A One System Integrated Approach to Simulant Selection for Hanford High Level Waste Mixing and Sampling Tests – 13342

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ABSTRACT

The Hanford Tank Operations Contractor (TOC) and the Hanford Waste Treatment and Immobilization Plant (WTP) contractor are both engaged in demonstrating mixing, sampling, and transfer system capabilities using simulated Hanford High-Level Waste (HLW) formulations. This represents one of the largest remaining technical issues with the high-level waste treatment mission at Hanford. Previous testing has focused on very specific TOC or WTP test objectives and consequently the simulants were narrowly focused on those test needs. A key attribute in the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2010-2 is to ensure testing is performed with a simulant that represents the broad spectrum of Hanford waste. The One System Integrated Project Team is a new joint TOC and WTP organization intended to ensure technical integration of specific TOC and WTP systems and testing. A new approach to simulant definition has been mutually developed that will meet both TOC and WTP test objectives for the delivery and receipt of HLW. The process used to identify critical simulant characteristics, incorporate lessons learned from previous testing, and identify specific simulant targets that ensure TOC and WTP testing addresses the broad spectrum of Hanford waste characteristics that are important to mixing, sampling, and transfer performance are described.

INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) is responsible for management and completion of the River Protection Project (RPP) mission, which comprises both the Hanford Site tank farms operations and the WTP. The RPP mission is to store, retrieve, and treat Hanford's tank waste; store and dispose of treated wastes; and close the tank farm waste management areas and treatment facilities in a safe, environmentally compliant, cost-effective, and energy-effective manner.

The RPP work scope is currently performed by two primary contractors: Washington River Protection Solutions, LLC (WRPS) (the TOC); and Bechtel National, Inc. (BNI), the WTP Construction and Commissioning Contractor. WRPS is responsible for the construction, operation, and maintenance activities necessary to store, retrieve, and transfer tank wastes; provide supplemental pretreatment for tank waste; and provide secondary low-activity waste (LAW) treatment, storage, and/or disposal of the immobilized product and secondary waste streams. BNI is responsible for the design, construction, and commissioning of the WTP Pretreatment Facility, two vitrification facilities (one for HLW and one for LAW), a dedicated analytical and radiochemical laboratory, and supporting facilities to convert radioactive tank wastes into glass for long-term storage or final disposal. [1]

MIXING PROGRAM BACKGROUND

The TOC has identified two critical risks, TOC-12-65 and TOC-12-64 [2] that address emerging Waste Acceptance Criteria (WAC) and sampling method requirements. These risks address uncertainty associated with the tank farms ability to adequately mix HLW slurry in million gallon double shell tanks (DSTs) and representatively sample the slurry in order to confirm that the delivered feed will meet the WTP WAC. The tank farms mixing and sampling demonstration program was scoped to address these risks. In addition, the Waste Feed Delivery (WFD) Mixing and Sampling Program will address system performance related to WTP safety issues raised by the DNFSB Recommendation 2010-2 and the Implementation Plan submitted by DOE to resolve these issues.

At the WTP the two comparable risks are the ability to adequately mix the HLW slurries in the Pulsed Jet Mixer (PJM) agitated tanks and demonstrating that the in-process samples represent the waste slurry. Aspects of the PJM systems mixing capability have been studied from the inception of the WTP and the External Flowsheet Review Team issue M3 focused the project on Newtonian waste slurry mixing effectiveness. The integrated operation and sampler performance are also discussed in the DNFSB Recommendation 2010-2. The WTP is actively working both of these technical issues.

Both Tank Farms and WTP have developed testing programs designed to gather performance data on the ability of the systems to adequately mix, sample, and transfer high level slurry. These programs both used scaled equipment and are focused on the behavior of undisolved solids (UDS) within measured waste property ranges using non-radioactive simulated waste slurries.

PREVIOUS APPROACH

Previous TOC testing (see WM 10083, 11193, 12093) very specifically focused on the first WTP feed tank (tank AY-102) and simulant was water based in order to reduce cost and demonstrate conservative mixing, sampling, and transfer behavior. WTP testing was previously focused on either WTP design basis characteristics or specific simulant formulations needed for validation and verification of the Fluent computational fluid dynamics (CFD) code proposed for specific design analysis.

Tank Farms Approach

The approach to initial testing involved testing sampling and batch transfer effectiveness in two scaled DST systems that were built around the configuration of the first DST planned to deliver waste to the WTP (AY-102). One meter (43 inch) diameter (~1/20th scale) and three meter (120 inch) diameter (~1/8th scale) test vessels were selected for the testing. [3] Testing was conducted using inert particulate materials in water with the expectation that results would conservatively bound expected performance in more realistic supernatant with higher fluid density and viscosity. If system performance, as measured by sample representativeness to batch transfers, is demonstrated to be acceptable in water then performance in more dense and viscous fluids is expected to be better.

Simulant particulate selection focused on matching the particulate size and density ranges identified for DST AY-102. Fortunately AY-102 is one of the best characterized tanks in the Hanford tank farms and a good estimate of the solids Particle Size and Density Distribution (PSDD) is described [4]. The composition and particle size of the four primary particles that make up 98% of the solids volume in AY-102 provided the basis for the simulant PSDD target. These four primary solid components are Al(OH)3, Fe2O3, Ca5OH(PO4), and MnO2. Simulant selection rationale [5] was generally selected to match AY-102 particulate properties as close as practical while considering availability, test platform design, analytical techniques, and ability to visually distinguish simulant components from one another. The selected simulant is described in the results report [6] and consisted of Zirconium Oxide, Gibbsite, Bismuth Oxide, Silicon Carbide, and Stainless Steel.

The simulant profile can be plotted by comparing volume percent of particle sizes with normalized volume percent plotted on the left axis and the cumulative volume percent plotted on the right axis. As can be seen from the green data points in Figure 1, the simulant selected for SSMD (solid green diamonds) has particle size distributions larger than that of the AY-102 (open green diamonds). This simulant selection contributed to the conservative behavior of the testing when compared to AY-102.

Waste Treatment Plant approach

WTP simulant design was not based on any one particular Hanford Tank characterization but was based on the WTP design basis assumptions regarding potential particle size distributions as defined by RPP-9805 [7]. Similar to the simulant selection approach described above for the tank farm approach, the objective was to combine a set of simple simulant components such that the cumulative particle size distribution approached the 95% upper confidence limit values provided by RPP-9805. The WTP M3 simulant consisted of Gibbsite, Silicon Oxide, sand, glass particulate, and Tungsten Carbide [8]. Figure 1 shows the selected simulant (solid red circles) has particle size distributions larger than the RPP-9805 distribution (open red circles).

The simulant used for initial tank farm and WTP testing were similar but had different material composition and different target distributions.

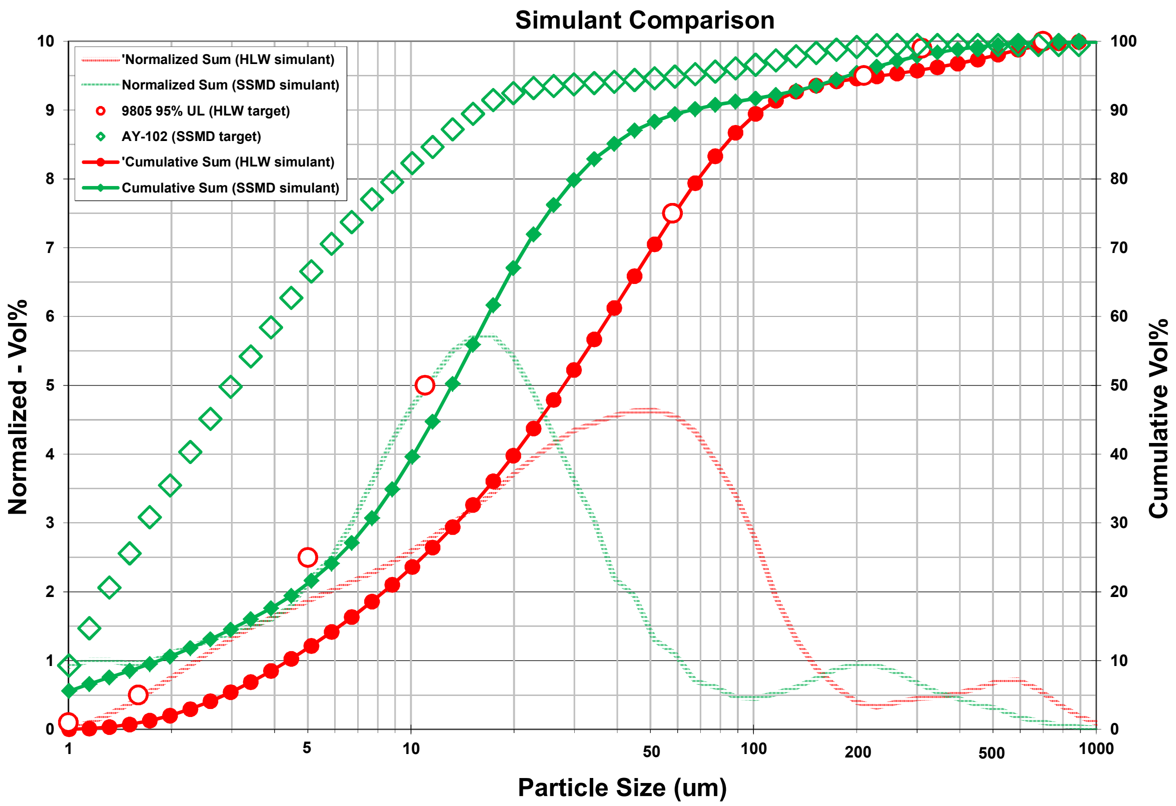

Figure 1, SSMD Simulant Particle Size Distribution

ONE SYSTEM APPROACH

In October 2011, BNI and WRPS submitted a proposal that provides the RPP an integrated management and technical execution approach for waste feed delivery (WFD) and WTP startup as well as demonstrate the ability and commitment to work together to execute this technical work scope. This approach is called "2020 Vision One System" (herein referred to as One System). The One System strategy is to assure successful completion of all activities necessary to achieve WTP Initial Plant Operations (IPO) by 2022 to meet the Consent Decree, State of Washington v. DOE, Case No. 08-5085-FVS (Consent Decree) commitments, lower costs and risks, and accelerate completion of the RPP mission. The overall objective of this strategy is to increase our combined focus on accelerating completion of key supporting work scope elements and to instill accountability for jointly delivering the One System. The key elements of the One System strategy are:

- Embrace One System as the overarching approach to the tank waste treatment and closure mission
- Create a One System integrated project team (IPT) that is mission-focused and staffed by both contractors
- Modify baseline work scope for each contractor, as needed, to meet One System goals
- Define joint and complementary incentives for both WTP and TOC [9]

The One System approach created the need for an integrated approach to the mixing, sampling, and transfer issues that looked beyond existing interface requirements or contract boundaries.

While simulant used for these previous WTP and TOC testing was appropriate for the specific test objectives it does not allow for a common testing basis that will demonstrate system performance expected over the broad spectrum of Hanford waste and therefore over the life-cycle of the treatment mission. A common simulant was needed that is reflective of waste to be transferred to the WTP and that is compatible with existing TOC and WTP testing platforms.

SYSTEM REQUIREMENTS

Simulant development must start with a basic understanding of the systems that are to be simulated, the projection of the waste to be processed by those systems, and an understanding of the capabilities of the test platforms that had already been constructed and used for earlier testing.

Tank Farm Feed Delivery

The tank farms feed delivery strategy is described in the River Protection Project System Plan [10] and involves movement of Hanford waste from single shell tanks (SSTs) and DSTs into specifically selected DSTs that serve as WTP feed staging tanks. The feed staging DSTs are flat bottom underground tanks with a working volume of 4.2 million liters (1.1 million gallons) and are mixed by two submerged and rotating centrifugal mixer pumps each with a flow rate of approximately 38,000 liters (10,000 gallons) per minute. The waste staging is planned such that the waste transferred to these feed staging tanks is expected to be compliant with the WTP WAC. Once the feed is staged the tanks will be mixed and sampled. The samples are analyzed in an analytical laboratory to confirm that the staged feed is compliant with the WTP WAC. The RPP System Plan estimates the contents of each feed delivery batch planned through the course of the RPP mission. These estimates combined with the existing characterization of Hanford waste provides the boundaries for the range of waste the simulant is expected to represent.

Waste Treatment Plant Feed Receipt

The WTP Pretreatment facility is designed to accept two specific waste streams from the tank farms, LAW and HLW. LAW is primarily liquid with little to no undissolved solids. HLW is a combination of liquid and undissolved solids. The mixing demonstration programs, and this paper, focus on the HLW and the difficulties associated with mixing sampling and transferring the fast settling particulates that are part of the HLW feed. The HLW feed will be delivered to one receipt vessel within the WTP Pretreatment facility, HLP-22. HLP-22 is a flanged and dished bottom vessel with a working volume of 530,000 liters (140,000 gallons) and is mixed with an array of 18 PJMs. The waste expected to be received in HLP-22 will be identical to that delivered from the tank farm feed staging tanks with the exception that some dilution will occur as a result of flush water received after each waste transfer. In some cases, additional dilution may be required to ensure the solids loading does not exceed the HLP-22 design basis. The range of simulant properties necessary to test the range of expected HLW feed received over the course of the RPP mission is the same as that defined for tank farm feed delivery.

Test System Design and Operation Needs

The test platforms are essentially geometrically scaled duplicates of the feed staging tanks and the feed receipt tank. Non-prototypic mixing and transfer pumping systems are needed for the scaled feed staging tank. It is not possible to procure submerged centrifugal pumps that match the scaled flow characteristics of the mixer and transfer pumps. Therefore, a system driven by pumps external to the test tank has been developed that allows for matching the scaled flow characteristics. These non-prototypic systems create additional simulant concerns related to transfer line plugging, positive suction head, and equipment erosion concerns.

SIMULANT CHARACTERISTICS

There are a number of characteristics important to simulant selection that are discussed in length in SRNL-STI-2012-0062 [11] and RPP-PLAN-51625 [12]. While multiple characteristics associated with the test platforms ability to detect and measure the simulant behavior must be considered to ensure the test objectives can be accomplished, this document focuses on the two primary characteristics that have the most physical impact on the distribution of solids in the planned mixing, sampling, and transfer test systems. Additional simulant drivers that are consistent with both WTP and TOC test platforms is the preference for use of non-hazardous materials that can be characterized to determine concentrations of each component in different sample streams and can be disposed readily as non-hazardous waste.

Important Characteristics

The two simulant characteristics most important to match with Hanford waste are: 1) the particle mobility and settling tendencies, and 2) the carrier fluid characteristics. Particle mobility and settling tendencies are primarily related to:

- Distribution of particle size
- Distribution of particle densities
- Critical shear stress for erosion of a settled layer of non-cohesive particles
- Particle concentration.

Carrier fluid characteristics are primarily related to:

- Suspending fluid density
- Suspending fluid viscosity (for Newtonian liquids)
- Suspending fluid rheology (such as Bingham yield stress and consistency for non-Newtonian slurries).

Unfortunately, comprehensive Hanford waste characterization information for the above characteristics does not currently exist. Additionally, most of these characteristics are not included in the Hanford Tank Waste Operations Simulator (HTWOS) model[1] which is used to plan the individual feed batches identified in the RPP System Plan. Selected Hanford waste types, for specific situations have been characterized and studied for the characteristics of interest. This information allows some judgment to be used when identifying a range of simulant properties that covers the planned WTP feed.

Comparison to Hanford Waste

Two primary documents are used to compare simulant properties of interest to Hanford waste properties. The most comprehensive source for describing the knowledge of Hanford waste with regards to the characteristics of interest is PNNL- 20646 [13]. The concepts for comparing the particle mobility characteristics are presented and used in PNNL-20637 [14] and are used as the primary comparison of simulant particle properties to Hanford waste particle properties.

Rheology Metrics

Newtonian fluid characteristics of most importance to the transport of suspended particulates are the liquid density and liquid viscosity. The HTWOS model has the ability to track and calculate the liquid density of the feed batches, therefore a good understanding of liquid density range exists. HTWOS does not track or calculate liquid viscosity so an alternate means of estimating range of viscosity is needed. Based on the available Hanford waste characterization data, correlations between liquid density and liquid viscosity can be developed and used to estimate viscosity ranges.

Non-Newtonian fluids present additional complications to particle movement and simulant definition. Some Hanford slurries can be characterized rheologically as non-Newtonian, Bingham plastic fluids. A primary method for characterizing the non-Newtonian properties is through measurement of Bingham Yield Stress which is a measurement of the fluids resistance to flow under changing flow (shear stress) conditions. The available data on Hanford waste is not complete, however there is sufficient data evaluated in RPP-PLAN-51625 to suggest that more than 95% of slurries with solids concentrations less than 15% by mass, and within the WTP feed temperature range, the yield stress could range from less than 1 Pa up to 4 Pa. It is recognized that this data is based on a limited data set of waste that is not yet staged for feed delivery; however this provides an insight into the range of Bingham yield stresses that should be considered for DST simulant development.

Solids Metrics

Hanford HLW waste is composed of a large variety of solid particulates with a broad range of particle and agglomerate sizes and densities. The mixing, sampling, and transfer performance of these particulates is a strong function of the particle size and density distribution; however this function is not necessarily dominated by any one physical phenomenon. For example, a specific property that is pertinent to DST mixing performance is the settling of the particles, which can be

[1] The HTWOS model is a dynamic event simulation model programmed to track the waste as it moves through storage, retrieval, feed staging, and multiple treatment processes during the entire RPP mission.

directly related to the Archimedes (Ar) Number. The Archimedes Number, a dimensionless term describing settling behavior related to density differences, is defined by:

$$Ar = \frac{\left(\frac{\rho_S}{\rho_L} - 1\right) g d^3}{\nu^2} \qquad \text{(Eq.-1)}$$

where d is the particle diameter, ρ_S is the particle density, ρ_L is the liquid density, ν is the kinematic viscosity of the liquid, and g is the gravitational constant[2]. Based on available characterization data, the Archimedes number can be plotted to provide an indication of the range covered by characterized Hanford wastes. This plot (Figure 2) can then be used to provide a relative comparison of simulant formulations to the range of Hanford waste properties.

It is important to note that movement of particles in a mixed DST are not always characterized by settling behavior; therefore some correlations related to lofting and transport of particles are also appropriate. For example, a semi-empirical model to predict the jet velocity needed to achieve a certain degree of solids suspension (e.g., 100% of the solids suspended) can be expressed as a function of the Ar number by:

$$U_n = \frac{\nu}{d}\left[0.13X^{0.22}Ar^{0.38}\left(\frac{D}{d_j}\right)^2\left(1+0.25\left(\frac{z}{d_j}\right)\right)^{-0.25}\left(1+0.75\left(\frac{z}{D}\right)\right)\right] \qquad \text{(Eq.-2)}$$

where d_j is the jet nozzle diameter and z is the nozzle clearance above the tank bottom. The solids loading ratio X and tank diameter D are set to the maximum tested during correlation development, 5 and 1 m respectively, and the nozzle diameter and clearance set to nominal testing values of 0.04 m and 0.5 m respectively.[3] Similar to the Archimedes number, the jet velocity can be plotted (Figure 3) for characterized Hanford waste.

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[2] Waste Feed Delivery Mixing and Sampling Program simulant Definition for Tank Farm Performance Testing, RPP-PLAN-51625, Rev.0, March 2012, p 20 & 21

[3] Comparison of Waste Feed Delivery Small Scale Mixing Demonstration Simulant to Hanford Waste, PNNL-20637, Rev.2, B.E. Wells, P.A. Gauglitz, D.R. Rector, Pacific Northwest National Laboratory, July 2012, p. 2.7

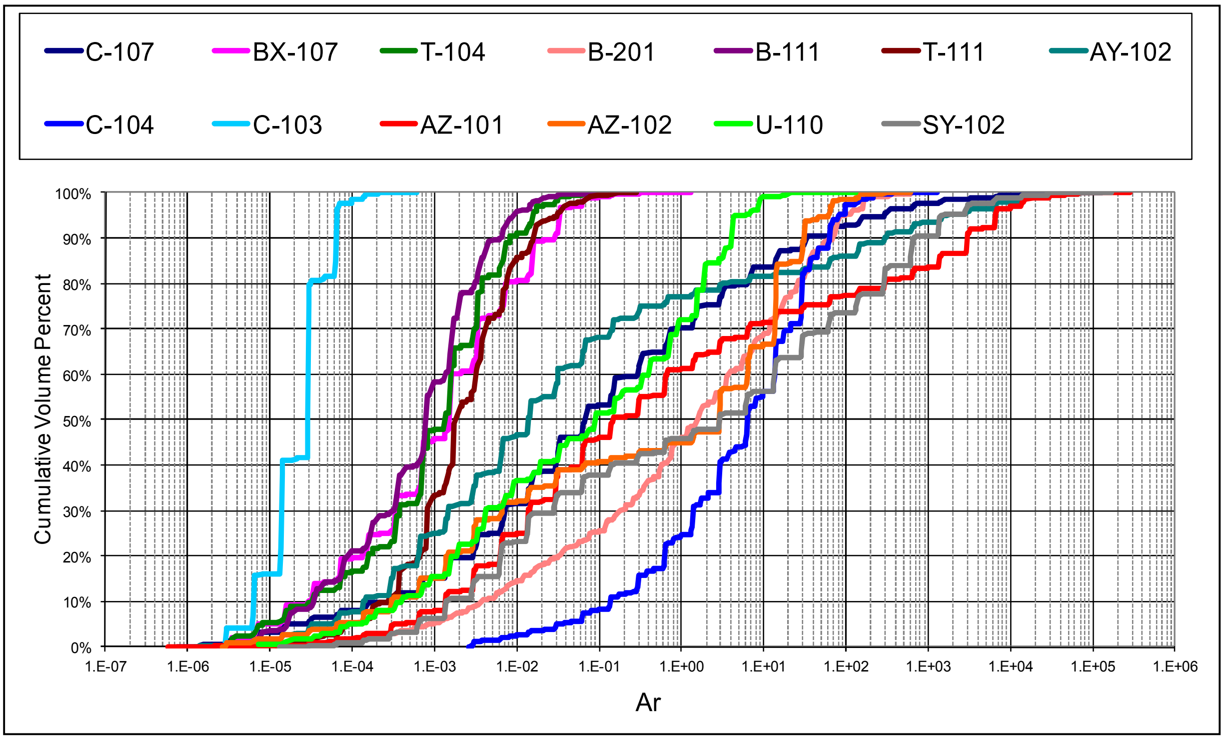

Figure 2, Archimedes Number Comparison

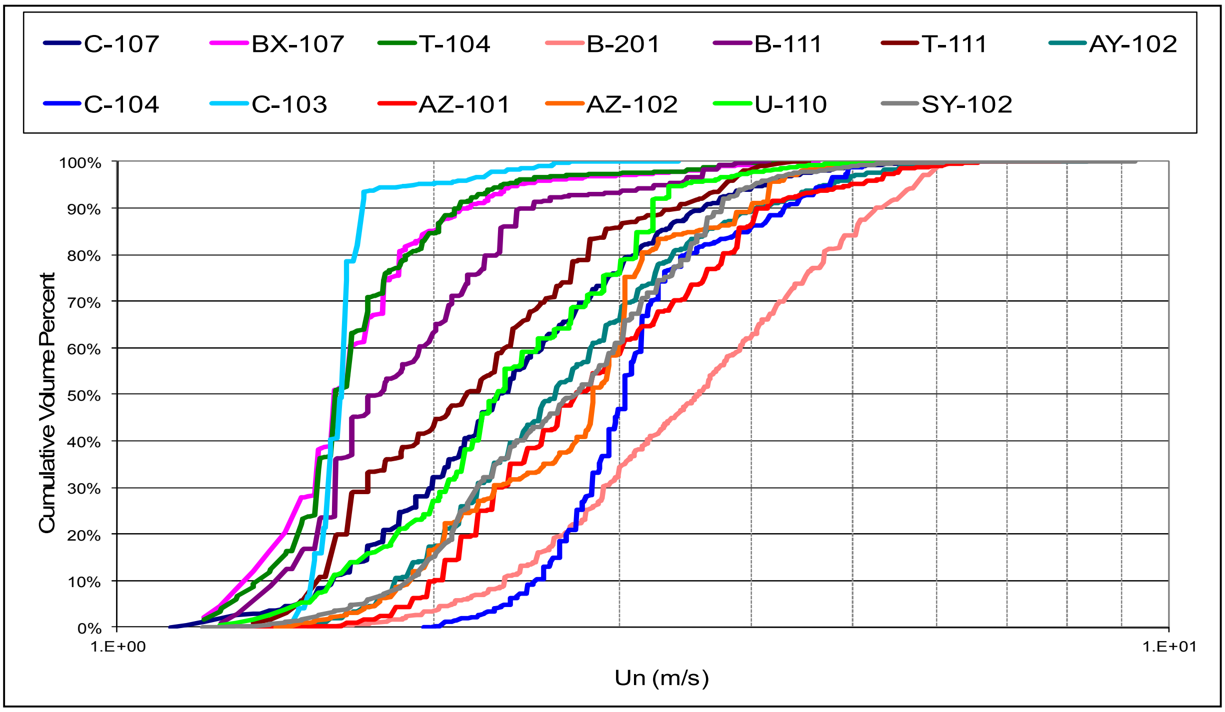

Figure 3, Jet Velocity to Achieve a Certain Degree of Suspension Comparison

While there are many similarities, it is important to note the differences in these two plots. Most notably, tank AZ-101 is the most difficult (furthest to the right) when plotted by Archimedes number, but when plotted by jet velocity needed for suspension, tank B-201 is the most difficult. This change in relative difficulty is driven largely by the differing particle size and density distributions which have different relative importance depending on the performance characteristic being evaluated (e.g. settling based phenomena or mixing based phenomena).

Simulant selection should consider relative performance against multiple performance phenomena to ensure that the selected simulant is representative of the broad spectrum of Hanford waste performance. In addition to the two metrics identified above, a similar methodology can be used for:

- Settling velocity, U_T,
- Critical shear stress for erosion of noncohesive particles, τ_c,
- Just-suspended impeller speed, N_{js},
- PJM critical suspension velocity for noncohesive solids, U_{CS},
- PJM cloud height for noncohesive solids, H_C,
- Pipeline critical transport velocity, U_C[4]

SELECTED SIMULANT RANGE

The intention of performance testing is to evaluate performance across the range of expected WTP feed conditions. The goal of the simulant selection process, was to identify readily available components that could be added to water to achieve rheological and particulate targets associated with a low, typical, and high range as identified by the metrics described in the Simulant Characteristics Section above.

Supernatant Simulants

The process and alternatives considered for Newtonian and non-Newtonian liquids are described in PNNL-21791 [15]. Recipes for five Newtonian liquids were developed to match low and high targets for density and viscosity and to match a typical density and typical viscosity target. The recipes were developed using aqueous solutions of sodium thiosulfate or sodium thiosulfate and glycerol to match the density and viscosity targets for four of the five targets. Sodium thiosulfate was the preferred salt because it is nonhazardous and inexpensive. An aqueous solution of sodium bromide, which gives lower viscosities in concentrated solutions, was selected as a preferred material for a high-density/low-viscosity target. The effect of temperature on viscosity was determined for all the solutions; the solutions including glycerol are the most temperature sensitive. All of these solutions were stable (no salt precipitation after about a day) down to 10°C.

[4] Waste Feed Delivery Mixing and Sampling Program simulant Definition for Tank Farm Performance Testing, RPP-PLAN-51625, Rev.0, March 2012, p.25

There was only one liquid/particle compatibility issue observed during the testing, and this was when a specific gibbsite material was added to a solution of glycerol in water (low density/ high-viscosity target). For this mixture, slurries always stayed cloudy during settling and would form settled layers that were difficult to resuspend. This recipe was reformulated by adding 0.1 wt% sodium thiosulfate, which altered the particle behavior, and the settling and resuspension results were much improved. In cases where it was not possible to match both density and viscosity with a single component in water, density was selected as the primary target and viscosity was allowed to vary.

For the non-Newtonian slurries, simulant recipes were developed using slurries of kaolin clay in water or kaolin clay in sodium thiosulfate solutions. For the kaolin in sodium thiosulfate solutions, the proportions of both the sodium thiosulfate and kaolin were adjusted to obtain slurries with Bingham yield stresses of 1, 3 and 10 Pa having a constant density (matching the high-density Newtonian target). For the kaolin-in-water slurries, the density was not adjusted but was comparable to the low-density Newtonian target. The effect of temperature on the Bingham yield stress and consistency were determined and slurries were stable (no salt precipitation) down to 10°C.[5] Simulant targets and recipe properties are shown in Tables 2 and 3.

Table 2 – Newtonian Liquid Properties

Simulant (density/viscosity)	Targets from Tank Waste Data(a)		Simulant Properties (20°C)(c)		Simulant Recipes
	Density (g/mL)	Viscosity (mPa·s)	Density (g/mL)	Viscosity (mPa·s)	
Low/Low	1.1	1	1.098	1.62	12 wt% $Na_2S_2O_3$ 88 wt% water
Low/High	1.1	8	1.135	7.96	53 wt% glycerol 0.1 wt% $Na_2S_2O_3$ 46.9 wt% water
High/Low	1.37	1	1.370	2.00	37 wt% NaBr 63 wt% water
High/High	1.37	15	1.368	14.6	19.5 wt% glycerol 47.1 wt% water 33.4 wt% $Na_2S_2O_3$
Typical/Typical	1.29	2.6	1.284	3.60	31.5 wt% $Na_2S_2O_3$ in water

[5] Simulant Development for Hanford Double-Shell Tank Mixing and Waste Feed Delivery Testing, PNNL-21791, Rev.0, P.A. Gauglitz, D.N. Tran, W.C. Buchmiller, Pacific Northwest National Laboratory, September 2012, p.iii.

Table 3 – Non-Newtonian Slurry Properties

Simulant (Bingham Yield Stress)	Targets from Tank Waste Data		Simulant Properties (20°C)(d)			Simulant Recipes
	Density (g/mL)	Bingham Yield Stress (Pa)	Density (g/mL)	Bingham Yield Stress (Pa)	Bingham Consistency(mPa·s)	
Low	1.37	1	1.36	1.1	7.3	9.5 wt% Kaolin 29.6 wt% $Na_2S_2O_3$
Middle	1.37	3	1.36	3.7	8.1	14.5 wt% Kaolin 24.9 wt% $Na_2S_2O_3$
High	1.37	10	1.34	11	10	20.0 wt% Kaolin 19.9 wt% $Na_2S_2O_3$
Low	1.1	1	1.13	1.2	3.4	20 wt% Kaolin
Middle	1.1	3	1.15	2.6	4.0	22.5 wt% Kaolin
High	1.1	10	1.19	11	6.0	26.5 wt% Kaolin

Solid Particulate Simulants

The process and alternatives considered for solid particulate simulants are described in RPP-PLAN-51625 [12]. Three base simulants, representing Low, Typical, and High particle-size density distributions (PSDDs), are described, using gibbsite, zirconium oxide (ZrO), sand, and stainless steel (SS) as undissolved solids particulate materials. The particle size distribution for the selected components are based on commercially available products used in previous testing or log-normal distributions about a specified median value. Considering availability, cost, and test platform compatibility, the preferred components were selected and then ratios of these components were adjusted and applied to the performance metrics (discussed in the Solids Metrics Section above) until appropriate low, typical, and high blends were identified. Figure 4 demonstrates the performance of the selected blend using the Archimedes Number comparison. Note that the low (light blue open squares) and high (red open squares) simulants border the left and right edges of waste distributions and that the typical (green open squares) is closely aligned with the volume weighted combination of the combined Hanford sludge (black squares).

As discussed above, the Archimedes Number is one of several metrics that should be used to judge relative mixing performance of a simulant compared to Hanford waste. Reference [12] provides an evaluation of the selected simulant recipes against all metrics considered. Table 4 provides a summary of the selected simulant recipes.

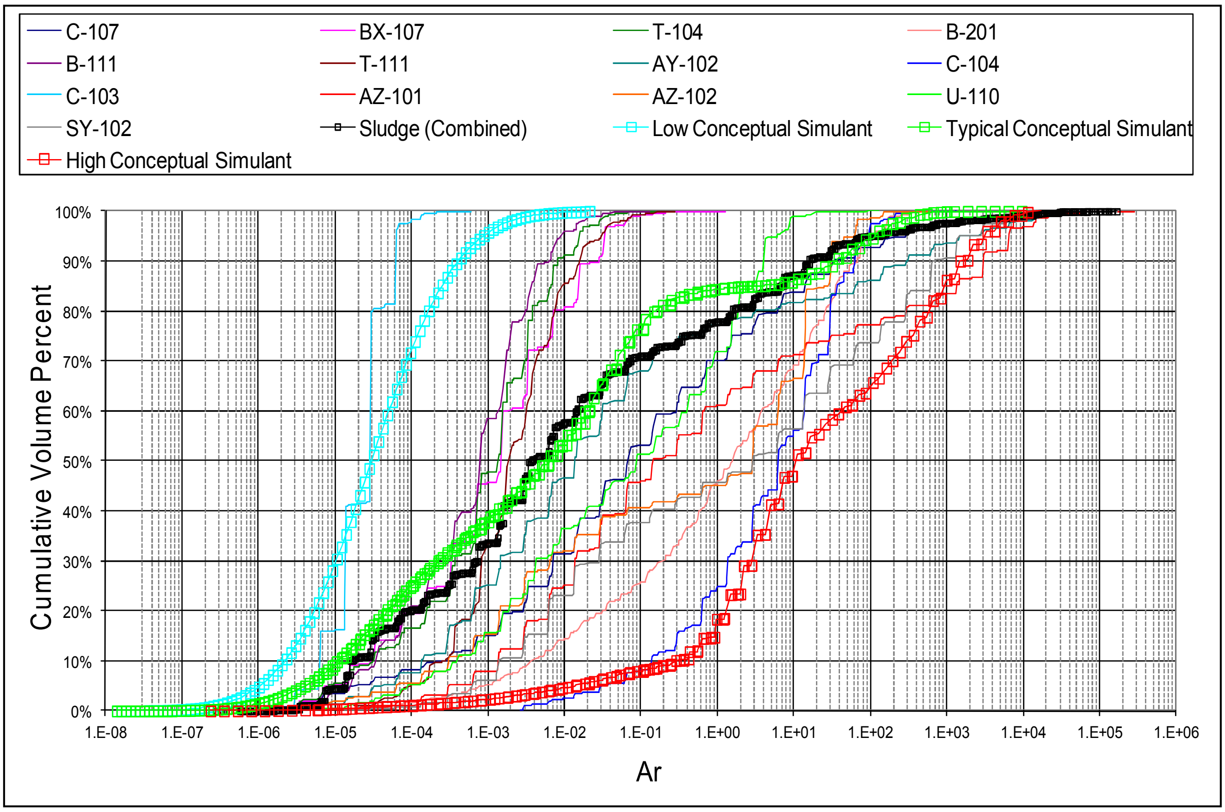

Figure 4 – Low, Typical, High Archimedes Number comparison

Table 4 – Simulant Compositions

Component	Low		Typical		High	
	volume	mass	volume	mass	volume	mass
Small Gibbsite	1.00	1.00	0.30	0.27	-	-
Large Gibbsite	-	-	0.50	0.44	0.05	0.03
Small Sand	-	-	-	-	0.47	0.35
Medium Sand	-	-	0.13	0.13	-	-
Large Sand	-	-	-	-	0.28	0.21
ZrO_2	-	-	0.05	0.10	0.05	0.08
Stainless Steel	-	-	0.02	0.06	0.15	0.33
Volume weighted average UDS density (g/mL)	2.42		2.73		3.59	
Density Range (g/mL)	2.42		2.42 to 8		2.42 to 8	
Size Range (μm)	0.10 to 11.5		0.10 to 517		0.17 to 1020	

CONCLUSION

Selecting simulant formulations that represent the broad spectrum of Hanford waste that could be delivered to the WTP is an approach that is consistent with One System objectives and provides a common base for both WTP feed delivery testing and WTP feed receipt testing. Testing that is focused on one test objective may not support or be in the best interest in developing an integrated approach to WTP feed delivery and RPP mission completion.

Because the majority of mixing, sampling, and transfer risks relate to the ability to move undissolved solids in the waste, simulant identification and development efforts must consider the multiple physical phenomena occurring simultaneously within the mixed systems. Targeting simulants that represent a low, typical, and high range of performance metrics will provide test data that spans the expected behavior of the broad spectrum of Hanford waste. Simulant qualification should be based on demonstrating the simulant generally fits the relative trends seen in all performance metrics rather than precisely aligning with any one metric. This concept allows a common simulant set to be used and provides consistency between TOC and WTP testing.

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