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Remote In-Cell Sampling Improvements Program at the Savannah River Site (SRS) Defense Waste Processing Facility (DWPF) WSRC-STI-2007-00677

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Remote Systems Engineering (RSE) of the Savannah River National Lab (SRNL) in combination with the Defense Waste Processing Facility(DWPF) Engineering and Operations has evaluated the existing equipment and processes used in the facility sample cells for "pulling" samples from the radioactive waste stream and performing equipment in-cell repairs/replacements. RSE has designed and tested equipment for improving remote in-cell sampling evolutions and reducing the time required for in-cell maintenance of existing equipment. The equipment within the present process tank sampling system has been in constant use since the facility start-up over 17 years ago. At present, the method for taking samples within the sample cells produces excessive maintenance and downtime due to frequent failures relative to the sampling station equipment and manipulator. Location and orientation of many sampling stations within the sample cells is not conducive to manipulator operation. The overextension of manipulators required to perform many in-cell operations is a major cause of manipulator failures.

To improve sampling operations and reduce downtime due to equipment maintenance, a Portable Sampling Station (PSS), wireless in-cell cameras, and new commercially available sampling technology has been designed, developed and/or adapted and tested. The uniqueness of the design(s), the results of the scoping tests, and the benefits relative to in-cell operation and reduction of waste are presented.

I. INTRODUCTION

The existing Non-Waste Form Affecting (NWFA) sampling stations (Fig. 1) within the DWPF sampling cells utilize a Hydragard™ valve (Fig. 2) that provides a continuous flow of the waste stream to a sampling vial that is contained within a hydragard shroud positioned by a lift station. The positioning of the hydragard shroud permits the septum of the sampling vial to seal around an "insertion needle" of the Hydragard™ valve, therefore creating a seal for continuous flow from the sampled waste stream. The insertion needle is designed to allow the flow from the waste stream to enter the sampling vial and flow from the vial through valves/piping to the RCT during the sampling period of approximately 20 seconds. Figure 3 illustrates the piping arrangement of a sampling station.

Disadvantages of the existing sampling method include:
1) The waste stream is diverted to the RCT during the sampling period for each sample taken (20 – 30 sample vials) therefore creating excessive liquid waste that must be treated and solid waste due to the one-time use of the vial.
2) The sampling vial must create a leak tight seal to prevent the waste stream from dripping and/or spraying into the sample cell area which can potentially increase the contamination level within the cells.
3) The existing location of the sampling stations has created excessive wear on the manipulators which are used to remotely operate and maintain/replace the lift station and Hydragard™ valve.
4) The maintenance activities requiring the removal and/or installation of piping and components within the sample cells can be extremely time consuming due to the orientation of the components/piping within the cells.
5) The complexity required for the fabricating a lift station, the close machining tolerances necessary for alignment for sampling and the harsh environment has generated frequent equipment failures
6) The lab operator is required to perform several tasks which include maneuvering the manipulator to raise and lower the lift station, turn the Hydragard™ valve ON and OFF, open and close the lid on the hydragard shroud, and remove and insert a sampling vial, for each sample that is pulled from the waste stream. The excessive use of the manipulators, for pulling samples with the existing sampling stations, increases the frequency of repair of the manipulators.

The Portable Sampling Station (PSS) provides better access to the sampling station for maintenance and sampling activities. The PSS, as shown in Figure 4, is designed to address improvements for conditions stated in 3 and 4 of the preceding paragraph, whereas the Isolok sampler and associated alignment station (Fig. 7) provides improvements for conditions 1 through 6.

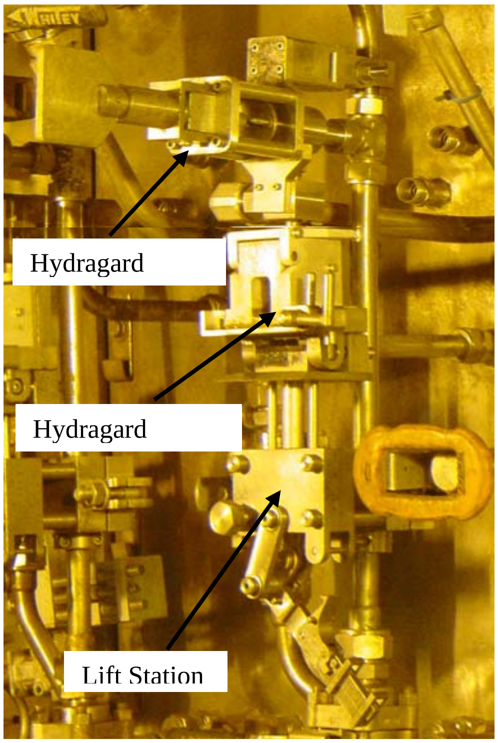


Fig. 1 - NWFA Sampling Station located in DWPF Sampling Cells

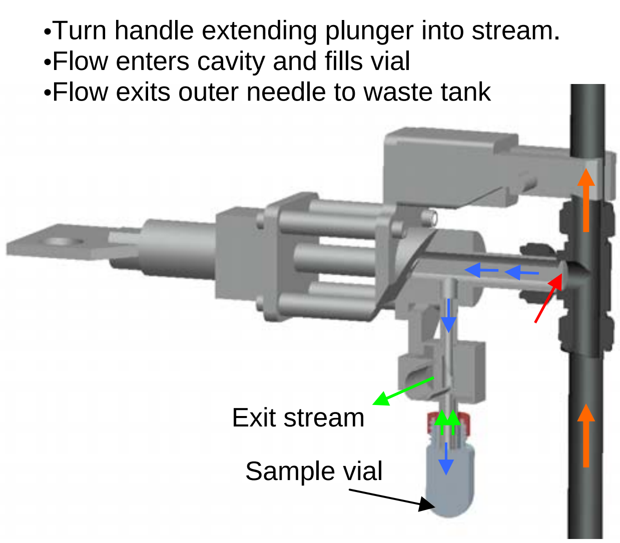


Fig. 2 – Operation of a hydragard sampling valve

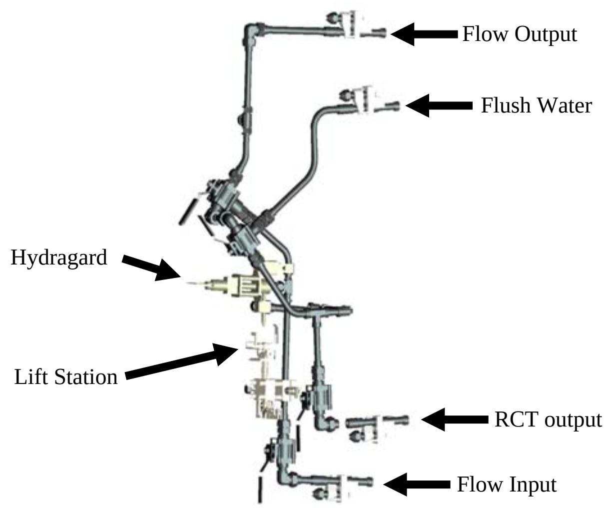


Fig.3 – Existing process piping arrangement

II. SAMPLING MECHANISMS

Equipment functional and sludge simulant sampling tests of a PSS and an Isolok sampler have been performed to evaluate the ability for remote operation in the DWPF samples cells and to determine if representative samples relative to the weight percent total dried solids can be collected. The PSS and the Isolok sampler are alternative sampling equipment for the DWPF sample cells and the tests conducted were scoping tests and are restricted to evaluating the use of the Portable Sampling Station and the Isolok for the sampling of NWFA waste streams.

II.A. Portable Sampling Station

The Portable Sampling Station (PSS) as shown in Figure 4 was designed to permit portable placement within the sampling cells at DWPF. The PSS is arranged with the identical sampling station and valving that presently exists in the sample cells. The PSS incorporates a Hydragard™ valve for sampling, which is the existing sampling technology used in the DWPF sample cells. The hydragard operates by diverting a sample stream to provide continuous flow through a sampling vial for a period of time (approximately 20 seconds) prior to stopping the sample stream and capturing the sample within the vial. Due to its ability to be placed in front of a cell window, the manipulator would be able to easily access the sampling station for pulling samples. In addition, the rotating feature of the PSS stand in conjunction with the flexibility of placement within the sample cells, provides improved access to the sampling station piping and components for ease of maintenance and/or repair. The PSS elevation is also adjustable to allow transferring the equipment into the cells via the existing transfer drawer.

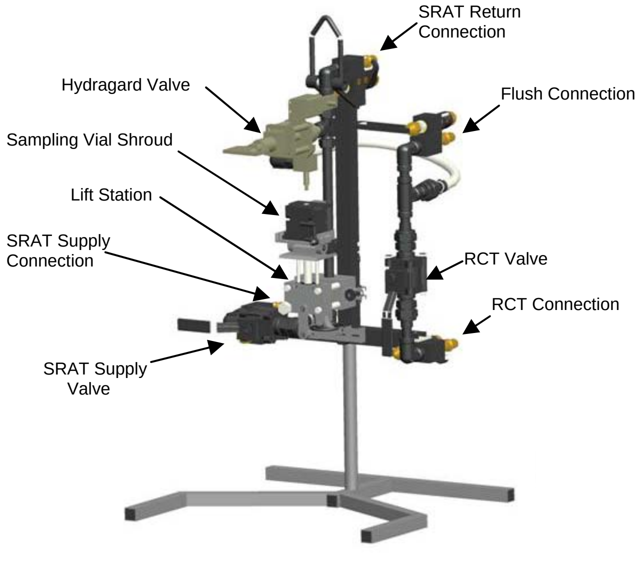


Fig. 4 – Portable Sampling Station

Four reinforced Tygon® hoses connect the PSS to existing system piping. Swing clamps are use to simplify in-cell connections. Colored heat shrink attached to each of the hoses enable identification of correct process line connection (Fig. 5). Swing clamp connections are also provided on the PSS permitting usage of a single tool type to complete the installation of the hoses.

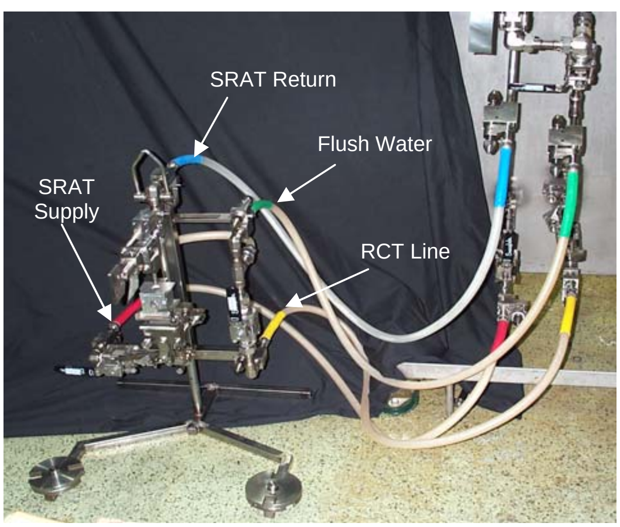


Fig. 5 – PSS connected to mockup sample process lines

II.B. Isolok Sampler

Figure 6 shows the Isolok sampler connected to a sample cell piping mockup panel. The Isolok is a grab sampler that extracts a sample from the process line and displaces the sample into a sampling container. Each stroke of the Isolok spool provided a 3 mL discharge. A 12 mL glass vial was used as the sampling container and therefore 4 strokes of the Isolok sampler spool was required to fill the vial.

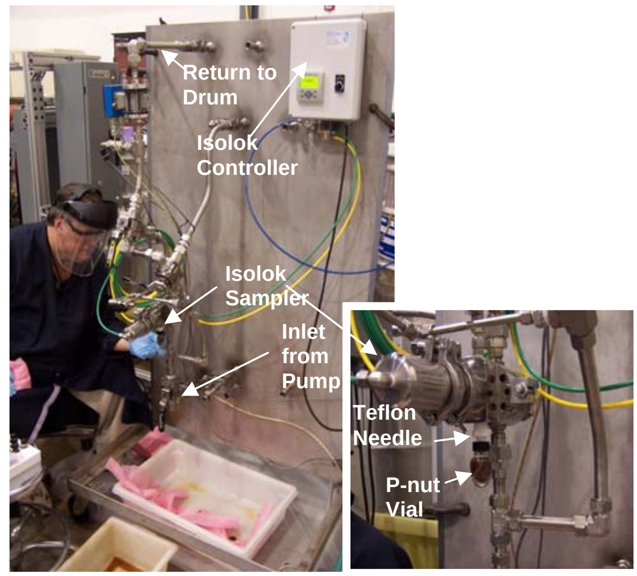


Fig. 6 – Isolok Sampler

Design modifications to the Isolok included the addition of mounting brackets to simplify remote installation within the sample cells. A vent and flush connection was also added to the Isolok sampler. A Teflon dispensing "needle" was designed and fabricated to minimize surface tension when discharging the sample into the vial.

An alignment station, as shown in Figure 7 was designed and fabricated for the Isolok sampler to permit sampling using a manipulator. Advantages of the Isolok alignment station are 1) lighter weight - reduces the manipulator stress during installation and maintenance, 2) automated control reduces manipulator use when pulling samples and 3) simple design greatly reduces machining costs and eliminates the expensive hydragard shroud. This alignment station will take up to 10 samples via remote wireless control. If more samples are required, the vial-holding platform is removed and replaced with one containing empty vials.

Fig. 7 Isolok rotary multi-sampler with ten sampling vials

II.C. Testing of the Portable Sampling Station

Tank 8 sludge simulant, certified for weight percent solids between 15 and 18 percent, was used in testing to determine if the design of the PSS would affect the sampling characteristics. To conduct the test, the PSS was connected to the sample cell piping mockup-panel as shown in Figure 8. The sludge was circulated through the mockup system under in-cell conditions. The mockup panel was designed to provide sample cell elevation conditions of the piping. Placing the PSS on the floor provided the relative difference in elevation that would exist in the sample cells.

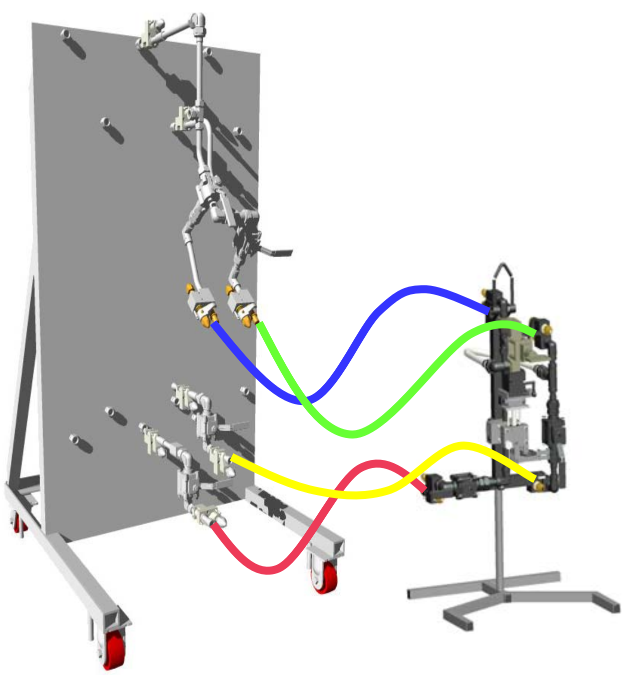


Fig. 8 Panel to mock up existing sample cell process piping and equipment

The sampling station on the PSS was operated manually. Sampling vials, placed in the hydragard shroud, were used to collect the sludge simulant samples. A composite liquid waste sampler (Coliwasa) under the guidance of an ASTM standard practice (D 5495 – 03), was used to ensure a homogeneous mix of simulant. A drum mixer was used to agitate the sludge simulant for a minimum of one hour prior to re-circulating the simulant through the sample cell piping mockup. Samples were pulled after a 30-minute re-circulation through the mockup piping and the PSS. The samples were dried at 115^{o} C for a 24 hour period in a mechanical convection oven, prior to determining the weight percent dried solids.

II.D. Testing of the Isolok Sampler

Tank 8 sludge simulant was also used in testing to determine if the Isolok sampler is comparable to the existing sampling equipment used in the DWPF sampling cells. To conduct the test, the Isolok sampler was connected to the sample cell piping mockup-panel as shown in Figure 6. The setup for testing with the Tank 8 sludge simulant was identical to that of the simulant testing of the PSS. The vial was manually placed around the insertion needle to “catch” the sludge simulant sample being dispensed by the Isolok. A Coliwasa was used to ensure a homogeneous mix of the simulant. A drum mixer was used to agitate the sludge simulant for a minimum of one hour prior to re-circulating the simulant through the sample cell piping mockup. Samples were pulled after a 30 minute re-circulation through the mockup piping. The samples were dried at 115^{o} C for a 24 hour period in a mechanical convection oven, prior to determining the weight percent dried solids.

Wear testing using Tank 8 sludge simulant was performed to determine the equipment life expectancy for a NWFA application. The test setup was identical to that of the simulant testing, however the sample from the waste stream was continuously displaced into a large container instead of a 12 mL sample vial. The test was conducted over a period of several days until the Isolok sampler accumulated approximately 20,000 cycles of operation, which is equivalent to one year of operation in the sample cells. After each day of testing (4000 cycles), the sampler spool was flushed, inspected and returned to service. The flushing of the sampler is required after use. The design incorporates a valve to provide the flush.

II.E. Wireless Camera for the Sample Cells

Due to the location and orientation of the piping, fittings and components that support the sampling process, it can become very difficult to perform maintenance (removal and installation) on equipment with a remote manipulator, when the piping connections and/or fasteners are not visible through the sample cell window. To assist the mechanics in performing maintenance tasks within the DWPF sample cells, a wireless camera was designed and fabricated.

Fig. 9 Sample Cell Wireless Camera and Charger

The camera housing, shown in Figure 9, contains the camera, video transmitter, rechargeable battery, and electronic circuitry to prevent the lithium-polymer battery from an excessive discharge which can destroy the battery. A lithium-polymer battery charger, shown in Figure 9, is placed inside the sample cells to permit recharging of the camera battery (12 VDC). The camera housing is made of ABS plastic by the fused deposition modeling method of "3-D printing," which makes reproduction of the housing rapid and cost effective. This technique also enables the fabrication of intricate geometry to enclose each of the components between partitions in the housing. The recesses in the camera housing provide a place for the manipulator to grasp for a secure hold. The mechanic can then position a manipulator to permit a view of the process piping section requiring repair. A monitor connected to the video receiver is placed outside of the sample cells to provide the mechanic remote visibility of the camera view. The camera can be operated approximately 9 hours before requiring a recharge.

III. RESULTS

II1.A. Portable Sampling Station Simulant Testing

Testing of the PSS indicated no statistical difference in the mean or variation in the weight percent dried solids of the samples collected using the Tank 8 sludge simulant when compared to the samples taken using the Coliwasa drum sampler. The data and analysis were provided in the SRNL correspondence "A Statistical Review of Measurements from SRAT Product Simulant Testing with the Isolok Valve," [1]. An example of the test data is shown in Figure 10. The example test data indicates that the weight percent dried solids of the drum was determined to be 17.54, whereas the average for the PSS samples was 17.92 with a standard deviation of 0.07 which is within the acceptance criteria of 3% variation.

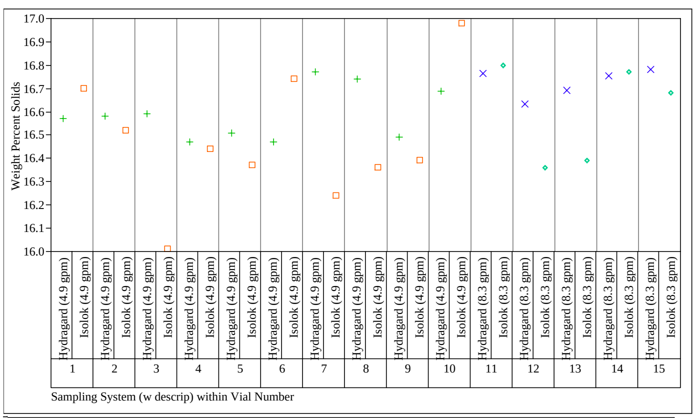
Vial Number	Empty Vial and Cap	Wet Sample Vial and Cap	Dry Sample Vial and Cup	Total Wet Sample	Total Dry Sample	Weight Percent Solids
1	27.856	41.657	30.339	13.801	2.483	17.99
2	27.686	40.776	30.025	13.090	2.339	17.87
3	27.839	41.843	30.356	14.004	2.517	17.97
4	27.562	39.860	29.760	12.298	2.198	17.87
5	28.732	43.022	31.277	14.290	2.545	17.81
6	27.855	42.150	30.412	14.295	2.557	17.89
7	27.357	40.667	29.748	13.310	2.391	17.96
8	28.011	42.490	30.588	14.479	2.577	17.80
9	28.562	42.119	30.986	13.557	2.424	17.88
10	27.911	41.887	30.404	13.976	2.493	17.84
11	28.222	42.728	30.813	14.506	2.591	17.86
12	27.905	41.848	30.401	13.943	2.496	17.90
13	27.532	40.494	29.853	12.962	2.321	17.91
14	28.024	42.010	30.535	13.986	2.511	17.95
15	28.667	41.966	31.058	13.299	2.391	17.98
16	27.595	41.506	30.110	13.911	2.515	18.08
17	27.832	40.409	30.080	12.577	2.248	17.87
18	27.695	41.433	30.142	13.738	2.447	17.81
19	27.497	40.760	29.874	13.263	2.377	17.92
20	27.373	41.834	29.961	14.461	2.588	17.90
21	27.724	41.314	30.174	13.590	2.450	18.03
22	27.859	40.182	30.086	12.323	2.227	18.07
23	27.378	40.036	29.648	12.658	2.270	17.93
24	27.760	41.986	30.319	14.226	2.559	17.99
25	29.410	41.103	31.510	11.693	2.100	17.96
26	27.642	41.483	30.131	13.841	2.489	17.98
27	28.298	42.485	30.842	14.187	2.544	17.93
28	28.097	42.096	30.589	13.999	2.492	17.80
29	27.377	41.850	29.976	14.473	2.599	17.96
30	27.885	40.092	30.068	12.207	2.183	17.88
Avg. Weight	13.565	**Avg. WT% Solids**	17.92	**Percent Error**	1.47	
Min. Weight	11.693	**Min. WT% Solids**	17.80			
Max. Weight	14.506	**Max. WT% Solids**	18.08			
Std. Dev.	0.78	**St Dev**	0.07	**Drum = 17.54 WT% Solids**		

Fig. 10 Simulant testing of the PSS for weight percent dried solids

II1.B. Isolok Sampler Simulant Testing

The Isolok sampler and mockup piping panel were tested using Tank 8 sludge simulant. A hydragard valve was placed in line with the Isolok sampler to provide a comparison in the performance between the existing sampling equipment (Hydragard™) and the Isolok sampler). The contents of the drum were sampled using a Coliwasa per the guidance of ASTM standard practice (D 5495 – 03) and used as the reference for the sampling. During the testing, 5 samples were taken using the hydragard and then 5 samples were taken using the Isolok. This method was repeated until the sampling was completed. The hydragard valve was manually opened for 20 second period to permit flow into the sample vial. The controller for the Isolok sampler was programmed to extend the sample spool into the flow stream for a 4 second period and then retract for 4 seconds.

Testing of the Isolok sampler indicated no statistical difference in the mean or variation in the weight percent dried solids of the samples "pulled" using the Tank 8 sludge simulant when compared to the samples taken using the Coliwasa drum sampler. The data and analysis were provided in the SRNL correspondence "A Statistical Review of Measurements from SRAT Product Simulant Testing with the Isolok Valve," [1]. The simulant was pumped through the mockup system at two different flow rates to determine if the flow rate would affect the results of the testing. The graph in Figure 11 shows the results of the simulant scoping tests for the hydragard and the Isolok samplers. The testing statistically indicated that the Isolok sampling of wt% solids is comparable to Hydragard sampling however Hydragard repeatability is better than Isolok. There was also no significant difference in mean or standard deviation of Isolok when compared to Coliwasa drum samples [1].



Sampling System	Flow Rate (gpm)	N Rows	Mean (Weight Percent Solids)	Std Dev (Weight Percent Solids)	% Rel Std Dev (Weight Percent Solids)
Hydragard	4.9	10	16.588	0.111	0.67
Hydragard	8.3	5	16.722	0.061	0.37
Isolok	4.9	10	16.475	0.275	1.67
Isolok	8.3	5	16.6	0.210	1.27

Fig. 11 Simulant test results of the hydragard and Isolok samplers at two flow

Additional simulant testing was performed at various flow rates between 4 and 10 gpm using the Isolok sampler. The flow rate boundary was specified as the range for sampling in the DWPF sample cells. The results of this testing are shown in Figure 12. Statistically, there was no indication of a significant difference in the Isolok sampling standard deviation or mean when comparing the sample weight percent dried solids and the flow rate using the Coliwasa as the reference measurement [1].

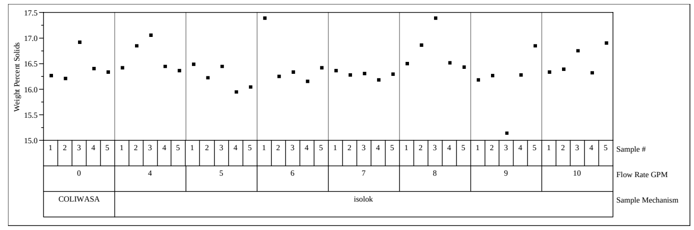


Fig.12 Simulant test results of the Isolok sampler at different flow rates

Isolok sampler wear testing was conducted over a period of several days until the Isolok sampler accumulated approximately 20,000 cycles of operation, which is equivalent to one year of operation in the sample cells. No wear was observed in the Isolok sampler spool or the bore of the Isolok sampler. A minimal amount of wear was observed on the viton o-rings located on the spool of the Isolok sampler. This wear did permit minimal simulant leakage past the o-rings into the pneumatic actuator of the sampler, however this wear was not significant enough to prevent additional sampling with the device or affect the sampling characteristics.

II1.C. Wireless Camera Operation

Wireless camera(s) have been in operation within the sample cells at DWPF for over a year. The camera has been used on numerous occasions during maintenance and inspections and has vastly reduced maintenance time and effort which has resulted in a significant cost savings.

REFERENCES

[1] SRNL Correspondence "A Statistical Review of Measurements from SRAT Product Simulant Testing with the Isolok Valve," Tommy Edwards, SRNL Statistical Consulting Group, October, 2007.

[2] ASTM International, "Standard Practice for Sampling with a Composite Liquid Waste Sampler (Coliwasa)," D 5495 – 03, ASTM International, West Conshohocken, PA, January, 2004.

ACRONYMS

ASTM – American Society of Testing Materials
Coliwasa – Composite Liquid Sampler
DWPF – Defense Waste Processing Facility
NWFA – Non-Waste Form Affecting
PSS – Portable Sampling Station
RCT – Recycle Collection Tank
SRAT – Sludge Receipt and Adjustment Tank

SRNL – Savannah River National Laboratory
SRS – Savannah River Site

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