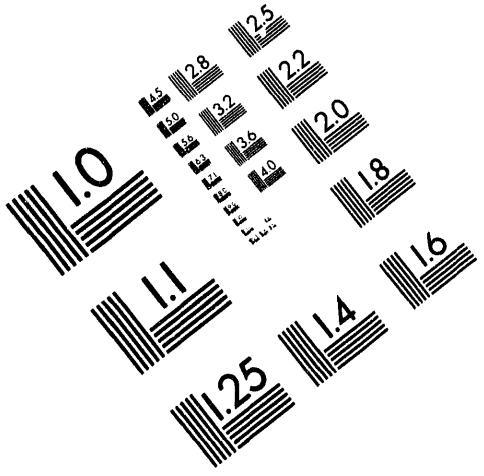
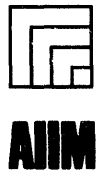
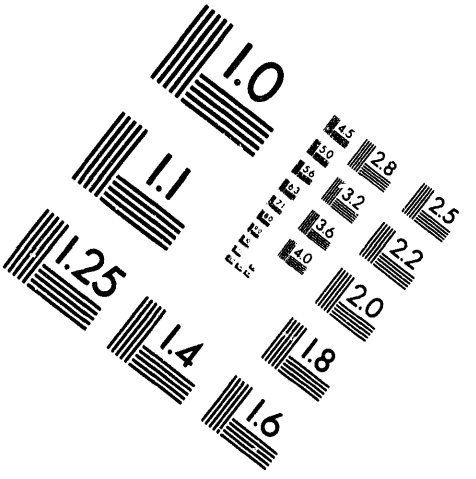
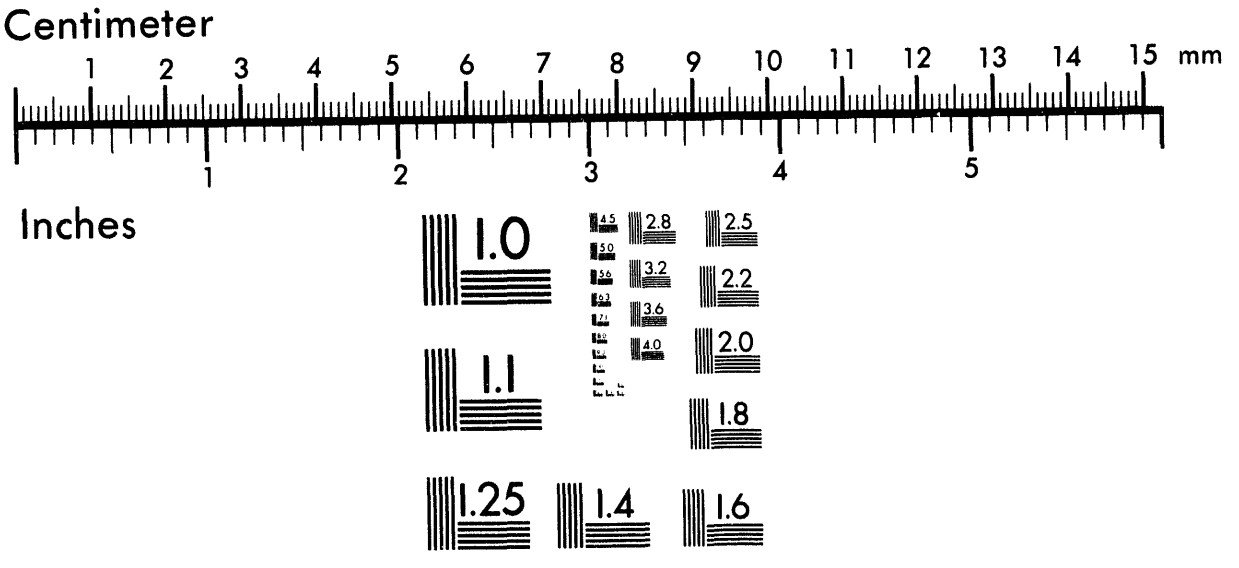
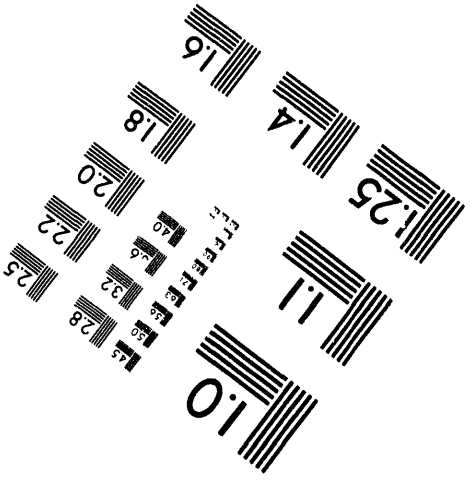


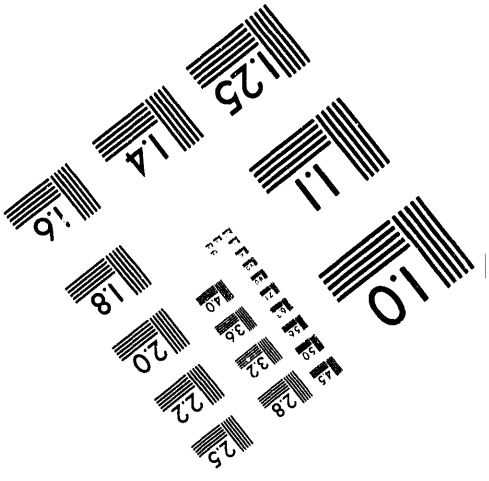


Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202









1 of 1

Conf-940815--40

WSRC-MS-94-00282

Keywords: DWPF, Product Control, Waste Acceptance

EFFECT OF MELTER RESIDENCE TIME AND TEMPERATURE ON DEFENSE WASTE PROCESSING FACILITY GLASS DURABILITY

by

Connie A. Cicero

Westinghouse Savannah River Company
Savannah River Technology Center
P.O. Box 616
Aiken, SC 29802

A Paper Proposed for Publication in the Proceedings of Spectrum '94: International Nuclear and Hazardous Waste Management meeting, August 14-18, 1994, in Atlanta, Georgia.

M. Allen Rodriguez
Authorized Derivative Classifier

DISCLAIMER

EFFECT OF MELTER RESIDENCE TIME AND TEMPERATURE ON DEFENSE WASTE PROCESSING FACILITY GLASS DURABILITY

Connie A. Cicero
Westinghouse Savannah River Company
Savannah River Technology Center
P. O. Box 616
Aiken, South Carolina 29802
(803) 725-5306

ABSTRACT

The Defense Waste Processing Facility (DWPF) located at the Savannah River Site (SRS) in Aiken, South Carolina, is currently scheduled to vitrify more than 130 million liters of High Level Waste (HLW). The glass product that will be produced must meet certain specifications, as defined in the Waste Acceptance Product Specifications (WAPS)[1], in order for the DWPF canistered waste forms to be sent to the Civilian Radioactive Waste Management System (repository). WAPS 1.3 requires that the DWPF produce a consistent product, which is better than the Environmental Assessment (EA) glass as measured by the B, Na, and Li release from the Product Consistency Test (PCT)[2].

An important part of the DWPF's Glass Product Control Program (GPCP) is ensuring that slurry feed is sufficiently reacted to achieve a durable product which satisfies the product consistency specification. The purpose of this study was to determine the minimum melter residence time and temperature necessary to develop a consistent product in terms of durability. Results indicate that simulated DWPF Batch 1 and/or Purex feed will produce a durable product when melted for a minimum of 0.25 hours at 1150° and 1050°C, for a minimum of 0.5 hours at 950°C, and for a minimum of 1 hour at 850°C. In fact, durabilities of the glasses, as measured by the PCT, were only slightly affected by increasing melter residence time at melting temperatures of 1150, 1050, and 950°C, but were more noticeably affected for increasing melter residence times at a melting temperature of 850°C.

The results of this study are in agreement with the results found by D.F. Bickford, et al., in their work with DWPF Scale Glass Melter (SGM) glass and West Valley Demonstration Project (WVDP) Slurry-Fed (SF) melter glass.[3] The primary difference between this study and the earlier study is that the DWPF PCT was performed on the glasses in this task, whereas it was not performed previously. This information is required for WAPS 1.3.

I. INTRODUCTION

In order for the DWPF canistered waste forms to be sent to a federal repository, they must meet the requirements of the WAPS. Specification 1.3 of the WAPS requires that the DWPF produce a consistent product, which is better than the EA glass as measured by the B, Na, and Li release on the PCT.[1] The DWPF strategy for compliance, the GPCP, is based on the tenet of control of feed composition. One of the GPCP's main principles is that the chemical composition of the glass and the uniformity of feed to the melter are the only parameters that the DWPF can directly control which affect the results of the PCT. Thus the objectives of these studies are to prove that melting time and temperature, which are under direct control by the DWPF, have very little effect on glass durability.

This hypothesis was supported by isothermal fusions of four simulated waste glass types performed by D.F. Bickford, et al., to determine the minimum melter residence time and temperature necessary for minimal glass leachability. Slurry samples from the DWPF-SGM demonstrations performed at the Engineering Test Facility (ETF) and a surrogate of slurry feed from the WVDP were used as typical melter feeds. Approximately 30 mL samples were fused for 0.25, 0.5, 1, 2, and 4 hours at 650, 750, 850, 950, and 1150°C.[3]

Bickford, et al., found that fusion of feed samples occurred in about 15 minutes at 1150°C, which is the nominal DWPF operating temperature. Extending the fusion time to 4 hours improved glass durability only slightly. In fact, they reported that most of the homogenization and improvement in leach resistance occurred within the first hour of melting, at

temperatures as low as 850°C. The x-ray diffraction (XRD) data presented in the report supports this finding, since it indicates essentially complete ground silica dissolution in molten waste glass occurring after only 1 hour at 850°C.[3]

Though these conclusions were sufficient to satisfy the melter residence time and temperature issue, the standard DWPF durability test, the PCT, was not developed at that time and a modified Corning Glass Works (CGW) powder leach test method was performed instead. The CGW test used 1 gram samples of <200 diameter powder that was heated for 2 hours at 80°C in 100 mL of deionized water contained in sealed 250 mL polyethylene bottles. The leachate was decanted after cooling and the pH was determined. The leachates were then treated with one drop of ultrex nitric acid and digested for 24 hours at 80°C, so they could be analyzed by inductively coupled plasma emission spectroscopy (ICPES).[3] Though this method produced consistent data, an accurate estimate of the B, Na, and Li leachate concentrations based on the PCT was later needed to fulfill the requirements of the WAPS.

Bickford's studies focused on lower melting temperatures, so temperatures that better represented the temperatures possible during vitrification and pouring of the glass in the DWPF melter were selected for the current experiments. The temperatures selected were 850, 950, 1050, and 1150°C. As stated earlier, the nominal operating temperature of the DWPF melter is 1150°C, however, the minimum melter operating temperature is 1050°C, while the minimum pour spout temperature is 950°C. Before glass pouring can be initiated, the lower glass temperature must be greater than 1090°C and the pour spout must be greater than 1050°C. The 850°C testing temperature was chosen for conservatism.

One other difference that should be noted between this experiment and Bickford's is the use of Precipitate Hydrolysis Aqueous (PHA) in the feed stream. At the time Bickford's experiments were performed, the DWPF was a sludge only process, i.e. melter feed contained only sludge and frit, so the effect of the PHA on the reaction time needed to be studied in more detail. Although the sludge only process consisted of 2 feed streams and the current process consists of 3 feed streams, the overall feed composition and glass composition were very similar.

II. EXPERIMENTAL

Fusions of simulated DWPF feed were conducted to determine the minimum melter residence time and temperature for acceptable glass leachability. Feed with a composition similar to the DWPF's Batch 1 feed was used as typical melter feed. The feed was prepared from simulated PHA from the Precipitate Hydrolysis Experimental Facility (PHEF)-Run 62, simulated sludge from Drum 14 (Blend type) of 774-A, and Frit 202. A representative oxide composition of the PHA, sludge, and frit based on analyses performed by the Savannah River Technology Center's (SRTC) Analytical Development Section (ADS) is given in Table 1.

Table 1 - Batch 1 Feed Material Compositions

Oxide	Run 62 PHA (wt%)	Drum 14 Sludge (wt%)	Frit 202 (wt%)
Al_2O_3	0.124	11.993	0.541
B_2O_3	27.057	0.472	8.232
BaO	ND	ND	0.022
CaO	0.431	4.582	0.001
Cr_2O_3	ND	0.393	0.006
Cs_2O	0.843	ND	ND
CuO	3.810	0.349	ND
Fe_2O_3	0.142	44.438	0.002
K_2O	32.979	0.470	0.425
Li_2O	ND	0.195	6.547
MgO	0.435	0.152	1.876
MnO_2	ND	7.177	ND
Na_2O	31.053	15.217	6.574
NiO	ND	3.396	0.006
P_2O_5	ND	0.306	ND
PbO	ND	ND	0.010
SiO_2	0.126	9.785	75.620
SrO	ND	0.152	ND
TiO_2	3.001	0.041	0.116
ZnO	ND	0.718	ND
ZrO2	ND	0.006	0.034
Totals	100.000	99.482	100.000

The batch materials were mixed in the expected DWPF ratio of 8 wt% PHA, 28 wt% sludge, and 64 wt% frit based on a dry oxide basis. To best represent the conditions of the DWPF, the PHA and sludge were mixed in a 2:1 ratio and then dried overnight. The amount of frit to be added was calculated based on the mass of hydrous oxides present in the sludge and PHA and the 64% frit to 36% waste ratio. The calculated amount of frit was added, along with 3 wt% nitric acid to adjust the redox of the glass, and then the feed was dried overnight again. Approximately 50 grams of dried feed were placed in covered high purity (99.8%) alumina crucibles for each sample. The crucibles of feed were fused for 0.25, 0.5, 1, 2, and 4 hours at temperatures of 850, 950, 1050, and 1150°C in a preheated programmable Lindberg furnace. They were removed after the specified time and air-cooled to room temperature.

Feed samples were also melted at times bracketing the predetermined melting times to ensure that no unusual reactions were occurring in the interval melting times or for extended melting times. The times and associated temperatures selected were 6 and 1.5 hours at 1150°C, 0.75 hours at 1050°C, 3 and 0.75 hours at 950°C, and 6 and 3 hours at 850°C.

Since there was not enough Drum 14 sludge to fabricate these glasses, Drum 13 sludge was obtained and used instead. This sludge is actually closer to the DWPF's Purex composition, but Bickford's results found that minor composition changes had little effect on the time necessary to produce an acceptable glass[3], so the substitution was not expected to affect the overall results. To ensure that the results would not be affected, remelts of the predetermined times and temperatures were performed with Purex feed to ensure that they reacted in the same time period as the Batch 1 glasses did. The representative oxide composition of the simulated PHA from PHEF Run 65, simulated sludge from Drum 13 (Purex type) of 774-A, and Frit 202 are contained in Table 2. The Purex type sludge was mixed with the PHA and frit utilizing the same method used for the Batch 1 sludge.

Table 2 - Purex Feed Material Compositions

Oxide	Run 65 PHA (wt%)	Drum 13 Sludge (wt%)	Frit 202 (wt%)
Al_2O_3	0.004	13.108	0.541
B_2O_3	25.870	0.626	8.232
BaO	ND	0.002	0.022
CaO	0.433	3.210	0.001
Cr_2O_3	ND	0.433	0.006
Cs_2O	0.048	ND	ND
CuO	3.839	0.290	ND
Fe_2O_3	0.005	46.227	0.002
K_2O	37.428	NA	0.425
Li_2O	ND	0.273	6.547
MgO	0.400	0.186	1.876
MnO_2	ND	5.625	ND
Na_2O	28.530	11.394	6.574
NiO	ND	2.713	0.006
P_2O_5	ND	0.359	ND
PbO	ND	0.032	0.010
SiO_2	0.024	14.940	75.620
SrO	ND	0.097	ND
TiO_2	3.420	0.043	0.116
ZnO	ND	0.261	ND
ZrO2	ND	0.024	0.034
Totals	100.000	99.843	100.000

After the glasses had cooled and were removed from the crucibles, they were analyzed for chemical composition, phase assemblage, redox state, and durability. The chemical compositions of the fabricated glasses were determined using ICPES and Atomic Adsorption (AA) analyses. The glass samples were dissolved by Na_2O_2 with a HCl uptake for ICPES analysis and by microwave dissolution for AA and ICPES (for Na, Ni, and Zr) analyses. These analyses are helpful in determining how close the surrogate came to the projected composition and in accurately normalizing the PCT results.

XRD and Scanning Electron Microscopy (SEM) were used to identify the crystalline phases present in each glass sample. XRD samples were prepared by adding 10 wt% silicon to <200 mesh powder of each glass. The major peaks present in each sample were identified and the ratio of the integrated intensity of the reflection from the peak to the integrated intensity of the Si_{111} reflection calculated. This method is known as the "internal standard" technique.[4] Standard calibration curves generated for previous SRTC researchers[5-8] were used to calculate the volume fraction of the crystalline species present in

each sample. Previous experiments indicated an accuracy of ±1-2 vol% for the heavier crystalline phases and ±5-10 vol% for the lighter species. SEM was performed to confirm the XRD results and to determine the chemical composition of the crystalline phases present.

A representative piece of glass from each sample was submitted for iron redox analysis using the colorimetric method. The DWPF has established a $Fe^{2+}/\sum Fe$ limit of 0.10, since higher ratios tend to cause precipitation of metallic phases and can lead to damage of the melter electrodes.[9] In order for the glass samples to be truly representative of DWPF vitrified glass, their iron redox ratios should also abide by this limit. Iron redox also plays an important role in determining the durability of glass, since Fe^{2+} acts as a network modifier which decreases durability, while Fe^{3+} can be a network former which increases durability.

Durability was assessed using the PCT procedure.[2] This method required glass samples to be ground and sieved to a 100-200 mesh powder and then washed with ASTM Type I water and absolute alcohol and dried before performance of the test. The actual PCT consisted of placing three and a half grams of glass and 35 mL of ASTM Type I water in a Teflon® vessel, which was leached for 7 days at 90°C. The resulting leachates were filtered using a 0.45 μm filter to remove colloids and/or particulates and analyzed for pH and elemental concentrations using ICPES and AA analyses. The main elements of interest for the WAPS are B, Na, and Li.

III. RESULTS AND DISCUSSION

After fusion, all samples were visually examined for determination of how completely the feed material reacted. All samples appeared to produce glass except for the 850°C-0.25 hour sample. However, appearance alone gives no insight into the durability of the vitrified product.

The simulated Batch 1 feed for this task was batched four separate times, but the composition was fairly consistent. The average glass composition and composition range, based on analyses of the simulated Batch 1 feed glass, along with the theoretical batched composition, are given in Table 3. As can be seen from the average glass composition, the major glass components were close to the expected theoretical batched composition. The Na_2O, K_2O, and B_2O_3 average contributions were a little higher than expected, while the Al_2O_3 and Fe_2O_3 average contributions were a little lower than expected. This fact would tend to make the PCT results more conservative since the glass would be less durable. These observations possibly also indicate that the sludge loading was a little low and the PHA content was a little high.

Table 3 - Simulated Batch 1 Glass Composition

Oxide	Theoretical (wt%)	Average (wt%)	Range (wt%)
Al_2O_3	3.714	2.610	2.088 - 4.454
B_2O_3	7.565	9.164	8.482 - 9.610
BaO	0.014	0.016	0.012 - 0.020
CaO	1.318	1.083	0.906 - 1.345
Cr_2O_3	0.114	0.081	0.057 - 0.112
CuO	0.403	0.615	0.462 - 0.859
Fe_2O_3	12.455	8.148	6.885 - 9.162
K_2O	3.042	5.839	4.562 - 9.755
Li_2O	4.245	4.161	2.899 - 4.624
MgO	1.278	1.373	1.308 - 1.502
MnO_2	2.010	1.906	1.633 - 2.168
Na_2O	10.952	11.159	10.645 - 11.891
NiO	0.955	0.652	0.543 - 0.742
SiO_2	51.145	50.682	48.109 - 55.992
TiO_2	0.326	0.591	0.355 - 0.859
ZnO	0.201	0.202	0.109 - 0.269
ZrO_2	0.023	0.011	0.004 - 0.045
Totals	99.760	98.337	

As mentioned earlier, simulated Purex feed was used to melt additional glasses. The theoretical batched composition, the average glass composition, and composition range of the simulated Purex feed glasses are contained in Table 4. As was the case with the Batch 1 glasses, the major oxide average composition is close to the expected theoretical batch composition.

Also, the B_2O_3 concentration was a little higher than expected once again, while the SiO_2, Al_2O_3, and Fe_2O_3 concentration were a little less than expected. However, these variations did not seem to affect the durability of the simulated Purex glasses.

Table 4 - Simulated Purex Glass Composition

Oxide	Theoretical (wt%)	Average (wt%)	Range (wt%)
Al_2O_3	4.017	3.669	2.675 - 5.968
B_2O_3	7.513	8.390	7.856 - 8.958
BaO	0.015	0.004	0.000 - 0.008
CaO	0.934	1.456	1.194 - 1.833
Cr_2O_3	0.125	0.110	0.056 - 0.181
CuO	0.388	0.680	0.550 - 0.787
Fe_2O_3	12.945	11.228	8.632 - 12.967
K_2O	3.266	2.870	2.534 - 3.770
Li_2O	4.267	4.073	3.726 - 4.372
MgO	1.285	1.367	1.267 - 1.462
MnO_2	1.575	2.604	2.259 - 3.065
Na_2O	9.680	9.931	9.382 - 11.270
NiO	0.763	0.894	0.752 - 1.007
SiO_2	52.580	50.274	46.722 - 54.211
TiO_2	0.360	0.518	0.434 - 0.584
ZnO	0.073	0.064	0.034 - 0.090
ZrO_2	0.028	0.007	0.003 - 0.019
Totals	99.797	98.138	

XRD analysis of the -200 mesh ground glass indicated that small amounts of trevorite ($NiFe_2O_4$) were present in most of the glasses, while quartz (SiO_2) was also present in the glass melted at 850°C for 0.25 hours. As mentioned earlier, the 850°C-0.25 hour sample was the only one fabricated that did not produce a glass. The absence of a separate silica phase in almost all of the glass samples supports the conclusion that the glasses were completely reacted. SEM analysis was also performed on the glasses to verify the phase assemblage determined by XRD. The quantitative XRD results on a volume percentage crystallinity basis and the qualitative SEM results for the Batch 1 feed glasses are given in Table 5. Quantitative XRD was not performed on the Purex batch glasses, so only the phases detected and the SEM results are shown. By observing the XRD results in this table, it can be seen that the amount of crystals present in the samples increased as the melter residence time decreased. As a general rule, an increase in crystallization usually leads to a decrease in glass durability.

Table 5 - Phase Assemblage Results

Sample (°C-hrs)	XRD Result	SEM Result	Sample (°C-hrs)	XRD Result	SEM Result
1150-4	ND	Clean Glass	950-4	0.5% Trevorite	Clean Glass
1150-2	ND	Clean Glass	950-2	0.5% Trevorite	Trevorite (Mn,Fe,Ni,Cr)
1150-1	ND	Clean Glass	950-1	0.6% Trevorite	Trevorite (Mn,Fe,Ni)
1150-0.5	ND	Clean Glass	950-0.5	0.8% Trevorite	Trevorite (Mn,Fe,Ni)
1150-0.25	ND	Clean Glass	950-0.25	1.9% Trevorite	None detected
1050-4	ND	Clean Glass	850-4	1.4% Trevorite	Trevorite (Mn,Fe,Ni,Ti,Cr)
1050-2	ND	Clean Glass	850-2	1.4% Trevorite	Trevorite (Mn,Fe,Ni,Ti,Cr)
1050-1	0.3% Trevorite	Trevorite (Mn,Fe,Ni)	850-1	1.4% Trevorite	Trevorite (Mn,Fe,Ni,Ti,Cr)
1050-0.5	0.3% Trevorite	Trevorite (Mn,Fe,Ni,Ti)	850-0.5	3.0% Trevorite	Trevorite (Mn,Fe,Ni,Ti,Cr)
1050-0.25	0.9% Trevorite	Trevorite (Mn,Fe,Ni,Ti,Cr)	850-0.25	3.0% Trevorite, 0.2% Quartz	Trevorite (Mn,Fe,Ni,Ti)
Purex Glasses					
1150-6	ND	Clean Glass	950-3	Trevorite	Trevorite (Mn,Fe,Ni)
1150-1.5	ND	Clean Glass	950-1	Trevorite	Cr Crystals
1150-0.5	Trevorite	Clean Glass	950-0.75	Trevorite	Trevorite (Mn,Fe,Ni)
1050-0.75	ND	Clean Glass	850-6	Trevorite	Trevorite (Mn,Fe,Ni,Cr)
1050-0.5	Trevorite	Trevorite (Mn,Fe,Ni,Cr)	850-4	Trevorite	Trevorite (Mn,Fe,Ni,Cr)
			850-3	Trevorite	Trevorite (Mn,Fe,Ni)

The iron redox results ($Fe^{2+}/\Sigma Fe$) for all glasses produced as determined by ADS using the colorimetric method are given in Table 6. As can be seen from the table, all glasses were well below the $Fe^{2+}/\Sigma Fe$ limit of 0.10 established for the DWPF, except for the Purex remelts at the predetermined times.

Table 6 - Iron Redox Results

Sample (°C-hrs)	$Fe^{2+}/\Sigma Fe$ Ratio	Sample (°C-hrs)	$Fe^{2+}/\Sigma Fe$ Ratio
1150-6(PX)	0.085	950-4	0.015
1150-4	0.085	950-3	0.011
1150-2	0.043	950-2	0.006
1150-1.5	0.051	950-1	0.007
1150-1	0.032	950-1(PX)	0.195
1150-0.5	0.027	950-0.75	0.075
1150 -0.5(PX)	0.196	950-0.5	0.022
1150-0.25	0.029	950-0.25	0.003
1050-4	0.024	850-4	0.002
1050-2	0.014	850-4(PX)	0.138
1050-1	0.011	850-3	0.004
1050-0.75	0.039	850-2	0.032
1050-0.5	0.012	850-1	0.048
1050-0.5(PX)	0.257	850-0.5	0.006
1050-0.25	0.006	850-0.25	0.002

As previously mentioned, the WAPS require that the DWPF produce a consistent product in terms of B, Na, and Li release on the PCT. The PCT was performed on all glass samples produced during this task to determine the B, Na, and Li releases. The normalized PCT results for B, Na, and Li for the Batch 1 glasses, as well as the accepted values for the EA glass PCT results as documented in WSRC-TR-92-346[10], are presented in Table 7.

Table 7 - Normalized Elemental Releases (g/L) for Batch 1 Glasses

Sample	B	Na	Li
1150-4	2.254	1.895	2.949
1150-2	3.557	3.065	3.279
1150-1	3.372	2.881	2.949
1150-0.5	12.708	11.539	8.293
1150-0.25	3.574	2.983	3.234
1050-4	2.297	1.904	2.691
1050-2	2.493	2.138	2.161
1050-1	6.555	5.695	5.561
1050-0.5	12.924	11.463	8.730
1050-0.25	8.871	8.753	7.648
950-4	3.990	3.095	3.324
950-2	10.323	9.111	8.655
950-1	9.179	8.656	7.704
950-0.5	6.862	6.769	6.393
950-0.25	11.009	10.713	9.513
850-4	12.963	11.852	8.437
850-2	7.105	7.356	6.253
850-1	7.183	7.160	6.529
850-0.5	12.291	12.239	10.480
850-0.25	18.540	18.152	15.303
EA Value[10]	16.695	13.346	9.565
EA Std. Dev.[10]	1.390	1.11	0.9

As can be seen from Table 7, the 950°C-0.25 hour sample exceeded the Li EA accepted value when the 2 standard deviations were taken into account, while the 850°C-0.25 hour sample exceeded all of the EA accepted values. This was expected for the 850°C-0.25 hour sample since it did not produce glass. The other major discrepancy that existed in the data was that the 1150°C-0.5 hour, 1050°C-0.5 hour, 950°C-2 hour, 950°C-1 hour, and 850°C-4 hour glasses had B, Na, and Li releases that were not in line with the rest of the glass samples melted at these temperatures (see Table 7). Considering that

samples fused at these temperatures for less time had lower normalized releases, these results seemed suspect. The general trend expected and previously found was that durability decreased as melter residence time decreased.

The PCT results for these glasses did not exceed any of the accepted EA values, but the releases seemed a little high. One explanation why these glasses might not have "fit" with the other glasses was that the K_2O concentration was higher and the SiO_2 concentration was lower than the other Batch 1 glasses, which would tend to make them less durable.

The fabricated Purex glasses were also subjected to the PCT to determine durability. The normalized releases as shown in Table 8 were well below the B, Na, and Li EA glass accepted values. Purex remelts of the glasses melted at the predetermined times and temperatures fit in well with the Batch 1 PCT data points. This further supports Bickford's findings[3] and the notion that problems occurred in batching of the five suspect glasses.

Table 8 - Normalized Elemental Releases (g/L) for Purex Glasses

Sample	B	Na	Li
1150-6	0.658	0.819	0.698
1150-1.5	1.458	1.531	1.359
1150-0.5	1.032	1.014	0.899
1050-0.75	2.508	2.301	2.142
1050-0.5	1.900	1.814	1.123
950-3	2.798	2.780	2.521
950-1	1.560	1.573	1.449
950-0.75	3.863	4.247	3.468
850-6	1.746	1.929	1.640
850-4	1.952	1.957	1.610
850-3	3.317	3.782	2.935
EA Value[10]	16.695	13.346	9.565
EA Std. Dev.[10]	1.390	1.11	0.9

The normalized B, Na, and Li releases for all of the glasses fabricated are shown on Figures 1-3. The Batch 1 glasses are shown on one figure, while the Batch 1 and additional Purex glasses are shown on the adjacent figure. The durabilities of Batch 1 and Purex glasses differ slightly, but the same general trend can be observed.

Figure 1 - Normalized B Release (g/L)

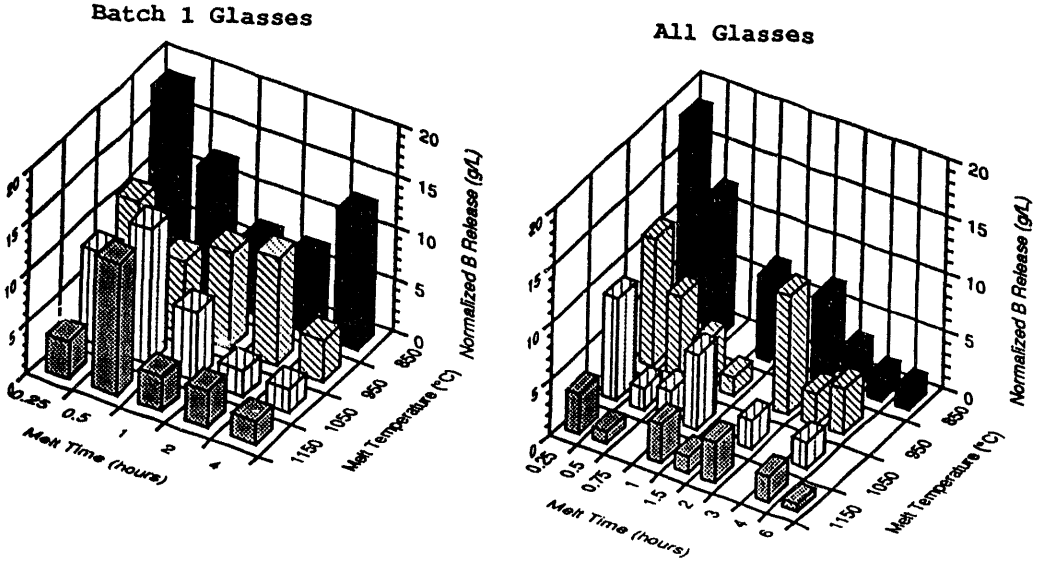


Figure 2 - Normalized Na Release (g/L)

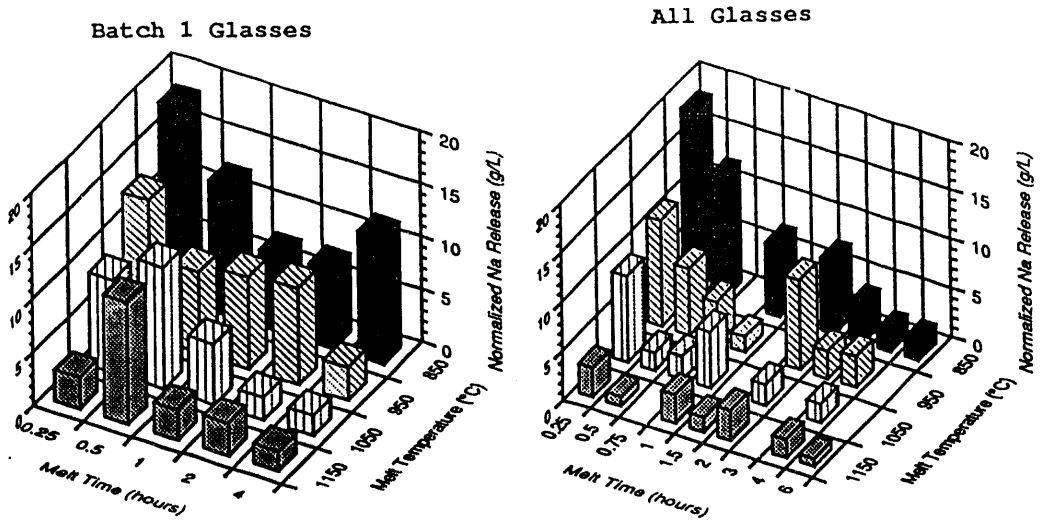
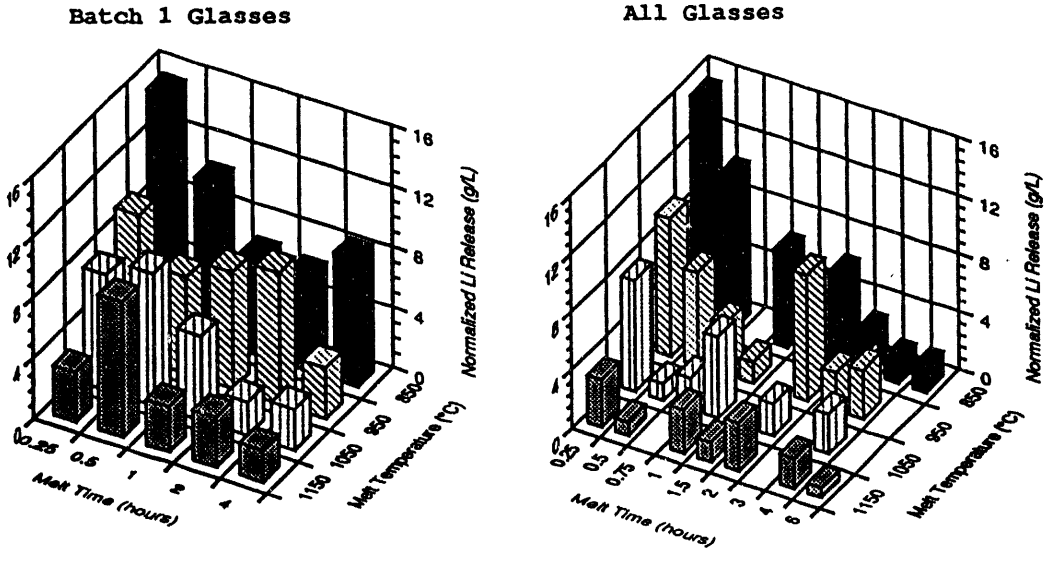


Figure 3 - Normalized Li Release (g/L)



When the normalized releases are presented in these figures, the decrease in durability is easily detected with the decrease in melter residence time and temperature. This was as expected and it was also found in previous research by Bickford.[3] These figures also show that at 1150°C, the durability was only slightly affected by increasing the fusion time from 15 minutes to 4 hours. This observation also held true for the 1050 and 950°C melter residence temperatures. The greatest affect on durability by decreasing melter residence time was shown at 850°C, especially for fusion times shorter than 1 hour.

IV. CONCLUSIONS

As was found in previous research by Bickford, et. al.,[3] increasing fusion times (melter residence times) had little effect on the glasses produced at fusion temperatures (melter residence temperatures) of 1150, 1050, and 950°C, and had only a slight effect on the glasses produced at fusion temperatures of 850°C. All glasses, with the exception of the 950°C-0.25 hour, 850°C-0.5 hour, and 850°C-0.25 hour glasses, performed better than the EA glass when subjected to the PCT. The 950°C-0.25 hour and 850°C-0.5 hour glass performed better than the EA glass for B and Na, but had higher Li releases, while the 850°C-0.25 hour glass exceeded the EA glass for all three elements.

DATE
FILMED
7/18/94

END