Designation: C1752 – 21

Standard Guide for Measuring Physical and Rheological Properties of Radioactive Solutions, Slurries, and Sludges[1]

This standard is issued under the fixed designation C1752; 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 guidance for the measurement and calculation of physical and rheological properties of radioactive solutions, slurries, and sludges as well as simulants designed to model the properties of these radioactive materials.

1.2 *Applicability:*

1.2.1 This guide is intended for measurement of mass and volume of the solution, slurries, and sludges as well as dissolved solids content in the liquid fraction and solids content associated with the slurries and sludges. Particle size distribution is also measured.

1.2.2 This guide identifies the data required and the equations recommended for calculation of density (bulk, settled solids, supernatant, and centrifuged solids), settling rate, volume and weight percent of the centrifuged solids and settled solids, and the weight percent undissolved solids, dissolved solids, and total oxides.

1.2.3 This guide is intended for measurement of shear strength and shear stress as a function of shear rate.

1.2.4 Rheological property measurement guidelines in this guide are limited to rotational rheometers.

1.2.5 This guide is limited to measurements of viscous and incipient flow and does not include oscillatory rheometry.

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

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C859 Terminology Relating to Nuclear Materials

C1750 Guide for Development, Verification, Validation, and Documentation of Simulated High-Level Tank Waste

C1751 Guide for Sampling Radioactive Tank Waste

D1193 Specification for Reagent Water

2.2 *ISO Standard:*[3]

ISO 13320:2020 Particle size analysis — Laser diffraction methods

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide but not defined herein, refer to Terminology C859.

3.1.1 *apparent viscosity, n*—measured shear stress divided by the measured shear rate.

3.1.2 *density, n*—in the United States, mass per unit volume.

3.1.3 *Newtonian fluid, n*—a fluid whose apparent viscosity is independent of shear rate.

3.1.4 *non-Newtonian fluid, n*—a fluid whose apparent viscosity varies with shear rate.

3.1.5 *rheogram, n*—plot of shear stress versus shear rate.

3.1.5.1 *Discussion*—A rheogram is also called a flow curve.

3.1.6 *shear rate, n—in laminar flow*, the velocity gradient perpendicular to the direction of shear flow in parallel adjacent layers of a fluid body under shear force.

3.1.7 *shear strength, n*—maximum shear stress measured during incipient motion.

[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 International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

3.1.8 *shear stress, n*—shear force per unit area.

3.1.9 *supernatant liquid, n*—a liquid phase overlying material deposited by settling, precipitation, or centrifugation.

3.1.10 *weight percent (wt%) dissolved solids, n*—mass of dissolved species in the supernatant liquid divided by the total mass of the supernatant liquid on a percentage basis.

3.1.11 *weight percent (wt%) dried solids, n*—percentage of the mass of the sample that remains after removing volatiles including free water by drying at 105 ± 5 °C to a stable mass.

3.1.11.1 *Discussion*—wt% total dried solids and wt% centrifuged dried solids are the wt% dried solids in the bulk sample and centrifuged solids, respectively.

3.1.12 *weight percent (wt%) total oxides, n*—percentage of the mass of the bulk sample that remains after converting all non-volatile elements to oxides at 1000 °C.

3.1.13 *weight percent (wt%) undissolved solids, n*—calculated value reflecting the percent mass of solids remaining if all the supernatant liquid and interstitial solution were removed from the bulk slurry.

3.1.14 *yield stress, n*—minimum stress required to initiate fluid movement as determined by a flow curve using a rheological model.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *interstitial solution, n—in this guide*, interstitial solution is the solution contained between the suspended, settled, or centrifuged solid particles of a sludge sample.

3.2.2 *sludge, n—in this guide*, sludge is wet solids having little or no standing liquid (that is, mud-like).

3.2.3 *slurry, n—in this guide*, a slurry is a mixture of solids and solution.

3.2.4 *solids settling rate, n—in this guide*, the rate at which solids in a homogenized sample settle as defined by the change in the settled solids height as a function of time.

3.2.5 *volume percent (vol%) centrifuged solids, n—in this guide*, the volume of the solids layer with its interstitial liquid that separates from the bulk slurry after centrifugation at a specified time and centrifugal force divided by the total sample volume on a percentage basis.

3.2.6 *volume percent (vol%) settled solids, n—in this guide*, the percentage of the volume of the slurry sample that the settled solids with its interstitial liquid occupy after settling for a specified time under one gravity.

3.2.7 *weight percent (wt%) centrifuged solids, n—in this guide*, the mass of the solids layer with its interstitial liquid that separates from the bulk slurry after centrifugation at a specified time and centrifugal force divided by the total bulk slurry sample mass on a percentage basis.

3.3 *Abbreviations:*

3.3.1 b—Herschel-Bulkley power law exponent (unitless)

3.3.2 B—steady-state torque in a shear strength test in N·cm

3.3.3 D—diameter of the shear vane in cm

3.3.4 D_T—diameter of the shear strength sample cup in cm

3.3.5 H—height of the shear vane in cm

3.3.6 k—Herschel-Bulkley consistency coefficient in $Pa{\cdot}s^b$

3.3.7 m—power law consistency coefficient in $Pa{\cdot}s^n$

3.3.8 M_B—total mass of bulk slurry after centrifugation in g

3.3.9 M_{CC}—mass of the centrifuge cone in g

3.3.10 M_{CR}—mass of the crucible in g

3.3.11 M_{CS}—mass of the centrifuged solids and their interstitial liquid in g

3.3.12 M_{DCL}—mass of the oven dried centrifuged supernatant liquid in g

3.3.13 M_{DCS}—mass of the oven dried centrifuged solids in g

3.3.14 M_{FSC}—mass of the fired solids (1000 °C) in the crucible in g

3.3.15 M_{OSC}—mass of the oven dried solids (105 °C) in the crucible in g

3.3.16 M_S—mass of the decanted supernatant liquid after centrifugation in g

3.3.17 M_{SL}—mass of the supernatant liquid after gravity settling in g

3.3.18 M_{SS}—mass of the settled solids and interstitial liquid after gravity settling in g

3.3.19 M_{VL}—mass of a subsample of the decanted centrifuged supernatant liquid in g

3.3.20 M_{WCS}—mass of the wet sample in the crucible in g

3.3.21 n—power law exponent (unitless)

3.3.22 N—rotational rate of the shear vane in revolutions per min

3.3.23 P_{MCS}—percent mass of centrifuged solids with the associated interstitial liquid in the slurry

3.3.24 P_{MDS}—percent mass of oven dried solids in the crucible

3.3.25 P_{MOX}—percent mass of oxides in the slurry

3.3.26 P_{MSS}—percent mass of settled solids with its associated interstitial liquid

3.3.27 P_{MTS}—percent mass of total solids

3.3.28 P_{MUS}—percent mass of undissolved solids in the slurry

3.3.29 P_{ODS}—percent mass of oven dried solids in the centrifuged solids including interstitial liquid

3.3.30 P_{VCS}—percent volume of centrifuged solids with its associated interstitial liquid in the slurry

3.3.31 P_{VSS}—percent volume of settled solids with its associated interstitial liquid in the slurry

3.3.32 r^2—correlation coefficient (unitless)

3.3.33 R_1—radius of the inner cylinder of the viscometer concentric cylinder geometry in cm

3.3.34 R_2—radius of the outer cylinder of the viscometer concentric cylinder geometry in cm

3.3.35 R_e—Reynolds number (unitless)

3.3.36 R_t—maximum torque in a shear strength test in N·cm