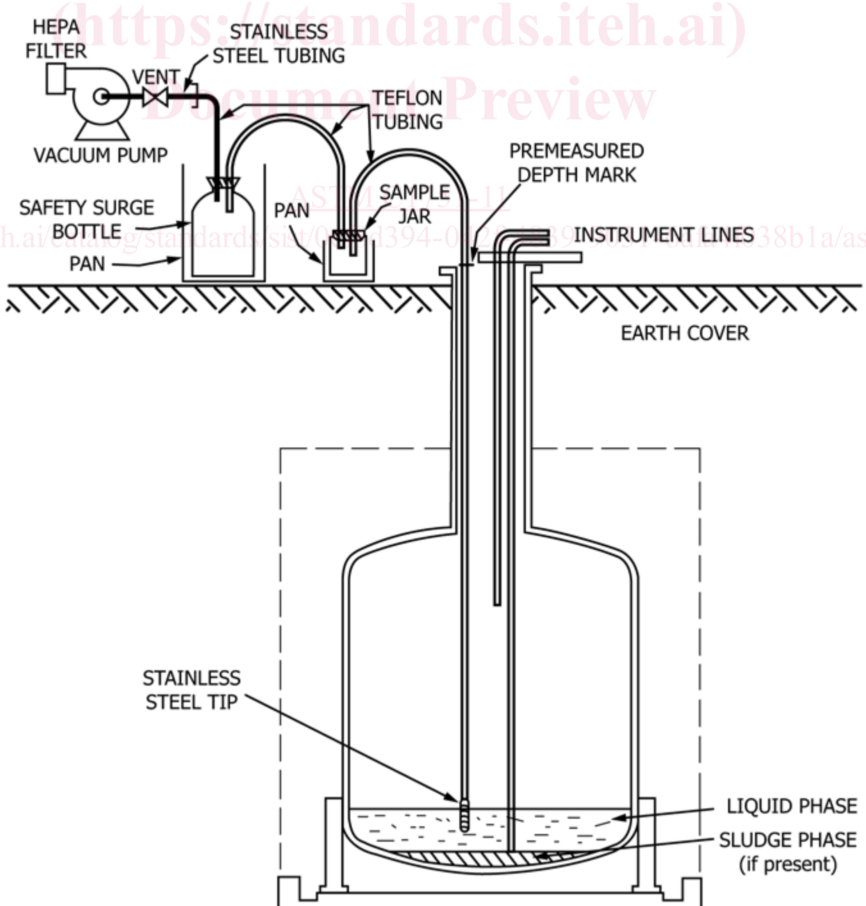

FIG. 1 Vacuum Pump Sampling System