Designation: C1750 – 21

Standard Guide for Development, Verification, Validation, and Documentation of Simulants for Hazardous Materials and Process Streams[1]

This standard is issued under the fixed designation C1750; 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 *Intent:*

1.1.1 The intent of this guide is to provide general considerations for the development, verification, validation, and documentation of tank simulants for hazardous materials (for example, radioactive wastes) and process streams. Due to the expense and hazards associated with obtaining and working with actual hazardous materials, especially radioactive wastes, simulants are used in a wide variety of applications including process and equipment development and testing, equipment acceptance testing, and plant commissioning. This standard guide facilitates a consistent methodology for development, preparation, verification, validation, and documentation of simulants.

1.2 This guide provides direction on (*1*) defining simulant use, (*2*) defining simulant-design requirements, (*3*) developing a simulant preparation procedure, (*4*) verifying and validating that the simulant meets design requirements, and (*5*) documenting simulant-development activities and simulant preparation procedures.

1.3 *Applicability:*

1.3.1 This guide is intended for persons and organizations tasked with developing simulants to either mimic certain characteristics and properties of hazardous materials or provide representative performance for the phenomenon being evaluated. The process for simulant development, verification, validation, and documentation is shown schematically in Fig. 1. Specific approval requirements for the simulant developed under this guide are not provided. This topic is left to the performing organization. Approval requirements are associated with the design of the simulant, makeup procedures, and final simulant produced.

1.3.2 While this guide is directed at simulants for radioactive materials (for example, nuclear waste), the guidance is also applicable to other aqueous based solutions and slurries.

1.3.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 This guide is not a substitute for sound chemistry and chemical engineering skills, proven practices and experience. It is not intended to be prescriptive but rather to provide considerations for the development and use of simulants.

1.5 *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.*

1.6 *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]

C859 Terminology Relating to Nuclear Materials

2.2 *ASME Standard:*[3]

NQA-1 Quality Assurance Requirements for Nuclear Facility Applications

2.3 *Environmental Protection Agency SW-846 Methods:*[4]

Method 3010A Acid digestion of Aqueous Samples and Extracts for total metals for Analysis by FLAA or ICP Spectroscopy

Method 3050B Acid Digestion of Sediments, Sludges and Soils

[1] This guide 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] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov.

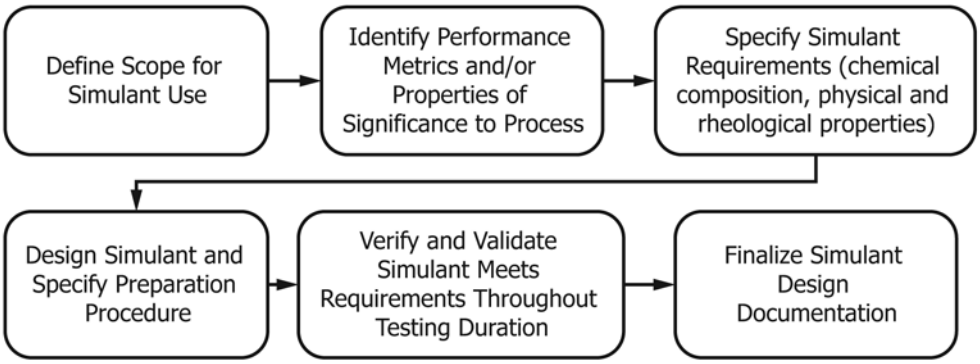

FIG. 1 Simulant Development, Verification, Validation, and Documentation Flowsheet

Method 3051A Microwave Assisted Acid Digestion of Sediments, Sludges and Soils
Method 3052 Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices
Method 6010C Inductively Coupled Plasma-Atomic Emission Spectrometry
Method 6020A Inductively Coupled Plasma-Mass Spectrometry
Method 9056A Determination of Inorganic Anions by Ion Chromatography

3. Terminology

3.1 Refer to Terminology C859 for additional terminology, which may not be defined below.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cognizant engineer, n*—lead engineer responsible for overall supervision and direction of simulant development.

3.2.2 *simulant, n*—a solution or slurry that mimics or replicates selected chemical, physical or rheological properties, or both, of an actual process or waste stream and is utilized to reduce hazards and costs associated with working with the actual material.

3.2.3 *simulant development test plan, n*—a document that describes the simulant development process that results in a simulant that meets the usage and design requirements identified in the simulant requirements specification.

3.2.4 *simulant preparation procedure, n*—a document that specifies the step by step process of producing the simulant.

3.2.5 *simulant requirements specification, n*—a document that specifies the simulant use and design requirements.

3.2.6 *simulant validation, n*—establishment of documented evidence that confirms that behavior of the simulant adequately mimics the targeted actual waste behavior or performance; simulant validation can be expressed by the query, "Are you making the correct simulant?" and refers back to the needs for which the simulant is being developed.

3.2.7 *simulant verification, n*—establishment of documented evidence which provides a high degree of assurance that the simulant meets the predetermined design and quality requirements; simulant verification can be expressed by the query, "Are you making the simulant properly?"

3.3 *Acronyms:*

3.3.1 *ASME*—American Society of Mechanical Engineers
3.3.2 *DI*—Deionized Water
3.3.3 *DOE*—U.S. Department of Energy
3.3.4 *GFC*—Glass Forming Chemicals
3.3.5 *HLW*—High-Level Waste
3.3.6 *LAW*—Low-Activity Waste
3.3.7 *N/A*—Not Applicable
3.3.8 *NQA-1*—Nuclear Quality Assurance
3.3.9 *PSD*—Particle Size Distribution
3.3.10 *QA*—Quality Assurance
3.3.11 *QC*—Quality Control

4. Summary of Guide

4.1 This guide provides general considerations on the development, preparation, validation, verification, and documentation of simulants.

4.2 The first step in the process is to define the purpose for which the simulant will be used and to identify the key process performance metrics or properties, or both, relevant to the phenomenon being assessed. The performance metrics/parameters provide a means of comparing simulant performance against that for actual waste (based on available performance or characterization data, or both, for the waste) for the process or phenomenon being evaluated as exemplified by Peterson et al.,[5] Wells,[6] and Lee et al.[7] This first step also includes specifying the target values or range of values for the chemical composition and physical properties (including rheology) of the simulant. The quality assurance requirements are also defined in the first step in accordance with the project requirements for which the simulant is being developed.

4.3 The next step is to define the simulant design requirements. This involves determining the necessary and sufficient

[5] Peterson, R. A., Wells, B. E., Daniel, R. C., and Russell, R., "Performance-Based Simulants for Hanford Radioactive Waste Treatment Process Testing," *Separation Science and Technology*, February 2021.

[6] Wells, B. E., "Simulant Development for Hanford Tank Farms Double Valve isolation (DVI) Valves Testing," *PNNL-22121*, Pacific Northwest National Laboratory, Richland, WA, 2013.

[7] Lee, K. P., Wells, B. E., and Gauglitz, P. A, and Sexton, R. A., "Waste Feed Delivery Mixing and Sampling Program Simulant Definition for Tank Farm Performance Testing," *RPP-PLN-51625*, Washington River Protection Solutions, LLC, Richland, WA, 2012.