DISPOSAL OF NONROUTINE HIGH LEVEL WASTE IN DWPF CANISTERS AT SAVANNAH RIVER SITE – A PRECEDENT THROUGHOUT THE DWPF COMPLEX

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ABSTRACT

Savannah River National Laboratory (SRNL) at Savannah River Site (SRS) has been actively reducing the inventory of radioactive material stored in its Shielded Cells Facility. Part of this inventory was a large number of 500 mL stainless steel beakers containing SRS radioactive high level waste (HLW) sludge immobilized in a borosilicate glass. Since the beakers at SRNL contain HLW, federal mandate requires that this material be shipped to the geologic repository for permanent disposal. A detailed assessment was prepared that included a full characterization of the borosilicate glass as well as an evaluation of the impacts of placing the SRNL beakers in the canisters produced at the SRS Defense Waste Processing Facility (DWPF). Additionally, special equipment had to be designed and fabricated for use at SRNL along with the vitrification facility since DWPF was designed only to receive HLW slurries pumped from SRS waste tanks that would be processed into molten glass and poured from the melter into DWPF canisters.

Different tasks were required to be performed at SRNL for implementation of this activity including confirmation of the beaker material, beaker tab removal and loading of the magazine tube and magazine rack with the beakers. New as well as existing procedures were utilized at DWPF to place the beakers into DWPF canisters and fill the canisters with molten borosilicate glass. This disposal path for the HLW glass-filled stainless steel beakers sets a precedent throughout the DOE complex since it is expected that other nonroutine HLW at SRS and other DOE production facilities will need to be placed in permanent disposal at the federal repository.

INTRODUCTION

Much of the radioactive waste that was produced in the SRNL Shielded Cells was the result of demonstration runs performed for the DWPF using a remotely operated joule-heated melter. These runs were performed with radioactive sludge from the SRS Tank Farm and demonstrated that actual waste could be safely immobilized in glass using the DWPF process. Four sets of radioactive glass samples were generated in the Shielded Cells as a result of three demonstration runs and a major flushing of the SRNL melter.

The first demonstration run at SRNL was performed in December 1990 using radioactive sludge from SRS Tanks 8 and 12. The next DWPF demonstration run occurred in January 1991 and used Tank 51 sludge. The third demonstration run was performed in October 1995 and used a new sludge sample from Tank 51. During these three campaigns, borosilicate glass was poured out of the melter into 58 stainless steel beakers (500 mL) each holding approximately 1 kg of glass. Next, in July 1997, the Shielded Cells melter was flushed with nonradioactive frit to remove the radioactive glass from the 1995 Tank 51 demonstration run. Seventy-five beakers were filled during the flushing campaign.

The initial strategy for the 58 glass-filled beakers, which were placed into two 55-gallon lead-lined drums, was to transfer the drums/beakers into the DWPF Failed Equipment Storage Vault (FESV). However, the FESV is an interim storage location at the DWPF and is not a permanent means of disposal for the legacy SRNL glass. As a result, a new strategy was proposed to include the disposal of the SRNL glass samples in DWPF canisters [1]. Prior to implementing this disposal option, an evaluation of the waste acceptance impacts on the DWPF canistered waste forms had to be completed along with a method for repackaging the beakers for remote handling, transporting the beakers to DWPF and finally loading the beakers into DWPF canisters inside the vitrification canyon.

The DWPF has been immobilizing HLW sludge since startup of the facility in March 1996. In the nearly ten years of production, DWPF has poured over 2,000 canisters with each containing approximately 4,000 pounds of glass. The facility has processed approximately two million gallons of sludge slurry and immobilized greater than ten million curies of radioactivity. All 2000+ canisters poured and currently in interim storage at the DWPF Glass Waste Storage Building have met all regulatory requirements.

DISCUSSION

Evaluation of the Waste Acceptance Product Specifications

The DWPF canistered waste form must meet the DOE Office of Environmental Management (EM) Waste Acceptance Product Specifications (WAPS) in order to ensure acceptance of the vitrified high level waste (HLW) into the Civilian Radioactive Waste Management System (CRWMS) [2]. The elements of the canistered waste form include the borosilicate waste glass, the stainless steel canister and the sealed canistered waste form. Related to the borosilicate waste glass, the Producer (DWPF) shall report the chemical composition and the radionuclide inventory of the waste as well as demonstrate the consistency of the waste form using the Product Consistency Test (PCT).

Specifically, the WAPS require that the DWPF report those elements (as oxides) that are present in the glass at greater than 0.5 wt%. Additionally, the WAPS require that the DWPF report those radionuclides with half-lives greater than 10 years and which contribute greater than 0.05% of the curies out to 1100 years after production. There are also radionuclides that must be reported as required by the International Atomic Energy Agency (IAEA) – specifically, uranium and plutonium isotopes. Finally, the durability of the glass must be demonstrated using the PCT. The mean PCT results for each waste type must be at least two standard deviations below the mean PCT results of the Environmental Assessment (EA) benchmark glass as demonstrated by the ASTM C-1285 leach test.

The chemical compositions produced during the four campaigns were determined by dissolving samples of the glass and measuring the elements in the solutions. Different glass formers chemicals (i.e., frits) were used in each of the campaigns and therefore the chemical composition of each campaign varied even when the same sludge batch material (i.e., Tank 51) was used. The frit constituents (silicon, boron, sodium, lithium, etc.) made up greater than 70 wt% of the waste. For each campaign, there were either 11 or 12 elements that were required to be reported per the WAPS criterion (concentration > 0.5 wt% excluding oxygen). Al_2O_3, B_2O_3, CaO, Fe_2O_3, K_2O, Li_2O, MgO, MnO, Na_2O and SiO_2 were reportable in all four campaigns and NiO, TiO_2 and U_3O_8 were reportable in at least one of the campaigns. The chemical compositions for the different SRNL campaigns are shown in Table I.

Table I. Measured Glass Chemical Compositions – SRNL Glass Campaigns

Oxide	**Tank 8 and 12 Campaign – 1990 (wt%)**	**Tank 51 Campaign – 1991 (wt%)**	**Tank 51 Campaign – 1995 (wt%)**	**Tank 51 Melter Flushing – 1997 (wt%)**
Al_2O_3	5.90	4.48	6.5	4.74
B_2O_3	12.90	6.23	7.8	7.29
CaO	0.53	1.26	1.0	0.98
CuO	N.R. (<0.5)	N.R. (<0.5)	N.R. (<0.5)	N.R. (<0.5)
Fe_2O_3	9.00	13.0	10.5	11.3
K_2O	1.80	1.43	1.8	2.36
Li_2O	3.10	4.55	3.9	3.18
MgO	1.60	2.06	2.7	0.86
MnO	0.72	1.42	0.97	1.34
Na_2O	11.70	8.52	12.7	9.84
NiO	0.70	N.R. (<0.5)	N.R. (<0.5)	0.81
SiO_2	47.50	48.3	55	50.3
TiO_2	N.R. (<0.5)	N.R. (<0.5)	N.R. (<0.5)	0.72
U_3O_8	1.46	1.07	1.2	N.R. (<0.5)

N.R. - Not Reportable

The radionuclide inventory of the beakers produced in the campaigns was either estimated or measured depending on whether actual radionuclide analysis was performed on the glass. In the first campaign, the inventory was not measured and had to be determined from knowing the radionuclide inventory of the sludge in the two SRS tanks that furnished the HLW for this campaign. In the 1991 Tank 51 campaign, radionuclide analysis also was not performed because the radionuclides (with the exception of uranium) comprised less than 1 percent of the mass of the waste and consequently had no effect on the properties of the glass product. Radionuclide analyses were performed on the 1995 Tank 51 sample and these radionuclide inventory results were assigned to the beakers poured during the 1991 campaign, the 1995 campaign and the 1997 melter flushing campaign. (These concentrations were an upper bound for the 1997-campaign beakers since the SRNL melter was purposely flushed to get the transuranic level of the residual glass in the melter to below 100 nCi/g total alpha.) See Table II for the 26 reportable WAPS radionuclides as well as the one additional radionuclide (U-235) required to be reported for IAEA purposes.

Table II. Radionuclide Inventory – SRNL Glass Campaigns

Radionuclide	Tank 8 and 12 Campaign – 1990 (Ci/kg glass)	Tank 51 Campaign – 1991 (Ci/kg glass)	Tank 51 Campaign – 1995 (Ci/kg glass)	Tank 51 Melter Flushing – 1997 (Ci/kg glass)
Ni-59	3.4E-04	1.9E-05	1.9E-05	1.9E-05
Ni-63	4.3E-02	2.5E-03	2.5E-03	2.5E-03
Se-79	1.9E-04	4.7E-06	4.7E-06	4.7E-06
Sr-90	1.1E+01	1.2E-01	1.2E-01	1.2E-01
Zr-93	1.8E-03	2.0E-05	2.0E-05	2.0E-05
Nb-93m	1.5E-03	1.6E-05	1.6E-05	1.6E-05
Tc-99	3.3E-03	6.5E-05	6.5E-05	6.5E-05
Sn-126	2.1E-04	1.8E-06	1.8E-06	1.8E-06
Cs-137	6.4E-01	7.6E-03	7.6E-03	7.6E-03
Sm-151	6.1E-01	6.6E-03	6.6E-03	6.6E-03
Th-229	3.5E-07	4.4E-08	4.4E-08	4.4E-08
U-233	4.3E-05	1.2E-05	1.2E-05	1.2E-05
U-234	4.0E-06	1.2E-05	1.2E-05	1.2E-05
U-235	1.1E-07	1.6E-08	1.6E-08	1.6E-08
U-236	3.2E-07	3.9E-07	3.9E-07	3.9E-07
U-238	2.2E-06	3.3E-06	3.3E-06	3.3E-06
Np-237	9.5E-06	3.0E-06	3.0E-06	3.0E-06
Pu-238	1.3E-01	1.4E-02	1.4E-02	1.4E-02
Pu-239	3.0E-03	1.4E-03	1.4E-03	1.4E-03
Pu-240	1.5E-03	7.0E-04	7.0E-04	7.0E-04
Pu-241	1.7E-02	6.3E-04	6.3E-04	6.3E-04
Pu-242	2.2E-06	1.4E-06	1.4E-06	1.4E-06
Am-241	6.0E-02	2.5E-03	2.5E-03	2.5E-03
Am-243	6.8E-06	4.4E-05	4.4E-05	4.4E-05
Cm-244	8.0E-04	1.9E-03	1.9E-03	1.9E-03
Cm-245	4.6E-08	4.2E-07	4.2E-07	4.2E-07
Cm-246	3.4E-07	4.0E-06	4.0E-06	4.0E-06

The PCT was used to determine the durability of the glass produced in the four campaigns and the results are included in Table III. The mean releases of boron (B), lithium (Li) and sodium (Na), given in units of grams per liter, summed with the measured two standard deviations were compared against the leachate concentrations for the EA glass and verified to meet the WAPS product consistency specification. In Table III, the durability of the first and last beaker poured during the 1997 melter flushing campaign was measured using the PCT and averaged together and reported.

Table III. Normalized Product Consistency Test Results – SRNL Glass Campaigns

Element	**Tank 8 and 12 Campaign – 1990 (g/L)**	**Tank 51 Campaign – 1991 (g/L)**	**Tank 51 Campaign – 1995 (g/L)**	**Tank 51 Melter Flushing – 1997 (g/L)**
Boron				
Mean	1.72	0.83	1.63[a] (projected PCT)	0.58
2 Std. Deviations	0.20	0.08		0.02
Mean + 2 Std. Dev.	1.92	0.91		0.60
EA Glass Limit (Mean)	*16.7*	*16.7*	*14.3*[b]	*16.7*
Lithium				
Mean	1.64	0.80	1.47[a] (projected PCT)	0.72
2 Std. Deviations	0.18	0.06		0.02
Mean + 2 Std. Dev.	1.82	0.86		0.74
EA Glass Limit (Mean)	*9.6*	*9.6*	*8.1*[b]	*9.6*
Sodium				
Mean	1.40	0.78	1.56[a] (projected PCT)	0.61
2 Std. Deviations	0.06	0.06		0.02
Mean + 2 Std. Dev.	1.46	0.84		0.63
EA Glass Limit (Mean)	*13.3*	*13.3*	*11.5*[b]	*13.3*

[a] Chemical composition results given in Table I (1995 Tank 51 Campaign) were used to calculate PCT results using the PCT/chemical composition correlation.

[b] EA Glass Limit = EA Glass Mean – 2 Standard Deviations

In addition to the waste form reporting requirements discussed above, a full evaluation of the SRNL beakers is given in Table IV [1]. The presence of SRNL beakers in DWPF canisters was evaluated against the criteria in the WAPS [2] as well as the technical basis for DWPF compliance documented in the Waste Form Compliance Plan [3] and the Waste Form Qualification Report [4]. As part of this evaluation, a specific technical evaluation was performed to determine the impact from an SRNL beaker filled with glass dropped into a DWPF canister. The maximum credible cumulative effect for 10 beakers resulted in a total penetration of 0.070 inches (calculated from 9 beakers impacting on their bottom or side and 1 beaker impacting on the handle). This is bounding since all beaker handles were removed prior to dropping the beakers into the canister. The bottom shell of the canister is much thicker than this value (nominal thickness of 0.50 inches). Therefore, penetration of the canister bottom will not occur.

Table IV. Assessment of WAPS Criteria for Beaker Disposal Method in DWPF Canisters

WAPS Criterion	Assessment
1. Waste Form Specifications	
1.1 Chemical Specification	Chemical composition of contents of beakers will be included in the Production Records.
1.2 Radionuclide Inventory Specification	Radionuclide inventory of contents of beakers will be included in the Production Records.
1.3 Specification for Product Consistency	Product consistency results will be included in the Production Records.
1.4 Specification for Phase Stability	No impact. The phase stability behavior of the glass contained in the beakers is within the bounds of the information presented in the Waste Form Qualification Report.
1.5 Hazardous Waste Specification	No impact. The well-characterized glass contained in the beakers is neither hazardous listed waste nor characteristic hazardous waste as discussed in the Waste Form Qualification Report.
1.6 IAEA Safeguards Reporting for HLW Specification	IAEA radionuclides will be included in the Production Records.
2. Canister Specifications	
2.1 Material Specification	No impact. The beakers are constructed of austenitic stainless steel.
2.2 Fabrication and Closure Specification	N/A
2.3 Identification and Labeling Specification	N/A
2.4 Specification for Canister Length and Diameter	N/A
3. Canistered Waste Form Specifications	
3.1 Free Liquid Specification	No impact. The filled beakers are not a free liquid.
3.2 Gas Specification	No impact. The filled beakers are not a free gas nor will interactions with the glass present in the canister result in free gases being evolved.
3.3 Specification for Explosiveness, Pyrophoricity, and Combustibility	No impact. The filled beakers are neither explosive, pyrophoric, or combustible. Interactions between the filled beakers and glass will not result in explosive, pyrophoric or combustible materials within the canistered waste form.
3.4 Organic Materials Specification	No impact. The filled beakers are not an organic material.
3.5 Chemical Compatibility Specification	No impact. The filled beakers will not adversely affect the corrosion performance of the stainless steel canister.
3.6 Fill Height Specification	No impact. The volume of 10 beakers (or less) will be negligible when evaluating the canister fill height.
3.7 Specification for Removable Radioactive Contamination on External Surfaces	N/A
3.8 Heat Generation Specification	N/A
3.9 Specification for Maximum Dose Rates	No impact. The SRNL glass will not impact the canister dose rates.
3.10 Subcriticality Specification	N/A
3.11 Specifications for Weight and Overall Dimensions	No impact. The weight of the SRNL glass/beakers is insignificant compared to the weight of the DWPF canistered waste form.
3.12 Drop Test Specification	No impact. The inclusion of SRNL beakers in DWPF canisters will not affect the drop test results included in the Waste Form Qualification Report.
3.13 Handling Features Specification	N/A
3.14 Concentration of Plutonium in each Canister Specification	No impact. The Pu concentration in canisters containing beakers will be less than the WAPS limit based on the low Pu conc. in SRS HLW.

It was assumed that a maximum of 10 beakers would be placed into an empty DWPF canister. This would displace less than 1% of the canister volume, and, therefore, voids would not be a problem in the canistered waste form. During DWPF Waste Qualification Runs, a DWPF canister containing a rack and 20 small cans of surrogate Pu glass was filled with glass from the DWPF melter as part of the Pu disposition can-in-canister proposal and experienced no significant voiding. (The rack and 20 cans displaced approximately 5% of the canister volume.) With regards to pouring molten glass (1050°C) over the stainless steel beakers, there will be no pressure control issues since there are no volatiles associated with the glass in the SRNL beakers.

The Production Records for the canisters containing SRNL glass will include a sheet attached containing the ID numbers of the SRNL beakers present in the DWPF canisters as well as the applicable characterization data. From a reporting standpoint the amount of SRNL glass that will be present in a DWPF canister (i.e., 10 beakers per canister) is insignificant compared to the total amount of DWPF glass poured into the canister. The contribution of the SRNL glass (10 kg) is only 0.6 wt% of the entire canister (1818 kg glass) and therefore is negligible with regards to the overall macro-batch composition. Furthermore, when the macro-batch exceeds 400 canisters, the SRNL glass is less than 0.02 wt% of the glass poured into the DWPF canisters. Based on this very small weight percentage, the SRNL glass has a negligible impact on the overall macro-batch composition as well as reported errors in the chemical composition and radionuclide inventory.

<u>Implementing the Approved Disposal Path</u>

In late 1998 Westinghouse Savannah River Company (WSRC) received approval from DOE to place the SRNL stainless steel beakers containing the waste glass into DWPF canisters. Due to the lack of funding, the activities required to implement this disposal option were put on hold until FY2003. During that time period, a QA audit was performed on this SRNL glass disposal method and it was concluded that the QA records associated with the procurement of the beakers did not meet all the requirements of the CRWMS quality assurance program (RW-0333P) [5].

As a result an alloy analysis was required to be performed on each beaker to be disposed of in a DWPF canister [6]. A Koslow Thermoelectric Alloy Sorter was used for alloy identification. From the calibration data for the sorter, it was determined that austenitic stainless steels would produce an alloy sorter thermoelectric number between -5 and 13 versus ferritic and martensitic steels producing a reading in the range from 63 to 100. A section of each beaker was cleaned (i.e., the oxidation layer was removed) using a grinding mechanism prior to completing the alloy analysis, which was performed three times to verify that the specified requirement range was met. After the process was performed on five beakers, the alloy analyzer was checked against a standard to ensure the reliability of the instrument. Data sheets completed in the SRNL procedure included the three alloy readings and provided objective evidence that all 133 beakers were constructed of austenitic stainless steel.

Following the alloy check of the beaker material in the Shielded Cells Facility, it was also necessary to remove the tab attached to each beaker to ensure that the beaker would fit into the beaker carrier and ultimately into the DWPF canister. A tab shear assembly along with the fabrication of a tray (used to catch any glass that might fracture during the cutting of the tabs) was used successfully in the removal of the tabs from the 133 beakers (see Fig. 1).

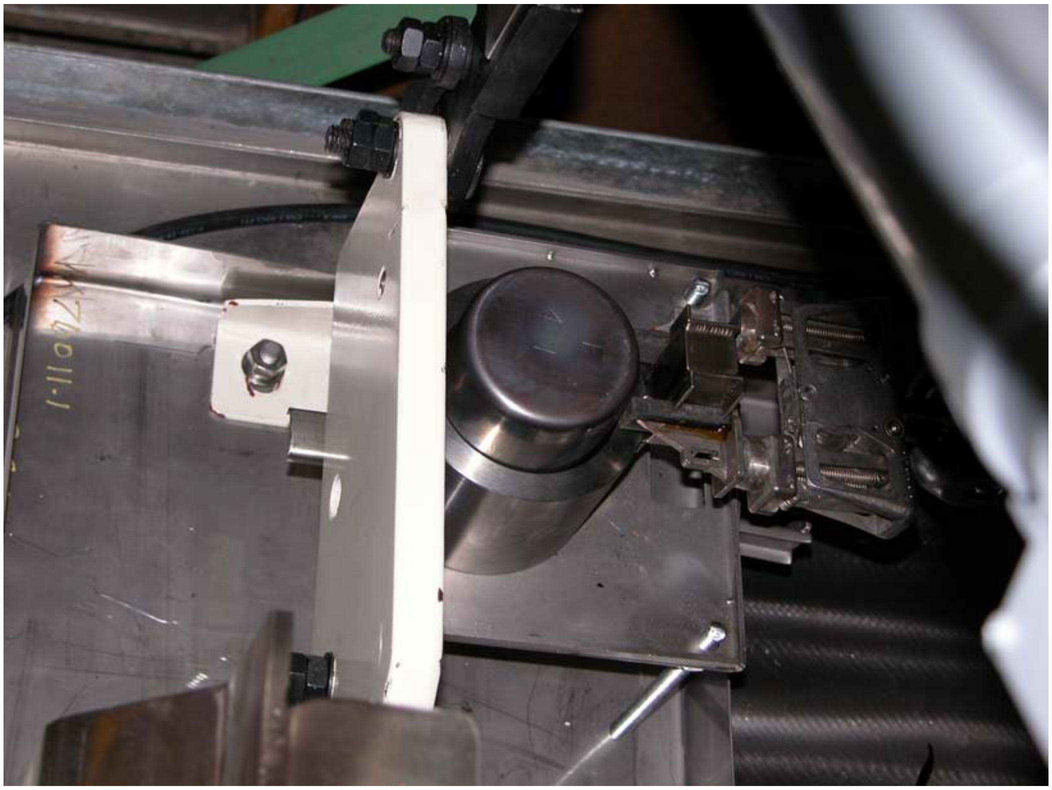

Fig. 1. Tab Shear assembly with manipulator positioning the SRNL beaker

SRNL also designed and fabricated cylindrical tubes (i.e., magazines) and a magazine rack that could be used to transport the beakers safely to DWPF for final disposal in the canistered waste forms (see Fig. 2). All equipment was successfully tested with beakers containing simulant glass in the SRNL mock-up area prior to placing the magazines and rack in the Shielded Cells Facility. Each magazine tube was designed to hold up to five beakers and the magazine rack was sized to house up to 16 magazines. When five beakers were loaded into each magazine, a locking pin was pushed into place to hold the beakers in the magazine. The data sheet in the SRNL beaker procedure containing the alloy readings for the individual beakers also included the magazine ID number for each beaker. Magazine loading and rack loading instructions were also provided in the SRNL procedure. An SRNL QA independent inspector was responsible for independently verifying the beaker's identification number, the correct recording of the reading of the alloy sorter as well as the placement of the beaker into the magazine and recording the magazine number.

Fig. 2. Sixteen beaker magazines (empty) loaded into magazine rack

Once the magazine rack was filled with the required number of loaded magazines, the rack was placed into an In-Cell Liner (for contamination control purposes) and then shipped to DWPF in an Encapsulated Lead Shipping Package (ELSP). The ELSP provided the necessary shielding so that the rack could be safely transported to DWPF. Following receipt at DWPF, cranes at the DWPF were used to unload the container and transport the magazine rack to the DWPF Melt Cell. A DWPF operations procedure, which was developed to provide instructions for the placement of the glass-filled beakers into DWPF canisters, was then used to remove each magazine out of the rack using the Melt Cell crane and position it over the selected canister. As shown in Fig. 3, the magazine was lowered into the throat protector installed on the canister and the bottom pin retracted to allow the beakers to enter the canister. A DWPF QA independent inspector was present during the loading of beakers into each DWPF canister to ensure that the correct beaker ID numbers were recorded from the SRNL data sheet and that no foreign materials, other than the designated stainless steel glass-filled beakers, were added to the canister. Once the canister was loaded with the desired number of beakers, the canister was placed on the pour turntable, and the standard DWPF operating procedures were then used for glass pouring, insertion of the inner canister closure plug, etc.

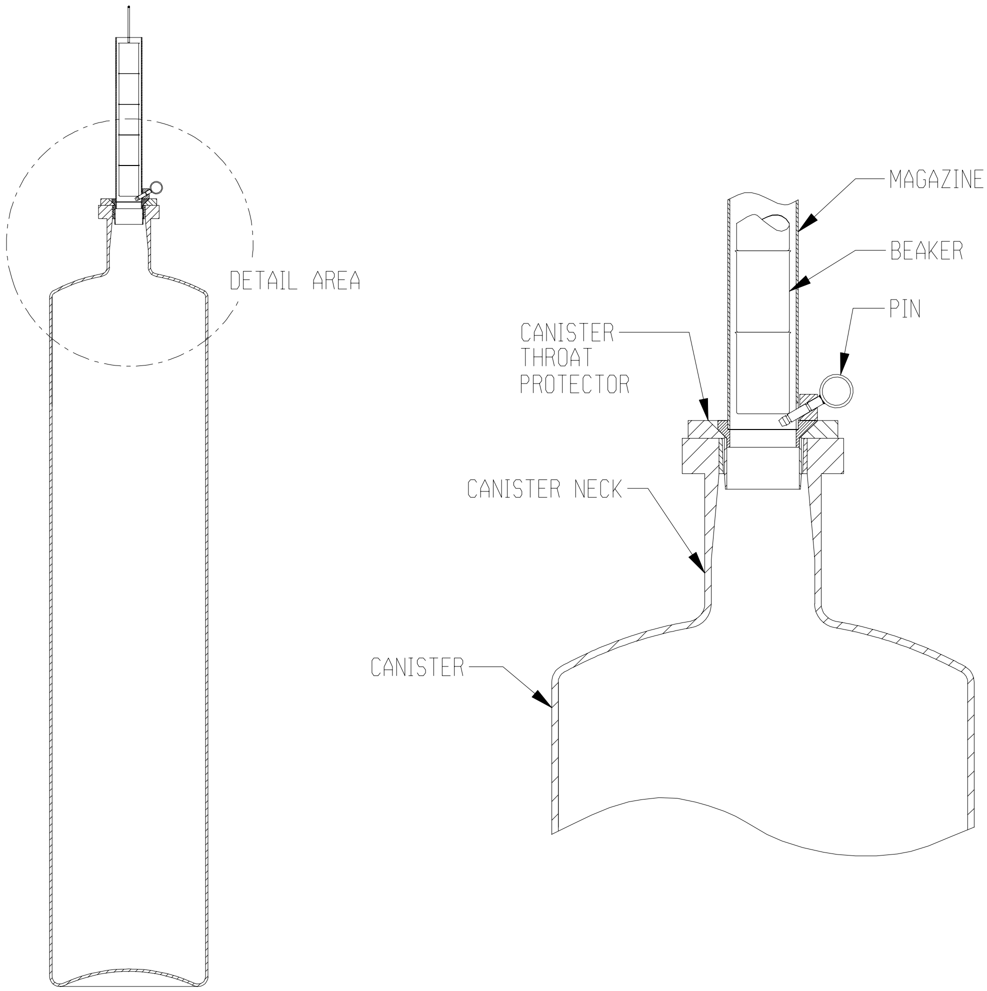

Fig. 3. Placement of magazine over a DWPF canister

In the two shipments of the ELSP from SRNL to DWPF (August 2004 and December 2004), all 133 beakers were successfully dispositioned in 15 DWPF canisters. One problem that was encountered during the shipments was the locking pin becoming disengaged and allowing the beakers to be released from the magazine. The pins on two of the magazines in the first shipment became disengaged and this resulted in one SRNL beaker falling to the Melt Cell floor. An engineering path forward was developed and was successfully implemented to recover the beaker and place the beaker into a DWPF canister. Prior to the loading of the second group of magazines into the rack and ELSP, the SRNL procedure was revised to include visual inspection of the pin using an in-cell camera in the Shielded Cells Facility. Fig. 4 is an example of one of the photographs taken to provide evidence that the locking pin of a specific magazine was engaged prior to shipment to DWPF. Additionally, verification steps were added to the DWPF beaker procedure for the operator to verify that the pin was fully engaged prior to removing the magazine from the rack in the DWPF Melt Cell. Upon receipt of the second shipment of beakers and performance of the beaker procedure, the pin to one of the magazines was found to be disengaged. A recovery plan was developed and the beakers in that magazine were successfully reloaded.

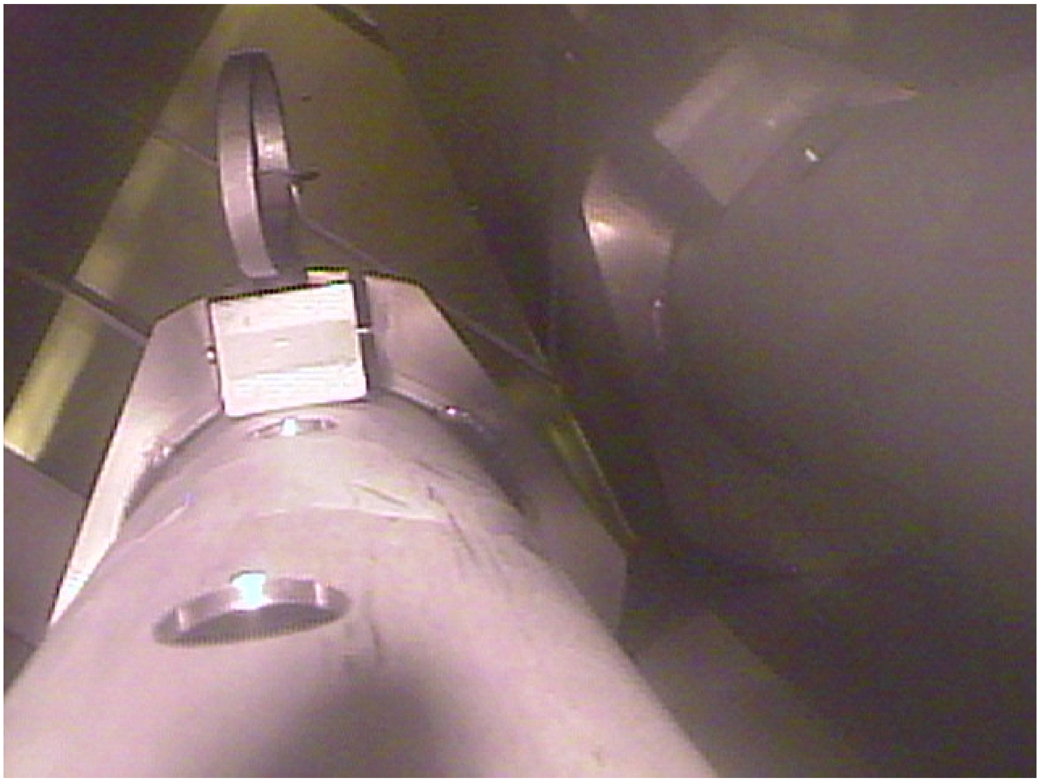

Fig. 4. Verification of engagement of magazine pin in the shielded cells facility

There were some lessons learned from implementation of this disposal method [6]. Another type of locking mechanism should be considered if a magazine concept should be used again for placement of waste into a DWPF canister. Additionally, backup equipment should be available and calibrated (if possible) when performing work in the Shielded Cells Facility. The alloy analyzer that was used with the first 75 beakers failed during the initial testing of the second set of beakers in the Shielded Cells Facility. This caused a delay in completing the alloy analysis, tab removal and loading of the beakers into the magazines.

Disposal Options for Other Potential Waste

Introducing austenitic stainless steel (in the form of beakers) into the DWPF canister is acceptable since the canister itself is fabricated of stainless steel (304L) and stainless steel temporary plug(s) are procedurally dropped into the canister. The stainless steel beakers themselves are not considered a "foreign material" (i.e., stainless steel is not a free liquid, a free gas, an explosive, pyrophoric or combustible material, an organic material or a corrosive material).

This disposal method could also potentially be applied to future glass produced in the SRNL Shielded Cells associated with DWPF small-scale demonstration runs (e.g., crucible glass, thimbles, etc.) and slurry waste converted into glass. However, before any future SRNL glass can be dispositioned in this manner, a characterization report of the SRNL glass (including all information needed for the WAPS evaluation) must be prepared. The disposal of “qualified” glass present on the DWPF Melt Cell floor (due to pour spout cleanings) has already been approved and implemented by DWPF following DOE approval of that waste compliance strategy. Similarly, a WAPS evaluation was performed on DWPF canisters containing Inconel melter pour spout inserts, which were inadvertently dropped from the melter pour spout into DWPF canisters, and the same conclusion was reached that no WAPS criteria were violated.

Currently, the only HLW “package” that is planned to be accepted by the federal repository for permanent disposal is either a 10-foot canistered waste form (SRS and West Valley) or a 15-ft canistered waste form (Hanford) [7]. Non-routine HLW that is generated at a DOE site must either be qualified to be placed in a HLW canister or be deemed waste with no identified path to disposal [8]. The goal at SRS and other DOE production facilities is to minimize the waste with no identified path to disposal since this waste must remain on-site and be addressed in the future (at most likely a higher cost).

CONCLUSIONS

In summary, the glass-filled stainless steel beakers produced in the SRNL Shielded Cells supporting DWPF glass qualification work were shown to meet all the regulatory requirements to support disposal in DWPF canisters. Special testing was required to support this evaluation as well as new equipment to package the beakers and transport them to DWPF for disposal. With the required QA oversight, all 133 beakers were placed in a total of 15 DWPF canistered waste forms. This method sets a precedent for SRS as well as other DOE sites to be proactive in evaluating the different options for disposal of nonroutine HLW that is required by federal mandate to be shipped to a geologic repository for permanent disposal.

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