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THE IMPACT OF THE PROPOSED ΔG_P LIMITS ON GLASS FORMULATION EFFORTS: Part II. Experimental Results

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EXECUTIVE SUMMARY

The Savannah River National Laboratory (SRNL) has initiated studies to assess alternative durability options that may provide access to compositional regions of interest in support of the accelerated clean-up mission at the Defense Waste Processing Facility (DWPF) (Peeler and Edwards 2004). One of the options being pursued is the redefinition of the durability model acceptability limits. In response, Edwards et al. (2003) identified and eliminated some of the conservative steps utilized in establishing the current limits without compromising the high confidence required for meeting the specification on the waste form quality. The results led to a set of three new Property Acceptability Region (PAR) values for the preliminary glass dissolution estimator (ΔG_P) that has the potential to allow access to compositional regions of interest to improve melt rate or waste loading.

Although these limits are available for implementation (Edwards et al. 2003), there is no driving force to do so with the current sludge batch (i.e., the current Frit 418 – Sludge Batch 3 (SB3) system is T_L limited). The objectives of this task were to investigate (and generate) the incentive of applying the proposed durability limits in the Product Composition Control System (PCCS) from a glass formulation perspective. Glass compositions were identified or developed to transition into and through the region of ΔG_P acceptability as defined by the current and proposed durability limits. The progression through the newly defined acceptability region was accomplished by increasing the total alkali in the glass via higher alkali frits and/or waste loading (WL). The focus of this report is on the measured durability response as it compares to model predictions to assess the applicability and/or potential conservatism of the various limits or durability approaches.

The normalized boron release values (NL [B] g/L) for the study glasses ranged from approximately 1.0 g/L to 2.0 g/L. The Product Consistency Test (PCT) responses provide evidence that implementation of the proposed ΔG_P limits will provide access to higher alkali compositional regions without compromising product quality. In fact, the data provide evidence that the proposed limits may still be overly conservative. These results also provide continued incentive to assess the index system and other durability alternatives to provide access into compositional regions of interest to improve melt rate and waste loading which play a major role in defining waste throughput for DWPF.

Although incentive for implementation of the proposed durability limits (for the pursuit of alternative durability approaches) has been demonstrated through this study in terms of the measured durability response for higher alkali systems, assessments of melt rate should be performed to establish a clear motive or driver for implementation. More specifically, a “significant” increase in melt rate may be required to provide the incentive for DWPF to implement the change rather than a “paper study” incentive or PCT assessment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ADT	Alternative Durability Task
ANOVA	analysis of variance
ARM	Approved Reference Material
ASTM	American Society for Testing and Materials
ccc	canister centerline cooled
DWPF	Defense Waste Processing Facility
ΔG_P	preliminary glass dissolution estimator
EA	Environmental Assessment
ICP – AES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
LAW	low-activity waste
LM	lithium metaborate
MAR	Measurement Acceptability Region
NL [B]	normalized boron release (in g/L)
PAR	Property Acceptability Region
PCCS	Product Composition Control System
PCT	Product Consistency Test
PF	peroxide fusion
QA	quality assurance
SB	sludge batch
SME	Slurry Mix Evaporator
SRNL	Savannah River National Laboratory
SRNL-ML	Savannah River National Laboratory – Mobile Laboratory
T_L	liquidus temperature
TTR	technical task request
U_{STD}	uranium standard
VIS	viscosity
WL	waste loading

1.0 INTRODUCTION

In support of accelerated mission goals, glass formulation efforts have been focused on melt rate and waste loading (WL) which ultimately dictate waste throughput for the Defense Waste Processing Facility (DWPF). With respect to melt rate, the general trend for improvement has been to enhance the total alkali concentration in the glass system by increasing the alkali concentration in the frit (Lambert et al. 2001), utilizing (or targeting) a less washed sludge, or using a combination of the two. Previous assessments have indicated that as higher alkali systems are pursued, a transition can occur in which predictions of durability begin limiting upper waste loadings rather than predictions of liquidus temperature (Peeler and Edwards 2002). Recent results have also suggested that the current durability model can lead to conservative decisions during the Slurry Mix Evaporator (SME) acceptability process (Peeler et al. 2001 and Cozzi et al. 2003). As a result, the model has restricted access to glass compositional regions that could potentially enhance melt rate and/or waste loading by classifying a specific glass composition as "unacceptable" even though experimentally determined durability (as defined by the Product Consistency Test (PCT)) is "acceptable" relative to the Environmental Assessment (EA) glass (WAPS 1996).

Part of the strategy used in establishing current SME acceptability criteria centered on the definition of an "acceptable" free energy of hydration (ΔG_P – preliminary glass dissolution estimator) limit. This limit is currently used to classify a specific SME batch as acceptable (or unacceptable) from a product performance perspective (i.e., durability as measured by the PCT (ASTM 2002)). It is a model-based limit in that its value was developed through the application of models that relate the PCT responses for boron, sodium, and lithium of a glass to the ΔG_P of the glass (Jantzen et al. 1995). The ΔG_P of a glass is determined from the chemical composition. For SME acceptability, the current ΔG_P Property Acceptability Region (PAR) limit is approximately -12.78 kcal/mol (as reported by Brown, Postles, and Edwards (2002)), and a predicted ΔG_P value (based on a measured SME analysis) less than this results in the classification of the SME batch as "unacceptable" from a durability perspective.

Given the known conservatism, Edwards et al. (2003) revisited the technical basis from which the current durability SME acceptability limits were established. The specific objective was to identify and eliminate some of the conservative steps utilized in establishing the current limits without comprising the high confidence required for meeting the specification on the waste form quality. The results led to a set of three new values for ΔG_p: –14.1058, –13.8695, and –14.1991 kcal/mol for boron, lithium, and sodium, respectively. It should be noted that the most conservative limit (–13.8695 kcal/mol for lithium) would be used to assess various compositions for acceptability.

Although these limits are available for implementation, there is currently no driving force to do so. More specifically, model-based predictions for the Frit 418 – Sludge Batch 3 (SB3) system (the current glass system being processed in DWPF) indicate that upper WLs are liquidus temperature (T_L) limited (followed closely by low viscosity). Predictions of durability are not an issue over the entire WL range of 25 – 60% for this system. However, the new durability limits could provide an opportunity to increase the total alkali content in the glass (either through the use of an alternative frit or by the addition of trim chemicals) in an effort to increase melt rate and ultimately total waste throughput.[1]

[1] Given SB3 has already been qualified and also contains Neptunium (Np), the ability to increase the alkali concentration in glass through sludge washing is no longer an option.

Peeler et al. (2004) performed model-based assessments to identify a series of glass compositions (using various frit compositions coupled with SB3 estimates) that would be predicted to transition from "acceptable" to "unacceptable" over an interval of ΔG_P values covering both the current and proposed durability limits. Initial assessments were performed with Frit 418 with supplemental frits being developed to challenge durability predictions with the primary focus being increased alkali concentrations. In addition, Frit 202 was assessed in terms of the projected operating window and predicted properties given recent interest in the potential impact of viscosity on pour stream stability.[2]

As a result of Measurement Acceptability Region (MAR) based assessments, Peeler et al. (2004) identified eight glasses that transitioned into and through the region of acceptability as defined by the current and proposed durability limits. These glasses (referred to as "ADT" (Alternative Durability Task) glasses) were selected to investigate (and potentially generate) the incentive for implementing the proposed durability limits in the Product Composition Control System (PCCS) from a glass formulation perspective. The ADT glasses have been fabricated in the laboratory and their PCTs measured. In this report, the measured durability response is compared to model predictions to assess the applicability and/or potential conservatism of the various limits.

Even if incentive for implementation of the proposed durability limits can be demonstrated through this study in terms of the measured durability response for higher alkali systems, assessments of melt rate should also be performed to establish a clear motive or driver to implement a frit change for SB3. More specifically, a "significant" increase in melt rate may be required to provide the incentive for DWPF to implement the change rather than a "paper study" incentive or PCT assessment. Assessments of melt rate for select ADT-based systems will be the focus of a subsequent report.

Objectives for this task are specified in Section 2.0. In Section 3.0, the targeted glass compositions, as defined by Peeler and Edwards (2004), are presented. Section 4.0 summarizes the experimental procedures. The results of the compositional analysis and PCT assessments are discussed in detail in Section 5.0. A summary is provided in Section 6.0, with recommendations for future work summarized in Section 7.0.

[2] Frit 202 is being used for a limited duration with SB3 (in replacement of Frit 418) beginning in the late July 2004 timeframe to address the potential impact of viscosity on pour stream stability. In addition, use of Frit 202 is a cost savings since the frit is currently on hand.

2.0 OBJECTIVE

The objective of this task is to investigate (and potentially generate) incentive from a glass formulation perspective for applying the proposed durability limits in PCCS. This task will assess the glass durability of frit compositional changes that could be made in an attempt to increase melt rate and/or waste loadings which together ultimately drive waste throughput for DWPF. The compositional changes will be specific to the SB3 system with Frit 418 serving as a baseline case from which alternatives will be assessed. The specific compositional adjustments to be made will include assessments of higher alkali contents (given its known impact on melt rate) relative to Frit 418. Higher alkali containing frits will be developed and assessed that transition into and through the region of ΔG_P acceptability as defined by the current and proposed durability limits. Specifically, glasses will be defined that:

(1) fail the MAR for the current durability limit (-12.78 kcal/mol) but pass the MAR for the proposed durability limit (-13.8 kcal/mol), and
(2) fail the MAR for both the current and proposed durability limits while maintaining acceptable predictions for all other properties.

The focus of this report is on the measured durability response as it compares to model predictions to assess the applicability and/or potential conservatism of the various limits or durability approaches. It should be noted that although this study is focused on SB3, the incentive to implement the proposed durability limits may be advantageous to glass formulation efforts for future sludge batches. For example, access to higher alkali contents via the relaxed constraints may reduce liquidus temperatures for systems with relatively high concentrations of troublesome components (such as NiO, Cr_2O_3, and/or MnO).

This work has been prepared to address technical issues identified in a Technical Task Request (TTR) (Occhipinti 2003) and in accordance with the Task Technical and Quality Assurance Plan (Peeler, Edwards, and Herman 2003). It is noted that this work is being performed under RW-0333P Quality Assurance (QA) requirements as specified in the TTR.

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3.0 TARGET GLASSS COMPOSITIONS

Based on the MAR assessments performed by Peeler et al. (2004), eight glasses were selected to investigate the incentive of implementing the proposed durability limits in PCCS from a glass formulation perspective. Glass compositions based on specific frits and targeting specific WLs were selected to challenge the current ΔG_P limits, the proposed ΔG_P limits, or both. Table 3-1 summarizes the target compositions of the eight ADT glasses. In addition, two Frit 418 – SB3 glasses (SB2/3-4 and SB2/3-7) are also included in Table 3-1. These glasses were fabricated as part of the SB3 Phase 2 variability study (Lorier et al. 2003) and were used to "fill in" the transition into and through the region of ΔG_P acceptability for this study. SB2/3-4 and SB2/3-7 have targeted WLs of 35 and 40%, respectively, and serve as a baseline for this report as they represent the current system being processed in DWPF.

Figure 3-1 is a conceptual view (not to scale) of the ADT and SB2/3 glasses supporting this assessment. For each frit – sludge system, two glasses are shown: one targeting 35% WL and the other targeting 40% WL. The current SME acceptability PAR limit is defined by the vertical solid black line at a ΔG_P value of ~ -12.78 kcal/mol. The vertical blue line at a ΔG_P value of ~ -13.8 kcal/mol represents the proposed durability limits as defined by Edwards et al. (2003).[3] The shift to a more negative ΔG_P limit has the potential to provide access into a glass compositional region in which DWPF could process more "alkali-rich" systems that could potentially improve melt rate and/or waste loading without compromising product quality.

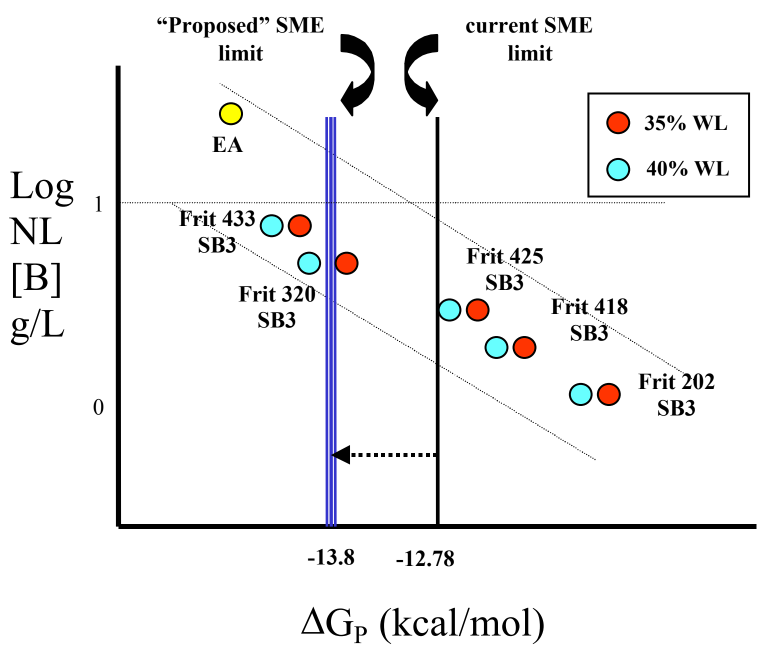

Figure 3-1. Conceptual View of the ADT and SB2/3 Glasses within the ΔG_P versus log NL [B] Diagram.

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[3] The vertical lines shown in Figure 3-1 represent the PAR limits associated with the current and proposed durability limits. The points representing the targeted glass compositions have been placed relative to these PAR limits based on assessments at the MAR for this conceptual view.

Table 3-1. Target Compositions of the Alternative Durability Task (ADT) and SB2/3 Glasses. (wt%, oxide calcine basis)

Glass ID	ADT-1	ADT-2	ADT-3	ADT-4	ADT-5	ADT-6	ADT-7	ADT-8	SB2/3-4	SB2/3-7
	Frit 202	Frit 202	Frit 425	Frit 425	Frit 320	Frit 320	Frit 433	Frit 433	Frit 418	Frit 418
WL	35%	40%	35%	40%	35%	40%	35%	40%	35%	40%
Oxide	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
Al_2O_3	5.359	6.124	5.359	6.124	5.359	6.124	5.359	6.124	5.384	6.154
B_2O_3	5.200	4.800	5.200	4.800	5.200	4.800	5.200	4.800	5.200	4.800
BaO	0.052	0.059	0.052	0.059	0.052	0.059	0.052	0.059	0.052	0.060
CaO	1.018	1.164	1.018	1.164	1.018	1.164	1.018	1.164	1.035	1.182
Ce_2O_3	0.084	0.096	0.084	0.096	0.084	0.096	0.084	0.096	0.084	0.096
Cr_2O_3	0.083	0.095	0.083	0.095	0.083	0.095	0.083	0.095	0.086	0.098
CuO	0.031	0.036	0.031	0.036	0.031	0.036	0.031	0.036	0.029	0.033
Fe_2O_3	11.445	13.080	11.445	13.080	11.445	13.080	11.445	13.080	11.427	13.059
K_2O	0.073	0.084	0.073	0.084	0.073	0.084	0.073	0.084	0.329	0.376
La_2O_3	0.041	0.047	0.041	0.047	0.041	0.047	0.041	0.047	0.043	0.050
Li_2O	4.550	4.200	5.200	4.800	5.200	4.800	3.250	3.000	5.200	4.800
MgO	2.548	2.626	1.248	1.426	1.248	1.426	1.248	1.426	1.252	1.430
MnO	2.340	2.674	2.340	2.674	2.340	2.674	2.340	2.674	2.339	2.673
Na_2O	11.608	12.410	14.208	14.810	15.508	16.010	17.458	17.810	12.685	13.354
NiO	0.617	0.706	0.617	0.706	0.617	0.706	0.617	0.706	0.639	0.730
PbO	0.050	0.057	0.050	0.057	0.050	0.057	0.050	0.057	0.051	0.058
SiO_2	51.134	47.439	49.184	45.639	47.884	44.439	47.884	44.439	50.397	46.740
ThO_2	0.012	0.014	0.012	0.014	0.012	0.014	0.012	0.014	0.012	0.014
TiO_2	0.012	0.014	0.012	0.014	0.012	0.014	0.012	0.014	0.009	0.010
U_3O_8	3.597	4.110	3.597	4.110	3.597	4.110	3.597	4.110	3.601	4.116
ZnO	0.053	0.061	0.053	0.061	0.053	0.061	0.053	0.061	0.055	0.062
ZrO_2	0.093	0.107	0.093	0.107	0.093	0.107	0.093	0.107	0.090	0.100
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3-2 summarizes each glass system in terms of the total alkali content (targeted) and classification via SME acceptability for both the current and proposed durability limits. A "No" indicates that the glass system would not be processable in DWPF given model predictions suggest an unacceptable glass would be produced. A "Yes" represents a glass system classified as "acceptable" in terms of durability via model predictions. It should be noted that all other glass properties and/or processing constraints of the PCCS MAR (e.g., viscosity, T_L, and Al_2O_3) are acceptable for all study glasses. The glasses in Table 3-2 have been ordered to mimic the graphical representation shown in Figure 3-1. More specifically, as one transitions from left to right in eitherTable 3-2 or Figure 3-1, the glasses are predicted to become more durable and therefore have a higher likelihood of being classified as "acceptable" based on the assumed SME acceptability criteria for durability. In terms of total alkali content, the general trend is as the total alkali content in the glass decreases (left to right in Table 3-2), the lower the tendency of the model to classify the glass as unacceptable. The increase in total alkali content in the glass is strictly a function of the alkali content of the frit given the use of a "constant" sludge composition.[4] The Frit 433 and Frit 320 glasses (ADT-5 through ADT-8, having the highest total alkali contents) represent the most extreme cases with respect to acceptability. That is, the current model's response to these higher alkali systems leads to a classification of "unacceptable". This trend agrees with general glass science (ignoring overall compositional effects). It is noted that some glasses with ~20% total alkali (and higher) are known to be very durable (as measured by the PCT). In fact, previous research for Hanford low-activity waste (LAW) glasses targeted 20% Na_2O (or higher) to meet contractual requirements in terms of waste loading while maintaining an acceptable PCT response (Feng et al. 1995 and Li et al. 1995).

Table 3-2 indicates that most of the ADT glasses and both SB2/3 glasses are predicted to be acceptable. Four of the eight glasses were either baseline Frit 418 glasses (SB2/3-4 and SB2/3-7) or systems of interest due to the known transition from Frit 418 to Frit 202 (ADT-1 and ADT-2) to address the impact of viscosity on pour stream stability and/or as a financial savings as Frit 202 is currently available. The total alkali content of the Frit 202-based glasses is approximately 16.5 wt% – almost 2% lower than the Frit 418 baseline glasses with approximately 18.3 wt%. The lower total alkali content of the Frit 202-based glasses should result in a more durable glass; however, a practical difference in the PCT response as compared to other higher alkali systems (as determined in this study) may not be observed.

As total alkali content increases, the model predictions shift from "acceptable" to "unacceptable" – with the Frit 320-based glasses being a primary focal point with respect to the current and proposed durability limits. ADT-5 is the only glass which changes classification based on the use of the two sets of durability limits. Three glasses (ADT-6, ADT-7, and ADT-8) will provide insight into the potential conservatism of the proposed limits – even though some degree of conservatism was removed in establishing these new limits (see Edwards et al. 2003).

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[4] It should be noted that there was a slight difference in the sludge compositions between the ADT and SB2/3 glasses. The differences are very minor and are not seen as having any practical significance with respect to programmatic objectives.

Table 3-2. Total Alkali Content for the ADT and Select SB2/3 Glasses.

Glass ID	ADT-8	ADT-7	ADT-6	ADT-5	ADT-4	ADT-3	SB2/3-7	SB2/3-4	ADT-2	ADT-1
Frit	433	433	320	320	425	425	418	418	202	202
WL	40%	35%	40%	35%	40%	35%	40%	35%	40%	35%
Total Alkali (wt% in glass - target)	20.894	20.781	20.894	20.781	19.694	19.481	18.534	18.214	16.694	16.231
Al_2O_3 (wt% in glass- target)	6.124	5.359	6.124	5.359	6.124	5.359	6.154	5.384	6.124	5.359
SME Classification										
Current ΔG_P Limits	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Proposed ΔG_P Limits	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.0 EXPERIMENTAL

4.1 Glass Fabrication

Each glass was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts in a 150-g batch using SRNL technical procedure "Glass Batching" (SRNL 2002a).[5] Batch sheets were filled out as the materials were weighed. The raw materials were thoroughly mixed and placed into a 95% Platinum/5% Gold 250-mL crucible. The batch was subsequently placed into a high-temperature furnace at the target melt temperature of 1150°C and melted (SRNL 2002b). After an isothermal hold at 1150°C for 1.0 h, the crucible was removed, and the glass was poured onto a clean stainless steel plate and allowed to air cool.

Approximately 140 g of glass was removed (poured) from the crucible while ~10 g remained in the crucible along the walls. The pour patty was used as a sampling stock for the various property measurements (i.e., chemical composition and durability).

4.2 Chemical Composition Analysis

To confirm that the "as-fabricated" glasses corresponded to the defined target compositions, a representative sample from each ADT glass pour patty was submitted to the SRNL Mobile Laboratory (SRNL-ML) for chemical analysis. Edwards (see Appendix A) provided an analytical plan that accompanied these samples. This plan identified the cations to be analyzed and the dissolution techniques (i.e., sodium peroxide fusion [PF] and lithium-metaborate [LM]) to be used. Each glass was prepared in duplicate for each cation dissolution technique (PF and LM). Concentrations (as mass %) for the cations of interest were measured by inductively coupled plasma – atomic emission spectroscopy (ICP – AES). The analytical plan was developed to provide the opportunity to evaluate potential sources of error. Glass standards were intermittently run to assess the performance of the ICP – AES over the course of these analyses and for potential bias-correction needs. [6]

4.3 Product Consistency Test (PCT)

The PCT was performed in triplicate on each "quenched" ADT glass to assess chemical durability using technical procedure "Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT)" (ASTM 2002). Also included in this experimental test matrix were the EA glass (Jantzen et al. 1993), the Approved Reference Material (ARM) glass, and blanks. Samples were ground, washed, and prepared according to procedure. Fifteen milliliters of Type I American Society for Testing and Materials (ASTM) water were added to 1.5 g of glass in stainless steel vessels. The vessels were closed, sealed, and placed in an oven at 90 ± 2°C where the samples were maintained for 7 days. The resulting solutions (once cooled) were sampled (filtered and acidified), labeled (according to the analytical plan), and analyzed. Edwards provided an analytical plan for the SRNL-ML analysis (see Appendix B). The overall philosophy of the plan was to provide an opportunity to assess the consistency (repeatability) of the PCT and analytical procedures in an effort to evaluate the chemical durability of the ADT glasses. Normalized release rates were calculated based on

[5] Lorier et al. (2003) summarize the fabrication process of SB2/3-4 and SB2/3-7 which was consistent with this study.

[6] An analytical plan (SRT-SCS-2003-00039) was used to support the chemical composition analysis of the SB2/3 glasses. This plan is documented as Appendix B in Lorier et al. (2003).

targeted, measured, and bias-corrected compositions using the average of the logs of the leachate concentrations.[7]

To bound the effects of thermal history on the product performance, approximately 25 g of each ADT glass was heat treated to simulate cooling along the centerline of a DWPF-type canister (Marra and Jantzen 1993). This cooling regime is commonly referred to as the canister centerline cooled (ccc) curve. This terminology will be used in this report to differentiate samples from different cooling regimes (quenched versus ccc). PCTs were conducted in triplicate for these glasses and were included in the analytical plans.[8]

[7] An analytical plan (SRT-SCS-2003-00040) was used to support the PCT analysis of the SB2/3 glasses. This plan is documented as Appendix C in Lorier et al. (2003).

[8] Lorier et al. (2003) provide a detailed discussion of the compositional analysis or views (target, measured, and measured bias-corrected) of SB2/3-4 and SB2/3-7. As will be performed in the current study, PCT responses were normalized for both quenched and centerline canister cooled glasses based on each compositional view. The compositional analyses of the SB2/3 glasses are not discussed in this report but the PCT information will be presented and used.

5.0 RESULTS

5.1 A Statistical Review of the Chemical Composition Measurements

In this section, the measured versus targeted compositions of the 8 ADT study glasses are presented and compared. The targeted compositions for these glasses are provided in Table 3-2 as well as Table C1 of Appendix C. Chemical composition measurements for these glasses were conducted by the SRNL-ML following an analytical plan provided in Appendix A. This analytical plan included the 8 ADT glasses of interest in this study as well as 6 glasses, labeled VIS-1 through VIS-6, which were part of a separate study.[9] Two dissolution methods were utilized in measuring these chemical compositions: samples prepared by LM dissolution were used to measure elemental concentrations of aluminum (Al), barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), iron (Fe), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), silicon (Si), thorium (Th), titanium (Ti), uranium (U), zinc (Zn), and zirconium (Zr), while samples from glasses prepared by PF dissolution were used to measure elemental concentrations of boron (B) and lithium (Li).[10] For each study glass, measurements were obtained from samples prepared in duplicate by each of these dissolution methods. All of the prepared samples were analyzed (twice for each element of interest) by ICP-AES (with the instrumentation being re-calibrated between the duplicate analyses).

Table C2 in Appendix C provides the elemental concentration measurements derived from the samples prepared using LM, and Table C3 in Appendix C provides the measurements derived from the samples prepared using PF. Measurements for standards (Batch 1 and a uranium standard, U_{std}) that were included in the SRNL-ML analytical plan along with the ADT and VIS study glasses are also provided in these two tables.

The elemental concentrations were converted to oxide concentrations by multiplying the values for each element by the gravimetric factor for the corresponding oxide. During this process, an elemental concentration that was determined to be below the detection limit of the analytical procedures used by the SRNL-ML was reduced to half of that detection limit as the oxide concentration was determined.

In the sections that follow, the analytical sequence of the measurements is explored, the measurements of the standards are investigated and used for bias correction, the measurements for each glass are reviewed, the average chemical compositions (measured and bias-corrected) for each glass are determined, and comparisons are made between the measurements and the targeted compositions for the glasses.

5.1.1 Measurements in Analytical Sequence

Exhibit C1 in Appendix C provides plots of the measurements for samples prepared using the LM method. The plots are in analytical sequence with different symbols and colors being used to represent each of the study and standard glasses. Similar plots for samples prepared using the PF

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[9] The VIS (for viscosity) glasses are associated with a specific study to evaluate the impact of waste loading on viscosity for the Frit 418 – SB3 composition region and these results will be documented elsewhere. Including the VIS glasses in the analytical plan did not compromise the quality of the data for this study but provided a cost effective mechanism to obtain quality data for both studies under the auspices of one analytical plan.

[10] Although the analytical plan (see Appendix A) indicated that Si concentrations were to be measured using the PF dissolution, the SRNL-ML reported the Si values from the PF dissolution (see Table C1 in Appendix C).

method are provided in Exhibit C2 in Appendix C. These plots include all of the measurement data from Tables C2 and C3. That is, the plots include the VIS study glasses as well as the ADT study glasses. A review of these plots indicates no significant patterns or trends in the analytical process over the course of these measurements, and there appear to be no obvious outliers in these chemical composition measurements. The VIS study glasses (and the SB2/3 glasses of Table 3-2) are not included in the discussion of composition that follows since they were not a part of this study.

5.1.2 Batch 1 and Uranium Standard Results

In this section, the chemical compositions of the Batch 1 and uranium standard (U_{std}) glasses are reviewed. These measurements are investigated across the ICP analytical blocks, and the results are used to bias correct the measurements for the ADT glasses.

Exhibit C3 in Appendix C provides statistical analyses of the Batch 1 and U_{std} results generated by the LM prep method by analytical block for each oxide of interest. The results include analysis of variance (ANOVA) investigations looking for statistically significant differences among the block means for each of the oxides for each of the standards. The results from the statistical tests for the Batch 1 standard may be summarized as follows: the BaO, Fe_2O_3, K_2O, MgO, Na_2O, and TiO_2 measurements indicate a statistically significant ICP calibration effect on these averages at the 5% significance level. For the U_{std}, the Al_2O_3, CuO, Fe_2O_3, MgO, Na_2O, TiO_2, and U_3O_8 measurements indicate a significant ICP calibration effect on these averages at the 5% significance level. The reference values for the oxide concentrations of the standard are given in the headers for each set of measurements in the exhibit.

Exhibit C4 in Appendix C provides a similar set of analyses for the measurements derived from samples prepared via the PF method. In this exhibit, none of the measurements for Batch 1 indicate a significant ICP calibration effect on these averages at the 5% significance level, while the measurements for B_2O_3 for the U_{std} show significant ICP calibration effects on these averages at the 5% significance level. The reference values for the oxide concentrations of the standard are given in the headers for each set of measurements in the exhibit.

Overall the results suggest that it may be helpful to bias correct the oxide measurements of the ADT glasses for the effect of the ICP calibration on each of the analytical blocks. The basis for this bias correction is presented as part of Exhibits C3 and C4 – the average measurement for Batch 1 for each ICP block for Al_2O_3, B_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, Li_2O, MgO, MnO, Na_2O, NiO, SiO_2, and TiO_2 and the average measurement for U_{std} for each ICP block for U_3O_8. The Batch 1 results served as the basis for bias correcting all of the oxides (that were bias corrected) except uranium. The U_{std} results were used to bias correct for uranium. For the other oxides, the Batch 1 results were used to conduct the bias correction as long as the reference value for the oxide concentration in the Batch 1 glass was greater than or equal to 0.1 wt%. Thus, applying this approach and based upon the information in the exhibits, the Batch 1 results were used to bias correct the Al_2O_3, B_2O_3, BaO, CaO, Cr_2O_3, CuO, Fe_2O_3, K_2O, Li_2O, MgO, MnO, Na_2O, NiO, SiO_2, and TiO_2 measurements. No bias correction was conducted for Ce_2O_3, La_2O_3, PbO, ThO_2, ZnO, or ZrO_2.

The bias correction was conducted as follows. For each oxide, let $\bar{a}_{ij}$ be the average measurement for the i^{th} oxide at analytical block j for Batch 1 (or U_{std} for uranium), and let t_i be the reference value for the i^{th} oxide for Batch 1 (or for U_{std} if uranium). (The averages and reference values are provided in Exhibits C3 and C4.) Let $\overline{c}_{ijk}$ be the average measurement for the ith oxide at analytical block j for the kth glass. The bias adjustment was conducted as follows

$$\overline{c}_{ijk} \bullet \left(1 - \frac{\overline{a}_{ij} - t_i}{\overline{a}_{ij}}\right) = \overline{c}_{ijk} \bullet \frac{t_i}{\overline{a}_{ij}}$$

Bias-corrected measurements are indicated by a "bc" suffix, and such adjustments as stated above were performed for all of the oxides of this study except for Ce_2O_3, La_2O_3, PbO, ThO_2, ZnO, and ZrO_2. Both measured and measured "bc" values are included in the discussion that follows. In these discussions values for Ce_2O_3, La_2O_3, PbO, ThO_2, ZnO, and ZrO_2 are included for completeness (e.g., to allow a sum of oxides to be computed for the bias-corrected results) but are the same values as the original Ce_2O_3, La_2O_3, PbO, ThO_2, ZnO, and ZrO_2 values (i.e., once again, no bias correction was performed for this group of oxides).

5.1.3 Composition Measurements by Glass Number

Exhibits C5 and C6 in Appendix C provide plots of the oxide concentration measurements by Glass ID (including both Batch 1 and U_{std}) for the measured and bias-corrected (bc) values for the LM and PF preparation methods, respectively. Different symbols and colors are used to represent the different glasses. These plots show the individual measurements across the duplicates of each preparation method and the two ICP calibrations. A review of the exhibited plots reveals the repeatability of the four individual, oxide values for each glass. There appears to be a good bit of scatter in the Fe_2O_3 and SiO_2 values for many of the glasses. No other problems are evident in these plots.

More detailed discussions of the average, measured chemical compositions of the study glasses are provided in the sections that follow.

5.1.4 Measured versus Targeted Compositions

The four measurements for each oxide for each glass (over both preparation methods) were averaged to determine a representative chemical composition for the glass. These determinations were conducted both for the measured and for the bias-corrected data. A sum of oxides was also computed for each glass based upon both the measured and bias-corrected values. Exhibit C7 in Appendix C provides plots showing results for each glass for each oxide to help highlight the comparisons among the measured, bias-corrected, and targeted values.

Some observations from the plots of Exhibit C7 are offered: For nearly every ADT glass the measured Al_2O_3 values are greater than their respective targeted concentrations. (Note: the measured Al_2O_3 concentrations for the U_{STD} and Batch 1 standard appear to be in-line with expectations). For Ce_2O_3, Fe_2O_3, NiO, and ZrO_2 the measured values for most of the study glasses fall below their respective targets for these oxides. The detection limits of the ICP-AES for ThO_2 is higher than the targeted values therefore the values appear to be consistently higher than targeted. In addition, the Cr_2O_3 value for the U_{std} glass is approximately 0.25 wt% where the reported value is 0.0 wt%. This observation is consistent with previous results.

Table C4 in Appendix C provides a summary of the average compositions as well as the targeted compositions and some associated differences and relative differences. Notice that the targeted sums of oxides for the standard glasses do not sum to 100% given all oxides reported for these standards (Batch 1 (glass # 100) and U_{std} (glass # 101)) were not measured for. All of the sums of oxides (both measured and bias-corrected) for the study glasses fall within the interval of 95 to 105 wt%.

Entries in Table C4 show the relative differences between the measured or bias-corrected values and the targeted values. These differences are shaded when they are greater than or equal to 5%. Overall, these comparisons between the measured and targeted compositions suggest that there were some difficulties in hitting the targeted compositions for some of the oxides for some of the glasses. However, these differences are not seen as being of practical concern.[11]

5.2 A Statistical Review of the PCT Measurements

The ADT study glasses, after being batched and fabricated, were subjected to the 7-day PCT to assess their durabilities. More specifically, Method A of the PCT (ASTM 2002) was used for these measurements. Durability is the critical product quality metric for DWPF glass studies. The PCTs were conducted in triplicate for each of two heat treatments (quenched and ccc). PCTs were also conducted in triplicate for samples of the EA glass and for samples of the ARM glass. Blanks (samples consisting only of ASTM Type I water) were also submitted for the PCT.

An analytical plan, presented in Appendix B, was provided to the SRNL-ML to support the measurement of the compositions of the solutions resulting from the PCTs. This analytical plan included the PCTs for the ADT glasses of interest in this study as well as the VIS glasses, which were part of a separate study.[12] Samples of a multi-element, standard solution were also included in the analytical plan (as a check on the accuracy of the ICP-AES used for these measurements).

Table D1 in Appendix D provides the elemental leachate concentration measurements determined by the SRNL-ML for the solution samples generated by the PCTs covered in the analytical plan. One of the quality control checkpoints for the PCT procedure is solution-weight loss over the course of the 7-day test. While none of these PCT results indicated a solution-weight loss problem, the contents of one vessel were spilled and lost (i.e., ADT-5ccc denoted as “pa58” per the analytical plan). No measurements were possible for this PCT replicate, which is indicated as a shaded row in Table D1. Any measurement in Table D1 below the detection limit of the analytical procedure (indicated by a “<”) was replaced by ½ of the detection limit in subsequent analyses. In addition to adjustments for detection limits, the values were adjusted for the acid dilution factors: the values for the study glasses, the blanks, and the ARM glass in Table D1 were multiplied by 1.6667 to determine the values in parts per million (ppm) and the values for EA were multiplied by 16.6667. Table D2 in Appendix D provides the resulting measurements including those from the VIS glasses.

In the sections that follow, the analytical sequence of the measurements is explored, the measurements of the standards are investigated and used to assess the overall accuracy of the ICP measurement process, the measurements for each glass are reviewed, plots are provided that explore the effects of the heat treatment on the PCTs for these glasses, the PCTs are normalized using the compositions (targeted, measured, and bias-corrected) presented in Table C4, and the

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[11] These observations are consistent with those reported by Lorier et al. (2003) for the SB2/3 glasses.

[12] The VIS glasses are associated with a specific study to evaluate the impact of waste loading on viscosity for the Frit 418 – SB3 composition region and these results will be documented elsewhere. Including the VIS glasses in the analytical plan did not compromise the quality of the data for this study but provided a cost effective mechanism to obtain quality data for both studies under the auspice of one analytical plan.

normalized PCTs are compared to durability predictions for these compositions generated from the current DWPF models (Jantzen et al. 1995).

5.2.1 Measurements in Analytical Sequence

Exhibits D1 and D2 in Appendix D provide plots of the leachate (ppm) concentrations in analytical sequence as generated by the SRNL-ML for all of the data including the VIS glass results and for only the ADT study glasses, respectively. A different color is used for each type of sample with a small, solid square used to represent a ccc glass and a plus being used to represent a quenched glass. The blanks and solution standard results are also represented using small squares while the ARM results are represented by an open circle and the EA results by a closed circle. No problems are seen in these plots, and the VIS results are not included in the discussion that follows.

5.2.2 Results for the Samples of the Multi-Element Solution Standard

Exhibit D3 in Appendix D provides analyses of the SRNL-ML measurements of the samples of the multi-element solution standard by ICP analytical (or calibration) block. An ANOVA investigating for statistically significant differences among the block averages for these samples for each element of interest is included in these exhibits. These results indicate a statistically significant (at the 5% level) difference among the Al, Fe, Li, Na, and Si average measurements over these blocks. However, no bias correction of the PCT results for the study glasses was conducted. This approach was taken since the triplicate PCTs for a single study glass were placed in different ICP blocks. Averaging the ppm's for each set of triplicates helps to minimize the impact of the ICP effects.

Table 5-1 summarizes the average measurements and the reference values for the 4 primary elements of interest. The results indicate consistent and accurate measurements from the SRNL-ML processes used to conduct these analyses.

Table 5-1. Results from Samples of the Multi-Element Solution Standard.

Set/ Analytical Block	Avg B (ppm)	Avg Li (ppm)	Avg Na (ppm)	Avg Si (ppm)
1	20.53	9.67	79.53	48.83
2	20.23	9.60	79.93	48.23
3	19.87	9.65	79.90	48.13
4	20.20	9.66	81.00	47.43
5	20.83	9.81	82.43	49.97
6	20.97	9.65	79.63	48.90
Grand Average	20.44	9.67	80.41	48.58
Reference Value	20	10	81	50
% difference	2.19%	-3.26%	-0.73%	-2.83%

5.2.3 Measurements by Glass Number

Exhibits D4 and D5 in Appendix D provide plots of the leachate concentrations for each type of submitted sample: the study glasses and the standards (EA, ARM, the multi-element solution standard, and blanks) with EA and the blanks and without them, respectively. These plots allow for the assessment of the repeatability of the measurements, which suggests some scatter in the triplicate values for some analytes for some of the glasses.[13] However, none of the values have been excluded from the calculations that follow.

5.2.4 Quenched versus Centerline Canister Cooled PCTs

Exhibit D6 in Appendix D provides a closer look at the effect of heat treatment on the PCTs of the ADT glasses. This exhibit provides a paired t-test comparing the quenched and ccc versions of each glass for each analyte. Based upon the results of this exhibit, only Na and Si show a statistically significant (at the 5% significance level) difference between the quenched PCTs and the ccc PCTs. For both analytes, the quenched PCTs leached higher than their ccc counterparts, about 10 ppm more for Na and 3.3 ppm for Si.

5.2.5 Normalized PCT Results

PCT leachate concentrations are typically normalized using the cation composition (expressed as a weight percent) in the glass to obtain a grams-per-liter (g/L) leachate concentration. The normalization of the PCTs is usually conducted using the measured compositions of the glasses. This is the preferred normalization process for the PCTs. For completeness, the targeted cation and the bias-corrected cation compositions were also used to conduct this normalization. As is the usual convention, the common logarithm of the normalized PCT (normalized leachate, NL) for each element of interest was determined and used for comparison. To accomplish this computation, one must

1. Determine the common logarithm of the elemental parts per million (ppm) leachate concentration for each of the triplicates and each of the elements of interest (these values are provided in Table D2 of Appendix D),

2. Average the common logarithms over the triplicates for each element of interest, and then

Normalizing Using Measured Composition (preferred method)

3. Subtract a quantity equal to 1 plus the common logarithm of the average cation measured concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Or Normalizing Using Target Composition

3. Subtract a quantity equal to 1 plus the common logarithm of the target cation concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Or Normalizing Using Measured Bias-Corrected Composition

3. Subtract a quantity equal to 1 plus the common logarithm of the measured bias-corrected cation concentration (expressed as a weight percent of the glass) from the average computed in step 2.

Exhibit D7 in Appendix D provides scatter plots for these results and offers an opportunity to investigate the consistency in the leaching across the elements for the glasses of this study. All

[13] It is noted that one replicate of ADT-5ccc (pa58 per the analytical plan) was spilled so the averaged ppm value for this glass is based on duplicates.

normalizations of the PCTs (i.e., those generated using the targeted, measured, and bias-corrected compositional views) are represented in these plots. A plot encompassing all of the compositional views is presented at the beginning of the exhibit.

Consistency in the leaching across the elements (i.e., congruent dissolution) is typically demonstrated by a high degree of linear correlation among the values for pairs of these elements. A high degree of correlation is seen for these data for most of the pairs of the elements; the smallest correlation (88.9%) among the individual compositional views is between Na and Li for the measured bias-corrected data.

Table 5-2 summarizes the normalized PCTs for the glasses of this study. The results are by glass identifier. Results for both heat treatments for each of the study glasses as well as results for the two standards, ARM and EA, are shown in this table.

Table 5-2. PCT Results for ADT and SB2/3 Study Glasses.[14]

Glass ID	Heat Treatment	Composition	log NL [B(g/L)]	log NL [Li(g/L)]	log NL [Na(g/L)]	log NL [Si(g/L)]	NL B(g/L)	NL Li(g/L)	NL Na(g/L)	NL Si(g/L)
ARM	-	Jantzen et al. (1995)	-0.1765	-0.1581	-0.2071	-0.5030	0.67	0.69	0.62	0.31
EA	-	Jantzen et al. (1993)	1.2410	0.9627	1.1278	0.5796	17.42	9.18	13.42	3.80
ADT-1	quenched	measured	-0.0133	-0.0388	-0.0237	-0.2589	0.97	0.91	0.95	0.55
ADT-1	ccc	measured	-0.0200	-0.0450	-0.0395	-0.2640	0.96	0.90	0.91	0.54
ADT-1	quenched	measured bc	-0.0022	-0.0464	-0.0269	-0.2481	0.99	0.90	0.94	0.56
ADT-1	ccc	measured bc	-0.0089	-0.0526	-0.0428	-0.2532	0.98	0.89	0.91	0.56
ADT-1	quenched	targeted	-0.0106	-0.0400	-0.0359	-0.2599	0.98	0.91	0.92	0.55
ADT-1	ccc	targeted	-0.0173	-0.0462	-0.0518	-0.2650	0.96	0.90	0.89	0.54
ADT-2	quenched	measured	0.0579	0.0008	0.0490	-0.2263	1.14	1.00	1.12	0.59
ADT-2	ccc	measured	0.0409	0.0093	0.0309	-0.2293	1.10	1.02	1.07	0.59
ADT-2	quenched	measured bc	0.0688	-0.0067	0.0458	-0.2155	1.17	0.98	1.11	0.61
ADT-2	ccc	measured bc	0.0518	0.0017	0.0277	-0.2185	1.13	1.00	1.07	0.60
ADT-2	quenched	targeted	0.0706	0.0084	0.0381	-0.2210	1.18	1.02	1.09	0.60
ADT-2	ccc	targeted	0.0536	0.0168	0.0199	-0.2239	1.13	1.04	1.05	0.60
ADT-3	quenched	measured	0.1046	0.0660	0.1171	-0.1308	1.27	1.16	1.31	0.74
ADT-3	ccc	measured	0.1152	0.0747	0.0915	-0.1378	1.30	1.19	1.23	0.73
ADT-3	quenched	measured bc	0.0942	0.0556	0.1138	-0.1200	1.24	1.14	1.30	0.76
ADT-3	ccc	measured bc	0.1048	0.0643	0.0882	-0.1270	1.27	1.16	1.23	0.75
ADT-3	quenched	targeted	0.0854	0.0555	0.1073	-0.1358	1.22	1.14	1.28	0.73
ADT-3	ccc	targeted	0.0960	0.0642	0.0817	-0.1428	1.25	1.16	1.21	0.72
ADT-4	quenched	measured	0.2100	0.1199	0.1838	-0.0786	1.62	1.32	1.53	0.83
ADT-4	ccc	measured	0.2054	0.1216	0.1576	-0.0956	1.60	1.32	1.44	0.80
ADT-4	quenched	measured bc	0.1996	0.1094	0.1807	-0.0678	1.58	1.29	1.52	0.86
ADT-4	ccc	measured bc	0.1951	0.1111	0.1545	-0.0848	1.57	1.29	1.43	0.82
ADT-4	quenched	targeted	0.1881	0.1116	0.1754	-0.0875	1.54	1.29	1.50	0.82
ADT-4	ccc	targeted	0.1835	0.1133	0.1491	-0.1045	1.53	1.30	1.41	0.79
ADT-5	quenched	measured	0.1719	0.1277	0.2218	-0.0478	1.49	1.34	1.67	0.90
ADT-5	ccc	measured	0.1903	0.1573	0.2059	-0.0425	1.55	1.44	1.61	0.91
ADT-5	quenched	measured bc	0.1825	0.1201	0.2186	-0.0370	1.52	1.32	1.65	0.92
ADT-5	ccc	measured bc	0.2009	0.1496	0.2028	-0.0317	1.59	1.41	1.60	0.93
ADT-5	quenched	targeted	0.1897	0.1326	0.2062	-0.0490	1.55	1.36	1.61	0.89
ADT-5	ccc	targeted	0.2081	0.1621	0.1904	-0.0437	1.61	1.45	1.55	0.90
ADT-6	quenched	measured	0.3064	0.2006	0.2770	0.0022	2.02	1.59	1.89	1.01
ADT-6	ccc	measured	0.3095	0.2409	0.2583	-0.0041	2.04	1.74	1.81	0.99
ADT-6	quenched	measured bc	0.2960	0.1901	0.2839	0.0106	1.98	1.55	1.92	1.02
ADT-6	ccc	measured bc	0.2991	0.2305	0.2653	0.0043	1.99	1.70	1.84	1.01
ADT-6	quenched	targeted	0.2906	0.1873	0.2696	-0.0046	1.95	1.54	1.86	0.99
ADT-6	ccc	targeted	0.2937	0.2276	0.2509	-0.0109	1.97	1.69	1.78	0.98
ADT-7	quenched	measured	0.1001	0.0447	0.1867	-0.1101	1.26	1.11	1.54	0.78
ADT-7	ccc	measured	0.0790	0.0367	0.1351	-0.1329	1.20	1.09	1.36	0.74
ADT-7	quenched	measured bc	0.1107	0.0371	0.1937	-0.1017	1.29	1.09	1.56	0.79
ADT-7	ccc	measured bc	0.0896	0.0291	0.1420	-0.1245	1.23	1.07	1.39	0.75
ADT-7	quenched	targeted	0.1114	0.0470	0.1739	-0.1181	1.29	1.11	1.49	0.76
ADT-7	ccc	targeted	0.0903	0.0390	0.1223	-0.1409	1.23	1.09	1.33	0.72
ADT-8	quenched	measured	0.2128	0.0702	0.2133	-0.0955	1.63	1.18	1.63	0.80
ADT-8	ccc	measured	0.1950	0.0826	0.1749	-0.1103	1.57	1.21	1.50	0.78
ADT-8	quenched	measured bc	0.2025	0.0597	0.2099	-0.0847	1.59	1.15	1.62	0.82
ADT-8	ccc	measured bc	0.1846	0.0722	0.1715	-0.0995	1.53	1.18	1.48	0.80
ADT-8	quenched	targeted	0.1809	0.0667	0.2012	-0.0976	1.52	1.17	1.59	0.80
ADT-8	ccc	targeted	0.1630	0.0792	0.1628	-0.1123	1.46	1.20	1.45	0.77

[14] The normalized PCT information for SB2/3-4 and SB2/3-7 were obtained from Lorier et al. (2003). These two glasses represent the Frit 418 – SB3 system at 35% and 40% WL, respectively. In addition, the normalized release values for ADT-5ccc are the average of duplicate samples (not triplicate) given the loss of pa58 (one of the triplicates as defined in the analytical plan).

Glass ID	Heat Treatment	Composition	log NL [B(g/L)]	log NL [Li(g/L)]	log NL [Na(g/L)]	log NL [Si(g/L)]	NL B(g/L)	NL Li(g/L)	NL Na(g/L)	NL Si(g/L)
SB2/3-4	quenched	measured	-0.0039	0.0018	0.0240	-0.2183	0.99	1.00	1.06	0.60
SB2/3-4	ccc	measured	-0.0056	0.0147	-0.0054	-0.2202	0.99	1.03	0.99	0.60
SB2/3-4	quenched	measured bc	-0.0100	-0.0058	0.0424	-0.2182	0.98	0.99	1.10	0.61
SB2/3-4	ccc	measured bc	-0.0117	0.0072	0.0130	-0.2201	0.97	1.02	1.03	0.60
SB2/3-4	quenched	targeted	-0.0080	0.0013	0.0418	-0.2180	0.98	1.00	1.10	0.61
SB2/3-4	ccc	targeted	-0.0096	0.0142	0.0125	-0.2199	0.98	1.03	1.03	0.60
SB2/3-7	quenched	measured	0.0456	0.0072	0.0448	-0.2206	1.11	1.02	1.11	0.60
SB2/3-7	ccc	measured	0.0456	0.0148	0.0198	-0.2175	1.11	1.03	1.05	0.61
SB2/3-7	quenched	measured bc	0.0306	-0.0032	0.0510	-0.2244	1.07	0.99	1.12	0.60
SB2/3-7	ccc	measured bc	0.0306	0.0044	0.0260	-0.2212	1.07	1.01	1.06	0.60
SB2/3-7	quenched	targeted	0.0152	-0.0060	0.0553	-0.2264	1.04	0.99	1.14	0.59
SB2/3-7	ccc	targeted	0.0152	0.0015	0.0302	-0.2232	1.04	1.00	1.07	0.60

5.2.6 Predicted versus Measured PCTs

For the ADT glasses, the normalized boron release values (NL [B] g/L) range from ~1.0 g/L (ADT-1; the most durable glass) to ~2.0 g/L (ADT-6; the least durable glass). ADT-6 is a Frit 320-based glass targeting 40% WL. This glass (as well as ADT-8) has the highest target total alkali content (20.894 wt% - see Table 3-2) of all the ADT glasses. ADT-1 (the most durable glass) is based on Frit 202, targets 35% WL and represents the lowest sum of alkali tested in this study. Table 5-3 summarizes some critical compositional and PCT information (based on targeted compositions and quenched PCT response) associated with the study glasses. The general trend in the data indicates as the total alkali content in the glass decreases (either through frit adjustments when considering the same WL or at the lower WL when considering the same frit) the glasses become more durable. However, the difference between the maximum and minimum response (1.0 g/L to 2.0 g/L) is not a practical concern as the releases suggest all of the study glasses would meet the current durability criteria (two standard deviations below 16.695 g/L as reported by Jantzen et al. 1993) by almost an order of magnitude. It is noted that the PCT response for the Frit 418 and Frit 202 glasses are comparable (NL [B] on the order of 1.0 – 1.1 g/L). Although not expected in terms of the total alkali argument, the similar responses may be due to slight differences in the sludge composition.

Table 5-3. Critical Compositional and PCT Information for the ADT Glasses.

Glass ID	Frit	WL	NL [B] (g/L)	Total Alkali (wt% in glass - target)	Al_2O_3 (wt% in glass- target)
ADT-8	433	40%	1.52	20.894	6.124
ADT-7	433	35%	1.29	20.781	5.359
ADT-6	320	40%	1.95	20.894	6.124
ADT-5	320	35%	1.55	20.781	5.359
ADT-4	425	40%	1.54	19.694	6.124
ADT-3	425	35%	1.22	19.481	5.359
SB2/3-7	418	40%	1.04	18.534	6.154
SB2/3-4	418	35%	0.98	18.214	5.384
ADT-2	202	40%	1.18	16.694	6.124
ADT-1	202	35%	0.98	16.231	5.359

The PCT responses shown in Table 5-2 (and Table 5-3) provide evidence that implementation of the proposed durability limits will provide access to higher alkali compositional regions without compromising product quality. Although only one glass (ADT-5) falls into the "transitional region" (i.e., classified as "unacceptable" based on the current limits but "acceptable" based on the proposed limits), the durability responses of ADT-6, ADT-7 and ADT-8 provide evidence that the proposed constraints may still be overly conservative. More specifically, the PCT responses for these glasses were very acceptable (less than ~2 g/L) although they would not be processable in DWPF based on model predictions of durability.

It is interesting to note that the PCT response for ADT-7 and ADT-8 (both Frit 433 based glasses) are lower than those of ADT-5 and ADT-6 (both Frit 320 based glasses) even though their respective ΔG_P values are more negative (i.e., leading to predictions of a less durable glass). Frit 433 and Frit 320 have identical total alkali content but the partitioning between Na_2O and Li_2O differs. This difference drives the ΔG_P values for the Frit 433 glasses to more negative values as compared to the Frit 320 counterparts. Based on the PCT response, it appears that one could potentially achieve the same total alkali content (in glass) but maintain a lower normalized boron release by simply partitioning more of the total alkali to Li_2O. Although this is a potential advantage with respect to maintaining lower PCT responses, the advantage is somewhat suspect given the PCT response for the Frit 320 glasses are very acceptable and do not need to be "lowered". In addition, the real driver for which partitioning route to take may not be the PCT response (given both are acceptable) but the melt rate response. Previous work by Stone and Josephs (2001) suggests that higher Li_2O content could increase melt rate. More specifically, they assessed the melt rate of two frit compositions (Frit 324 and Frit 323) that targeted the same total alkali content based on a wt% (13.47 wt%) but differed significantly on a mol% basis. To accomplish this, the concentrations of Li_2O and Na_2O were switched between the two frits: Frit 324 targeting 8.28 and 5.19 wt% Li_2O and Na_2O, respectively, and Frit 323 targeting 5.19 and 8.28 wt% Li_2O and Na_2O. Based on dry-fed melt rate furnace results, Frit 324 melted faster than Frit 323. It was postulated that the higher impact from lithium was likely the result of the lower molecular weight, resulting in more moles of alkali in the glass for a given weight percent of alkali.

Although incentive for implementation of the proposed durability limits has been demonstrated through this study in terms of the measured durability response for higher alkali systems, assessments of melt rate should be performed to establish a clear motive or driver to implement a frit change for SB3. More specifically, a "significant" increase in melt rate may be required to provide the incentive for DWPF to implement the change rather than a "paper study" incentive or PCT assessment for SB3. The application of the proposed durability limits could aid in future frit development efforts as the increased alkali could not only enhance melt rate but could lower liquidus temperatures for systems with troublesome components. There is additional incentive to continue the assessment of alternative durability options (as defined by Peeler and Edwards 2003) given the results of this study imply that even the proposed limits are still conservative with respect to predictions of durability which could restrict access into compositional regions of interest.

5.2.7 Applicability of the ΔG_P Model

Exhibit D8 in Appendix D provides plots of the DWPF models that relate the logarithm of the normalized PCT (for each element of interest) to a linear function of a free energy of hydration term (ΔG_p, kcal/100g glass) derived from all of the glass compositional views (Jantzen et al. 1995). Figure 5-1 is a plot of the logarithm of the normalized PCT B release versus ΔG_p for the

ADT glasses using targeted compositions. Prediction limits (at a 95% confidence) for an individual PCT result are also plotted along with the linear fit. Notice that all of the study glasses are predictable indicating the applicability of the model.

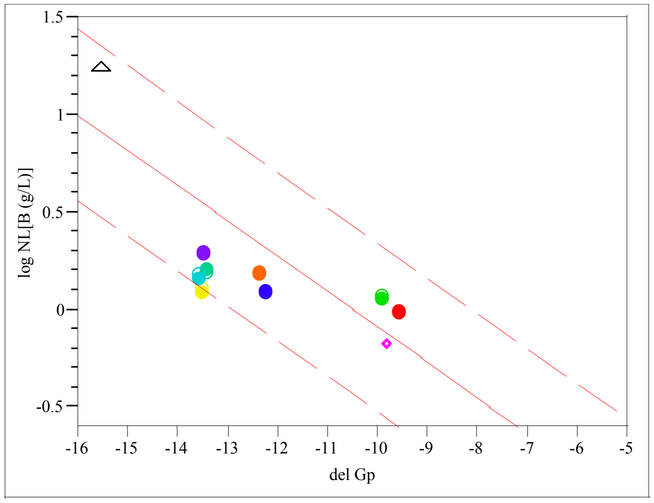

Figure 5-1. Normalized PCT B Release versus ΔG_p for the ADT Glasses using Targeted Compositions.
(note: the open triangle with a ΔG_P value of ~ -15.5 kcal/mol is the EA glass)

5.2.8 Applicability of the INDEX system

Although perhaps premature, the index system developed by Brewer et al. (2003) was applied to the ADT and SB2/3 compositions (all compositional views). All ADT and SB2/3 glasses (for all compositional views) are classified as "acceptable" based on this system and the 10 g/L limit. Given the measured PCT responses for these glasses and assuming implementation of this approach is feasible (Manz 2003), the index system would allow access to compositional regions not attainable through the ΔG_P model even with the less conservative, durability limits proposed by Edwards et al. (2003). More specifically, this approach would allow Frit 433 to be utilized for SB3 or higher WLs to be attained with Frit 320 and SB3. These results provide continued incentive to assess the index system and other durability alternatives (as defined by Peeler and Edwards 2003) to provide access into compositional regions of interest to improve melt rate and/or waste loading which play a vital role in determining waste throughput for DWPF. However, possible implementation of the new durability limits or an alternative approach may be dependent upon the demonstration that the higher alkali systems continue to improve melt rate for the SB3 system.

It should be noted that a direct comparison between the ability of the ΔG_P model and the index system to classify glasses as "acceptable" or "unacceptable" is not a 1-to-1 comparison. That is, the index system utilizes an "acceptance" limit of 10 g/L or less while the ΔG_P values used for acceptability translate into approximately 2.5 and 4.0 g/L for the current and proposed limits, respectively, per the following equation.

$$\log_{10}\{NL[B\ (g/L)]\} = -1.901 - 0.181\Delta G_P$$

Therefore, there is a higher probability that a composition would be deemed acceptable by the index system as compared to the use of the new durability limits – especially for those systems which challenge durability.

6.0 SUMMARY

The normalized boron release values (NL [B] g/L) for the study glasses ranged from 1.0 g/L (ADT-1; the most durable glass) to ~2.0 g/L (ADT-6; the least durable glass). ADT-6 is a Frit 320-based glass targeting 40% WL. This glass (as well as ADT-8) has the highest targeted total alkali content (20.894 wt%) of all the ADT glasses. ADT-1 (the most durable glass) is based on Frit 202 and targets 35% WL. The general trend in the ADT data indicates as the total alkali content in the glass decreases (either through frit adjustments when considering the same WL or at the lower WL when considering the same frit) the glasses become more durable. However, the difference between 1.0 g/L and 2.0 g/L is not a practical concern, and the releases suggest all of the study glasses would meet the current durability criteria by almost an order of magnitude (relative to the 16.695 g/L reported for EA (Jantzen et al. 1993)).

The PCT responses provide evidence that implementation of the proposed ΔG_P limits will provide access to higher alkali compositional regions without compromising product quality. In fact, the data provide evidence that the proposed limits may still be overly conservative. More specifically, the PCT responses for these glasses were very acceptable (less than ~2 g/L) although some would not be processable in DWPF based on model predictions of durability.

Application of the index system (Brewer et al. 2003 correctly classified the ADT and SB2/3 glasses as acceptable. Given the measured PCT responses for these glasses and assuming implementation of this approach is feasible (Manz 2003), the index system would allow access to compositional regions not attainable through the ΔG_P model even with the less conservative, durability limits proposed by Edwards et al. (2003). More specifically, this approach would allow Frit 433 to be utilized for SB3 or higher WLs to be attained with Frit 320 and SB3. These results provide continued incentive to assess the index system and other durability alternatives (as defined by Peeler and Edwards 2003) to provide access into compositional regions of interest to improve melt rate, waste loading, and/or waste throughput for DWPF.

Although incentive for implementation of the proposed durability limits (and pursuit of alternative durability approaches) has been demonstrated through this study in terms of the measured durability response for higher alkali systems, assessments of melt rate should be performed to establish a clear motive or driver to implement a frit change. More specifically, a "significant" increase in melt rate may be required to provide the incentive for DWPF to implement the change rather than a "paper study" incentive or PCT assessment. In addition, the application of the proposed durability limits could aid in future frit development efforts as the increased alkali could not only enhance melt rate but could lower liquidus temperatures for systems with troublesome components.

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7.0 RECOMMENDATIONS

Based on the results of this study, the following recommendations are made:

(1) Generate melt rate data to support implementation of the proposed durability limits.

The incentive for implementation of the proposed durability limits has been demonstrated through this study in terms of the measured durability response for higher alkali systems. However, assessments of melt rate should be performed to establish a clear motive or driver to implement a frit change. More specifically, a "significant" increase in melt rate may be required to provide the incentive for DWPF to implement the change rather than a "paper study" incentive or PCT assessment.

(2) Assess applicability of the durability model with the proposed ΔG_P limits.

Assuming an incentive in melt rate for the Frit 320 – SB3 system can be demonstrated and DWPF intends to implement, an assessment of the applicability of the durability model with the proposed limits must be performed (i.e., a variability study). This effort would identify the anticipated glass compositional region based on Frit 320 composition, the known SB3 composition (including any variation needed), and WLs of interest. Once defined, applicability could be demonstrated either by: (a) a review of the compiled database (PCT – compositional database) to see if existing glasses could be used to demonstrate model applicability and PCT response acceptability or (b) a variability study could be performed targeting specific Frit 320 – SB3 glasses to develop the required data.

(3) Assess the potential for additional conservatism in the proposed limits by evaluating the PCT response of glasses in the "unacceptable" region (as defined by proposed limits) and continue assessment of alternative durability approaches.

Data presented in this study suggest that SME acceptability decisions using the proposed limits may still be overly conservative with respect to the measured durability – thus limiting access to compositional regions of interest. This being the case, additional data may be required to support an alternative durability approach (assuming the incentive for melt rate is demonstrated). Prior to developing a series of glasses to support this effort, an assessment of the data contained in the current PCT – composition database should be performed. Included in this assessment should be an evaluation of "how far can the system be pushed with respect to total alkali" prior to the measured durability response becoming an issue.

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APPENDIX A

Chemical Composition Analytical Plan

SRS savannah river site

WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2004-00017

April 23, 2004

To:	D. K. Peeler, 999-W		
cc:	R. A. Baker, 773-42A	I. A.	Reamer, 999-1W
	D. R. Best, 786-1A (wo)	P. A.	Toole, 786-1A (wo)
	S. L. Marra, 999-W (es)	R. C.	Tuckfield, 773-42A
		R. J.	Workman, 999-1W

TBE

From: T. B. Edwards, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — 04/29/2004 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 4/29/04 Date

An Analytical Plan for Measuring the Chemical Compositions of the ADT and VIS Study Glasses (U)

1.0 Executive Summary

This memorandum has been prepared to assist two glass studies that are being conducted by the Savannah River Technology Center (SRTC) in support of the accelerated mission at the Defense Waste Processing Facility (DWPF). One study is investigating the relationship between viscosity and waste loading for the Sludge Batch 3 (SB3)/Frit 418 glass system, while the second study is investigating alternative durability options for the DWPF. Glasses are being batched and fabricated for each of these studies: 6 glasses (designated by a "VIS" prefix for VIScosity) for the first study and 8 glasses (designated by an "ADT" prefix for Alternative Durability Task) for the second study. The chemical compositions of these glasses are to be determined by the Savannah River Technology Center – Mobile Laboratory (SRTC-ML). This memorandum provides an analytical plan to direct and support the measurement of the chemical compositions for both sets of study glasses.

2.0 Introduction

This memorandum has been prepared to assist two glass studies that are being conducted by the Savannah River Technology Center (SRTC) in support of the accelerated mission at the Defense Waste Processing Facility (DWPF). One study is investigating the relationship between viscosity and waste loading for the Sludge Batch 3 (SB3)/Frit 418 glass system, while the second study is investigating alternative durability options for the DWPF. Glasses are being batched and fabricated for each of these studies: 6 glasses (designated by a "VIS" prefix for VIScosity) for the first study and 8 glasses (designated by an "ADT" prefix for Alternative Durability Task) for the second study. The chemical compositions of these glasses are to be determined by the Savannah River Technology Center – Mobile Laboratory (SRTC-ML). This memorandum provides an analytical plan to direct and support the measurement of the chemical compositions for both sets of study glasses.

3.0 Analytical Plan

The analytical procedures used by the SRTC-ML to determine cation concentrations for a glass sample include steps for sample preparation and for instrument calibration. Each glass is to be prepared in duplicate by each of two dissolution methods: lithium metaborate (LM) and sodium peroxide fusion (PF).

The primary measurements of interest are to be acquired as follows. The samples prepared by LM are to be measured for aluminum (Al), barium (Ba), calcium (Ca), cerium (Ce), chromium (Cr), copper (Cu), iron (Fe), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), thorium (Th), titanium (Ti), uranium (U), zinc (Zn), and zirconium (Zr) concentrations. Samples prepared by PF are to be measured for boron (B), lithium (Li), and silicon (Si). Samples dissolved by both preparation methods are to be measured using Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES). It should be noted that some of these elements are minor components that may be near detection limits for most, if not all, of the study glasses. If the measurements for an element are determined using samples prepared in a manner that differs from the above description, these changes should be noted as part of the information provided by the SRTC-ML in reporting the results from this study.

As stated above, each glass sample submitted to the SRTC-ML will be prepared in duplicate by the LM and PF dissolution methods. Every prepared sample will be read twice by ICP-AES, with the instrument being calibrated before each of these two sets of readings. This will lead to four measurements for each cation of interest for each submitted glass.

Randomizing the preparation steps and blocking and randomizing the measurements for the ICP-AES are of primary concern in the development of this analytical plan. The sources of uncertainty for the analytical procedure used by the SRTC-ML to determine the cation concentrations are dominated by the dissolution step in the preparation of the sample and by the calibrations of the ICP-AES.

Samples of standard glasses will be included in the analytical plan to allow performance checks on the instrumentation over the course of the analyses and for potential bias correction. Specifically, several samples of Waste Compliance Plan (WCP) Batch 1 (BCH) [1] and of a uranium standard glass (Ustd) are included in this analytical plan. The reference compositions of these glasses are provided in Table 1. The standards will be referred to using the short identifiers BCH and Ustd in the remainder of this memo.

Table 1: Oxide Compositions of WCP Batch 1 (BCH) and the Uranium Standard (Ustd)

Oxide/ Anion	BCH (wt%)	Ustd (wt%)
Al_2O_3	4.877	4.1
B_2O_3	7.777	9.209
BaO	0.151	0.00
CaO	1.220	1.301
CdO	0.00	0.00
Cl	0.00	0.00
Cr_2O_3	0.107	0.00
Cs_2O	0.060	0.00
CuO	0.399	0.00
F	0.00	0.00
Fe_2O_3	12.839	13.196
K_2O	3.327	2.999
Li_2O	4.429	3.057
MgO	1.419	1.21
MnO	1.726	2.892
MoO_3	0.00	0.00
Na_2O	9.003	11.795
Nd_2O_3	0.147	0.00
NiO	0.751	1.12
P_2O_5	0.00	0.00
PbO	0.00	0.00
RuO_2	0.0214	0.00
SiO_2	50.22	45.353
SnO_2	0.00	0.00
SO_3	0.00	0.00
TiO_2	0.677	1.049
U_3O_8	0.00	2.406
ZrO_2	0.098	0.00
Sum of Oxides	99.2484	99.687

Table 2 presents identifying codes, va01 through va14, for the 14 glasses for these two studies. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[15]

Table 2: Glass Identifiers to Establish Blind Samples for the SRTC-ML

Glass ID	Sample ID
VIS-1	va11
VIS-2	va05
VIS-3	va09
VIS-4	va12
VIS-5	va01
VIS-6	va14
ADT-1	va03
ADT-2	va13
ADT-3	va04
ADT-4	va06
ADT-5	va08
ADT-6	va07
ADT-7	va02
ADT-8	va10

3.1 Preparation of the Samples

Each of the 14 glasses included in this analytical plan is to be prepared in duplicate by the LM and PF dissolution methods. Thus, the total number of prepared glass samples is determined by $14 \cdot 2 \cdot 2 = 56$, not including the samples of the BCH and Ustd glass standards that are to be prepared.

Tables 3a and 3b provide blocking and (random) sequencing schema for conducting the preparation steps of the analytical procedures. One block of preparation work is provided for each preparation method to facilitate the scheduling of activities by work shift. The identifier for each of the prepared samples indicates the sample identifier (ID), preparation method, and duplicate number.

[15] Renaming these samples helps to ensure that they will be processed as blind samples within the SRTC-ML. Table 2 is not shown in its entirety in the copies going to the SRTC-ML.

Tables 3a and 3b: Preparation Blocks by Method

Table 3a: LM (Lithium Metaborate) Preparation Block

va12LM1
va05LM1
va14LM1
va05LM2
va04LM1
va09LM1
va07LM1
va12LM2
va03LM1
va03LM2
va04LM2
va07LM2
va09LM2
va14LM2
va13LM1
va10LM1
va13LM2
va10LM2
va08LM1
va11LM1
va06LM1
va02LM1
va01LM1
va06LM2
va08LM2
va11LM2
va01LM2
va02LM2

Table 3b: PF (Peroxide Fusion) Preparation Block

va05PF1
va13PF1
va05PF2
va01PF1
va08PF1
va07PF1
va01PF2
va03PF1
va08PF2
va09PF1
va14PF1
va12PF1
va07PF2
va03PF2
va13PF2
va09PF2
va06PF1
va12PF2
va04PF1
va14PF2
va11PF1
va10PF1
va04PF2
va02PF1
va10PF2
va06PF2
va11PF2
va02PF2

3.2 ICP-AES Calibration Blocks

The glass samples prepared by the LM and PF dissolution methods are to be analyzed using ICP-AES instrumentation calibrated for the particular preparation method. After the initial set of cation concentration measurements, the ICP-AES instrumentation is to be recalibrated and a second set of concentration measurements for the cations determined.

Randomized plans for measuring cation concentrations in the LM-prepared and PF-prepared samples are provided in Tables 4a and 4b, respectively. The cations to be measured are specified in the header of each table. In the tables, the sample identifiers for the 14 study glasses have been modified by the addition of a suffix (a "1" or a "2") to indicate whether the measurement was made during the first or second (respectively) ICP-AES calibration group. The identifiers for the BCH and Ustd samples have been further modified to indicate that each of these prepared samples is to be read 3 times (mirrored in the corresponding suffix of 1, 2, or 3) per calibration block.

Tables 4a and 4b: ICP-AES Blocks & Calibration Groups By Preparation Method

Table 4a: LM Preparation Method (Used to Measure Elemental Al, Ba, Ca, Ce, Cr, Cu, Fe, K, La, Mg, Mn, Na, Ni, Pb, Th, Ti, U, Zn, & Zr)

Calibration 1-1	Calibration 1-2	Calibration 2-1	Calibration 2-2
bchLM111	bchLM121	bchLM211	bchLM221
ustdLM111	ustdLM121	ustdLM211	ustdLM221
va14LM11	va02LM22	va12LM11	va12LM12
va02LM21	va01LM12	va13LM11	va12LM22
va05LM11	va09LM12	va03LM11	va10LM12
va07LM11	va07LM22	va04LM11	va03LM12
va09LM21	va14LM22	va06LM11	va04LM12
va11LM21	va02LM12	va06LM21	va10LM22
va05LM21	va11LM22	va08LM11	va13LM12
bchLM112	bchLM122	bchLM212	bchLM222
ustdLM112	ustdLM122	ustdLM212	ustdLM222
va07LM21	va14LM12	va10LM11	va13LM22
va11LM11	va05LM12	va03LM21	va06LM22
va01LM21	va09LM22	va10LM21	va04LM22
va09LM11	va01LM22	va08LM21	va08LM12
va01LM11	va05LM22	va04LM21	va03LM22
va02LM11	va07LM12	va12LM21	va08LM22
va14LM21	va11LM12	va13LM21	va06LM12
ustdLM113	ustdLM123	ustdLM213	ustdLM223
bchLM113	bchLM123	bchLM213	bchLM223

Table 4b: PF Preparation Method (Used to Measure Elemental B, Li, & Si)

Calibration 1-1	Calibration 1-2	Calibration 2-1	Calibration 2-2
bchPF111	bchPF121	bchPF211	bchPF221
ustdPF111	ustdPF121	ustdPF211	ustdPF221
va04PF11	va12PF12	va02PF11	va11PF22
va12PF11	va01PF22	va13PF21	va05PF12
va06PF21	va12PF22	va11PF21	va14PF22
va04PF21	va01PF12	va08PF21	va08PF22
va09PF11	va04PF22	va05PF21	va13PF12
va12PF21	va06PF12	va03PF21	va03PF12
va01PF11	va04PF12	va14PF11	va02PF22
bchPF112	bchPF122	bchPF212	bchPF222
ustdPF112	ustdPF122	ustdPF212	ustdPF222
va07PF11	va07PF22	va08PF11	va03PF22
va07PF21	va06PF22	va02PF21	va05PF22
va10PF11	va10PF12	va14PF21	va13PF22
va06PF11	va07PF12	va05PF11	va14PF12
va09PF21	va09PF12	va11PF11	va11PF12
va10PF21	va09PF22	va13PF11	va08PF12
va01PF21	va10PF22	va03PF11	va02PF12
ustdPF113	ustdPF123	ustdPF213	ustdPF223
bchPF113	bchPF123	bchPF213	bchPF223

4.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies two preparation blocks in Tables 3a and 3b and several ICP-AES calibration blocks in Tables 4a and 4b for use by the SRTC-ML. The sequencing of the activities associated with each of the steps in the analytical procedures has been randomized. The size of each of the blocks was selected so that it could be completed in a single work shift.

If a problem is discovered while measuring samples in a calibration block, the instrument should be calibrated and the block of samples re-measured in its entirety. If the measurements for one or more of the elements are determined using a different sample preparation method than outlined above, the changes should be noted with the other information reported by the SRTC-ML. This is also true for changes in the measurement order.

The analytical plan indicated in this memorandum should be modified by the personnel of SRTC-ML to include any calibration check standards and/or other standards that are part of their routine operating procedures. It is also recommended that the solutions resulting from each of the prepared samples be archived for some period, considering the "shelf-life" of the solutions, in case questions arise during data analysis. This would allow for the solutions to be rerun without additional preparations, thus minimizing cost.

5.0 REFERENCE

[1] Jantzen, C. M., 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™) (U)," WSRC-TR-93-673, Rev. 1, Volume 2, Table B.1, pp. B.9, 1995.

APPENDIX B

PCT Analytical Plan

WESTINGHOUSE SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

SRT-SCS-2004-00019

April 30, 2004

To: D. K. Peeler, 999-W

cc: R. A. Baker, 773-42A
D. R. Best, 786-1A (wo)
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From: T. B. Edwards, 773-42A (5-5148)
Statistical Consulting Section

wo – without glass identifiers
es – executive summary only

R. A. Baker, Technical Reviewer — 5/4/2004 Date

R. C. Tuckfield, Manager
Statistical Consulting Section — 5/5/04 Date

An Analytical Plan for Measuring the PCTs of the ADT and VIS Study Glasses (U)

1.0 EXECUTIVE SUMMARY

This memorandum has been prepared to assist two glass studies that are being conducted by the Savannah River Technology Center (SRTC) in support of the accelerated mission at the Defense Waste Processing Facility (DWPF). One study is investigating the relationship between viscosity and waste loading for the Sludge Batch 3 (SB3)/Frit 418 glass system, while the second study is investigating alternative durability options for the DWPF. Glasses are being batched and fabricated for each of these studies: 6 glasses (designated by a "VIS" prefix for VIScosity) for the first study and 8 glasses (designated by an "ADT" prefix for Alternative Durability Task) for the second study. The durability of a glass is measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002. For these studies, the durabilities of two different cooling treatments—quenched and centerline-canister-cooled (ccc)—are to be measured for the glasses.

The Savannah River Technology Center-Mobile Laboratory (SRTC-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRTC-ML to follow in measuring the compositions of the leachate solutions resulting from the PCT procedures for these glasses.

2.0 INTRODUCTION

This memorandum has been prepared to assist two glass studies that are being conducted by the Savannah River Technology Center (SRTC) in support of the accelerated mission at the Defense Waste Processing Facility (DWPF). One study is investigating the relationship between viscosity and waste loading for the Sludge Batch 3 (SB3)/Frit 418 glass system, while the second study is investigating alternative durability options for the DWPF. Glasses are being batched and fabricated for each of these studies: 6 glasses (designated by a "VIS" prefix for VIScosity) for the first study and 8 glasses (designated by an "ADT" prefix for Alternative Durability Task) for the second study. The durability of a glass is measured using the Product Consistency Test (PCT) as defined in ASTM C-1285-2002 [1]. For these studies, the durabilities of two different cooling treatments—quenched and centerline-canister-cooled (ccc)—are to be measured for the glasses.

The Savannah River Technology Center-Mobile Laboratory (SRTC-ML) is to be used to measure elemental concentrations of the resulting leachate solutions from the PCTs. This memorandum provides an analytical plan for the SRTC-ML to follow in measuring the compositions of the leachate solutions resulting from the PCT procedures for these glasses.

3.0 DISCUSSION

Both heat treatments of the 14 study glasses are to be subjected to the PCT in triplicate. In addition to the 84 (= 14 glasses × 2 heat treatments × 3 PCTs each) PCTs required for the study glasses, triplicate PCTs are to be conducted on a sample of the Approved Reference Material (ARM) glass and a sample of the Environmental Assessment (EA) glass. Two reagent blank samples are also to be included in these tests. This results in 92 sample solutions being required to complete these PCTs.

The leachates from these tests will be diluted by adding 4 mL of 0.4 M HNO_3 to 6 mL of the leachate (a 6:10 volume to volume, v:v, dilution) before being submitted to the SRTC-ML. The EA leachates will be further diluted (1:10 v:v) with deionized water prior to submission to the SRTC-ML in order to prevent problems with the nebulizer.

Table 1 presents identifying codes, pa01 through pa92, for the individual solutions required for the PCTs of the study glasses and of the standards (EA, ARM, and blanks). This provides a naming convention that is to be used by the SRTC-ML in analyzing the solutions and reporting the relevant concentration measurements.[16]

Table 1: Identifiers for the PCT Solutions

Original Sample	Solution Identifier	Original Sample	Solution Identifier	Original Sample	Solution Identifier
VIS-1	pa11	VIS-6	pa56	ADT-5	pa67
VIS-1	pa05	VIS-6	pa74	ADT-5ccc	pa71
VIS-1	pa45	VIS-6ccc	pa54	ADT-5ccc	pa58
VIS-1ccc	pa39	VIS-6ccc	pa34	ADT-5ccc	pa52
VIS-1ccc	pa20	VIS-6ccc	pa66	ADT-6	pa03
VIS-1ccc	pa26	ADT-1	pa24	ADT-6	pa62
VIS-2	pa79	ADT-1	pa06	ADT-6	pa16
VIS-2	pa63	ADT-1	pa69	ADT-6ccc	pa18
VIS-2	pa23	ADT-1ccc	pa44	ADT-6ccc	pa28
VIS-2ccc	pa29	ADT-1ccc	pa49	ADT-6ccc	pa90
VIS-2ccc	pa80	ADT-1ccc	pa91	ADT-7	pa25
VIS-2ccc	pa50	ADT-2	pa46	ADT-7	pa86
VIS-3	pa12	ADT-2	pa87	ADT-7	pa84
VIS-3	pa61	ADT-2	pa76	ADT-7ccc	pa08
VIS-3	pa60	ADT-2ccc	pa07	ADT-7ccc	pa85
VIS-3ccc	pa33	ADT-2ccc	pa83	ADT-7ccc	pa19
VIS-3ccc	pa59	ADT-2ccc	pa81	ADT-8	pa15
VIS-3ccc	pa10	ADT-3	pa73	ADT-8	pa89
VIS-4	pa31	ADT-3	pa57	ADT-8	pa22
VIS-4	pa48	ADT-3	pa88	ADT-8ccc	pa55
VIS-4	pa01	ADT-3ccc	pa65	ADT-8ccc	pa70
VIS-4ccc	pa04	ADT-3ccc	pa41	ADT-8ccc	pa51
VIS-4ccc	pa64	ADT-3ccc	pa40	ARM	pa72
VIS-4ccc	pa75	ADT-4	pa21	ARM	pa68
VIS-5	pa02	ADT-4	pa47	ARM	pa38
VIS-5	pa82	ADT-4	pa17	EA	pa92
VIS-5	pa42	ADT-4ccc	pa30	EA	pa36
VIS-5ccc	pa77	ADT-4ccc	pa32	EA	pa43
VIS-5ccc	pa53	ADT-4ccc	pa78	blank	pa09
VIS-5ccc	pa35	ADT-5	pa13	blank	pa27
VIS-6	pa37	ADT-5	pa14		

4.0 ANALYTICAL PLAN

The analytical plan for the SRTC-ML is provided in this section. Each of the solution samples submitted to the SRTC-ML is to be analyzed only once for each of the following: aluminum, (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), and uranium (U). The measurements are to be made in parts per million (ppm). The analytical procedure used by the SRTC-ML to determine the concentrations utilizes an Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-AES). The PCT solutions (as identified in Table 1) are grouped in six ICP-AES blocks for processing by the SRTC-ML in Table 2. Each block requires a different calibration of the ICP-AES.

16 Renaming these samples ensures that they will be processed as blind samples by the SRTC-ML. This table does not contain the solution identifiers for those on the distribution list with a "wo" following their names.

Table 2: ICP-AES Calibration Blocks for Leachate Measurements

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
std-b1-1	std-b2-1	std-b3-1	std-b4-1	std-b5-1	std-b6-1
pa39	pa63	pa38	pa19	pa52	pa41
pa64	pa20	pa26	pa70	pa32	pa86
pa80	pa66	pa75	pa22	pa73	pa47
pa05	pa53	pa74	pa69	pa28	pa58
pa60	pa92	pa34	pa43	pa65	pa57
pa33	pa59	pa79	pa90	pa36	pa15
std-b1-2	std-b2-2	std-b3-2	pa62	pa89	pa03
pa77	pa01	pa31	pa40	pa17	pa72
pa68	pa12	pa61	std-b4-2	std-b5-2	std-b6-2
pa27	pa29	pa50	pa71	pa44	pa18
pa48	pa04	pa45	pa25	pa08	pa13
pa56	pa82	pa10	pa87	pa16	pa55
pa54	pa11	pa42	pa83	pa24	pa30
pa02	pa37	pa35	pa91	pa14	pa09
pa23	std-b2-3	std-b3-3	pa88	pa84	pa76
std-b1-3			pa67	pa51	pa85
			pa78	pa81	pa06
			pa21	pa46	pa49
			std-b4-3	std-b5-3	pa07
					std-b6-3

A multi-element solution standard (denoted by "std-bi-j" where i=1 to 6 represents the block number and j=1, 2, and 3 represents the position in the block) was added at the beginning, middle, and end of each of the six blocks. This standard may be useful in checking for bias in the concentration measurements arising from the ICP calibrations.

5.0 SUMMARY

In summary, this analytical plan provides identifiers for the PCT solutions in Table 1 and six ICP-AES calibration blocks in Table 2 for the SRTC-ML to use in conducting the aluminum, (Al), boron (B), iron (Fe), lithium (Li), sodium (Na), silicon (Si), and uranium (U) concentration measurements for this PCT study. The sequencing of the activities associated with each of the steps in the analytical procedure has been randomized. The size of the blocks was selected so that the block could be completed in a single work shift. If for some reason the measurements are not conducted in the sequence presented in this memorandum, the actual order should be recorded along with any explanative comments.

The analytical plan indicated in the preceding tables should be modified by the personnel of the SRTC-ML to include any calibration check standards and/or other standards that are part of their standard operating procedures.

6.0 REFERENCE

[1] ASTM C-1285-2002, "Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT)," ASTM, 2002.

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APPENDIX C

Tables and Exhibits Supporting the Analysis of the Chemical Composition Measurements of the ADT Study Glasses

Table C1. Targeted Oxide Concentrations (as wt%'s) for the ADT Study Glasses

Glass ID	Al_2O_3	B_2O_3	BaO	CaO	Ce_2O_3	Cr_2O_3	CuO	Fe_2O_3	K_2O	La_2O_3	Li_2O	MgO	MnO	Na_2O	NiO	PbO	SiO_2	ThO_2	TiO_2	U_3O_8	ZnO	ZrO_2	Sum
ADT-1	5.359	5.200	0.052	1.018	0.084	0.083	0.031	11.445	0.073	0.041	4.550	2.548	2.340	11.608	0.617	0.050	51.134	0.012	0.012	3.597	0.053	0.093	100.000
ADT-2	6.124	4.800	0.059	1.164	0.096	0.095	0.036	13.080	0.084	0.047	4.200	2.626	2.674	12.410	0.706	0.057	47.439	0.014	0.014	4.110	0.061	0.107	100.000
ADT-3	5.359	5.200	0.052	1.018	0.084	0.083	0.031	11.445	0.073	0.041	5.200	1.248	2.340	14.208	0.617	0.050	49.184	0.012	0.012	3.597	0.053	0.093	100.000
ADT-4	6.124	4.800	0.059	1.164	0.096	0.095	0.036	13.080	0.084	0.047	4.800	1.426	2.674	14.810	0.706	0.057	45.639	0.014	0.014	4.110	0.061	0.107	100.000
ADT-5	5.359	5.200	0.052	1.018	0.084	0.083	0.031	11.445	0.073	0.041	5.200	1.248	2.340	15.508	0.617	0.050	47.884	0.012	0.012	3.597	0.053	0.093	100.000
ADT-6	6.124	4.800	0.059	1.164	0.096	0.095	0.036	13.080	0.084	0.047	4.800	1.426	2.674	16.010	0.706	0.057	44.439	0.014	0.014	4.110	0.061	0.107	100.000
ADT-7	5.359	5.200	0.052	1.018	0.084	0.083	0.031	11.445	0.073	0.041	3.250	1.248	2.340	17.458	0.617	0.050	47.884	0.012	0.012	3.597	0.053	0.093	100.000
ADT-8	6.124	4.800	0.059	1.164	0.096	0.095	0.036	13.080	0.084	0.047	3.000	1.426	2.674	17.810	0.706	0.057	44.439	0.014	0.014	4.110	0.061	0.107	100.000

Table C2. Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	Al	Ba	Ca	Ce	Cr	Cu	Fe	K	La	Mg	Mn	Na	Ni	Pb	Si	Th	Ti	U	Zn	Zr
Batch 1	BCHLM111	1	1	1	2.61	0.129	0.857	<0.010	0.076	0.299	8.91	2.54	<0.010	0.818	1.34	6.84	0.548	<0.020	24.1	<0.100	0.390	<0.100	<0.010	0.076
Ustd	USTDLM111	1	1	2	2.08	<0.010	0.867	<0.010	0.159	0.012	9.09	2.42	<0.010	0.675	2.16	8.78	0.754	<0.020	21.1	<0.100	0.541	1.98	<0.010	<0.010
VIS-6	VA14LM11	1	1	3	3.78	0.051	0.917	0.065	0.051	0.044	9.02	0.103	0.037	0.861	2.34	10.7	0.503	0.063	19.8	<0.100	0.015	3.66	0.090	0.068
ADT-7	VA02LM21	1	1	4	2.94	0.045	0.694	0.049	0.057	0.037	7.64	0.073	0.031	0.711	1.83	12.7	0.433	0.048	22.2	<0.100	0.013	2.91	0.041	0.062
VIS-2	VA05LM11	1	1	5	2.79	0.041	0.670	0.047	0.049	0.034	6.84	0.072	0.029	0.645	1.72	9.41	0.388	0.042	23.7	<0.100	0.012	2.77	0.041	0.056
ADT-6	VA07LM11	1	1	6	3.33	0.050	0.809	0.060	0.063	0.039	8.82	0.084	0.035	0.799	2.07	11.8	0.492	0.054	20.6	<0.100	0.013	3.36	0.048	0.068
VIS-3	VA09LM21	1	1	7	3.02	0.048	0.734	0.054	0.061	0.037	7.25	0.074	0.031	0.709	1.86	9.83	0.436	0.052	23.7	<0.100	0.012	2.84	0.041	0.062
VIS-1	VA11LM21	1	1	8	2.54	0.040	0.601	0.050	0.048	0.031	6.42	0.061	0.027	0.620	1.57	9.05	0.380	0.043	25.2	<0.100	0.011	2.46	0.048	0.054
VIS-2	VA05LM21	1	1	9	2.80	0.042	0.673	0.048	0.050	0.035	6.92	0.070	0.030	0.663	1.74	9.42	0.400	0.043	24.1	<0.100	0.012	2.77	0.041	0.057
Batch 1	BCHLM112	1	1	10	2.58	0.129	0.857	<0.010	0.077	0.302	8.71	2.56	<0.010	0.825	1.30	6.77	0.551	<0.020	24.0	<0.100	0.389	<0.100	<0.010	0.077
Ustd	USTDLM112	1	1	11	2.08	<0.010	0.878	<0.010	0.161	0.012	8.99	2.44	<0.010	0.680	2.15	8.70	0.759	<0.020	21.3	<0.100	0.546	1.98	<0.010	<0.010
ADT-6	VA07LM21	1	1	12	3.33	0.050	0.808	0.060	0.063	0.039	8.67	0.085	0.035	0.799	2.04	11.6	0.477	0.054	20.4	<0.100	0.013	3.31	0.047	0.068
VIS-1	VA11LM11	1	1	13	2.57	0.041	0.620	0.052	0.047	0.033	6.55	0.061	0.028	0.637	1.60	9.09	0.392	0.043	25.3	<0.100	0.011	2.50	0.037	0.056
VIS-5	VA01LM21	1	1	14	3.43	0.051	0.803	0.052	0.073	0.042	8.42	0.089	0.036	0.789	2.15	10.4	0.478	0.053	21.8	<0.100	0.013	3.34	0.048	0.067
VIS-3	VA09LM11	1	1	15	3.04	0.049	0.736	0.054	0.062	0.038	7.36	0.074	0.032	0.719	1.87	9.77	0.442	0.049	24.0	<0.100	0.013	2.86	0.039	0.063
VIS-5	VA01LM11	1	1	16	3.51	0.051	0.811	0.051	0.077	0.044	8.51	0.094	0.036	0.793	2.18	10.6	0.476	0.053	22.3	<0.100	0.013	3.40	0.074	0.068
ADT-7	VA02LM11	1	1	17	2.89	0.043	0.671	0.046	0.054	0.041	7.28	0.078	0.030	0.671	1.76	12.6	0.402	0.044	21.7	<0.100	0.012	2.85	0.040	0.058
VIS-6	VA14LM21	1	1	18	3.84	0.052	0.914	0.068	0.049	0.044	9.04	0.095	0.038	0.878	2.34	10.8	0.516	0.057	20.8	<0.100	0.014	3.71	0.056	0.070
Ustd	USTDLM113	1	1	19	2.09	<0.010	0.879	<0.010	0.162	0.012	8.94	2.47	<0.010	0.680	2.13	8.82	0.758	<0.020	21.5	<0.100	0.545	2.00	<0.010	<0.010
Batch 1	BCHLM113	1	1	20	2.64	0.130	0.858	<0.010	0.078	0.305	8.70	2.57	<0.010	0.818	1.31	6.89	0.553	<0.020	24.3	<0.100	0.392	<0.100	<0.010	0.076
Batch 1	BCHLM121	1	2	1	2.58	0.127	0.867	<0.010	0.075	0.303	8.84	2.59	<0.010	0.811	1.34	6.78	0.551	<0.020	24.0	<0.100	0.389	<0.100	<0.010	0.076
Ustd	USTDLM121	1	2	2	2.08	<0.010	0.866	<0.010	0.160	0.009	9.05	2.45	<0.010	0.676	2.17	8.80	0.761	<0.020	20.8	<0.100	0.547	1.96	<0.010	<0.010
ADT-7	VA02LM22	1	2	3	2.92	0.043	0.703	0.050	0.055	0.035	7.68	0.071	0.031	0.711	1.86	12.7	0.438	0.048	22.4	<0.100	0.012	2.90	0.040	0.061
VIS-5	VA01LM12	1	2	4	3.48	0.049	0.811	0.051	0.077	0.042	8.62	0.092	0.036	0.786	2.22	10.4	0.477	0.052	22.1	<0.100	0.012	3.34	0.072	0.068
VIS-3	VA09LM12	1	2	5	3.00	0.047	0.740	0.054	0.060	0.036	7.45	0.072	0.031	0.714	1.92	9.62	0.442	0.048	23.9	<0.100	0.012	2.83	0.037	0.063
ADT-6	VA07LM22	1	2	6	3.32	0.047	0.803	0.059	0.061	0.036	8.94	0.081	0.034	0.789	2.11	11.5	0.476	0.052	20.5	<0.100	0.012	3.29	0.046	0.067
VIS-6	VA14LM22	1	2	7	3.76	0.049	0.912	0.067	0.047	0.042	9.54	0.092	0.037	0.870	2.42	10.4	0.517	0.056	20.5	<0.100	0.013	3.64	0.054	0.071
ADT-7	VA02LM12	1	2	8	2.85	0.041	0.677	0.046	0.052	0.038	7.33	0.075	0.029	0.663	1.79	12.3	0.401	0.044	21.6	<0.100	0.011	2.81	0.038	0.059
VIS-1	VA11LM22	1	2	9	2.52	0.038	0.616	0.051	0.047	0.029	6.56	0.060	0.027	0.624	1.62	8.94	0.383	0.044	24.8	<0.100	0.010	2.45	0.047	0.055
Batch 1	BCHLM122	1	2	10	2.56	0.128	0.864	<0.010	0.076	0.303	8.77	2.60	<0.010	0.820	1.33	6.72	0.552	<0.020	23.7	<0.100	0.395	<0.100	<0.010	0.077
Ustd	USTDLM122	1	2	11	2.07	<0.010	0.872	<0.010	0.160	0.009	9.11	2.46	<0.010	0.673	2.20	8.66	0.759	<0.020	20.9	<0.100	0.550	1.97	<0.010	<0.010
VIS-6	VA14LM12	1	2	12	3.76	0.048	0.920	0.066	0.050	0.042	9.07	0.100	0.037	0.853	2.38	10.6	0.499	0.062	19.5	<0.100	0.013	3.63	0.089	0.070
VIS-2	VA05LM12	1	2	13	2.78	0.039	0.677	0.048	0.048	0.032	6.90	0.071	0.029	0.641	1.75	9.27	0.388	0.041	23.6	<0.100	0.011	2.76	0.040	0.058
VIS-3	VA09LM22	1	2	14	2.98	0.046	0.751	0.055	0.060	0.035	7.23	0.072	0.031	0.710	1.86	9.64	0.436	0.051	23.3	<0.100	0.012	2.80	0.039	0.063
VIS-5	VA01LM22	1	2	15	3.42	0.048	0.805	0.052	0.072	0.040	8.46	0.088	0.036	0.783	2.19	10.4	0.476	0.051	21.4	<0.100	0.012	3.33	0.046	0.068
VIS-2	VA05LM22	1	2	16	2.82	0.041	0.678	0.049	0.049	0.033	6.89	0.069	0.030	0.665	1.76	9.56	0.400	0.042	23.7	<0.100	0.011	2.78	0.040	0.058
ADT-6	VA07LM12	1	2	17	3.32	0.048	0.817	0.060	0.062	0.037	8.76	0.083	0.035	0.801	2.08	11.8	0.492	0.052	20.3	<0.100	0.012	3.34	0.046	0.070
VIS-1	VA11LM12	1	2	18	2.56	0.039	0.613	0.052	0.045	0.030	6.50	0.057	0.027	0.634	1.61	9.07	0.392	0.043	24.9	<0.100	0.010	2.48	0.035	0.056
Ustd	USTDLM123	1	2	19	2.07	<0.010	0.878	<0.010	0.160	0.009	9.08	2.47	<0.010	0.674	2.18	8.66	0.755	<0.020	21.0	<0.100	0.552	1.96	<0.010	<0.010
Batch 1	BCHLM123	1	2	20	2.59	0.127	0.869	<0.010	0.076	0.305	8.82	2.61	<0.010	0.819	1.34	6.72	0.550	<0.020	23.5	<0.100	0.394	<0.100	<0.010	0.076
Batch 1	BCHLM211	2	1	1	2.59	0.128	0.852	<0.010	0.076	0.300	8.85	2.57	<0.010	0.811	1.34	6.78	0.549	<0.020	24.0	<0.100	0.389	<0.100	<0.010	0.077
Ustd	USTDLM211	2	1	2	2.11	<0.010	0.862	<0.010	0.160	0.010	9.01	2.45	<0.010	0.677	2.18	8.89	0.759	<0.020	21.2	<0.100	0.545	1.99	<0.010	<0.010
VIS-4	VA12LM11	2	1	3	3.21	0.046	0.747	0.056	0.069	0.037	7.84	0.075	0.031	0.733	2.00	9.91	0.443	0.049	22.4	<0.100	0.013	3.10	0.048	0.061
ADT-2	VA13LM11	2	1	4	3.37	0.051	0.842	0.047	0.050	0.037	8.41	0.080	0.034	1.363	2.10	9.33	0.489	0.055	22.4	<0.100	0.012	3.45	0.073	0.070

Table C2. Measured Elemental Concentrations (wt%) for Samples Prepared Using Lithium Metaborate

Glass ID	SRTC-ML ID	Block	Sub-Block	Analytical Sequence	Al	Ba	Ca	Ce	Cr	Cu	Fe	K	La	Mg	Mn	Na	Ni	Pb	Si	Th	Ti	U	Zn	Zr
ADT-1	VA03LM11	2	1	5	2.96	0.044	0.703	0.046	0.045	0.033	7.23	0.069	0.029	1.310	1.80	8.64	0.428	0.047	23.2	<0.100	0.011	2.95	0.041	0.064
ADT-3	VA04LM11	2	1	6	2.97	0.042	0.737	0.047	0.051	0.034	7.62	0.073	0.029	0.712	1.85	10.7	0.426	0.047	22.2	<0.100	0.010	3.02	0.042	0.061
ADT-4	VA06LM11	2	1	7	3.39	0.049	0.802	0.065	0.052	0.037	8.73	0.085	0.034	0.787	2.08	11.2	0.479	0.053	20.8	<0.100	0.012	3.37	0.047	0.069
ADT-4	VA06LM21	2	1	8	3.38	0.050	0.803	0.066	0.052	0.036	8.59	0.082	0.034	0.803	2.09	11.3	0.490	0.054	20.9	<0.100	0.012	3.36	0.047	0.072
ADT-5	VA08LM11	2	1	9	3.00	0.043	0.732	0.060	0.063	0.033	7.69	0.073	0.030	0.716	1.83	11.7	0.436	0.047	22.4	<0.100	0.011	2.89	0.043	0.063
Batch 1	BCHLM212	2	1	10	2.59	0.128	0.860	<0.010	0.076	0.302	8.74	2.57	<0.010	0.818	1.32	6.80	0.552	<0.020	23.8	<0.100	0.392	<0.100	<0.010	0.078
Ustd	USTDLM212	2	1	11	2.12	<0.010	0.861	<0.010	0.162	0.010	8.91	2.43	<0.010	0.680	2.15	8.90	0.764	<0.020	21.2	<0.100	0.549	2.01	<0.010	<0.010
ADT-8	VA10LM11	2	1	12	3.30	0.050	0.805	0.033	0.060	0.040	8.37	0.074	0.034	0.802	2.07	12.9	0.494	0.053	20.6	<0.100	0.012	3.37	0.048	0.071
ADT-1	VA03LM21	2	1	13	2.97	0.045	0.704	0.046	0.047	0.033	7.27	0.070	0.030	1.316	1.80	8.66	0.429	0.048	24.5	<0.100	0.011	2.94	0.048	0.065
ADT-8	VA10LM21	2	1	14	3.42	0.050	0.823	0.034	0.064	0.045	8.50	0.079	0.035	0.814	2.10	13.3	0.504	0.053	21.2	<0.100	0.013	3.47	0.049	0.072
ADT-5	VA08LM21	2	1	15	2.92	0.043	0.716	0.060	0.063	0.034	7.58	0.069	0.030	0.720	1.80	11.4	0.441	0.046	22.6	<0.100	0.011	2.84	0.043	0.066
ADT-3	VA04LM21	2	1	16	2.96	0.044	0.722	0.050	0.052	0.034	7.60	0.066	0.031	0.734	1.83	10.5	0.449	0.049	23.2	<0.100	0.011	3.03	0.045	0.064
VIS-4	VA12LM21	2	1	17	3.16	0.047	0.753	0.056	0.072	0.037	8.10	0.073	0.031	0.748	1.96	9.91	0.451	0.049	23.1	<0.100	0.014	3.10	0.047	0.063
ADT-2	VA13LM21	2	1	18	3.34	0.051	0.800	0.051	0.050	0.037	8.31	0.075	0.034	1.367	2.08	9.27	0.489	0.055	22.5	<0.100	0.012	3.43	0.047	0.071
Ustd	USTDLM213	2	1	19	2.12	<0.010	0.868	<0.010	0.160	0.010	8.86	2.45	<0.010	0.681	2.13	8.77	0.756	<0.020	21.6	<0.100	0.547	1.98	<0.010	<0.010
Batch 1	BCHLM213	2	1	20	2.62	0.129	0.865	<0.010	0.076	0.305	8.68	2.59	<0.010	0.820	1.31	6.88	0.552	<0.020	24.5	<0.100	0.396	<0.100	<0.010	0.077
Batch 1	BCHLM213	2	2	1	2.59	0.128	0.866	<0.010	0.076	0.303	9.23	2.58	<0.010	0.806	1.38	6.60	0.548	<0.020	24.0	<0.100	0.385	<0.100	<0.010	0.077
Ustd	USTDLM213	2	2	2	2.09	<0.010	0.872	<0.010	0.159	0.009	9.08	2.42	<0.010	0.664	2.17	8.58	0.746	<0.020	21.2	<0.100	0.537	1.97	<0.010	<0.010
VIS-4	VA12LM12	2	2	3	3.19	0.046	0.749	0.055	0.068	0.036	7.91	0.074	0.032	0.724	1.98	9.58	0.437	0.050	22.4	<0.100	0.013	3.07	0.047	0.060
VIS-4	VA12LM22	2	2	4	3.14	0.047	0.758	0.056	0.072	0.036	8.33	0.073	0.033	0.738	2.01	9.48	0.448	0.050	22.4	<0.100	0.014	3.09	0.047	0.062
ADT-8	VA10LM12	2	2	5	3.30	0.049	0.807	0.033	0.061	0.039	8.38	0.074	0.035	0.796	2.06	12.4	0.494	0.054	20.2	<0.100	0.012	3.36	0.048	0.071
ADT-1	VA03LM12	2	2	6	2.92	0.044	0.700	0.046	0.046	0.032	7.28	0.067	0.030	1.291	1.79	8.14	0.427	0.048	23.5	<0.100	0.012	2.89	0.041	0.064
ADT-3	VA04LM12	2	2	7	2.95	0.042	0.726	0.047	0.051	0.033	7.50	0.072	0.030	0.702	1.82	10.1	0.425	0.048	22.7	<0.100	0.011	2.98	0.042	0.060
ADT-8	VA10LM22	2	2	8	3.42	0.050	0.823	0.034	0.064	0.044	8.38	0.078	0.036	0.810	2.05	12.8	0.500	0.055	20.7	<0.100	0.013	3.42	0.048	0.071
ADT-2	VA13LM12	2	2	9	3.31	0.050	0.832	0.047	0.050	0.036	8.37	0.079	0.035	1.347	2.07	8.67	0.484	0.055	22.9	<0.100	0.013	3.34	0.072	0.070
Batch 1	BCHLM222	2	2	10	2.61	0.129	0.857	<0.010	0.076	0.301	8.85	2.57	<0.010	0.809	1.33	6.44	0.549	<0.020	24.1	<0.100	0.386	<0.100	<0.010	0.077
Ustd	USTDLM222	2	2	11	2.09	<0.010	0.873	<0.010	0.161	0.009	9.18	2.42	<0.010	0.673	2.20	8.21	0.756	<0.020	21.3	<0.100	0.540	1.96	<0.010	<0.010
ADT-2	VA13LM22	2	2	12	3.34	0.051	0.807	0.048	0.049	0.036	8.63	0.075	0.035	1.352	2.15	8.64	0.486	0.055	22.0	<0.100	0.013	3.36	0.047	0.070
ADT-4	VA06LM22	2	2	13	3.33	0.049	0.803	0.066	0.052	0.035	8.89	0.082	0.035	0.794	2.13	10.3	0.485	0.054	20.9	<0.100	0.013	3.29	0.046	0.071
ADT-3	VA04LM22	2	2	14	2.95	0.043	0.708	0.049	0.052	0.032	7.66	0.065	0.032	0.729	1.84	9.92	0.446	0.050	22.8	<0.100	0.011	2.97	0.044	0.063
ADT-5	VA08LM12	2	2	15	2.96	0.042	0.717	0.059	0.064	0.032	7.72	0.071	0.031	0.709	1.83	10.7	0.433	0.048	22.3	<0.100	0.011	2.82	0.043	0.062
ADT-1	VA03LM22	2	2	16	2.92	0.044	0.698	0.046	0.047	0.031	7.38	0.068	0.030	1.291	1.83	8.05	0.423	0.048	24.2	<0.100	0.012	2.86	0.048	0.063
ADT-5	VA08LM22	2	2	17	2.91	0.043	0.725	0.060	0.063	0.033	7.84	0.068	0.031	0.714	1.85	10.6	0.438	0.048	22.0	<0.100	0.011	2.78	0.042	0.064
ADT-4	VA06LM12	2	2	18	3.35	0.049	0.803	0.065	0.053	0.036	9.00	0.084	0.035	0.783	2.12	10.3	0.476	0.054	21.0	<0.100	0.012	3.27	0.047	0.069
Ustd	USTDLM223	2	2	19	2.10	<0.010	0.876	<0.010	0.161	0.009	9.19	2.46	<0.010	0.672	2.19	8.07	0.751	<0.020	21.0	<0.100	0.540	1.93	<0.010	<0.010
Batch 1	BCHLM223	2	2	20	2.58	0.128	0.858	<0.010	0.076	0.302	9.18	2.57	<0.010	0.807	1.38	6.27	0.548	<0.020	24.0	<0.100	0.385	<0.100	<0.010	0.076

Table C3. Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion

Glass ID	SRTC-ML ID	Block	Sub Block	Analytical Sequence	B	Li
Batch 1	BCHPF111	1	1	1	2.47	1.98
Ustd	USTDPF111	1	1	2	2.91	1.41
ADT-3	VA04PF11	1	1	3	1.63	2.35
VIS-4	VA12PF11	1	1	4	1.56	2.32
ADT-4	VA06PF21	1	1	5	1.45	2.18
ADT-3	VA04PF21	1	1	6	1.56	2.36
VIS-3	VA09PF11	1	1	7	1.56	2.39
VIS-4	VA12PF21	1	1	8	1.52	2.31
VIS-5	VA01PF11	1	1	9	1.43	2.23
Batch 1	BCHPF112	1	1	10	2.31	2.03
Ustd	USTDPF112	1	1	11	2.73	1.43
ADT-6	VA07PF11	1	1	12	1.50	2.15
ADT-6	VA07PF21	1	1	13	1.42	2.18
ADT-8	VA10PF11	1	1	14	1.41	1.39
ADT-4	VA06PF11	1	1	15	1.39	2.19
VIS-3	VA09PF21	1	1	16	1.50	2.40
ADT-8	VA10PF21	1	1	17	1.37	1.38
VIS-5	VA01PF21	1	1	18	1.36	2.25
Ustd	USTDPF113	1	1	19	2.72	1.43
Batch 1	BCHPF113	1	1	20	2.27	2.04
Batch 1	BCHPF121	1	2	1	2.50	1.99
Ustd	USTDPF121	1	2	2	2.84	1.42
VIS-4	VA12PF12	1	2	3	1.58	2.32
VIS-5	VA01PF22	1	2	4	1.46	2.22
VIS-4	VA12PF22	1	2	5	1.52	2.30
VIS-5	VA01PF12	1	2	6	1.44	2.22
ADT-3	VA04PF22	1	2	7	1.52	2.37
ADT-4	VA06PF12	1	2	8	1.38	2.18
ADT-3	VA04PF12	1	2	9	1.47	2.35
Batch 1	BCHPF122	1	2	10	2.33	2.00
Ustd	USTDPF122	1	2	11	2.75	1.43
ADT-6	VA07PF22	1	2	12	1.45	2.18
ADT-4	VA06PF22	1	2	13	1.45	2.20
ADT-8	VA10PF12	1	2	14	1.38	1.38
ADT-6	VA07PF12	1	2	15	1.38	2.14
VIS-3	VA09PF12	1	2	16	1.49	2.40
VIS-3	VA09PF22	1	2	17	1.47	2.39
ADT-8	VA10PF22	1	2	18	1.38	1.38
Ustd	USTDPF123	1	2	19	2.70	1.43
Batch 1	BCHPF123	1	2	20	2.27	2.01
Batch 1	BCHPF211	2	1	1	2.54	2.01
Ustd	USTDPF211	2	1	2	2.96	1.44
ADT-7	VA02PF11	2	1	3	1.66	1.49
ADT-2	VA13PF21	2	1	4	1.54	1.97
VIS-1	VA11PF21	2	1	5	1.69	2.55
ADT-5	VA08PF21	2	1	6	1.56	2.33
VIS-2	VA05PF21	2	1	7	1.60	2.47
ADT-1	VA03PF21	2	1	8	1.55	2.08
VIS-6	VA14PF11	2	1	9	1.33	2.05
Batch 1	BCHPF212	2	1	10	2.34	2.00
Ustd	USTDPF212	2	1	11	2.81	1.46
ADT-5	VA08PF11	2	1	12	1.80	2.66
ADT-7	VA02PF21	2	1	13	1.63	1.52
VIS-6	VA14PF21	2	1	14	1.35	2.05
VIS-2	VA05PF11	2	1	15	1.62	2.49
VIS-1	VA11PF11	2	1	16	1.67	2.58
ADT-2	VA13PF11	2	1	17	1.45	1.97
ADT-1	VA03PF11	2	1	18	1.56	2.12
Ustd	USTDPF213	2	1	19	2.82	1.43
Batch 1	BCHPF213	2	1	20	2.34	2.02
Batch 1	BCHPF213	2	2	1	2.61	2.01
Ustd	USTDPF213	2	2	2	3.02	1.44
VIS-1	VA11PF22	2	2	3	1.84	2.57
VIS-2	VA05PF12	2	2	4	1.76	2.50
VIS-6	VA14PF22	2	2	5	1.47	2.06
ADT-5	VA08PF22	2	2	6	1.66	2.34

Table C3. Measured Elemental Concentrations (wt%) for Samples Prepared Using Peroxide Fusion

Glass ID	SRTC-ML ID	Block	Sub Block	Analytical Sequence	B	Li
ADT-2	VA13PF12	2	2	7	1.57	1.99
ADT-1	VA03PF12	2	2	8	1.67	2.12
ADT-7	VA02PF22	2	2	9	1.67	1.53
Batch 1	BCHPF222	2	2	10	2.49	2.03
Ustd	USTDPF222	2	2	11	2.98	1.45
ADT-1	VA03PF22	2	2	12	1.72	2.11
VIS-2	VA05PF22	2	2	13	1.77	2.52
ADT-2	VA13PF22	2	2	14	1.58	2.01
VIS-6	VA14PF12	2	2	15	1.43	2.10
VIS-1	VA11PF12	2	2	16	1.83	2.63
ADT-5	VA08PF12	2	2	17	1.71	2.44
ADT-7	VA02PF12	2	2	18	1.67	1.53
Ustd	USTDPF223	2	2	19	3.00	1.49
Batch 1	BCHPF223	2	2	20	2.54	2.06

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by ADT Glass Number

(100-Batch 1 and 101-U std)

Glass #	Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
1	ADT-1	Al_2O_3 (wt%)	5.5599	5.5265	5.3586	0.2013	0.1679	3.8%	3.1%
1	ADT-1	B_2O_3 (wt%)	5.2323	5.1005	5.2000	0.0323	-0.0995	0.6%	-1.9%
1	ADT-1	BaO (wt%)	0.0494	0.0521	0.0518	-0.0024	0.0003	-4.6%	0.5%
1	ADT-1	CaO (wt%)	0.9812	0.9952	1.0182	-0.0370	-0.0230	-3.6%	-2.3%
1	ADT-1	Ce_2O_3 (wt%)	0.0539	0.0539	0.0835	-0.0296	-0.0296	-35.5%	-35.5%
1	ADT-1	Cr_2O_3 (wt%)	0.0676	0.0651	0.0834	-0.0158	-0.0183	-18.9%	-21.9%
1	ADT-1	CuO (wt%)	0.0404	0.0426	0.0313	0.0091	0.0113	29.0%	36.1%
1	ADT-1	Fe_2O_3 (wt%)	10.4225	10.4934	11.4448	-1.0223	-0.9514	-8.9%	-8.3%
1	ADT-1	K_2O (wt%)	0.0825	0.0885	0.0731	0.0094	0.0154	12.9%	21.1%
1	ADT-1	La_2O_3 (wt%)	0.0349	0.0349	0.0408	-0.0059	-0.0059	-14.5%	-14.5%
1	ADT-1	Li_2O (wt%)	4.5372	4.6171	4.5500	-0.0128	0.0671	-0.3%	1.5%
1	ADT-1	MgO (wt%)	2.1588	2.2757	2.5481	-0.3893	-0.2724	-15.3%	-10.7%
1	ADT-1	MnO (wt%)	2.3306	2.3196	2.3399	-0.0093	-0.0203	-0.4%	-0.9%
1	ADT-1	Na_2O (wt%)	11.2861	11.3706	11.6084	-0.3223	-0.2378	-2.8%	-2.0%
1	ADT-1	NiO (wt%)	0.5430	0.5831	0.6174	-0.0744	-0.0343	-12.0%	-5.6%
1	ADT-1	PbO (wt%)	0.0514	0.0514	0.0500	0.0014	0.0014	2.9%	2.9%
1	ADT-1	SiO_2 (wt%)	51.0223	49.7680	51.1337	-0.1114	-1.3657	-0.2%	-2.7%
1	ADT-1	ThO_2 (wt%)	0.0569	0.0569	0.0122	0.0447	0.0447	366.4%	366.4%
1	ADT-1	TiO_2 (wt%)	0.0192	0.0200	0.0119	0.0073	0.0081	61.2%	68.3%
1	ADT-1	U_3O_8 (wt%)	3.4315	3.5480	3.5966	-0.1651	-0.0486	-4.6%	-1.4%
1	ADT-1	ZnO (wt%)	0.0554	0.0554	0.0533	0.0021	0.0021	3.9%	3.9%
1	ADT-1	ZrO_2 (wt%)	0.0865	0.0865	0.0932	-0.0067	-0.0067	-7.2%	-7.2%
1	ADT-1	Sum of Oxides	98.1036	97.2050	100.0002	-1.8966	-2.7952	-1.9%	-2.8%
2	ADT-2	Al_2O_3 (wt%)	6.3109	6.2731	6.1242	0.1867	0.1489	3.0%	2.4%
2	ADT-2	B_2O_3 (wt%)	4.9425	4.8204	4.8000	0.1425	0.0204	3.0%	0.4%
2	ADT-2	BaO (wt%)	0.0567	0.0597	0.0592	-0.0025	0.0005	-4.3%	0.9%
2	ADT-2	CaO (wt%)	1.1477	1.1641	1.1637	-0.0160	0.0004	-1.4%	0.0%
2	ADT-2	Ce_2O_3 (wt%)	0.0565	0.0565	0.0955	-0.0390	-0.0390	-40.8%	-40.8%
2	ADT-2	Cr_2O_3 (wt%)	0.0727	0.0700	0.0953	-0.0226	-0.0253	-23.7%	-26.5%
2	ADT-2	CuO (wt%)	0.0457	0.0482	0.0357	0.0100	0.0125	28.0%	35.0%
2	ADT-2	Fe_2O_3 (wt%)	12.0524	12.1337	13.0798	-1.0274	-0.9461	-7.9%	-7.2%
2	ADT-2	K_2O (wt%)	0.0931	0.0998	0.0835	0.0096	0.0163	11.4%	19.5%
2	ADT-2	La_2O_3 (wt%)	0.0405	0.0405	0.0466	-0.0061	-0.0061	-13.2%	-13.2%
2	ADT-2	Li_2O (wt%)	4.2735	4.3486	4.2000	0.0735	0.1486	1.8%	3.5%
2	ADT-2	MgO (wt%)	2.2505	2.3723	2.6263	-0.3758	-0.2540	-14.3%	-9.7%
2	ADT-2	MnO (wt%)	2.7115	2.6986	2.6742	0.0373	0.0244	1.4%	0.9%
2	ADT-2	Na_2O (wt%)	12.1017	12.1913	12.4096	-0.3079	-0.2183	-2.5%	-1.8%
2	ADT-2	NiO (wt%)	0.6197	0.6654	0.7056	-0.0859	-0.0402	-12.2%	-5.7%
2	ADT-2	PbO (wt%)	0.0592	0.0592	0.0571	0.0021	0.0021	3.8%	3.8%
2	ADT-2	SiO_2 (wt%)	48.0273	46.8466	47.4385	0.5888	-0.5919	1.2%	-1.2%
2	ADT-2	ThO_2 (wt%)	0.0569	0.0569	0.0139	0.0430	0.0430	309.3%	309.3%
2	ADT-2	TiO_2 (wt%)	0.0209	0.0218	0.0136	0.0073	0.0082	53.3%	60.1%
2	ADT-2	U_3O_8 (wt%)	4.0034	4.1392	4.1104	-0.1070	0.0288	-2.6%	0.7%
2	ADT-2	ZnO (wt%)	0.0744	0.0744	0.0609	0.0135	0.0135	22.1%	22.1%
2	ADT-2	ZrO_2 (wt%)	0.0949	0.0949	0.1065	-0.0116	-0.0116	-10.9%	-10.9%
2	ADT-2	Sum of Oxides	99.1124	98.3353	100.0001	-0.8877	-1.6648	-0.9%	-1.7%
3	ADT-3	Al_2O_3 (wt%)	5.5882	5.5547	5.3586	0.2296	0.1961	4.3%	3.7%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by ADT Glass Number

(100-Batch 1 and 101-U std)

Glass #	Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
3	ADT-3	B_2O_3 (wt%)	4.9747	5.0955	5.2000	-0.2253	-0.1045	-4.3%	-2.0%
3	ADT-3	BaO (wt%)	0.0477	0.0503	0.0518	-0.0041	-0.0015	-7.9%	-2.9%
3	ADT-3	CaO (wt%)	1.0120	1.0264	1.0182	-0.0062	0.0082	-0.6%	0.8%
3	ADT-3	Ce_2O_3 (wt%)	0.0565	0.0565	0.0835	-0.0270	-0.0270	-32.3%	-32.3%
3	ADT-3	Cr_2O_3 (wt%)	0.0753	0.0725	0.0834	-0.0081	-0.0109	-9.7%	-13.1%
3	ADT-3	CuO (wt%)	0.0416	0.0439	0.0313	0.0103	0.0126	33.0%	40.3%
3	ADT-3	Fe_2O_3 (wt%)	10.8586	10.9340	11.4448	-0.5862	-0.5108	-5.1%	-4.5%
3	ADT-3	K_2O (wt%)	0.0831	0.0892	0.0731	0.0100	0.0161	13.7%	22.0%
3	ADT-3	La_2O_3 (wt%)	0.0358	0.0358	0.0408	-0.0050	-0.0050	-12.3%	-12.3%
3	ADT-3	Li_2O (wt%)	5.0755	5.1991	5.2000	-0.1245	-0.0009	-2.4%	0.0%
3	ADT-3	MgO (wt%)	1.1926	1.2572	1.2481	-0.0555	0.0091	-4.4%	0.7%
3	ADT-3	MnO (wt%)	2.3694	2.3583	2.3399	0.0295	0.0184	1.3%	0.8%
3	ADT-3	Na_2O (wt%)	13.8911	13.9970	14.2084	-0.3173	-0.2114	-2.2%	-1.5%
3	ADT-3	NiO (wt%)	0.5554	0.5964	0.6174	-0.0620	-0.0210	-10.0%	-3.4%
3	ADT-3	PbO (wt%)	0.0522	0.0522	0.0500	0.0022	0.0022	4.5%	4.5%
3	ADT-3	SiO_2 (wt%)	48.6156	47.4205	49.1837	-0.5681	-1.7632	-1.2%	-3.6%
3	ADT-3	ThO_2 (wt%)	0.0569	0.0569	0.0122	0.0447	0.0447	366.4%	366.4%
3	ADT-3	TiO_2 (wt%)	0.0179	0.0187	0.0119	0.0060	0.0068	50.7%	57.3%
3	ADT-3	U_3O_8 (wt%)	3.5376	3.6578	3.5966	-0.0590	0.0612	-1.6%	1.7%
3	ADT-3	ZnO (wt%)	0.0538	0.0538	0.0533	0.0005	0.0005	1.0%	1.0%
3	ADT-3	ZrO_2 (wt%)	0.0837	0.0837	0.0932	-0.0095	-0.0095	-10.1%	-10.1%
3	ADT-3	Sum of Oxides	98.2754	97.7106	100.0002	-1.7248	-2.2896	-1.7%	-2.3%
4	ADT-4	Al_2O_3 (wt%)	6.3534	6.3153	6.1242	0.2292	0.1911	3.7%	3.1%
4	ADT-4	B_2O_3 (wt%)	4.5642	4.6745	4.8000	-0.2358	-0.1255	-4.9%	-2.6%
4	ADT-4	BaO (wt%)	0.0550	0.0579	0.0592	-0.0042	-0.0013	-7.1%	-2.1%
4	ADT-4	CaO (wt%)	1.1232	1.1392	1.1637	-0.0405	-0.0245	-3.5%	-2.1%
4	ADT-4	Ce_2O_3 (wt%)	0.0767	0.0767	0.0955	-0.0188	-0.0188	-19.7%	-19.7%
4	ADT-4	Cr_2O_3 (wt%)	0.0764	0.0736	0.0953	-0.0189	-0.0217	-19.9%	-22.8%
4	ADT-4	CuO (wt%)	0.0451	0.0475	0.0357	0.0094	0.0118	26.2%	33.2%
4	ADT-4	Fe_2O_3 (wt%)	12.5849	12.6681	13.0798	-0.4949	-0.4117	-3.8%	-3.1%
4	ADT-4	K_2O (wt%)	0.1003	0.1076	0.0835	0.0168	0.0241	20.1%	28.8%
4	ADT-4	La_2O_3 (wt%)	0.0405	0.0405	0.0466	-0.0061	-0.0061	-13.2%	-13.2%
4	ADT-4	Li_2O (wt%)	4.7095	4.8242	4.8000	-0.0905	0.0242	-1.9%	0.5%
4	ADT-4	MgO (wt%)	1.3128	1.3839	1.4263	-0.1135	-0.0424	-8.0%	-3.0%
4	ADT-4	MnO (wt%)	2.7180	2.7049	2.6742	0.0438	0.0307	1.6%	1.1%
4	ADT-4	Na_2O (wt%)	14.5247	14.6288	14.8096	-0.2849	-0.1808	-1.9%	-1.2%
4	ADT-4	NiO (wt%)	0.6140	0.6592	0.7056	-0.0916	-0.0464	-13.0%	-6.6%
4	ADT-4	PbO (wt%)	0.0579	0.0579	0.0571	0.0008	0.0008	1.4%	1.4%
4	ADT-4	SiO_2 (wt%)	44.7114	43.6124	45.6385	-0.9271	-2.0261	-2.0%	-4.4%
4	ADT-4	ThO_2 (wt%)	0.0569	0.0569	0.0139	0.0430	0.0430	309.3%	309.3%
4	ADT-4	TiO_2 (wt%)	0.0204	0.0213	0.0136	0.0068	0.0077	50.2%	56.9%
4	ADT-4	U_3O_8 (wt%)	3.9179	4.0509	4.1104	-0.1925	-0.0595	-4.7%	-1.4%
4	ADT-4	ZnO (wt%)	0.0582	0.0582	0.0609	-0.0027	-0.0027	-4.4%	-4.4%
4	ADT-4	ZrO_2 (wt%)	0.0949	0.0949	0.1065	-0.0116	-0.0116	-10.9%	-10.9%
4	ADT-4	Sum of Oxides	97.8162	97.3544	100.0001	-2.1839	-2.6457	-2.2%	-2.6%
5	ADT-5	Al_2O_3 (wt%)	5.5693	5.5359	5.3586	0.2107	0.1773	3.9%	3.3%
5	ADT-5	B_2O_3 (wt%)	5.4175	5.2872	5.2000	0.2175	0.0872	4.2%	1.7%
5	ADT-5	BaO (wt%)	0.0477	0.0503	0.0518	-0.0041	-0.0015	-7.9%	-2.9%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by ADT Glass Number

(100-Batch 1 and 101-U std)

Glass #	Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
5	ADT-5	CaO (wt%)	1.0109	1.0253	1.0182	-0.0073	0.0071	-0.7%	0.7%
5	ADT-5	Ce_2O_3 (wt%)	0.0700	0.0700	0.0835	-0.0135	-0.0135	-16.2%	-16.2%
5	ADT-5	Cr_2O_3 (wt%)	0.0924	0.0890	0.0834	0.0090	0.0056	10.8%	6.8%
5	ADT-5	CuO (wt%)	0.0413	0.0436	0.0313	0.0100	0.0123	32.0%	39.2%
5	ADT-5	Fe_2O_3 (wt%)	11.0194	11.0936	11.4448	-0.4254	-0.3512	-3.7%	-3.1%
5	ADT-5	K_2O (wt%)	0.0846	0.0908	0.0731	0.0115	0.0177	15.8%	24.2%
5	ADT-5	La_2O_3 (wt%)	0.0358	0.0358	0.0408	-0.0050	-0.0050	-12.3%	-12.3%
5	ADT-5	Li_2O (wt%)	5.2585	5.3518	5.2000	0.0585	0.1518	1.1%	2.9%
5	ADT-5	MgO (wt%)	1.1851	1.2493	1.2481	-0.0630	0.0012	-5.0%	0.1%
5	ADT-5	MnO (wt%)	2.3597	2.3484	2.3399	0.0198	0.0085	0.8%	0.4%
5	ADT-5	Na_2O (wt%)	14.9628	15.0716	15.5084	-0.5456	-0.4368	-3.5%	-2.8%
5	ADT-5	NiO (wt%)	0.5561	0.5971	0.6174	-0.0613	-0.0203	-9.9%	-3.3%
5	ADT-5	PbO (wt%)	0.0509	0.0509	0.0500	0.0009	0.0009	1.8%	1.8%
5	ADT-5	SiO_2 (wt%)	47.7599	46.5853	47.8837	-0.1238	-1.2984	-0.3%	-2.7%
5	ADT-5	ThO_2 (wt%)	0.0569	0.0569	0.0122	0.0447	0.0447	366.4%	366.4%
5	ADT-5	TiO_2 (wt%)	0.0183	0.0192	0.0119	0.0064	0.0073	54.2%	61.0%
5	ADT-5	U_3O_8 (wt%)	3.3401	3.4535	3.5966	-0.2565	-0.1431	-7.1%	-4.0%
5	ADT-5	ZnO (wt%)	0.0532	0.0532	0.0533	-0.0001	-0.0001	-0.2%	-0.2%
5	ADT-5	ZrO_2 (wt%)	0.0861	0.0861	0.0932	-0.0071	-0.0071	-7.6%	-7.6%
5	ADT-5	Sum of Oxides	99.0765	98.2447	100.0002	-0.9237	-1.7555	-0.9%	-1.8%
6	ADT-6	Al_2O_3 (wt%)	6.2826	6.2532	6.1242	0.1584	0.1290	2.6%	2.1%
6	ADT-6	B_2O_3 (wt%)	4.6286	4.7407	4.8000	-0.1714	-0.0593	-3.6%	-1.2%
6	ADT-6	BaO (wt%)	0.0544	0.0574	0.0592	-0.0048	-0.0018	-8.1%	-3.1%
6	ADT-6	CaO (wt%)	1.1323	1.1454	1.1637	-0.0314	-0.0183	-2.7%	-1.6%
6	ADT-6	Ce_2O_3 (wt%)	0.0700	0.0700	0.0955	-0.0255	-0.0255	-26.7%	-26.7%
6	ADT-6	Cr_2O_3 (wt%)	0.0910	0.0873	0.0953	-0.0043	-0.0080	-4.5%	-8.4%
6	ADT-6	CuO (wt%)	0.0473	0.0497	0.0357	0.0116	0.0140	32.4%	39.3%
6	ADT-6	Fe_2O_3 (wt%)	12.5778	12.8474	13.0798	-0.5020	-0.2324	-3.8%	-1.8%
6	ADT-6	K_2O (wt%)	0.1003	0.1074	0.0835	0.0168	0.0239	20.1%	28.7%
6	ADT-6	La_2O_3 (wt%)	0.0408	0.0408	0.0466	-0.0058	-0.0058	-12.5%	-12.5%
6	ADT-6	Li_2O (wt%)	4.6556	4.7690	4.8000	-0.1444	-0.0310	-3.0%	-0.6%
6	ADT-6	MgO (wt%)	1.3215	1.3817	1.4263	-0.1048	-0.0446	-7.3%	-3.1%
6	ADT-6	MnO (wt%)	2.6792	2.6995	2.6742	0.0050	0.0253	0.2%	0.9%
6	ADT-6	Na_2O (wt%)	15.7379	15.4882	16.0096	-0.2717	-0.5214	-1.7%	-3.3%
6	ADT-6	NiO (wt%)	0.6162	0.6602	0.7056	-0.0894	-0.0454	-12.7%	-6.4%
6	ADT-6	PbO (wt%)	0.0571	0.0571	0.0571	0.0000	0.0000	0.0%	0.0%
6	ADT-6	SiO_2 (wt%)	43.7487	42.9130	44.4385	-0.6898	-1.5255	-1.6%	-3.4%
6	ADT-6	ThO_2 (wt%)	0.0569	0.0569	0.0139	0.0430	0.0430	309.3%	309.3%
6	ADT-6	TiO_2 (wt%)	0.0209	0.0216	0.0136	0.0073	0.0080	53.3%	59.0%
6	ADT-6	U_3O_8 (wt%)	3.9208	4.0507	4.1104	-0.1896	-0.0597	-4.6%	-1.5%
6	ADT-6	ZnO (wt%)	0.0582	0.0582	0.0609	-0.0027	-0.0027	-4.4%	-4.4%
6	ADT-6	ZrO_2 (wt%)	0.0922	0.0922	0.1065	-0.0143	-0.0143	-13.4%	-13.4%
6	ADT-6	Sum of Oxides	97.9902	97.6476	100.0001	-2.0099	-2.3525	-2.0%	-2.4%
7	ADT-7	Al_2O_3 (wt%)	5.4796	5.4538	5.3586	0.1210	0.0952	2.3%	1.8%
7	ADT-7	B_2O_3 (wt%)	5.3370	5.2078	5.2000	0.1370	0.0078	2.6%	0.1%
7	ADT-7	BaO (wt%)	0.0480	0.0506	0.0518	-0.0038	-0.0012	-7.3%	-2.3%
7	ADT-7	CaO (wt%)	0.9602	0.9713	1.0182	-0.0580	-0.0469	-5.7%	-4.6%
7	ADT-7	Ce_2O_3 (wt%)	0.0559	0.0559	0.0835	-0.0276	-0.0276	-33.0%	-33.0%

Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by ADT Glass Number

(100-Batch 1 and 101-U std)

Glass #	Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
7	ADT-7	Cr_2O_3 (wt%)	0.0797	0.0764	0.0834	-0.0037	-0.0070	-4.5%	-8.4%
7	ADT-7	CuO (wt%)	0.0473	0.0497	0.0313	0.0160	0.0184	51.0%	58.9%
7	ADT-7	Fe_2O_3 (wt%)	10.6977	10.9271	11.4448	-0.7471	-0.5177	-6.5%	-4.5%
7	ADT-7	K_2O (wt%)	0.0894	0.0958	0.0731	0.0163	0.0227	22.4%	31.1%
7	ADT-7	La_2O_3 (wt%)	0.0355	0.0355	0.0408	-0.0053	-0.0053	-13.0%	-13.0%
7	ADT-7	Li_2O (wt%)	3.2670	3.3244	3.2500	0.0170	0.0744	0.5%	2.3%
7	ADT-7	MgO (wt%)	1.1424	1.1945	1.2481	-0.1057	-0.0536	-8.5%	-4.3%
7	ADT-7	MnO (wt%)	2.3371	2.3548	2.3399	-0.0028	0.0149	-0.1%	0.6%
7	ADT-7	Na_2O (wt%)	16.9511	16.6817	17.4584	-0.5073	-0.7767	-2.9%	-4.4%
7	ADT-7	NiO (wt%)	0.5325	0.5706	0.6174	-0.0849	-0.0468	-13.7%	-7.6%
7	ADT-7	PbO (wt%)	0.0496	0.0496	0.0500	-0.0004	-0.0004	-0.9%	-0.9%
7	ADT-7	SiO_2 (wt%)	47.0111	46.1145	47.8837	-0.8726	-1.7692	-1.8%	-3.7%
7	ADT-7	ThO_2 (wt%)	0.0569	0.0569	0.0122	0.0447	0.0447	366.4%	366.4%
7	ADT-7	TiO_2 (wt%)	0.0200	0.0208	0.0119	0.0081	0.0089	68.2%	74.4%
7	ADT-7	U_3O_8 (wt%)	3.3814	3.4933	3.5966	-0.2152	-0.1033	-6.0%	-2.9%
7	ADT-7	ZnO (wt%)	0.0495	0.0495	0.0533	-0.0038	-0.0038	-7.2%	-7.2%
7	ADT-7	ZrO_2 (wt%)	0.0810	0.0810	0.0932	-0.0122	-0.0122	-13.0%	-13.0%
7	ADT-7	Sum of Oxides	97.7099	96.9154	100.0002	-2.2903	-3.0848	-2.3%	-3.1%
8	ADT-8	Al_2O_3 (wt%)	6.3487	6.3107	6.1242	0.2245	0.1865	3.7%	3.0%
8	ADT-8	B_2O_3 (wt%)	4.4596	4.5674	4.8000	-0.3404	-0.2326	-7.1%	-4.8%
8	ADT-8	BaO (wt%)	0.0555	0.0585	0.0592	-0.0037	-0.0007	-6.2%	-1.1%
8	ADT-8	CaO (wt%)	1.1396	1.1559	1.1637	-0.0241	-0.0078	-2.1%	-0.7%
8	ADT-8	Ce_2O_3 (wt%)	0.0392	0.0392	0.0955	-0.0563	-0.0563	-58.9%	-58.9%
8	ADT-8	Cr_2O_3 (wt%)	0.0910	0.0876	0.0953	-0.0043	-0.0077	-4.5%	-8.0%
8	ADT-8	CuO (wt%)	0.0526	0.0555	0.0357	0.0169	0.0198	47.3%	55.3%
8	ADT-8	Fe_2O_3 (wt%)	12.0202	12.1040	13.0798	-1.0596	-0.9758	-8.1%	-7.5%
8	ADT-8	K_2O (wt%)	0.0919	0.0985	0.0835	0.0084	0.0150	10.0%	18.0%
8	ADT-8	La_2O_3 (wt%)	0.0410	0.0410	0.0466	-0.0056	-0.0056	-11.9%	-11.9%
8	ADT-8	Li_2O (wt%)	2.9764	3.0489	3.0000	-0.0236	0.0489	-0.8%	1.6%
8	ADT-8	MgO (wt%)	1.3356	1.4079	1.4263	-0.0907	-0.0184	-6.4%	-1.3%
8	ADT-8	MnO (wt%)	2.6728	2.6605	2.6742	-0.0014	-0.0137	-0.1%	-0.5%
8	ADT-8	Na_2O (wt%)	17.3218	17.4584	17.8096	-0.4878	-0.3512	-2.7%	-2.0%
8	ADT-8	NiO (wt%)	0.6337	0.6804	0.7056	-0.0719	-0.0252	-10.2%	-3.6%
8	ADT-8	PbO (wt%)	0.0579	0.0579	0.0571	0.0008	0.0008	1.4%	1.4%
8	ADT-8	SiO_2 (wt%)	44.2300	43.1420	44.4385	-0.2085	-1.2965	-0.5%	-2.9%
8	ADT-8	ThO_2 (wt%)	0.0569	0.0569	0.0139	0.0430	0.0430	309.3%	309.3%
8	ADT-8	TiO_2 (wt%)	0.0209	0.0218	0.0136	0.0073	0.0082	53.3%	60.0%
8	ADT-8	U_3O_8 (wt%)	4.0152	4.1518	4.1104	-0.0952	0.0414	-2.3%	1.0%
8	ADT-8	ZnO (wt%)	0.0601	0.0601	0.0609	-0.0008	-0.0008	-1.4%	-1.4%
8	ADT-8	ZrO_2 (wt%)	0.0962	0.0962	0.1065	-0.0103	-0.0103	-9.6%	-9.6%
8	ADT-8	Sum of Oxides	97.8168	97.3613	100.0001	-2.1833	-2.6388	-2.2%	-2.6%
100	Batch 1	Al_2O_3 (wt%)	4.9033	4.8770	4.8770	0.0263	0.0000	0.5%	0.0%
100	Batch 1	B_2O_3 (wt%)	7.7841	7.7770	7.7770	0.0071	0.0000	0.1%	0.0%
100	Batch 1	BaO (wt%)	0.1433	0.1510	0.1510	-0.0077	0.0000	-5.1%	0.0%
100	Batch 1	CaO (wt%)	1.2045	1.2200	1.2200	-0.0155	0.0000	-1.3%	0.0%
100	Batch 1	Ce_2O_3 (wt%)	0.0059	0.0059	0.0000	0.0059	0.0059		
100	Batch 1	Cr_2O_3 (wt%)	0.1113	0.1070	0.1070	0.0043	0.0000	4.0%	0.0%
100	Batch 1	CuO (wt%)	0.3787	0.3990	0.3990	-0.0203	0.0000	-5.1%	0.0%

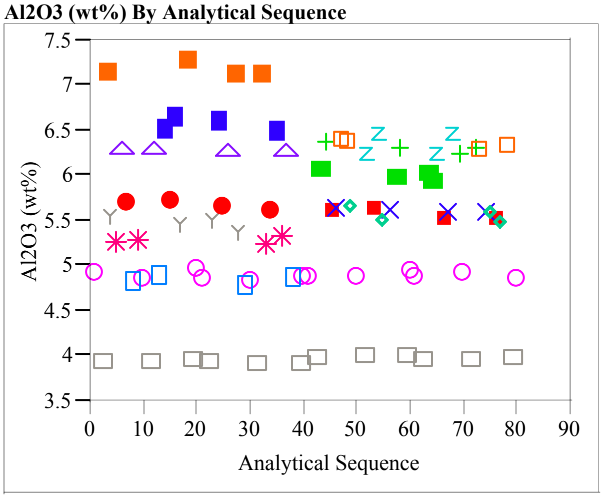
Table C4. Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide by ADT Glass Number

(100-Batch 1 and 101-U std)

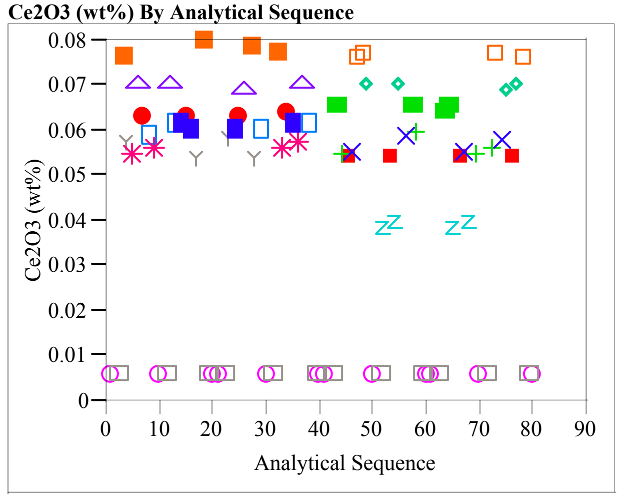
Glass #	Glass ID	Oxide	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	Diff of Measured	Diff of Meas BC	% Diff of Measured	% Diff of Meas BC
100	Batch 1	Fe_2O_3 (wt%)	12.6624	12.8390	12.8390	-0.1766	0.0000	-1.4%	0.0%
100	Batch 1	K_2O (wt%)	3.1039	3.3270	3.3270	-0.2231	0.0000	-6.7%	0.0%
100	Batch 1	La_2O_3 (wt%)	0.0059	0.0059	0.0000	0.0059	0.0059		
100	Batch 1	Li_2O (wt%)	4.3381	4.4290	4.4290	-0.0909	0.0000	-2.1%	0.0%
100	Batch 1	MgO (wt%)	1.3516	1.4190	1.4190	-0.0674	0.0000	-4.7%	0.0%
100	Batch 1	MnO (wt%)	1.7238	1.7260	1.7260	-0.0022	0.0000	-0.1%	0.0%
100	Batch 1	Na_2O (wt%)	9.0417	9.0030	9.0030	0.0387	0.0000	0.4%	0.0%
100	Batch 1	NiO (wt%)	0.7002	0.7510	0.7510	-0.0508	0.0000	-6.8%	0.0%
100	Batch 1	PbO (wt%)	0.0108	0.0108	0.0000	0.0108	0.0108		
100	Batch 1	SiO_2 (wt%)	51.3432	50.2200	50.2200	1.1232	0.0000	2.2%	0.0%
100	Batch 1	ThO_2 (wt%)	0.0569	0.0569	0.0000	0.0569	0.0569		
100	Batch 1	TiO_2 (wt%)	0.6508	0.6770	0.6770	-0.0262	0.0000	-3.9%	0.0%
100	Batch 1	U_3O_8 (wt%)	0.0590	0.0609	0.0000	0.0590	0.0609		
100	Batch 1	ZnO (wt%)	0.0062	0.0062	0.0000	0.0062	0.0062		
100	Batch 1	ZrO_2 (wt%)	0.1036	0.1036	0.0980	0.0056	0.0056	5.7%	5.7%
100	Batch 1	Sum of Oxides	99.6889	99.1721	99.0200	0.6689	0.1521	0.7%	0.2%
101	Ustd	Al_2O_3 (wt%)	3.9522	3.9311	4.1000	-0.1478	-0.1689	-3.6%	-4.1%
101	Ustd	B_2O_3 (wt%)	9.1874	9.1792	9.2090	-0.0216	-0.0298	-0.2%	-0.3%
101	Ustd	BaO (wt%)	0.0056	0.0059	0.0000	0.0056	0.0059		
101	Ustd	CaO (wt%)	1.2187	1.2344	1.3010	-0.0823	-0.0666	-6.3%	-5.1%
101	Ustd	Ce_2O_3 (wt%)	0.0059	0.0059	0.0000	0.0059	0.0059		
101	Ustd	Cr_2O_3 (wt%)	0.2345	0.2254	0.0000	0.2345	0.2254		
101	Ustd	CuO (wt%)	0.0125	0.0132	0.0000	0.0125	0.0132		
101	Ustd	Fe_2O_3 (wt%)	12.9257	13.1074	13.1960	-0.2703	-0.0886	-2.0%	-0.7%
101	Ustd	K_2O (wt%)	2.9452	3.1571	2.9990	-0.0538	0.1581	-1.8%	5.3%
101	Ustd	La_2O_3 (wt%)	0.0059	0.0059	0.0000	0.0059	0.0059		
101	Ustd	Li_2O (wt%)	3.0966	3.1615	3.0570	0.0396	0.1045	1.3%	3.4%
101	Ustd	MgO (wt%)	1.1199	1.1757	1.2100	-0.0901	-0.0343	-7.4%	-2.8%
101	Ustd	MnO (wt%)	2.7987	2.8026	2.8920	-0.0933	-0.0894	-3.2%	-3.1%
101	Ustd	Na_2O (wt%)	11.6647	11.6145	11.7950	-0.1303	-0.1805	-1.1%	-1.5%
101	Ustd	NiO (wt%)	0.9626	1.0325	1.1200	-0.1574	-0.0875	-14.0%	-7.8%
101	Ustd	PbO (wt%)	0.0108	0.0108	0.0000	0.0108	0.0108		
101	Ustd	SiO_2 (wt%)	45.2997	44.3083	45.3530	-0.0533	-1.0447	-0.1%	-2.3%
101	Ustd	ThO_2 (wt%)	0.0569	0.0569	0.0000	0.0569	0.0569		
101	Ustd	TiO_2 (wt%)	0.9089	0.9455	1.0490	-0.1401	-0.1035	-13.4%	-9.9%
101	Ustd	U_3O_8 (wt%)	2.3279	2.4060	2.4060	-0.0781	0.0000	-3.2%	0.0%
101	Ustd	ZnO (wt%)	0.0062	0.0062	0.0000	0.0062	0.0062		
101	Ustd	ZrO_2 (wt%)	0.0068	0.0068	0.0000	0.0068	0.0068		
101	Ustd	Sum of Oxides	98.7533	98.3925	99.6870	-0.9337	-1.2945	-0.9%	-1.3%

Exhibit C1. Oxide Measurements in Analytical Sequence by Set for Samples Prepared Using the LM Method

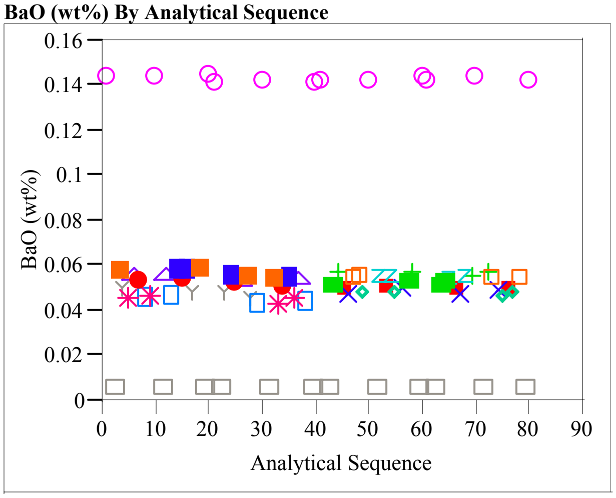
Al2O3 (wt%) By Analytical Sequence



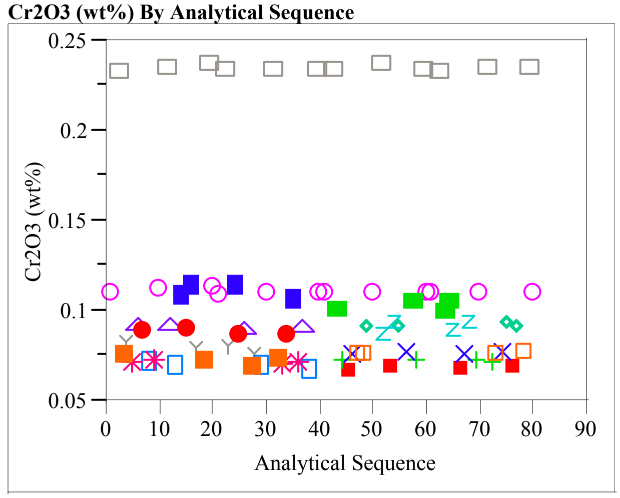
Ce2O3 (wt%) By Analytical Sequence



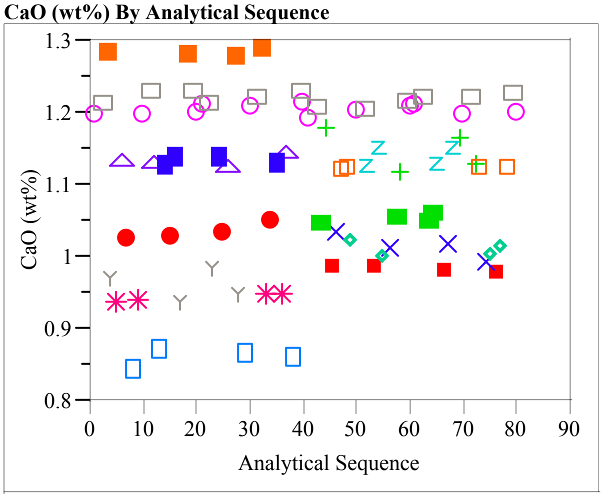
BaO (wt%) By Analytical Sequence



Cr2O3 (wt%) By Analytical Sequence



CaO (wt%) By Analytical Sequence



CuO (wt%) By Analytical Sequence

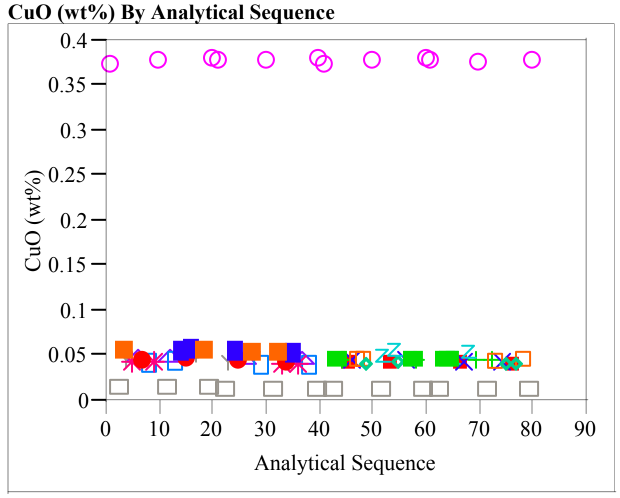
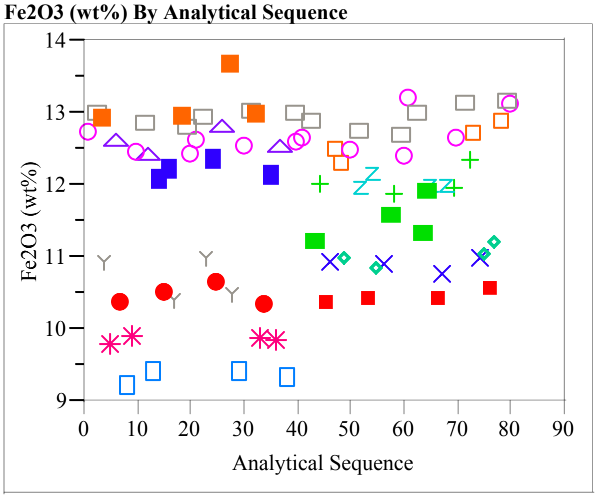
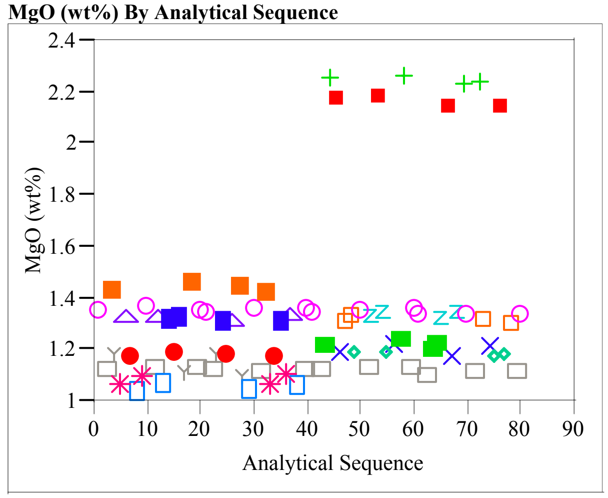


Exhibit C1. Oxide Measurements in Analytical Sequence by Set for Samples Prepared Using the LM Method

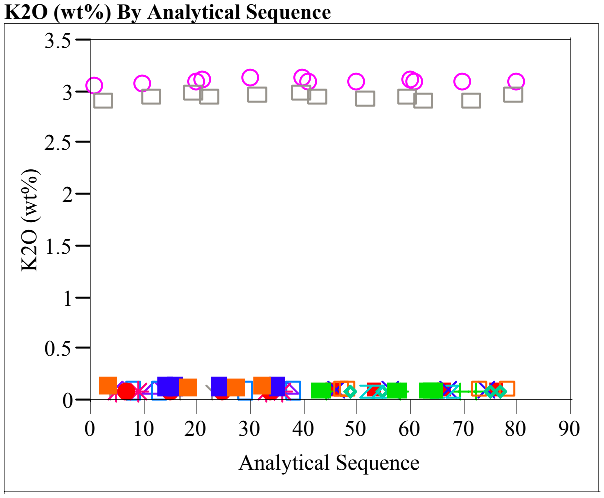
Fe2O3 (wt%) By Analytical Sequence



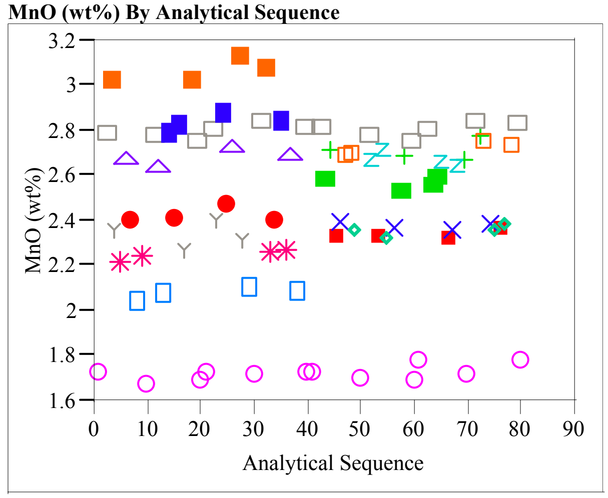
MgO (wt%) By Analytical Sequence



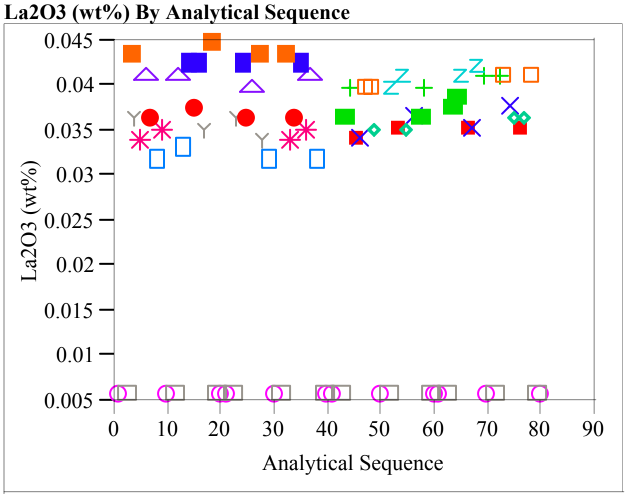
K2O (wt%) By Analytical Sequence



MnO (wt%) By Analytical Sequence



La2O3 (wt%) By Analytical Sequence



Na2O (wt%) By Analytical Sequence

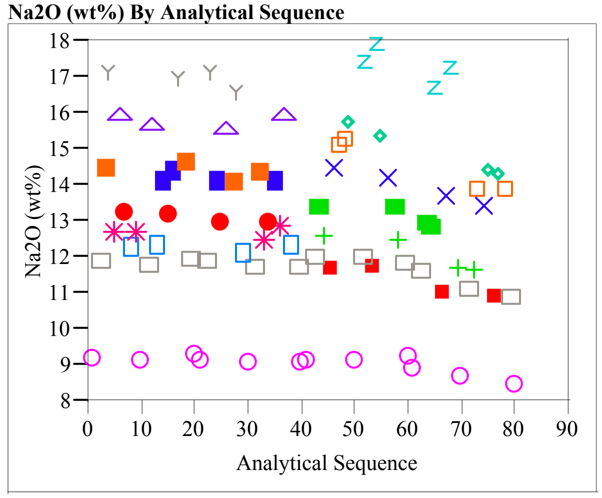


Exhibit C1. Oxide Measurements in Analytical Sequence by Set for Samples Prepared Using the LM Method

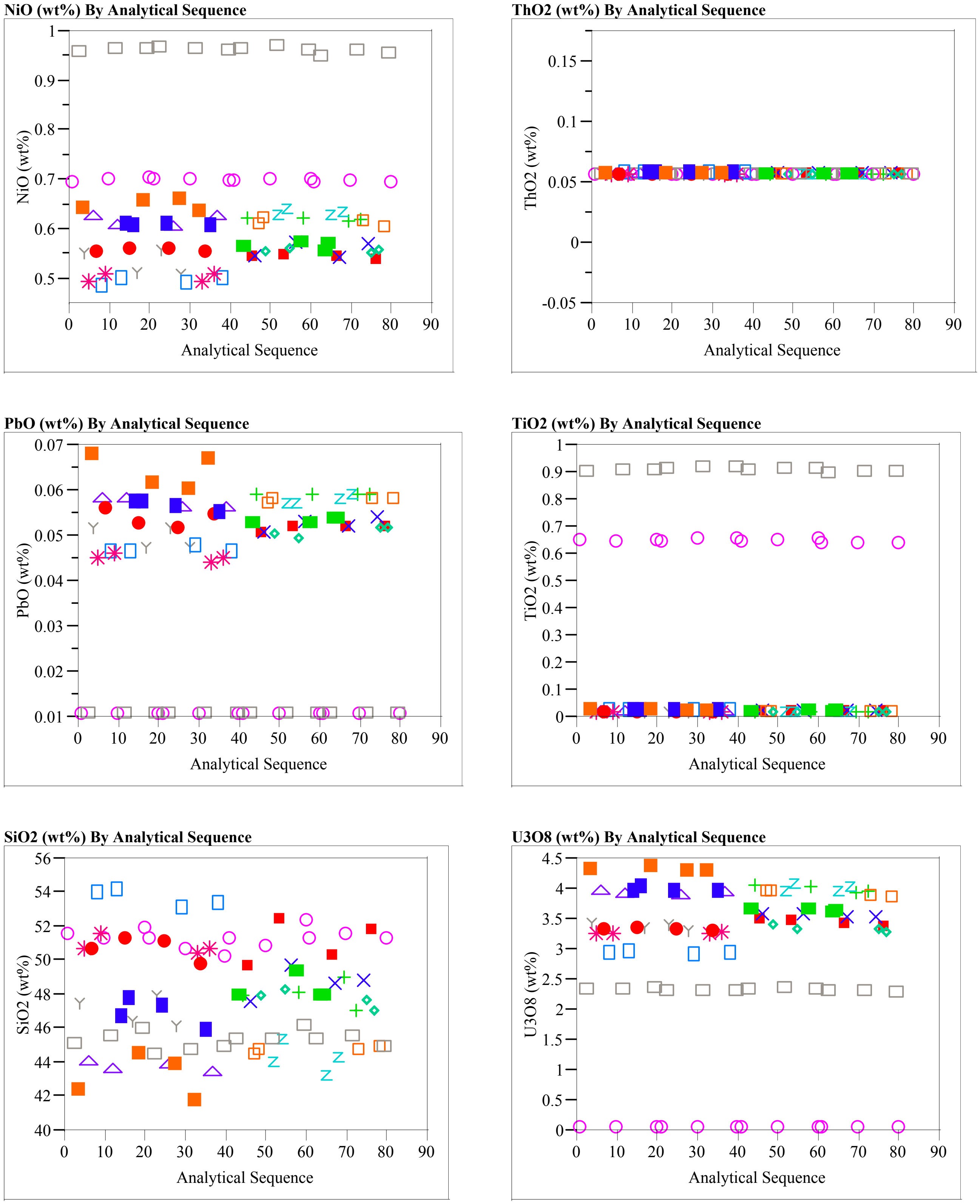
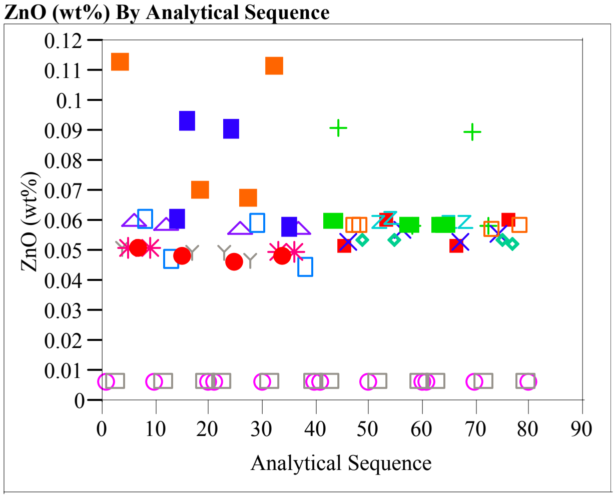


Exhibit C1. Oxide Measurements in Analytical Sequence by Set for Samples Prepared Using the LM Method

ZnO (wt%) By Analytical Sequence



ZrO2 (wt%) By Analytical Sequence

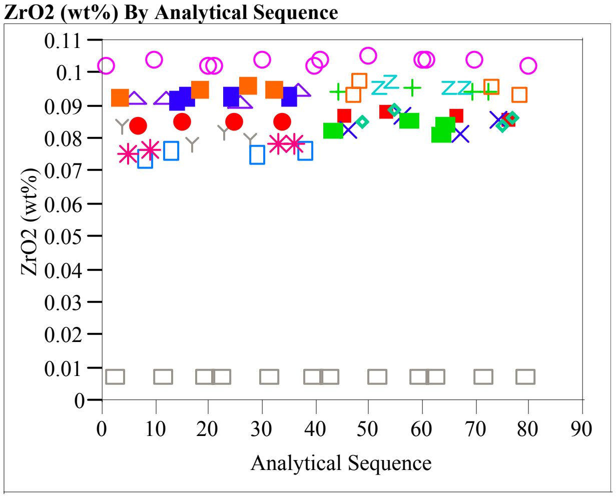
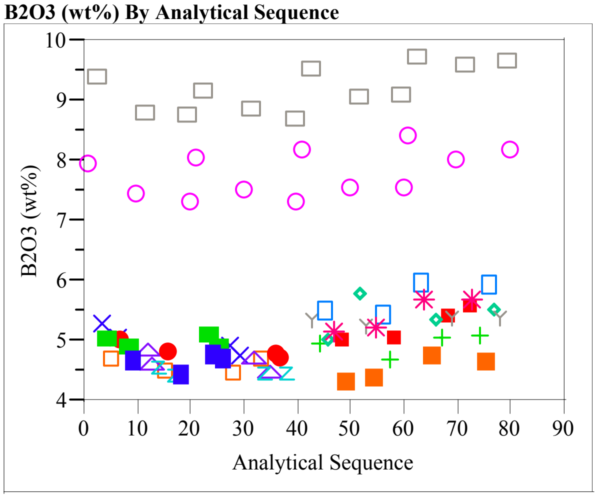


Exhibit C2. Oxide Measurements in Analytical Sequence by Set for Samples Prepared Using the PF Method

B2O3 (wt%) By Analytical Sequence



Li2O (wt%) By Analytical Sequence

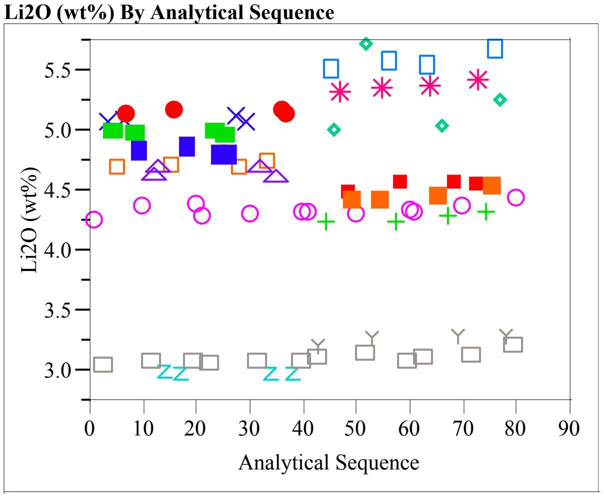
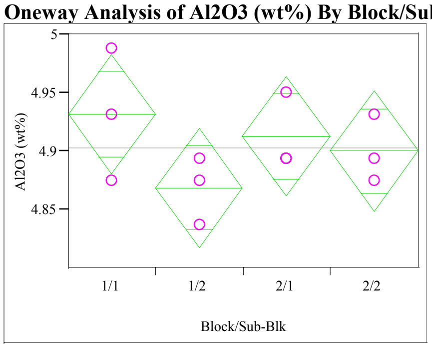


Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1 reference value 4.877 wt%
Oneway Analysis of Al2O3 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.346405
Root Mean Square Error	0.038569
Mean of Response	4.903252
Observations (or Sum Wgts)	12

Analysis of Variance

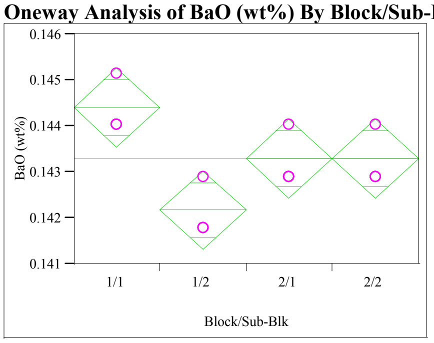
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00630737	0.002102	1.4133	0.3084
Error	8	0.01190070	0.001488		
C. Total	11	0.01820807			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.93160	0.02227	4.8802	4.9829
1/2	3	4.86861	0.02227	4.8173	4.9200
2/1	3	4.91270	0.02227	4.8613	4.9641
2/2	3	4.90010	0.02227	4.8488	4.9515

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 0.151 wt%
Oneway Analysis of BaO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.692308
Root Mean Square Error	0.000645
Mean of Response	0.143284
Observations (or Sum Wgts)	12

Analysis of Variance

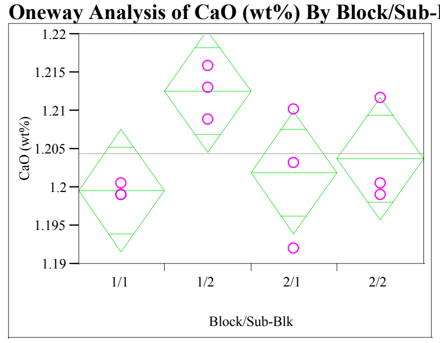
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00000748	0.0000025	6.0000	0.0191
Error	8	0.00000332	4.1552e-7		
C. Total	11	0.00001080			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.144401	0.00037	0.14354	0.14526
1/2	3	0.142168	0.00037	0.14131	0.14303
2/1	3	0.143284	0.00037	0.14243	0.14414
2/2	3	0.143284	0.00037	0.14243	0.14414

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 1.220 wt%
Oneway Analysis of CaO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.5028
Root Mean Square Error	0.006018
Mean of Response	1.204478
Observations (or Sum Wgts)	12

Analysis of Variance

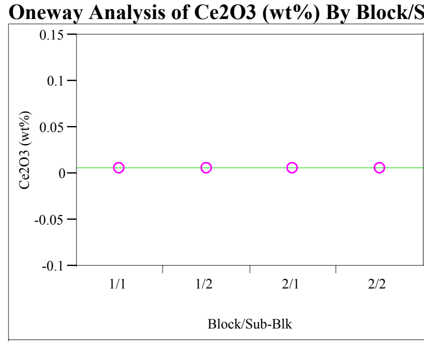
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00029301	0.000098	2.6967	0.1165
Error	8	0.00028975	0.000036		
C. Total	11	0.00058276			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	1.19958	0.00347	1.1916	1.2076
1/2	3	1.21264	0.00347	1.2046	1.2207
2/1	3	1.20191	0.00347	1.1939	1.2099
2/2	3	1.20378	0.00347	1.1958	1.2118

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 0 wt%
Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

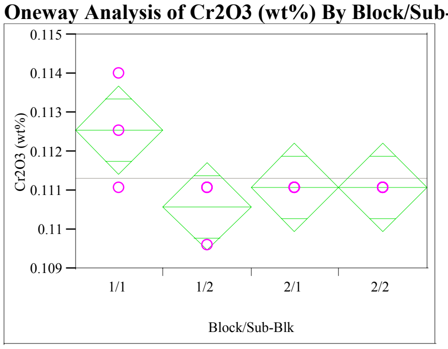
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005857	0	0.00586	0.00586
1/2	3	0.005857	0	0.00586	0.00586
2/1	3	0.005857	0	0.00586	0.00586
2/2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1 reference value 0.107 wt%
Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.529412
Root Mean Square Error	0.000844
Mean of Response	0.111325
Observations (or Sum Wgts)	12

Analysis of Variance

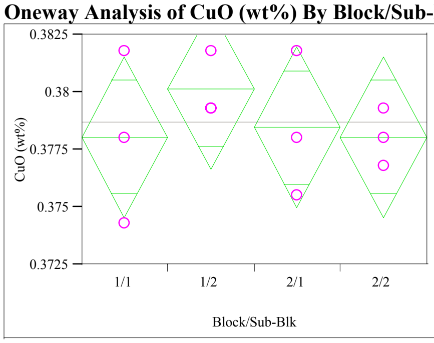
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00000641	0.0000021	3.0000	0.0951
Error	8	0.00000570	7.1209e-7		
C. Total	11	0.00001211			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.112543	0.00049	0.11142	0.11367
1/2	3	0.110594	0.00049	0.10947	0.11172
2/1	3	0.111082	0.00049	0.10996	0.11221
2/2	3	0.111082	0.00049	0.10996	0.11221

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 0.399 wt%
Oneway Analysis of CuO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.138211
Root Mean Square Error	0.002631
Mean of Response	0.378669
Observations (or Sum Wgts)	12

Analysis of Variance

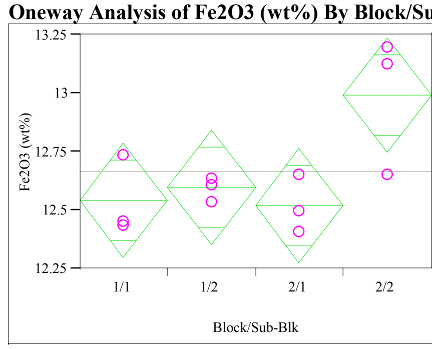
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00000888	0.000003	0.4277	0.7387
Error	8	0.00005537	0.0000069		
C. Total	11	0.00006425			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.378044	0.00152	0.37454	0.38155
1/2	3	0.380130	0.00152	0.37663	0.38363
2/1	3	0.378461	0.00152	0.37496	0.38196
2/2	3	0.378044	0.00152	0.37454	0.38155

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 12.839 wt%
Oneway Analysis of Fe2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.62291
Root Mean Square Error	0.182812
Mean of Response	12.66238
Observations (or Sum Wgts)	12

Analysis of Variance

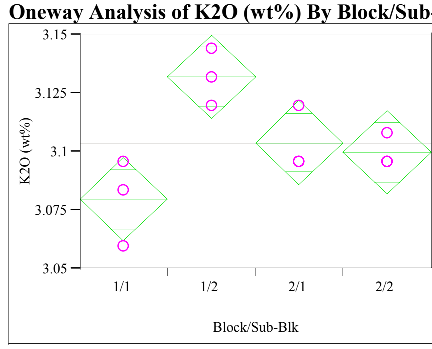
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.44164936	0.147216	4.4050	0.0415
Error	8	0.26736071	0.033420		
C. Total	11	0.70901007			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	12.5432	0.10555	12.300	12.787
1/2	3	12.5957	0.10555	12.352	12.839
2/1	3	12.5194	0.10555	12.276	12.763
2/2	3	12.9912	0.10555	12.748	13.235

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 3.327 wt%
Oneway Analysis of K2O (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.741379
Root Mean Square Error	0.013468
Mean of Response	3.103853
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00415971	0.001387	7.6444	0.0098
Error	8	0.00145106	0.000181		
C. Total	11	0.00561077			

Means for Oneway Anova

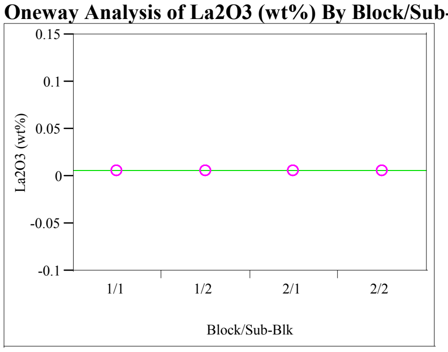
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	3.07976	0.00778	3.0618	3.0977
1/2	3	3.13196	0.00778	3.1140	3.1499
2/1	3	3.10385	0.00778	3.0859	3.1218
2/2	3	3.09984	0.00778	3.0819	3.1178

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1 reference value 0 wt%

Oneway Analysis of La2O3 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

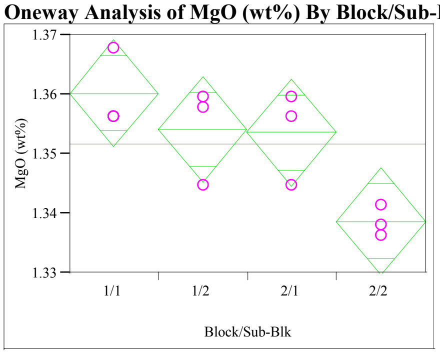
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005864	0	0.00586	0.00586
1/2	3	0.005864	0	0.00586	0.00586
2/1	3	0.005864	0	0.00586	0.00586
2/2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 1.419 wt%

Oneway Analysis of MgO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.677896
Root Mean Square Error	0.006701
Mean of Response	1.351628
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00075606	0.000252	5.6122	0.0228
Error	8	0.00035924	0.000045		
C. Total	11	0.00111530			

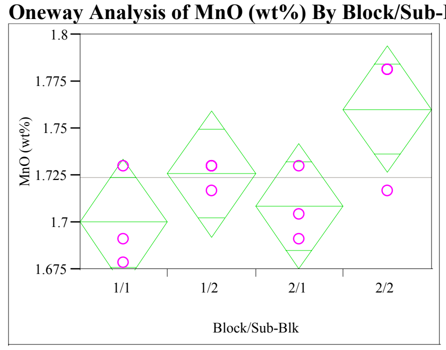
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	1.36019	0.00387	1.3513	1.3691
1/2	3	1.35412	0.00387	1.3452	1.3630
2/1	3	1.35356	0.00387	1.3446	1.3625
2/2	3	1.33864	0.00387	1.3297	1.3476

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 1.726 wt%

Oneway Analysis of MnO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.555556
Root Mean Square Error	0.02528
Mean of Response	1.723752
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00639092	0.002130	3.3333	0.0770
Error	8	0.00511274	0.000639		
C. Total	11	0.01150366			

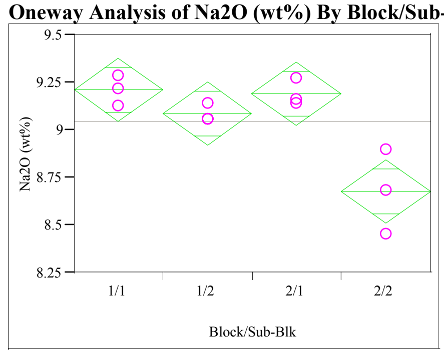
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	1.70008	0.01460	1.6664	1.7337
1/2	3	1.72590	0.01460	1.6922	1.7596
2/1	3	1.70869	0.01460	1.6750	1.7423
2/2	3	1.76034	0.01460	1.7267	1.7940

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 9.003 wt%

Oneway Analysis of Na2O (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.815727
Root Mean Square Error	0.125853
Mean of Response	9.04171
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.56092486	0.186975	11.8047	0.0026
Error	8	0.12671272	0.015839		
C. Total	11	0.68763758			

Means for Oneway Anova

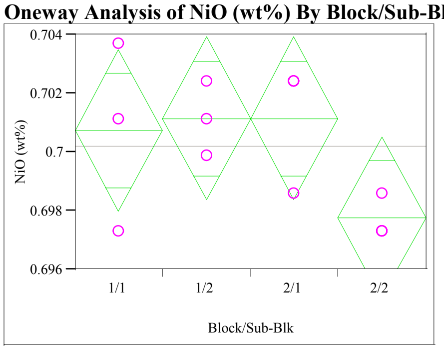
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	9.21133	0.07266	9.0438	9.3789
1/2	3	9.08552	0.07266	8.9180	9.2531
2/1	3	9.19336	0.07266	9.0258	9.3609
2/2	3	8.67663	0.07266	8.5091	8.8442

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1 reference value 0.751 wt%

Oneway Analysis of NiO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.411494
Root Mean Square Error	0.002078
Mean of Response	0.700193
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00002415	0.0000081	1.8646	0.2139
Error	8	0.00003454	0.0000043		
C. Total	11	0.00005870			

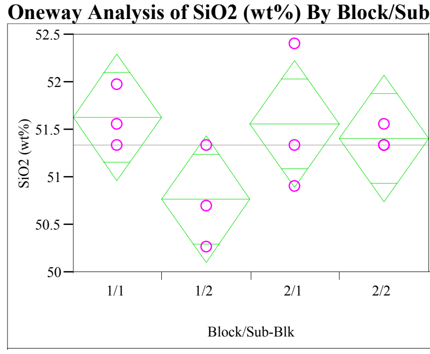
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.700723	0.00120	0.69796	0.70349
1/2	3	0.701147	0.00120	0.69838	0.70391
2/1	3	0.701147	0.00120	0.69838	0.70391
2/2	3	0.697754	0.00120	0.69499	0.70052

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 50.22 wt%

Oneway Analysis of SiO2 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.405405
Root Mean Square Error	0.50171
Mean of Response	51.3432
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	1.3729813	0.457660	1.8182	0.2218
Error	8	2.0137060	0.251713		
C. Total	11	3.3866873			

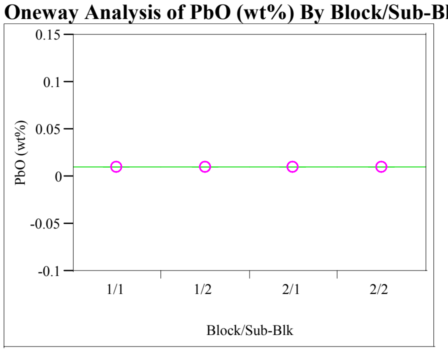
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	51.6284	0.28966	50.960	52.296
1/2	3	50.7727	0.28966	50.105	51.441
2/1	3	51.5571	0.28966	50.889	52.225
2/2	3	51.4145	0.28966	50.747	52.082

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0
Root Mean Square Error	2.12e-18
Mean of Response	0.010772
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	0.0000	1.0000
Error	8	3.6111e-35	4.514e-36		
C. Total	11	3.6111e-35			

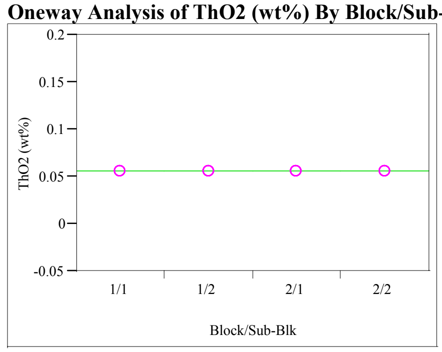
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.010772	1.227e-18	0.01077	0.01077
1/2	3	0.010772	1.227e-18	0.01077	0.01077
2/1	3	0.010772	1.227e-18	0.01077	0.01077
2/2	3	0.010772	1.227e-18	0.01077	0.01077

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value ~0 wt%

Oneway Analysis of ThO2 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

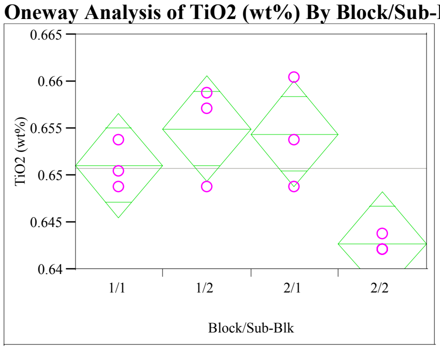
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.056895	0	0.05690	0.05690
1/2	3	0.056895	0	0.05690	0.05690
2/1	3	0.056895	0	0.05690	0.05690
2/2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Batch 1 reference value 0.677 wt%
Oneway Analysis of TiO2 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.670282
Root Mean Square Error	0.004198
Mean of Response	0.650798
Observations (or Sum Wgts)	12

Analysis of Variance

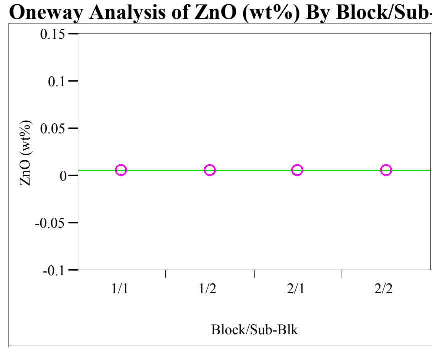
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00028657	0.000096	5.4211	0.0249
Error	8	0.00014097	0.000018		
C. Total	11	0.00042754			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.651076	0.00242	0.64549	0.65666
1/2	3	0.654968	0.00242	0.64938	0.66056
2/1	3	0.654412	0.00242	0.64882	0.66000
2/2	3	0.642736	0.00242	0.63715	0.64832

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value ~0 wt%
Oneway Analysis of ZnO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	12

Analysis of Variance

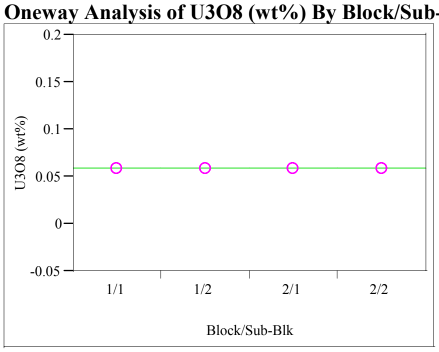
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.006224	0	0.00622	0.00622
1/2	3	0.006224	0	0.00622	0.00622
2/1	3	0.006224	0	0.00622	0.00622
2/2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 0 wt%
Oneway Analysis of U3O8 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.05896
Observations (or Sum Wgts)	12

Analysis of Variance

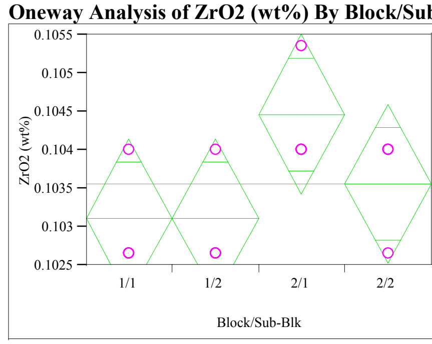
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.058960	0	0.05896	0.05896
1/2	3	0.058960	0	0.05896	0.05896
2/1	3	0.058960	0	0.05896	0.05896
2/2	3	0.058960	0	0.05896	0.05896

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 0.098 wt%
Oneway Analysis of ZrO2 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.428571
Root Mean Square Error	0.00078
Mean of Response	0.103561
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00000365	0.0000012	2.0000	0.1927
Error	8	0.00000487	6.0822e-7		
C. Total	11	0.00000852			

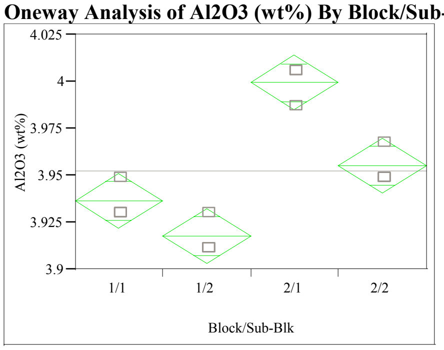
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.103111	0.00045	0.10207	0.10415
1/2	3	0.103111	0.00045	0.10207	0.10415
2/1	3	0.104462	0.00045	0.10342	0.10550
2/2	3	0.103561	0.00045	0.10252	0.10460

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Ustd reference value 4.1 wt%
Oneway Analysis of Al2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.920792
Root Mean Square Error	0.010909
Mean of Response	3.952204
Observations (or Sum Wgts)	12

Analysis of Variance

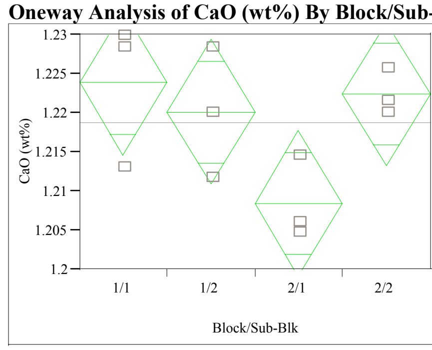
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.01106765	0.003689	31.0000	<.0001
Error	8	0.00095206	0.000119		
C. Total	11	0.01201971			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	3.93646	0.00630	3.9219	3.9510
1/2	3	3.91756	0.00630	3.9030	3.9321
2/1	3	3.99944	0.00630	3.9849	4.0140
2/2	3	3.95535	0.00630	3.9408	3.9699

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 1.301 wt%
Oneway Analysis of CaO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.533019
Root Mean Square Error	0.006961
Mean of Response	1.218703
Observations (or Sum Wgts)	12

Analysis of Variance

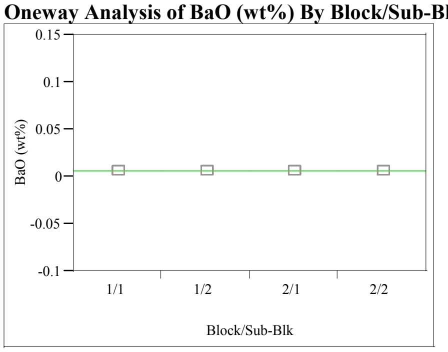
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00044245	0.000147	3.0438	0.0925
Error	8	0.00038764	0.000048		
C. Total	11	0.00083009			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	1.22383	0.00402	1.2146	1.2331
1/2	3	1.22010	0.00402	1.2108	1.2294
2/1	3	1.20844	0.00402	1.1992	1.2177
2/2	3	1.22243	0.00402	1.2132	1.2317

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 0 wt%
Oneway Analysis of BaO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005583
Observations (or Sum Wgts)	12

Analysis of Variance

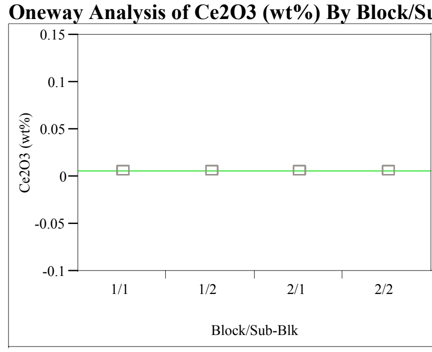
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005583	0	0.00558	0.00558
1/2	3	0.005583	0	0.00558	0.00558
2/1	3	0.005583	0	0.00558	0.00558
2/2	3	0.005583	0	0.00558	0.00558

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value ~0 wt%
Oneway Analysis of Ce2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

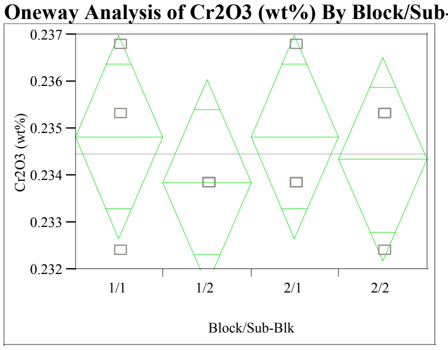
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005857	0	0.00586	0.00586
1/2	3	0.005857	0	0.00586	0.00586
2/1	3	0.005857	0	0.00586	0.00586
2/2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Ustd reference value ~0 wt%
Oneway Analysis of Cr2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.083969
Root Mean Square Error	0.001634
Mean of Response	0.234465
Observations (or Sum Wgts)	12

Analysis of Variance

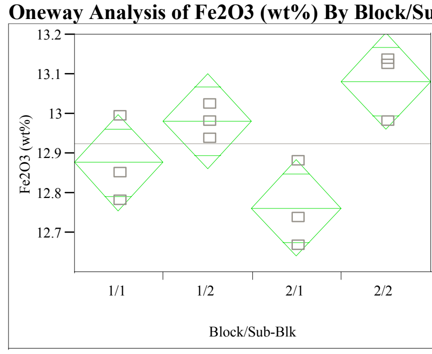
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00000196	6.5275e-7	0.2444	0.8630
Error	8	0.00002136	0.0000027		
C. Total	11	0.00002332			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.234830	0.00094	0.23265	0.23701
1/2	3	0.233856	0.00094	0.23168	0.23603
2/1	3	0.234830	0.00094	0.23265	0.23701
2/2	3	0.234343	0.00094	0.23217	0.23652

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 13.196 wt%
Oneway Analysis of Fe2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.718306
Root Mean Square Error	0.091173
Mean of Response	12.92568
Observations (or Sum Wgts)	12

Analysis of Variance

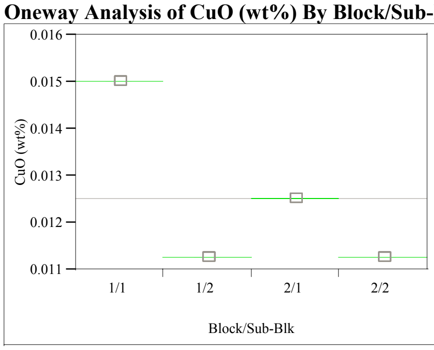
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.16957033	0.056523	6.7999	0.0136
Error	8	0.06649950	0.008312		
C. Total	11	0.23606983			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	12.8768	0.05264	12.755	12.998
1/2	3	12.9817	0.05264	12.860	13.103
2/1	3	12.7625	0.05264	12.641	12.884
2/2	3	13.0818	0.05264	12.960	13.203

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 0 wt%
Oneway Analysis of CuO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	1
Root Mean Square Error	2.91e-11
Mean of Response	0.012518
Observations (or Sum Wgts)	12

Analysis of Variance

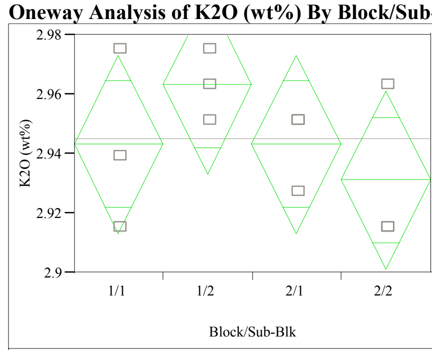
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00002821	0.0000094	1.11e+16	<.0001
Error	8	0.00000000	8.47e-22		
C. Total	11	0.00002821			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.015022	1.68e-11	0.01502	0.01502
1/2	3	0.011266	1.68e-11	0.01127	0.01127
2/1	3	0.012518	1.68e-11	0.01252	0.01252
2/2	3	0.011266	1.68e-11	0.01127	0.01127

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 2.999 wt%
Oneway Analysis of K2O (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.282051
Root Mean Square Error	0.022536
Mean of Response	2.945247
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00159617	0.000532	1.0476	0.4229
Error	8	0.00406297	0.000508		
C. Total	11	0.00565914			

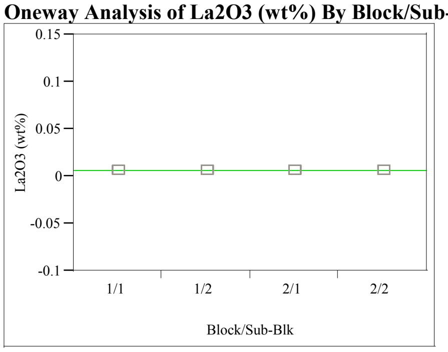
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	2.94324	0.01301	2.9132	2.9732
1/2	3	2.96332	0.01301	2.9333	2.9933
2/1	3	2.94324	0.01301	2.9132	2.9732
2/2	3	2.93119	0.01301	2.9012	2.9612

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Ustd reference value 0 wt%
Oneway Analysis of La2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	12

Analysis of Variance

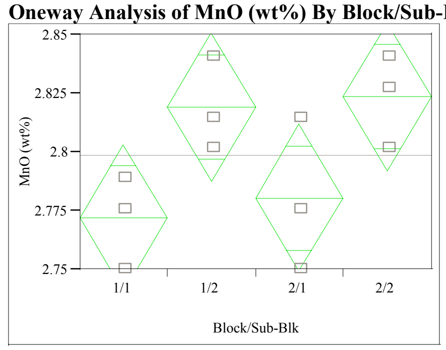
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.005864	0	0.00586	0.00586
1/2	3	0.005864	0	0.00586	0.00586
2/1	3	0.005864	0	0.00586	0.00586
2/2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 2.892 wt%
Oneway Analysis of MnO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.584955
Root Mean Square Error	0.023574
Mean of Response	2.798676
Observations (or Sum Wgts)	12

Analysis of Variance

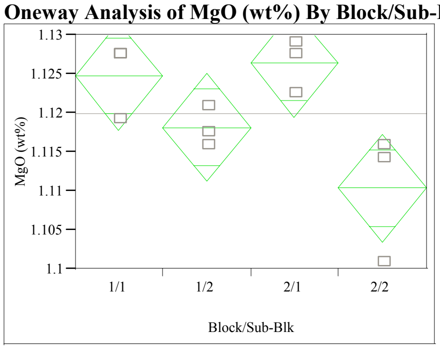
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00626588	0.002089	3.7583	0.0596
Error	8	0.00444586	0.000556		
C. Total	11	0.01071174			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	2.77178	0.01361	2.7404	2.8032
1/2	3	2.81912	0.01361	2.7877	2.8505
2/1	3	2.78038	0.01361	2.7490	2.8118
2/2	3	2.82342	0.01361	2.7920	2.8548

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 1.21 wt%
Oneway Analysis of MgO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.688962
Root Mean Square Error	0.005199
Mean of Response	1.119908
Observations (or Sum Wgts)	12

Analysis of Variance

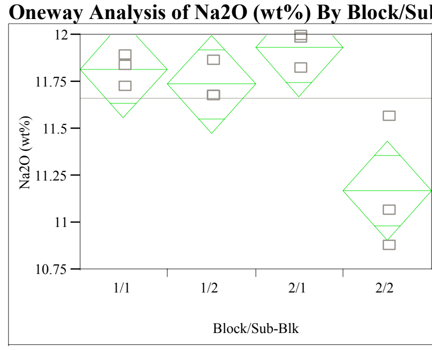
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00047906	0.000160	5.9068	0.0200
Error	8	0.00021628	0.000027		
C. Total	11	0.00069534			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	1.12474	0.00300	1.1178	1.1317
1/2	3	1.11811	0.00300	1.1112	1.1250
2/1	3	1.12640	0.00300	1.1195	1.1333
2/2	3	1.11037	0.00300	1.1035	1.1173

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 11.795 wt%
Oneway Analysis of Na2O (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.770533
Root Mean Square Error	0.196426
Mean of Response	11.66469
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	1.0364761	0.345492	8.9545	0.0062
Error	8	0.3086654	0.038583		
C. Total	11	1.3451415			

Means for Oneway Anova

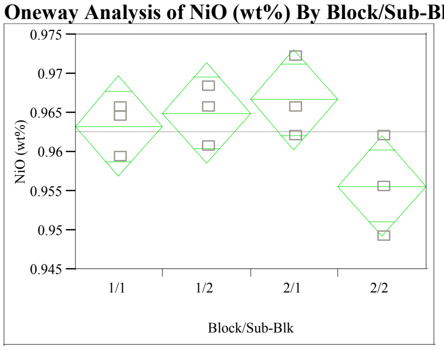
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	11.8175	0.11341	11.556	12.079
1/2	3	11.7366	0.11341	11.475	11.998
2/1	3	11.9343	0.11341	11.673	12.196
2/2	3	11.1704	0.11341	10.909	11.432

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Ustd reference value 1.12 wt%

Oneway Analysis of NiO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.533063
Root Mean Square Error	0.004832
Mean of Response	0.962646
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00021320	0.000071	3.0443	0.0924
Error	8	0.00018675	0.000023		
C. Total	11	0.00039996			

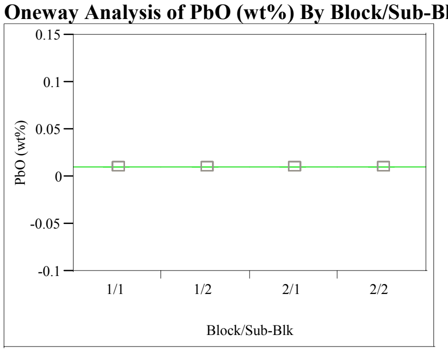
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.963282	0.00279	0.95685	0.96972
1/2	3	0.964979	0.00279	0.95855	0.97141
2/1	3	0.966676	0.00279	0.96024	0.97311
2/2	3	0.955647	0.00279	0.94921	0.96208

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0
Root Mean Square Error	2.12e-18
Mean of Response	0.010772
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	0.0000	1.0000
Error	8	3.6111e-35	4.514e-36		
C. Total	11	3.6111e-35			

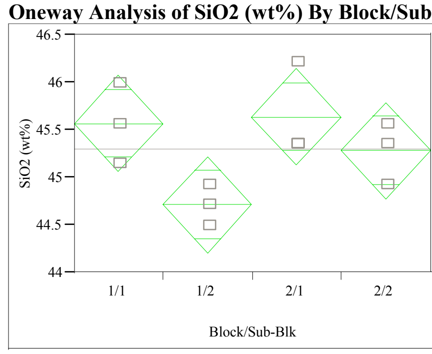
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.010772	1.227e-18	0.01077	0.01077
1/2	3	0.010772	1.227e-18	0.01077	0.01077
2/1	3	0.010772	1.227e-18	0.01077	0.01077
2/2	3	0.010772	1.227e-18	0.01077	0.01077

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 45.353 wt%

Oneway Analysis of SiO2 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	0.57953
Root Mean Square Error	0.380691
Mean of Response	45.29968
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	1.5979977	0.532666	3.6754	0.0626
Error	8	1.1594065	0.144926		
C. Total	11	2.7574042			

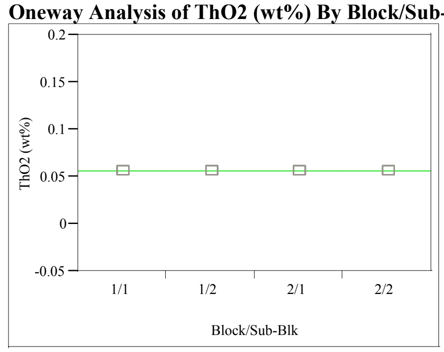
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	45.5671	0.21979	45.060	46.074
1/2	3	44.7114	0.21979	44.205	45.218
2/1	3	45.6384	0.21979	45.132	46.145
2/2	3	45.2818	0.21979	44.775	45.789

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 0 wt%

Oneway Analysis of ThO2 (wt%) By Block/Sub-Blk



Oneway Anova

Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

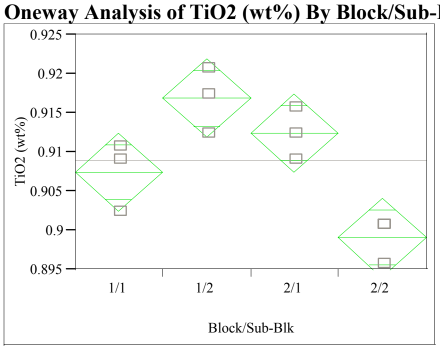
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.056895	0	0.05690	0.05690
1/2	3	0.056895	0	0.05690	0.05690
2/1	3	0.056895	0	0.05690	0.05690
2/2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

Exhibit C3. SRTC-ML Measurements by Set by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Glass ID=Ustd reference value 1.049 wt%
Oneway Analysis of TiO2 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.822352
Root Mean Square Error	0.003761
Mean of Response	0.908921
Observations (or Sum Wgts)	12

Analysis of Variance

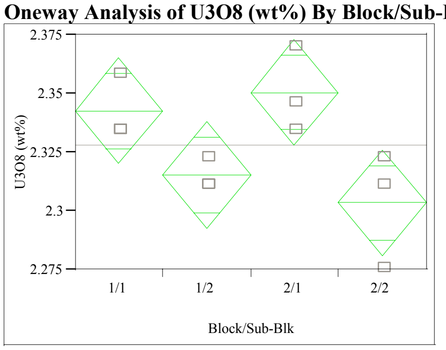
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00052375	0.000175	12.3443	0.0023
Error	8	0.00011314	0.000014		
C. Total	11	0.00063690			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.907392	0.00217	0.90239	0.91240
1/2	3	0.916844	0.00217	0.91184	0.92185
2/1	3	0.912396	0.00217	0.90739	0.91740
2/2	3	0.899052	0.00217	0.89405	0.90406

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 2.406 wt%
Oneway Analysis of U3O8 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.659284
Root Mean Square Error	0.01702
Mean of Response	2.327937
Observations (or Sum Wgts)	12

Analysis of Variance

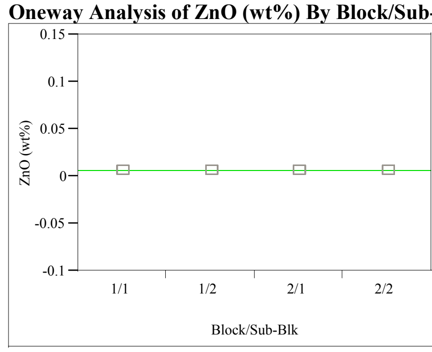
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00448440	0.001495	5.1600	0.0283
Error	8	0.00231752	0.000290		
C. Total	11	0.00680192			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	2.34268	0.00983	2.3200	2.3653
1/2	3	2.31516	0.00983	2.2925	2.3378
2/1	3	2.35054	0.00983	2.3279	2.3732
2/2	3	2.30337	0.00983	2.2807	2.3260

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 0 wt%
Oneway Analysis of ZnO (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	12

Analysis of Variance

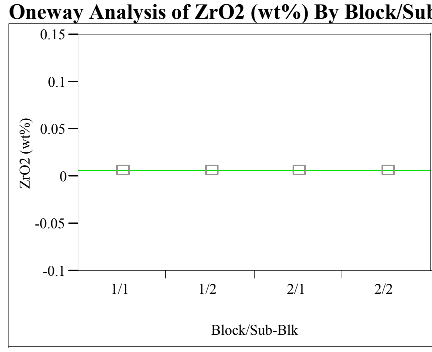
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.006224	0	0.00622	0.00622
1/2	3	0.006224	0	0.00622	0.00622
2/1	3	0.006224	0	0.00622	0.00622
2/2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 0 wt%
Oneway Analysis of ZrO2 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.006754
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0	0	.	.
Error	8	0	0		
C. Total	11	0			

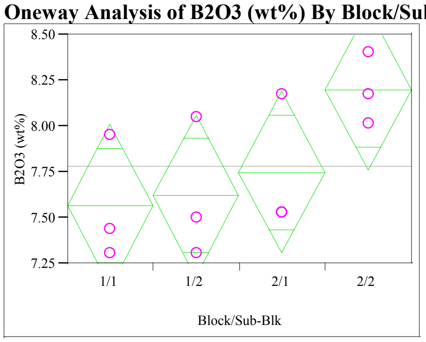
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	0.006754	0	0.00675	0.00675
1/2	3	0.006754	0	0.00675	0.00675
2/1	3	0.006754	0	0.00675	0.00675
2/2	3	0.006754	0	0.00675	0.00675

Std Error uses a pooled estimate of error variance

Exhibit C4. SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method

Glass ID=Batch 1 reference value 7.777 wt%
Oneway Analysis of B2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.458579
Root Mean Square Error	0.331509
Mean of Response	7.784108
Observations (or Sum Wgts)	12

Analysis of Variance

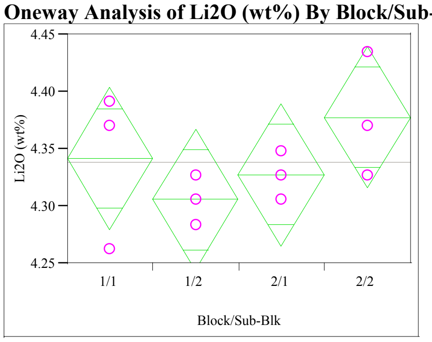
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.7446641	0.248221	2.2586	0.1588
Error	8	0.8791857	0.109898		
C. Total	11	1.6238498			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	7.56677	0.19140	7.1254	8.0081
1/2	3	7.62043	0.19140	7.1791	8.0618
2/1	3	7.74923	0.19140	7.3079	8.1906
2/2	3	8.20001	0.19140	7.7587	8.6414

Std Error uses a pooled estimate of error variance

Glass ID=Batch 1 reference value 4.429 wt%
Oneway Analysis of Li2O (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.321212
Root Mean Square Error	0.046508
Mean of Response	4.338093
Observations (or Sum Wgts)	12

Analysis of Variance

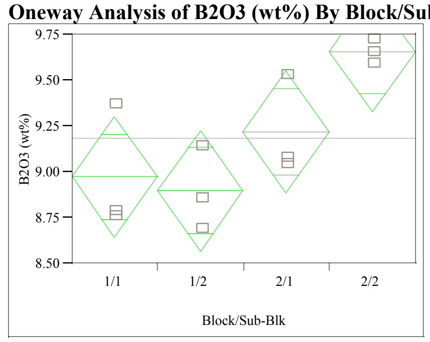
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.00818846	0.002729	1.2619	0.3508
Error	8	0.01730392	0.002163		
C. Total	11	0.02549238			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	4.34168	0.02685	4.2798	4.4036
1/2	3	4.30580	0.02685	4.2439	4.3677
2/1	3	4.32733	0.02685	4.2654	4.3892
2/2	3	4.37756	0.02685	4.3156	4.4395

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 9.209 wt%
Oneway Analysis of B2O3 (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.681899
Root Mean Square Error	0.248892
Mean of Response	9.187448
Observations (or Sum Wgts)	12

Analysis of Variance

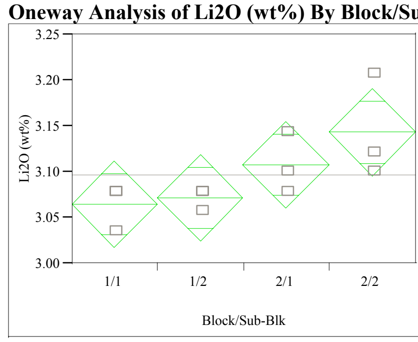
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	1.0623494	0.354116	5.7164	0.0217
Error	8	0.4955787	0.061947		
C. Total	11	1.5579281			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	8.97279	0.14370	8.6414	9.3042
1/2	3	8.89766	0.14370	8.5663	9.2290
2/1	3	9.21965	0.14370	8.8883	9.5510
2/2	3	9.65970	0.14370	9.3283	9.9911

Std Error uses a pooled estimate of error variance

Glass ID=Ustd reference value 3.057 wt%
Oneway Analysis of Li2O (wt%) By Block/Sub-Blk



Oneway Anova
Summary of Fit

Rsquare	0.538462
Root Mean Square Error	0.035702
Mean of Response	3.096588
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block/Sub-Blk	3	0.01189644	0.003965	3.1111	0.0885
Error	8	0.01019695	0.001275		
C. Total	11	0.02209340			

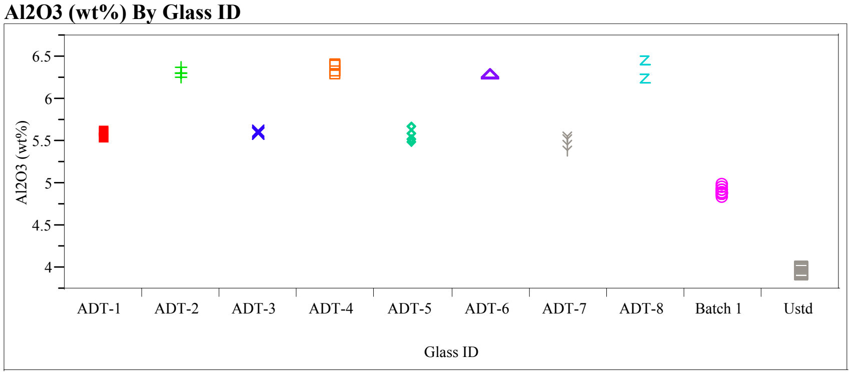
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1/1	3	3.06429	0.02061	3.0168	3.1118
1/2	3	3.07147	0.02061	3.0239	3.1190
2/1	3	3.10735	0.02061	3.0598	3.1549
2/2	3	3.14323	0.02061	3.0957	3.1908

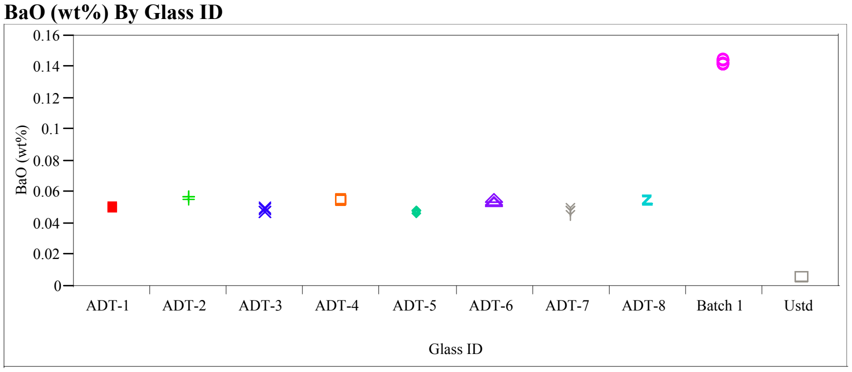
Std Error uses a pooled estimate of error variance

Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

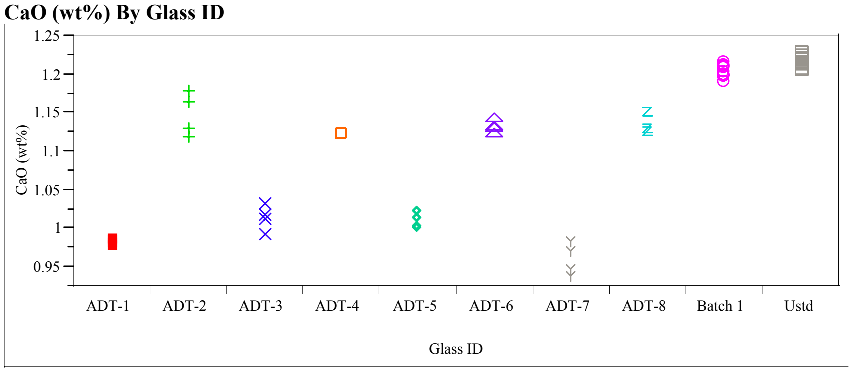
Al2O3 (wt%) By Glass ID



BaO (wt%) By Glass ID



CaO (wt%) By Glass ID



Ce2O3 (wt%) By Glass ID

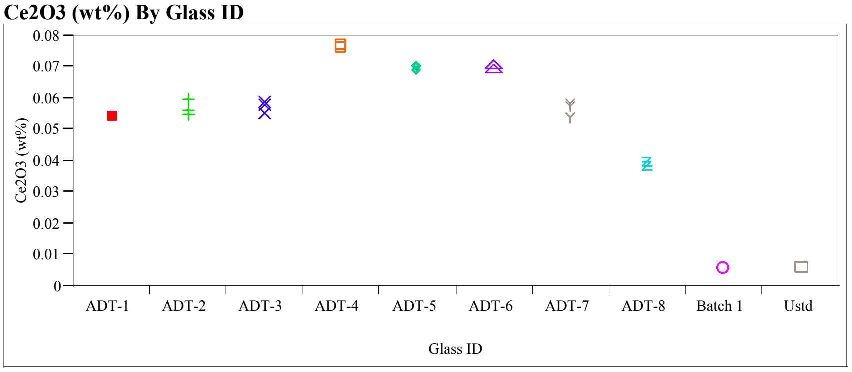
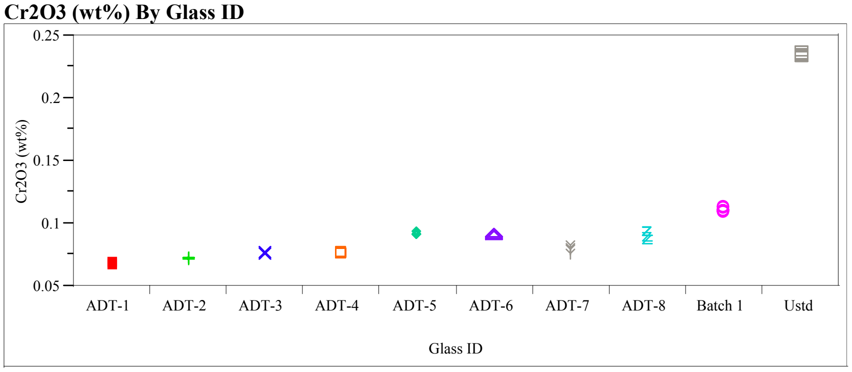
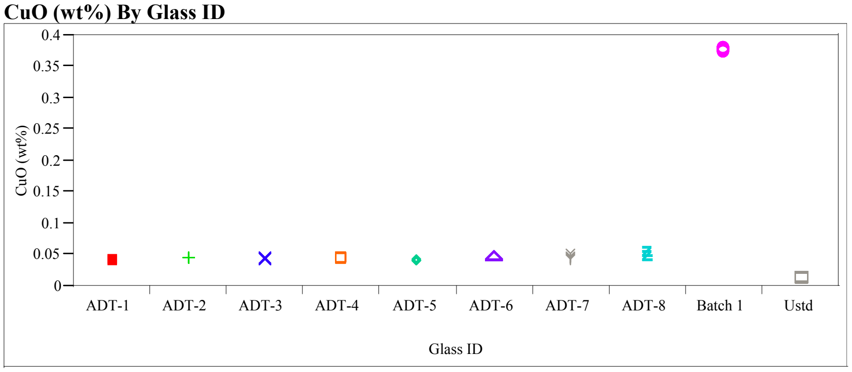


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

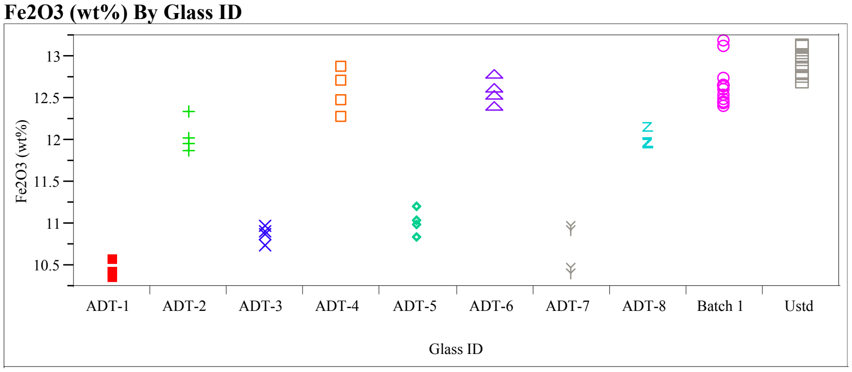
Cr2O3 (wt%) By Glass ID



CuO (wt%) By Glass ID



Fe2O3 (wt%) By Glass ID



K2O (wt%) By Glass ID

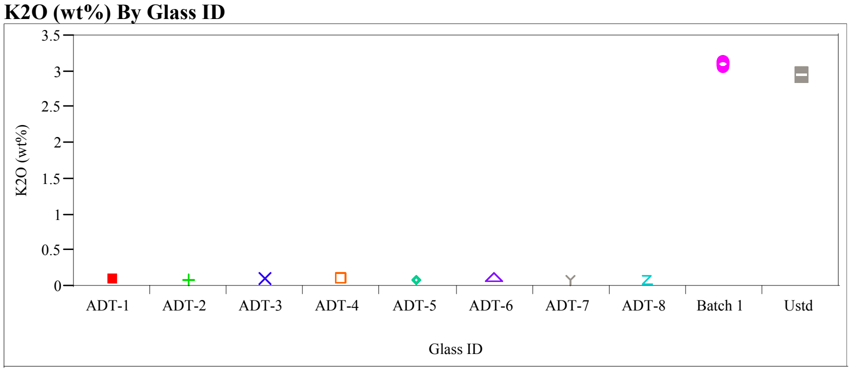
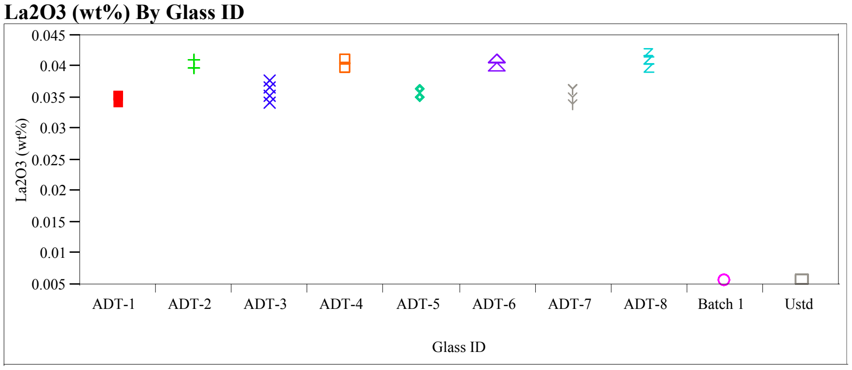
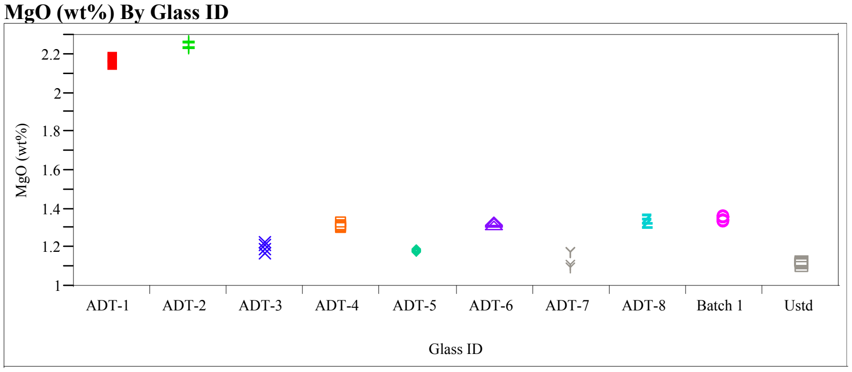


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

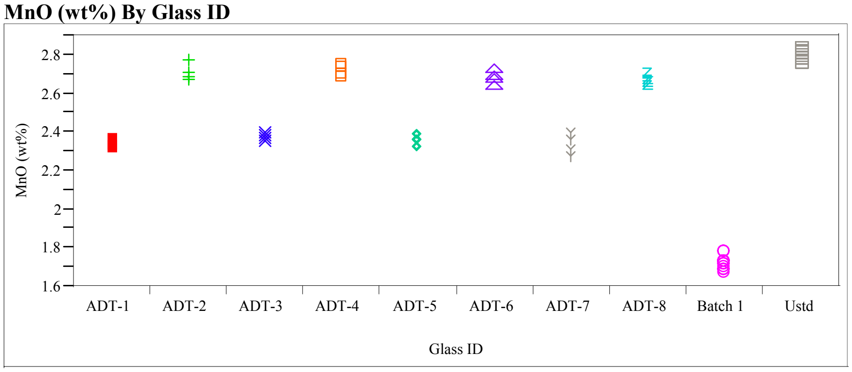
La2O3 (wt%) By Glass ID



MgO (wt%) By Glass ID



MnO (wt%) By Glass ID



Na2O (wt%) By Glass ID

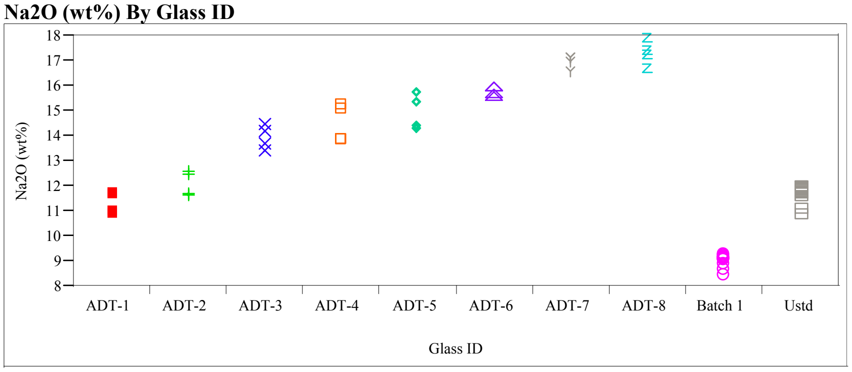
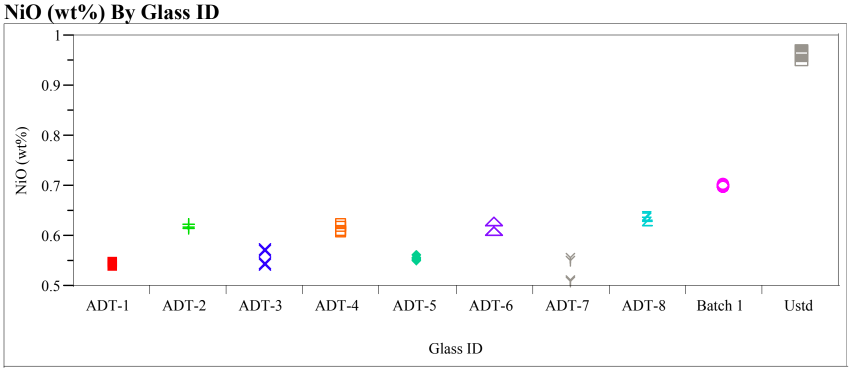
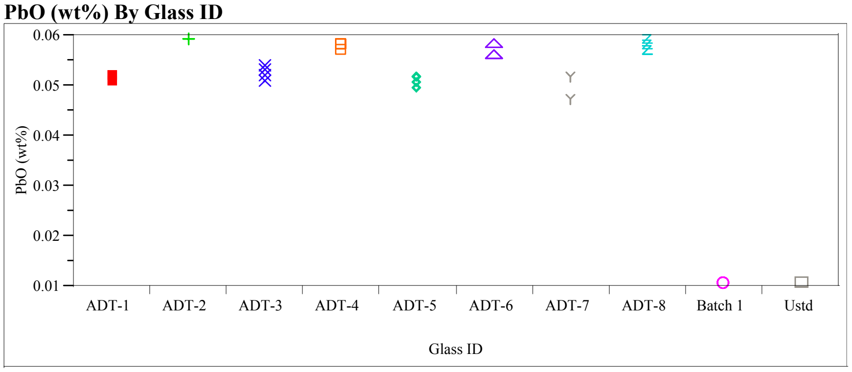


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

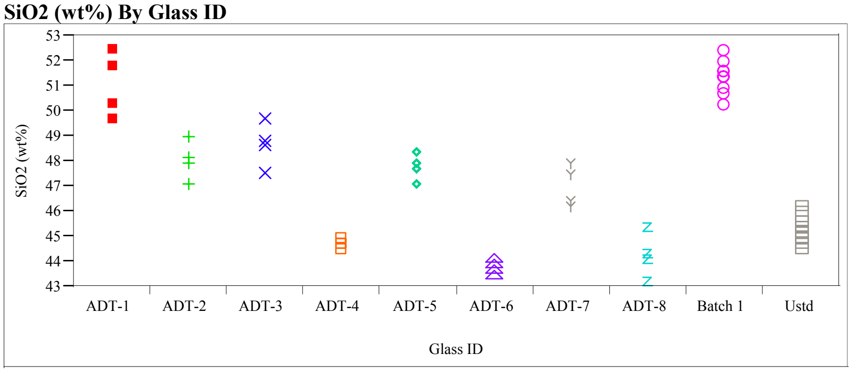
NiO (wt%) By Glass ID



PbO (wt%) By Glass ID



SiO2 (wt%) By Glass ID



ThO2 (wt%) By Glass ID

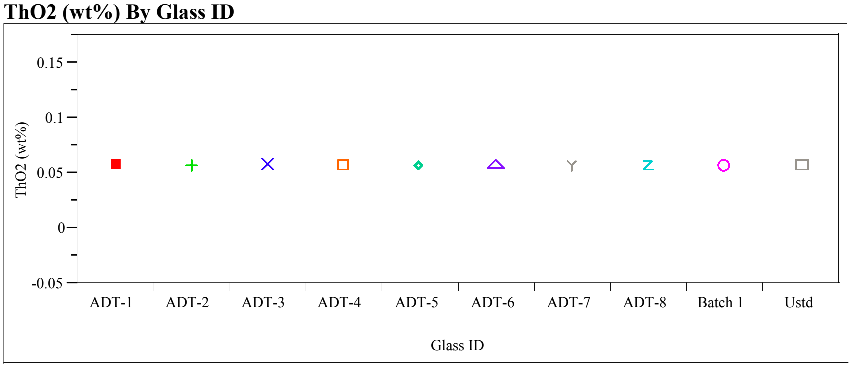
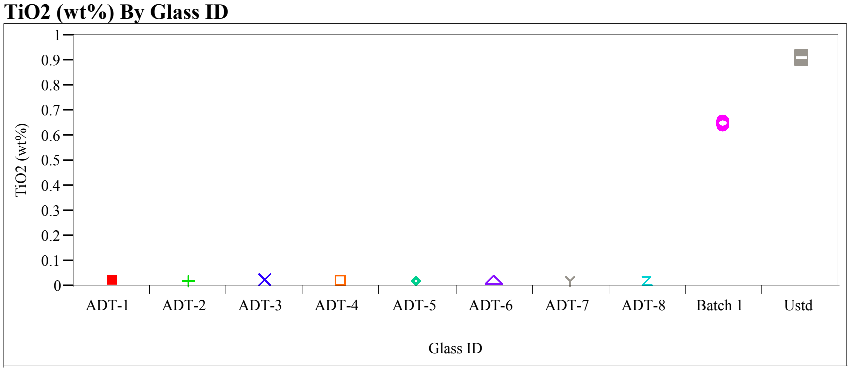
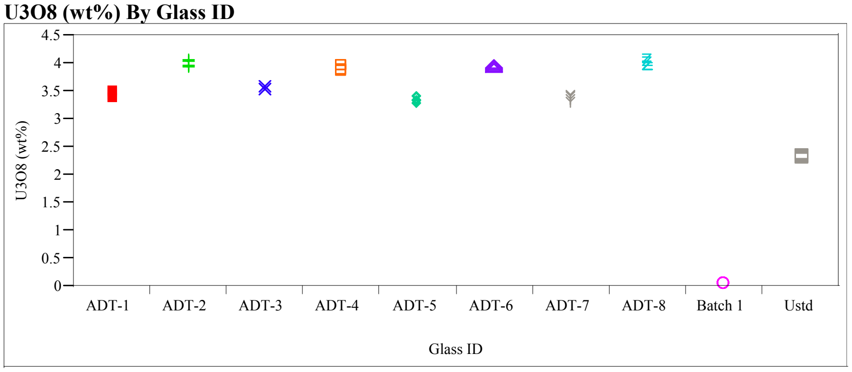


Exhibit C5. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the LM Method

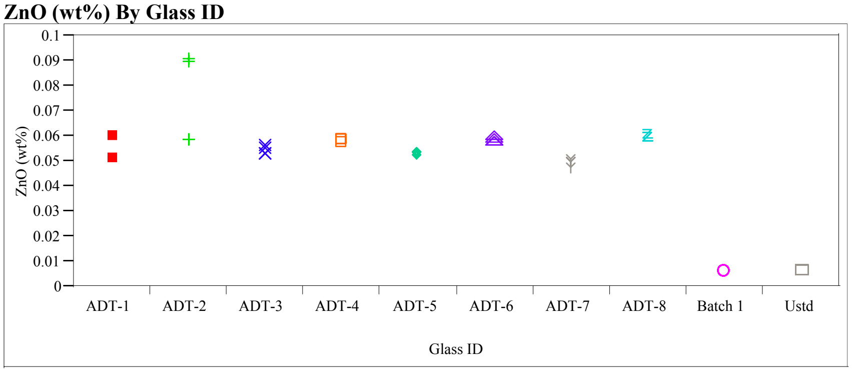
TiO2 (wt%) By Glass ID



U3O8 (wt%) By Glass ID



ZnO (wt%) By Glass ID



ZrO2 (wt%) By Glass ID

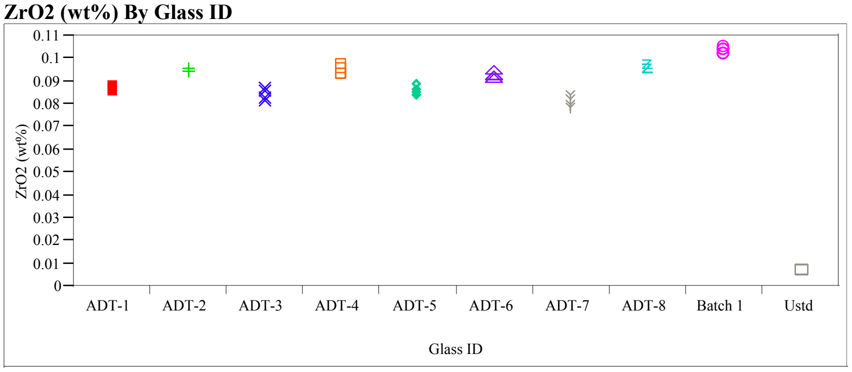
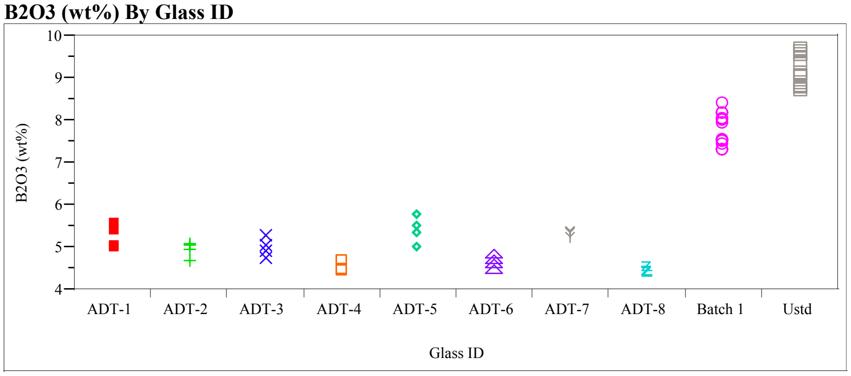
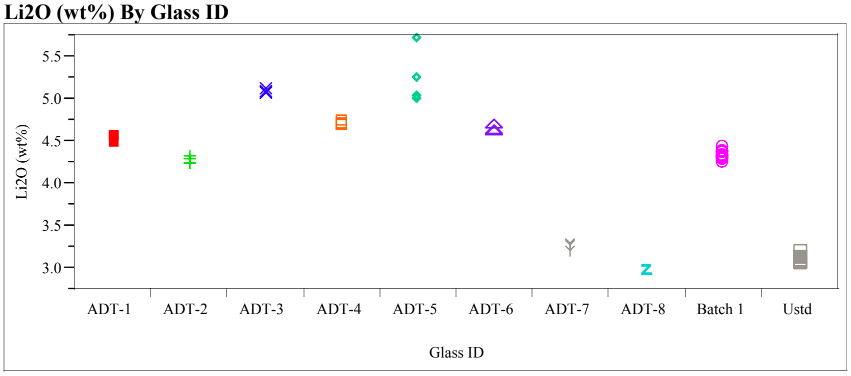


Exhibit C6. Measured and Measured Bias-Corrected Oxide Weight Percents by Glass # for the Glasses Prepared Using the PF Method

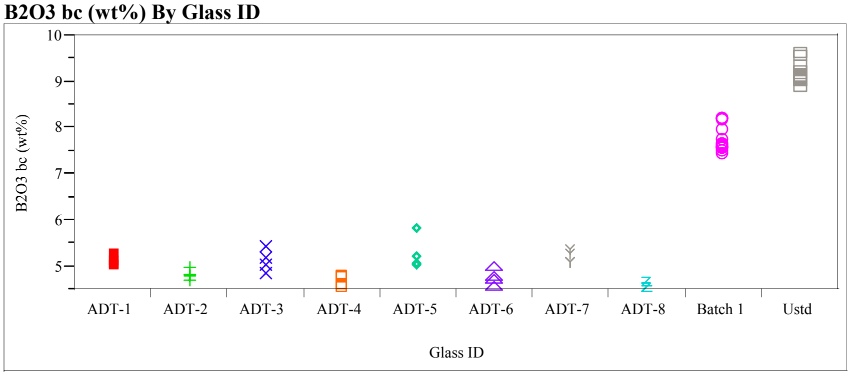
B2O3 (wt%) By Glass ID



Li2O (wt%) By Glass ID



B2O3 bc (wt%) By Glass ID



Li2O bc (wt%) By Glass ID

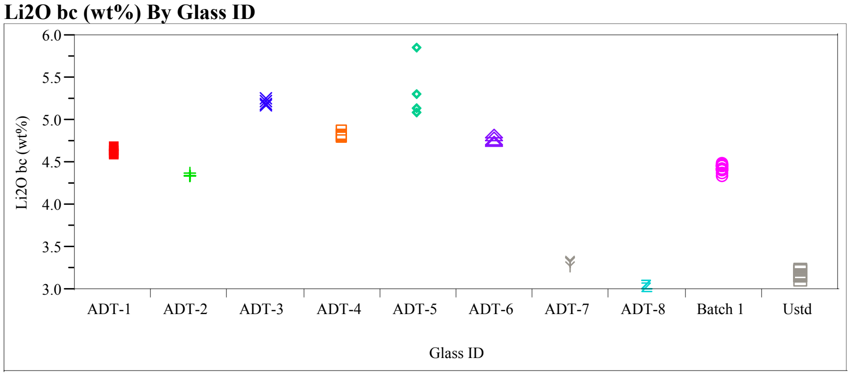
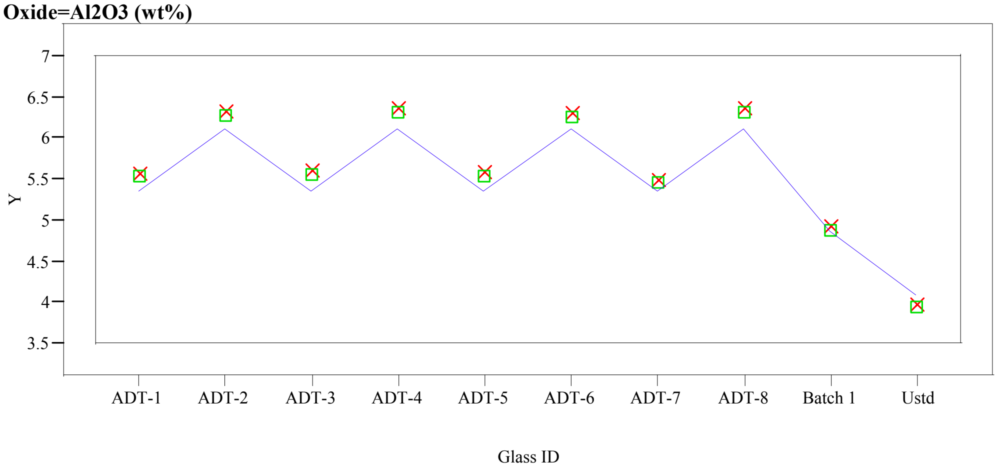
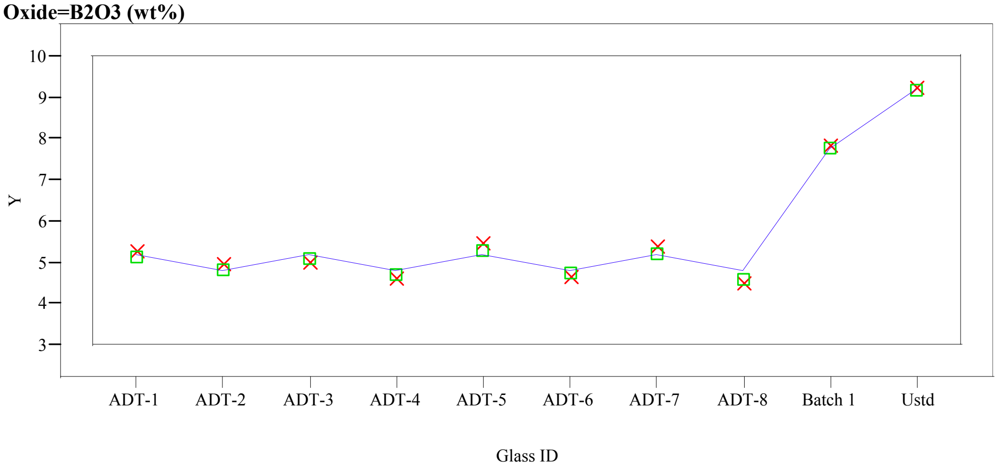


Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

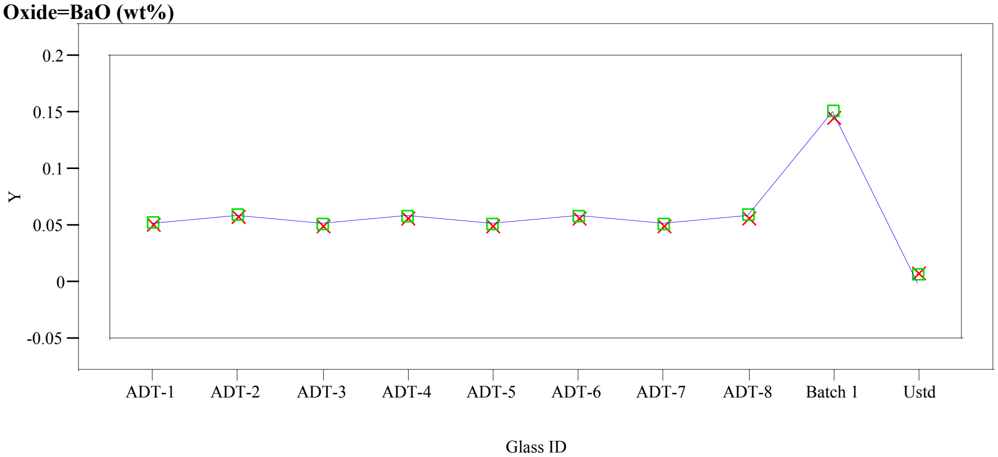
Oxide=Al2O3 (wt%)



Oxide=B2O3 (wt%)



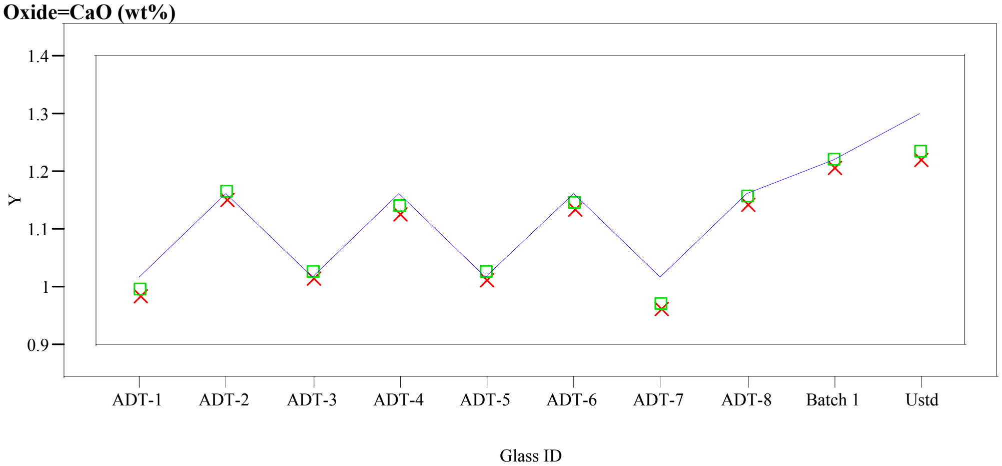
Oxide=BaO (wt%)



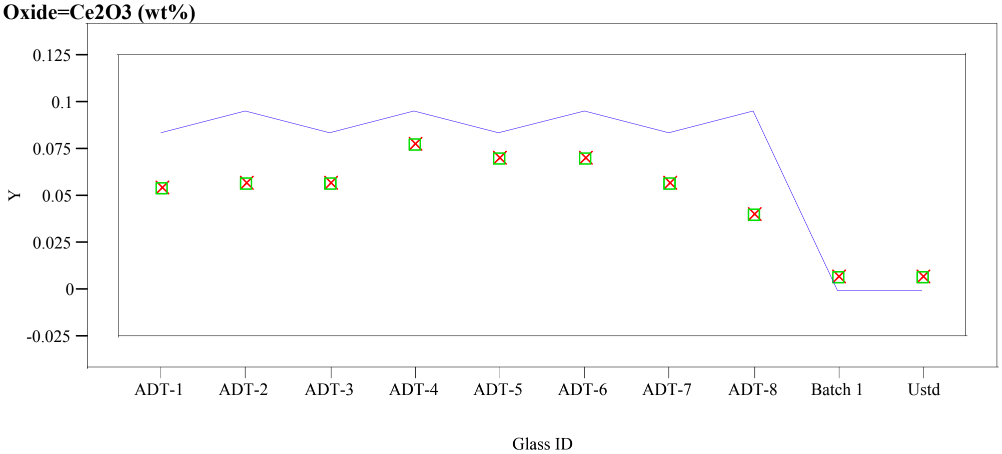
Y ✕ Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

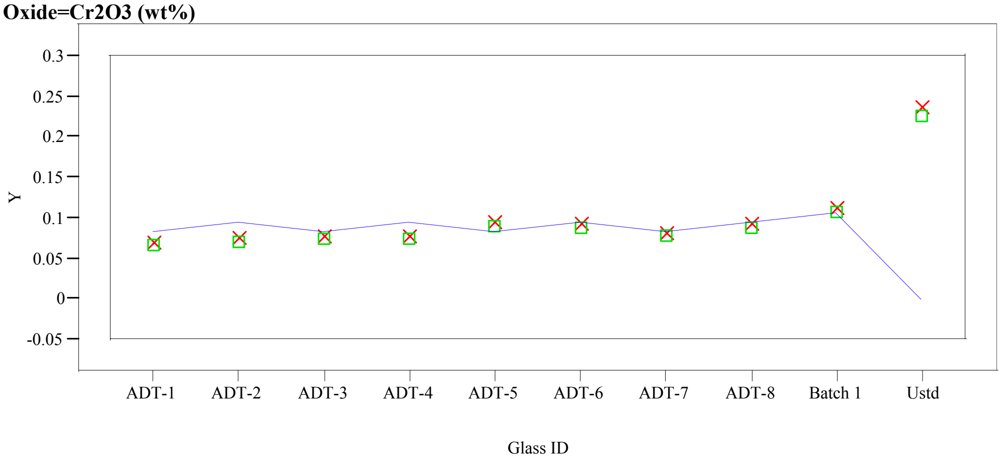
Oxide=CaO (wt%)



Oxide=Ce2O3 (wt%)



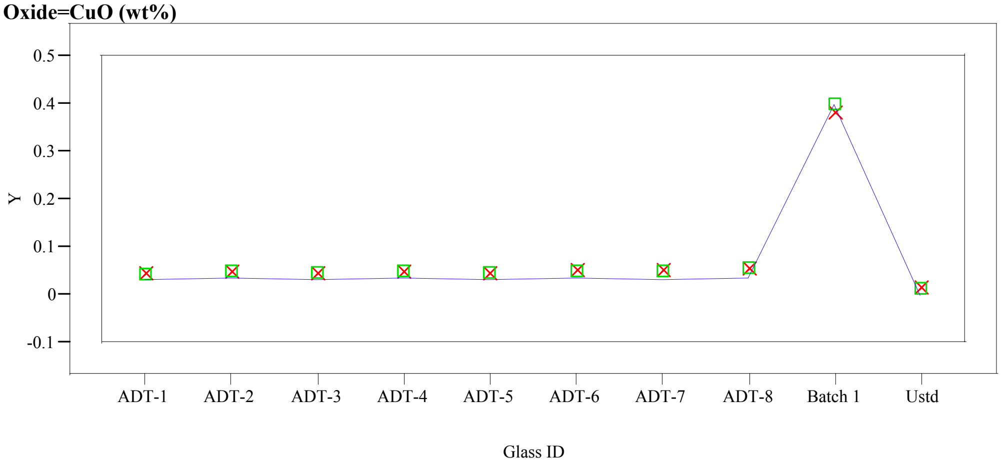
Oxide=Cr2O3 (wt%)



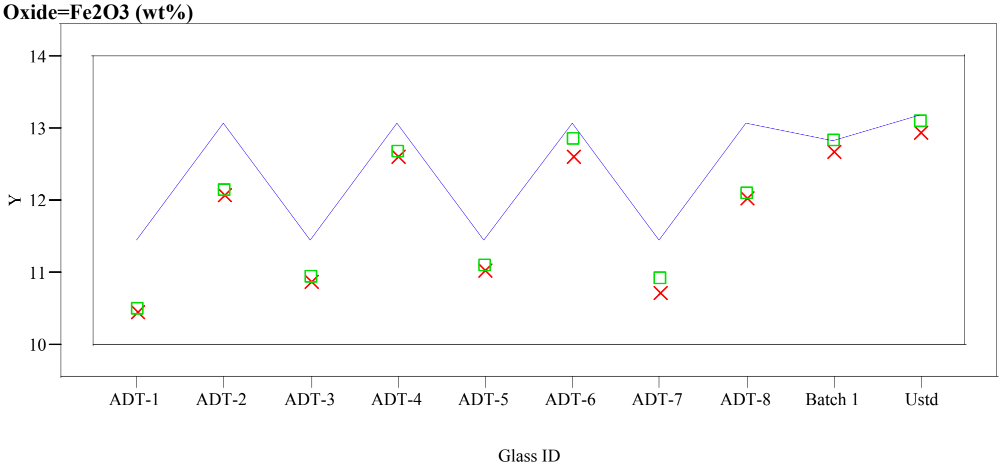
Y ✕ Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

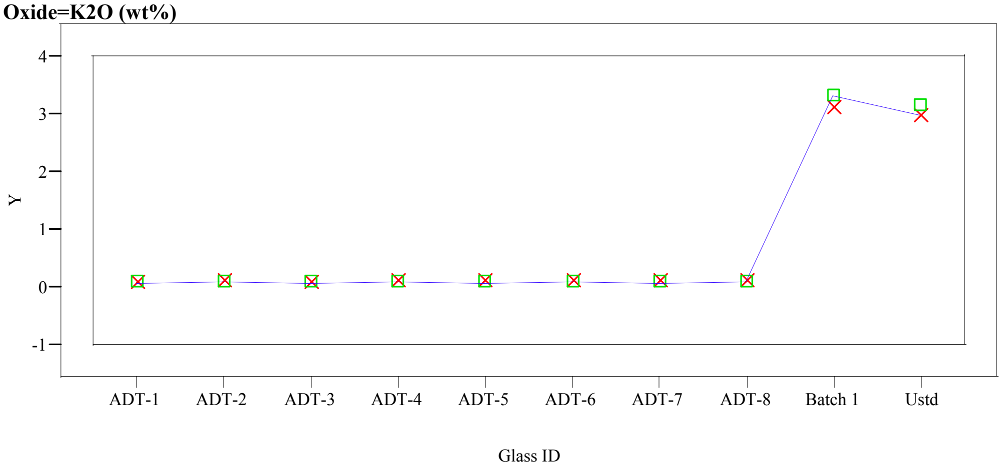
Oxide=CuO (wt%)



Oxide=Fe2O3 (wt%)



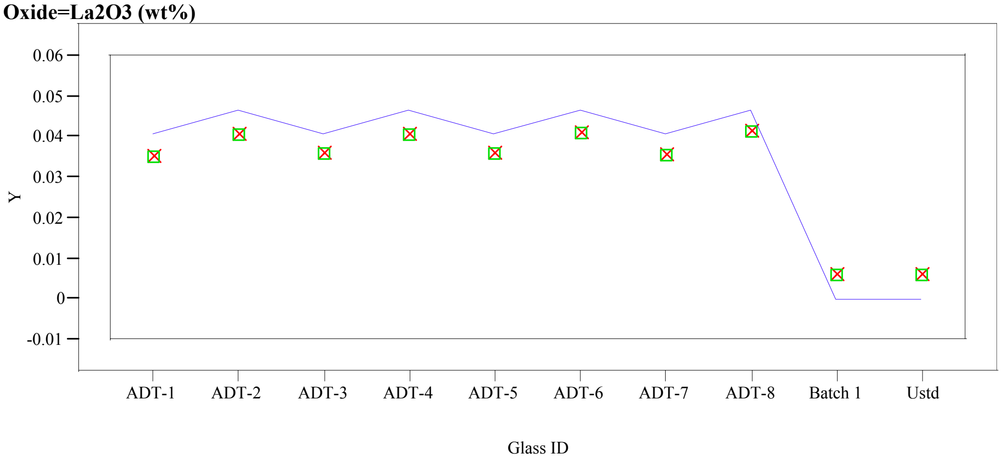
Oxide=K2O (wt%)



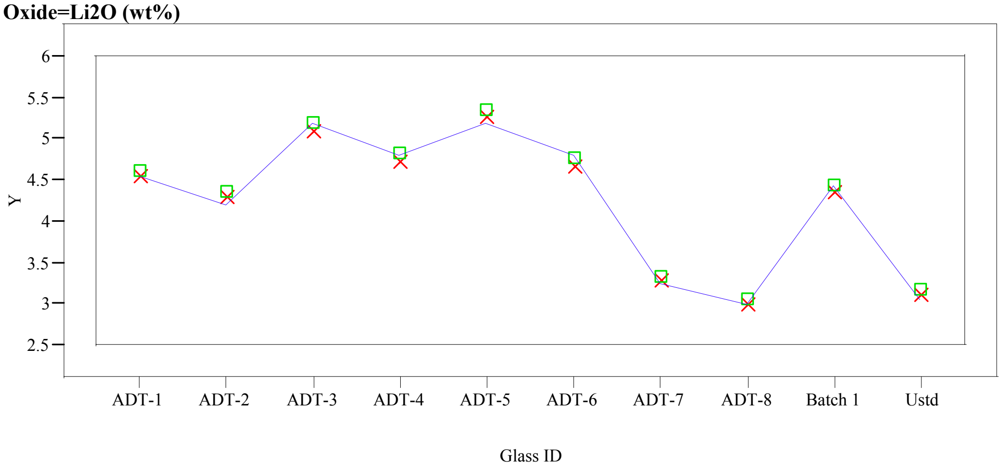
Y × Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

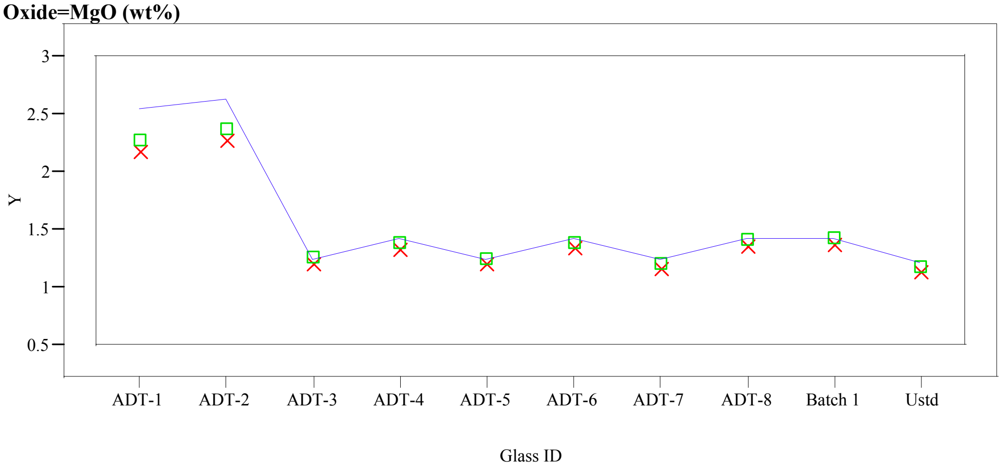
Oxide=La2O3 (wt%)



Oxide=Li2O (wt%)



Oxide=MgO (wt%)



Y ✕ Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

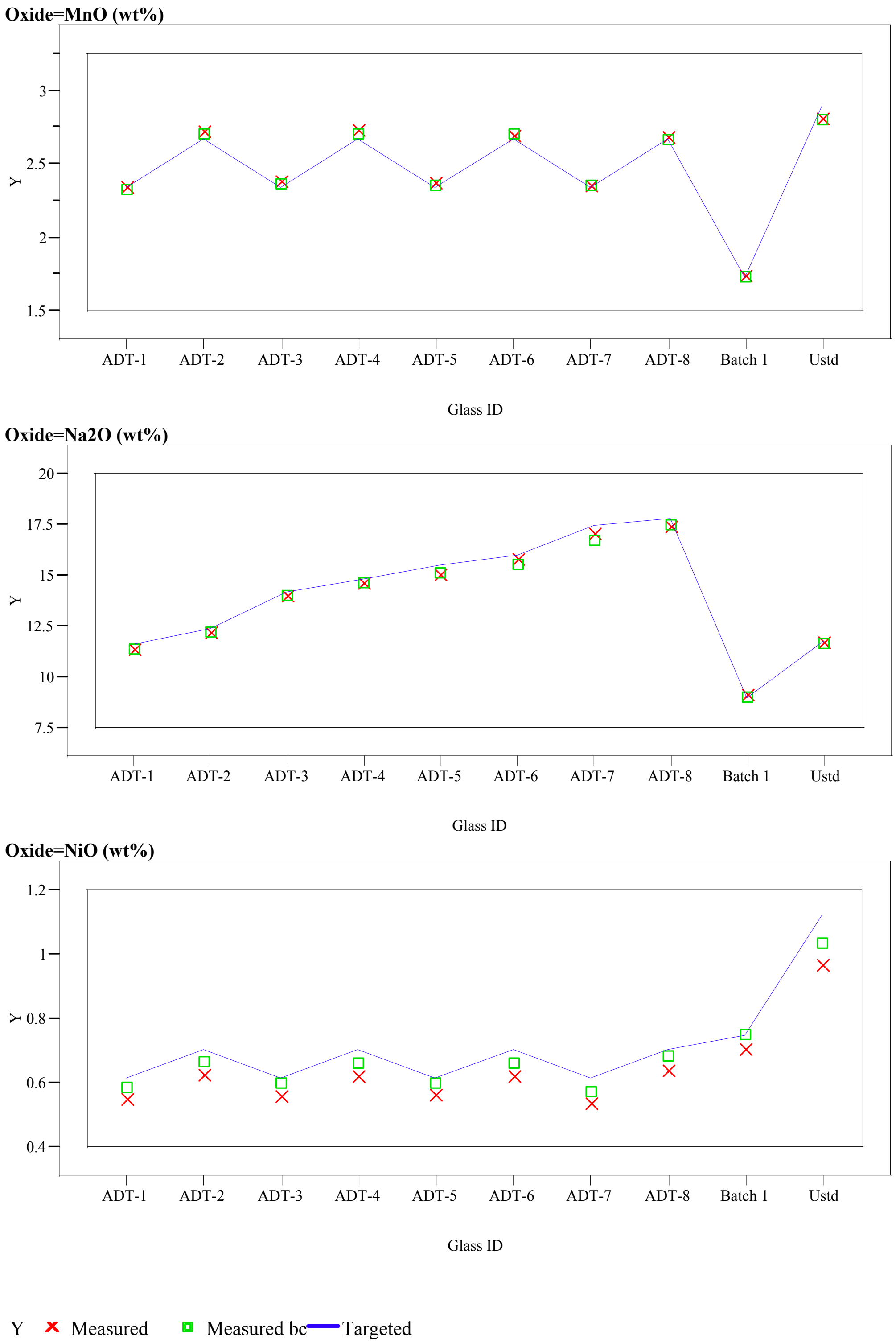
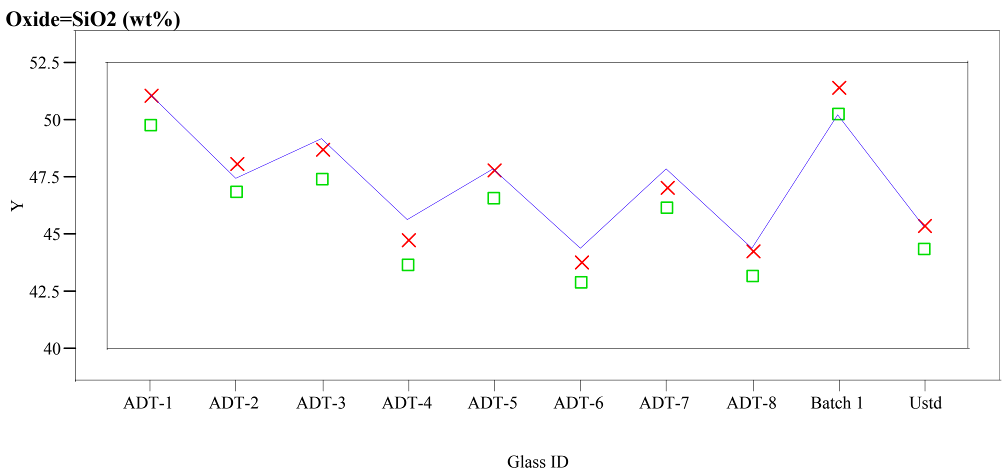
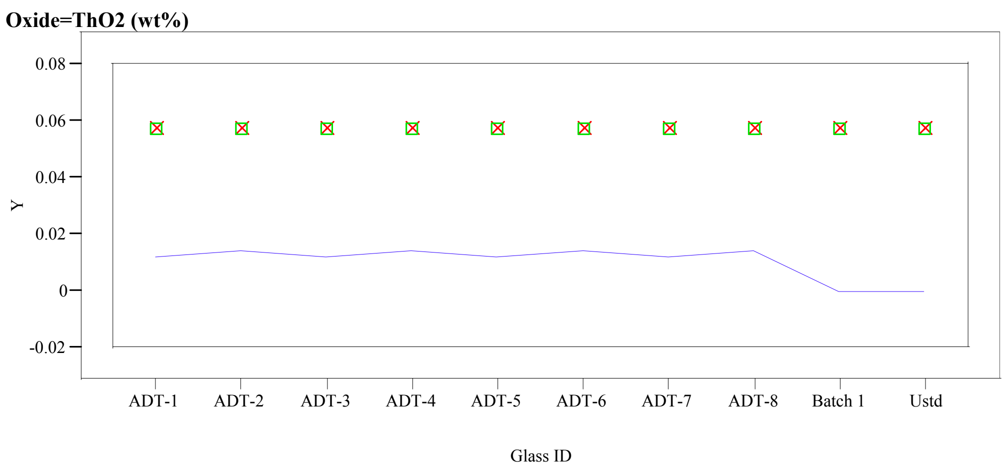


Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

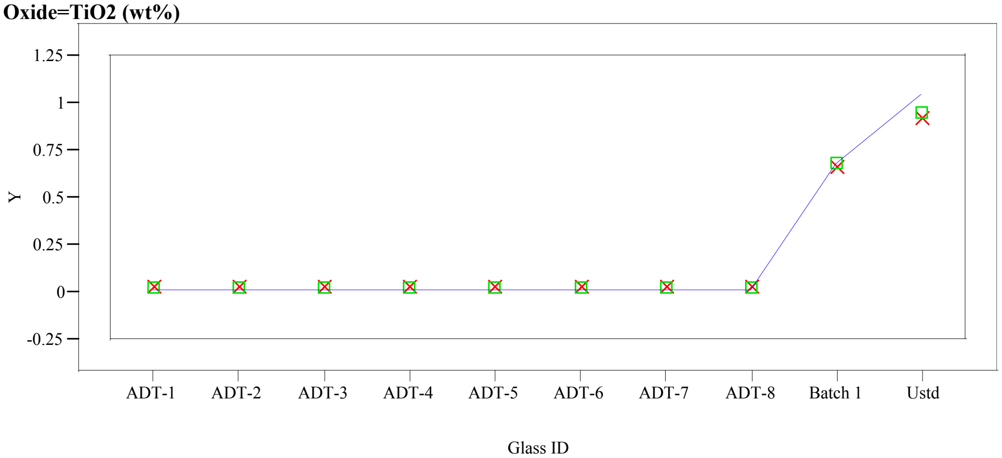




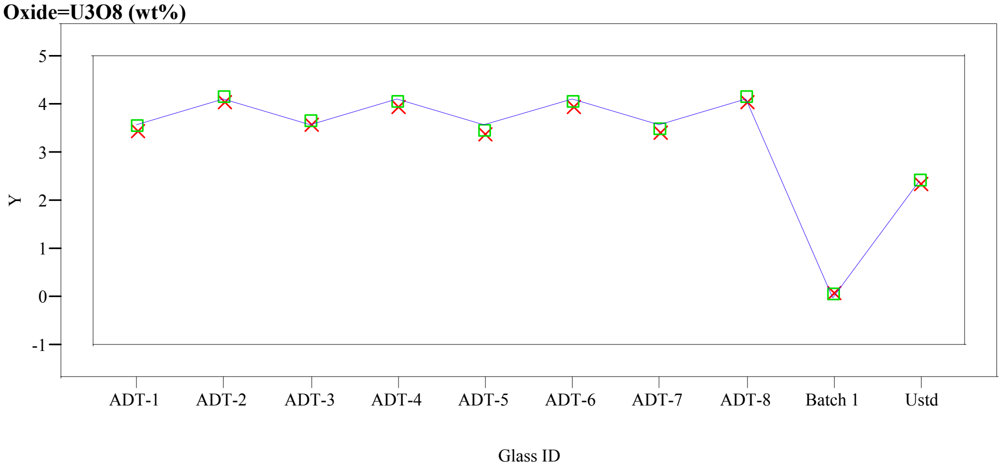
Y × Measured □ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide

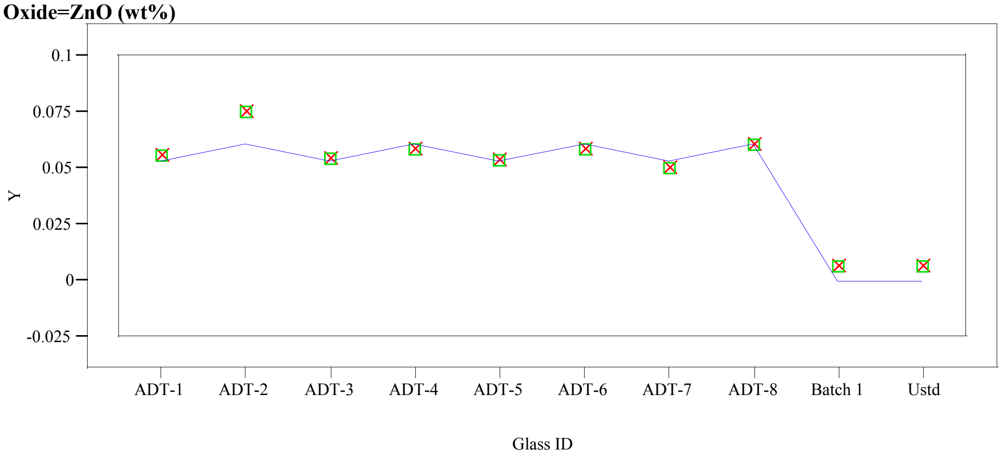
Oxide=TiO2 (wt%)



Oxide=U3O8 (wt%)

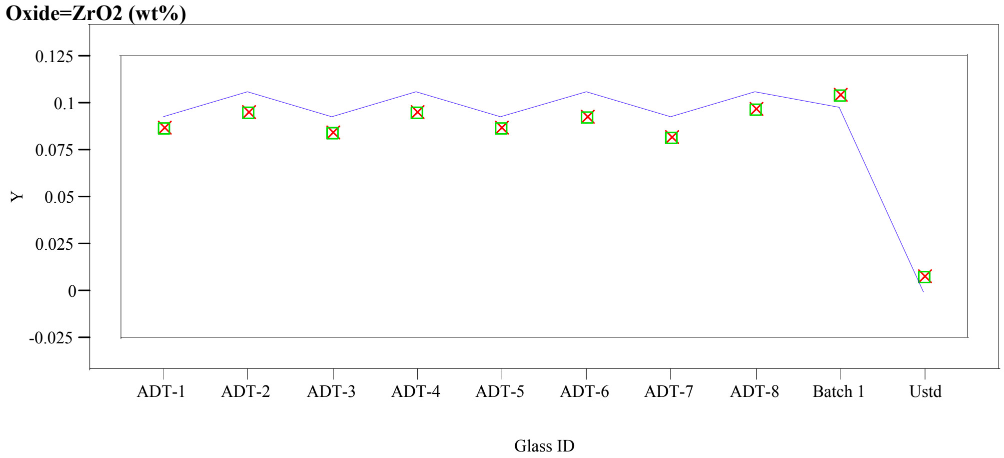


Oxide=ZnO (wt%)



Y ✕ Measured ▫ Measured bc — Targeted

Exhibit C7. Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass # by Oxide



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APPENDIX D

Tables and Exhibits Supporting the Analysis of the PCT Results for the ADT Glasses

Table D1. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses

Glass	SRTC-ML		Seq	As reported values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
soln std	STD-B1-1	1	1	3.75	21.5	4.34	9.69	80	48.8	<0.100
VIS-1ccc	pa39	1	2	6.32	10.4	7.53	15.9	51.2	94.4	3.35
VIS-4ccc	pa64	1	3	8.59	11.3	7.95	16.2	66.4	94.7	2.61
VIS-2ccc	pa80	1	4	6.82	9.92	6.04	15.4	55.3	91.3	2.55
VIS-1	pa05	1	5	5.94	9.81	6.11	15.2	53	92.4	3.36
VIS-3	pa60	1	6	7.57	10.5	6.57	15.5	65.3	92.4	2.3
VIS-3ccc	pa33	1	7	7.31	10	5.57	15	59.1	90.4	2.49
soln std	STD-B1-2	1	8	3.71	20.4	4.4	9.67	79.5	48.8	<0.100
VIS-5ccc	pa77	1	9	10.1	12.7	9.83	18	78.2	101	2.62
ARM	pa68	1	10	2.76	13.5	<0.010	10	26.3	41.8	<0.100
blank	pa27	1	11	<0.015	<0.100	<0.010	<0.100	<0.100	<0.200	<0.100
VIS-4	pa48	1	12	8	10.7	5.46	15.2	68.3	92.1	2.49
VIS-6	pa56	1	13	12.5	13.5	9.12	16.7	97.8	97.1	2.89
VIS-6ccc	pa54	1	14	15.3	14.1	19	20.1	99	100	3.89
VIS-5	pa02	1	15	9.61	12	7.76	16.1	80.3	93.8	2.63
VIS-2	pa23	1	16	7.01	9.79	7.21	15	59.7	92	2.95
soln std	STD-B1-3	1	17	3.67	19.7	4.31	9.66	79.1	48.9	<0.100
soln std	STD-B2-1	2	1	3.77	21	4.23	9.57	79.2	48.2	<0.100
VIS-2	pa63	2	2	7	10.4	6.84	14.9	58.8	91.2	3.14
VIS-1ccc	pa20	2	3	6.27	10	6.04	16.5	53.7	95.7	2.89
VIS-6ccc	pa66	2	4	14.8	14.5	14.7	20.2	99.9	108	3.14
VIS-5ccc	pa53	2	5	10.8	12.4	12.4	17.7	77.7	101	3.27
EA	pa92	2	6	0.109	34.9	<0.010	10.4	95.3	50.1	<0.100
VIS-3ccc	pa59	2	7	7.48	10	5.9	15.1	61.1	89.7	2.63
soln std	STD-B2-2	2	8	3.77	19.9	4.27	9.6	80.8	48.1	<0.100
VIS-4	pa01	2	9	8.3	11	6.48	15.2	68.8	91.6	2.52
VIS-3	pa12	2	10	7.65	10	7.23	14.9	63.4	91.4	3.4
VIS-2ccc	pa29	2	11	6.95	9.63	5.98	15.4	56.2	92.2	2.61
VIS-4ccc	pa04	2	12	8.42	10.3	7.15	15.7	64	92.2	2.59
VIS-5	pa82	2	13	9.46	11.5	6.8	15.9	78.8	92.9	2.53
VIS-1	pa11	2	14	6.11	9.44	5.55	15.7	55.5	93.2	2.8
VIS-6	pa37	2	15	12.4	13.3	7.99	16.7	98.3	95.1	2.79
soln std	STD-B2-3	2	16	3.79	19.8	4.34	9.63	79.8	48.4	<0.100
soln std	STD-B3-1	3	1	3.82	20.6	4.42	9.7	79.1	48.9	<0.100
ARM	pa38	3	2	2.79	13.9	<0.010	9.52	25.9	39.8	<0.100
VIS-1ccc	pa26	3	3	6.54	10.2	7.4	16.5	53	96.5	3.06
VIS-4ccc	pa75	3	4	9.02	11.1	9.53	16.3	67.7	96	3.03
VIS-6	pa74	3	5	12.6	13.6	8.64	16.7	100	95.2	2.7
VIS-6ccc	pa34	3	6	15.3	13.9	18.6	19.8	99.3	106	3.81
VIS-2	pa79	3	7	6.94	9.45	6.91	14.6	59.4	87.5	3.32
soln std	STD-B3-2	3	8	3.83	19.6	4.47	9.61	80.6	48	<0.100
VIS-4	pa31	3	9	8.46	10.8	6.56	15	68.1	89.5	2.55
VIS-3	pa61	3	10	7.64	10.2	5.93	15.4	64.5	89.6	2.55

Table D1. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses

Glass	SRTC-ML		Seq	As reported values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
VIS-2ccc	pa50	3	11	7.1	9.34	6.77	15.2	55.5	89.3	2.69
VIS-1	pa45	3	12	6.17	9.31	6.34	15.2	54.9	90.7	3.36
VIS-3ccc	pa10	3	13	7.89	9.65	7.79	15.2	61.6	91	2.92
VIS-5	pa42	3	14	9.73	11	7.65	15.8	78.5	91.2	2.53
VIS-5ccc	pa35	3	15	10.8	11.6	12.4	17.4	77.7	97.8	3.43
soln std	STD-B3-3	3	16	3.83	19.4	4.43	9.63	80	47.5	<0.100
soln std	STD-B4-1	4	1	3.78	21.3	4.28	9.74	81	48	<0.100
ADT-7ccc	pa19	4	2	8.34	12.4	6.97	10.2	106	98.1	2.25
ADT-8ccc	pa70	4	3	11.5	12.7	11	10	115	95.6	2.91
ADT-8	pa22	4	4	10.8	13.4	7.92	9.84	128	97.8	2.53
ADT-1	pa69	4	5	5.41	9.32	3.6	11.5	47.8	76.3	2.14
EA	pa43	4	6	0.1	37.2	<0.010	11.1	104	52	<0.100
ADT-6ccc	pa90	4	7	14.3	16.8	19.8	21.9	125	120	4.18
ADT-6	pa62	4	8	12.8	17.4	13.1	20.8	136	123	3.46
ADT-3ccc	pa40	4	9	8.11	11.6	6.85	16.7	76.1	97.1	2.63
soln std	STD-B4-2	4	10	3.79	19.8	4.28	9.56	79.9	46.8	<0.100
ADT-5ccc	pa71	4	11	9.68	15.3	11	21	107	118	3
ADT-7	pa25	4	12	9.13	12.2	9.31	10.3	119	101	2.5
ADT-2	pa87	4	13	7.09	10.2	4.3	11.8	59.9	78.2	2.07
ADT-2ccc	pa83	4	14	8.08	9.87	6.58	12.1	58	77.6	2.3
ADT-1ccc	pa91	4	15	5.62	8.9	3.69	11.3	45.6	75.6	2.24
ADT-3	pa88	4	16	8.33	11.3	7.49	16.5	81.9	99.7	2.5
ADT-5	pa67	4	17	9.15	14.9	8.17	20	113	117	3.08
ADT-4ccc	pa78	4	18	10.1	12.7	7.72	17.3	92.7	97.9	2.78
ADT-4	pa21	4	19	10.8	13.2	10.1	17.5	100	102	2.88
soln std	STD-B4-3	4	20	3.75	19.5	4.24	9.69	82.1	47.5	<0.100
soln std	STD-B5-1	5	1	3.79	21.5	4.31	9.71	80.6	49.4	<0.100
ADT-5ccc	pa52	5	2	10.8	16	15.7	21.1	107	125	3.92
ADT-4ccc	pa32	5	3	9.98	14	7	17.6	94.8	102	2.72
ADT-3	pa73	5	4	8.22	11.9	7.24	16.5	81.1	102	2.47
ADT-6ccc	pa28	5	5	14.6	17.6	21.2	23	130	116	4.4
ADT-3ccc	pa65	5	6	8.3	11.8	7.61	16.9	76.4	102	2.43
EA	pa36	5	7	0.099	38	<0.010	11.2	102	53.7	<0.100
ADT-8	pa89	5	8	11.2	13.5	10.5	9.61	126	101	3.16
ADT-4	pa17	5	9	11	13.9	11.8	17.5	100	107	3.38
soln std	STD-B4-2	5	10	3.79	20.7	4.34	9.86	82.7	50.4	<0.100
ADT-1ccc	pa44	5	11	5.74	9.5	4.25	11.5	46.7	79.7	2.26
ADT-7ccc	pa08	5	12	8.35	11.5	7.99	9.64	101	96.5	2.81
ADT-6	pa16	5	13	12	17.9	11.3	21.2	137	125	3.16
ADT-1	pa24	5	14	5.59	9.61	4.34	11.9	49.7	81.9	2.21
ADT-5	pa14	5	15	10	14.7	12.8	19.7	112	122	3.78
ADT-7	pa84	5	16	8.8	12.1	8.8	9.88	115	103	2.88
ADT-8ccc	pa51	5	17	10.5	12.5	8.32	10	115	95.9	2.6
ADT-2ccc	pa81	5	18	7.9	10	5.64	12.3	58.4	81.5	2.37

Table D1. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses

Glass	SRTC-ML		Seq	As reported values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
ADT-2	pa46	5	19	7.1	10.2	4.45	11.9	61.1	80.7	2.24
soln std	STD-B5-3	5	20	3.76	20.3	4.24	9.87	84	50.1	<0.100
soln std	STD-B6-1	6	1	3.79	21.5	4.28	9.69	80.4	48.8	<0.100
ADT-3ccc	pa41	6	2	7.68	12.9	5.4	16.8	76.5	98.8	2.49
ADT-7	pa86	6	3	8.88	13.3	7.83	10.1	114	103	2.55
ADT-4	pa47	6	4	11.1	14.3	12.8	16.9	96.2	105	3.62
ADT-5ccc[17]	pa58	6	5							
ADT-3	pa57	6	6	8.18	12.2	7.13	16.4	79.9	101	2.44
ADT-8	pa15	6	7	11.1	13.8	8.89	9.8	124	99.9	2.54
ADT-6	pa03	6	8	13.1	17.1	15.1	19.8	125	122	4.15
ARM	pa72	6	9	2.73	14.7	0.114	10	28	41.3	<0.100
soln std	STD-B6-2	6	10	3.78	20.7	4.26	9.59	78.4	48.9	<0.100
ADT-6ccc	pa18	6	11	12.8	18.4	14	22.9	126	129	3.58
ADT-5	pa13	6	12	10.2	15.4	13.6	19.3	108	121	3.94
ADT-8ccc	pa55	6	13	10.8	13.9	8.59	10.1	116	97.2	2.5
ADT-4ccc	pa30	6	14	10.1	14.3	7.59	17.2	91.3	102	2.66
blank	pa09	6	15	0.025	0.601	<0.010	<0.100	<0.100	<0.200	<0.100
ADT-2	pa76	6	16	6.93	11.2	3.76	12.1	59.9	81.1	2.06
ADT-7ccc	pa85	6	17	8.3	11.9	6.71	9.89	102	96.7	2.35
ADT-1	pa06	6	18	5.42	9.44	3.26	11.3	45.3	78.4	2.2
ADT-1ccc	pa49	6	19	5.63	9.55	3.88	11.4	45.3	78.5	2.18
ADT-2ccc	pa07	6	20	7.77	10.5	5.56	12.1	57.1	79.3	2.25
soln std	STD-B6-3	6	21	3.78	20.7	4.26	9.67	80.1	49	<0.100

[17] Sample was spilled, therefore no analysis of this triplicate was obtained.

Table D2. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses After Appropriate Adjustments

Glass	SRTC-ML		Seq	Values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
soln std	STD-B1-1	1	1	3.750	21.500	4.340	9.690	80.000	48.800	0.050
VIS-1ccc	Pa39	1	2	10.534	17.334	12.550	26.501	85.335	157.336	5.583
VIS-4ccc	Pa64	1	3	14.317	18.834	13.250	27.001	110.669	157.836	4.350
VIS-2ccc	Pa80	1	4	11.367	16.534	10.067	25.667	92.169	152.170	4.250
VIS-1	Pa05	1	5	9.900	16.350	10.184	25.334	88.335	154.003	5.600
VIS-3	Pa60	1	6	12.617	17.500	10.950	25.834	108.836	154.003	3.833
VIS-3ccc	Pa33	1	7	12.184	16.667	9.284	25.001	98.502	150.670	4.150
soln std	STD-B1-2	1	8	3.710	20.400	4.400	9.670	79.500	48.800	0.050
VIS-5ccc	Pa77	1	9	16.834	21.167	16.384	30.001	130.336	168.337	4.367
ARM	Pa68	1	10	4.600	22.500	0.008	16.667	43.834	69.668	0.083
blank	Pa27	1	11	0.013	0.083	0.008	0.083	0.083	0.167	0.083
VIS-4	Pa48	1	12	13.334	17.834	9.100	25.334	113.836	153.503	4.150
VIS-6	Pa56	1	13	20.834	22.500	15.200	27.834	163.003	161.837	4.817
VIS-6ccc	Pa54	1	14	25.501	23.500	31.667	33.501	165.003	166.670	6.483
VIS-5	Pa02	1	15	16.017	20.000	12.934	26.834	133.836	156.336	4.383
VIS-2	Pa23	1	16	11.684	16.317	12.017	25.001	99.502	153.336	4.917
soln std	STD-B1-3	1	17	3.670	19.700	4.310	9.660	79.100	48.900	0.050
soln std	STD-B2-1	2	1	3.770	21.000	4.230	9.570	79.200	48.200	0.050
VIS-2	Pa63	2	2	11.667	17.334	11.400	24.834	98.002	152.003	5.233
VIS-1ccc	Pa20	2	3	10.450	16.667	10.067	27.501	89.502	159.503	4.817
VIS-6ccc	Pa66	2	4	24.667	24.167	24.500	33.667	166.503	180.004	5.233
VIS-5ccc	Pa53	2	5	18.000	20.667	20.667	29.501	129.503	168.337	5.450
EA	Pa92	2	6	1.817	581.668	0.083	173.334	1588.337	835.002	0.833
VIS-3ccc	Pa59	2	7	12.467	16.667	9.834	25.167	101.835	149.503	4.383
soln std	STD-B2-2	2	8	3.770	19.900	4.270	9.600	80.800	48.100	0.050
VIS-4	Pa01	2	9	13.834	18.334	10.800	25.334	114.669	152.670	4.200
VIS-3	Pa12	2	10	12.750	16.667	12.050	24.834	105.669	152.336	5.667
VIS-2ccc	Pa29	2	11	11.584	16.050	9.967	25.667	93.669	153.670	4.350
VIS-4ccc	Pa04	2	12	14.034	17.167	11.917	26.167	106.669	153.670	4.317
VIS-5	Pa82	2	13	15.767	19.167	11.334	26.501	131.336	154.836	4.217
VIS-1	Pa11	2	14	10.184	15.734	9.250	26.167	92.502	155.336	4.667
VIS-6	Pa37	2	15	20.667	22.167	13.317	27.834	163.837	158.503	4.650
soln std	STD-B2-3	2	16	3.790	19.800	4.340	9.630	79.800	48.400	0.050
soln std	STD-B3-1	3	1	3.820	20.600	4.420	9.700	79.100	48.900	0.050
ARM	Pa38	3	2	4.650	23.167	0.008	15.867	43.168	66.335	0.083
VIS-1ccc	Pa26	3	3	10.900	17.000	12.334	27.501	88.335	160.837	5.100
VIS-4ccc	Pa75	3	4	15.034	18.500	15.884	27.167	112.836	160.003	5.050
VIS-6	Pa74	3	5	21.000	22.667	14.400	27.834	166.670	158.670	4.500
VIS-6ccc	Pa34	3	6	25.501	23.167	31.001	33.001	165.503	176.670	6.350
VIS-2	Pa79	3	7	11.567	15.750	11.517	24.334	99.002	145.836	5.533
soln std	STD-B3-2	3	8	3.830	19.600	4.470	9.610	80.600	48.000	0.050
VIS-4	Pa31	3	9	14.100	18.000	10.934	25.001	113.502	149.170	4.250
VIS-3	Pa61	3	10	12.734	17.000	9.884	25.667	107.502	149.336	4.250
VIS-2ccc	Pa50	3	11	11.834	15.567	11.284	25.334	92.502	148.836	4.483

Table D2. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses After Appropriate Adjustments

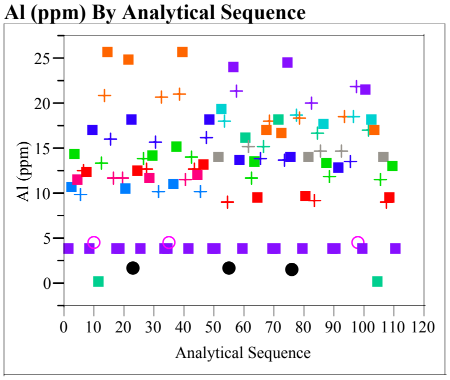
Glass	SRTC-ML		Seq	Values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
VIS-1	Pa45	3	12	10.284	15.517	10.567	25.334	91.502	151.170	5.600
VIS-3ccc	Pa10	3	13	13.150	16.084	12.984	25.334	102.669	151.670	4.867
VIS-5	Pa42	3	14	16.217	18.334	12.750	26.334	130.836	152.003	4.217
VIS-5ccc	Pa35	3	15	18.000	19.334	20.667	29.001	129.503	163.003	5.717
soln std	STD-B3-3	3	16	3.830	19.400	4.430	9.630	80.000	47.500	0.050
soln std	STD-B4-1	4	1	3.780	21.300	4.280	9.740	81.000	48.000	0.050
ADT-7ccc	Pa19	4	2	13.900	20.667	11.617	17.000	176.670	163.503	3.750
ADT-8ccc	Pa70	4	3	19.167	21.167	18.334	16.667	191.671	159.337	4.850
ADT-8	Pa22	4	4	18.000	22.334	13.200	16.400	213.338	163.003	4.217
ADT-1	Pa69	4	5	9.017	15.534	6.000	19.167	79.668	127.169	3.567
EA	Pa43	4	6	1.667	620.001	0.083	185.000	1733.337	866.668	0.833
ADT-6ccc	Pa90	4	7	23.834	28.001	33.001	36.501	208.338	200.004	6.967
ADT-6	Pa62	4	8	21.334	29.001	21.834	34.667	226.671	205.004	5.767
ADT-3ccc	Pa40	4	9	13.517	19.334	11.417	27.834	126.836	161.837	4.383
soln std	STD-B4-2	4	10	3.790	19.800	4.280	9.560	79.900	46.800	0.050
ADT-5ccc	Pa71	4	11	16.134	25.501	18.334	35.001	178.337	196.671	5.000
ADT-7	Pa25	4	12	15.217	20.334	15.517	17.167	198.337	168.337	4.167
ADT-2	Pa87	4	13	11.817	17.000	7.167	19.667	99.835	130.336	3.450
ADT-2ccc	Pa83	4	14	13.467	16.450	10.967	20.167	96.669	129.336	3.833
ADT-1ccc	Pa91	4	15	9.367	14.834	6.150	18.834	76.002	126.003	3.733
ADT-3	Pa88	4	16	13.884	18.834	12.484	27.501	136.503	166.170	4.167
ADT-5	Pa67	4	17	15.250	24.834	13.617	33.334	188.337	195.004	5.133
ADT-4ccc	Pa78	4	18	16.834	21.167	12.867	28.834	154.503	163.170	4.633
ADT-4	Pa21	4	19	18.000	22.000	16.834	29.167	166.670	170.003	4.800
soln std	STD-B4-3	4	20	3.750	19.500	4.240	9.690	82.100	47.500	0.050
soln std	STD-B5-1	5	1	3.790	21.500	4.310	9.710	80.600	49.400	0.050
ADT-5ccc	Pa52	5	2	18.000	26.667	26.167	35.167	178.337	208.338	6.533
ADT-4ccc	Pa32	5	3	16.634	23.334	11.667	29.334	158.003	170.003	4.533
ADT-3	Pa73	5	4	13.700	19.834	12.067	27.501	135.169	170.003	4.117
ADT-6ccc	Pa28	5	5	24.334	29.334	35.334	38.334	216.671	193.337	7.333
ADT-3ccc	Pa65	5	6	13.834	19.667	12.684	28.167	127.336	170.003	4.050
EA	Pa36	5	7	1.650	633.335	0.083	186.667	1700.003	895.002	0.833
ADT-8	Pa89	5	8	18.667	22.500	17.500	16.017	210.004	168.337	5.267
ADT-4	Pa17	5	9	18.334	23.167	19.667	29.167	166.670	178.337	5.633
soln std	STD-B4-2	5	10	3.790	20.700	4.340	9.860	82.700	50.400	0.050
ADT-1ccc	Pa44	5	11	9.567	15.834	7.083	19.167	77.835	132.836	3.767
ADT-7ccc	Pa08	5	12	13.917	19.167	13.317	16.067	168.337	160.837	4.683
ADT-6	Pa16	5	13	20.000	29.834	18.834	35.334	228.338	208.338	5.267
ADT-1	Pa24	5	14	9.317	16.017	7.233	19.834	82.835	136.503	3.683
ADT-5	Pa14	5	15	16.667	24.500	21.334	32.834	186.670	203.337	6.300
ADT-7	Pa84	5	16	14.667	20.167	14.667	16.467	191.671	171.670	4.800
ADT-8ccc	Pa51	5	17	17.500	20.834	13.867	16.667	191.671	159.837	4.333
ADT-2ccc	Pa81	5	18	13.167	16.667	9.400	20.500	97.335	135.836	3.950
ADT-2	Pa46	5	19	11.834	17.000	7.417	19.834	101.835	134.503	3.733

Table D2. SRNL-ML Measurements of the PCT Solutions for the ADT – VIS Glasses After Appropriate Adjustments

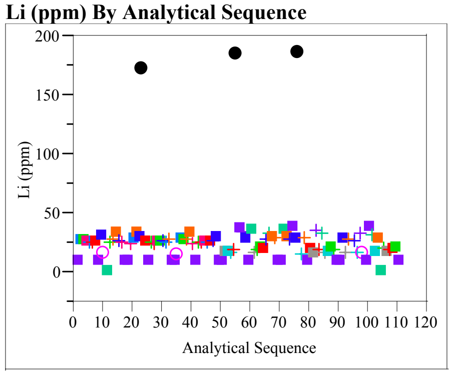
Glass	SRTC-ML		Seq	Values in parts per million (ppm)						
ID	ID	Block	#	Al	B	Fe	Li	Na	Si	U
soln std	STD-B5-3	5	20	3.760	20.300	4.240	9.870	84.000	50.100	0.050
soln std	STD-B6-1	6	1	3.790	21.500	4.280	9.690	80.400	48.800	0.050
ADT-3ccc	Pa41	6	2	12.800	21.500	9.000	28.001	127.503	164.670	4.150
ADT-7	Pa86	6	3	14.800	22.167	13.050	16.834	190.004	171.670	4.250
ADT-4	Pa47	6	4	18.500	23.834	21.334	28.167	160.337	175.004	6.033
ADT-5ccc	Pa58-missing	6	5	.	.	.	.	.	.	.
ADT-3	Pa57	6	6	13.634	20.334	11.884	27.334	133.169	168.337	4.067
ADT-8	Pa15	6	7	18.500	23.000	14.817	16.334	206.671	166.503	4.233
ADT-6	Pa03	6	8	21.834	28.501	25.167	33.001	208.338	203.337	6.917
ARM	Pa72	6	9	4.550	24.500	0.190	16.667	46.668	68.835	0.083
soln std	STD-B6-2	6	10	3.780	20.700	4.260	9.590	78.400	48.900	0.050
ADT-6ccc	Pa18	6	11	21.334	30.667	23.334	38.167	210.004	215.004	5.967
ADT-5	Pa13	6	12	17.000	25.667	22.667	32.167	180.004	201.671	6.567
ADT-8ccc	Pa55	6	13	18.000	23.167	14.317	16.834	193.337	162.003	4.167
ADT-4ccc	Pa30	6	14	16.834	23.834	12.650	28.667	152.170	170.003	4.433
blank	Pa09	6	15	0.042	1.002	0.008	0.083	0.083	0.167	0.083
ADT-2	Pa76	6	16	11.550	18.667	6.267	20.167	99.835	135.169	3.433
ADT-7ccc	Pa85	6	17	13.834	19.834	11.184	16.484	170.003	161.170	3.917
ADT-1	Pa06	6	18	9.034	15.734	5.433	18.834	75.502	130.669	3.667
ADT-1ccc	Pa49	6	19	9.384	15.917	6.467	19.000	75.502	130.836	3.633
ADT-2ccc	Pa07	6	20	12.950	17.500	9.267	20.167	95.169	132.169	3.750
soln std	STD-B6-3	6	21	3.780	20.700	4.260	9.670	80.100	49.000	0.050

Exhibit D1. SRNL-ML PCT Measurements in Analytical Sequence for ADT – VIS Study Glasses, EA, ARM, Blanks, and Solution Standards

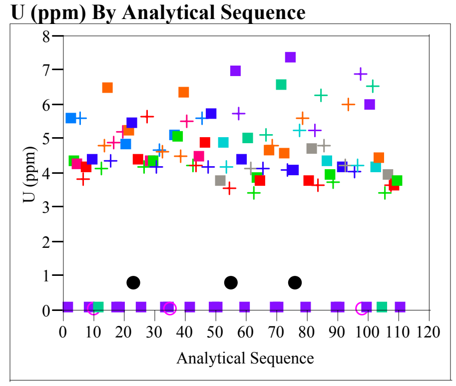
Al (ppm) By Analytical Sequence



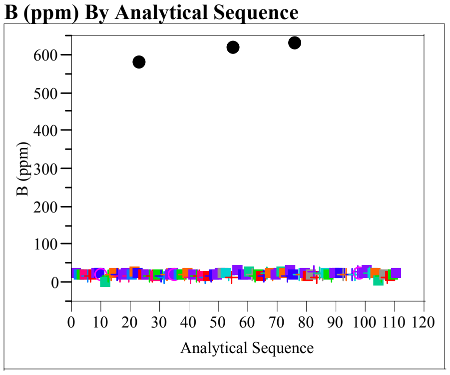
Li (ppm) By Analytical Sequence



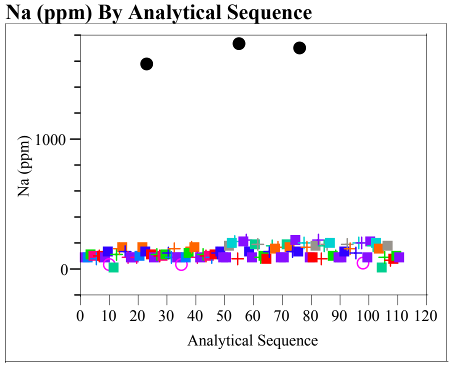
U (ppm) By Analytical Sequence



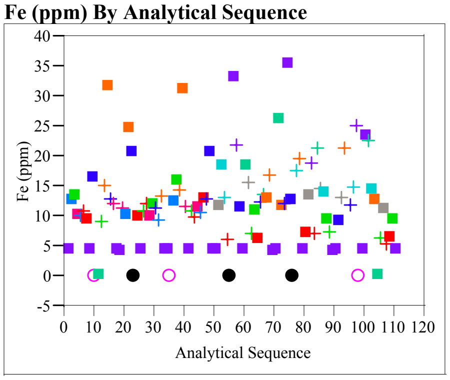
B (ppm) By Analytical Sequence



Na (ppm) By Analytical Sequence



Fe (ppm) By Analytical Sequence



Si (ppm) By Analytical Sequence

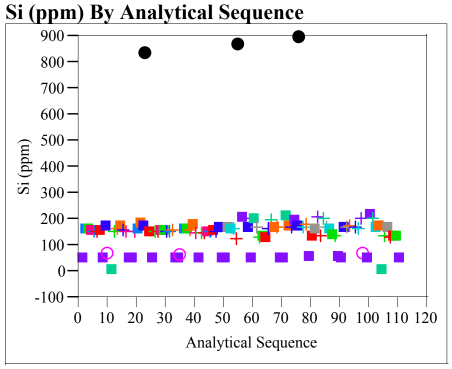
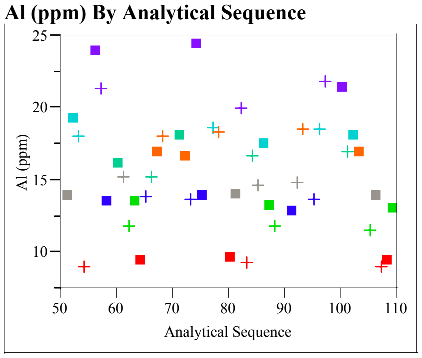
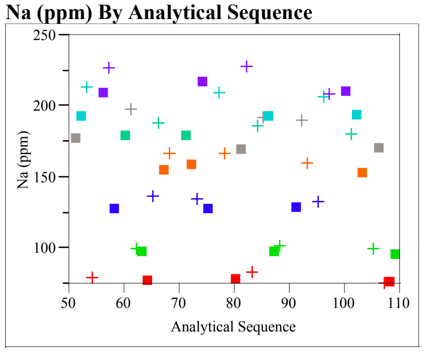


Exhibit D2. SRNL-ML PCT Measurements in Analytical Sequence for ADT Study Glasses Only

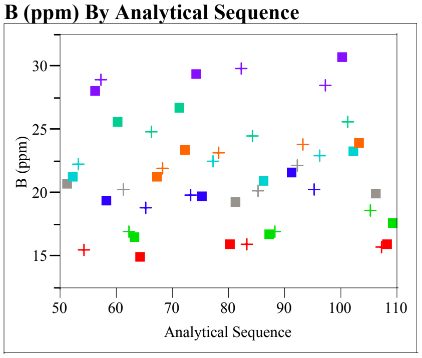
Al (ppm) By Analytical Sequence



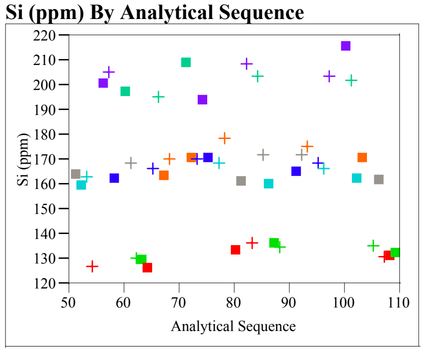
Na (ppm) By Analytical Sequence



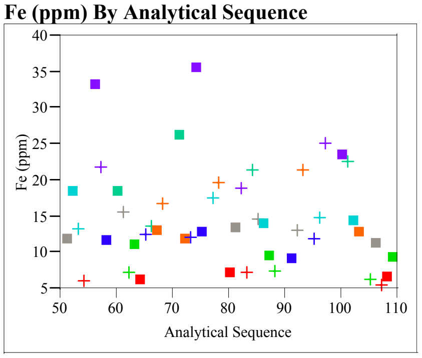
B (ppm) By Analytical Sequence



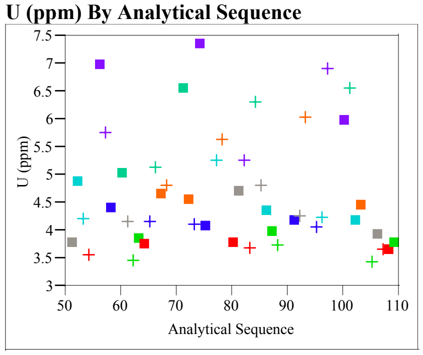
Si (ppm) By Analytical Sequence



Fe (ppm) By Analytical Sequence



U (ppm) By Analytical Sequence



Li (ppm) By Analytical Sequence

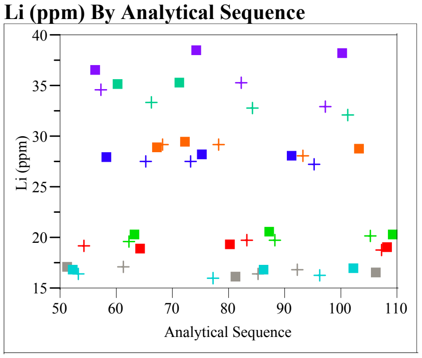
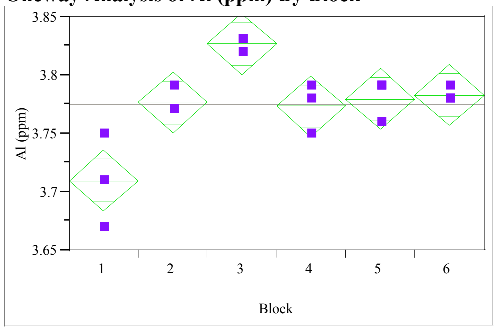


Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of Al (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.805502
Adj Rsquare	0.724462
Root Mean Square Error	0.020548
Mean of Response	3.775
Observations (or Sum Wgts)	18

Analysis of Variance

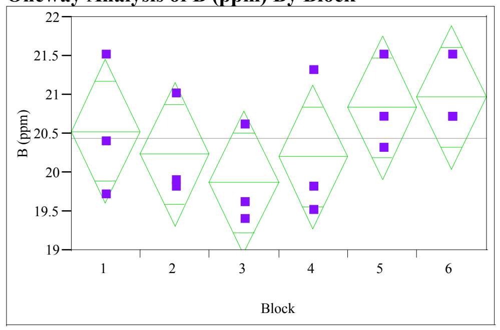
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.02098333	0.004197	9.9395	0.0006
Error	12	0.00506667	0.000422		
C. Total	17	0.02605000			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	3.71000	0.01186	3.6842	3.7358
2	3	3.77667	0.01186	3.7508	3.8025
3	3	3.82667	0.01186	3.8008	3.8525
4	3	3.77333	0.01186	3.7475	3.7992
5	3	3.78000	0.01186	3.7542	3.8058
6	3	3.78333	0.01186	3.7575	3.8092

Std Error uses a pooled estimate of error variance

Oneway Analysis of B (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.289849
Adj Rsquare	-0.00605
Root Mean Square Error	0.729916
Mean of Response	20.43889
Observations (or Sum Wgts)	18

Analysis of Variance

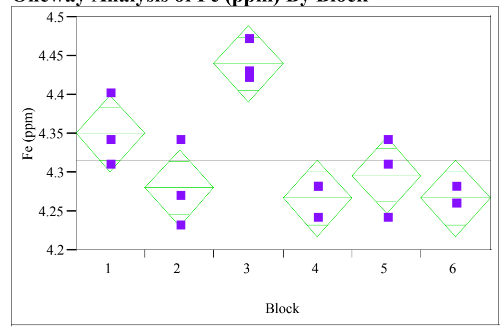
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	2.6094444	0.521889	0.9796	0.4687
Error	12	6.3933333	0.532778		
C. Total	17	9.0027778			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	20.5333	0.42142	19.615	21.452
2	3	20.2333	0.42142	19.315	21.152
3	3	19.8667	0.42142	18.948	20.785
4	3	20.2000	0.42142	19.282	21.118
5	3	20.8333	0.42142	19.915	21.752
6	3	20.9667	0.42142	20.048	21.885

Std Error uses a pooled estimate of error variance

Oneway Analysis of Fe (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.789954
Adj Rsquare	0.702435
Root Mean Square Error	0.039158
Mean of Response	4.316667
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.06920000	0.013840	9.0261	0.0009
Error	12	0.01840000	0.001533		
C. Total	17	0.08760000			

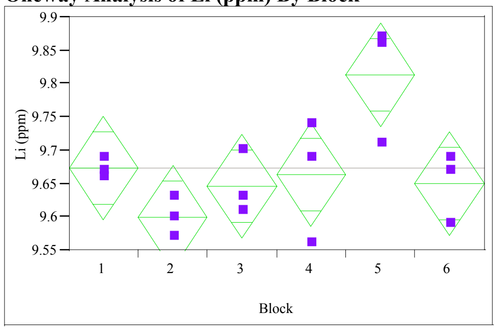
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	4.35000	0.02261	4.3007	4.3993
2	3	4.28000	0.02261	4.2307	4.3293
3	3	4.44000	0.02261	4.3907	4.4893
4	3	4.26667	0.02261	4.2174	4.3159
5	3	4.29667	0.02261	4.2474	4.3459
6	3	4.26667	0.02261	4.2174	4.3159

Std Error uses a pooled estimate of error variance

Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of Li (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.633625
Adj Rsquare	0.480968
Root Mean Square Error	0.061689
Mean of Response	9.674444
Observations (or Sum Wgts)	18

Analysis of Variance

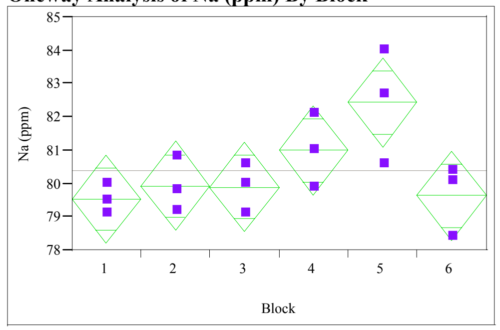
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0.07897778	0.015796	4.1507	0.0202
Error	12	0.04566667	0.003806		
C. Total	17	0.12464444			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	9.67333	0.03562	9.5957	9.7509
2	3	9.60000	0.03562	9.5224	9.6776
3	3	9.64667	0.03562	9.5691	9.7243
4	3	9.66333	0.03562	9.5857	9.7409
5	3	9.81333	0.03562	9.7357	9.8909
6	3	9.65000	0.03562	9.5724	9.7276

Std Error uses a pooled estimate of error variance

Oneway Analysis of Na (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.583609
Adj Rsquare	0.410113
Root Mean Square Error	1.060136
Mean of Response	80.40556
Observations (or Sum Wgts)	18

Analysis of Variance

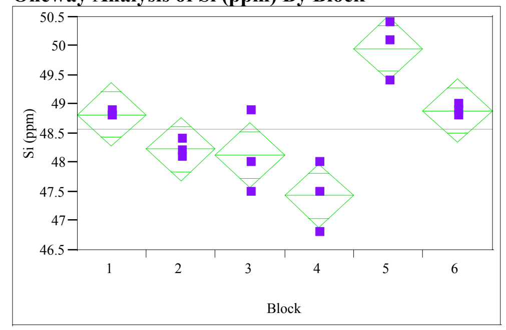
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	18.902778	3.78056	3.3638	0.0395
Error	12	13.486667	1.12389		
C. Total	17	32.389444			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	79.5333	0.61207	78.200	80.867
2	3	79.9333	0.61207	78.600	81.267
3	3	79.9000	0.61207	78.566	81.234
4	3	81.0000	0.61207	79.666	82.334
5	3	82.4333	0.61207	81.100	83.767
6	3	79.6333	0.61207	78.300	80.967

Std Error uses a pooled estimate of error variance

Oneway Analysis of Si (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0.827224
Adj Rsquare	0.755235
Root Mean Square Error	0.440959
Mean of Response	48.58333
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	11.171667	2.23433	11.4909	0.0003
Error	12	2.333333	0.19444		
C. Total	17	13.505000			

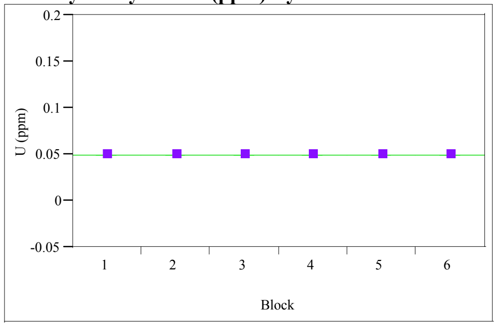
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	48.8333	0.25459	48.279	49.388
2	3	48.2333	0.25459	47.679	48.788
3	3	48.1333	0.25459	47.579	48.688
4	3	47.4333	0.25459	46.879	47.988
5	3	49.9667	0.25459	49.412	50.521
6	3	48.9000	0.25459	48.345	49.455

Std Error uses a pooled estimate of error variance

Exhibit D3. Measurements of the Multi-Element Solution Standard by ICP Block

Oneway Analysis of U (ppm) By Block



Oneway Anova
Summary of Fit

Rsquare	0
Adj Rsquare	-0.41667
Root Mean Square Error	8.5e-18
Mean of Response	0.05
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Block	5	0	0	0.0000	1.0000
Error	12	8.6667e-34	7.222e-35		
C. Total	17	8.6667e-34			

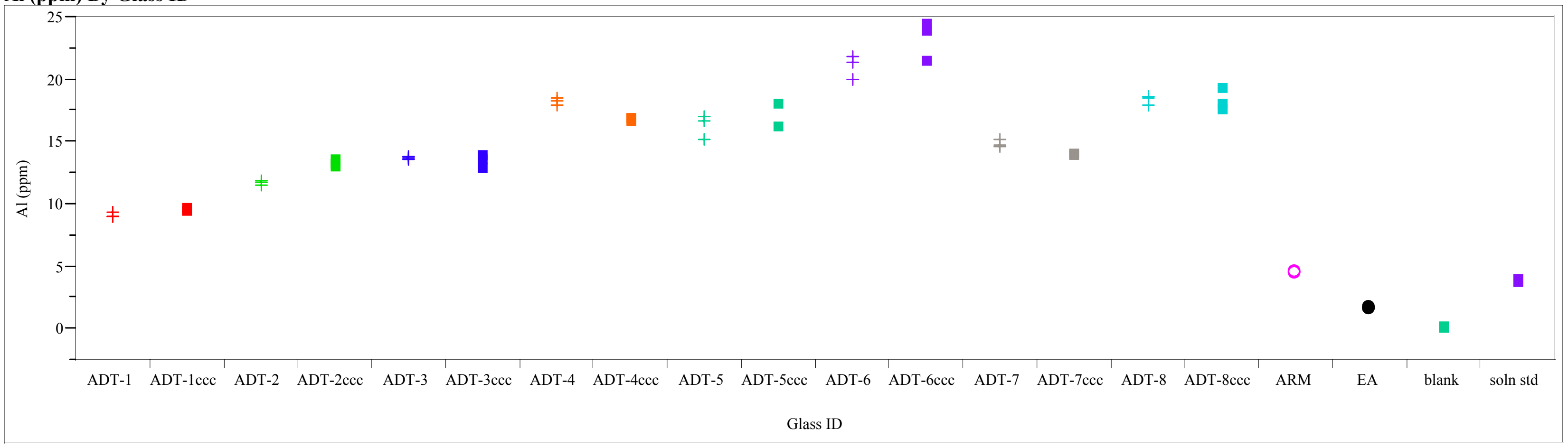
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	3	0.050000	4.907e-18	0.05000	0.05000
2	3	0.050000	4.907e-18	0.05000	0.05000
3	3	0.050000	4.907e-18	0.05000	0.05000
4	3	0.050000	4.907e-18	0.05000	0.05000
5	3	0.050000	4.907e-18	0.05000	0.05000
6	3	0.050000	4.907e-18	0.05000	0.05000

Std Error uses a pooled estimate of error variance

Exhibit D4. SRNL-ML PCT Measurements by ADT Study Glass and Standards

Al (ppm) By Glass ID



B (ppm) By Glass ID

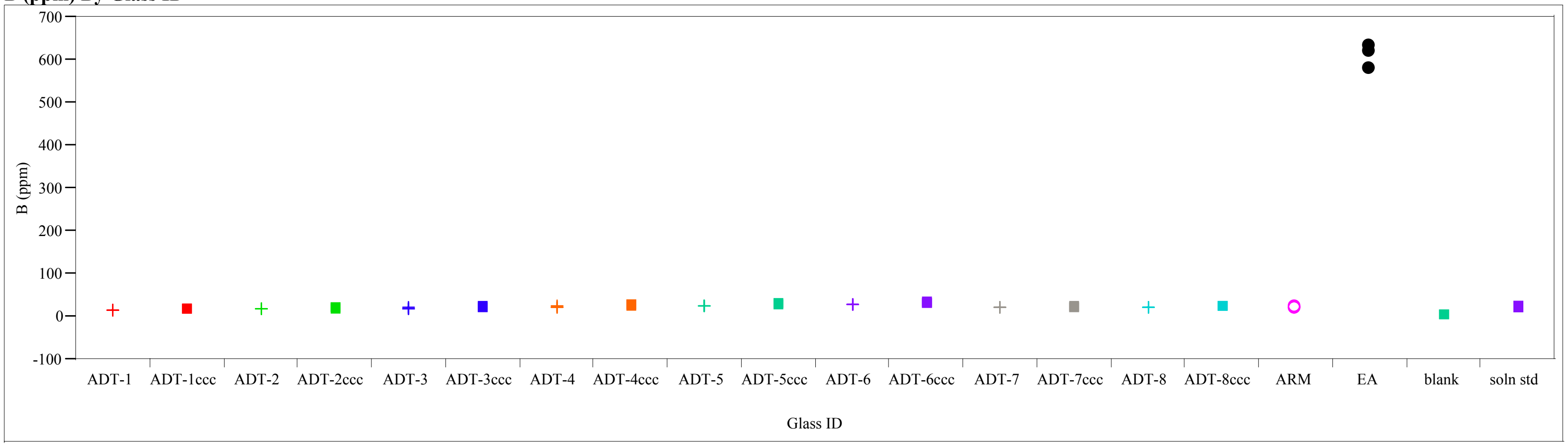
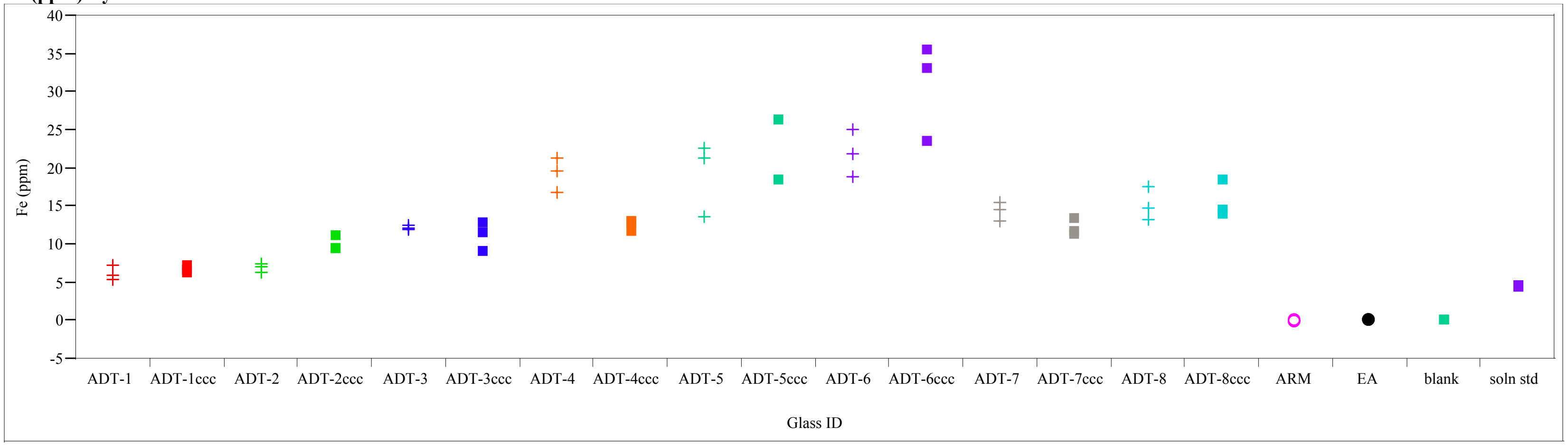


Exhibit D4. SRNL-ML PCT Measurements by ADT Study Glass and Standards

Fe (ppm) By Glass ID



Li (ppm) By Glass ID

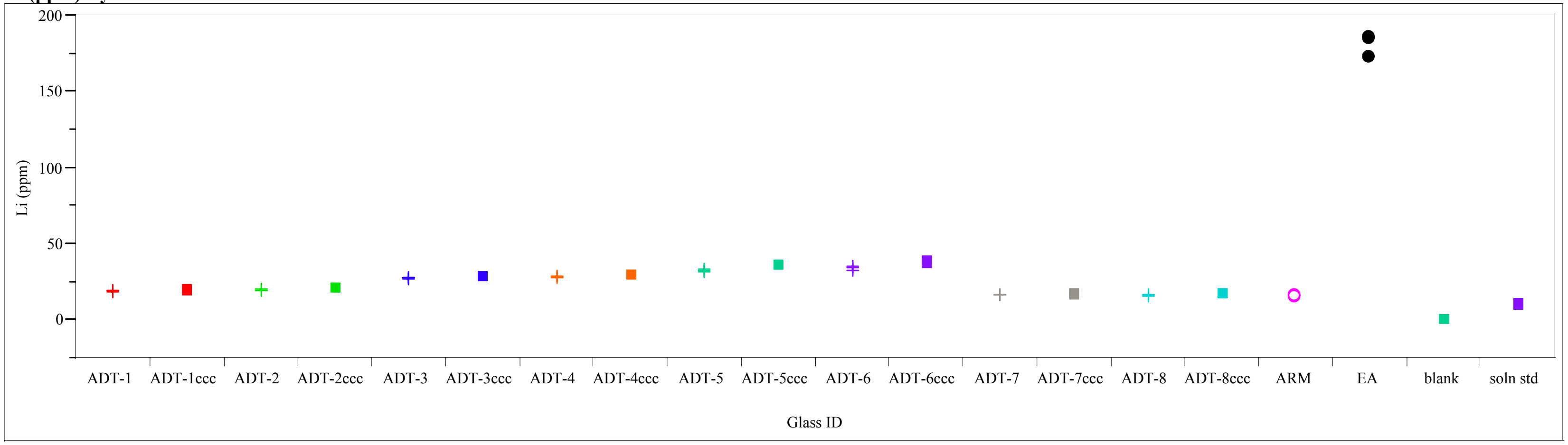
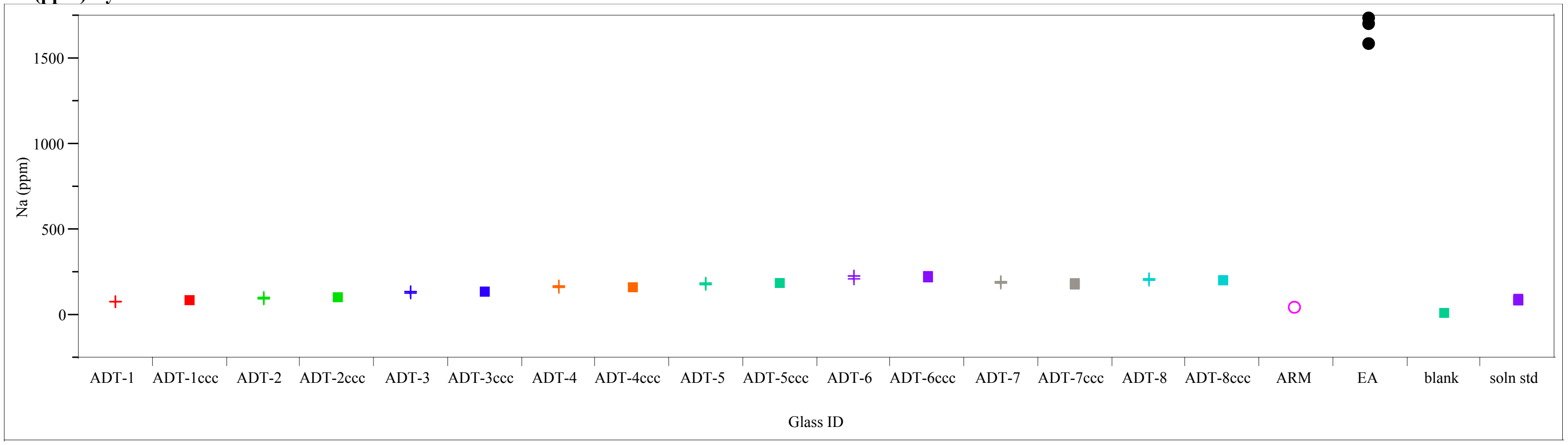


Exhibit D4. SRNL-ML PCT Measurements by ADT Study Glass and Standards

Na (ppm) By Glass ID



Si (ppm) By Glass ID

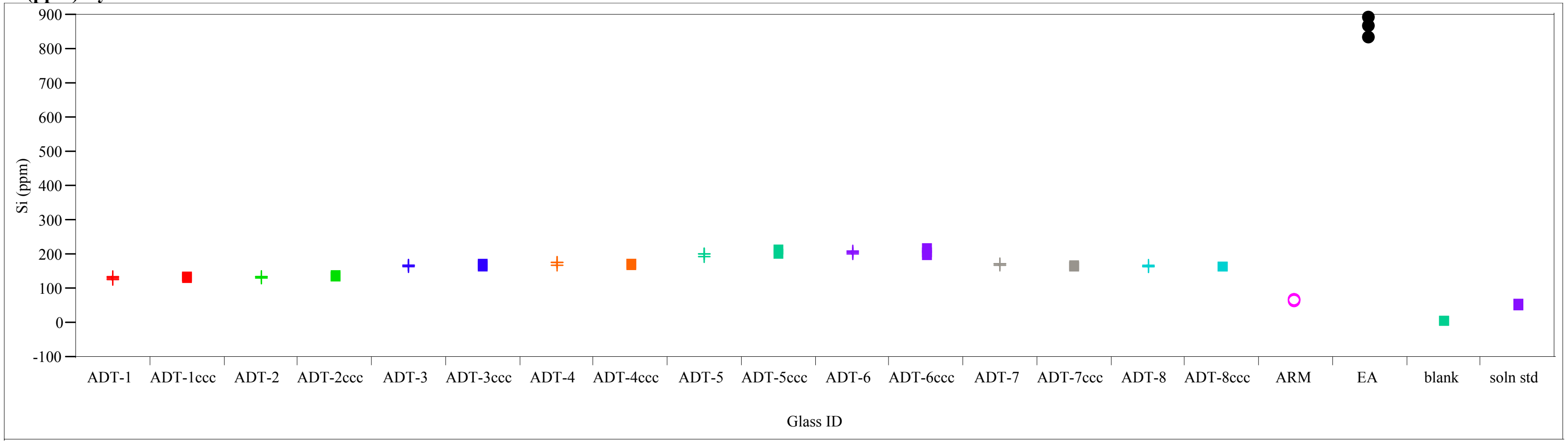


Exhibit D4. SRNL-ML PCT Measurements by ADT Study Glass and Standards

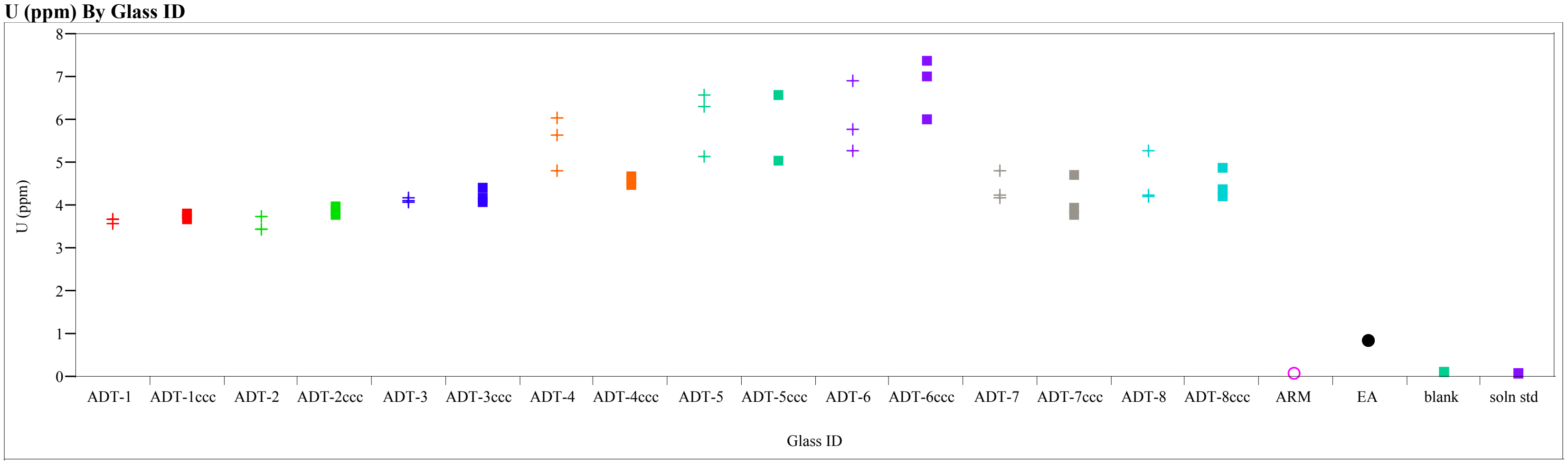
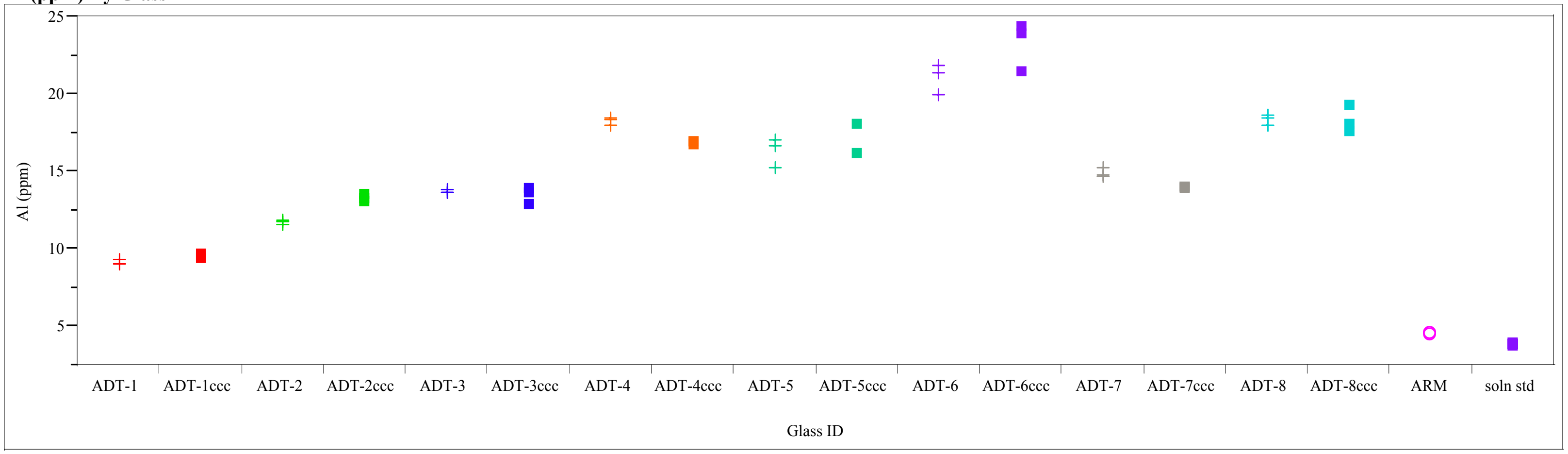


Exhibit D5. SRNL-ML PCT Measurements by ADT Study, ARM-1, and Solution Standards

(EA and blanks Excluded)

Al (ppm) By Glass ID



B (ppm) By Glass ID

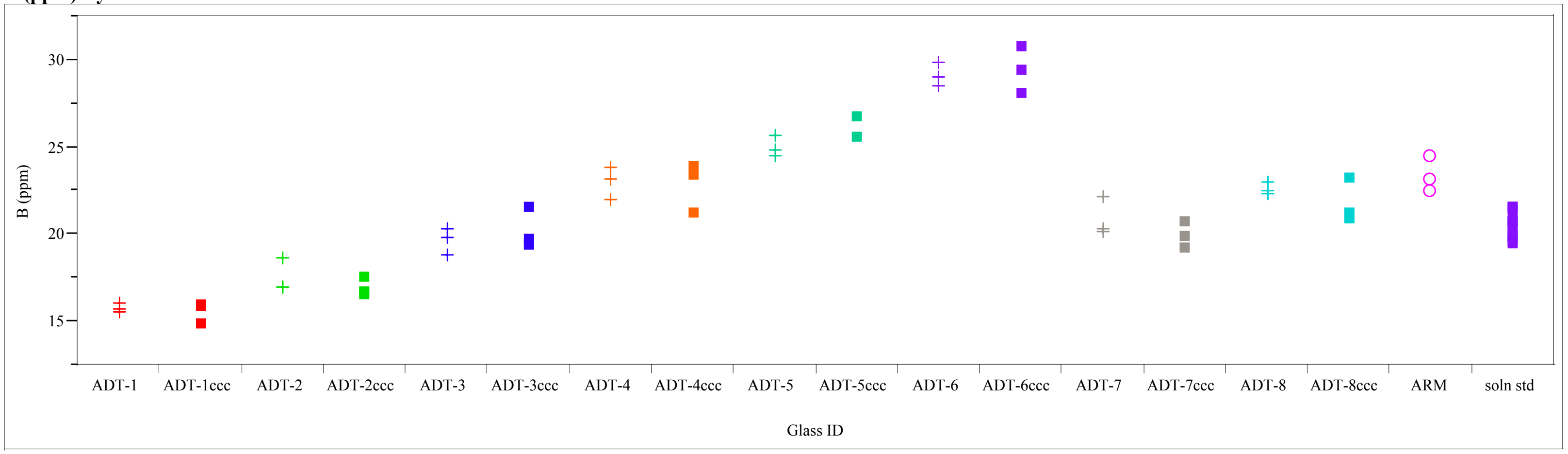
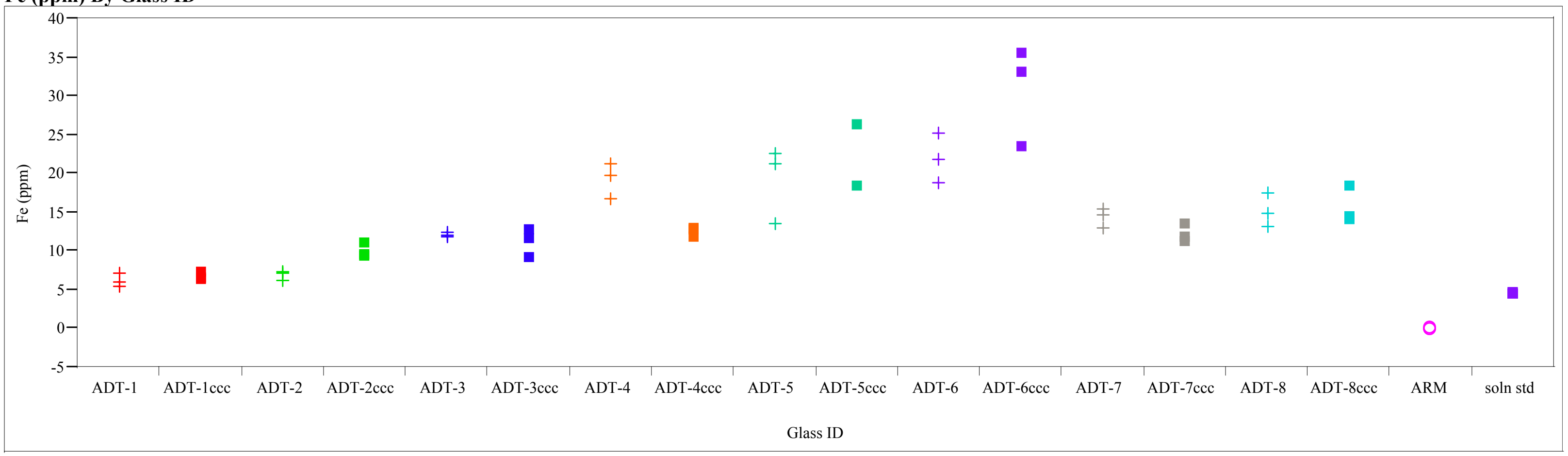


Exhibit D5. SRNL-ML PCT Measurements by ADT Study, ARM-1, and Solution Standards

(EA and blanks Excluded)

Fe (ppm) By Glass ID



Li (ppm) By Glass ID

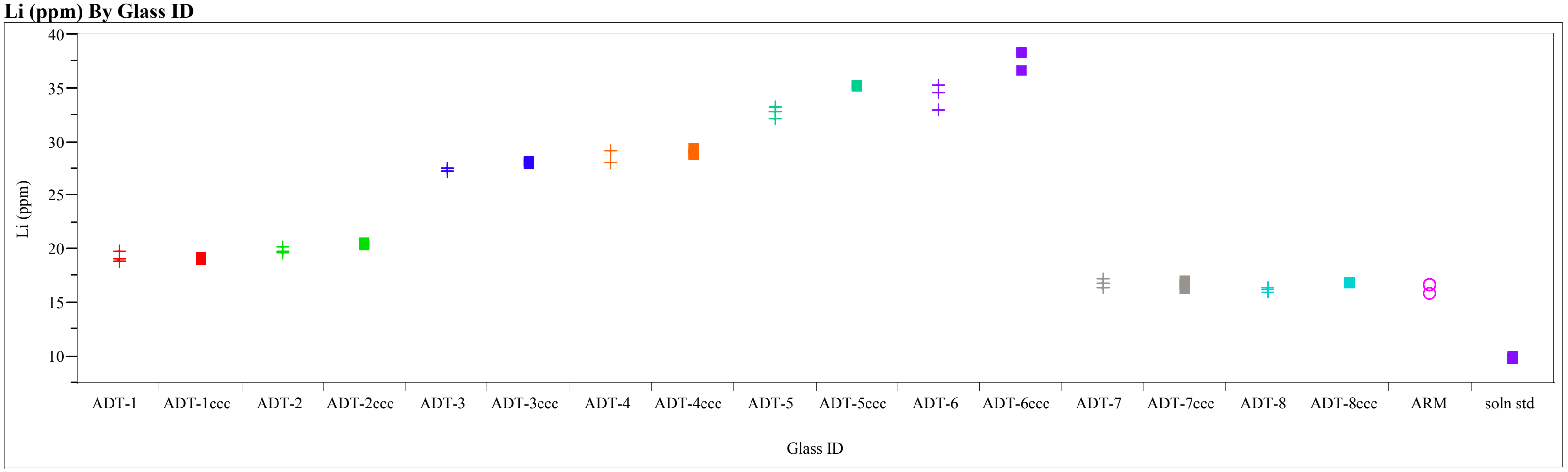
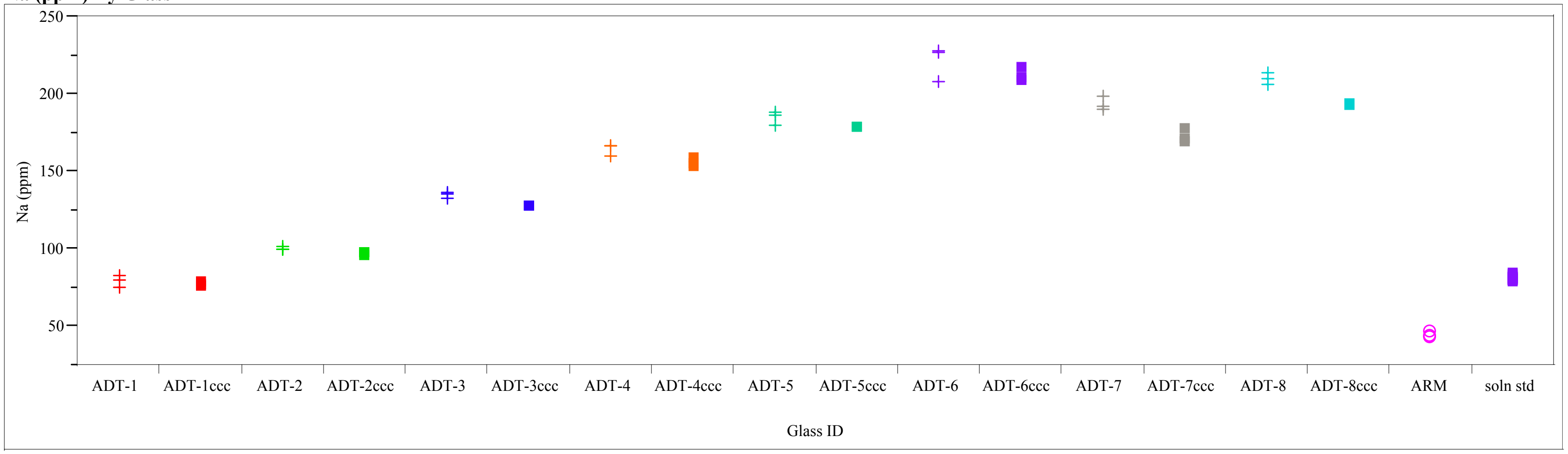


Exhibit D5. SRNL-ML PCT Measurements by ADT Study, ARM-1, and Solution Standards

(EA and blanks Excluded)

Na (ppm) By Glass ID



Si (ppm) By Glass ID

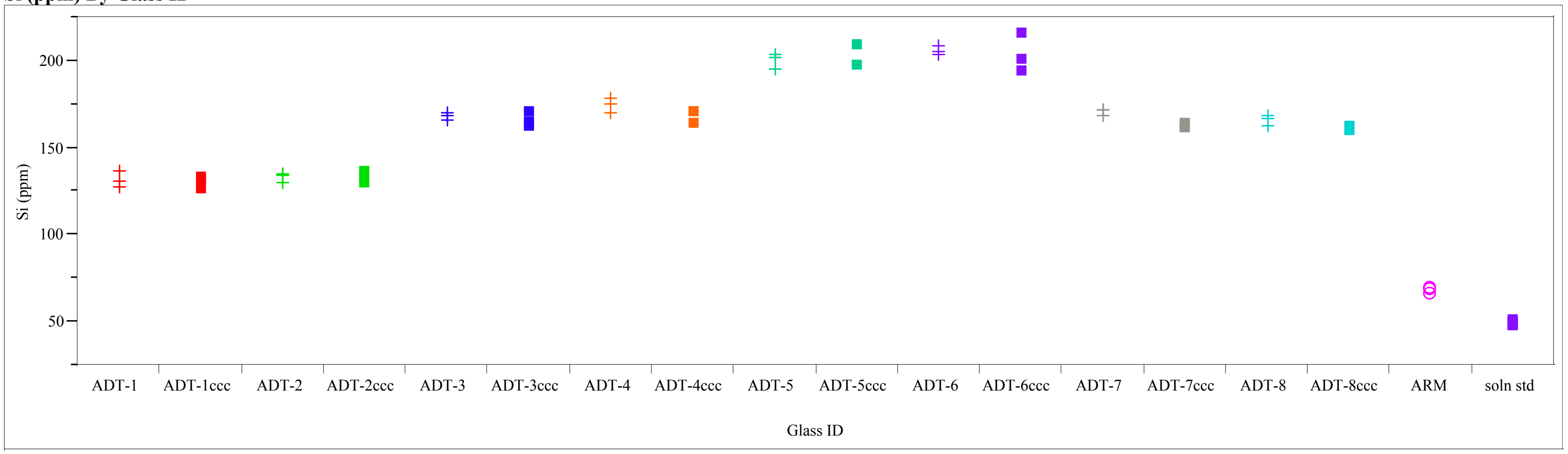


Exhibit D5. SRNL-ML PCT Measurements by ADT Study, ARM-1, and Solution Standards

(EA and blanks Excluded)

U (ppm) By Glass ID

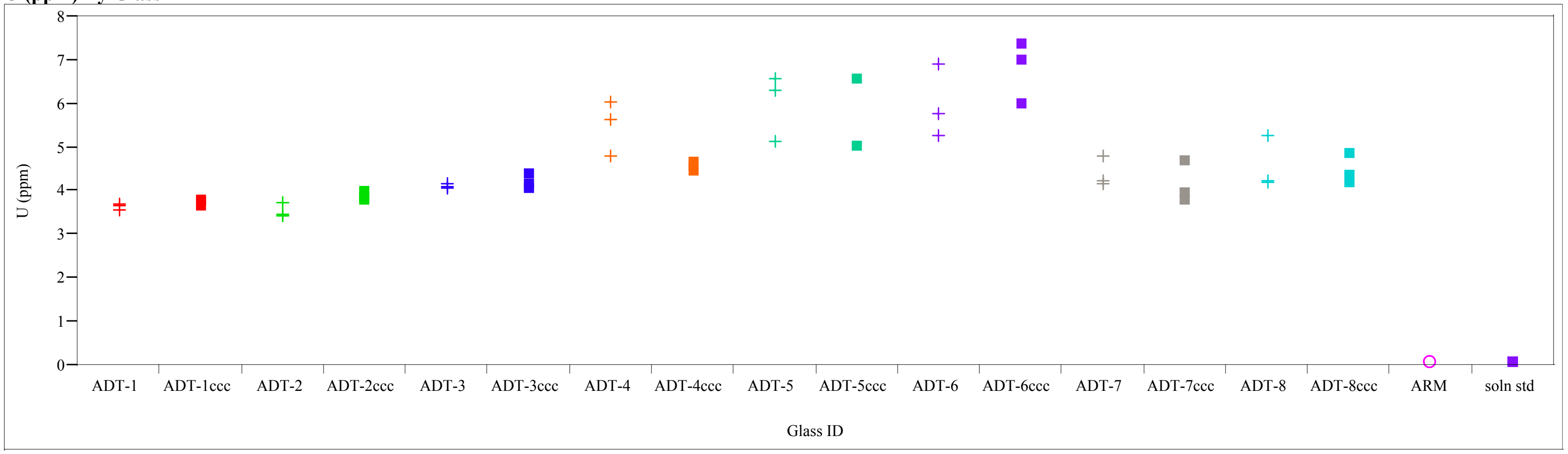
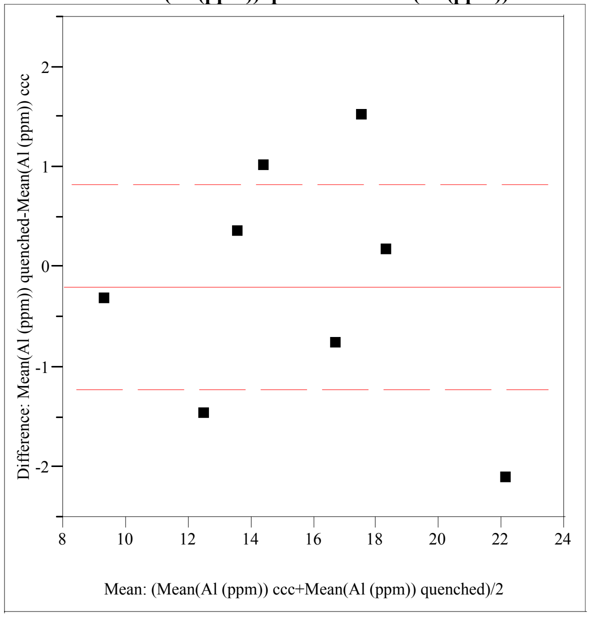


Exhibit D6. Effects of Heat Treatment on PCT Response over the ADT Study Glasses

(Paired t-test Comparisons)

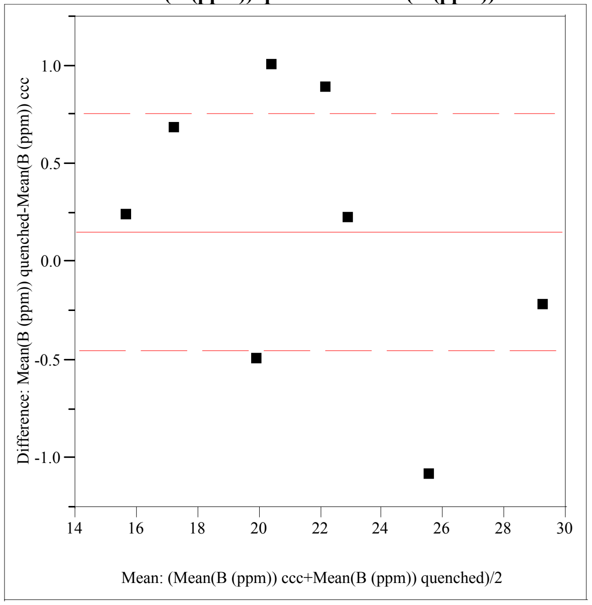
Matched Pairs

Difference: Mean(Al (ppm)) quenched-Mean(Al (ppm)) ccc



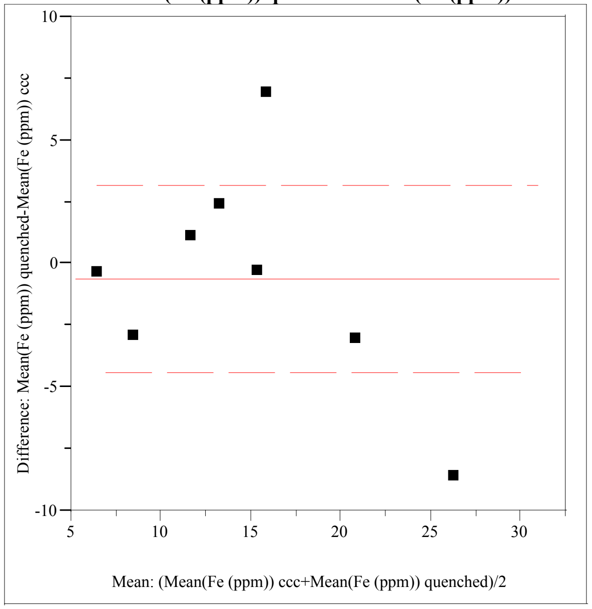
Mean(Al (ppm)) quenched	15.4399	t-Ratio	-0.46551
Mean(Al (ppm)) ccc	15.6406	DF	7
Mean Difference	-0.2007	Prob > |t|	0.6557
Std Error	0.43114	Prob > t	0.6721
Upper95%	0.81879	Prob < t	0.3279
Lower95%	-1.2202		
N	8		
Correlation	0.95545		

Difference: Mean(B (ppm)) quenched-Mean(B (ppm)) ccc



Mean(B (ppm)) quenched	21.6997	t-Ratio	0.598655
Mean(B (ppm)) ccc	21.547	DF	7
Mean Difference	0.15278	Prob > |t|	0.5683
Std Error	0.25521	Prob > t	0.2841
Upper95%	0.75625	Prob < t	0.7159
Lower95%	-0.4507		
N	8		
Correlation	0.98922		

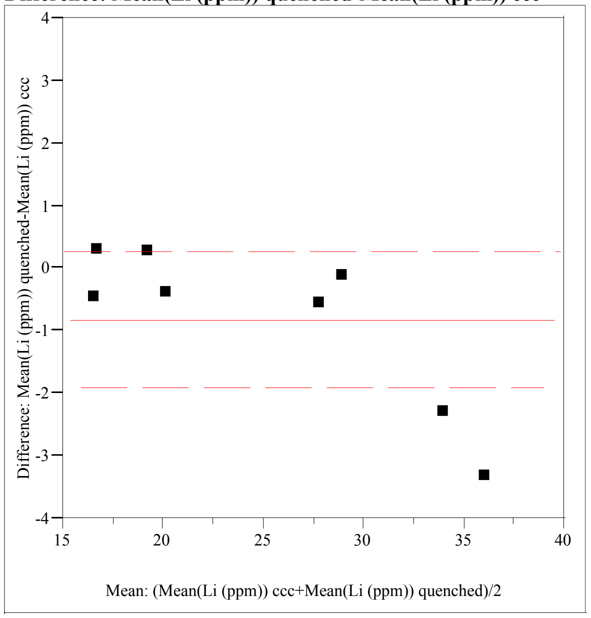
Difference: Mean(Fe (ppm)) quenched-Mean(Fe (ppm)) ccc



Mean(Fe (ppm)) quenched	14.4163	t-Ratio	-0.38223
Mean(Fe (ppm)) ccc	15.0281	DF	7
Mean Difference	-0.6118	Prob > |t|	0.7136
Std Error	1.60064	Prob > t	0.6432
Upper95%	3.1731	Prob < t	0.3568
Lower95%	-4.3967		
N	8		
Correlation	0.81674		

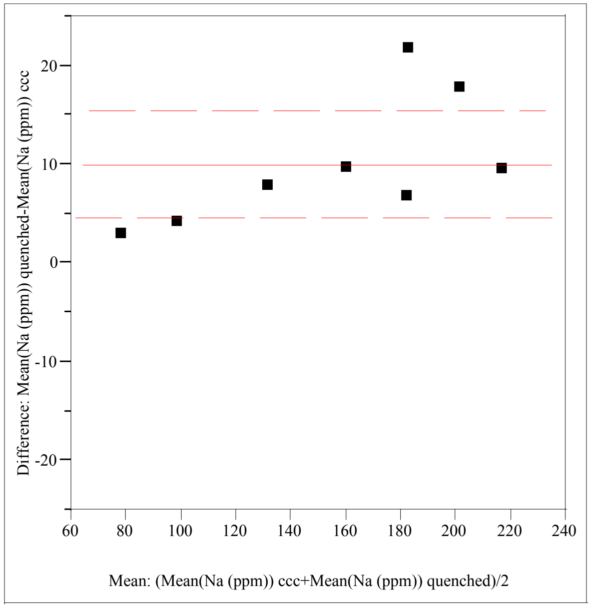
Exhibit D6. Effects of Heat Treatment on PCT Response by ADT Study Glass *(continued)*

Difference: Mean(Li (ppm)) quenched-Mean(Li (ppm)) ccc



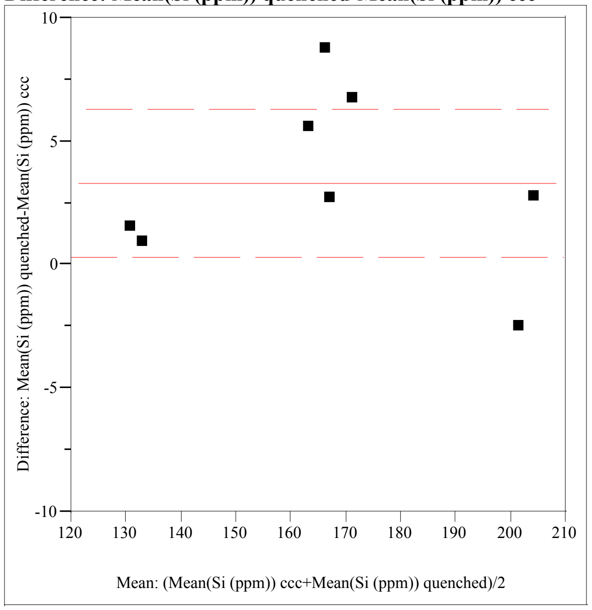
Mean(Li (ppm)) quenched	24.454	t-Ratio	-1.78704
Mean(Li (ppm)) ccc	25.2769	DF	7
Mean Difference	-0.8229	Prob > |t|	0.1171
Std Error	0.4605	Prob > t	0.9415
Upper95%	0.26598	Prob < t	0.0585
Lower95%	-1.9118		
N	8		
Correlation	0.99543		

Difference: Mean(Na (ppm)) quenched-Mean(Na (ppm)) ccc



Mean(Na (ppm)) quenched	161.1	t-Ratio	4.327816
Mean(Na (ppm)) ccc	151.107	DF	7
Mean Difference	9.99326	Prob > |t|	0.0034
Std Error	2.30908	Prob > t	0.0017
Upper95%	15.4534	Prob < t	0.9983
Lower95%	4.53316		
N	8		
Correlation	0.99506		

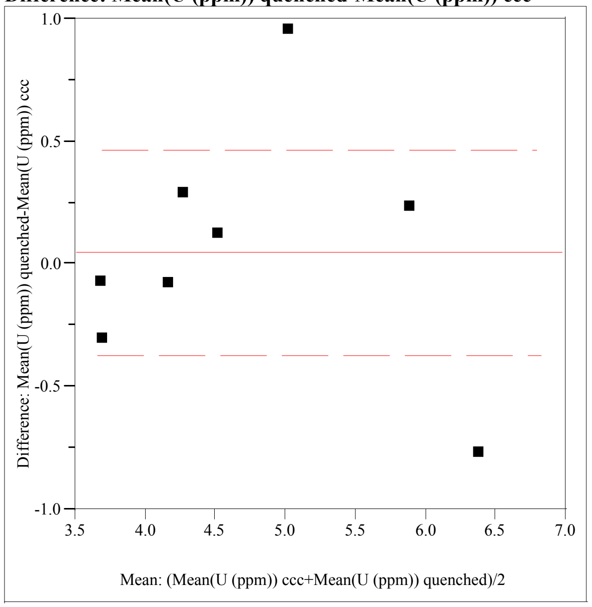
Difference: Mean(Si (ppm)) quenched-Mean(Si (ppm)) ccc



Mean(Si (ppm)) quenched	168.684	t-Ratio	2.611135
Mean(Si (ppm)) ccc	165.385	DF	7
Mean Difference	3.29868	Prob > |t|	0.0349
Std Error	1.26331	Prob > t	0.0174
Upper95%	6.28593	Prob < t	0.9826
Lower95%	0.31142		
N	8		
Correlation	0.99132		

Exhibit D6. Effects of Heat Treatment on PCT Response by ADT Study Glass *(continued)*

Difference: Mean(U (ppm)) quenched-Mean(U (ppm)) ccc



Mean(U (ppm)) quenched	4.71815	t-Ratio	0.263234
Mean(U (ppm)) ccc	4.67162	DF	7
Mean Difference	0.04653	Prob > |t|	0.8000
Std Error	0.17676	Prob > t	0.4000
Upper95%	0.4645	Prob < t	0.6000
Lower95%	-0.3714		
N	8		
Correlation	0.88198		

Exhibit D7. Correlations and Scatter Plots of Normalized PCTs by Compositional View for the ADT Study Glasses

Comp View=All

	log NL[B (g/L)]	log NL[Li (g/L)]	log NL[Na (g/L)]	log NL[Si (g/L)]
log NL[B (g/L)]	1.0000	0.9540	0.9358	0.9446
log NL[Li (g/L)]	0.9540	1.0000	0.8906	0.9462
log NL[Na (g/L)]	0.9358	0.8906	1.0000	0.9728
log NL[Si (g/L)]	0.9446	0.9462	0.9728	1.0000

Scatterplot Matrix

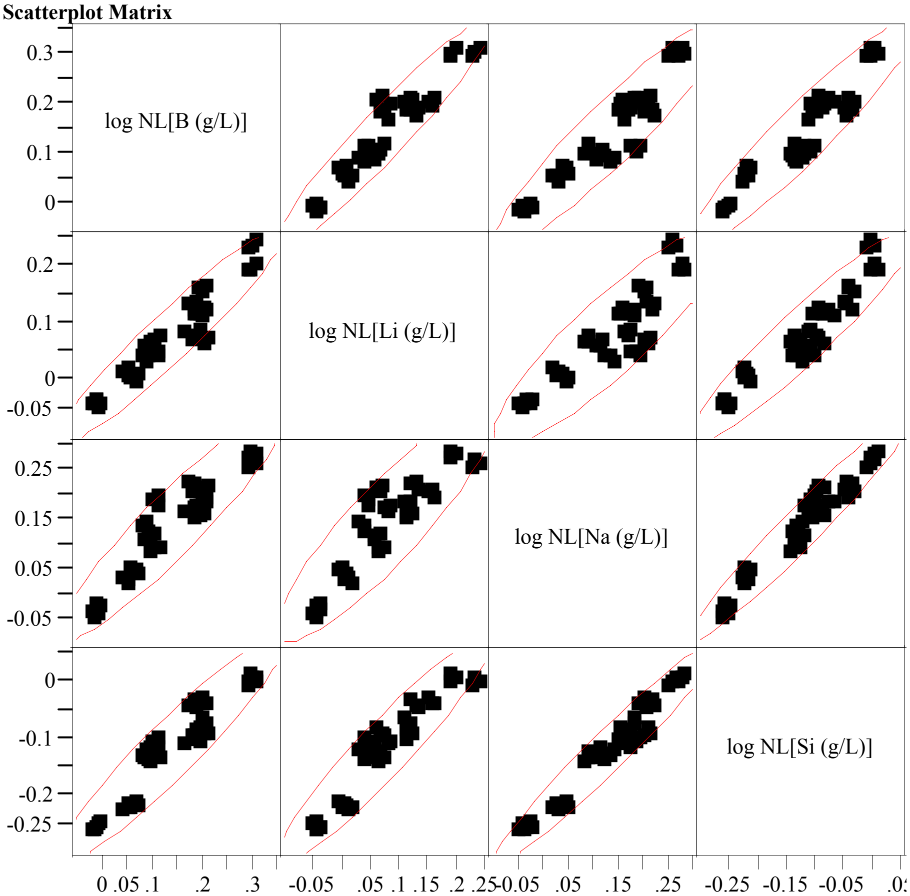


Exhibit D7. Correlations and Scatter Plots of Normalized PCTs by Compositional View for the ADT Study Glasses *(continued)*

Comp View=measured

Correlations

	log NL[B (g/L)]	log NL[Li (g/L)]	log NL[Na (g/L)]	log NL[Si (g/L)]
log NL[B (g/L)]	1.0000	0.9478	0.9258	0.9343
log NL[Li (g/L)]	0.9478	1.0000	0.8907	0.9508
log NL[Na (g/L)]	0.9258	0.8907	1.0000	0.9747
log NL[Si (g/L)]	0.9343	0.9508	0.9747	1.0000

Scatterplot Matrix

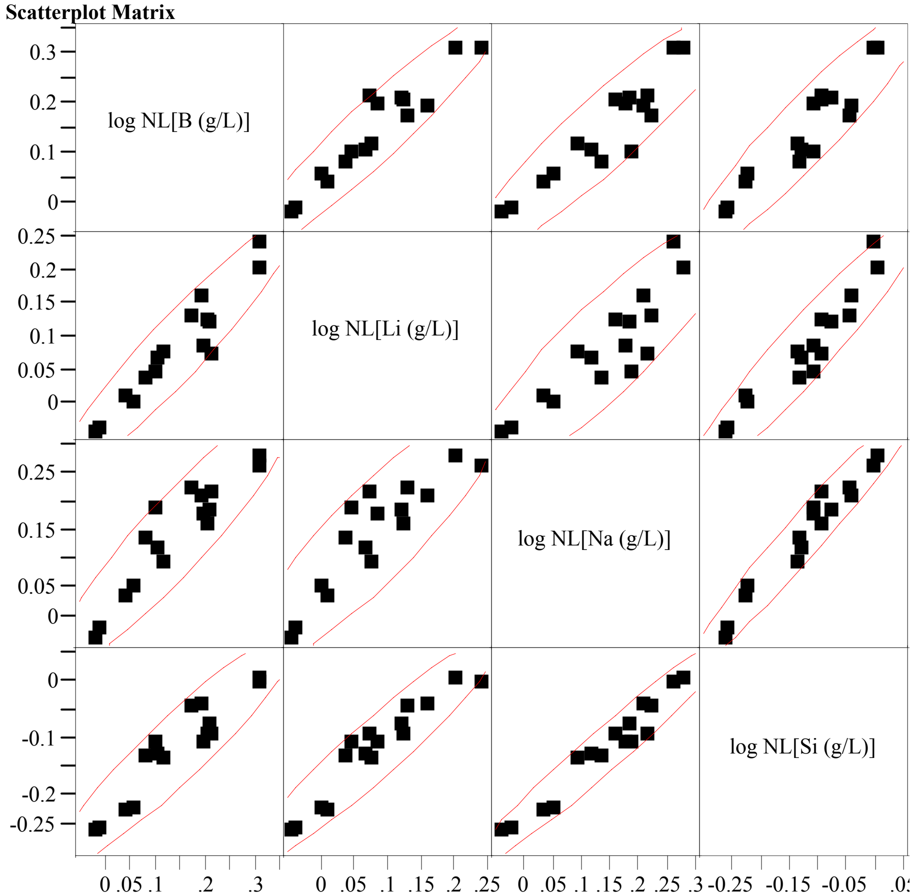


Exhibit D7. Correlations and Scatter Plots of Normalized PCTs by Compositional View for the ADT Study Glasses *(continued)*

Comp View=measured bc

Correlations

	log NL[B (g/L)]	log NL[Li (g/L)]	log NL[Na (g/L)]	log NL[Si (g/L)]
log NL[B (g/L)]	1.0000	0.9533	0.9356	0.9459
log NL[Li (g/L)]	0.9533	1.0000	0.8890	0.9513
log NL[Na (g/L)]	0.9356	0.8890	1.0000	0.9721
log NL[Si (g/L)]	0.9459	0.9513	0.9721	1.0000

Scatterplot Matrix

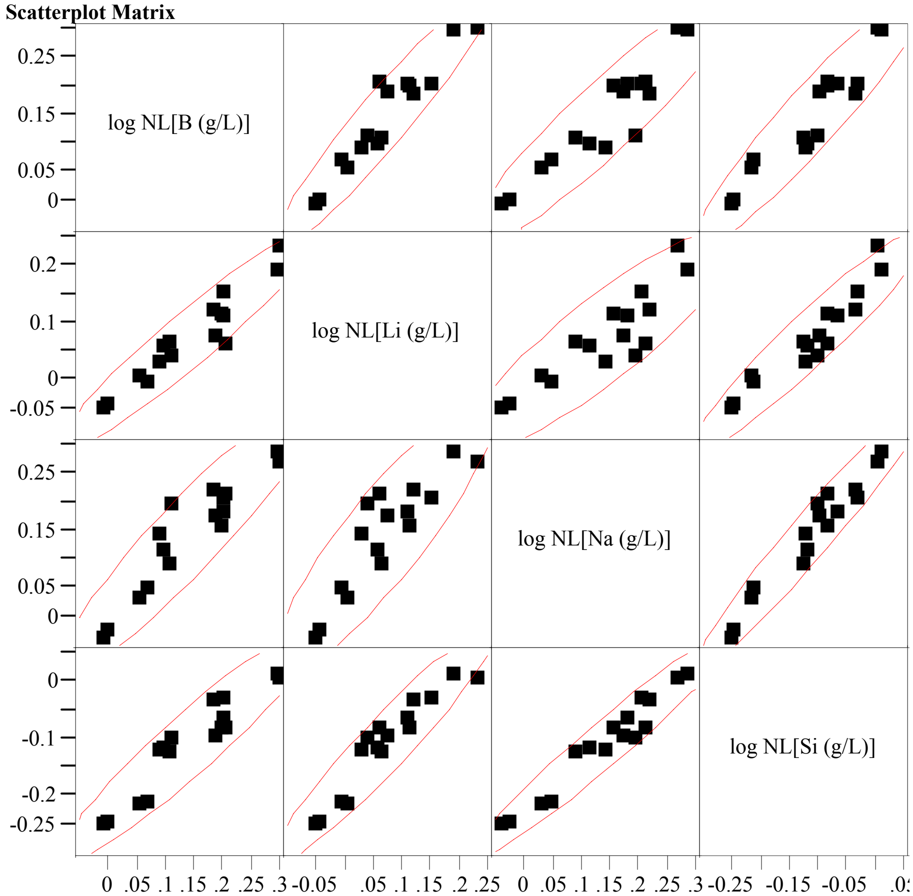


Exhibit D7. Correlations and Scatter Plots of Normalized PCTs by Compositional View for the ADT Study Glasses *(continued)*

Comp View=targeted

Correlations

	log NL[B (g/L)]	log NL[Li (g/L)]	log NL[Na (g/L)]	log NL[Si (g/L)]
log NL[B (g/L)]	1.0000	0.9689	0.9502	0.9605
log NL[Li (g/L)]	0.9689	1.0000	0.9018	0.9568
log NL[Na (g/L)]	0.9502	0.9018	1.0000	0.9764
log NL[Si (g/L)]	0.9605	0.9568	0.9764	1.0000

Scatterplot Matrix

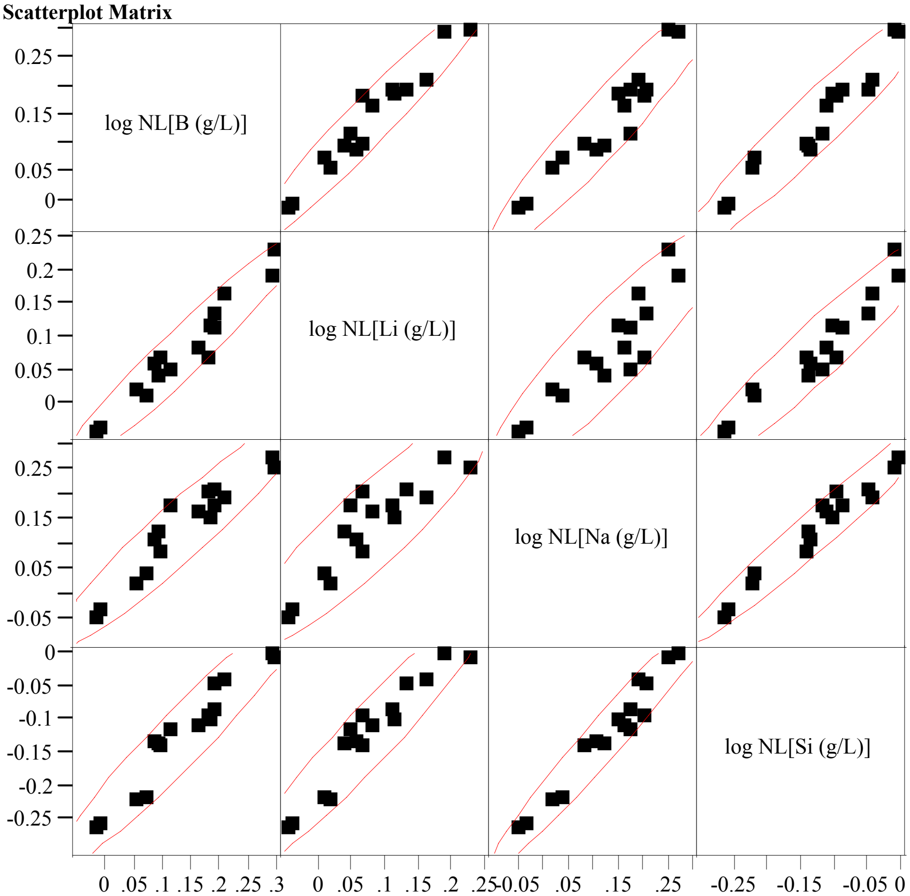
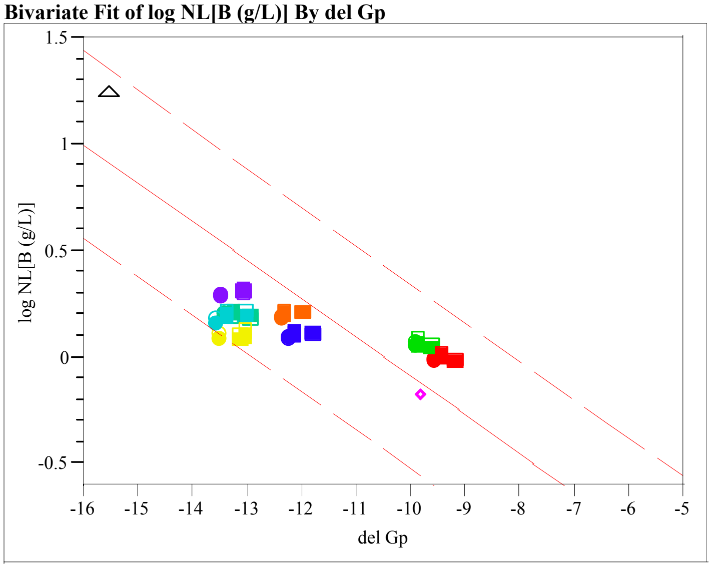


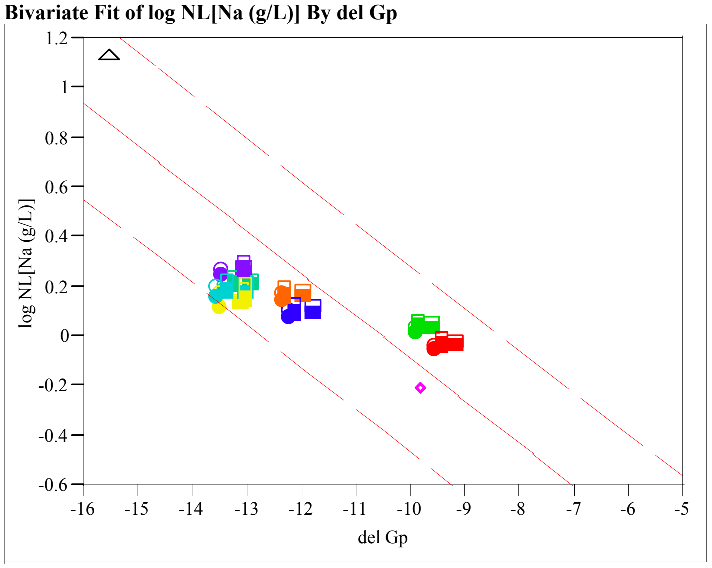
Exhibit D8. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View for ADT Glasses[18]

All Data

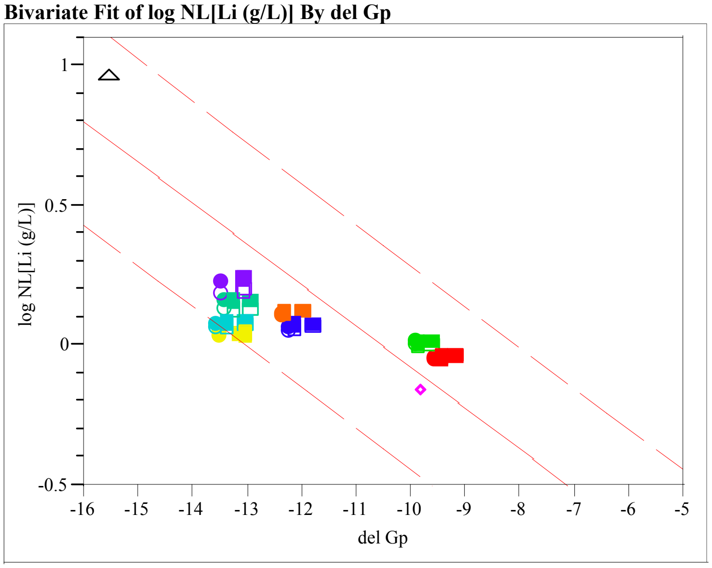
Bivariate Fit of log NL[B (g/L)] By del Gp



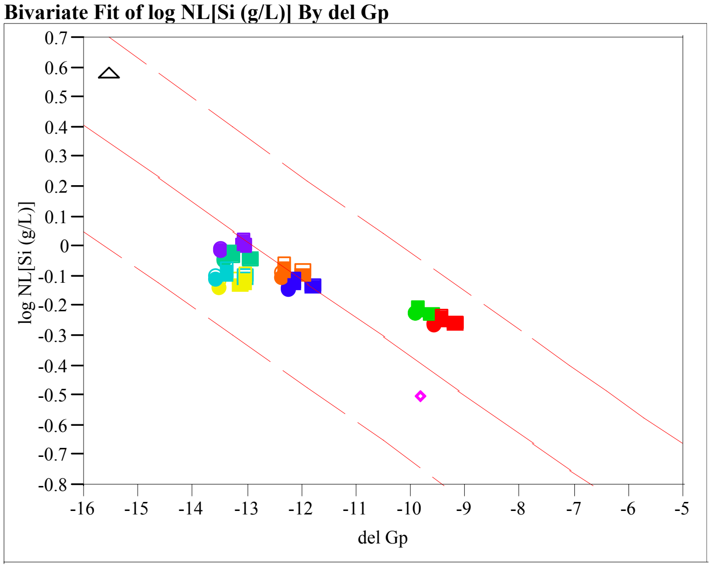
Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp



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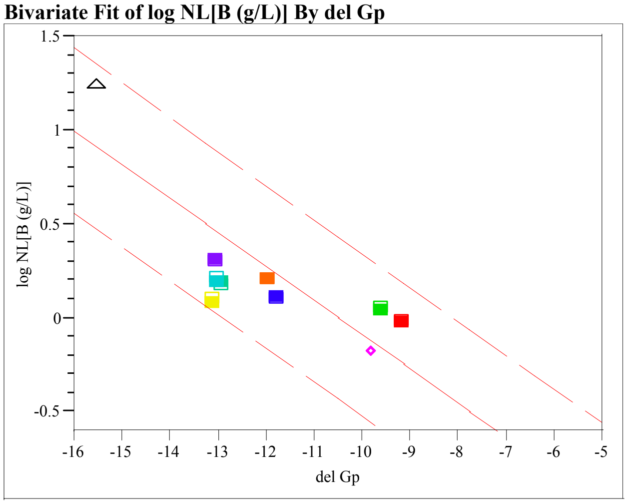
[18] Note: the open triangle represents the EA glass.

Exhibit D8. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View for ADT Glasses[19]

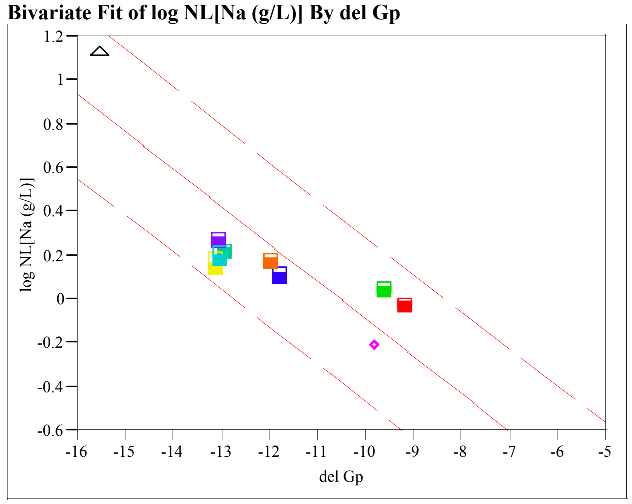
(continued)

Measured Data

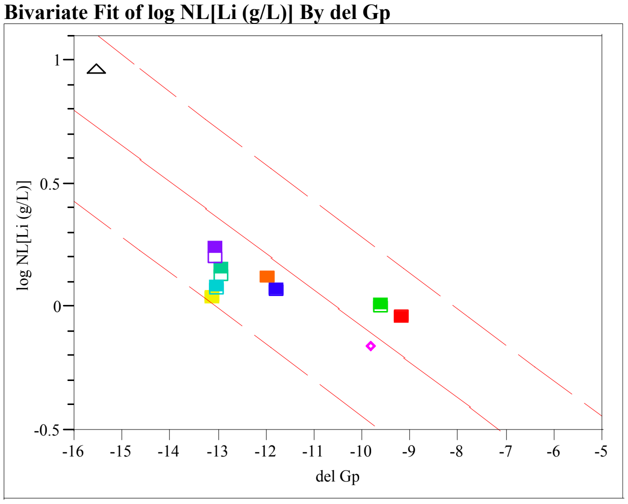
Bivariate Fit of log NL[B (g/L)] By del Gp



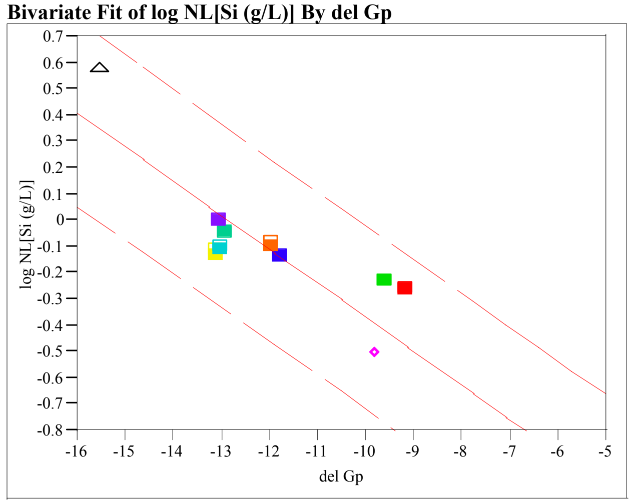
Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp



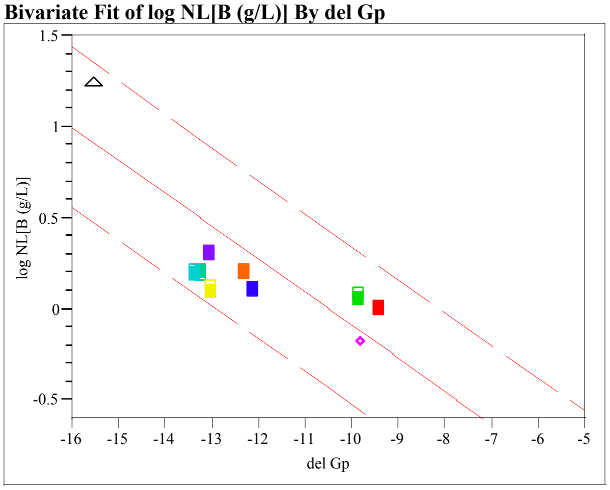
[19] Note: the open triangle represents the EA glass

Exhibit D8. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View for ADT Glasses[20]

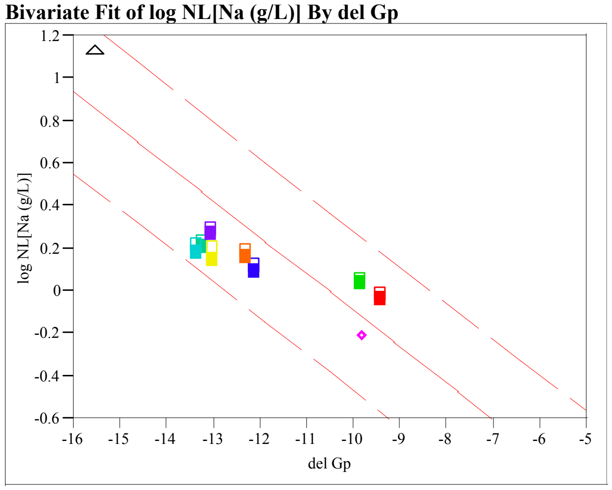
(continued)

Measured bc Data

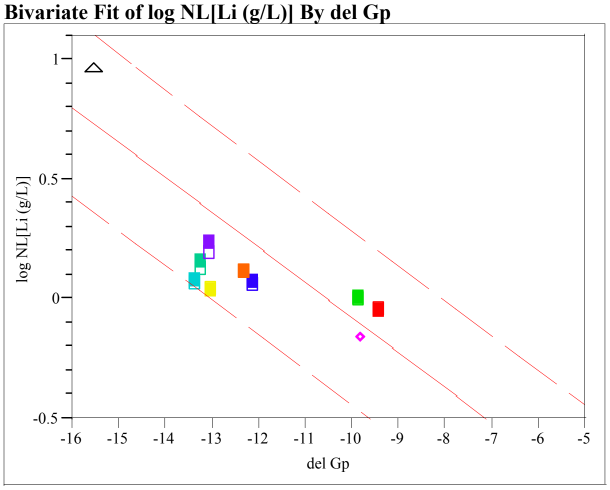
Bivariate Fit of log NL[B (g/L)] By del Gp



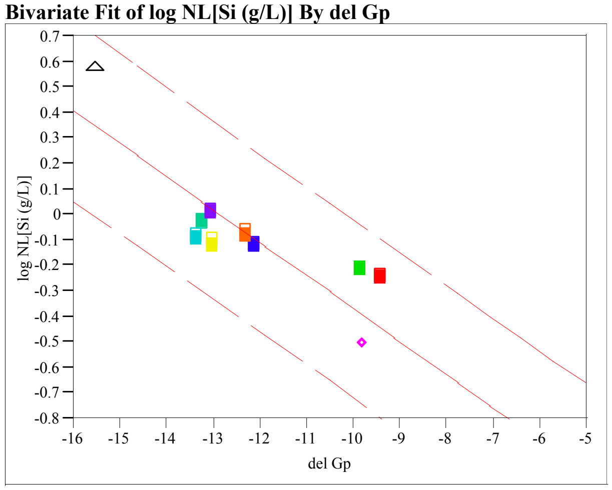
Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp



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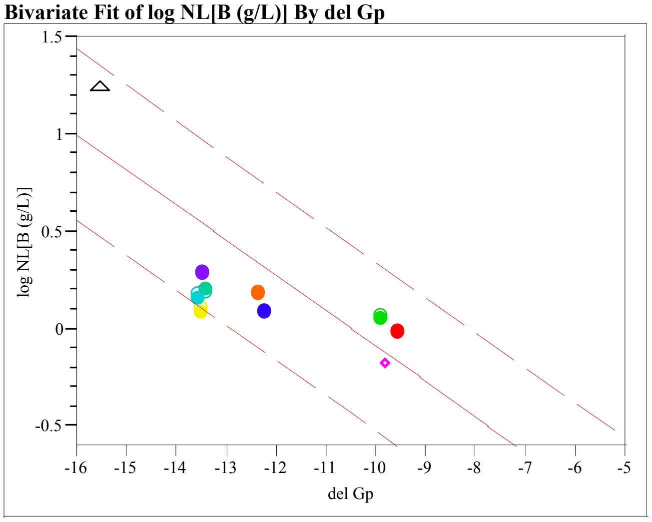
[20] Note: the open triangle represents the EA glass

Exhibit D8. del Gp (ΔG_p) Predictions versus Common Logarithm Normalized Leachate (log NL[.]) for B, Li, Na, and Si by Compositional View for ADT Glasses[21]

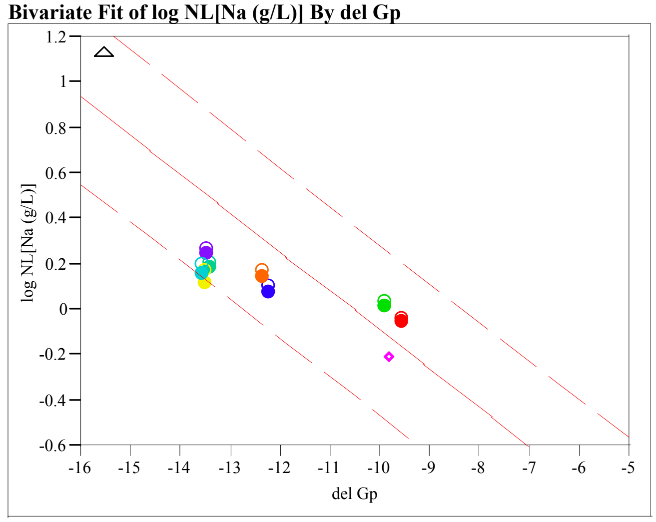
(continued)

Targeted Data

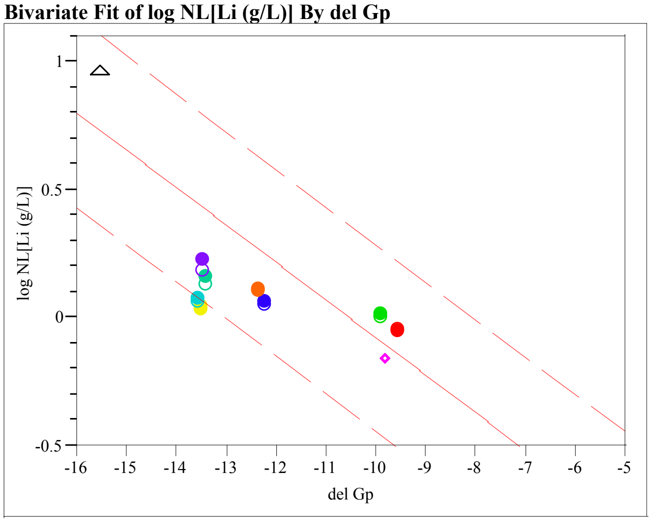
Bivariate Fit of log NL[B (g/L)] By del Gp



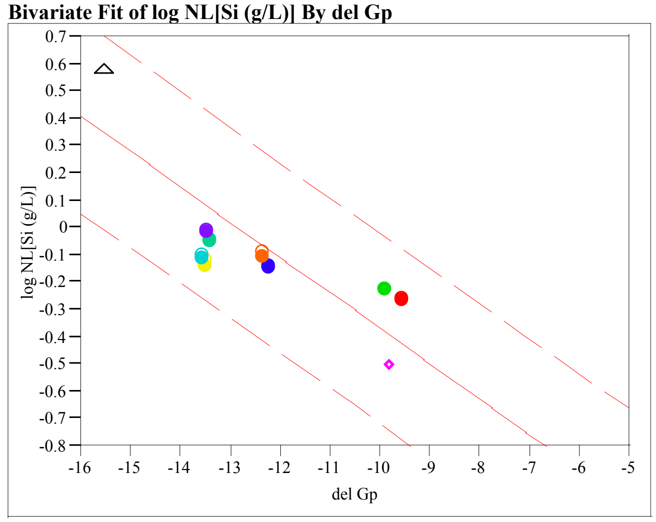
Bivariate Fit of log NL[Na (g/L)] By del Gp



Bivariate Fit of log NL[Li (g/L)] By del Gp



Bivariate Fit of log NL[Si (g/L)] By del Gp



[21] Note: the open triangle represents the EA glass