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Composition Measurements and Product Consistency Test Results for the EMHQ-LBE-04-B Glass

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EXECUTIVE SUMMARY

This report provides the results from the chemical analyses of the glass composition and the Product Consistency Test leachate analyses for the EMHQ-LBE-04-B glass. These data will be used in the development, validation, and implementation of enhanced property/composition models for waste glass vitrification at Hanford.

Chemical analyses were performed on a sample of the EMHQ-LBE-04-B glass. The relative differences between the targeted and measured concentrations of Li_2O, Na_2O, and SO_3 for the glass were greater than 10%. The relative differences between the measured compositions of the EMHQ-LBE-04-B and EMHQ-LBE-04 glasses were all less than 10%.

The measured and targeted EMHQ-04-LBE-B glass compositions were used in the normalization of the Product Consistency Test results. The NC_B, NC_{Na}, and NC_{Si} values were less than the Hanford Tank Waste Treatment Immobilization Plant low-activity waste constraint of 4 g/L. The measured concentrations of the analytes in the test blank samples included with the Product Consistency Test leachates were below detection limits. The average measured concentrations of B, Li, Na, and Si for the Approved Reference Material-1 glass fell within control chart values indicating proper test performance.

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LIST OF ABBREVIATIONS

ARM-1	Approved Reference Material-1
ASTM	American Society for Testing and Materials
BDL	below detection limit
DF	dilution factor
DOE	U. S. Department of Energy
IC	ion chromatography
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
KH	potassium hydroxide fusion
LAW	low-activity waste
LM	lithium metaborate fusion
LRM	low-activity test reference material
NCi	normalized concentration of element "i"
ORP	Office of River Protection
PCT	Product Consistency Test
PF	sodium peroxide fusion
PNNL	Pacific Northwest National Laboratory
%RSD	percent relative standard deviation
seq	sequence
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
std	High Purity Standards ICP multi-element custom solution SM-744-013
TTQAP	Task Technical and Quality Assurance Plan
wt.%	weight percent
WTP	Waste Treatment and Immobilization Plant

1.0 Introduction

The U.S. Department of Energy (DOE) is responsible for building the Hanford Tank Waste Treatment and Immobilization Plant (WTP) at the Hanford site in Washington to remediate 55 million gallons of radioactive waste that is temporarily stored in 177 underground tanks. The Office of River Protection (ORP) has requested that the Savannah River National Laboratory (SRNL) contribute in areas of recognized capabilities and expertise for glass waste form development to support successful startup of the WTP.

Successful efforts have allowed for demonstration of greatly enhanced treatment efficiencies of those projected from the minimum requirements set forth in the WTP Contract[a] Additional flexibility and expansion of the qualified glass forming region are the current focus.[1] SRNL support of this work is defined in the Task Technical and Quality Assurance Plan (TTQAP).[2]

This report provides results from the chemical analyses of the EMHQ-LBE-04-B glass and the resulting Product Consistency Test (PCT) leachates. The glasses were selected as part of a broader study of the influence of glass composition on chemical durability, sulfur retention, and other properties.[3] The resulting data will be used in the development, validation, and implementation of enhanced property/composition models for nuclear waste glasses.[1]

2.0 Experimental Procedure

2.1 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in Savannah River Site (SRS) Manual E7, Procedure 2.60.[4] SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011.[5] Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-04. The glass provided by the Pacific Northwest National Laboratory (PNNL) was designed and fabricated following a Task Plan.[1]

2.2 Glass Selected for Study

The glass composition in this study was selected and fabricated by PNNL. A sample of the glass was received at SRNL for chemical composition analysis. The PNNL identifier for this sample was “EMHQ-LBE-04-B” and the SRNL identifier was S-13644.

American Society for Testing and Materials (ASTM) C1285-21 PCT Method A[6] was performed on the study glass. The resulting PCT leachates were sent to SRNL for chemical analysis. Identifiers (IDs) for the PCT leachates are listed in Table 2-1.

[a] Contract DE-AC27-01RV14136, as amended, U.S. Department of Energy, Richland, WA (2000).

Table 2-1. Identifiers for the PCT Leachates

PNNL ID	SRNL ID
EMHQ-LBE-04-B-PCT-A	S-13647
EMHQ-LBE-04-B-PCT-B	S-13648
EMHQ-LBE-04-B-PCT-C	S-13649
ARM-1-STD-GLASS-PCT-A-020822	S-13650
ARM-1-STD-GLASS-PCT-B-020822	S-13651
ARM-1-STD-GLASS-PCT-C-020822	S-13652
MQ-WATER BLANK-PCT-A-020822	S-13653
MQ-WATER BLANK-PCT-B-020822	S-13654

2.3 Glass Composition Analysis

Three dissolution techniques (potassium hydroxide fusion (KH), lithium metaborate fusion (LM), and sodium peroxide fusion (PF)) were used for preparing the EMHQ-LBE-04-B glass sample for analysis.[7-9]

The EMHQ-LBE-04-B sample was analyzed twice for each element of interest by inductively coupled plasma – optical emission spectroscopy (ICP-OES)[10] or ion chromatography (IC),[11] for a total of two measurements per element per glass. A sample of the low-activity test reference material (LRM) was included with the sample glass measurements. The LRM composition reported as the "Consensus Average" is used as the reference composition of this glass.[12] The preparation and measurement methods used for each of the reported glass components are listed in Table 2-2.

Table 2-2. Preparation and Measurement Methods used in Reporting the Analyte Concentrations of the EMHQ-LBE-04-B Study Glass and LRM Standard Glass

Analyte	Measurement Method	Preparation Method
Al	ICP-OES	PF
B	ICP-OES	PF
Ca	ICP-OES	LM
Cl	IC	KH
Cr	ICP-OES	LM
F	IC	KH
Fe	ICP-OES	LM
K	ICP-OES	LM
Li	ICP-OES	PF
Mg	ICP-OES	LM
Mn	ICP-OES	LM
Na	ICP-OES	LM
P	ICP-OES	PF
S	ICP-OES	LM
Si	ICP-OES	PF
Ti	ICP-OES	LM
V	ICP-OES	LM
Zr	ICP-OES	LM

2.4 PCT Leachate Analysis

PNNL supplied leachates resulting from the PCT of the EMHQ-LBE-04-B study glass. Samples were measured twice by ICP-OES along with samples of High Purity Standards ICP multi-element custom solution SM-744-013 (std). PNNL provided the dilution factor (DF) used in preparing the PCT leachates for analysis. The leachate measurements were adjusted using the provided DF of 5. Normalized release values were calculated for the study glass based on the targeted and measured glass compositions.

3.0 Results and Discussion

JMP® Version 16.0.0 (SAS Institute, Inc.)[13] was used to support these analyses.

3.1 EMHQ-LBE-04-B Chemical Composition Measurements

Table A-1, Table A-2, and Table A-3 in Appendix A provide the elemental concentration measurements in weight percent (wt.%) from the EMHQ-LBE-04-B and LRM glasses prepared using KH, LM, and PF methods, respectively. Table A-4 in Appendix A provides a summary of the average compositions, targeted compositions and some associated differences and relative differences for the LRM glass.

3.1.1 Treatment of Detection Limits

The elemental concentrations in Table A-1, Table A-2, and Table A-3 in Appendix A were converted to oxide concentrations by multiplying the values of each element by the gravimetric factor for the corresponding oxide. A concentration measurement that was reported to be below the detection limit was set to the detection limit for the purposes of data review and calculating a sum of oxides for each glass. Concentration measurements that were below the detection limit (BDL) are denoted with a less than symbol (<).

3.1.2 Measured versus Target Compositions

Table 3-1 provides a summary of the average compositions, targeted compositions and some associated differences and relative differences. The measured sums of oxides for the EMHQ-LBE-04-B glass is 99.8 wt.%, indicating acceptable recovery of the glass components.[14] Entries in Table 3-1 show the relative differences between the measured and targeted values for the analytes with measured and targeted values above 1 wt.%. The relative differences were shaded if they are 10% or more. The relative differences for Li_2O, Na_2O, and SO_3 were greater than 10%.

Table 3-1. Comparison of Measured and Target EMHQ-LBE-04-B Glass Compositions

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
EMHQ-LBE-04-B	Al_2O_3	3.62	3.54	0.078	2%
EMHQ-LBE-04-B	B_2O_3	12.7	13.5	-0.781	-6%
EMHQ-LBE-04-B	CaO	12.7	12.2	0.491	4%
EMHQ-LBE-04-B	Cl^-	0.0704	0.0760	-0.006	
EMHQ-LBE-04-B	Cr_2O_3	<0.0365	0.0250	0.012	
EMHQ-LBE-04-B	F^-	0.0707	0.0950	-0.024	
EMHQ-LBE-04-B	Fe_2O_3	0.119	0.131	-0.012	
EMHQ-LBE-04-B	K_2O	0.0592	0.0870	-0.028	
EMHQ-LBE-04-B	Li_2O	1.96	1.67	0.286	17%
EMHQ-LBE-04-B	MgO	0.203	0.180	0.023	
EMHQ-LBE-04-B	MnO	<0.0129	0.0130	0	
EMHQ-LBE-04-B	Na_2O	11.6	9.81	1.769	18%
EMHQ-LBE-04-B	P_2O_5	<0.229	0.158	0.071	
EMHQ-LBE-04-B	SiO_2	48.8	49.6	-0.824	-2%
EMHQ-LBE-04-B	SO_3	1.39	1.69	-0.303	-18%
EMHQ-LBE-04-B	TiO_2	0.0799	0.0910	-0.011	
EMHQ-LBE-04-B	V_2O_5	4.27	4.03	0.237	6%
EMHQ-LBE-04-B	ZrO_2	1.88	2.00	-0.116	-6%
EMHQ-LBE-04-B	**Sum of Oxides**	**99.8**	**98.9**	**0.861**	**1%**

3.1.3 Comparison of EMHQ-LBE-04-B and EMHQ-LBE-04 Measured Compositions

Table 3-2 provides a summary of the average EMHQ-LBE-04-B measured compositions, average EMHQ-LBE-04 measured compositions[15], and relative differences with measured values above 1 wt.%. None of the relative differences were greater than 10%.

Table 3-2. Comparison of EMHQ-LBE-04-B and EMHQ-LBE-04 Measured Compositions

PNNL ID	Oxide	Measured (wt.%)	Measured EMHQ-LBE-04 (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
EMHQ-LBE-04-B	Al_2O_3	3.62	3.58	0.040	1%
EMHQ-LBE-04-B	B_2O_3	12.7	12.4	0.300	2%
EMHQ-LBE-04-B	CaO	12.7	11.6	1.100	9%
EMHQ-LBE-04-B	Cl^-	0.0704	0.0679	0.003	
EMHQ-LBE-04-B	Cr_2O_3	<0.0365	0.0223	0.014	
EMHQ-LBE-04-B	F^-	0.0707	0.0708	0.000	
EMHQ-LBE-04-B	Fe_2O_3	0.119	0.12	-0.001	
EMHQ-LBE-04-B	K_2O	0.0592	0.0557	0.004	
EMHQ-LBE-04-B	Li_2O	1.96	1.85	0.110	6%
EMHQ-LBE-04-B	MgO	0.203	0.197	0.006	
EMHQ-LBE-04-B	MnO	<0.0129	<0.0129	0.000	
EMHQ-LBE-04-B	Na_2O	11.6	11.5	0.100	1%
EMHQ-LBE-04-B	P_2O_5	<0.229	0.144	0.085	
EMHQ-LBE-04-B	SiO_2	48.8	47.8	1.000	2%
EMHQ-LBE-04-B	SO_3	1.39	1.35	0.040	3%
EMHQ-LBE-04-B	TiO_2	0.0799	0.0746	0.005	
EMHQ-LBE-04-B	V_2O_5	4.27	4.02	0.250	6%
EMHQ-LBE-04-B	ZrO_2	1.88	1.96	-0.080	-4%
EMHQ-LBE-04-B	**Sum of Oxides**	**99.8**	**96.9**	**2.900**	**3%**

3.2 Measured Compositions of the PCT Leachates

Table 3-3 provides the average elemental concentration measurements in mg/L for the PCT leachates. These values have been adjusted using the provided DF of 5 to correct for dilutions performed at PNNL. Note that the measured concentrations of the analytes in the test blank samples were BDL and denoted by a less than symbol (<).

Table 3-3. Average PCT Leachate Measurements (mg/L)

PNNL ID	B	Li	Na	Si
EMHQ-LBE-04-B-PCT-A	32.5	8.33	81.8	93.0
EMHQ-LBE-04-B-PCT-B	34.6	8.75	86.8	96.0
EMHQ-LBE-04-B-PCT-C	29.5	7.40	76.8	94.0
ARM-1-STD-GLASS-PCT-A-020822	19.2	15.8	41.7	68.0
ARM-1-STD-GLASS-PCT-B-020822	18.6	14.2	40.4	66.8
ARM-1-STD-GLASS-PCT-C-020822	18.1	13.8	40.4	66.0
MQ-WATER BLANK-PCT-A-020822	<5.00	<5.00	<5.00	<5.00
MQ-WATER BLANK-PCT-B-020822	<5.00	<5.00	<5.00	<5.00

Table B-1 in Appendix B provides the elemental concentration measurements in mg/L for the PCT leachates and standard solutions as measured by ICP-OES in analytical sequence. These values are shown as received from the analytical laboratory and after using the provided DF of 5 to correct for dilutions performed at PNNL.

Table B-2 in Appendix B provides measurements for the samples of the approved reference material (ARM-1) reference glass included in the PCTs after using the provided DF of 5 to correct for dilutions performed at PNNL. One of the duplicate Li measurements for ARM-1-STD-GLASS-PCT-A-020822 was outside of the control chart values. This is likely due to differences in the ICP-OES calibration curves between the two analysis blocks. The average of the two Li measurements for this sample falls within the control chart values. Note that all other measured concentrations of the analytes fell within control chart values indicating proper test performance.[16]

Following the guidance in ASTM C1285,[6] the mean, standard deviation, and percent relative standard deviation (%RSD) were determined for each element present in the solution standard for each analytical block. As shown in Table B-3 in Appendix B, the mean value for each analytical block was found to be less than 10% from the reference value (i.e., a percent relative bias less than 10%), and the %RSD was less than 10% for each element. Thus, these analytical results are acceptable per the criteria in ASTM C1285[6], which indicates no significant issues with the analytical outcomes for the measurements of the PCT leachates.

3.3 Normalization of PCT Data

The PCT leachate data were used to determine normalized concentrations for each element of interest using both the targeted and average measured compositions[15] of the glasses following the expression given in ASTM C1285.[6]

$$NC_i = \frac{c_i(sample)}{f_i}$$

where NC_i is the normalized concentration in units of $g_{\text{waste form}}/L_{\text{leachant}}$, $c_i(sample)$ is the concentration of element "*i*" in the leachate in units of g_i/L (corrected for the dilutions performed at PNNL), and f_i is the mass fraction of element "*i*" in the unleached glass in units of g_i/g_{glass}.[b]

An equation was developed to allow for calculation of the NC_i values using the units of measurement provided with the analytical results for this study and to accommodate the triplicate leachate measurements for each of the study glasses. Note that the symbols in this second equation were kept consistent with those used in ASTM C1285,[6] but the units of measurement differ. The common logarithm of the normalized concentration for each element "*i*" (NC_i) for each of the study glasses was determined using the equation:

$$\log_{10}(NC_i) = \overline{\log_{10} c_i} - [1 + \log_{10} f_i]$$

where NC_i remains in units of $g_{\text{waste form}}/L_{\text{leachant}}$, $\overline{\log_{10} c_i}$ is the average of the common logarithms of the measured concentrations of element "*i*" in the triplicate leachates in units of mg/L (corrected for the dilutions performed at PNNL as discussed in Section 3.2), and $\log_{10} f_i$ is either the common logarithm of the targeted concentration of element "*i*" in the glass in units of wt.% or the common logarithm of the average measured concentration of element "*i*" in the glass in units of wt.% (reported in Table 3-1).

Table 3-4 provides the normalized PCT responses for B, Li, Na, and Si, for each of the EMHQ-LBE-04-B study glass as well as the response for the ARM-1 reference glass[17]. The results are grouped by compositional view.

The NC_B, NC_{Na}, and NC_{Si} values fell below 4 g/L for all glasses, meeting the WTP constraints.[c]

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[b] Note that the waste forms in this study were assumed to be of similar density. The PCT-A reference volume of leachant to sample mass ratio was used, and the 100 to 200 mesh reference particle size was used. Thus, no adjustment for the density of the glasses was made in normalizing the PCT results. Data provided in the appendices of this report allow for the calculation of normalized elemental mass loss (NL_i) if glass densities are measured at a later date.

[c] Contract DE-AC27-01RV14136, as amended, U.S. Department of Energy, Richland, WA (2000).

Table 3-4. Normalized PCT Results (g/L)

Glass ID	Comp. View	NC_B (g/L)	NC_{Li} (g/L)	NC_{Na} (g/L)	NC_{Si} (g/L)
EMHQ-LBE-04-B	Target	0.0.764	1.05	1.12	0.407
EMHQ-LBE-04-B	Measured	0.812	0.893	0.948	0.413
ARM-1-STD-GLASS-PCT-020822	Reference	0.528	0.615	0.568	0.308
EMHQ-LBE-04[15]	Target	0.856	1.19	1.22	0.397
EMHQ-LBE-04[15]	Measured	0.932	1.07	1.04	0.412
EMHQ-LBE-STD[15]	Reference	0.469	0.621	0.478	0.281

4.0 Summary

Chemical analyses were performed on a sample of the EMHQ-LBE-04-B glass.The relative differences between the targeted and measured concentrations of Li_2O, Na_2O, and SO_3 for the glass were greater than 10%. The relative differences between the measured compositions of the EMHQ-LBE-04-B and EMHQ-LBE-04 glasses were all less than 10%.

The measured and targeted EMHQ-04-LBE-B glass compositions were used in the normalization of the Product Consistency Test results. The NC_B, NC_{Na}, and NC_{Si} values were less than the WTP low-activity waste constraint of 4 g/L. The measured concentrations of the analytes in the test blank samples included with the PCT leachates were below detection limits. The average measured concentrations of B, Li, Na, and Si for the ARM-1 glass fell within control chart values indicating proper test performance.

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Appendix A. Tables Supporting the Glass Composition Measurements of EMHQ-LBE-04-B

Table A-1. KH Measurements (wt.%) of the LRM Glass and EMHQ-LBE-04-B

PNNL ID	Lab ID	Cl^-	F^-
LRM	LRM	<0.0250	0.904
EMHQ-LBE-04-B	S-13644	0.0667	0.0705
EMHQ-LBE-04-B	S-13644	0.0741	0.0709

Table A-2. LM Measurements (wt.%) of the LRM Glass and EMHQ-LBE-04-B

PNNL ID	Lab ID	Ca	Cr	Fe	K	Mg	Mn	Na	S	Ti	V	Zr
LRM	LRM	0.365	0.131	0.949	1.15	0.0658	0.0622	15.1	0.0858	0.0604	<0.100	0.659
EMHQ-LBE-04-B	S-13644	9.10	<0.0250	0.0836	0.0464	0.122	<0.0100	8.67	0.553	0.0478	2.40	1.39
EMHQ-LBE-04-B	S-13644	9.04	<0.0250	0.0822	0.0519	0.123	<0.0100	8.51	0.558	0.0480	2.38	1.40

Table A-3. PF Measurements (wt.%) of the LRM Glass and EMHQ-LBE-04-B

PNNL ID	Lab ID	Al	B	Li	P	Si
LRM	LRM	5.22	2.28	<0.100	0.204	25.1
EMHQ-LBE-04-B	S-13644	1.90	3.92	0.906	<0.100	22.5
EMHQ-LBE-04-B	S-13644	1.93	3.98	0.911	<0.100	23.1

Table A-4. Comparison of Measured and Reference Compositions for the LRM Glass

PNNL ID	Oxide	Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LRM	Al_2O_3	9.86	9.51	0.353	4%
LRM	B_2O_3	7.34	7.85	-0.509	-6%
LRM	CaO	0.511	0.54	-0.029	
LRM	Cl^-	<0.025	0	0.025	
LRM	Cr_2O_3	0.191	0.19	0.001	
LRM	F^-	0.904	0.86	0.044	
LRM	Fe_2O_3	1.36	1.38	-0.023	-2%
LRM	K_2O	1.39	1.48	-0.095	-6%
LRM	Li_2O	<0.215	0.11	0.105	
LRM	MgO	0.109	0.1	0.009	
LRM	MnO	0.0803	0.08	0	
LRM	Na_2O	20.4	20	0.325	2%
LRM	P_2O_5	0.467	0.54	-0.073	
LRM	SiO_2	53.7	54.2	-0.504	-1%
LRM	SO_3	0.214	0.3	-0.086	
LRM	TiO_2	0.101	0.1	0.001	
LRM	V_2O_5	<0.179	0	0.179	
LRM	ZrO_2	0.89	0.93	-0.04	
LRM	**Sum of Oxides**	**97.9**	**98.1**	**-0.235**	**0%**

Appendix B. Tables Containing the Measurement Data for the EMHQ-LBE-04-B PCT Leachates

Table B-1. PCT Measurements (mg/L)

				As Received Measurements					Dilution-Corrected Measurements			
PNNL ID	**Block**	**Seq**	**Lab ID**	**B**	**Li**	**Na**	**Si**	**DF**	**B**	**Li**	**Na**	**Si**
PCT std	1	1	PCT std 1	19.5	10.4	79.1	49.9	**1**	19.5	10.4	79.1	49.9
EMHQ-LBE-04-B-PCT-B	1	2	S-13648	6.75	1.73	16.9	19.0	**5**	33.8	8.65	84.5	95.0
ARM-1-STD-GLASS-PCT-C-020822	1	3	S-13652	3.43	2.86	7.89	12.9	**5**	17.2	14.3	39.5	64.5
EMHQ-LBE-04-B-PCT-A	1	4	S-13647	6.27	1.62	15.7	18.3	**5**	31.4	8.10	78.5	91.5
MQ-WATER BLANK-PCT-A-020822	1	5	S-13653	<1.00	<1.00	<1.00	<1.00	**5**	<5.00	<5.00	<5.00	<5.00
PCT std	1	6	PCT std 2	19.7	10.9	80.6	50.5	**1**	19.7	10.9	80.6	50.5
MQ-WATER BLANK-PCT-B-020822	1	7	S-13654	<1.00	<1.00	<1.00	<1.00	**5**	<5.00	<5.00	<5.00	<5.00
EMHQ-LBE-04-B-PCT-C	1	8	S-13649	5.62	1.41	14.6	18.3	**5**	28.1	7.05	73.0	91.5
ARM-1-STD-GLASS-PCT-A-020822	1	9	S-13650	3.61	2.97	8.02	13.2	**5**	18.1	14.9	40.1	66.0
ARM-1-STD-GLASS-PCT-B-020822	1	10	S-13651	3.48	2.91	7.72	12.9	**5**	17.4	14.6	38.6	64.5
PCT std	1	11	PCT std 3	18.9	10.1	75.9	48.7	**1**	18.9	10.1	75.9	48.7
PCT std	2	1	PCT std 1	20.6	10.9	85.4	51.6	**1**	20.6	10.9	85.4	51.6
EMHQ-LBE-04-B-PCT-B	2	2	S-13648	7.05	1.77	17.8	19.4	**5**	35.3	8.85	89.0	97.0
ARM-1-STD-GLASS-PCT-C-020822	2	3	S-13652	3.77	2.65	8.23	13.5	**5**	18.9	13.3	41.2	67.5
EMHQ-LBE-04-B-PCT-A	2	4	S-13647	6.69	1.71	17.0	18.9	**5**	33.5	8.55	85.0	94.5
MQ-WATER BLANK-PCT-A-020822	2	5	S-13653	<1.00	<1.00	<1.00	<1.00	**5**	<5.00	<5.00	<5.00	<5.00
PCT std	2	6	PCT std 2	19.9	10.5	81.7	50.5	**1**	19.9	10.5	81.7	50.5
MQ-WATER BLANK-PCT-B-020822	2	7	S-13654	<1.00	<1.00	<1.00	<1.00	**5**	<5.00	<5.00	<5.00	<5.00
EMHQ-LBE-04-B-PCT-C	2	8	S-13649	6.16	1.55	16.1	19.3	**5**	30.8	7.75	80.5	96.5
ARM-1-STD-GLASS-PCT-A-020822	2	9	S-13650	4.06	3.32	8.64	14.0	**5**	20.3	16.6	43.2	70.0
ARM-1-STD-GLASS-PCT-B-020822	2	10	S-13651	3.93	2.76	8.43	13.8	**5**	19.7	13.8	42.2	69.0
PCT std	2	11	PCT std 3	20.6	10.9	84.3	51.9	**1**	20.6	10.9	84.3	51.9

Table B-2. Dilution-Corrected ARM-1 Leachate Measurements (mg/L)

PNNL ID	Lab ID	B	Li	Na	Si
ARM-1-STD-GLASS-PCT-A-020822	S-13650	18.1	14.9	40.1	66.0
ARM-1-STD-GLASS-PCT-B-020822	S-13651	17.4	14.6	38.6	64.5
ARM-1-STD-GLASS-PCT-C-020822	S-13652	17.2	14.3	39.5	64.5
ARM-1-STD-GLASS-PCT-A-020822	S-13650	20.3	16.6	43.2	70.0
ARM-1-STD-GLASS-PCT-B-020822	S-13651	19.7	13.8	42.2	69.0
ARM-1-STD-GLASS-PCT-C-020822	S-13652	18.9	13.3	41.2	67.5

Ranges of Expected Test Results for ARM-1[d]
Boron: 12.89 – 22.65 mg/L (17.7 ± 4.89 mg/L)
Lithium: 10.80 – 16.32 mg/L (13.6 ± 2.76 mg/L)
Sodium: 28.86 – 43.58 mg/L (36.2 ± 7.36 mg/L)
Silicon: 49.03 – 73.43 mg/L (61.2 ± 12.2 mg/L)
Values that fall outside of the reference ranges are shaded grey.

[d] C.M. Jantzen, J.B. Pickett, K.G. Brown, T.B. Edwards, and D.C. Beam, "Process/Product Models for the Defense Waste Processing Facility (DWPF): Part I. Predicting Glass Durability from Composition Using a Thermodynamic Hydration Energy Reaction Model (THERMO)," Westinghouse Savannah River Company, Aiken, SC, WSRC-TR-93-672, Rev. 1, 1995.

Table B-3. Results from Samples of the Multi-Element Solution Standard Included with the PCT Leachates

Analytical Block	1	2	Reference Values (mg/L)
Mean (B (mg/L))	19.4	20.4	20.0
Mean (Li (mg/L))	10.5	10.8	10.0
Mean (Na (mg/L))	78.5	83.8	81.0
Mean (Si (mg/L))	49.7	51.3	50.0
% relative bias, B	-3.2	1.8	<10% per ASTM C1285
% relative bias, Li	4.7	7.7	
% relative bias, Na	-3.0	3.5	
% relative bias, Si	-0.6	2.7	
Standard Deviation (B (mg/L))	0.42	0.40	
Standard Deviation (Li (mg/L))	0.40	0.23	
Standard Deviation (Na (mg/L))	2.40	1.90	
Standard Deviation (Si (mg/L))	0.92	0.74	
%RSD (B)	2.1	2.0	<10% per ASTM C1285
%RSD (Li)	3.9	2.1	
%RSD (Na)	3.1	2.3	
%RSD (Si)	1.8	1.4	

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