Development and Testing of a High Level Waste Slurry Sampling Technique to Support Hanford Waste Processing – 17164

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ASTRACT

The Hanford Tank Operations Contractor must demonstrate the capability to adequately sample staged high-level waste feed. The sampler employed must have accuracy and precision performance that allow the Tank Operations Contractor (TOC) to meet the Waste Treatment and Immobilization Plant (WTP) Waste Acceptance Criteria Data Quality Objectives (DQO). A full-scale sampling loop was used at a test facility to develop and demonstrate sampler capability. This paper will discuss the modifications to a sampler configuration previously tested – modifications focused on the improvement of the accuracy of test results.

This work targets one of the remaining technical issues with the high-level waste treatment mission at Hanford. The sampling method employed must support both Tank Operations and Waste Treatment and Immobilization Plant requirements. To facilitate information transfer between the two facilities the mixing and sampling demonstrations are led by the TOC's Chief Technology Office in conjunction with the One System Integrated Project Team.

Results of the testing showed that performance of the Isolok®[1] sampler, chosen for implementation, can be greatly improved by modifying the systems configuration to provide accurate, repeatable results for Hanford's simulated high level waste.

INTRODUCTION

The U.S. Department of Energy, Office of River Protection manages the River Protection Project. The River Protection Project mission is to retrieve and treat Hanford's tank waste and close the tank farms to protect the Columbia River. Thus, the Office of River Protection is responsible for the retrieval, treatment, and disposal of approximately 208 million liters of radioactive waste contained in the Hanford Site waste tanks.

The Waste Treatment and Immobilization Plant will process the waste feed it receives from the TOC into its final disposal form. Waste, staged as feed, will be sampled to ensure it meets WTP – TOC interface agreements. The TOC's Chief Technology Office is tasked with developing and demonstrating waste feed capabilities.

Implementation of the sampling concept on a Hanford 3.8-million-liter (1 million gallon) double-shell tank will utilize the tank's transfer pump for recirculating waste feed through a sampling loop where a small portion of the waste will be captured before the

[1] Isolok® is a registered trademark of Sentry Equipment Corp. of Oconomowoc, WI

waste is returned to the tank. Sampling will occur while the tank is being mixed by two rotating jet mixer pumps. The sampling method must minimize contamination and be remotely operated to minimize operator exposure to radiation. The total amount of material to be sampled for qualification of a feed tank will be between four and ten liters (most of the sampled material will be used by WTP for process evaluation, not compositional analysis for acceptance). Sample container volume will be between 250 mL and 1000 mL; most likely 500 mL to best utilize current transportation systems. Therefore, the sampler employed must be able to easily sample a variety of sample volumes.

Two sampling methods are currently employed by the Tank Operations Contractor, core sampling and grab sampling. Neither of these methods was designed for meeting waste feed delivery sampling needs; each has issues which have led the TOC to choose a new sampling method for feed characterization – a modified Isolok® MSE sampler, by Sentry, in a closed sampling loop. The Isolok® sampler was previously tested in the same configuration as planned for use by the WTP using the TOC's Remote Sampler Demonstration (RSD) platform; a full-scale test platform. Simulants used during testing represented the typical and high end of the solids content for particle properties potentially transferred to Waste Treatment and Immobilization Plant in high level waste feed batches. The two simulants tested were initially documented in RPP-PLAN-51625, Rev. 0, *Waste Fee Delivery Mixing and Sampling Program Simulant Definition for Tank Farm Performance Testing* [1]. The simulants were modified to allow the use of sieving as the analytical technique, final target compositions were outlined in the test plan, RPP-PLAN-60373, Rev. 0, *One System Re-configured Isolok® Accuracy Test Plan* [2].

The goal of testing was to make an improvement on the results presented in RPP-RPT-58361, Rev. 00A, *One System Waste Feed Delivery Remote Sampler Accuracy Test Report* [3] (RSD Accuracy Test), regarding the sampler's performance for the fast settling solids components used in the simulants, ~115 μm stainless steel and ~400 μm sand, TABLE I. Testing also gathered data regarding slow setting solids to further verify that the bias for these particles is acceptable. The goal of testing was not to develop a new version of the Isolok® sampler, nor was it expected to eliminate all biases. The effort was one cycle of learning focused on reducing sampler bias, with the understanding that if the results are not deemed adequate, through DQO analysis, they would aid future improvements of the sampling system. The test pitted the Isolok® sampler against a dual stage Vezin sampler. Operation of Vezin samplers will not be addressed in this paper (see RPP-RPT-58361 [3]), however please note that the Vezin sampler follows ideal sampling protocol[2] and is considered to represent the actual value of the material flowing through the test loop. All biases are reported against results from Vezin sample analysis.

[2] Pierre Gy's Sampling Theory and Sampling Practice, 2nd Edition, Francis F. Pitard, CRC Press, 1993.

TABLE I. Results from RSD Accuracy Testing (RPP-RPT-58361).

Component	Typical Particulate Solids %Bias	High Particulate Solids %Bias
75 µm (primarily stainless steel, D_{50} ~115 µm and ρ 8.0 g/cm3)	112.6	78.2
180 µm (primarily sand, D_{50} ~400 µm and ρ 2.65 g/cm3)	43.0	46.9

METHOD/TESTING

Very little modification to the test platform was made from its use for Isolok® Accuracy Testing [3]. Components critical to the sampler were all full scale, which include: pipe size (80mm schedule 40 pipe (3" schedule 40)), flow rate (530±19 lpm (140±5 gpm), sampling system, and instrumentation. The remote sampler demonstration test system utilized a small, ~490 liter, mixing tank (in place of a full-scale Hanford double shell tank). The system is shown in Figure 1.

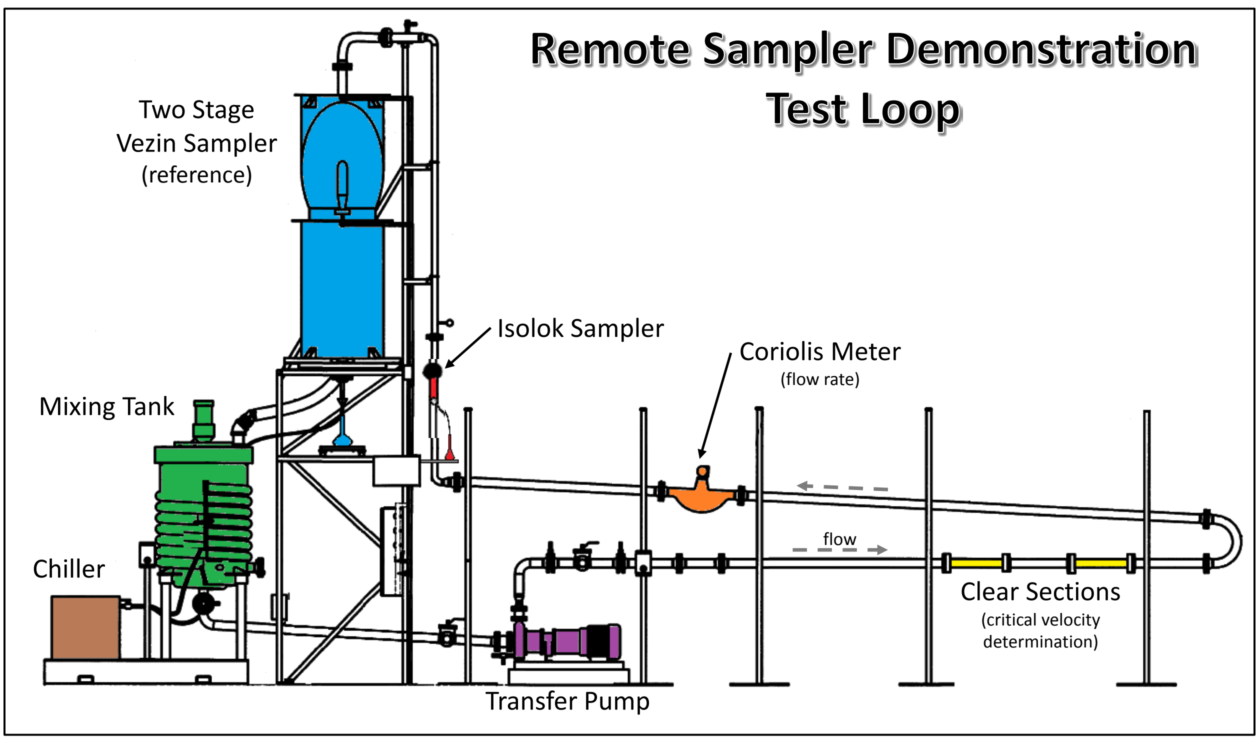

Fig. 1. Remote Sampler Demonstration, Closed Loop Test Platform.

The RSD Accuracy Test [3] concluded that the design of the pup piece, used to interface the Isolok® sampler with the process pipe (riser), contributed to the sampler's oversampling of large, dense particles. Brainstorming focused on implementable methods to:

- reduce dead zones, where the flow rate is much less than that of the bulk flow, in the sample capture area (see Figure 2),
- minimize the flow rate differential between the average upstream bulk flow and the flow rate in the location of the Isolok® during sampling,

and

- move the sampler's capture region into the slurry's path; from outside the test loop pipe circumference, as shown in Figure 2, to inside the test loop pipe flow path.

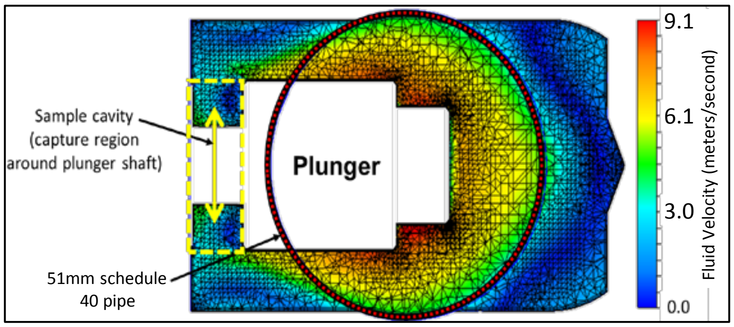

Fig. 2. Isolok® Sampler – Riser Interface (pup piece) Computational Fluid Dynamics Review.

Since only one round of testing was to be performed, design changes such as baffles or in-line mixers (which require optimization) were not investigated.

Computational fluid dynamics modeling started with the baseline configuration, Figure 2, RPP-RPT-59332, Rev 0, *Remote Sampler Demonstration Isolok® Configuration Test* [4]. With the plunger displacing much of the volume in the 51mm diameter pup piece, modeling estimated the flow rate to reach about 9.1 m/s (30 ft/s) near the outer surfaces of the plunger during its extension into the slurry and near 0 m/s in the sample capture region just prior to sample capture. Three concepts, each totally eliminating the 51mm style of Isolok® interface employed by the baseline configuration, were developed far enough to compare against the baseline configuration. They are summarized in TABLE II [4].

Of the three reviewed configurations, the D-shaped and Torpedo implemented the key test objectives. Both implement a shortened plunger, Figure 3, to reduce restriction of flow through the sampling region when the plunger is extended. These two configurations were manufactured and then tested to select one configuration for testing with formal HLW simulant. The two new Isolok® configurations were compared to each other using a simple simulant, sand and water. Performance of the Isolok® relative to the Vezin was made by comparing the bulk densities of material captured by each sampler and then against results obtained on the baseline configuration; since the solids were comprised of a single component the percent solids of each sample was calculated.

TABLE II. Review of Isolok® Sampler Interface Configurations

Sampler Configuration	Description	Design comments
Baseline	Riser size is 51mm (2 in.); interface (pup piece) has a different internal volume configuration relative to the riser	• Dead legs at both ends of the plunger zone – both in the sample capture region and opposite the sample capture region • No portion of the sample capture region is in the bulk flow • Flow velocity around plunger near 9.1 m/s • Flow velocity in the sample capture region near 0 m/s
Modified 76mm (3-in) Riser	Simple mount of Isolok® to a 76mm (3-in.) riser	• Quick and easy implementation that removes most of the dead leg from baseline • Sample capture region mostly into riser • Flow rate around the plunger much closer to typical riser flow rate
D-shape	Mount Isolok® to a 76mm riser via a flat plate (creating a D-shape), and a shortened head on plunger, Figure 3	• Removes all dead leg areas • Smaller plunger helps minimize impact to bulk flow through sample • In bulk flow, about 1/6 annulus diameter capture region • Flow rate around the plunger much closer to typical riser flow rate
Torpedo	Use D-shape design coupled with an obstruction (torpedo) in the center of bulk flow to decrease the apparent pipe diameter (relative to the Isolok® sample capture region); also incorporated a shortened head on the plunger	• Sample capture region is about 40 percent of annulus diameter • Removes all dead legs • Uses a shortened plunger to minimize flow impacts • Torpedo could impart solids segregation

The system was initially loaded with large sand, not previously sampled with the Isolok® as a separate component in water, and the results were unexpected – the baseline Isolok® sampler configuration under-sampled the large sand, TABLE III [4]. This was the first time since testing began that the Isolok® under-sampled large dense particles. TABLE IV provides sand size information [4]. The data and system were reviewed and no cause for the anomaly was identified.

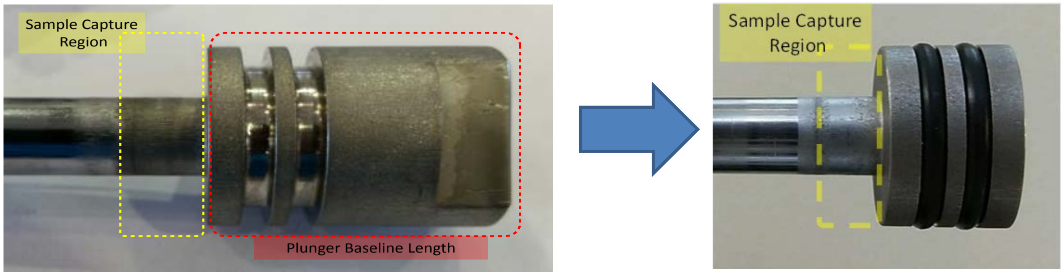

Fig. 3. Modified Plunger, Shortened Head.

With the goal of shifting the bias of the Isolok® sampler up by lowering the overall size of the sand, 50% of the mass of the large sand was added as small sand (solids were 2:1 large sand to small sand) and then the baseline sample configuration was retested. The bias did shift up, TABLE III, but the sampler still maintained a negative sampling bias. The decision was made to clean out the test loop and use the same sand, referred to as "WTP (flour)", used in the RSD Accuracy Test [3] break-in tests. With the same sand as used previously in the system, the baseline Isolok® configuration performed equivalent to what was seen in 2014, with the Isolok® having about a 14 percent oversampling bias. Results for the Large, Large + Small, and WTP (flour) sand and water testing show how quickly the bias can change based on particle parameters for the baseline configuration.

Configuration tests were then performed on the D-shaped and torpedo configurations using the water and "WTP (flour)" sand simulant.

TABLE III. Configuration Selection, Sand and Water, Results

Sand	Configuration	Sampler	N	Mean (% solids)	%Bias
Large	Baseline	Isolok®	5	5.3 ±0.2	-26.3
		Vezin	5	7.2 ±0.2	
Large + Small	Baseline	Isolok®	3	9.4 ±0.1	-7.2
		Vezin	3	10.1 ±0.0	
WTP (flour)	Baseline	Isolok®	6	8.3 ±0.3	14.3
		Vezin	6	7.3 ±0.1	
	Torpedo	Isolok®	5	5.9 ±0.1	-17.1
		Vezin	5	7.1 ±0.1	
	D-Shaped	Isolok®	5	6.3 ±0.3	-12.1
		Vezin	5	7.2 ±0.0	

WTP (flour) = sand initially used for testing by the Waste Treatment and Immobilization Plant.
%Bias = 100 x (Isolok® – Vezin) / Vezin

TABLE IV. Sand Used for Isolok® Sampler Interface Configuration Tests

Sand	D_{10}	D_{50}	D_{90}
Large sand	234 µm	545 µm	719 µm
Small sand	5 µm	46 µm	152 µm
WTP (flour)	196 µm	304 µm	433 µm

WTP (flour) = sand initially used for testing by the Waste Treatment and Immobilization Plant.

The system's flow performance during Isolok® sampler actuation for each configuration was reviewed by charting Coriolis meter flow rate data. Observations for the baseline configuration have always shown an average flow rate drop of about 19 lpm (5 gpm) during Isolok® sampling. Review of Coriolis data during sand and water testing showed that with the shortened plunger and moving the Isolok® to riser interface to an 80mm (3-in.) schedule 40 pipe (same size as used for the transfer system), the flow rate fluctuations were reduced to below the noise level of the Coriolis meter during Isolok® sampler operation, Figure 4 [4]. This was true for both the torpedo and D-shaped sampler configurations.

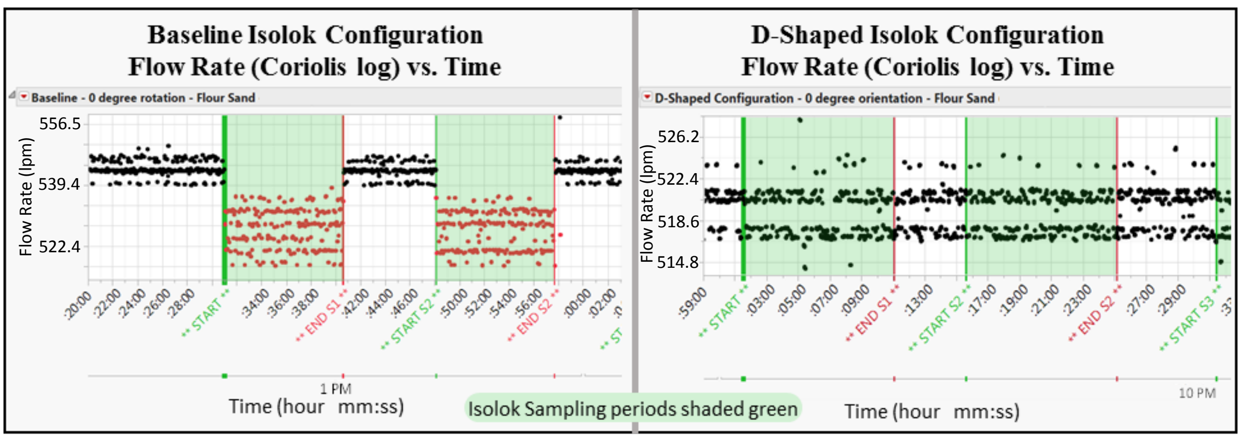

Fig. 4. Plunger Effect on Flow Rate by Configuration.

Although only a slight absolute difference, positive 14 percent to a negative 12 or 17 percent Isolok® sampling bias (TABLE III), between the baseline configuration and the new configurations was observed, the decision was made to move on to testing with HLW simulants; it was unknown how the configuration changes would affect the sampler's performance with HLW simulants or what was meant by the shift from a positive to a negative bias. The D-shaped sampler was chosen for formal testing due to its slightly better performance with sand and water, ease of future manufacturing, and lower likelihood of having process issues such as plugging, Figure 5 [4].

The Isolok® configuration test used the same two simulants as employed for the RSD Accuracy Test, simulants based off expected typical and high particulate HLW feeds. The size distributions of the solids were slightly modified from their original compositions, outlined in the simulant definition report [1], to allow analysis by sieving for both simulants. Pre-sieving was performed using ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves* [5] sieves.

The typical solids simulant is representative of the particle size and density distribution predicted for the average HLW slurry feed over the duration of the Hanford River Protection Project mission; majority of solids are small and large gibbsite. The weight percent solids loading for the high particulate solids simulant was modified (lowered) to target the maximum critical velocity allowed for delivery to the WTP by waste acceptance criteria specification for slurry critical velocity, <1.2 m/s (4.0 ft/s) per 24590-WTP-ICD-MG-01-019, *ICD-19 – Interface Control Document for Waste Feed* (ICD-19) [6]. The modified high particulate solids simulant was developed during Isolok® Accuracy Testing [3]. The denotation "high" for the high particulate solids slurry is not meant to indicate that the waste loading is higher or that it comprises larger particles. The denotation of "high" is relative to the mix of components – the use of a larger more dense bulk component (small sand versus gibbsite for the typical particulate slurry), and higher fractions of stainless steel and large sand. The high particulate solids simulant is representative of a worst case (i.e., more difficult to mobilize and transport) HLW slurry feed. TABLE V is the implemented undissolved component proportions for each of the simulants. The fast-settling solids in the slurry are defined as the particles with a size greater than 75 µm: large sand (ρ 2.65 g/cm^3) and stainless steel (ρ 8.0 g/cm^3) [4].

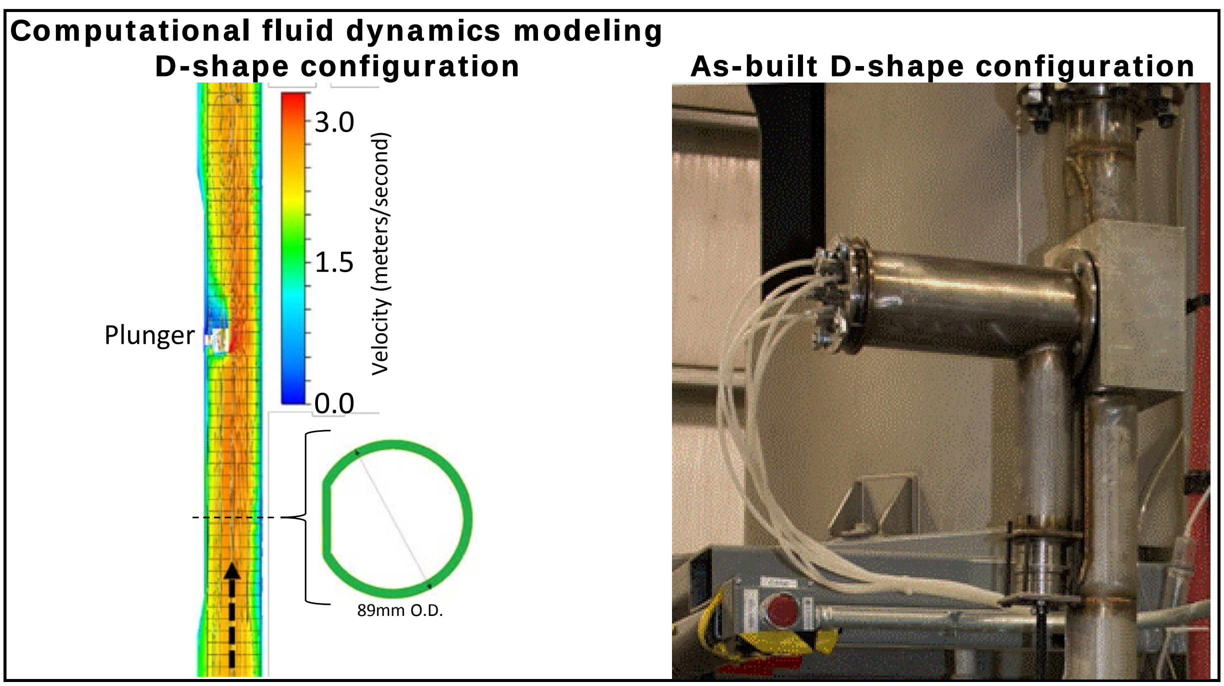

Fig. 5. D-shaped Isolok® Interface Configuration.

TABLE V. Particle Component by Solids Simulant

Component	Particle Density (g/cm³)	Particle Size D_{50} (µm)	Mass Fraction	
			Typical Solids Simulant	High Solids Simulant
Small Gibbsite	2.42	2.2	0.27	0
Large Gibbsite	2.42	9.9	0.44	0.053
Small Sand[a]	2.65	20.8	0.09	0.616
Large Sand (blend)[b]	2.65	414.3	0.04	0.074
Zirconium Oxide	5.7	17.6	0.10	0.141
Stainless Steel[c]	8.0	122.3	0.06	0.116
Bulk Solids Density (g/cm³)			2.721	3.111
Undissolved Solids Loading (wt%)			8.9	5.36

[a] Small sand was pre-sieved to be <63 µm.
[b] Large sand blend is three parts medium and one part large sand; both pre-sieved to be between 210 and 710 µm.
[c] Stainless steel was pre-sieved to be between 90 and 150 µm.

The suspending fluid for both simulants for the reconfigured Isolok® test was given the description of typical/typical (typical density/typical viscosity) in the simulant development report [1]. The typical supernate is a Newtonian fluid consisted of anhydrous sodium thiosulfate (approximately 31.5 wt%) dissolved in city water from Pasco WA. The target density is 1.29 g/mL, and target viscosity is 3.3 cP. The measured supernate density and viscosity for the high solids simulant were 1.285 g/mL and 3.2 cP, respectively. The measured supernate density and viscosity for the typical solids simulant were 1.298 g/mL and 3.5 cP, respectively [4].

To obtain data on the slow settling solids, solids were added in three stages for each simulant in a stepwise fashion with samples gathered after each addition, TABLE VI [4]. The zirconium oxide (ZrO_2) was added first, for two reasons: 1) ZrO_2 is a minor component of the slow-settling solids for both simulant types; its addition after main components of the slow settling solids (small sand for high solids slurry and gibbsite for typical solids slurry) would introduce noise in its analysis, and 2) the concentration is similar in both slurries, providing some degree of feedback on testing consistency from run to run. The second component added was the primary (or bulk) component for each simulant, gibbsite for the typical and small sand for the high solids simulants. Then the remaining components were added for the full simulate runs.

Samples were taken in pairs, over the same 9.5 minute time interval; the Isolok® taking 115 increments (~5.5 mL / increment, total sample volume ~630 mL) and the primary and secondary Vezin samplers taking approximately 80 cuts and 170 cuts per sample respectively (total sample volume ~1940mL) [4].

The only anomaly to occur during testing was the critical velocity for the typical solids simulant, Run C, which was higher than previously reported for this simulant, 1.11 m/s (3.64 ft/s) or 318 L/min (83.9 gal/min) in a 76.2 mm (3-in.) Schedule 40 pipe [4]. The

TABLE VI. Test Matrix

Simulant	Test Run	Description
Typical Solids	A[a]	Zirconium oxide
	B[a]	Zirconium oxide + small gibbsite + large gibbsite
	C	Full typical solids simulant (+small sand, large sand, and stainless steel)
High Solids	D[a]	Zirconium oxide
	E[a]	Zirconium oxide + small sand
	F	Full high solids simulant (+large gibbsite, large sand, and stainless steel)

[a] After samples were taken the mass of each component removed was estimated and added back into the test loop.
Note: During the test runs D, E, and F were performed prior to A, B, and C.

critical velocity target range for this simulant was 0.73 to 0.91 m/s (2.4 to 3.0 ft/s). Due to the nature of this simulant's behavior near it's critical velocity flow rate, the critical velocity could easily have been assumed to be reached early (flow rates are dropped during critical velocity measurement) by the inexperienced operations crew [4]. However, because the samplers are compared to each other and the critical velocity is below 1.2 m/s maximum allowable critical velocity, all results from the typical solids simulant test runs are applicable to the environment the Isolok® sampler is expected to operate in and met the intent of the test.

Analysis of samples was performed by sieving using ASTM E161-12, *Standard Specification for Precision Electroformed Sieves* [7] sieves. The sieve stack is show in Figure 6.

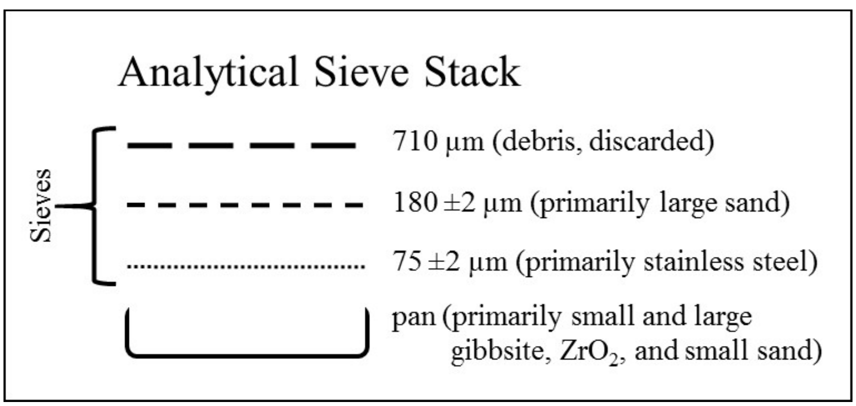

Fig. 6. Analytical Sieve Stack

For the Isolok®-to-Vezin statistical review, the method used to obtain a p-value was the Excel®[3] T.Test function. A p-value of 0.05 or greater indicates that the means of the

[3] Microsoft Excel® is a registered trademark of Microsoft Corporation, Redmond, Washington.

two datasets are not statistically different at the 95 percent confidence interval and no bias is reported. For p-values <0.05 biases are reported relative to Vezin sample results. Results for all six runs are reported in TABLE VII [4]. Vezin results show that the system was in control, with very little variation during the period of sample acquisition, first to last samples in each run.

TABLE VII. Reconfigured Isolok HLW Simulant Test Results

Run (N)	Sampler	[<75µm][a] (mg/mL)	<75µm %Bias[b] (p-value)	[75 µm sieve][c] (mg/mL)	75 µm sieve %Bias[b] (p-value)	[180 µm sieve][d] (mg/mL)	75 µm sieve %Bias[b] (p-value)
D (5)	Isolok®	9.25 ±.22	-5.6 (0.003)	-	-	-	-
	Vezin	10.09 ±0.07		-		-	
E (5)	Isolok®	52.56 ±0.60	None (0.259)	-	-	-	-
	Vezin	53.08 ±0.41		-		-	
F (8)	Isolok®	56.29 ±0.18	-0.9 (0.000)	8.40 ±0.08	2.3 (0.004)	5.25 ±0.06	-3.5 (0.000)
	Vezin	56.80 ±0.17		8.22 ±0.13		5.44 ±0.07	
A (6)	Isolok®	12.35 ±0.25	None (0.552)	-	-	-	-
	Vezin	12.50 ±0.44		-		-	
B (5)	Isolok®	98.11 ±0.85	-1.2 (0.0231)	-	-	-	-
	Vezin	99.35 ±0.38		-		-	
C (8)	Isolok®	108.51 ±0.31	-0.3 (0.009)	7.43 ±0.05	7.0 (0.000)	4.96 ±0.06	-2.2 (0.001)
	Vezin	108.89 ±0.21		6.94 ±0.05		5.07 ±0.05	

[a] [<75µm] → particles passing through the 75 µm sieve (primarily ZrO_2 and large and small gibbsite).
[b] % Bias = 100 × ([Isolok®] – [Vezin]) / [Vezin].
[c] [75 µm sieve] → particles passing through the 180 µm sieve, but retained on the 75 µm sieve (primarily stainless steel).
[d] [180 µm sieve] → particles passing through the 710 µm sieve, but retained on the 180 µm sieve (primarily large sand).
N = the number of sample pairs analyzed (i.e., the number of samples used to estimate the standard deviation).

Although statistically there was no bias identified for run A, both runs A and D had the largest bias variation of any samples taken relative to their corresponding Vezin samples. Run A had a bias of –1.1 ±4.6 percent and run D of –5.6 ±2.5 percent.

Based on a statistical review of the % bias values, Figure 7, it is likely that the difference is part of the normal variation of the Isolok® sampler. Based on Vezin sample results for run A (12.50 ±0.44 mg/mL), the RSD test loop was not as stable for run A as it was for run D (10.09 ±0.07 mg/mL). Figure 7 shows both T.Test and Tukey-Kramer honestly significant difference (HSD) p-values from JMP®[4], both indicating that the % biases for runs A and D are not statistically different at the 95% confidence level [4].

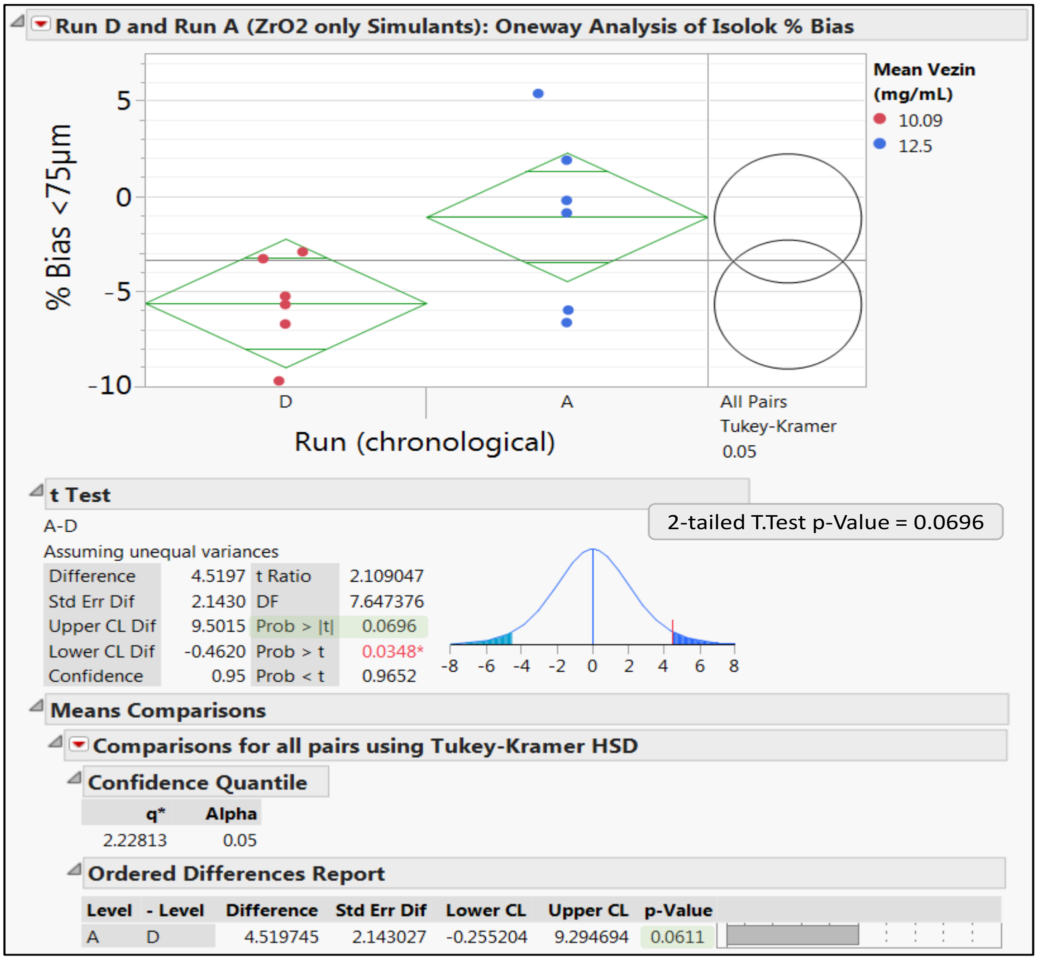

Fig. 7. Run A % Bias vs Run D % Bias.

CONCLUSIONS

Full-scale testing of a reconfigured Isolok®-based slurry sampling system was completed. Work was performed in two phases. First, two new configurations were tested against each other using a simple simulant of sand and water. This testing showed how sensitive the baseline Isolok® sampler configuration is to particle size with

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[4] JMP® v 11 is a registered trademark of SAS Institute, Inc., Cary, North Carolina, http://www.jmp.com.

sample biases ranging from negative 26% to positive 14%. Results were used to select one of the new configurations for testing with formal high level waste feed simulants.

Formal simulant testing was then performed on a D-shaped Isolok® interface configuration, Figure 8. This configuration removes all dead leg areas from the sample capture region, introduced a smaller plunger to minimize impact to bulk flow through sample capture region, and moved the sample capture region into the bulk flow. Testing was then performed using two simulants:

- Typical solids with a typical density/typical viscosity supernate
- High solids with a typical density/typical viscosity supernate

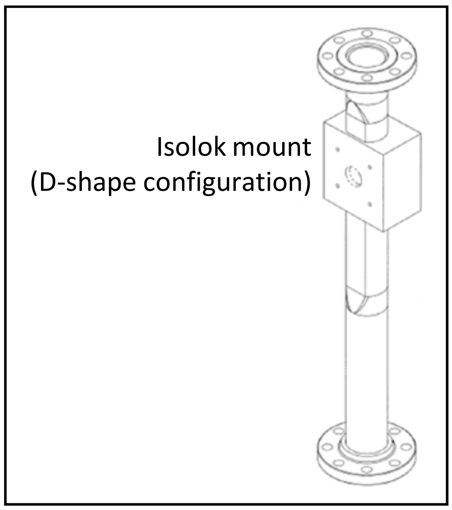

Fig. 8. D-shape Configuration.

The baseline Isolok® configuration had proven to be very repeatable. The repeatability of the D-shaped sampler reported for all test runs. Results are good and are summarized in terms of percent relative standard deviation (%RSD) in TABLE VIII; where possible they are compared to results from RSD Accuracy Testing [3] [4]. The percent relative standard deviation values show that the D-shaped configuration did not adversely affect the repeatability of the Isolok® sampler.

Review of the performance of the Isolok® sampler with the D-shaped interface configuration showed over one order of magnitude reduction of sampler bias for both fast settling solids tested, sand and stainless steel, TABLE IX [4].

Particle density was known to be of significance from previous RSD test campaigns, and our knowledge of its affect increased during reconfigured Isolok® testing. Stainless steel, the densest particle and the particle with the lowest surface-area-to-mass ratio, was the only particle to be oversampled with the D-shaped configuration. Large sand, which had seen a large positive sampling bias, showed a small negative bias. The initial hypothesis about slow-settling solids was found to still hold true – their sampling bias is small.

TABLE VIII. Reconfigured Isolok Test Precision Review

Test	Run	Parameter	N	Isolok® %RSD[a] (RSD Accuracy[b])	Vezin %RSD[a] (RSD Accuracy[b])
Typical Particulate Solids	A	[ZrO_2]	6	2.02	3.48
	B	[ZrO_2 + small & large gibbsite]	5	0.87	0.39
	C	Density (Full Simulant)	10	0.06 (0.11)	0.04 (0.12)
	C	[<75µm] (Full Simulant)	8	0.29	0.2
	C	[75 µm sieve] (Full Simulant)	8	0.63 (3.0)	0.68 (2.5)
	C	[180 µm sieve] (Full Simulant)	8	1.17 (3.2)	1.08 (2.2)
High Particulate Solids	D	[ZrO_2]	6	2.27	0.71
	E	[ZrO_2 + small sand]	5	1.15	0.77
	F	Density (Full Simulant)	10	0.06 (0.06)	0.04 (0.04)
	F	[<75µm] (Full Simulant)	8	0.32	0.3
	F	[75 µm sieve] (Full Simulant)	8	0.93 (2.5)	1.61 (2.8)
	F	[180 µm sieve] (Full Simulant)	8	1.07 (2.2)	1.36 (2.8)

[a] percent relative standard deviation (100 x (standard deviation)/(mean)) from the Isolok® configuration test report [6]
[b] %RSD reported during RSD Accuracy Testing [3]

TABLE IX. Accuracy Comparison of Baseline Configuration vs. D-shape Configuration

Sample Property	Typical Particulate Solids %Bias[a]		High Particulate Solids %Bias[a]	
	Baseline (N)	D-shaped (N)	Baseline (N)	D-shaped (N)
[75 µm sieve][b]	112.6% (30)	7.0% (8)	78.2% (30)	2.3% (8)
[180 µm sieve][c]	43.0% (30)	-2.2% (8)	46.9% (30)	-3.5% (8)
Sample Density	0.70% (34)	-0.07% (10)	0.70% (34)	0.07% (10)

[a] %Bias = 100 × ([Isolok®] – [Vezin]) / [Vezin].
[b] [75 µm sieve] → from particles passing through the 180 µm sieve, but retained on the 75 µm sieve (primarily stainless steel).
[c] [180 µm sieve] → particles passing through the 710 µm sieve, but retained on the180 µm sieve (primarily large sand).

The Isolok® sampler has many features that make it a good choice for hazardous chemical and radioactive material sampling. Although the configuration developed here can not address the sampler's design issues, which do not follow good sampling protocol regarding delimitation error, extraction error, segregation error, and periodic heterogeneity fluctuation error, it did greatly improve its accuracy regarding anticipated WTP high level waste feeds. The Chief Technology Office's RSD program lessened the impact of these errors by modifying the interface between the Isolok® sampler and the test loop pipe using a D-shaped configuration. The D-shaped Isolok® sampler configuration results were compared to Vezin sampler results, which conforms to good sampling protocols, for two HLW feed simulants designed to represent typical and bounding HLW undissolved solids properties. Work performed resulted in a large decrease in Isolok® sampler bias, and provides data for the development of future sampling DQOs regarding the acceptance of waste from the Tank Operations Contractor to meet the Waste Treatment and Immobilization Plant's waste feed acceptance criteria. The D-shaped Isolok® interface has been developed – it is capable of precisely and accurately sampling HLW feed.

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