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HANFORD SPA GLASSES:

Fabrication, Characterization, and Chemical Analysis

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EXECUTIVE SUMMARY

The U.S. Department of Energy is formulating plans to vitrify the 204,400 m^3 of radioactive waste contained in the 177 waste storage tanks at the Hanford Site in Washington State. Interim Hanford high-level waste glass T_L models for use in the site flowsheet software are currently being updated (Vienna et al. [2001]). An integral part of this approach involves fabrication and testing of specific properties for glasses that adequately cover the compositional region of interest. As a result, Pacific Northwest National Laboratory (PNNL) developed a 45-glass test matrix (referred to as the SPA glass test matrix or SPA glasses) for which liquidus temperature (T_L) will be measured. The Savannah River Technology Center (SRTC) is supporting PNNL efforts by (1) fabricating the SPA glasses and (2) analyzing their chemical composition.

Each of the 45 SPA glass batches was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts (including NaCl, $NaPO_3$, Na_2SO_4, and CaF_2) using standard procedures. Once batched, the glasses were melted using a standard thermal heat treatment and quenched by pouring onto a clean stainless steel plate. The resulting glasses were visually assessed for homogeneity with subsequent analysis via X-ray diffraction (XRD) and scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) to gain further insight into the characteristics of the as-fabricated glasses.

Of the 45 SPA glasses, 20 were characterized as a single-phase (homogeneous, based on observation) glass. XRD patterns were used to confirm observations of homogeneity for select SPA glasses. Of the 25 SPA glasses that were not characterized as single-phase glasses, four primary characteristics or features were observed. Two of the four characteristics (dull-brown cross section and metallic coatings) were attributed to the formation of spinel-type phases. Deposition of salt was also observed in 4 SPA glasses. The last major feature characterizing select SPA glasses was major “swirls.”

With respect to the primary deliverable to PNNL, the Savannah River Technology Center – Mobile Laboratory (SRTC-ML) analyzed the compositions of the SPA glasses to confirm that targeted compositions were indeed met. An analytical plan was developed to provide the opportunity to evaluate potential sources of error. To assess the performance of the inductively coupled plasma unit over the course of these analyses and for potential bias-correction needs, multi-element solution standards and glass standards were intermittently run. Overall, the results suggest that there are no practical differences between the target and measured compositions of the SPA glasses.

Reference

J. D. Vienna, G. F. Piepel, P. Hrma, and S. K. Cooley. 2001. *Test Plan for Updating the Hanford HLW Glass Liquidus Temperature Models,* TFA-IMM-01-01, Richland, Washington.

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GLOSSARY

ADS	Analytical Development Services
AES	atomic emission spectroscopy
ANOVA	analysis of variance
CVS	composition variation study
DWPF	Defense Waste Processing Facility
EDS	energy dispersive spectroscopy
HLW	high-level waste
HTWOS	Hanford Tank Waste Optimization Simulator
HWVP	Hanford Waste Vitrification Plant
IC	Ion Chromatography
ICDD	International Centre for Diffraction Data
ICP	inductively coupled plasma
INEEL	Idaho National Engineering and Environmental Laboratory
LAW	low-activity waste
LM	lithium metaborate
LRM	Low-activity Reference Material
MPO	memorandum purchase order
NCAW	neutralized current acid waste
PCT	Product Consistency Test
PH	potassium hydroxide
PNNL	Pacific Northwest National Laboratory
SEM	scanning electron microscopy
SP	sodium peroxide
SRTC	Savannah River Technology Center
SRTC-ML	Savannah River Technology Center – Mobile Laboratory
T_L	liquidus temperature
T_M	melt temperature
TFA	Tanks Focus Area
TTP	technical task plan
U_{std}	uranium standard glass
η	viscosity

WC	tungsten carbide
WCP	Waste Compliance Plan
WSRC	Westinghouse Savannah River Company
WTP	Waste Treatment Plant
WVDP	West Valley Demonstration Project
XRD	x-ray diffraction

ACKNOWLEDGMENTS

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1.0 INTRODUCTION

The Hanford Site in Southeastern Washington State has 177 underground waste tanks containing 204,400 m^3 of high-level waste (HLW) generated from over four decades of nuclear fuel processing and actinide separations (Kirkbride 2000). These wastes will be retrieved from the tanks, separated into HLW and low-activity waste (LAW) fractions, and separately vitrified.

From 1989 to 1994, Hrma et al. (1994) systematically studied the effects of nine glass components (Al_2O_3, B_2O_3, CaO, Fe_2O_3, Li_2O, MgO, Na_2O, SiO_2, and ZrO_2) on HLW glass properties. The results of their study (Hrma et al. [1994]), the composition variation study (CVS), included a set of property models that covered a composition region designed for the immobilization of neutralized current acid waste (NCAW) in the Hanford Waste Vitrification Plant (HWVP). The properties modeled included:

- normalized boron (B), lithium (Li), sodium (Na), and silicon (Si) releases from glasses subjected to the Product Consistency Test (PCT) (ASTM 1998) – r_B, r_{Li}, r_{Na}, and r_{Si}, respectively
- viscosity at 1150°C and the viscosity-temperature relationship
- electrical conductivity at 1150°C and the electrical conductivity-temperature relationship
- liquidus temperature of glasses in the spinel, acmite, and zirconia containing primary phase fields.

These models were incorporated into the Hanford Tank Waste Optimization Simulator (HTWOS). HTWOS is the site's integrated flowsheet that tracks the details of tank-farm operations, such as tank volumes, waste compositions, tank-transfer infrastructure, and manpower requirements (Kirkbride 2000). Waste Treatment Plant (WTP) operations, such as pretreatment, HLW and LAW vitrification, and canister-storage activities are currently being added/updated in HTWOS. HTWOS is also used to develop schedules and cost estimates for the River Protection Project.

Since the development of the CVS models, a number of waste glasses have been studied, including those for Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), Defense Waste Processing Facility (DWPF), and the West Valley Demonstration Project (WVDP) vitrification programs. Hrma et al. (2001) compiled an extensive glass-property database and fitted interim HLW glass property-models to these data. The interim models include terms for more components and have a broader range of applicability than the CVS models. They were verified and adopted in the HTWOS.[a] Calculations were made to estimate the waste loading, composition ranges, and waste-loading limiting properties of HLW glasses for all of Hanford's tanks by Perez et al. (2001). This exercise clearly showed that the interim models are inadequate to estimate the waste loading for a large fraction of Hanford HLW glasses for two reasons: (1) the composition region over which optimized glasses were calculated are not within current model validity region, and (2) no model exists for the estimation of T_L within the eskolaite (Cr_2O_3) primary phase field.

Vienna et al. (2001) discuss the approach being taken to update the interim Hanford HLW glass T_L models for use in the site-flowsheet software. An integral part of this approach involves fabrication and testing of specific properties for glasses that adequately cover the compositional region of interest. As a result, Pacific Northwest National Laboratory (PNNL) developed a 45-glass test matrix, referred to as the SPA glass test matrix or SPA glasses (for SPinel T_L data Augmentation), for which liquidus temperature (T_L) will be measured (Vienna et al. 2001). The Savannah River Technology Center (SRTC) is supporting PNNL efforts by (1) fabricating and (2) analyzing the chemical composition of the SPA

(a) Lambert, S. L. 2000. "Evaluation of Viscosity, PCT and Liquidus Temperature Models for HTWOS," Interoffice Memo to J. S. Garfield, dtd. November 8, 2000, Numatec Hanford Company, Richland, Washington.

glasses. These supporting tasks are defined in either the Tanks Focus Area (TFA) Technical Task Plan (TTP) for FY01 (SR16WT31) or a statement of work associated with Memorandum Purchase Order (MPO) Number 409602 (MPO 2001).[(a)] This report discusses the fabrication and characterization of the 45 SPA glasses as well as a detailed analysis of the measured chemical composition data.

2.0 EXPERIMENTAL

The glasses fabricated and data generated for the Hanford SPA study were accomplished via a joint effort between SRTC and PNNL. This work was performed according to applicable DOE/RW-0333P Quality Assurance Criteria.[(b)] This report discusses the fabrication, general characterization, and chemical analysis of the SPA glasses. This section describes the experimental procedures used to fabricate and the analytical techniques used to physically and chemically characterize the SPA glasses.

2.1 Glass Fabrication

Tables 1a and 1b identify the targeted compositions (major and minor components, respectively) of the 45 SPA glasses prepared for this study. Each batch was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts (including NaCl, $NaPO_3$, Na_2SO_4, and CaF_2) in 500-g batches using SRTC technical procedure "Glass Batch Preparation Procedure – GTOP-3-003" (SRTC 1994). Batch sheets were filled out as the materials were weighed.[(c)] Once batched, the glasses were melted using a standard thermal heat treatment. In general, the raw materials were thoroughly mixed and placed into a 95% platinum/5% rhodium 600-mL crucible. The batch was subsequently placed into a high-temperature furnace, and the temperature was increased at ~ 8°C/min until the target melt temperature (T_{M1}) was reached. The target melt temperatures ranged from 1100ºC to 1250ºC, to target a viscosity of 4 to 6 Pa·s.[(d)] Target or initial melt temperatures were calculated by PNNL, transmitted to SRTC, and are shown in Table 2 along with other property predictions of interest (for example, liquidus temperature [T_L] and the viscosity at 1150°C [$\eta_{1150°C}$]). After an isothermal hold at T_{M1} for 1.0 h, the crucible was removed, and the glass was poured onto a clean stainless steel plate and allowed to air cool. The observations of the resulting pour patty and residual crucible glass were documented.[(e)]

The pour patty and residual crucible glass were ground to roughly 1-µm particles in a tungsten carbide (WC) mill for approximately 2 min. The crushed glass was subsequently transferred to its original 95% platinum/5% rhodium 600-mL crucible for a second melt at T_{M2}. It should be noted that if there was an indication that the batch was unreacted (for example, a large fraction of undissolved solids observed in the bottom of the crucible or a partially reacted batch after T_{M1}), the T_{M2} was increased. After an isothermal hold at T_{M2} for 1.0 h, the crucible was removed, and the glass was poured onto a clean stainless steel plate and allowed to air cool. Observations of the resulting pour patty and residual crucible glass were documented. If necessary, a sample was melted a third time (at T_{M3} for 1.0 h) after grinding the pour patty and residual crucible glass from the second melt.

(a) MPO 2001. Memorandum Purchase Order, MPO No. 409602, D.L. Hannigan, Battelle, Pacific Northwest National Laboratory, Budget Office, Richland, Washington.

(b) As defined by the DOE/RW-0333P Quality Assurance Program.

(c) Batch sheets can be found in WSRC-NB-2001-00055.

(d) Although melters capable of operating at temperatures higher than 1250°C are being considered, this study will primarily focus on glass compositions for current or baseline melter technologies. The expansion of the viscosity/temperature range from the reference values will expand the glass-composition region further than can be effectively covered with glass compositions in the current study.

(e) Visual observations are recorded in WSRC-NB-2001-00055.

After the final melt, approximately 475 g of glass were removed (poured) from the crucible while ~ 25 g remained in the crucible along the walls. Glasses were stored in marked containers (using the unique SPA nomenclature as defined by Vienna et al. (2001) and either shipped to PNNL (for T_L and other property measurements of interest) or retained at SRTC (for homogeneity assessments and chemical-composition measurements).

2.2 PROPERTY MEASUREMENTS

2.2.1 Homogeneity

Samples were visually examined for homogeneity[(a)] and representative samples for selected "as-fabricated" SPA glasses were analyzed by X-ray diffraction (XRD). This analysis was used to confirm observations of homogeneity within a given detection limit (based on the run conditions of the diffractometer) and to identify the cause for inhomogeneity. Samples were run under conditions allowing an approximate 1.0-vol% detection limit. That is, if crystals are present at 1.0 vol% (or greater), the diffractometer will not only be capable of detecting these crystals, but will also allow a qualitative measure of cystal content and type. Otherwise, a characteristic high background devoid of crystalline spectral lines indicates that the glass product is amorphous.

As well as confirming observations of homogeneity, analytical techniques were also used to characterize unique features or microstructures observed in select SPA glasses. Analytical techniques used to characterize these features included XRD, scanning electron microscope (SEM) with energy dispersive spectroscopy (EDS), and inductively coupled plasma-atomic emission spectroscopy (ICP-AES) analysis.

(a) In this report, a glass is considered to be homogeneous (single-phased or amorphous) if the analytical techniques being used do not detect secondary phases that may have resulted from devitrification, undissolved solids from incomplete melting, and/or the formation of a salt layer. There was not a formal analysis for the presence of amorphous (glass-in-glass) phase separation. Visual observations of homogeneity are documented in WSRC-NB-2001-00055.

Table 1a. Targeted Oxide/Anion Compositions (in mass%) for the Major Components of the SPA Glasses

	Al_2O_3	B_2O_3	Bi_2O_3	CaO	CdO	Cr_2O_3	F	Fe_2O_3	K_2O	Li_2O	MnO	Na_2O	NiO	P_2O_5	SiO_2	SrO	ThO_2	TiO_2	U_3O_8	ZnO	ZrO_2	Others[(a)]
SPA-01	7.65	15.05	7.00	0.00	0.00	0.70	0.00	10.31	3.15	0.15	5.01	11.70	1.26	0.00	35.66	0.00	0.00	0.00	0.00	0.86	0.00	1.50
SPA-02	14.75	12.35	0.00	0.33	2.00	0.00	2.00	13.24	5.56	0.00	3.67	10.94	0.30	2.17	29.24	0.00	0.00	1.21	0.00	0.74	0.00	1.50
SPA-03	15.00	11.39	4.20	0.00	0.00	0.00	2.00	12.13	0.00	2.92	0.00	13.43	0.49	0.00	36.94	0.00	0.00	0.00	0.00	0.00	0.00	1.50
SPA-04	9.28	10.19	1.60	0.00	0.00	0.00	0.00	15.14	6.00	0.00	0.00	12.15	0.30	2.50	33.25	4.00	0.00	2.09	0.00	2.00	0.00	1.50
SPA-05	5.41	19.04	0.00	3.00	0.00	0.21	2.00	3.00	4.99	0.00	6.00	10.00	2.47	2.50	28.20	4.00	0.00	0.00	0.00	0.00	7.68	1.50
SPA-06	7.02	7.03	7.00	3.00	2.00	0.09	2.00	4.67	6.00	4.97	0.00	10.00	0.30	2.50	29.80	4.00	0.00	0.12	0.00	0.00	8.00	1.50
SPA-07	12.81	15.11	0.00	3.00	2.00	1.20	2.00	9.17	0.03	3.97	1.89	14.58	0.30	0.00	28.37	0.61	0.00	0.00	0.00	2.00	1.46	1.50
SPA-08	6.76	16.90	7.00	3.00	2.00	0.00	0.00	4.50	0.32	3.33	6.00	10.00	0.30	2.50	28.01	0.00	0.00	3.05	0.00	2.00	2.83	1.50
SPA-09	10.00	8.72	0.00	2.00	0.00	0.80	0.50	12.59	1.50	4.50	3.00	13.79	0.50	1.25	34.35	2.00	0.00	2.00	0.00	0.00	1.00	1.50
SPA-10	10.00	5.00	5.00	0.00	0.00	0.80	0.50	13.73	3.27	3.27	1.87	13.76	0.50	1.25	38.33	0.22	0.00	0.00	0.00	0.00	1.00	1.50
SPA-11	10.00	8.25	4.91	0.00	0.00	0.30	1.50	13.45	1.50	1.85	3.00	12.81	0.50	0.50	36.93	0.00	0.00	0.00	0.00	2.00	1.00	1.50
SPA-12	10.00	8.14	0.00	2.00	0.00	0.80	1.50	10.96	1.50	2.55	2.67	15.98	1.71	0.50	37.69	0.00	0.00	1.50	0.00	0.00	1.00	1.50
SPA-13	10.00	9.53	0.00	0.00	0.00	0.80	1.50	11.67	1.50	4.28	2.44	15.64	1.59	1.22	35.84	0.00	0.00	1.49	0.00	0.00	1.00	1.50
SPA-14	6.00	5.00	0.00	2.00	0.00	0.30	1.50	14.00	1.50	4.50	3.00	16.81	2.00	1.25	34.00	0.00	0.00	2.00	0.00	2.00	2.64	1.50
SPA-15	10.00	5.00	5.00	0.00	1.00	0.77	1.50	14.00	2.26	4.50	3.00	14.72	0.50	1.25	34.00	0.00	0.00	0.00	0.00	0.00	1.00	1.50
SPA-16	6.00	5.00	5.00	0.00	1.00	0.80	1.50	7.00	1.50	1.50	3.00	14.80	1.33	1.25	45.99	1.83	0.00	0.00	0.00	0.00	1.00	1.50
SPA-17	6.00	11.69	0.00	0.00	1.00	0.30	1.50	7.44	4.50	1.50	1.00	16.47	2.00	0.50	37.60	0.00	0.00	2.00	0.00	2.00	3.00	1.50
SPA-18	6.00	8.18	0.00	2.00	0.00	0.30	1.50	14.00	3.89	3.79	1.00	15.89	0.50	0.50	35.54	1.42	0.00	0.00	0.00	0.99	3.00	1.50
SPA-19	8.82	6.57	3.82	1.64	0.00	0.30	1.50	7.32	1.50	4.50	3.00	17.08	1.50	0.50	36.81	0.84	0.00	0.00	0.00	1.80	1.00	1.50
SPA-20	10.00	5.00	0.20	2.00	1.00	0.80	1.50	8.46	4.50	4.50	3.00	12.93	0.50	0.50	36.61	2.00	0.00	2.00	0.00	0.00	3.00	1.50
SPA-21	6.90	6.73	5.00	2.00	1.00	0.75	0.50	9.91	4.50	1.60	3.00	12.50	0.50	0.50	38.35	0.00	0.00	0.00	0.00	2.00	2.76	1.50
SPA-22	6.00	9.71	2.86	0.00	1.00	0.30	1.50	7.56	4.50	3.91	1.00	15.11	1.46	0.50	39.21	0.00	0.00	0.88	0.00	0.00	3.00	1.50
SPA-23	10.00	5.00	5.00	0.00	0.00	0.80	0.50	7.00	4.50	4.50	3.00	17.50	2.00	1.25	34.45	0.00	0.00	2.00	0.00	0.00	1.00	1.50
SPA-24	10.00	5.00	5.00	2.00	0.00	0.30	0.50	8.20	4.50	4.50	1.00	17.50	0.50	0.50	34.00	0.00	0.00	2.00	0.00	0.00	3.00	1.50
SPA-25	10.00	5.00	0.00	0.00	0.00	0.57	1.50	12.37	1.50	1.50	3.00	12.74	0.50	1.25	43.57	2.00	0.00	0.00	0.00	2.00	1.00	1.50
SPA-26	10.00	7.93	0.00	2.00	0.00	0.80	1.50	7.21	4.50	4.34	1.00	16.61	0.50	0.50	34.48	2.00	0.00	1.34	0.00	0.79	3.00	1.50
SPA-27	6.42	12.00	5.00	0.00	0.00	0.80	0.50	7.00	4.50	1.50	1.00	16.44	0.50	0.50	37.34	2.00	0.00	2.00	0.00	0.00	1.00	1.50

(a) The “Others” component is comprised of several minor components (see Table 1.b).

Table 1a (Contd)

	Al_2O_3	**B_2O_3**	**Bi_2O_3**	**CaO**	**CdO**	**Cr_2O_3**	**F**	**Fe_2O_3**	**K_2O**	**Li_2O**	**MnO**	**Na_2O**	**NiO**	**P_2O_5**	**SiO_2**	**SrO**	**ThO_2**	**TiO_2**	**U_3O_8**	**ZnO**	**ZrO_2**	**Others[(a)]**
SPA-28	10.00	5.56	0.00	0.46	1.00	0.80	0.50	14.00	4.50	4.50	3.00	12.50	0.50	1.25	34.47	0.46	0.00	0.00	0.00	2.00	3.00	1.50
SPA-29	6.13	9.68	5.00	2.00	0.00	0.80	0.50	12.93	1.50	4.50	1.00	12.80	0.97	0.50	35.76	2.00	0.00	0.00	0.00	1.43	1.00	1.50
SPA-30	6.00	12.00	5.00	2.00	0.00	0.80	0.50	11.44	2.76	1.50	1.00	16.26	1.44	0.50	34.87	0.00	0.00	0.00	0.00	1.43	1.00	1.50
SPA-31	9.66	5.00	4.83	0.00	0.00	0.30	1.50	13.76	1.50	3.93	1.00	15.93	1.12	1.04	35.93	2.00	0.00	0.00	0.00	0.00	1.00	1.50
SPA-32	6.05	10.09	0.00	0.00	0.00	0.30	1.50	7.00	4.50	1.50	3.00	17.50	0.50	1.25	42.27	0.00	0.00	0.00	0.00	2.00	1.04	1.50
SPA-33	6.33	12.00	5.00	2.00	1.00	0.73	1.50	13.77	1.50	1.50	3.00	13.26	0.50	0.50	34.75	0.16	0.00	0.00	0.00	0.00	1.00	1.50
SPA-34	6.00	6.44	0.00	2.00	1.00	0.80	0.50	11.38	4.50	4.50	3.00	14.35	2.00	1.25	35.15	0.38	0.00	0.25	0.00	2.00	3.00	1.50
SPA-35	7.99	12.00	0.00	0.00	1.00	0.80	1.50	7.00	4.50	2.29	1.00	17.02	0.50	0.50	36.19	2.00	0.00	1.21	0.00	2.00	1.00	1.50
SPA-36	7.29	9.52	2.68	1.15	0.77	0.46	0.77	9.52	2.30	2.30	2.30	13.83	1.34	0.96	36.40	1.54	0.00	1.54	0.00	0.77	3.06	1.50
SPA-37	7.29	9.52	2.68	1.15	0.77	0.46	0.77	9.52	2.30	2.30	2.30	13.83	1.34	0.96	36.40	1.54	0.00	1.54	0.00	0.77	3.06	1.50
SPA-38	8.00	7.00	0.00	1.00	0.70	0.22	0.06	12.50	0.28	3.00	0.36	15.73	0.52	0.46	46.01	0.03	0.00	0.03	0.00	0.04	1.85	2.21
SPA-39	2.50	9.99	0.00	0.30	0.00	0.30	0.00	14.99	1.50	5.99	3.00	10.99	0.05	0.00	49.20	0.00	0.00	0.60	0.00	0.00	0.00	0.59
SPA-40	16.00	5.60	0.00	0.10	1.53	0.12	0.01	13.56	0.03	1.40	1.16	21.00	0.87	0.28	33.94	1.66	0.00	0.01	0.00	0.05	1.86	0.81
SPA-41	10.00	10.06	0.00	0.00	1.00	0.80	1.50	7.94	4.50	1.50	1.00	12.50	2.00	1.25	40.72	0.00	0.73	0.00	2.00	0.00	1.00	1.50
SPA-42	6.32	8.18	5.00	0.00	1.00	0.73	1.50	7.32	1.50	4.50	1.00	12.78	1.35	0.50	40.07	2.00	1.14	0.00	2.61	0.00	1.00	1.50
SPA-43	6.00	5.00	0.00	0.00	0.00	0.80	0.50	9.49	1.93	1.96	3.00	15.47	0.50	1.25	34.00	2.00	2.00	1.73	8.00	2.00	2.87	1.50
SPA-44	6.00	11.95	0.00	0.37	0.00	0.80	0.50	11.17	4.50	1.50	1.46	17.50	0.50	1.25	34.00	0.00	2.00	0.00	2.00	0.00	3.00	1.50
SPA-45	6.69	5.00	5.00	2.00	1.00	0.30	1.50	7.50	1.50	4.37	1.00	16.39	1.66	0.50	36.73	0.00	1.91	0.78	2.00	1.67	1.00	1.50

Table 1.b. Targeted Oxide Compositions (in mass%) for the Others (minor) Component of the SPA Glasses

	Others[(a)]	**Ag_2O**	**As_2O_5**	**BaO**	**Ce_2O_3**	**Cl**	**CoO**	**Cs_2O**	**CuO**	**La_2O_3**	**MgO**	**MoO_3**	**Nd_2O_3**	**PbO**	**PdO**	**Rh_2O_3**	**RuO_2**	**Sb_2O_3**	**SeO_2**	**SO_3**	**TeO_2**	**V_2O_5**	**Y_2O_3**
SPA-01	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-02	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-03	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-04	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-05	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-06	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-07	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-08	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-09	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-10	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-11	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-12	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-13	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-14	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-15	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-16	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-17	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-18	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-19	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-20	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-21	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-22	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-23	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-24	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-25	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-26	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-27	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-28	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000

(a) Concentration (mass %) of "Others" targeted in each SPA glass.

Table 1b (Contd)

	Others[a]	Ag_2O	As_2O_5	BaO	Ce_2O_3	Cl	CoO	Cs_2O	CuO	La_2O_3	MgO	MoO_3	Nd_2O_3	PbO	PdO	Rh_2O_3	RuO_2	Sb_2O_3	SeO_2	SO_3	TeO_2	V_2O_5	Y_2O_3
SPA-29	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-30	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-31	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-32	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-33	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-34	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-35	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-36	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-37	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-38	2.209	0.070	0.000	0.303	0.067	0.010	0.081	0.000	0.030	0.272	0.600	0.010	0.182	0.172	0.000	0.030	0.030	0.070	0.090	0.192	0.000	0.000	0.000
SPA-39	0.590	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.000	0.000	0.000
SPA-40	0.814	0.022	0.000	0.046	0.082	0.057	0.005	0.000	0.005	0.352	0.137	0.000	0.024	0.031	0.006	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.017
SPA-41	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-42	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-43	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-44	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000
SPA-45	1.500	0.040	0.057	0.065	0.436	0.008	0.012	0.004	0.021	0.258	0.000	0.010	0.081	0.290	0.000	0.003	0.002	0.030	0.056	0.090	0.005	0.032	0.000

Table 2. Predicted Properties for the SPA Glasses

	T_M at 5 Pa·s	$h_{1150°C}$	Predicted T_L	T_{M1}		T_M at 5 Pa·s	$h_{1150°C}$	Predicted T_L	T_{M1}
SPA-01	1188	6.8	1159	1200	SPA-24	1005	1.3	909	1100
SPA-02	1146	4.8	1143	1150	SPA-25	1249	14.7	1218	1250
SPA-03	1121	3.6	1118	1150	SPA-26	1004	0.9	988	1100
SPA-04	1210	8.0	1074	1200	SPA-27	1072	2.4	936	1100
SPA-05	1064	1.4	1075	1100	SPA-28	1068	2.4	1165	1200
SPA-06	1019	0.8	871	1100	SPA-29	980	1.0	1128	1150
SPA-07	963	0.5	1186	1200	SPA-30	1024	1.5	1119	1150
SPA-08	959	0.9	853	1100	SPA-31	1053	1.8	1098	1150
SPA-09	1009	1.4	1143	1150	SPA-32	1096	2.7	791	1100
SPA-10	1149	4.9	1181	1200	SPA-33	1054	1.7	1146	1150
SPA-11	1152	5.1	1142	1200	SPA-34	989	1.1	1134	1150
SPA-12	1084	2.4	1231	1150	SPA-35	1030	1.3	930	1100
SPA-13	1017	1.2	1167	1150	SPA-36	1104	3.1	1112	1150
SPA-14	970	0.6	1100	1100	SPA-37	1104	3.1	1112	1150
SPA-15	1028	1.4	1132	1150	SPA-38	1191	7.0	1047	1200
SPA-16	1214	10.2	1113	1200	SPA-39	1043	2.1	893	1100
SPA-17	1070	2.0	990	1100	SPA-40	1205	7.7	1164	1200
SPA-18	988	0.8	951	1100	SPA-41	1176	6.7	1247	1250
SPA-19	1011	1.1	948	1100	SPA-42	1060	1.9	1063	1100
SPA-20	1072	2.0	1090	1150	SPA-43	1124	3.9	1120	1150
SPA-21	1175	6.4	1112	1200	SPA-44	1022	1.4	994	1100
SPA-22	1033	1.3	912	1100	SPA-45	1009	1.0	977	1100
SPA-23	1008	1.4	1062	1100					

2.2.2 Chemical Composition Analysis

To confirm that the "as-fabricated" glasses corresponded to the defined target compositions (as shown in Tables 1a and 1b), a representative sample from each SPA glass pour patty was submitted to the SRTC Mobile Laboratory (SRTC-ML) for chemical analysis. Edwards (see Appendix A) provided an analytical plan that accompanied these samples. This plan identified the cations and anions to be analyzed and the dissolution techniques (sodium peroxide [SP] fusion, lithium-metaborate [LM], and potassium hydroxide [PH] flux) to be used. Each glass was prepared in duplicate for the dissolution techniques used for cation analyses (SP and LM) and once for the dissolution technique (PH) used for anion analyses. Concentrations (as mass %) for the cations of interest were measured by ICP-AES and the anions measured by ion chromatography (IC). The analytical plan was developed in such a way as to provide the opportunity to evaluate potential sources of error for these measurements. The results were evaluated to confirm that the target glass compositions were adequately met. To assess the performance of the ICP-AES and IC over the course of these analyses and for potential bias-correction needs, glass standards were intermittently run as specified by the analytical plan.

3.0 RESULTS

3.1 HOMOGENEITY

Table 3 summarizes the melting temperatures (T_{M1} [target], T_{M2}, and T_{M3} [if applicable]) that were used to melt the SPA glasses. Target melt temperatures provided by PNNL produced glassy products in all cases with one exception: SPA-43. After 1 h at 1150°C (target T_{M1}), the batch was only partially reacted. Without removing the crucible, T_{M1} was increased to 1200°C,[(a)] and the batch was held for an additional hour. Although the 50°C increase in melt temperature improved the batch-to-glass conversion process, a foamy layer and undissolved solids were still present. Based on these observations, T_{M2} and T_{M3} were subsequently increased to 1250°C and 1300°C, respectively. The resulting product contained no undissolved solids but was characterized as having a metallic haze or coating on the pour-patty surface while the pour-patty cross section was dull brown. Final melt temperature (T_{M3} values) adjustments were also made to SPA-06, SPA-14, and SPA-42 as noted in Table 3.

Observations regarding homogeneity, color, unique characteristics, and/or deposits were documented for each SPA glass after each melt.[(b)] Appendix B summarizes the observations for each SPA glass.

Of the 45 SPA glasses, 20 were characterized as a single-phase (amorphous or homogeneous) glass based on visual observation. As examples, SPA-03, SPA-08, SPA-18, SPA-22, and SPA-39 were visually characterized as single-phase glasses. The glasses were analyzed by XRD to confirm observations, and the resulting patterns are shown in Figures 1 through 5, respectively. Each XRD pattern is characterized by a diffuse amorphous hump devoid of crystalline spectral lines, which is indicative of an amorphous (non-crystalline or homogeneous) product—confirming observations of homogeneity. If undissolved solids and/or crystallization were present in the sample in sufficient quantity, well-defined or distinct spectral lines would be observed, which could be used to identify the crystalline phase.

Of the 25 SPA glasses that were not characterized as single-phase glasses, four primary characteristics or features were observed. These defining characteristics included:

(1) Yellow deposits (presumably salt) on the interior wall of the crucible above the melt line or forming a ring around the glass at the melt line/crucible interface. This was observed in four SPA glasses: SPA-20, -23, -24, and –26.

(2) Pour patties characterized by a dull brown cross section (indicative of devitrification) with a thin glassy layer on the bottom of the pour patty where the glass was quenched on the stainless steel pour plate.

(3) Metallic (for example, silver) streaks, spots, and/or coatings on the surface of the pour patty.

(a) In Table 3, it should be noted that TM1 for SPA-43 is recorded as 1200°C instead of 1150°C.

(b) Visual observations were recorded in WSRC-NB-2001-00055. It should be noted that SPA-06, -35, and -39 were remelted by PNNL. Although visual observations of those glasses were not recorded by SRTC, samples were received by SRTC from PNNL for use in the chemical composition analysis to ensure that volatilzation did not occur during the PNNL remelt. This would also provide a solid technical basis for any composition-property models developed using these three glasses.

(4) "Swirls" as a result of two different colored "glasses." This phenomenon was only observed in SPA-06.

Each of these features is discussed in detail below. Analytical techniques used to characterize these unique features included XRD, SEM/EDS, and ICP analysis.

Table 3. Actual Melting Temperatures for the SPA Glasses

Glass	T_{M1}	T_{M2}	T_{M3}		Glass	T_{M1}	T_{M2}	T_{M3}
SPA-01	1200	1200	na		SPA-24A	1100	1100	1100
SPA-02	1150	1150	na		SPA-25	1250	1250	na
SPA-03	1150	1150	na		SPA-26A	1100	1100	1100
SPA-04	1200	1200	na		SPA-27	1100	1100	na
SPA-05	1100	1100	na		SPA-28	1200	1200	na
SPA-06	1100	1100	1150		SPA-29	1150	1150	na
SPA-07	1200	1200	na		SPA-30	1150	1150	na
SPA-08	1100	1100	na		SPA-31	1150	1150	na
SPA-09	1150	1150	na		SPA-32	1100	1100	na
SPA-10	1200	1200	na		SPA-33	1150	1150	1150
SPA-11	1200	1200	na		SPA-34	1150	1150	na
SPA-12	1150	1150	na		SPA-35	1100	1100	na
SPA-13	1150	1150	na		SPA-36	1150	1150	na
SPA-14	1100	1100	1150		SPA-37	1150	1150	na
SPA-15	1150	1150	na		SPA-38	1200	1200	na
SPA-16	1200	1200	na		SPA-39	1100	1100	na
SPA-17	1100	1100	na		SPA-40	1200	1200	na
SPA-18	1100	1100	na		SPA-41	1250	1250	na
SPA-19	1100	1100	na		SPA-42	1100	1100	1150
SPA-20A	1150	1150	1150		SPA-43	1200	1250	1300
SPA-21	1200	1200	na		SPA-44	1100	1100	na
SPA-22	1100	1100	na		SPA-45	1100	1100	na
SPA-23A	1100	1100	1100					

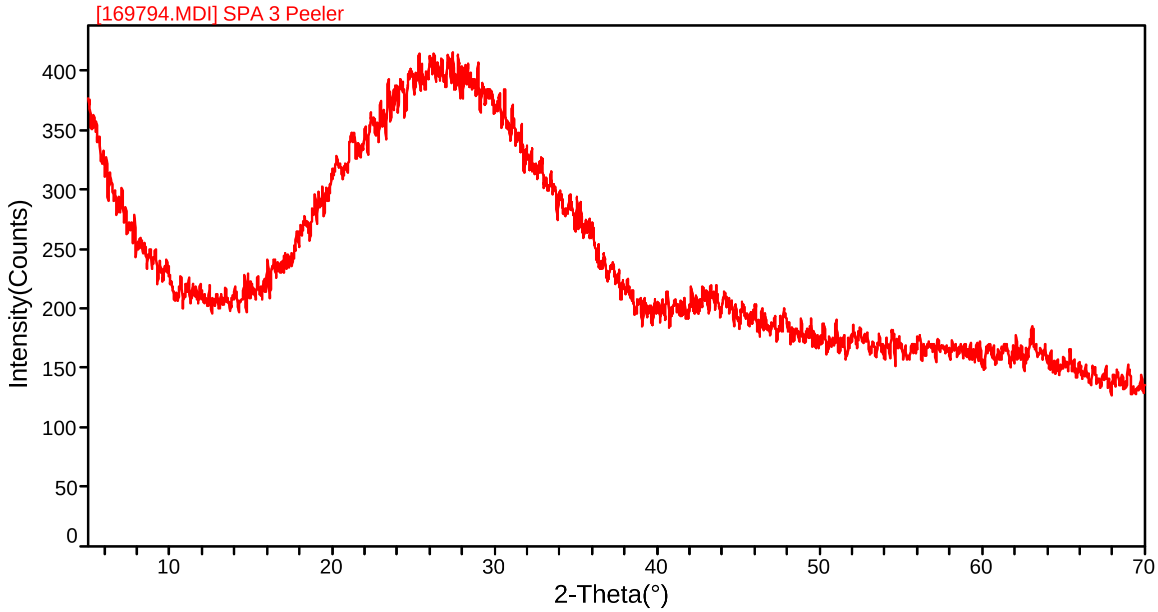


Figure 1. XRD Pattern of SPA-03

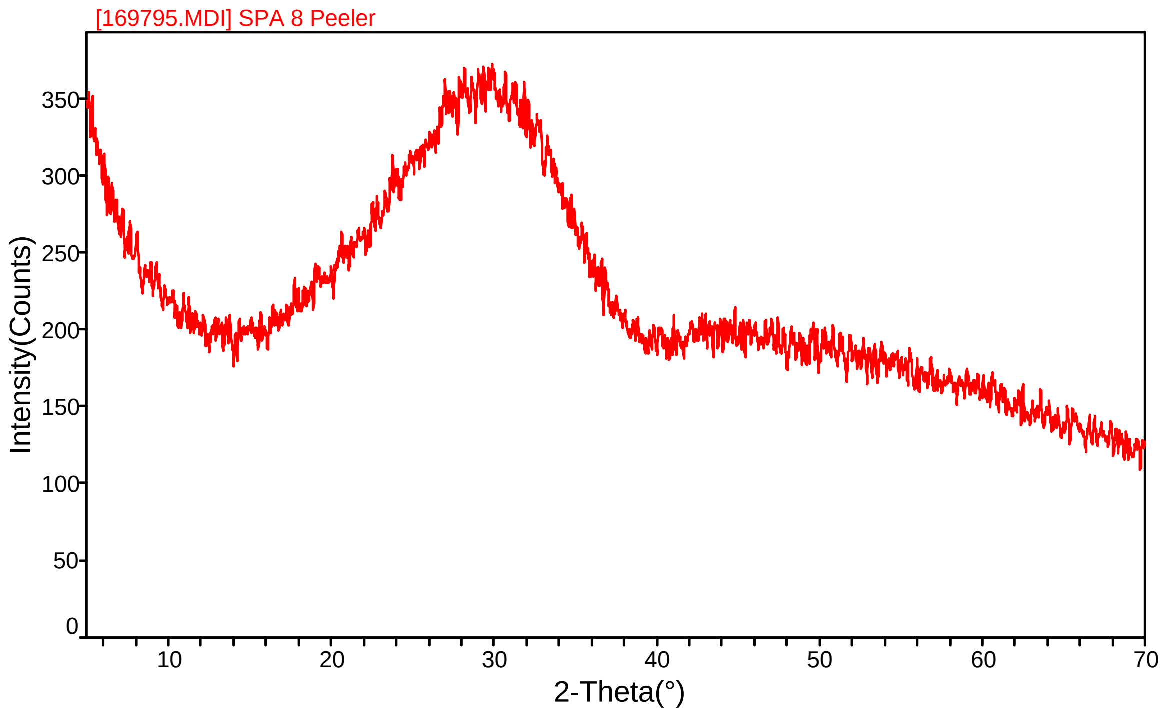


Figure 2. XRD Pattern of SPA-08

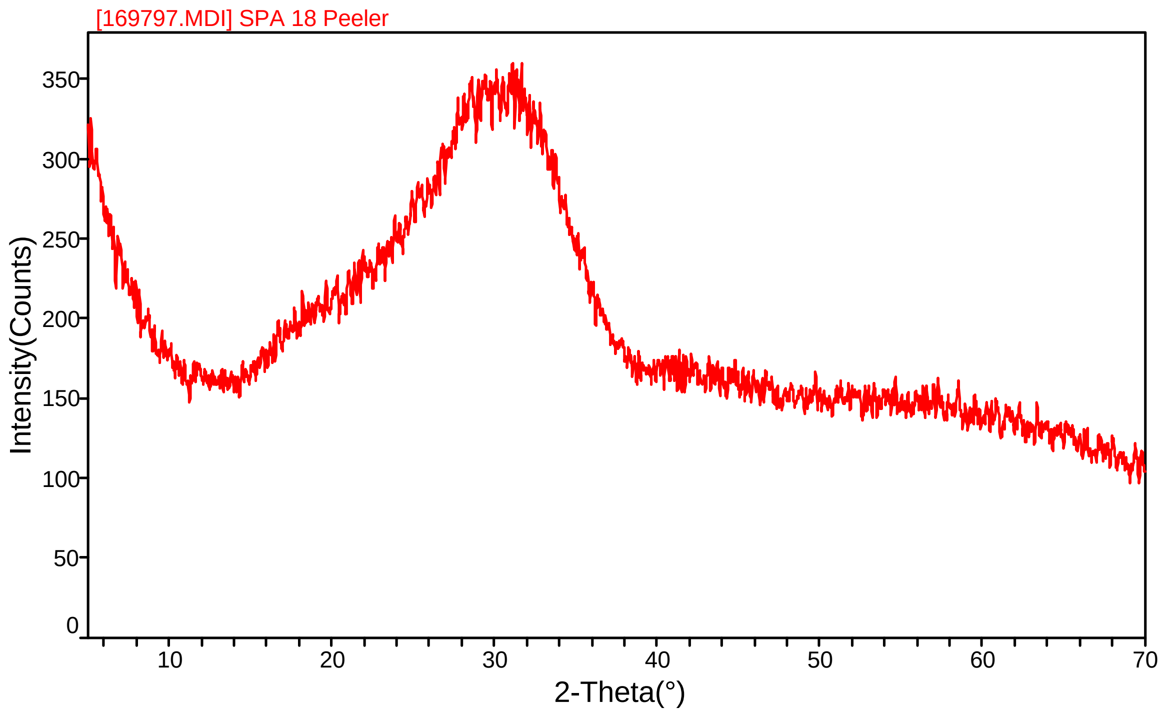


Figure 3. XRD Pattern of SPA-18

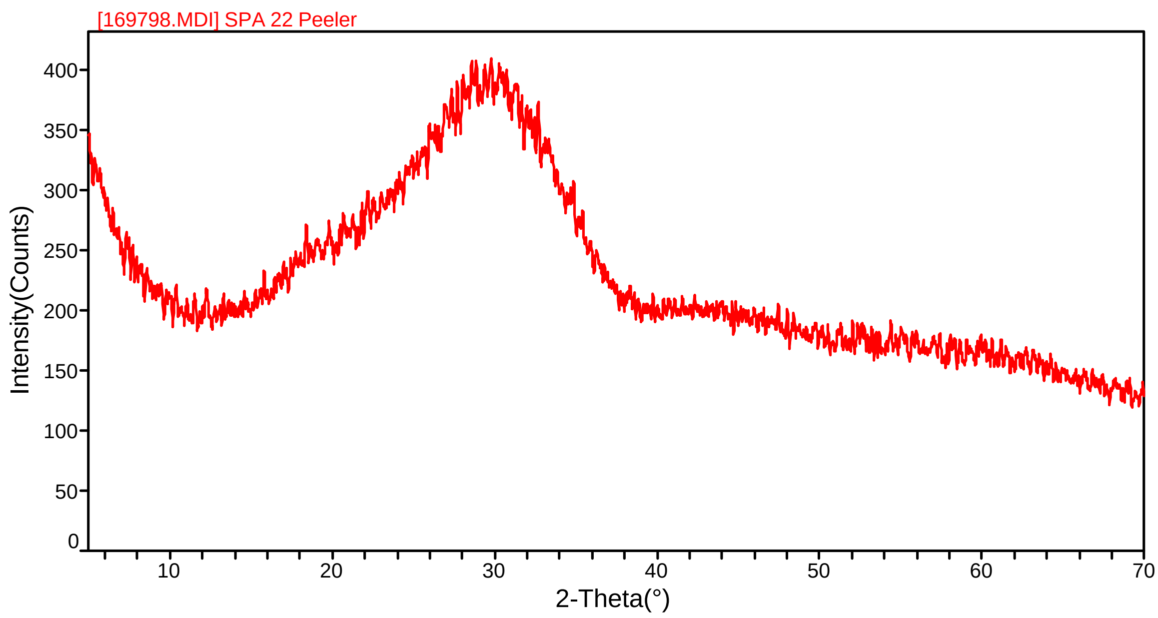


Figure 4. XRD Pattern of SPA-22

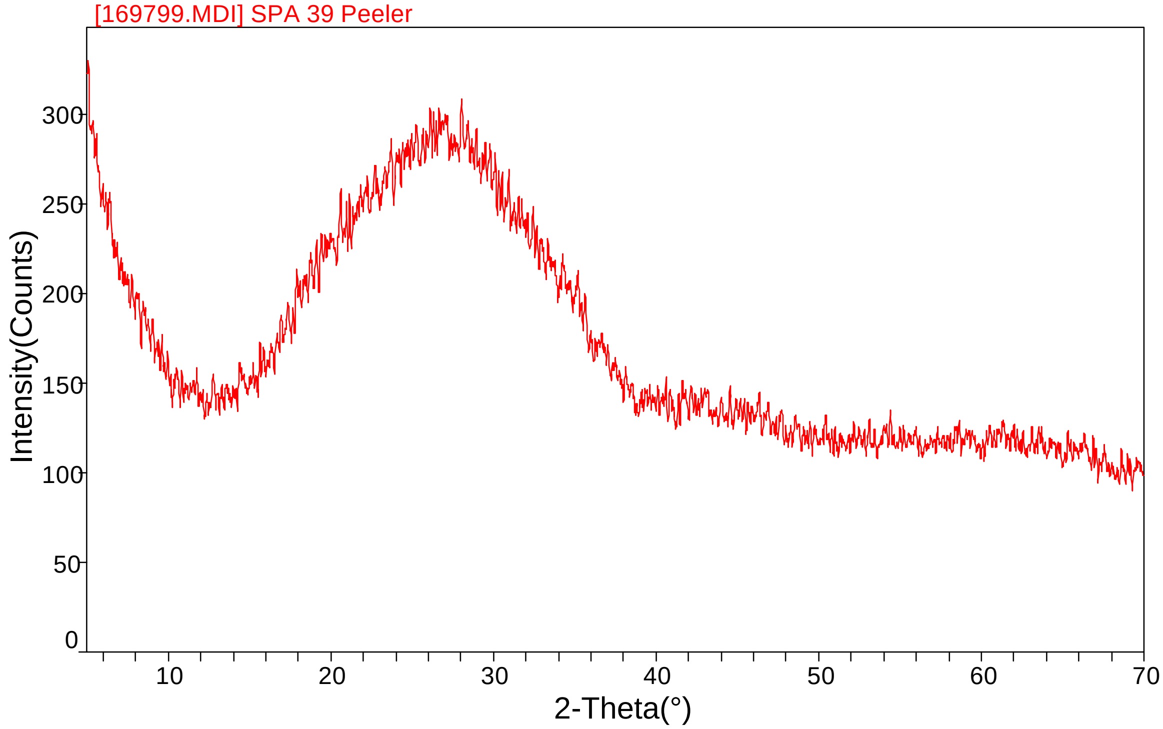


Figure 5. XRD Pattern of SPA-39

3.1.1 Yellow Deposits (Salt Formation)

After the initial melts of SPA-20, SPA-23, SPA-24, and SPA-26, a yellow deposit (presumably salt) was observed on the interior wall of the crucible above the melt line and/or forming a ring around the glass at the melt line/crucible interface. (The last four entries in Appendix B summarize the observations of the original melts of SPA-20, SPA-23, SPA-24, and SPA-26 using the standard melting procedure in which the deposits were observed.) A sample of the yellow deposit was obtained from the initial SPA-24 melt and chemically analyzed by ICP. The elemental results (in mg/L) shown in Table 4 indicate that the deposit is high in sulfur (S), chromium (Cr), and alkali (Na, potassium [K], Li, strontium [Sr])—typical of a salt layer.[a] It should be noted that 3-mL of deionized water was used to rinse the salt from the crucible, and the results shown in Table 4 have not been adjusted for this dilution.

Given that Cr_2O_3 has a significant impact on the property of interest (T_L), an alternate batching/melting technique was used to minimize the impact of salt formation. The technique (specific to these four glasses) involved batching all components (with the exception of Cr_2O_3) and performing an initial melt using standard procedures as discussed in Section 2.1. After the initial melt at T_{M1}, the pour patty and residual crucible glass were ground in the WC mill. During the grinding process, the target amount of Cr_2O_3 was added to and subsequently homogenized with the glass powder. The glass powder (including the Cr_2O_3) was then remelted at T_{M2}, ground, and remelted at T_{M3}. This technique proved successful in eliminating the formation of a visible

(a) The salt layer was not analyzed by IC; therefore, other anions may have partitioned to the salt layer. The analysis by ICP was to confirm expectations that the salt layer was sulfur based.

salt-layer and incorporating the Cr_2O_3 into the glass, thus yielding the opportunity to meet the original programmatic objectives for these glasses. It should be noted that the analysis of target versus measured compositions for these four glasses will provide further insight into the incorporation of Cr_2O_3 into the glass (see Section 3.2). The four glasses produced using the alternative melting technique are labeled as SPA-20A, SPA-23A, SPA-24A, and SPA-26A to distinguish them from the original melts in which a yellow salt layer was observed. This nomenclature is used throughout this report. Observations of these four alternative melts are included in Appendix B. The "A" glasses were analyzed for chemical composition (see Section 3.2) as these glasses were used in subsequent property measurements at PNNL.

Table 4. ICP Results (mg/L) of "Salt" Sample from SPA-24
(not corrected for 3-mL dilution)

Element	mg/L		Element	mg/L
Al	< 0.9		Mn	< 0.1
B	< 1.5		Ni	< 1.0
Bi	< 1.0		P	< 2.10
Ca	3.3		Si	< 8.0
Cd	< 0.3		Sr	5.92
Ce	< 2.9		Ti	< 0.7
Cr	1490		Zn	< 0.1
K	483		Zr	< 0.1
La	< 1.2		Na	59.7
Li	22.1		S	4.4

3.1.2 Dull Brown Cross Section with Thin Glassy Layer

One of the more common characteristics associated with the SPA glasses was the formation of a dull brown cross section in the pour patty. This layer appeared to be a result of devitrification that occurred upon slower cooling within the bulk. This latter statement is based on the fact that in all cases where a dull brown (multi-phased) cross section formed, a thin glassy layer on the bottom of the pour patty was also observed. The thin glassy layer presumably resulted from a rapid quench as the glass was poured on the stainless steel plate. SPA-11, SPA-14, and SPA-23A are examples of this general observation. A metallic haze on the pour-patty surface (see Section 3.1.3 for this discussion) also characterized SPA-14 and SPA-23A.

To characterize the cause of the dull-brown cross section appearance, a Siemens D500 XRD instrument with Bragg-Brentano optics was used to analyze the surfaces of select glasses. Analysis of the dull-brown cross section of SPA-11 is discussed below. To assess the interior section, the surface of the glass was ground in sequential steps using 220-, 320-, and 500-grit SiC paper on a Struers RotoPol-31 grinder. Once the interior was exposed, the glass was placed into a special sample mount and attached to the mount with Q-sealing compound.[a] The XRD used a copper x-ray tube (45kV, 40mA) with a scan range of 5 to 70° 2Θ in 0.02° step increments with a 1-s dwell time. The spectra were identified using search-match software, Jade 6.0, which incorporates the International Centre for Diffraction Data (ICDD) database. The resulting XRD pattern is shown in Figure 6. The dull brown inner surface of the glass matched a spinel phase with the copper manganese oxide ($CuMn_2O_4$) phase being the closest matched pattern.

(a) Q-Selaing compound—an Apiezon product. Product procured from Biddle Instruments, 510 Township Line Road, Blue Bell, Pennsylvania.

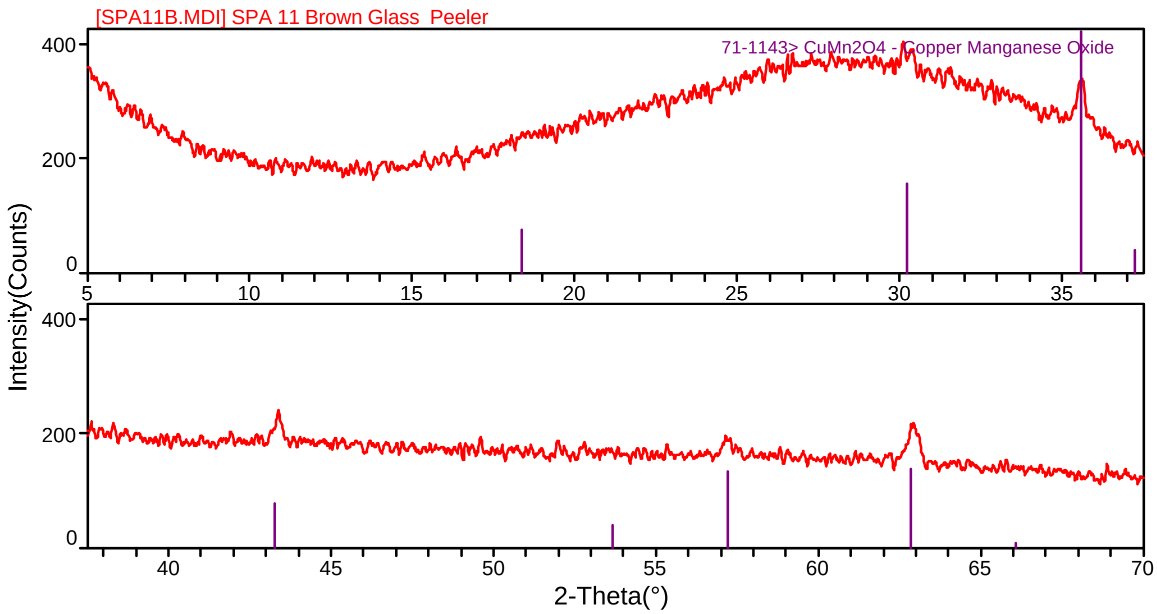


Figure 6. XRD Pattern of Dull Brown Cross Section of SPA-11

SPA-14 and SPA-23A were also characterized by the dull-brown cross section.[a] SEM with EDS was used to characterize both glasses. Figure 7 shows a SEM micrograph (58x—relatively low magnification) of SPA-14's cross section. The section of glass labeled "dark brown edge" is actually the thin glassy layer (or bottom or the pour patty) resulting from the rapid quench. As one moves from the outer edge (or bottom) of the pour patty to the interior (or bulk), crystallization becomes more predominant or concentrated in terms of volume. (Although not obvious from the SEM micrograph, the glassy layer is almost of consistent thickness, which then transitions into a glass matrix containing embedded crystals). A higher magnification micrograph (870x) of the bulk cross section is shown in Figure 8. EDS analysis (Figure 9) of these crystals indicates high concentrations of iron (Fe), nickel (Ni), manganese (Mn), and Cr—indicative of spinel-type crystals commonly observed in waste glasses. Spinel-type structures were identified by XRD in SPA-11's cross section (see Figure 6). Observations of SPA-14's cross section at higher magnifications show a more dense concentration of small crystals (see Figure 10—5.58 kX). EDS analysis was unable to differentiate compositional differences between the glass matrix and crystals given the small crystal size. It is hypothesized that the high density or concentration of crystals in the bulk imparts the dull-brown appearance to the cross section of select SPA glasses.

(a) SPA-14 and SPA-23A were also characterized by a metallic haze or coating on the surface of the pour patty. This feature is discussed in Section 3.1.3.

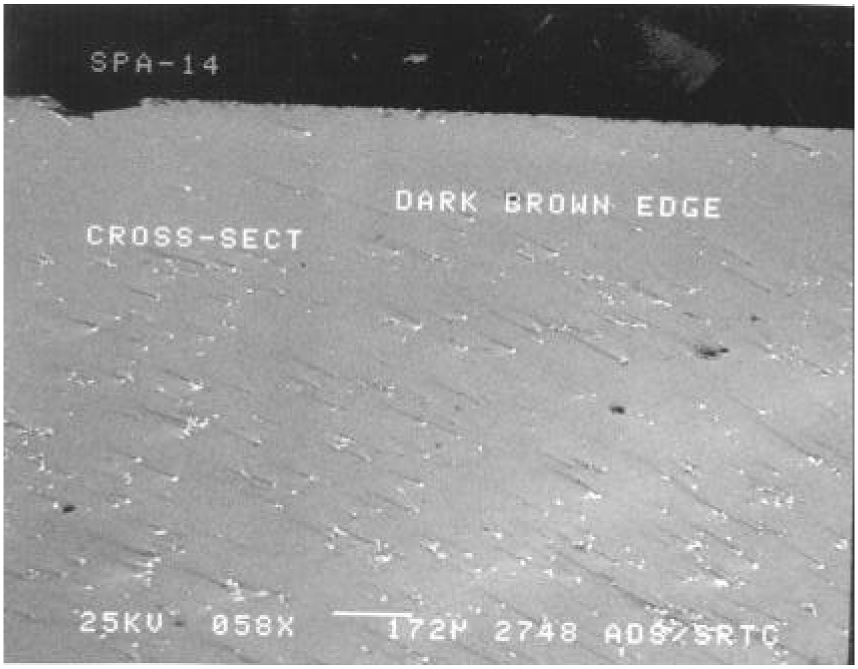


Figure 7. Cross Sectional View of SPA-14

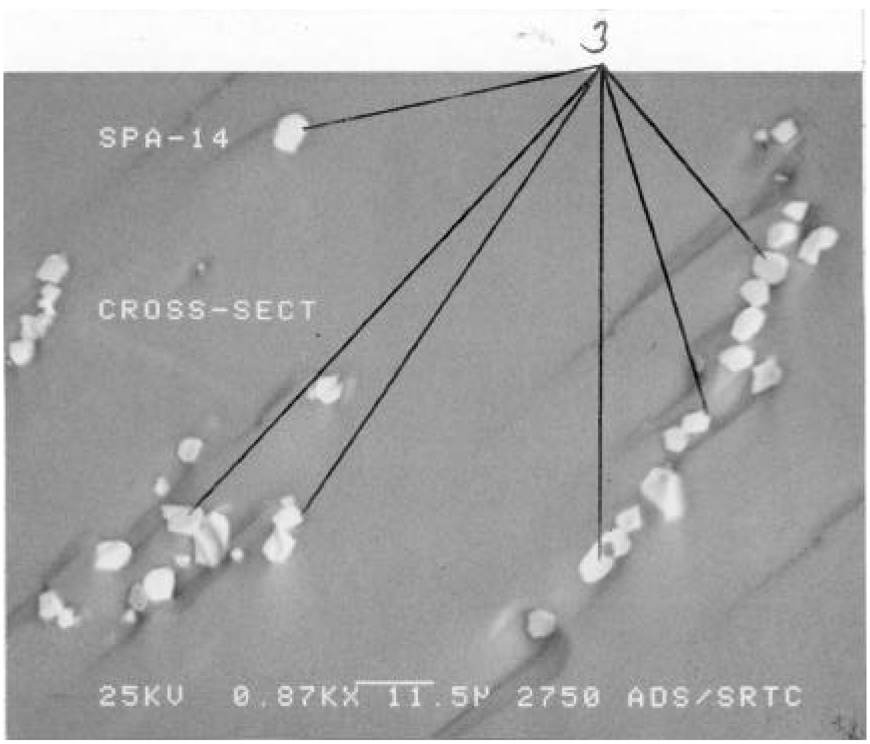
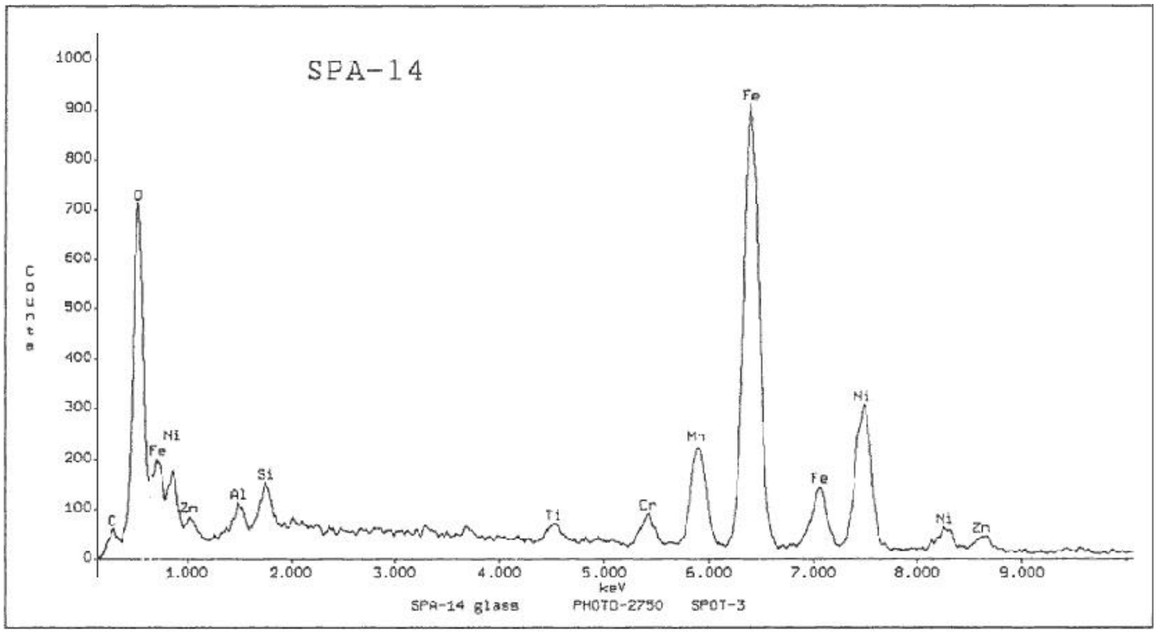


Figure 8. Crystals Associated with SPA-14 Cross Section



SPA-14 glass PHOTO-2750 SPOT-3

Figure 9. EDS Analysis of the Crystal in SPA-14 Cross Section (Spot 3 in Figure 8)

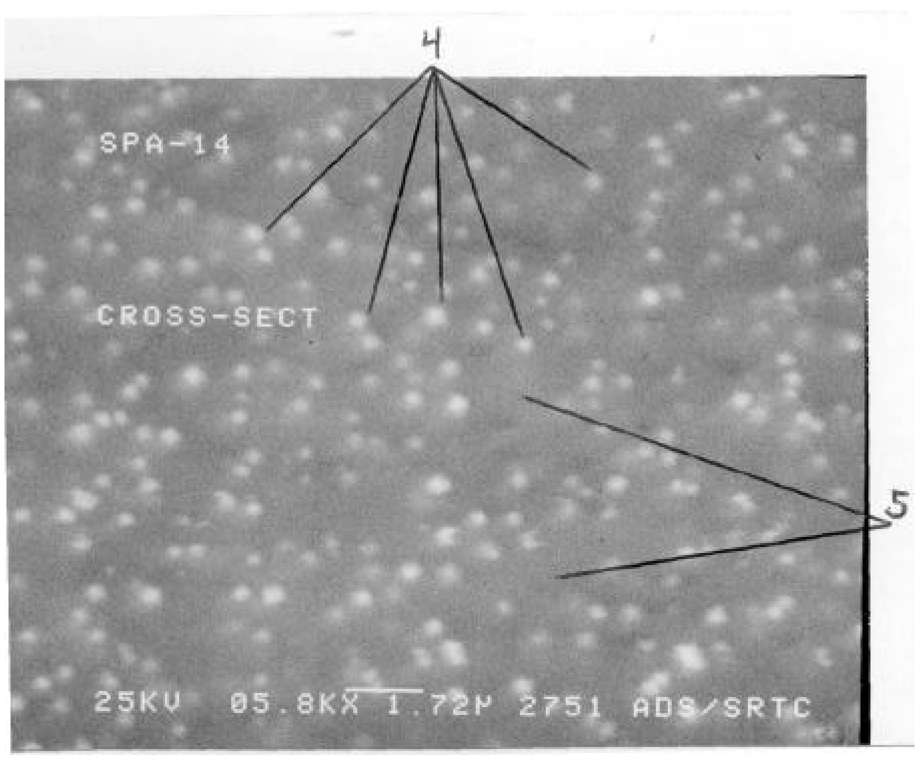


Figure 10. Crystals Densely Populating SPA-14's Cross Section

SPA-23A was also characterized by the dull brown cross section. Figure 11 shows the thin glassy layer (labeled dark brown edge—actually the bottom of the pour patty) and the cross section. Unlike SPA-14, crystals are not readily observed in the cross section at this lower magnification (see Figure 7 for a comparison to SPA-14). However, at higher magnification (3.3 kX), small and relatively densely populated crystals can be observed leading to the dull-brown cross-section appearance (see Figure 12). EDS analysis of the crystals (Figure 13) relative to the glass matrix (Figure 14) indicates a higher concentration of Ni. Relative concentration differences in Fe and Mn between the crystal and glass matrix are not discernable—although the small crystal size makes differential EDS analysis extremely complex.

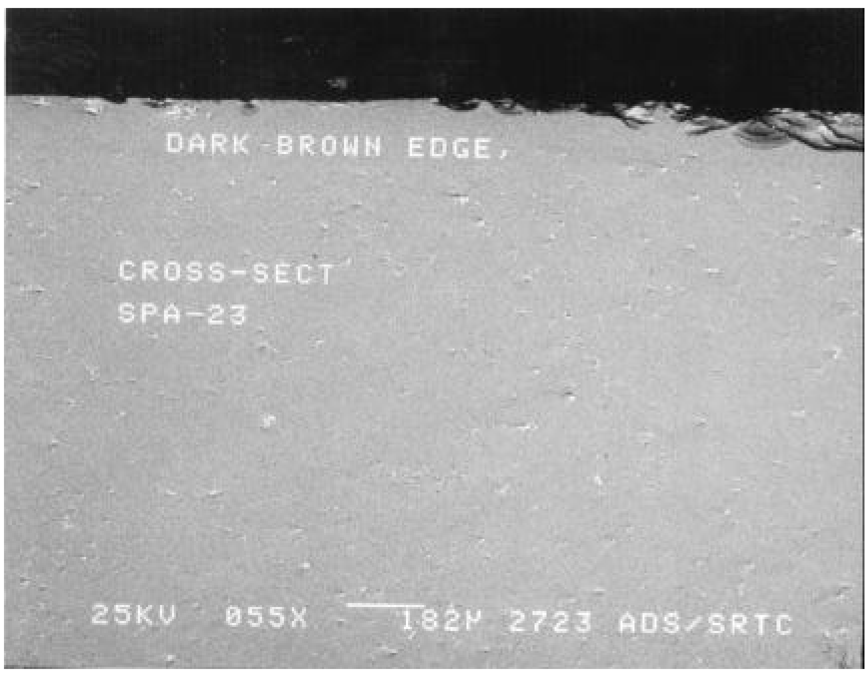


Figure 11. Cross Sectional View of SPA-23A

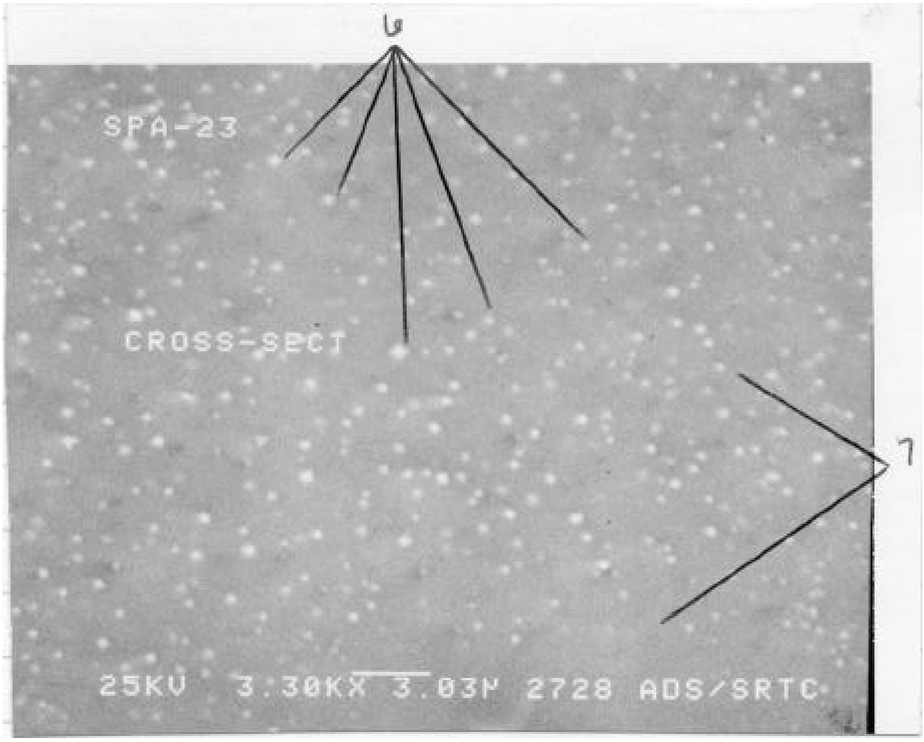
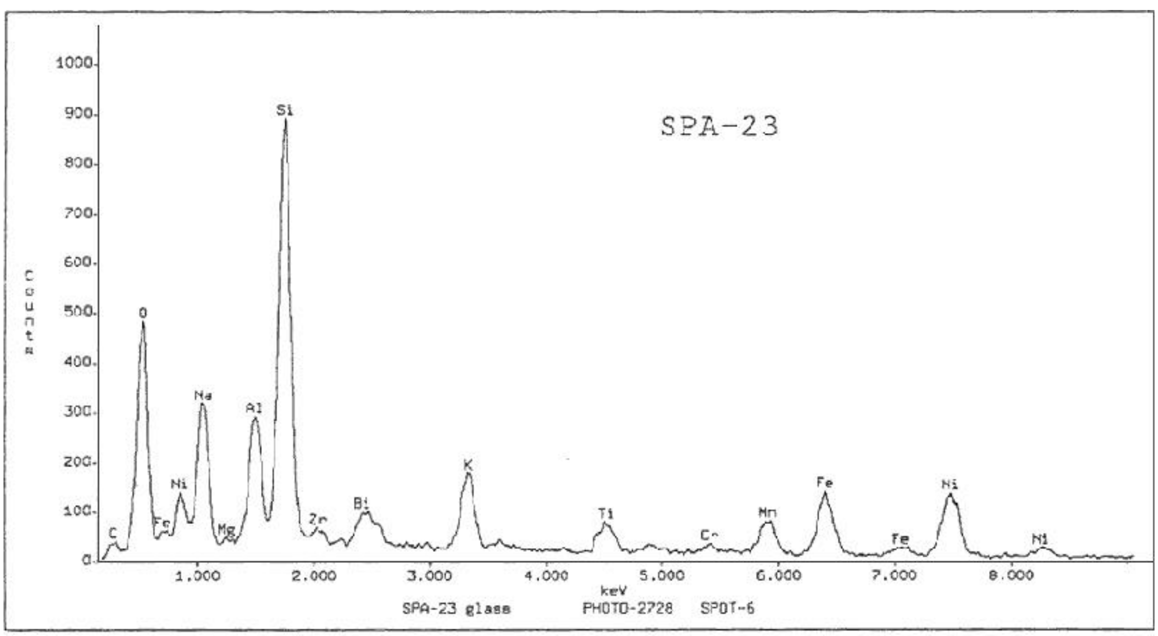
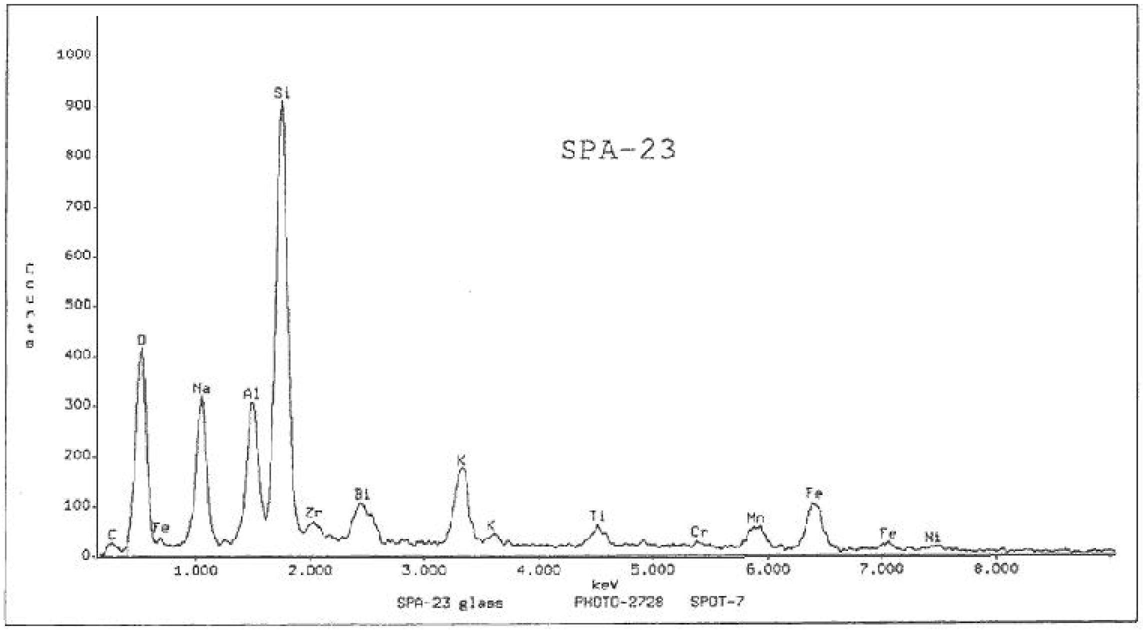


Figure 12. Higher Magnification of SPA-23A's Cross Section



SPA-23 glass PHOTO-2728 SPOT-6

Figure 13. EDS Analysis of SPA-23A Cross Section Crystals (Spot 6 in Figure 12)



SPA-23 glass PHOTO-2728 SPOT-7

Figure 14. EDS Analysis of SPA-23A Cross Section Residual Glass Matrix (Spot 7 in Figure 12)

As noted in Appendix B, SPA-24A and SPA-26A (glasses melting using the alternative technique) produced single-phase glasses after the initial melt (Cr_2O_3 absence). Upon adding Cr_2O_3 to the prefabricated glass and remelting at T_{M2}, a dull brown cross section and a metallic haze coating the surface characterized the resulting pour patty. This suggests that the presence of Cr_2O_3 in the glass induced the formation of these features. However, it should be noted that SPA-02 (target 0% Cr_2O_3) also formed a dull-brown cross section, indicating that Cr_2O_3 is not a prerequisite.

3.1.3 Metallic Streaks, Spots, Coatings, and/or Haze

Metallic streaks, spots, coatings, or haze on the top surface of the pour patty characterized several of the SPA glasses (see Appendix B for more detailed descriptions). Four glasses (SPA-14, -23A, -19, and -21) were further characterized to determine microstructural changes that could impart this particular feature. A metallic haze on the glass surface characterized SPA-14 and SPA-23A. SPA-19 was characterized by a “mirror-like” or “metallic coating” on the surface. Metallic streaks and large metallic spots on the pour-patty surface characterized SPA-21.

Figure 15 shows a SEM micrograph of a representative portion of SPA-14’s surface. One large crystal is evident near the center of the micrograph, but a large volume fraction of smaller crystals is also present. Figure 16 is a higher magnification micrograph centered on the single large crystal as shown in Figure 15 where it is obvious that morphology differences exist between the two crystal types. The morphology of the large crystal is similar to spinels observed by Hrma et al. (1997) that were separated from a HLW glass (see Figure 17). EDS analysis of the large

(Figure 18) indicates higher concentrations of Fe, Mn, Ni, and Cr relative to the glass matrix (Figure 19).

The morphology of the small, more densely populated crystals are also similar to crystals observed and described by Hrma et al. (1997) as "star-shaped". The relative small size of these crystals (< 1 μm) support a hypothesis that these crystals formed upon cooling (i.e., precipitated during quenching the glass on the stainless plate) and presumably led to the metallic appearance on the surface of SPA-14. EDS analysis of the smaller "star-shaped" crystals is shown in Figure 20. These crystals are enriched in Fe, Mn, and Ni relative to the glass matrix – note Cr is absence from these crystals as well as the glass matrix. The lack of Cr_2O_3 from these smaller crystals may be attributred to the unavailability of Cr_2O_3 as it may have been consumed by the formation of the larger crystals.

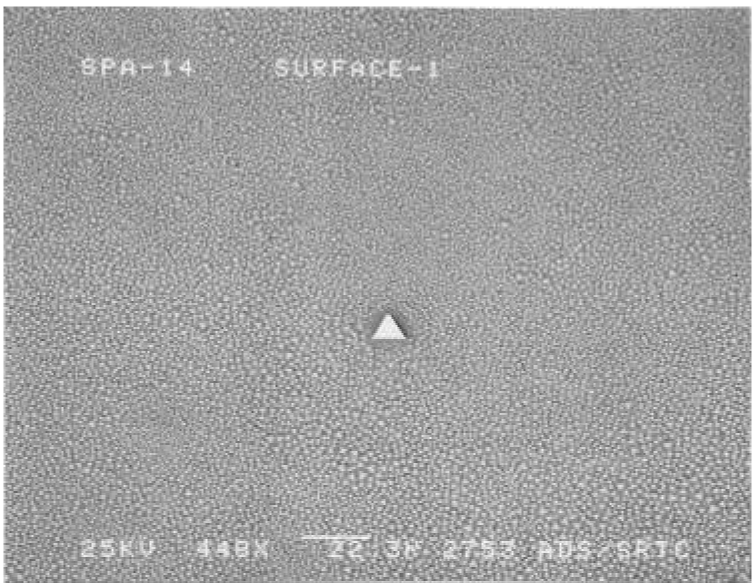


Figure 15. SEM Micrograph of the Metallic Haze Characterizing the Surface of SPA-14

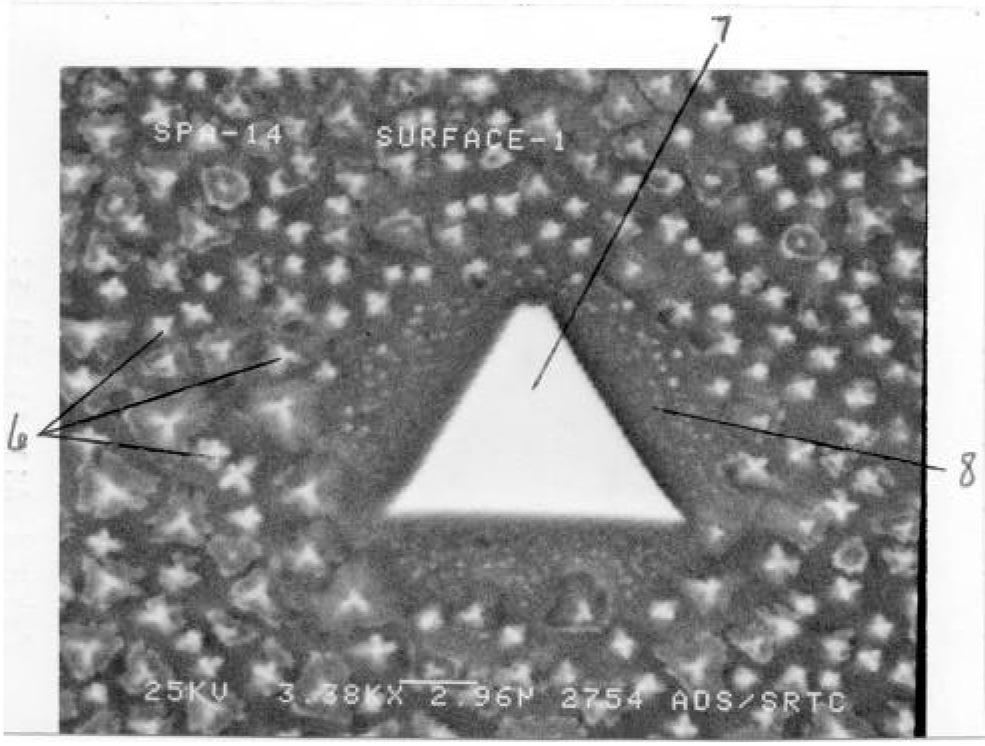


Figure 16. High Magnification SEM Micrograph of the SPA-14's Surface

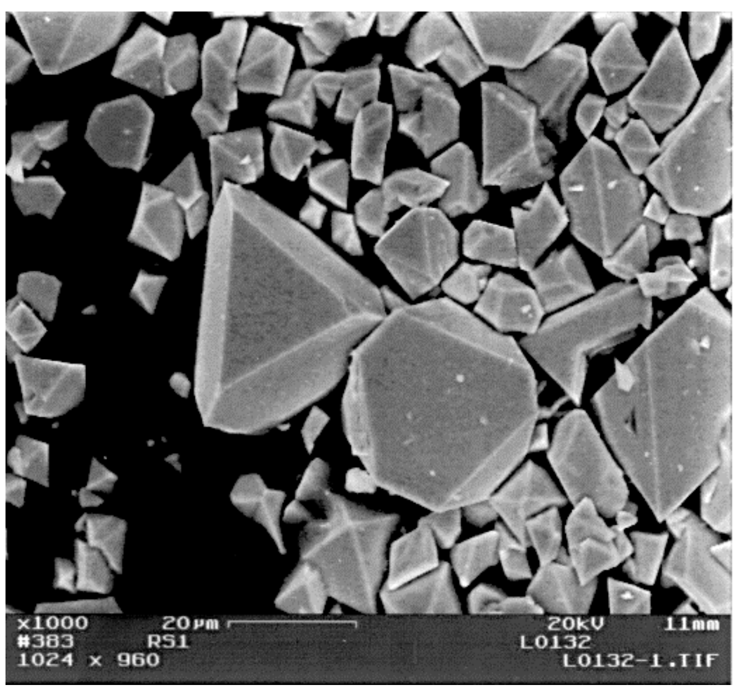
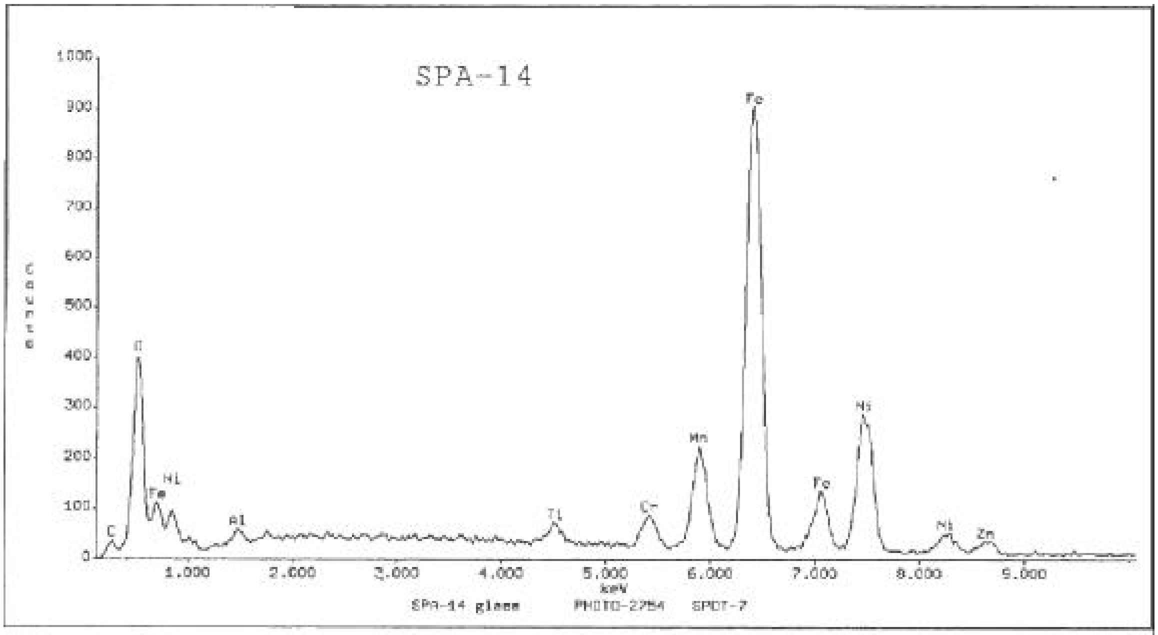


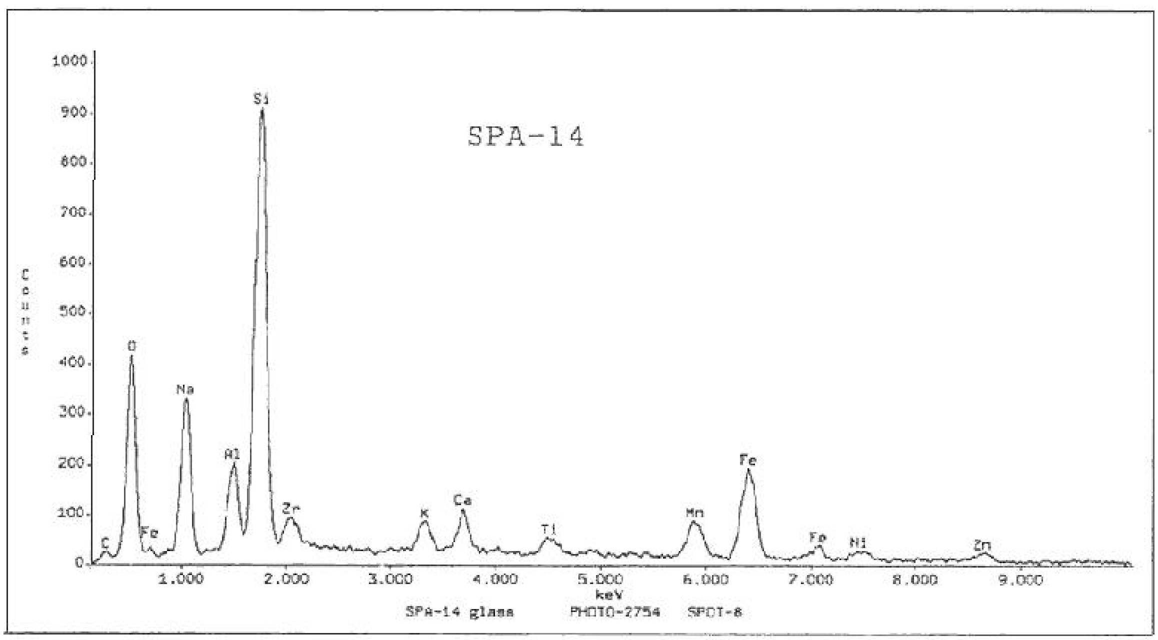
Figure 17. Spinel Crystals Separated from a HLW Glass (SEM)

(from Hrma et al. 1997)



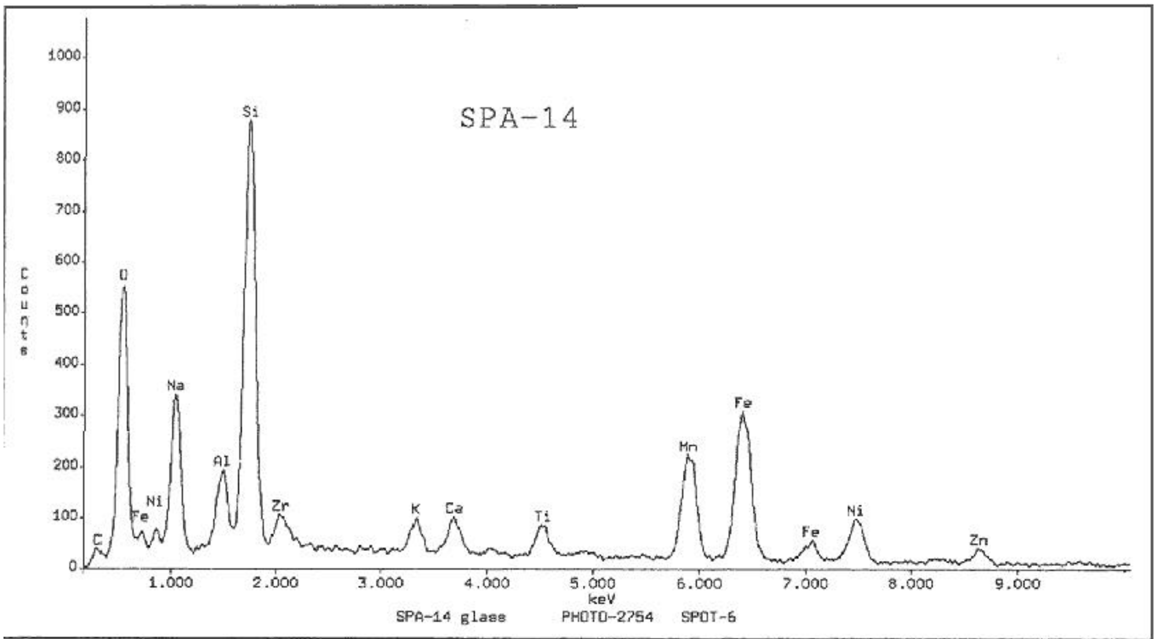
SPA-14 glass PHOTO-2754 SPOT-7

Figure 18. EDS Analysis of the "Large" Surface Crystal (Spot 7 in Figure 16)



SPA-14 glass PHOTO-2754 SPOT-8

Figure 19. EDS Analysis of the Glass Matrix (Spot 8 in Figure 16)



SPA-14 glass PHOTO-2754 SPOT-6

Figure 20. EDS Analysis of the Smaller, More Densely Populated Surface Crystals (Spot 6 in Figure 16)

Small, densely populated crystals also characterized the top surface of SPA-23A (see Figures 21 and 22). EDS analysis of the crystals (Figure 23) relative to the glass matrix (Figure 24) indicates higher concentrations of Mn, Fe, and Ni – similar to the EDS analysis of SPA-14. It should be noted that similar Cr_2O_3 peak intensities are observed in the EDS spectra associated with the crystal(s) and glass matrix – no determination can be made on selective partitioning.

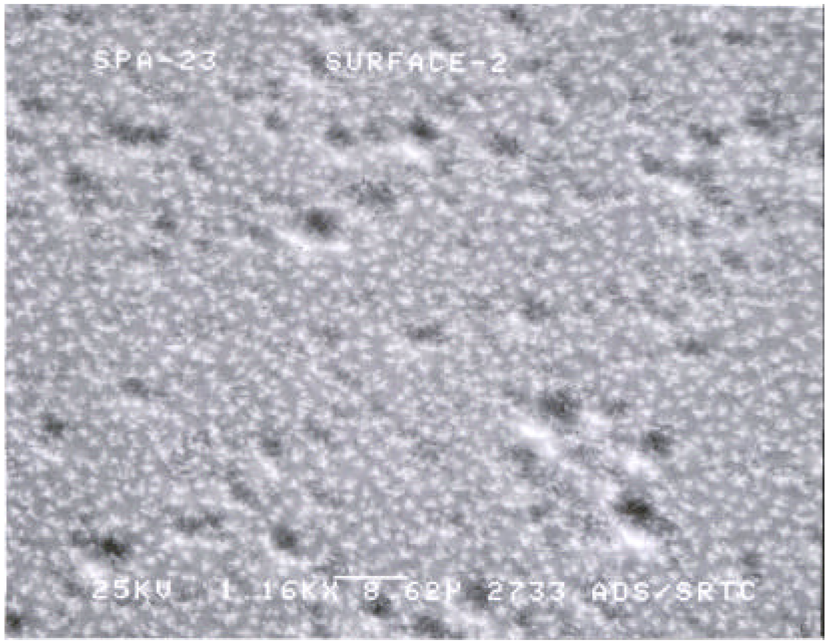


Figure 21. Crystals Densely Populating the Surface of SPA-23A

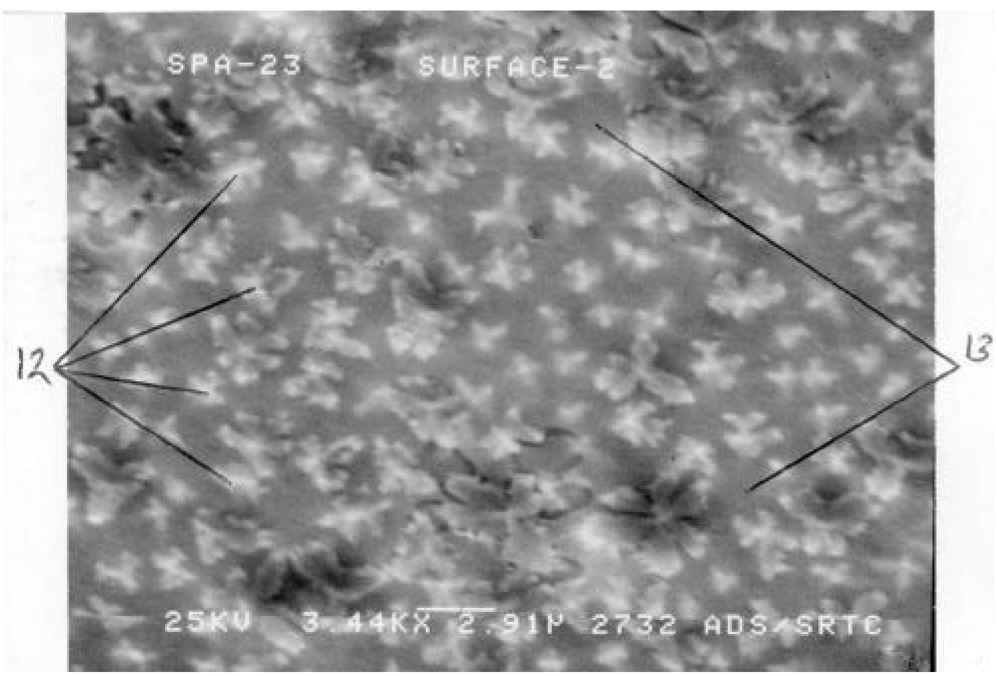
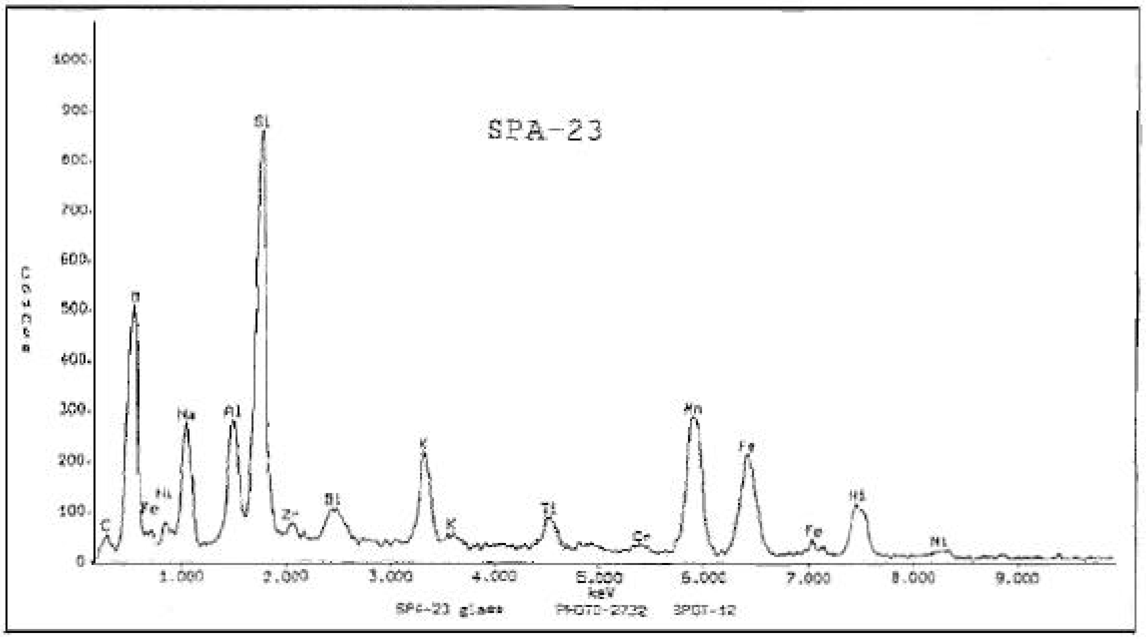
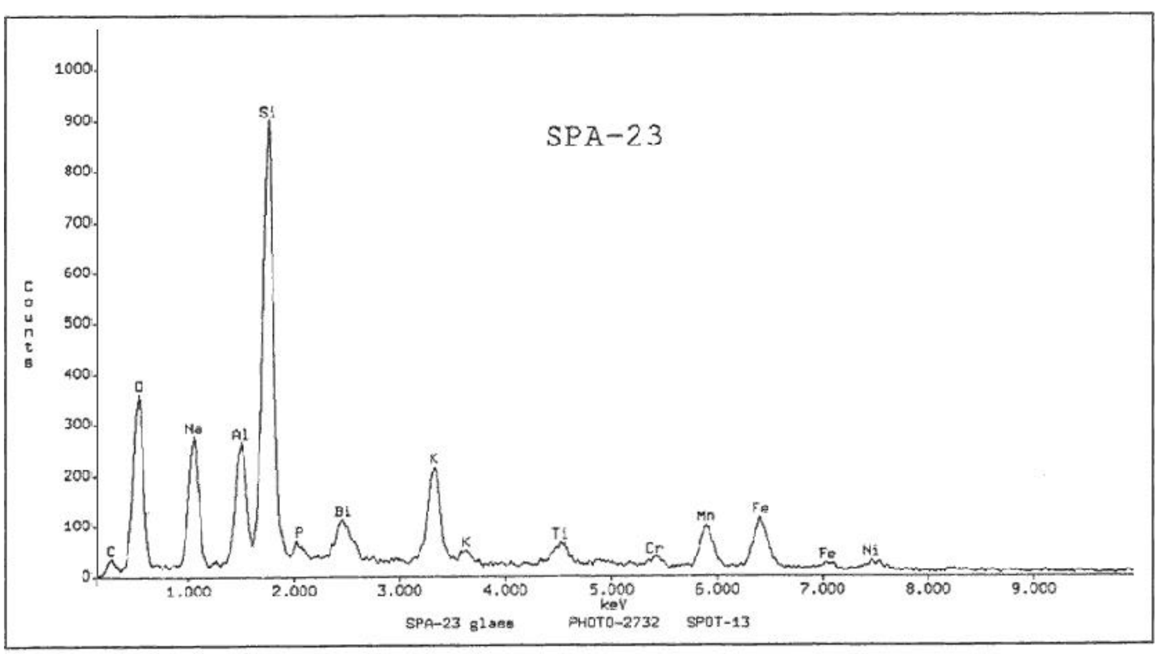


Figure 22. High Magnification of SPA-23A's Surface



SPA-23 glass PHOTO-2732 SPOT-12

Figure 23. EDS Analysis of SPA-23A Surface Crystals (Spot 12 in Figure 22)



SPA-23 glass PHOTO-2732 SPOT-13

Figure 24. EDS Analysis of Residual Glass Matrix on SPA-23A's Surface
(Spot 13 in Figure 22)

The metallic surface of SPA-23A was also analyzed by XRD. The resulting patterns are shown in Figures 25 and 26 and are characterized by two primary features:

(1) distinct (sharp) spectra lines associated with crystallization. The ICDD database identified the crystals as either nickel titanium oxide ($Ni_{2.44}Ti_{0.77}O_4$—Figure 25) or copper manganese oxide ($CuMn_2O_4$—Figure 26) as both patterns fit well—both are spinel-type structures. It should be noted that the peak shifts from the reference pattern are likely due to lattice substitutions.

(2) the lack of a well-defined diffuse amorphous hump associated with a glassy phase (or host glass matrix in which the crystals are embedded). This latter statement indicates that the volume fraction of crystals is quite high with a minimal residual glass matrix.

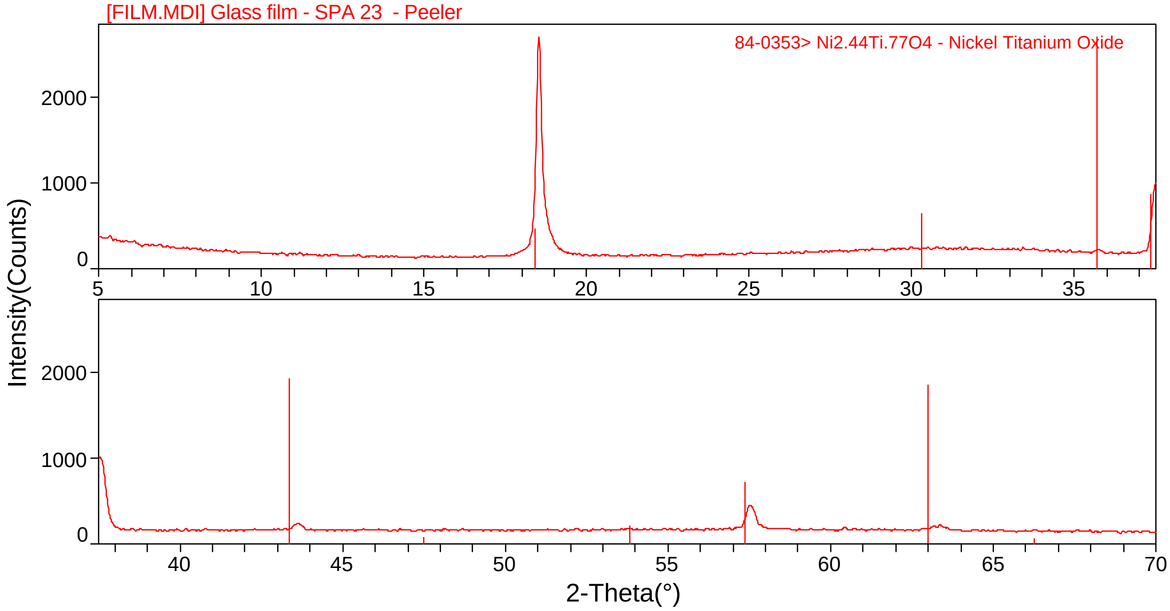


Figure 25. XRD Analysis of SPA-21's Metallic Surface ($Ni_{2.44}Ti_{0.77}O_4$)

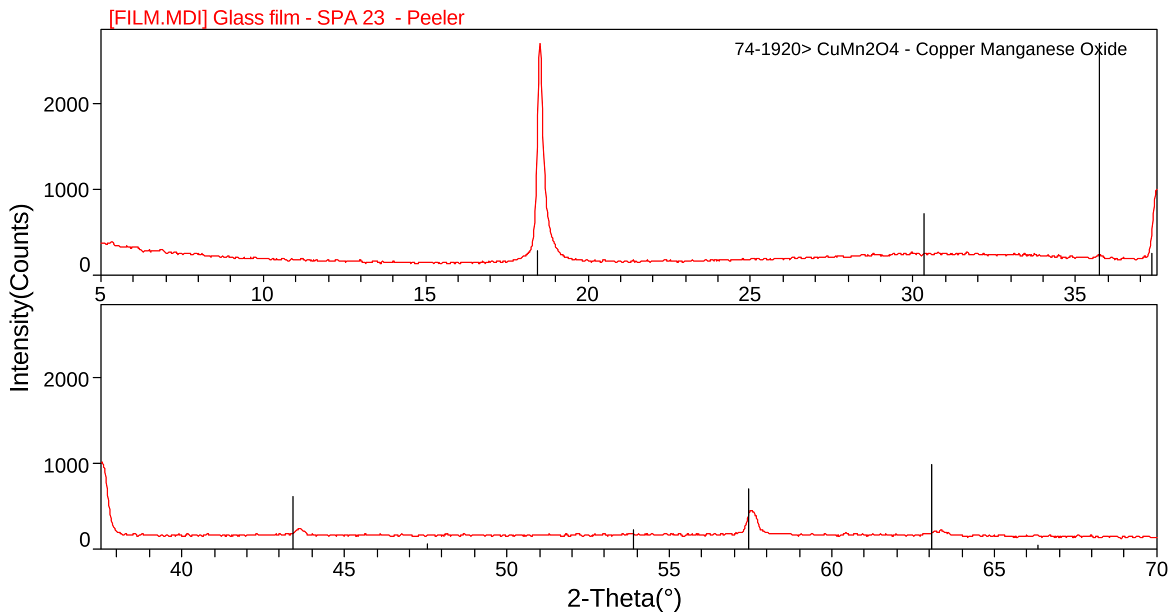


Figure 26. XRD Analysis of SPA-21's Metallic Surface ($CuMn_2O_4$)

A "metallic coating" or "almost mirror-like" surface characterized SPA-19 (see Appendix B for a more detailed description). SEM/EDS analyses of this glass are shown in Figures 27 through 31. At lower magnification (refer to Figure 27), the surface of SPA-19 appears to be single phased. However, analysis at higher magnifications reveals the small densely populated crystals (see Figures 28 and 29). EDS analysis (from the microstructure shown in Figure 29) indicates a higher concentration of Mn, Ni, and Fe in the crystal (Figure 30) relative to the residual glass matrix (Figure 31). It should be noted that Ni is not observed in the EDS spectra of the residual glass phase.

Figure 27. SEM Micrograph of the "Mirror-Like" Surface of SPA-19

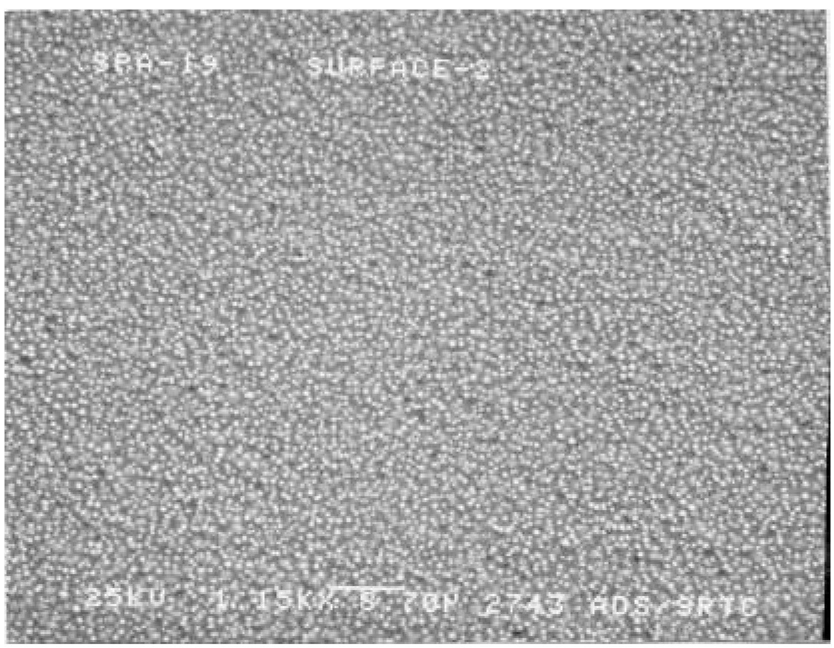


Figure 28. SEM Micrograph of the SPA-19's Metallic Surface

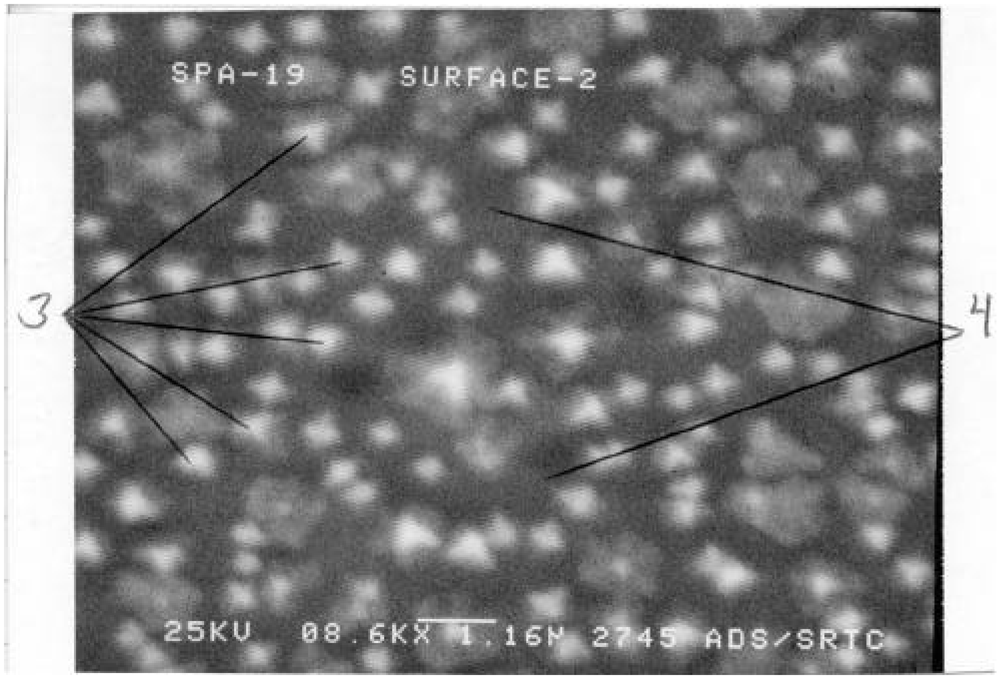
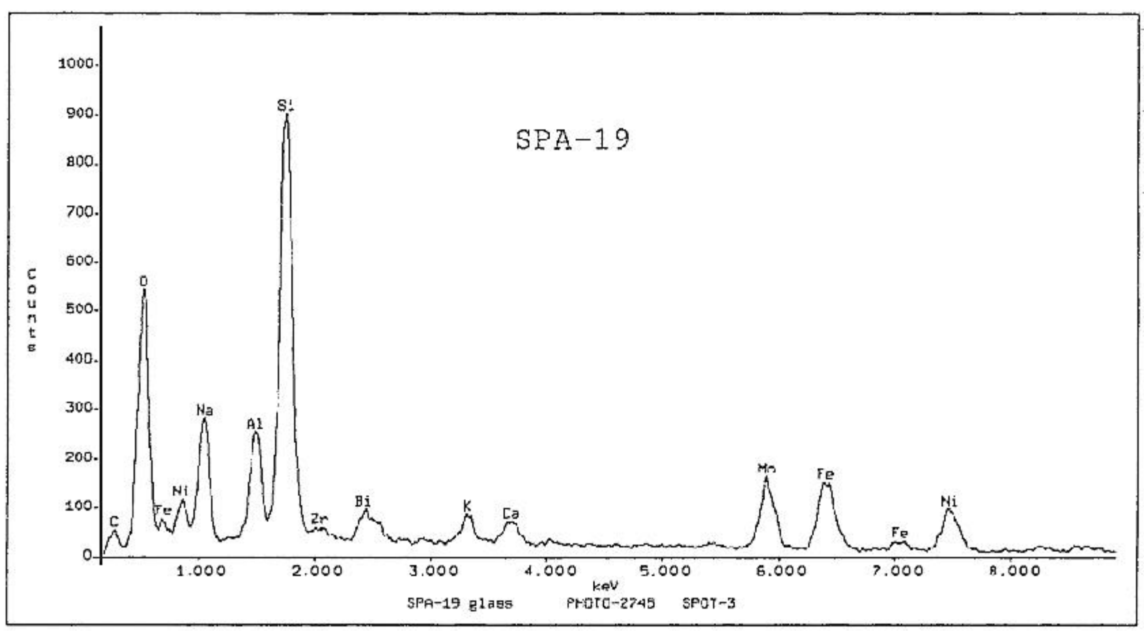
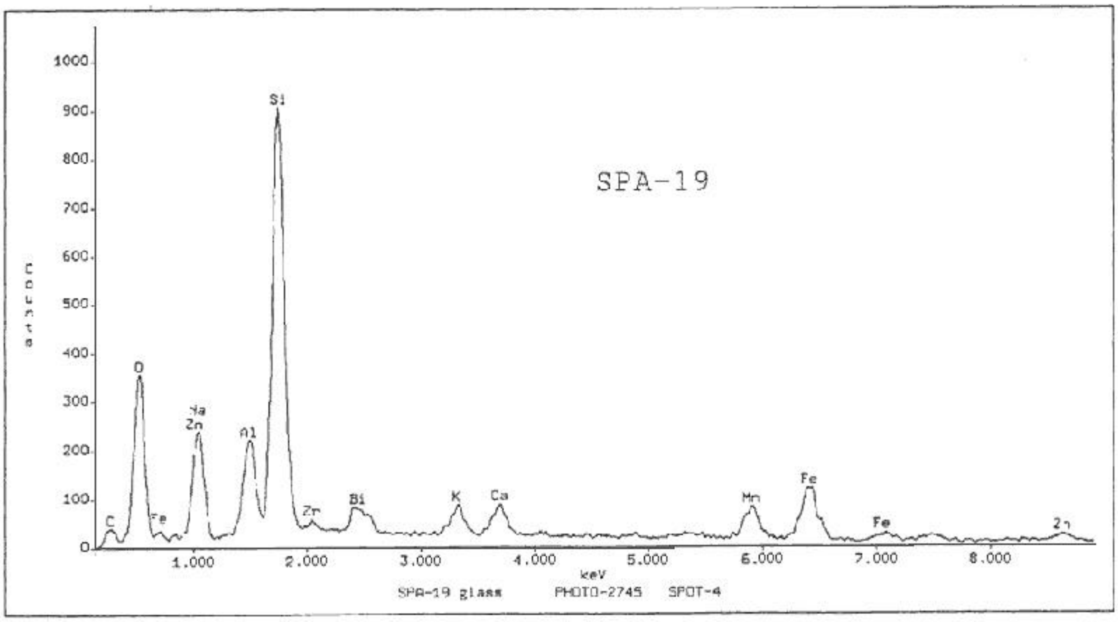


Figure 29. SEM Micrograph of the SPA-19's Metallic Surface (basis for EDS analysis)



SPA-19 glass PHOTO-2745 SPOT-3

Figure 30. EDS Analysis of the Smaller, More Densely Populated Surface Crystals (Spot 3 in Figure 29)



SPA-19 glass PHOTO-2745 SPOT-4

Figure 31. EDS Analysis of the Glass Matrix (Spot 4 in Figure 29)

Metallic swirls/streaks and large metallic spots on the bottom and surface of the pour patty characterized SPA-21 (see Appendix B for a more detailed description). Figure 32 is an optical micrograph of a large metallic spot on the surface of this glass. SEM/EDS analyses of this metallic spot are shown in Figures 33 through 36. As in previous EDS analyses in this section, the crystals are Fe, Mn, Cr, and Ni enriched (see Figure 35) relative to the glass matrix (see Figure 36). Note that Cr_2O_3 is only associated with the EDS spectra of the crystalline phase. Analysis by XRD identifies these crystals as spinel-type structures with either copper iron oxide ($CuFe_2O_4$—see Figure 37) or copper manganese oxide ($CuMn_2O_4$—see Figure 38) patterns matching quite well. However, Si is present in the EDS spectra of the crystals (see Figure 35) which is not consistent with the XRD patterns, possibly from penetration of the electron beam.

Figure 32. Optical Micrograph of a Large Metallic Spot Associated with SPA-21

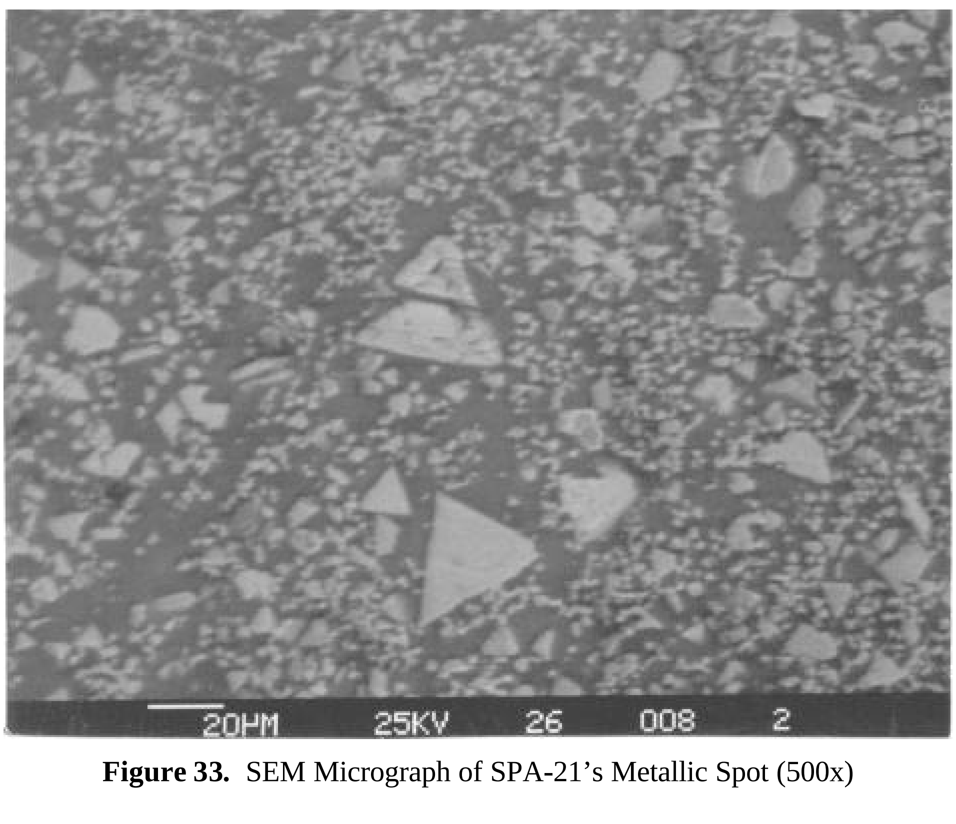


Figure 33. SEM Micrograph of SPA-21's Metallic Spot (500x)

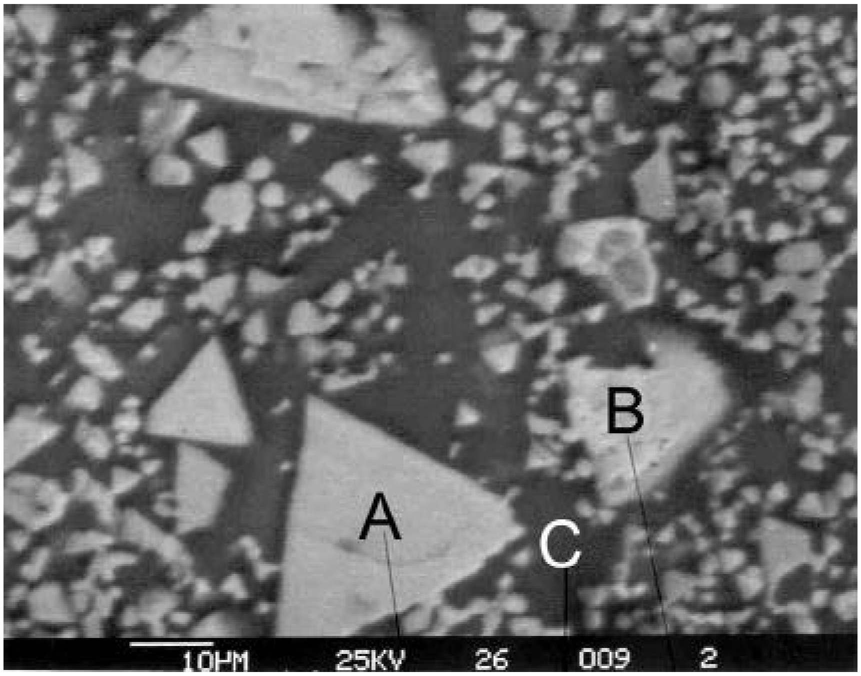


Figure 34. SEM Micrograph of SPA-21's Metallic Spot (basis for EDS analysis) (1000x)

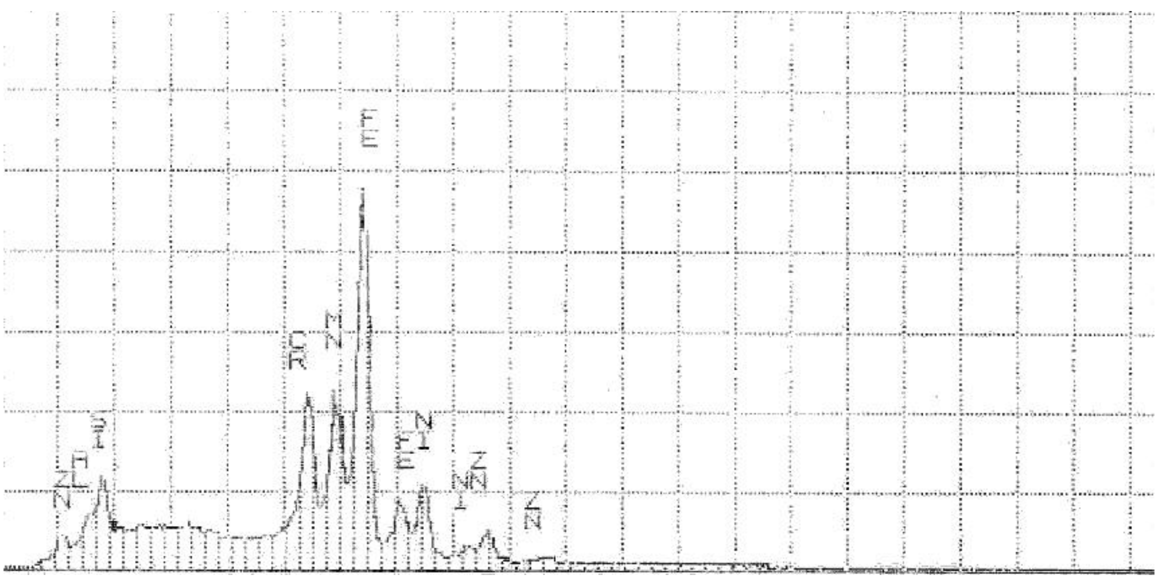


Figure 35. EDS Analysis of the Small, Densely Populated Crystals
(Spots A and B in Figure 34)

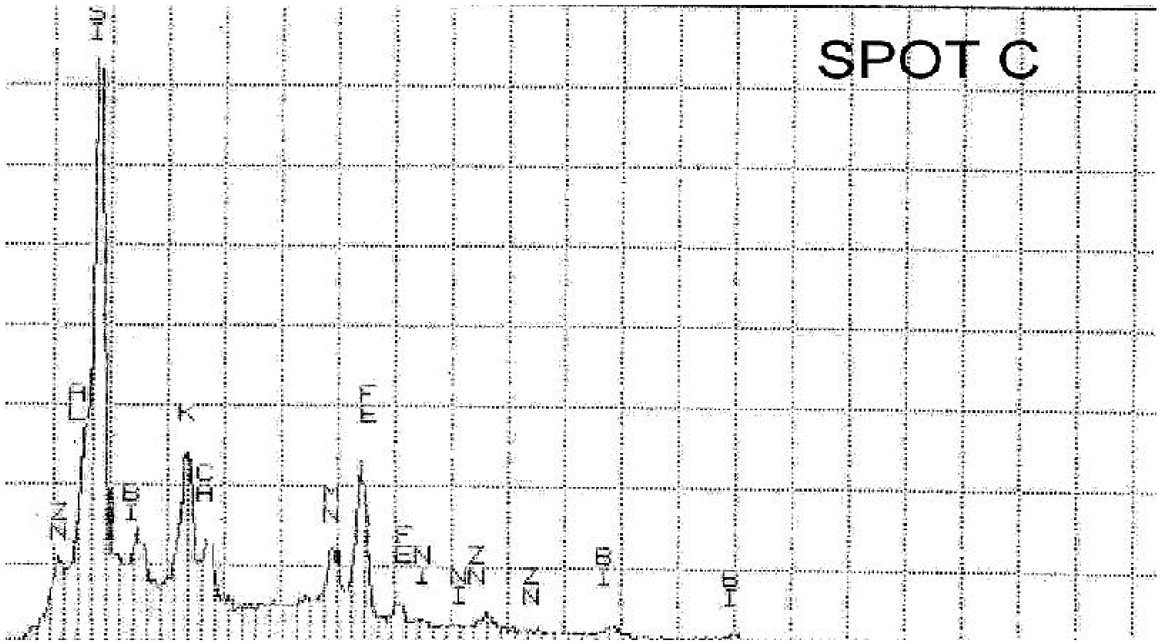


Figure 36. EDS Analysis of the Glass Matrix (Spot C in Figure 34)

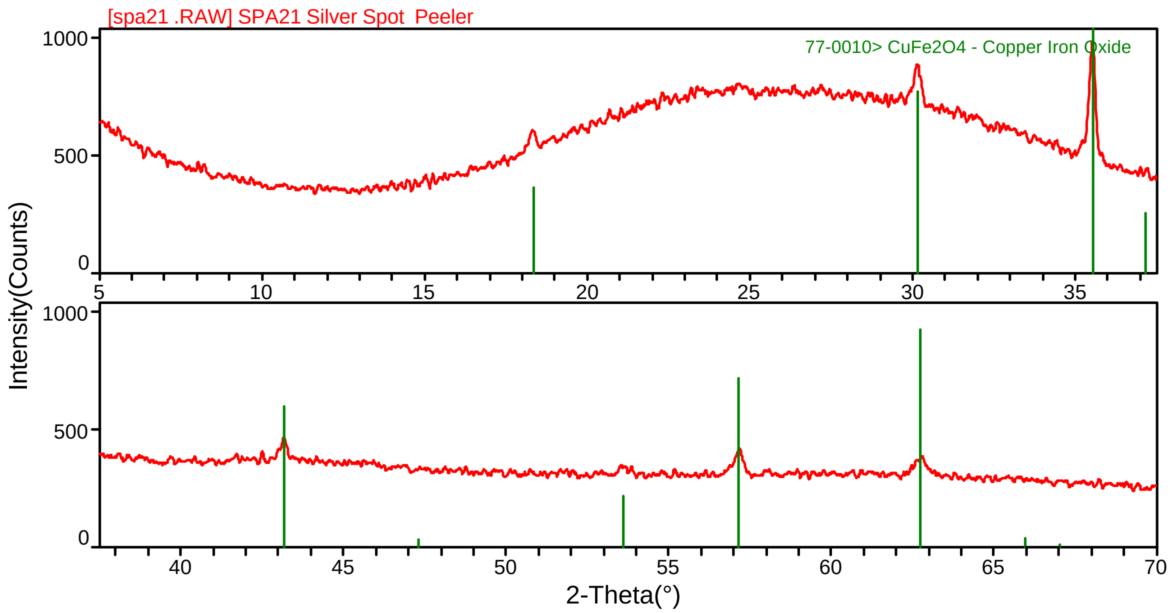


Figure 37. XRD Analysis of SPA-21's Metallic Spot ($CuFe_2O_4$)

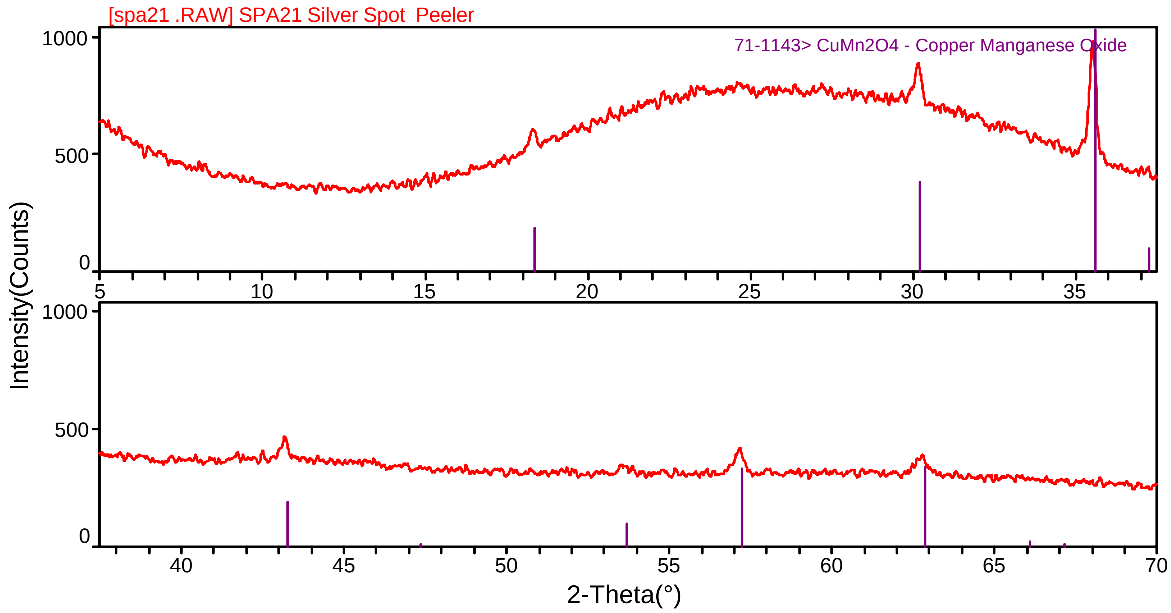


Figure 38. XRD Analysis of SPA-21's Metallic Spot ($CuMn_2O_4$)

3.1.4 Major Swirls

The last major characteristic observed was associated with one glass: SPA-06. Initial melts (T_{M1} and T_{M2}) were performed at 1100°C with both pour patties characterized by light brown and dark $_{M3}$) was performed at 1150°C to ascertain if a higher melt temperature would result in a single-phase glass, but no change was evident. Figure 39 shows a digital photo of the resulting pour patty after T_{M3}. This particular sample was not analyzed further. It should be mentioned that a representative sample of SPA-06 was obtained (by grinding a portion of the pour patty) for chemical composition analysis (see Section 3.2).

3.2 Chemical Composition Analysis

In this section, the measured versus targeted compositions of the 45 SPA glasses are presented and compared. The targeted compositions (as oxides and anions) for these glasses are provided in Tables 1a (major components) and 1b (minor components). The chemical compositions for these glasses were analyzed as described by Edwards (see Appendix A). Three dissolution methods were used. Samples prepared by LM dissolution were used to measure elemental concentrations of aluminum (Al), bismuth (Bi), calcium (Ca), cadmium (Cd), cerium (Ce), Cr, Fe, K, lanthanum (La), magnesium (Mg), Mn, Na, neodymium (Nd), Ni, phosphorous (P), lead (Pb), S, Si, Sr, thorium (Th), titanium (Ti), uranium (U), zinc (Zn), and zirconium (Zr). Samples prepared using a SP dissolution were used to measure elemental concentrations of B and Li. Samples prepared using PH were used to measure anions: chloride (Cl) and fluoride (F).

Figure 39. "Swirls" Characterizing SPA-06

Several of these analytes (Ce, La, Mg, Nd, Pb, S, and Cl) are minor components of the SPA glasses. They are included as part of an "Others" grouping of minor components whose targeted concentrations for the SPA glasses are provided in Table 1b. Notice that many of the components making up "Others" are at very low concentrations, and as a consequence, no attempt was made to measure them as part of the analytical plan covering this work (for example, Ag, As, Ba, Co, Cs, Cu, Mo, Pd, Rh, Ru, Sb, Se, Te, V, and Y). For each glass, measurements were obtained from samples prepared in duplicate by the LM and SP dissolution methods. All of the samples prepared using LM and SP were analyzed (twice for each element of interest) by ICP-AES (with the instrumentation being re-calibrated between the duplicate analyses). The samples prepared using PH were prepared only once with each prepared sample being measured twice by IC (with the instrumentation being re-calibrated between the duplicate analyses).

Table C.1 (see Appendix C) provides the elemental concentration measurements derived from the samples prepared using LM. Tables C.2 and C.3 provide the measurements derived from the samples prepared using SP and PH, respectively. Measurements for three standards—Waste Compliance Plan (WCP) Batch 1, a uranium standard (U_{std}) glass, and the Low-Activity Reference Material (LRM) glass—that were included in the analytical plan along with the SPA glasses are also provided in these three tables. As seen in the tables, samples of the Batch 1 and U_{std} glasses were included with the SPA glass samples that were prepared using the LM and SP methods while the LRM samples were included with the SPA glass samples prepared using the PH method.

The cation elemental concentrations were converted to the corresponding 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 SRTC-ML was reduced to half of that detection limit as the oxide concentration was determined. Anions were reported as elemental wt%. For those anion analytes, a reported concentration that was below the detection limit of the analytical procedures used was represented by half of that detection limit in this report.

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 composition (measured and bias-corrected) for each glass is determined
- comparisons are made between these measurements and the targeted compositions for these glasses.

3.2.1 Measurements in Analytical Sequence

Exhibit C.1 provides plots of the measurements from samples prepared using the LM method. These plots are in analytical sequence with different symbols and colors being used to represent each of the SPA and standard glasses. Similar plots for the samples prepared using the SP and PH methods are provided in Exhibit C.2 and Exhibit C.3, respectively.

A review of these plots indicates no significant patterns or trends, and there appear to be no obvious outliers in these chemical-composition measurements.

3.2.2 Batch 1, Uranium Standard, and LRM Results

In this section, the SRTC-ML measurements of the chemical compositions of the standard glasses are reviewed. These measurements are investigated across the ICP and IC analytical blocks, and the results are used to bias-correct measurements for the SPA glasses as discussed below.

Exhibit C.4 provides statistical analyses of the Batch 1 and U_{std} results generated by the LM prep method by analytical block. The results include analysis of variance (ANOVA) investigations looking for statistically significant differences among the block means for each of the standards. The results from these statistical tests may be summarized as follows: for the Batch 1 standard—the K, Mn, Na, Nd, Si, and Zr measurements indicate a significant ICP calibration effect at the 5% significance level and for the U_{std}—the Ca, Fe, K, Na, Si, and U measurements indicate a significant ICP calibration effect at the 5% significance level. Also, note that there is similarity between the patterns of behavior for the measurements of the two standards over the analytical blocks for some of the elements with significant calibration effects. The reference values for the oxide concentrations of the two standards are given in the header for each set of measurements in the exhibit.

Exhibit C.5 provides a similar set of analyses for the B_2O_3 and Li_2O measurements derived from samples prepared via the SP method. In this exhibit, the B_2O_3 values for the U_{std} and the Li_2O data for both Batch 1 and the U_{std} show statistically significant (at the 5% significance level) differences among the ICP analytical/calibration blocks.

Exhibit C.6 provides a similar set of analyses for the F^- and Cl^- measurements derived from the LRM samples prepared via the PH method. In this exhibit, there is no indication of statistically significant (at the 5% significance level) differences among the measurements for each of these analytes across the IC analytical/calibration blocks.

The results suggest that it may be helpful to bias-correct the measurements of the SPA glasses for the effects of the ICP and IC calibrations on the analytical blocks. The basis for this bias correction is presented as part of Exhibits C.4 through C.6—the average measurement for Batch 1 for each ICP block for Al, Ca, Cr, Fe, Mg, Mn, Na, Ni, P, Si, Ti, and Zr, the average measurement for U_{std} for each ICP block for U, and the average measurement for LRM for each IC block for F^- and Cl^-. The Batch 1 results served as the basis for bias-correcting the oxides, except for uranium. The U_{std} results were used to bias-correct for uranium. For the oxides, the Batch 1 results were used for 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, Ca, Cr, Fe, K, Mg, Mn, Na, Nd, Ni, Si, and Ti measurements. There were no bias corrections for Bi, Cd, Ce, La, P, Pb, S, Sr, Th, Zn or Zr. Once again, the measurements of the U_{std} glass samples were used for the bias correction for U. For the anions, the LRM results were used to bias-correct the F^- values while no bias correction was made for Cl^-.

The bias correction was conducted as follows. For the i^{th} oxide or anion, let $\bar{a}_{ij}$ be the average measurement for the i^{th} oxide/anion at analytical block j for the standard glass (Batch 1 for all oxides except for uranium, which relied on the U_{std} results, and LRM for F^-), and let t_i be the reference value for the i^{th} oxide/anion for the standard. (The averages and reference values are provided in Exhibits C.4 through C.6.) Let $\bar{c}_{ijk}$ be the average measurement for the i^{th} oxide/anion at analytical block j for the k^{th} glass. The bias adjustment was conducted as follows:

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

Bias-corrected measurements are indicated by a "bc" suffix, and all of the analytes of this study except Bi_2O_3, CdO, Ce_2O_3, Cl, La_2O_3, P_2O_5, PbO, SO_3, SrO, ThO_2, ZnO, and ZrO_2 were adjusted accordingly. Both measured values and measured "bc" values are included in the discussion that follows. In these discussions, bias-corrected values for all analytes are included for completeness (for example, to allow a sum of oxides to be computed for the bias-corrected results). Thus, the bias-corrected values are the same as the original measurements for Bi_2O_3, CdO, Ce_2O_3, Cl, La_2O_3, P_2O_5, PbO, SO_3, SrO, ThO_2, ZnO, and ZrO_2 (once again, these analytes were not corrected for bias).

3.2.3 Composition Measurements by Glass ID

Exhibits C.7 through C.9 provide plots of the oxide/anion concentration measurements by Glass ID (including the standard glasses) for the measured and bc values for the LM, SP, and PH preparation methods, respectively. These plots show the individual measurements across the duplicates of the LM and SP preparation methods and the two ICP/IC calibrations. A review of the plots presented in these exhibits reveals the repeatability of the four individual, oxide measurements and the two individual anion measurements for each glass.

The repeatability of the analyses for each of the glasses appears to be good. Based upon the y-axis scales of the plots shown in these exhibits, the Na_2O and SiO_2 results for some of the glasses appear to be among the most varying. Overall, however, the results indicate there are no problems of practical significance in using all of these measurements to represent the chemical compositions of these SPA glasses.

3.2.4 Measured versus Targeted Compositions

The measurements for each oxide/anion for each glass were averaged to determine a representative chemical composition for each glass. These determinations were conducted for the measured and bias-corrected data. A sum of oxides was also computed for each glass based upon both the measured and bias-corrected values. Table C.6 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 glasses do not sum to 100% due to the "Others" component of the SPA glasses and an incomplete coverage of the oxides/anions in the standard glasses. All of the sums of oxides (both measured and bias-corrected) fall within the interval of 95 to 105 wt%. This interval is commonly used as an assessment of the overall analytical process.

The entries of Table C.6 showing the relative differences between the measured or bias-corrected values and the targeted values are shaded for those differences greater than or equal to 5%. It should be noted that it is not surprising to see relatively large differences for those components at concentrations of < 0.5 wt% in glass. To help highlight the comparisons among the measured, bias-corrected, and targeted values, Exhibit C.10 provides comparison plots for each glass for each oxide/anion.

A review of the information in Table C.6 and the plots of Exhibit C.10 generated the following high-level observations regarding target versus measured compositions:

- The measured values for Al_2O_3, Bi_2O_3, Cr_2O_3, Fe_2O_3, La_2O_3, MnO, P_2O_5, and PbO for SPA-10 are low compared to targeted values.
- The measured values for SO_3, SiO_2, and CaO for SPA-10 are high compared to targeted values.
- SPA-20A is above its Bi_2O_3 target by an amount that equals the shortfall in SPA-24A's Bi_2O_3 measurement versus targeted value. In fact, the differences between SPA-20A's measurements versus targets for CdO, Cr_2O_3, F, Bi_2O_3, MnO, Na_2O, SiO_2, and SrO are the mirror images of SPA-24A's differences.
- The Cr_2O_3 measurement for SPA-07 is above its targeted value.
- The P_2O_5 measurements for SPA-28 and SPA-36 are below their respective targeted values.
- The PbO measurement for SPA-36 is above its targeted value.
- The K_2O measurements for SPA-02, SPA-04, and SPA-06 are high compared to targeted values.
- The NiO measurement for SPA-26A is low compared to targeted values.
- The ZrO_2 measurements for SPA-05, SPA-06, and SPA-28 are low compared to targeted values.

Overall, the general observations regarding the comparisons between the measured and targeted compositions suggest:

(1) SPA-10 was potentially misbatched given the large number of oxides/anions that show relative significant differences between target and measured values.

(2) SPA-20A and SPA-24A may have been mislabeled or switched during the fabricating process or during the analysis, given that the differences between SPA-20A and SPA-24A measurements for some of the oxides are mirror images.

To address the first major issue, the SPA-10 batch sheet[a] was reviewed to ensure that there was not a gross weighing error recorded relative to the required amounts of each raw material. This review provided no indication that the measured composition should be dramatically different than targeted. Before refabricating this particular glass, a second sample was analyzed. This sample was not submitted under the framework of an analytical plan, although routine procedures were used for the required dissolutions and measurements, and a glass standard was also submitted. The results of this second analysis (remeasurement) on SPA-10 are shown is Table 5. Table 6 summarizes the target and measured oxide concentrations for the Batch 1 glass standard submitted with the SPA-10 remeasurement.

Although the remeasurement sum of oxides is low (but acceptable given all the minor components not measured) compared to those from the original measurements under the analytical plan, almost all of the oxides are within the ±5% relative difference of targeted values. Those oxides/anions exceeding this limit include F, NiO, Nd_2O_3, PbO, SO_3, P_2O_5, and ZrO_2. The high relative differences of F, NiO, Nd_2O_3, PbO, and SO_3 are not surprising, given that the target values for these oxides/anions are 0.5 mass% or less in the glass—which when coupled with analytical error at these levels could yield the high relative differences. Relative differences for P_2O_5 and ZrO_2 are 8.8 and 12%, respectively, with both measurements being lower than target.

The remeasured values provide a high confidence (especially when coupled with the review of the associated batch-sheet entries) that the targeted SPA-10 composition was indeed met—thus this glass was not refabricated. This statement is based on the assumption that issues (although unidentified) with the initial measurements caused the relative differences to exceed 10% for almost all major components (i.e., > 0.5 wt% in glass) and that the single remeasurement accurately reflects the as-fabricated glass composition.

(a) The batch sheet for SPA-10 can be found on page 65 of WSRC-NB-2001-00055.

Table 5. Target, Measured, Measured Bias-Corrected, and Remeasured Compositional Analysis for SPA-10

Oxide	Targeted (wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Remeasured (wt%)	% Diff of Measured	% Diff of Meas BC	% Diff of Remeasured
Al_2O_3	10.0000	8.8098	9.0774	9.80	-11.90	-9.23	-2.00
B_2O_3	5.0000	5.6026	5.4491	5.08	12.05	8.98	1.60
Bi_2O_3	5.0000	3.7318	3.7318	4.78	-25.36	-25.36	-4.40
CaO	0.0000	0.9955	0.9612	0.03	-	-	-
CdO	0.0000	0.0057	0.0057	0.00	-	-	-
Ce_2O_3	0.4360	0.3827	0.3827	0.43	-12.22	-12.22	-1.38
Cl-	0.0080	0.1000	0.1000	NM	1150.00	1150.00	-
Cr_2O_3	0.8000	0.6077	0.6693	0.78	-24.04	-16.34	-2.50
F-	0.5000	0.3250	0.3540	0.38	-35.00	-29.20	-24.00
Fe_2O_3	13.7300	12.5814	12.6589	13.41	-8.37	-7.80	-2.33
K_2O	3.2700	2.7886	2.7247	3.32	-14.72	-16.68	1.53
La_2O_3	0.2580	0.1815	0.1815	0.25	-29.65	-29.65	-3.10
Li_2O	3.2700	2.9064	3.2607	3.11	-11.12	-0.28	-4.89
MgO	0.0000	0.0083	0.0081	0.00	-	-	-
MnO	1.8700	1.4591	1.4665	1.84	-21.97	-21.58	-1.60
Na_2O	13.7600	14.0866	13.5856	13.98	2.37	-1.27	1.60
Nd_2O_3	0.0810	0.0875	0.0875	0.12	8.02	8.02	48.15
NiO	0.5000	0.3687	0.3832	0.47	-26.26	-23.36	-6.00
P_2O_5	1.2500	0.8936	0.8936	1.14	-28.51	-28.51	-8.80
PbO	0.2900	0.2162	0.2162	0.27	-25.45	-25.45	-6.90
SO_3^-	0.0900	0.2784	0.2784	0.15	209.33	209.33	66.67
SiO_2	38.3300	42.2512	41.6447	37.43	10.23	8.65	-2.35
SrO	0.2200	0.1638	0.1638	0.21	-25.55	-25.55	-4.55
ThO_2	0.0000	0.0569	0.0569	0.00	-	-	-
TiO_2	0.0000	0.0083	0.0085	0.00	-	-	-
U_3O_8	0.0000	0.0590	0.0610	0.00	-	-	-
ZnO	0.0000	0.0062	0.0062	0.00	-	-	-
ZrO_2	1.0000	0.8699	0.8699	0.88	-13.01	-13.01	-12.00
Sum of Oxides	99.6630	99.8325	99.2874	97.86			

Table 6. Target and Measured Compositional Analysis for the Batch 1 Standard Glass Used in the Remeasurement of SPA-10

Oxide (wt%)	Remeasured (wt%)	Targeted (wt%)	% Diff of Remeasured
Al_2O_3	4.728	4.8770	-3.06
B_2O_3	8.018	7.7770	3.10
CaO	1.328	1.2200	8.85
Cr_2O_3	0.099	0.1070	-7.48
Fe_2O_3	12.810	12.8390	-0.23
K_2O	3.361	3.3270	1.02
Li_2O	4.348	4.4290	-1.83
MgO	1.446	1.4190	1.90
MnO	1.704	1.7260	-1.27
Na_2O	9.22	9.0030	2.41
Nd_2O_3	0.139	0.1470	-5.44
NiO	0.736	0.7510	-2.00
SiO_2	49.204	50.2200	-2.02
TiO_2	0.674	0.6770	-0.44
ZrO_2	0.082	0.0980	-16.33
sum of oxides	97.897	98.6170	

As previously mentioned, the second major issue regarding the comparisons between the measured and targeted compositions was the hypothesis that SPA-20A and SPA-24A may have been mislabeled or switched during the fabricating process or during analysis or reporting. This is based on the fact that the differences between SPA-20A and SPA-24A measurements for some of the major oxides are mirror images. More specifically, SPA-20A is above its Bi_2O_3 target by an amount that equals the shortfall in SPA-24A's Bi_2O_3 measurement versus targeted values. In fact, the differences between SPA-20A's measurement versus target values for CdO, Cr_2O_3, F, Bi_2O_3, MnO, Na_2O, SiO_2, and SrO are the mirror images of SPA-24A's differences.

As with SPA-10, representative samples from the archived glasses were obtained and reanalyzed. Samples were labeled according to the identification or nomenclature that appeared on the container to determine if the samples were switched during the fabrication process, mislabeled, or switched during the preparation and/or analysis. It should also be mentioned that a Batch 1 standard glass was also submitted with these samples, and the results are shown in Table 6.

Tables 7 and 8 show the target, initial measurement, measured bias corrected, and remeasured values for SPA-20A and SPA-24A, respectively. The major oxides/anions in question are CdO, Cr_2O_3, F, Bi_2O_3, MnO, Na_2O, SiO_2, and SrO and have been highlighted in the respective tables. The remeasured values are consistent with the initial values reported by the SRTC-ML via the analytical plan for both SPA-20A and SPA-24A.

Table 7. Target, Measured, Measured Bias-Corrected, and Remeasured Compositional Analysis for SPA-20A

Oxide (wt%)	Targeted	Measured	Measured Bias-Corrected	Remeasured
Al_2O_3	10.0000	9.7734	10.0503	9.80
B_2O_3	5.0000	4.9908	4.9121	5.02
Bi_2O_3	**0.2000**	**4.8912**	**4.8912**	**4.78**
CaO	2.0000	2.0743	1.9848	2.04
CdO	**1.0000**	**0.0057**	**0.0057**	**0.00**
Ce_2O_3	0.4360	0.4293	0.4293	0.45
Cl-	0.0080	0.1000	0.1000	NM
Cr_2O_3	**0.8000**	**0.2963**	**0.3270**	**0.31**
F-	**1.5000**	**0.3800**	**0.4139**	**0.39**
Fe_2O_3	8.4600	8.2101	8.1493	8.07
K_2O	4.5000	4.5986	4.5918	4.27
La_2O_3	0.2580	0.2442	0.2442	0.25
Li_2O	4.5000	4.2251	4.6172	4.35
MgO	0.0000	0.0083	0.0082	0.00
MnO	**3.0000**	**1.0120**	**1.0261**	**1.02**
Na_2O	**12.9300**	**17.4229**	**16.9712**	**17.29**
Nd_2O_3	0.0810	0.1318	0.1318	0.14
NiO	0.5000	0.4772	0.4992	0.48
P_2O_5	0.5000	0.5230	0.5230	0.48
PbO	0.2900	0.2645	0.2645	0.27
SO_3^-	0.0900	0.1174	0.1174	0.17
SiO_2	**36.6100**	**34.0684**	**33.7208**	**33.10**
SrO	**2.0000**	**0.0059**	**0.0059**	**0.00**
ThO_2	0.0000	0.0569	0.0569	0.00
TiO_2	2.0000	1.9474	1.9901	2.02
U_3O_8	0.0000	0.0590	0.0612	0.00
ZnO	0.0000	0.0062	0.0062	0.00
ZrO_2	3.0000	2.8536	2.8536	2.86
Sum of Oxides	99.6630	99.1733	98.9527	97.6

The results of the remeasurements indicate that the samples were switched or mislabeled during the fabrication process and not during sample preparation, analysis, or reporting. As a comparison, Tables 9 and 10 show the target versus measured compositions assuming that the samples were switched. The relative differences between the remeasured composition and target are also shown. These values also support the conclusion that the samples were switched or mislabeled during the fabrication process and that targeted compositions were indeed met.

Based on this supplemental data, the archived samples were relabeled to reflect the true targeted composition. It should be noted that the samples provided to PNNL for subsequent property measurements were also likely switched. This information was transmitted to PNNL, who analyzed the SPA-20A and SPA-24A "as received" samples using SEM/EDS. Their analysis confirmed that the samples had been switched during the sample fabrication process.

Table 8. Target, Measured, Measured Bias-Corrected, and Remeasured Compositional Analysis for SPA-24A

Oxide(wt%)	Targeted	Measured	Measured	Remeasured
Al_2O_3	10.0000	9.9577	10.2397	9.98
B_2O_3	5.0000	5.1760	5.0488	5.24
Bi_2O_3	**5.0000**	**0.2082**	**0.2082**	**0.19**
CaO	2.0000	2.1093	2.0137	2.06
CdO	**0.0000**	**0.9767**	**0.9767**	**0.92**
Ce_2O_3	0.4360	0.4369	0.4369	0.43
Cl-	0.0080	0.1000	0.1000	NM
Cr_2O_3	**0.3000**	**0.7907**	**0.8818**	**0.77**
F-	**0.5000**	**1.3300**	**1.5040**	**1.28**
Fe_2O_3	8.2000	8.2351	8.3707	8.35
K_2O	4.5000	4.8064	4.6253	4.73
La_2O_3	0.2580	0.2483	0.2483	0.24
Li_2O	4.5000	4.3273	4.5232	4.48
MgO	0.0000	0.0083	0.0082	0.00
MnO	**1.0000**	**2.9794**	**3.0131**	**2.82**
Na_2O	**17.5000**	**13.2070**	**12.8084**	**13.17**
Nd_2O_3	0.0810	0.1344	0.1344	0.14
NiO	0.5000	0.4880	0.5105	0.45
P_2O_5	0.5000	0.4869	0.4869	0.45
PbO	0.2900	0.2696	0.2696	0.26
SO_3^-	0.0900	0.1167	0.1167	0.18
SiO_2	**34.0000**	**36.3681**	**36.4329**	**35.80**
SrO	**0.0000**	**2.0607**	**2.0607**	**2.07**
ThO_2	0.0000	0.0569	0.0569	0.00
TiO_2	2.0000	1.9724	2.0216	1.89
U_3O_8	0.0000	0.0590	0.0611	0.00
ZnO	0.0000	0.0062	0.0062	0.00
ZrO_2	3.0000	2.9211	2.9211	2.75
Sum of oxides	99.6630	99.8373	100.0856	98.6

Table 9. Comparison of Target Versus Remeasured for SPA-20A Assuming SPA-20A and SPA-24A Were Switched

Oxide (wt%)	Targeted	Measured	Measured	Remeasured	% Diff of
Al_2O_3	10.0000	9.9577	10.2397	9.98	-0.20
B_2O_3	5.0000	5.1760	5.0488	5.24	4.80
Bi_2O_3	**0.2000**	**0.2082**	**0.2082**	**0.19**	**-5.00**
CaO	2.0000	2.1093	2.0137	2.06	3.00
CdO	**1.0000**	**0.9767**	**0.9767**	**0.92**	**-8.00**
Ce_2O_3	0.4360	0.4369	0.4369	0.43	-1.38
Cl-	0.0080	0.1000	0.1000	NM	-
Cr_2O_3	**0.8000**	**0.7907**	**0.8818**	**0.77**	**-3.75**
F-	**1.5000**	**1.3300**	**1.5040**	**1.28**	**-14.67**
Fe_2O_3	8.4600	8.2351	8.3707	8.35	-1.30
K_2O	4.5000	4.8064	4.6253	4.73	5.11
La_2O_3	0.2580	0.2483	0.2483	0.24	-6.98
Li_2O	4.5000	4.3273	4.5232	4.48	-0.44
MgO	0.0000	0.0083	0.0082	0.00	-
MnO	**3.0000**	**2.9794**	**3.0131**	**2.82**	**-6.00**
Na_2O	**12.9300**	**13.2070**	**12.8084**	**13.17**	**1.86**
Nd_2O_3	0.0810	0.1344	0.1344	0.14	72.84
NiO	0.5000	0.4880	0.5105	0.45	-10.00
P_2O_5	0.5000	0.4869	0.4869	0.45	-10.00
PbO	0.2900	0.2696	0.2696	0.26	-10.34
SO_3^-	0.0900	0.1167	0.1167	0.18	100.00
SiO_2	**36.6100**	**36.3681**	**36.4329**	**35.80**	**-2.21**
SrO	**2.0000**	**2.0607**	**2.0607**	**2.07**	**3.50**
ThO_2	0.0000	0.0569	0.0569	0.00	-
TiO_2	2.0000	1.9724	2.0216	1.89	-5.50
U_3O_8	0.0000	0.0590	0.0611	0.00	-
ZnO	0.0000	0.0062	0.0062	0.00	-
ZrO_2	3.0000	2.9211	2.9211	2.75	-8.33
Sum of Oxides	99.6630	99.8373	100.0856	98.6	

Table 10. Comparison of Target Versus Remeasured for SPA-24A Assuming SPA-20A and SPA-24A were Switched

Oxide (wt%)	Targeted	Measured	Measured	Remeasured	% Diff of
Al_2O_3	10.0000	9.7734	10.0503	9.80	-2.00
B_2O_3	5.0000	4.9908	4.9121	5.02	0.40
Bi_2O_3	**5.0000**	**4.8912**	**4.8912**	**4.78**	**-4.40**
CaO	2.0000	2.0743	1.9848	2.04	2.00
CdO	**0.0000**	**0.0057**	**0.0057**	**0.00**	**-**
Ce_2O_3	0.4360	0.4293	0.4293	0.45	3.21
Cl-	0.0080	0.1000	0.1000	NM	-
Cr_2O_3	**0.3000**	**0.2963**	**0.3270**	**0.31**	**3.33**
F-	**0.5000**	**0.3800**	**0.4139**	**0.39**	**-22.00**
Fe_2O_3	8.2000	8.2101	8.1493	8.07	-1.59
K_2O	4.5000	4.5986	4.5918	4.27	-5.11
La_2O_3	0.2580	0.2442	0.2442	0.25	-3.10
Li_2O	4.5000	4.2251	4.6172	4.35	-3.33
MgO	0.0000	0.0083	0.0082	0.00	-
MnO	**1.0000**	**1.0120**	**1.0261**	**1.02**	**2.00**
Na_2O	**17.5000**	**17.4229**	**16.9712**	**17.29**	**-1.20**
Nd_2O_3	0.0810	0.1318	0.1318	0.14	72.84
NiO	0.5000	0.4772	0.4992	0.48	-4.00
P_2O_5	0.5000	0.5230	0.5230	0.48	-4.00
PbO	0.2900	0.2645	0.2645	0.27	-6.90
SO_3^-	0.0900	0.1174	0.1174	0.17	88.89
SiO_2	**34.0000**	**34.0684**	**33.7208**	**33.10**	**-2.65**
SrO	**0.0000**	**0.0059**	**0.0059**	**0.00**	**-**
ThO_2	0.0000	0.0569	0.0569	0.00	-
TiO_2	2.0000	1.9474	1.9901	2.02	1.00
U_3O_8	0.0000	0.0590	0.0612	0.00	-
ZnO	0.0000	0.0062	0.0062	0.00	-
ZrO_2	3.0000	2.8536	2.8536	2.86	-4.67
Sum of Oxides	99.6630	99.1733	98.9527	97.6	

3.2.5 Alternative Melting Technique: Cr_2O_3 Concentration

In Section 3.1.1, the formation of a salt layer led to the use of an alternative melting process to increase the likelihood of incorporating the Cr_2O_3 into the glass (instead of partitioning with the salt layer as the ICP results indicated—see Table 4). More specifically, after the initial melts of SPA-20, SPA-23, SPA-24, and SPA-26, a yellow deposit (presumably salt) was observed on the interior wall of the crucible above the melt line and/or forming a ring around the glass at the melt line/crucible interface. (The last four entries in Appendix B summarize the observations of the original melts of SPA-20, SPA-23, SPA-24, and SPA-26 using the standard melting procedure in which the deposits were observed.) A sample of the yellow deposit was obtained from the initial SPA-24 melt and analyzed by ICP for composition. The elemental results (in mg/L) shown in Table 4 indicate that the deposit is a high Cr, alkali (Na, K, Li, Sr) salt layer.

Given that Cr_2O_3 has a significant impact on the major property of interest (T_L), an alternate batching/melting technique was used to minimize the potential for salt formation. The technique (specific to these four glasses) involved batching all components (with the exception of Cr_2O_3) and performing an initial melt using standard procedures as discussed in Section 2.1. This alternative melting technique was successful in avoiding the salt layer formation and based on the ICP results, was also successful in incorporating the Cr_2O_3 into the glass. Table 11 shows the target and measured Cr_2O_3 concentration for these four glasses.

Table 11. Target and Measured Cr_2O_3 Concentrations

Glass	Cr_2O_3 Target	Cr_2O_3 Measured[(a)]
SPA-20A	0.80	0.791
SPA-23A	0.80	0.813
SPA-24A	0.30	0.296
SPA-26A	0.80	0.765

(a) Cr_2O_3 values reported for SPA-20A and SPA-24A assume that these samples were switched and are based on the measured values from the analytical plan.

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4.0 SUMMARY

Interim Hanford HLW glass T_L models for use in the site flowsheet software are currently being updated (Vienna et al. [2001]). An integral part of this approach involves fabrication and testing of glasses that adequately cover the compositional region of interest. As a result, PNNL developed a 45-glass test matrix (referred to as the SPA glass test matrix or SPA glasses) for which various properties will be measured (Vienna et al. 2001). SRTC is supporting PNNL efforts through (1) fabrication of the SPA glasses and (2) chemical-composition analysis.

Each of the 45 SPA glass batches was prepared from the proper proportions of reagent-grade metal oxides, carbonates, H_3BO_3, and salts (including NaCl, $NaPO_3$, Na_2SO_4, and CaF_2) using standard procedures. Once batched, the glasses were melted using a standard thermal heat treatment and quenched by pouring onto a clean stainless steel plate. The resulting glasses were visually assessed for homogeneity with subsequent analysis via XRD and SEM/EDS to gain further insight into the characteristics of the as-fabricated glasses.

Of the 45 SPA glasses, 20 were characterized as a single-phase (homogeneous based on observation) glass. XRD patterns were used to confirm observations of homogeneity for select SPA glasses. Of the 25 SPA glasses that were not characterized as single-phase glasses, four primary characteristics or features were observed. These defining characteristics included:

(1) Yellow deposits (oxyanionic salts) on the interior wall of the crucible above the melt line or forming a ring around the glass at the melt line/crucible interface. This was observed in four SPA glasses: SPA-20, -23, -24, and –26.

(2) Pour patties characterized by a dull-brown cross section (indicative of devitrification) with a thin glassy layer on the bottom of the pour patty where the glass was quenched on the stainless steel pour plate.

(3) Metallic looking (for example, silver) streaks, spots, and/or coatings on the surface of the pour patty.

(4) “Swirls” as a result of two different colored “glasses.” This phenomenon was only observed in SPA-06.

The salt deposit was observed on the interior wall of the crucible above the melt line and/or forming a ring around the glass at the melt line/crucible interface after the initial melts of SPA-20, SPA-23, SPA-24, and SPA-26. A sample of the salt, obtained from the initial SPA-24 melt, was chemically analyzed using ICP. It was found to be high in Cr and alkali (Na, K, Li, Sr) leading to the conclusion of a salt-layer formation.

Given that Cr_2O_3 has a significant impact on the T_L of these test glasses, an alternate batching/melting technique was used to minimize the potential for salt formation. This technique proved successful in eliminating the salt-layer formation and incorporating the Cr_2O_3 into the glass, thus yielding a better opportunity to meet the original programmatic objectives for these glasses. The four glasses produced using the alternative melting technique are labeled as SPA-20A, SPA-23A, SPA-24A, and SPA-26A to distinguish them from the original melts in which a yellow salt layer was observed.

One of the more common characteristics associated with the SPA glasses was the formation of a dull-brown cross section in the pour patty. Based on XRD and SEM/EDS analysis, this layer was a result of devitrification that occurred upon slower cooling within the bulk. A thin glassy layer resulting from the rapid quench was also observed in these samples, providing more evidence that the interior or bulk crystallization occurred as the glass cooled (no impact of crystallization [at least on a gross scale] within the system at temperature). Both XRD and SEM/EDS analysis of these crystals indicated spinel-type minerals, as the crystals were enriched in Fe, Ni, Mn, and Cr. It is hypothesized that the high density or concentration of crystals in the bulk imparts the dull-brown appearance to the cross section of select SPA glasses.

Metallic streaks, spots, coatings, or haze on the top surface of the pour patty characterized several of the SPA glasses. In fact, SPA-19 was characterized as having a “mirror-like” or “metallic coating” on the surface. SEM/EDS and XRD analysis indicated the presence of spinel-type crystals—extremely small and densely populating the surface of these pour patties presumably led to the metallic appearance observed.

The last major characteristic of the SPA glasses was associated with one glass: SPA-06. This particular sample showed swirls of a different color within the glass. It was not analyzed further to ascertain the primary cause or compositional differences between the two phases.

With respect to the primary deliverable to PNNL, the analysis confirmed that targeted compositions were indeed met within measurement uncertainty. To confirm that the “as-fabricated” glasses corresponded to the defined target compositions, a representative sample from each SPA glass pour patty was chemically analyzed according to an analytical plan. The analytical plan was developed in such a way as to provide the opportunity to evaluate potential sources of error. To assess the performance of the ICP over the course of these analyses and for potential bias-correction needs, multi-element solution standards and glass standards were intermittently measured.

Reviewing the information in Table C.6 and the plots of Exhibit C.10 resulted in several high-level observations regarding target versus measured compositions regarding individual oxides for select SPA glasses. However, overall, the general observations regarding the comparisons between the measured and targeted compositions suggested that:

(1) SPA-10 was potentially misbatched given the large number of oxides/anions that show relative significant differences between target and measured values

(2) SPA-20A and SPA-24A may have been mislabeled or switched during the fabricating process or during analysis given the differences between SPA-20A and SPA-24A measurements because some of the oxides are mirror images.

To address the first major issue, the SPA-10 batch sheet was reviewed to ensure that there was not a gross weighing error recorded relative to the required amounts of each raw material. This review provided no indication that the measured composition should be dramatically different than targeted. Before refabricating this particular glass, a second sample was analyzed. This sample was not submitted under the analytical plan, although routine procedures were used for the required dissolutions and measurements, and a glass standard was also submitted. Although the remeasurement sum of oxides was low (but acceptable, given all the minor components not measured) compared to those from the original measurements under the analytical plan, almost all of the oxides are within the ±5% relative difference of targeted values. The remeasured values provide a high confidence (especially when coupled with the review of the associated batch-sheet entries) that the targeted SPA-10 composition was indeed met—thus this glass was not refabricated. This statement was based on the assumption that issues (although unidentified) with the initial measurements caused the relative differences to exceed 10% for almost all major components (i.e., > 0.5 wt% in glass) and that the single remeasurement accurately reflects the as-fabricated glass composition. It should be noted that in an attempt to identify the possible source(s) of error for these initial differences, the glass standard measurements were reviewed, which indicated no practical problems with the original analysis.

The second major general observation regarding the comparisons between the measured and targeted compositions was the hypothesis that SPA-20A and SPA-24A may have been mislabeled or switched during fabrication, analysis, or reporting. This is based on the fact that the differences between SPA-20A and SPA-24A measurements for some of the major oxides are mirror images. As with SPA-10, representative samples from the archived glasses were obtained and reanalyzed. Samples were labeled according to the identification or nomenclature that appeared on the container to determine if the samples were switched during the fabrication process, mislabeled, or switched during preparation and/or analysis. The remeasured values were consistent with the initial values for both SPA-20A and SPA-24A. The results of the remeasurements indicate that the samples were switched or mislabeled during the fabrication process not during sample preparation, analysis, or reporting. It should be noted that the samples provided to PNNL for subsequent property measurements were also likely switched. This information was transmitted to PNNL, who analyzed the SPA-20A and SPA-24A "as received" samples using SEM/EDS. Their analysis confirmed that the samples they tested had also been switched.

Overall, the results suggest that there are no practical differences between the target and measured compositions of the SPA glasses within measurement uncertainties.

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APPENDIX A

ANALYTICAL PLAN FOR MEASURING THE CHEMICAL COMPOSITIONS OF GLASSES FOR HANFORD'S T_L STUDY

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WESTINGHOUSE SAVANNAH RIVER COMPANY

INTEROFFICE MEMORANDUM

SRT-SCS-2001-00032

August 15, 2001

To: D. K. Peeler

cc:
D. R. Best, 773-41A (wo)
K. G. Brown, 773-42A
E. W. Holtzscheiter, 773-A (es)
S. L. Marra, 704-1T
D. J. Pittman, 786-1A
E. P. Shine, 773-42A
P A. Toole, 773-A
R. C. Tuckfield, 773-42A

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

wo – without glass identifiers
es – executive summary only

E. P. Shine, Technical Reviewer — 8/19/2001 Date

R. C. Tuckfield, Manager, Statistical Consulting Section — 8/20/01 Date

AN ANALYTICAL PLAN FOR MEASURING THE CHEMICAL COMPOSITIONS OF GLASSES FOR HANFORD'S T_L STUDY (U)

1.0 INTRODUCTION

Glass compositions were selected by the Pacific Northwest National Laboratory (PNNL) for batching and testing as part of a Tanks Focus Area task [1] to provide data to update the interim Hanford high level waste (HLW) glass liquidus temperature, T_L, models for use in that site's flowsheet software. These models relate the liquidus temperature of glasses in the spinel, acmite, and zirconia containing primary phase fields to the compositions of these glasses.

The Hanford Site in Southeastern Washington State has underground waste tanks containing HLW generated from over four decades of nuclear fuel processing and actinide separations. These wastes will be retrieved from the tanks, separated into high-level waste (HLW) and low-activity waste (LAW) fractions, and separately vitrified. Washed and leached tank solids and radionuclides separated from the liquid fraction of the waste comprise the HLW fraction. The glasses being considered in this analytical plan support the development of property models for HLW glasses in the spinel primary field.

The chemical compositions of these study glasses (referred to as "SPA" 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 these measurements at the SRTC-ML.

2.0 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 (SP), and each glass is to be prepared once using a potassium hydroxide (PH) dissolution method.

The primary measurements of interest are to be acquired as follows: the samples prepared by lithium metaborate (LM) are to be measured for aluminum (Al), bismuth (Bi), calcium (Ca), cadmium (Cd), cerium (Ce), chromium (Cr), iron (Fe), potassium (K), lanthanum (La), magnesium (Mg), manganese (Mn), sodium (Na), neodymium (Nd), nickel (Ni), phosphorous (P), lead (Pb), sulfur (S), silicon (Si), strontium (Sr), thorium (Th), titanium (Ti), uranium (U), zinc (Zn), and zirconium (Zr) concentrations. Samples prepared by sodium peroxide (SP) are to be measured for boron (B) and lithium (Li). Samples prepared by potassium hydroxide (PH) are to be measured for chloride (Cl^-) and fluoride (F^-). Samples dissolved by either of the first two preparation methods are to be measured using Inductively Coupled Plasma (ICP) – Atomic Emission Spectrometry (AES). The chloride (Cl^-) and fluoride (F^-) concentrations in the samples prepared using potassium hydroxide are to be measured by Ion Chromatography (IC). It should be noted that there are minor components associated with the SPA glasses that will not be measured due to their concentration being below detection limits of the ICP. These minor components include Ag, As, Ba, Co, Cs, Cu, Mo, Pd, Rh, Ru, Sb, Se, Te, V, and Y.

Randomizing the preparation steps and blocking and randomizing the measurements for both the ICP and IC 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 and anion concentrations for the submitted glass samples primarily involve the dissolution step in the preparation of the sample and the calibrations of the two instruments.

Samples of three standard glasses will be included in the analytical plan in order to check instrument performance over the course of the analyses and for potential bias-correction. Specifically, several samples of WCP Batch 1 (BCH) [2] and a LRM [3] standard that contains chloride and fluoride are also included in this plan. Samples of a glass containing uranium (UST) will also be included in this analytical plan. The reference compositions of these glasses are provided in Table 1. These standards will be referenced using the short identifier provided in Table 1 in the remainder of this memo.

Table 1: Oxide Compositions of WCP Batch 1 (BCH), Uranium Standard (UST) and Low Level Reference Material Glasses (wt%).

Oxide/ Anion	BCH (wt%)	UST (wt%)	LRM (wt%)
Al_2O_3	4.877	4.1	10.0
B_2O_3	7.777	9.209	8.0
BaO	0.151	0.00	0.005
CaO	1.220	1.301	0.5
CdO	0.00	0.00	0.2
Cl	0.00	0.00	0.8
Cr_2O_3	0.107	0.00	0.2
Cs_2O	0.060	0.00	0.0
CuO	0.399	0.00	0.00
F	0.00	0.00	1.0
Fe_2O_3	12.839	13.196	1.0
K_2O	3.327	2.999	1.5
Li_2O	4.429	3.057	0.1
MgO	1.419	1.21	0.1
MnO	1.726	2.892	0.1
MoO_3	0.00	0.00	0.1
Na_2O	9.003	11.795	20.0
Nd_2O_3	0.147	0.00	0.00
NiO	0.751	1.12	0.1
P_2O_5	0.00	0.00	0.5
PbO	0.00	0.00	0.1
RuO_2	0.0214	0.00	0.00
SiO_2	50.22	45.353	54.37
SnO_2	0.00	0.00	0.1
SO_3	0.00	0.00	0.2
TiO_2	0.677	1.049	0.1
U_3O_8	0.00	2.406	0.00
ZrO_2	0.098	0.00	1.0

Each glass sample submitted to SRTC-ML will be prepared in duplicate by the LM and SP dissolution methods. Each sample prepared using LM or SP will be read twice by ICP-AES, with the instrument being calibrated before each of these two sets of readings. Each glass sample submitted to SRTC-ML will also be prepared in once using the PH method, and each prepared sample will be read twice by IC, with the instrument being calibrated before each of the readings. This will lead to four measurements for each cation and two measurements for each anion of interest for each submitted glass.

Table 2 presents identifying codes, H01 through H45, for the 45 SPA glasses batched as part of this T_L study. The table provides a naming convention that is to be used in analyzing the glasses and reporting the measurements of their compositions.[(a)] The identifying codes for SPA-41 through SPF-45 have an "*" as a suffix. This convention is used throughout the report to indicate that these glasses contain uranium and thorium, which will require special handling as compared to the other 40 non-radioactive SPA glasses.

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

Glass ID	Sample ID	Glass ID	Sample ID	Glass ID	Sample ID
SPA-01	H04	SPA-16	H42	SPA-31	H34
SPA-02	H16	SPA-17	H40	SPA-32	H44
SPA-03	H12	SPA-18	H38	SPA-33	H07
SPA-04	H21	SPA-19	H39	SPA-34	H15
SPA-05	H08	SPA-20	H23	SPA-35	H13
SPA-06	H17	SPA-21	H05	SPA-36	H30
SPA-07	H35	SPA-22	H10	SPA-37	H24
SPA-08	H18	SPA-23	H14	SPA-38	H27
SPA-09	H26	SPA-24	H28	SPA-39	H19
SPA-10	H33	SPA-25	H01	SPA-40	H31
SPA-11	H09	SPA-26	H20	SPA-41	H36*
SPA-12	H06	SPA-27	H29	SPA-42	H03*
SPA-13	H37	SPA-28	H02	SPA-43	H41*
SPA-14	H25	SPA-29	H45	SPA-44	H22*
SPA-15	H11	SPA-30	H32	SPA-45	H43*

In the plan that follows, the identifiers of study and standard glass samples that contain uranium and/or thorium are marked with an asterisk as in Table 2. The scheme blocks these samples by preparation and measurement groups in order to facilitate special handling required for radioactive samples.

2.1 PREPARATION OF THE SAMPLES

Each of the 45 SPA glasses included in this analytical plan is to be prepared in duplicate by the LM and SP dissolution methods and once by the PH method. Thus, the total number of prepared glass samples is determined by $45 \cdot 2 \cdot 2 + 45 \cdot 1 \cdot 1 = 225$, not including the samples of the BCH, LRM, and UST glass standards that are to be prepared. Only the LRM standard is to be prepared by PH since the other standards do not contain Cl^- or F^-.

Tables 3a through 3c provide blocking and (random) sequencing schema for conducting the steps of the analytical procedures. Three blocks of preparation work are 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. As seen in these tables, fifteen SPA glasses are grouped together to allow for their preparation in duplicate in a single block for the LM and SP methods and individually in a single block for the

(a) 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 those copies going to the SRTC-ML.

PH method. The block size for the PH method is smaller due to more time-consuming aspects of this preparation method.

Table 3a: LM (Lithium Metaborate) Preparation Blocks

1	2	3
H39LM1	H09LM1	H41*LM1
H25LM1	H42LM1	H16LM1
H37LM1	H20LM1	H36*LM1
H13LM1	H42LM2	H26LM1
H21LM1	H31LM1	H36*LM2
H21LM2	H45LM1	H05LM1
H39LM2	H01LM1	H05LM2
H33LM1	H09LM2	H22*LM1
H13LM2	H31LM2	H38LM1
H11LM1	H18LM1	H16LM2
H28LM1	H20LM2	H32LM1
H34LM1	H10LM1	H32LM2
H35LM1	H14LM1	H12LM1
H37LM2	H01LM2	H41*LM2
H33LM2	H45LM2	H22*LM2
H27LM1	H08LM1	H38LM2
H04LM1	H18LM2	H06LM1
H27LM2	H30LM1	H06LM2
H25LM2	H40LM1	H07LM1
H28LM2	H02LM1	H26LM2
H34LM2	H10LM2	H44LM1
H29LM1	H24LM1	H43*LM1
H29LM2	H17LM1	H44LM2
H11LM2	H14LM2	H23LM1
H15LM1	H08LM2	H03*LM1
H35LM2	H40LM2	H12LM2
H04LM2	H02LM2	H43*LM2
H19LM1	H24LM2	H07LM2
H15LM2	H30LM2	H03*LM2
H19LM2	H17LM2	H23LM2

Table 3b: SP (Sodium Peroxide) Preparation Blocks

1	2	3
H30SP1	H34SP1	H22*SP1
H01SP1	H29SP1	H36*SP1
H01SP2	H14SP1	H02SP1
H45SP1	H34SP2	H02SP2
H21SP1	H12SP1	H17SP1
H10SP1	H14SP2	H17SP2
H24SP1	H42SP1	H26SP1
H45SP2	H09SP1	H03*SP1
H40SP1	H29SP2	H05SP1
H21SP2	H38SP1	H41*SP1
H07SP1	H25SP1	H43*SP1
H33SP1	H12SP2	H22*SP2
H23SP1	H06SP1	H36*SP2
H40SP2	H27SP1	H05SP2
H28SP1	H09SP2	H03*SP2
H24SP2	H35SP1	H11SP1
H07SP2	H42SP2	H20SP1
H10SP2	H37SP1	H04SP1
H19SP1	H35SP2	H13SP1
H33SP2	H31SP1	H26SP2
H18SP1	H15SP1	H39SP1
H30SP2	H08SP1	H16SP1
H32SP1	H08SP2	H11SP2
H23SP2	H27SP2	H39SP2
H18SP2	H06SP2	H41*SP2
H19SP2	H37SP2	H16SP2
H44SP1	H25SP2	H20SP2
H28SP2	H38SP2	H43*SP2
H32SP2	H31SP2	H04SP2
H44SP2	H15SP2	H13SP2

Table 3c: PH (Potassium Hydroxide) Preparation Blocks

1	2	3
H27PH1	H10PH1	H17PH1
H45PH1	H33PH1	H43*PH1
H26PH1	H13PH1	H03*PH1
H11PH1	H20PH1	H36*PH1
H02PH1	H40PH1	H06PH1
H23PH1	H14PH1	H28PH1
H08PH1	H21PH1	H12PH1
H24PH1	H35PH1	H15PH1
H16PH1	H39PH1	H32PH1
H44PH1	H09PH1	H30PH1
H01PH1	H38PH1	H41*PH1
H19PH1	H05PH1	H34PH1
H25PH1	H29PH1	H18PH1
H31PH1	H37PH1	H22*PH1
H07PH1	H42PH1	H04PH1

2.2 ICP Calibration Blocks

The glass samples prepared by LM and SP dissolution methods are to be analyzed using ICP instrumentation calibrated for the particular preparation method. After the initial set of cation concentration measurements, the ICP 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 SP-prepared samples are provided in Tables 4 and 5, respectively. The cations to be measured are specified in the header of each of these tables. In these tables, the sample identifiers for the 45 SPA 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 calibration group. The identifiers for the BCH, LRM, and UST samples have been 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. The UST samples are to be measured only in the ICP blocks of the LM-prepared glasses that include the samples containing uranium and/or thorium.

Table 4: ICP Blocks and Calibration Groups for Samples Prepared Using LM
(Used to Measure Elemental Al, Bi, Ca, Cd, Ce, Cr, Fe, K, La, Mg, Mn, Na, Nd, Ni, P, Pb, S, Si, Sr, Th, Ti, U, Zn, and Zr)

ICP Block 1		ICP Block 2		ICP Block 3		ICP Block 4		ICP Block 5	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHLM111	BCHLM121	BCHLM211	BCHLM221	BCHLM311	BCHLM321	BCHLM411	BCHLM421	BCHLM511	BCHLM521
LRMLM111	LRMLM121	LRMLM211	LRMLM221	LRMLM311	LRMLM321	LRMLM411	LRMLM421	LRMLM511	LRMLM521
H02LM11	H02LM22	H24LM21	H45LM22	H18LM11	H18LM22	H11LM21	H05LM12	USTLM511	USTLM521
H33LM21	H13LM12	H23LM11	H42LM12	H34LM11	H17LM22	H26LM21	H25LM22	H01LM11	H22*LM22
H13LM21	H02LM12	H35LM11	H24LM12	H21LM11	H15LM22	H04LM21	H04LM12	H36*LM21	H03*LM22
H44LM11	H32LM12	H24LM11	H37LM12	H28LM11	H34LM12	H05LM21	H20LM22	H41*LM21	H41*LM22
H44LM21	H38LM22	H35LM21	H40LM22	H30LM21	H08LM22	H07LM11	H25LM12	H41*LM11	H43*LM12
H32LM11	H33LM12	H37LM21	H19LM12	H10LM11	H10LM22	H39LM21	H39LM12	H09LM11	H31LM12
H14LM11	H44LM12	H23LM21	H42LM22	H18LM21	H30LM12	H04LM11	H07LM22	H06LM11	H06LM22
H33LM11	H38LM12	H40LM11	H40LM12	H17LM11	H21LM12	H25LM21	H27LM12	H22*LM11	H31LM22
H29LM21	H29LM22	H40LM21	H12LM12	H08LM21	H34LM22	H26LM11	H11LM12	H22*LM21	H09LM12
BCHLM112	BCHLM122	BCHLM212	BCHLM222	BCHLM312	BCHLM322	BCHLM412	BCHLM422	H36*LM11	H36*LM22
LRMLM112	LRMLM122	LRMLM212	LRMLM222	LRMLM312	LRMLM322	LRMLM412	LRMLM422	BCHLM512	BCHLM522
H32LM21	H33LM22	H37LM11	H35LM12	H21LM21	H21LM22	H07LM21	H26LM22	LRMLM512	LRMLM522
H14LM21	H13LM22	H12LM11	H19LM22	H08LM11	H08LM12	H39LM11	H04LM22	USTLM512	USTLM522
H29LM11	H16LM22	H45LM11	H45LM12	H17LM21	H10LM12	H05LM11	H26LM12	H31LM21	H01LM12
H13LM11	H14LM12	H42LM21	H35LM22	H28LM21	H28LM12	H27LM21	H20LM12	H31LM11	H01LM22
H38LM11	H32LM22	H42LM11	H37LM22	H15LM11	H17LM12	H11LM11	H07LM12	H03*LM11	H36*LM12
H38LM21	H14LM22	H12LM21	H12LM22	H15LM21	H30LM22	H20LM21	H05LM22	H01LM21	H03*LM12
H16LM21	H16LM12	H19LM21	H23LM12	H34LM21	H28LM22	H20LM11	H11LM22	H06LM21	H09LM22
H02LM21	H29LM12	H19LM11	H24LM22	H10LM21	H15LM12	H27LM11	H27LM22	H09LM21	H43*LM22
H16LM11	H44LM22	H45LM21	H23LM22	H30LM11	H18LM12	H25LM11	H39LM22	H03*LM21	H06LM12
BCHLM113	BCHLM123	BCHLM213	BCHLM223	BCHLM313	BCHLM323	BCHLM413	BCHLM423	H43*LM21	H41*LM12
LRMLM113	LRMLM123	LRMLM213	LRMLM223	LRMLM313	LRMLM323	LRMLM413	LRMLM423	H43*LM11	H22*LM12
								BCHLM513	BCHLM523
								LRMLM513	LRMLM523
								USTLM513	USTLM523

Table 5: ICP Blocks and Calibration Groups for Samples Prepared Using SP
(Used to Measure Elemental B and Li)

ICP Block 1		ICP Block 2		ICP Block 3		ICP Block 4		ICP Block 5	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**	**Calibration 1**	**Calibration 2**
BCHSP111	BCHSP121	BCHSP211	BCHSP221	BCHSP311	BCHSP321	BCHSP411	BCHSP421	BCHSP511	BCHSP521
LRMSP111	LRMSP121	LRMSP211	LRMSP221	LRMSP311	LRMSP321	LRMSP411	LRMSP421	LRMSP511	LRMSP521
H02SP11	H02SP22	H24SP21	H45SP22	H18SP11	H18SP22	H11SP21	H05SP12	H01SP11	H22*SP22
H33SP21	H13SP12	H23SP11	H42SP12	H34SP11	H17SP22	H26SP21	H25SP22	H36*SP21	H03*SP22
H13SP21	H02SP12	H35SP11	H24SP12	H21SP11	H15SP22	H04SP21	H04SP12	H41*SP21	H41*SP22
H44SP11	H32SP12	H24SP11	H37SP12	H28SP11	H34SP12	H05SP21	H20SP22	H41*SP11	H43*SP12
H44SP21	H38SP22	H35SP21	H40SP22	H30SP21	H08SP22	H07SP11	H25SP12	H09SP11	H31SP12
H32SP11	H33SP12	H37SP21	H19SP12	H10SP11	H10SP22	H39SP21	H39SP12	H06SP11	H06SP22
H14SP11	H44SP12	H23SP21	H42SP22	H18SP21	H30SP12	H04SP11	H07SP22	H22*SP11	H31SP22
H33SP11	H38SP12	H40SP11	H40SP12	H17SP11	H21SP12	H25SP21	H27SP12	H22*SP21	H09SP12
H29SP21	H29SP22	H40SP21	H12SP12	H08SP21	H34SP22	H26SP11	H11SP12	H36*SP11	H36*SP22
BCHSP112	BCHSP122	BCHSP212	BCHSP222	BCHSP312	BCHSP322	BCHSP412	BCHSP422	BCHSP512	BCHSP522
LRMSP112	LRMSP122	LRMSP212	LRMSP222	LRMSP312	LRMSP322	LRMSP412	LRMSP422	LRMSP512	LRMSP522
H32SP21	H33SP22	H37SP11	H35SP12	H21SP21	H21SP22	H07SP21	H26SP22	H31SP21	H01SP12
H14SP21	H13SP22	H12SP11	H19SP22	H08SP11	H08SP12	H39SP11	H04SP22	H31SP11	H01SP22
H29SP11	H16SP22	H45SP11	H45SP12	H17SP21	H10SP12	H05SP11	H26SP12	H03*SP11	H36*SP12
H13SP11	H14SP12	H42SP21	H35SP22	H28SP21	H28SP12	H27SP21	H20SP12	H01SP21	H03*SP12
H38SP11	H32SP22	H42SP11	H37SP22	H15SP11	H17SP12	H11SP11	H07SP12	H06SP21	H09SP22
H38SP21	H14SP22	H12SP21	H12SP22	H15SP21	H30SP22	H20SP21	H05SP22	H09SP21	H43*SP22
H16SP21	H16SP12	H19SP21	H23SP12	H34SP21	H28SP22	H20SP11	H11SP22	H03*SP21	H06SP12
H02SP21	H29SP12	H19SP11	H24SP22	H10SP21	H15SP12	H27SP11	H27SP22	H43*SP21	H41*SP12
H16SP11	H44SP22	H45SP21	H23SP22	H30SP11	H18SP12	H25SP11	H39SP22	H43*SP11	H22*SP12
BCHSP113	BCHSP123	BCHSP213	BCHSP223	BCHSP313	BCHSP323	BCHSP413	BCHSP423	BCHSP513	BCHSP523
LRMSP113	LRMSP123	LRMSP213	LRMSP223	LRMSP313	LRMSP323	LRMSP413	LRMSP423	LRMSP513	LRMSP523

2.3 IC Calibration Blocks

The glass samples prepared once by the potassium hydroxide (PH) dissolution method are to be analyzed using IC instrumentation, appropriately calibrated. After the initial set of anion concentration measurements, the IC instrumentation is to be recalibrated and a second set of concentration measurements for the anions determined. A (randomized) plan for measuring the concentrations in the prepared samples is provided in Table 6.

In this table, the convention for the sample identifiers and sample groupings follows that of Tables 4 and 5. The only standard glass included in this set of analyses is LRM since it is the only standard out of the three used here to contain chloride and fluoride (see Table 1).

Table 5: IC Blocks and Calibration Groups for Samples Prepared Using PH
(Used to Measure the anions Cl^- and F^-)

IC Block 1		IC Block 2	
Calibration 1	**Calibration 2**	**Calibration 1**	**Calibration 2**
LRMPH111	LRMPH121	LRMPH211	LRMPH221
H29PH11	H13PH12	H11PH11	H09PH12
H21PH11	H44PH12	H27PH11	H04PH12
H17PH11	H26PH12	H05PH11	H33PH12
H38PH11	H29PH12	H12PH11	H41*PH12
H35PH11	H38PH12	H07PH11	H11PH12
H39PH11	H34PH12	H02PH11	H05PH12
H15PH11	H24PH12	H37PH11	H27PH12
H45PH11	H35PH12	H41*PH11	H23PH12
H34PH11	H31PH12	H18PH11	H10PH12
H40PH11	H15PH12	H43*PH11	H07PH12
H44PH11	H45PH12	H01PH11	H01PH12
LRMPH112	LRMPH122	LRMPH212	LRMPH222
H16PH11	H16PH12	H20PH11	H20PH12
H26PH11	H39PH12	H23PH11	H37PH12
H31PH11	H17PH12	H32PH11	H06PH12
H24PH11	H14PH12	H04PH11	H32PH12
H19PH11	H42PH12	H36*PH11	H03*PH12
H42PH11	H08PH12	H10PH11	H02PH12
H13PH11	H40PH12	H03*PH11	H43*PH12
H25PH11	H21PH12	H06PH11	H12PH12
H28PH11	H30PH12	H22*PH11	H36*PH12
H14PH11	H25PH12	H09PH11	H22*PH12
H08PH11	H28PH12	H33PH11	H18PH12
H30PH11	H19PH12	LRMPH213	LRMPH223
LRMPH113	LRMPH123		

3.0 CONCLUDING COMMENTS

In summary, this analytical plan identifies several ICP calibration blocks in Tables 4 – 5 as well as nine preparation blocks in Table 3 and several IC blocks in Table 6 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.

In this plan, the identifiers of study and standard glass samples that contain uranium and/or thorium are marked with an asterisk as in Table 2. The scheme used to block these samples for preparation and measurement groups these samples together to facilitate the special handling that they require (as compared to the non-radioactive samples).

If a problem is discovered during the process of measuring the samples in a calibration block, the instrument should be re-calibrated and the block of samples re-measured in its entirety. If for some reason the measurements are not conducted in the sequences presented in this report, a record should be made of the actual order used along with any explanative comments.

The analytical plan described in the preceding tables 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.

4.0 REFERENCES

[1] Vienna, J. D., G. F. Piepel, P. Hrma, and S. K. Cooley, “Test Plan for Updating the Hanford HLW Glass Liquidus Temperature Models,” TFA-IMM-01-01, June 29, 2001.

[2] 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-93-672, Rev. 1, Volume 2, Table B.1, pp. B.9, 1995.

[3] Peeler, D.K., A.D. Cozzi, D.R. Best, C.J. Coleman, and I.A. Reamer, “Characterization of the Low Level Waste Reference Glass (LRM),” WSRC-TR-99-00095, Rev. 0, 1999.

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APPENDIX B

MELTING OBSERVATIONS

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Glass	T_{M1} Observations	T_{M2} Observations	T_{M3} Observations
SPA-01	A few metallic spots on surface of pour patty, light brown swirls on surface potentially a result of "stringers" from end of pour, undissolved spots on surface of pour patty, crucible remains contain undissolved solids	Single phase	NA
SPA-02	Crucible remains contain undissolved solids, metallic shine or haze on crucible remains, bulk of pour patty contained thin glassy layer on the quenched bottom, cross section is dull brown, surface of pour patty contains brownish swirls with metallic shine. Glass poured slow compared to previous melts, indicating high viscosity, potential undissolved solids on surface (spots)	Surface glassy/shiny with slight haze, cross section dull, indicating possible devitrification, thin glassy layer on bottom of pour patty	NA
SPA-03	Pour patty black and shiny, light-brown streaks on top and bottom, residual crucible glass also contained brownish streaks	Single phase	NA
SPA-04	Pour patty, cross section and residual crucible glass characterized by dull brown streaks	Black/brown streaks on surface of pour patty, no "haze" detectable, "leopard" spots on bottom of pour patty, residual crucible glass is black and shiny, but a light-brown layer surrounds edges where glass was poured up crucible wall	NA
SPA-05	Single phase	Single phase	NA
SPA-06	Major "swirls"; light-brown and dark-brown swirls	Major "swirls"; light-brown and dark-brown swirls	Major "swirls"; light-brown and dark-brown swirls, third melt at

			1150°C
SPA-07	Pour patty is black and shiny, 3-in. long x 1/16 in. metallic line/streak across surface, crucible remains contain undissolved solids	Single phase, black and shiny, glass poured very fast, indicating low viscosity	NA
SPA-08	Single-phased pour patty, a few spots of undissolved in residual crucible glass	Single phase	NA
SPA-09	Crucible remains contained a small amount of undissolved solids, pour patty is a black, shiny glass, “metallic streaks” and a few spots of undissolved on the surface	Clean surface with the exception of 2 - 3 metallic spots, cross section appears dull indicating possible devitrification, thin glassy layer on bottom of pour patty	NA
SPA-10	Pour patty is black and shiny with a few spots of undissolved solids on surface, metallic spots on surface, pour patty also characterized by light brown streaks on surface resulting from glass at end of pour	Pour patty characterized by thin layer of glass on bottom, dull brown cross section, surface black/brown, also note the last glass poured resulted in brown swirls on surface (from crucible stringers), a couple of large metallic looking spots on surface	NA
SPA-11	Pour patty is black and shiny with a few spots of undissolved solids on surface, metallic spots on bottom of pour patty, residual crucible glass is black and shiny with undissolved solids	Pour patty characterized by thin layer of glass on bottom, dull brown cross section, surface black/brown, also note the last glass poured resulted in brown swirls on surface (from crucible stringers)	NA
SPA-12	Crucible remains contained undissolved solids, pour patty is a black glass but surface has a opaque haze	Pour patty characterized by metallic haze on surface, metallic spots on surface as well, residual crucible glass appears clean	NA
SPA-13	Pour patty was black and shiny with a few spots of potentially undissolved solids on surface, cross section is single-phase and glassy with the exception of a very thin line of dull brown in the center of the cross section, residual crucible glass contains undissolved solids	Pour patty is characterized by metallic haze on surface, cross section is a black and shiny glass, no undissolved solids visible	NA

SPA-14	"Partially reacted"; undissolved solids apparent	Metallic haze on glass surface, no change in melt temp, undissolved solids still present	Third melt at 1150°C, metallic haze on surface, thin glass layer on bottom of glass, bulk appears to be multi-phased (dull brown)
SPA-15	Pour patty characterized by thin glassy layer on bottom, dull brown cross section, with thin metallic haze on surface, residual crucible glass contains a lot of "air bubbles" on bottom, undissolved solids present, metallic haze on residual glass	Pour patty characterized by thin glassy layer on bottom, dull brown cross section, with thin metallic haze on surface, residual crucible glass possibly contains 4 very small spots of undissolved	NA
SPA-16	Black and shiny glass, a few brown streaks on surface of pour patty potentially from "stringers" at end of pour, residual crucible glass characterized by a dull brown layer on the edges of the pour stream, undissolved solids on bottom of crucible	Single phase, residual crucible glass appears clean	NA
SPA-17	A few "hazy" or metallic looking spots on bottom glass pour patty, swirls on surface of pour patty	Single phase	NA
SPA-18	Single phase	Single phase	NA
SPA-19	"Opaque haze" across entire glass surface, cross section single phase, residual crucible glass appears clean	"Metallic coating" / "almost mirror-like" across entire glass surface, cross section single phase	NA
SPA-20A	Pour patty characterized by metallic swirls/spots on surface and bottom, thin glassy layer on bottom, cross section is dull brown, residual crucible glass appears single phase with no evidence of yellow deposit	Pour patty characterized by metallic haze on surface (mirror-like), cross section and bottom of pour patty appear single phase, residual crucible glass appears single phase, no evidence of yellow deposit	Pour patty characterized by metallic haze on surface (mirror-like), cross section and bottom of pour patty appear single phase, residual crucible glass appears single phase, no evidence of yellow deposit

SPA-21	Pour patty characterized by metallic swirls/streaks, large metallic spots on pour patty surface and bottom, “pits or voids” also noticed within the large metallic spots, residual crucible glass has a metallic shine, undissolved solids also present, a “foam like” layer around the melt line also present	Pour patty characterized by metallic swirls/streaks, large metallic spots on pour patty surface and bottom, “pits or voids” also noticed within the large metallic spots, residual crucible glass characterized by metallic shin and spots, no undissolved solids visible	
SPA-22	Single phase	Single phase	NA
SPA-23A	Pour patty characterized by metallic spots/swirls/haze on surface and bottom, thin glassy layer on bottom of pour patty as a result of being quenched on steel plate, cross section is dull brown, no evidence of yellow deposit	Pour patty characterized by metallic haze on surface and bottom, cross section is dull brown, residual crucible glass characterized by dull brown streaks along melt line and a metallic haze covers the glass along the path of the pour, no evidence of yellow deposit	Pour patty characterize by light metallic haze on surface, dull brown cross section, no evidence of yellow deposit
SPA-24A	Pour patty black and shiny, no haze or undissolved solids visible, light brown streaks (from stringers) within surface of pour patty, residual crucible glass appears single phase, no evidence of yellow deposit	Pour patty characterized by metallic haze on surface, cross section and pour patty bottom appear single phase, residual crucible glass also characterized by haze, no evidence of yellow deposit	Pour patty characterized by metallic haze, cross section and bottom of pour patty are single phase, residual crucible glass has haze, no evidence of yellow deposit
SPA-25	Partial coverage of metallic haze on surface, a few metallic spots/swirls on surface, cross section also appears to have metallic spots isolated within bulk, residual crucible glass contains undissolved solids	Metallic haze on glass surface, dull brown cross section, thin glassy layer on bottom of pour patty	NA
SPA-26A	Pour patty is single phase, black and shiny, residual crucible glass is single phase, no evidence of yellow deposit	Pour patty characterized by light metallic haze on surface, cross section of pour patty is single phase, residual crucible glass is single phase, no evidence of yellow deposit	Pour patty characterized by light metallic haze on surface, cross section of pour patty is single phase, residual crucible glass is single phase, no evidence of yellow deposit

SPA-27	Partial coverage of glass surface with metallic haze	Single phase	NA
SPA-28	Pour patty characterized by metallic spots/streaks/swirls on surface and bottom, thin glassy layer also observed on bottom of pour patty as a result of glass being quenched onto steel plate, cross section is dull brown, residual crucible glass contains undissolved solids	Pour patty characterized large metallic spots/swirls, thin glassy layer on bottom of pour patty, cross section dull brown color	NA
SPA-29	Black shiny glass pour patty, thin metallic lines across pour patty, residual crucible glass appears clean, no undissolved solids	Single phase, residual crucible glass appears clean	NA
SPA-30	Pour patty is a black, shiny glass, single phase, crucible remains contain a few spots of potentially undissolved solids	Single phase	NA
SPA-31	Pour patty is a black glass but surface has a opaque haze, crucible remains contains a few spots of undissolved solids	Pour patty characterized by film/haze across entire glass surface, cross section is glassy and single phase	NA
SPA-32	Single phase (perhaps a haze on surface)	Single phase (questionable haze on surface), very small pits on pour patty surface	NA
SPA-33	Crucible remains characterized by undissolved solids, light brown swirls on pour patty surface from “end of glass	Pour patty looks single phase, but residual crucible glass has undissolved solids	Pour patty and residual crucible glass were both single phase
SPA-34	Pour patty characterized by a uniform haze, cross section is glassy and single phase, surface contains swirls with potential undissolved solids, bottom of pour patty is black and shiny but does have a few metallic spots, residual crucible glass has metallic haze, a “foamy” metallic layer exist around the melt line up to the original batch height	Pour patty characterized by metallic haze on surface, a few larger metallic spots, cross section appears to be single phase, a few metallic spots on bottom of pour patty, residual crucible glass is black and shiny with some metallic spots	NA

SPA-35	Pour patty is a black and shiny glass, surface is partially covered with a film/haze, crucible remains appear to be single phase	Single phase	NA
SPA-36	Surface and bottom or pour patty characterized by large metallic spots and numerous swirls/streaks, residual crucible glass characterized by undissolved solids and a "foam-like" layer near the melt line	Pour patty characterized by large metallic spots (with associated voids/pits), and swirls randomly peppering surface, bottom of pour patty has metallic swirls/streaks, residual crucible glass has metallic shin and questionable undissolved solids	NA
SPA-37	Pour patty characterized by metallic spots/islands on surface, metallic swirls/streaks on bottom of pour patty, residual crucible glass contains undissolved solids and metallic spots	Pour patty characterized by metallic spots/islands on surface (with associated "pits/voids"), metallic swirls/streaks on bottom of pour patty, residual crucible glass appears clean	NA
SPA-38	Pour patty black and shiny, a few bubbles and/or undissolved solids may be present just under surface of pour patty (raised bumps on patty), a few very small metallic spots on bottom of patty, residual crucible glass is characterized by metallic shin on glass near top of melt line and pour stream	Single phase	NA
SPA-39	Pour patty is a black and shiny glass, a few spots of undissolved or crystallization on surface, crucible remains contain a few spots (very small) undissolved solids	Single phase	NA
SPA-40	Pour patty is dark brown color with metallic haze on surface, cross section and bottom of pour patty appear to be single phase, residual crucible glass contains a few spots of undissolved solids	Pour patty characterized by metallic haze on surface, cross section and bottom of pour patty appear single phase, residual crucible glass also characterized by haze	NA

SPA-41	Crucible remains contained undissolved solids, pour patty was black and shiny with a few spots of potentially undissolved solids on surface	Black and shiny glass, a couple of spot on surface (questionable undissolved), brown swirls (potentially from end of pour as stringers from crucible contacted pour patty), pour patty much thicker than previous melts indicating high viscosity	NA
SPA-42	Batch did not fully react (partial batch-to-glass conversion), glass was poured, top layer of glass characterized by undissolved solids and "metallic" swirls, the bulk/cross section was characterized by layers of green/brown/green, crucible remains contained undissolved solids	Second melt at 1100°C, pour patty shiny black glass with swirls (brown swirls of crystallization or undissolved solids), spots on the surface (potentially undissolved), bottom of pour patty characterized by a dull film / streaks, crucible remains contained undissolved solids	Black, shiny glass, single phase
SPA-43	First melt at 1150°C for 1 hour batch only partially reacted, 3/4 inch foamy layer on surface, unreacted batch prevalent, did not pour glass but increased temp to 1200°C for an additional hour. Glass poured and was still characterized by undissolved solids on surface of pour patty, small foamy layer still existed, bottom of pour patty contained the thin "glassy" layer but cross section was dull brown in color (potential devitrification), several "metallic" spots on bottom, surface characterized by "islands" of metallic spots, streaks or swirls	After grinding, melt temp increased to 1250°C for "2nd melt", pour patty characterized by the thin glassy layer on bottom (where quenched on steel plate), cross section of pour patty was dull brown, surface contained metallic spots/swirls/streaks, there appeared to be a thin glassy layer on the top surface as well, brown swirls on surface (this could be the result of the dull brown cross section emerging through or from the last glass poured from the crucible)	1300°C, pour patty characterized by thin glassy layer as a result of glass being quenched on stainless steel, cross section is dull brown, surface of pour patty has metallic haze/swirls, residual crucible glass also characterized by metallic haze
SPA-44	Pour patty contains swirls of lighter brown, characterized as a "film", crucible remains were single phase	Black and shiny glass, single phase	NA
SPA-45	Black and shiny glass, light opaque swirls on surface, crucible remains has a few spots of potentially undissolved solids	Crucible remains were clean, light streaks (from end of pour - stringers) characterize surface of pour patty, otherwise pour patty is glassy and single phase	NA

Observations of original melts of SPA-20, SPA-23, SPA-24, and SPA-26 using standard melting procedure. Note: observations of counterpart glasses using alternative melting technique are listed above and are labeled with an "A" to distinguish the two melting procedures and observations.			
SPA-20	Residual crucible is characterized by undissolved solids, metallic haze of residual crucible glass, right along the melt line / menaces a thin layer/line of light yellow, pour patty contains metallic spots, swirls on surface, cross section had thin layer of brown dull layer in center but surrounded by black glass	Pour patty characterized by thin glassy layer on bottom, dull brown cross section, metallic swirls/haze on pour patty surface, residual crucible glass had a metallic haze but no undissolved solids present	NA
SPA-23	Opaque haze on glass surface, yellow deposit on interior walls of crucible, deposit highly soluble in water (6.67 ppm S but unknown or dilution not controlled), thin glassy layer on bottom of pour patty, light and medium brown dull layers in cross section	"Metallic haze" still present but to a lesser degree; thin layer of single-phase glass on bottom of pour patty but cross sectional bulk glass appears "devitrified" or multi-phased (dull brown color)	NA
SPA-24	Pour patty is characterized by metallic haze on surface, possible undissolved solids also on pour patty surface, cross-section appears single phase, yellow deposit coating crucible wall from melt line 2" upward	Pour patty black and shiny, metallic haze on surface, cross section of pour patty appears single phase	NA
SPA-26	Crucible contains air bubbles on bottom surface (after pour), thin layer of yellow around melt line / meniscus, a faint yellow haze also existed from melt line up to original batch height in crucible, pour patty was black and shiny with hazy metallic swirls randomly dispersed, bottom of pour patty clean, small air bubbles on surface of patty	Pour patty characterized by metallic haze on surface, cross section is glassy and single phase, on the bottom of some pour patty pieces a "greenish tint or oil slick looking" pattern exists, residual crucible glass also characterized by metallic haze and numerous bubbles on bottom of crucible	NA

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APPENDIX C

CHEMICAL COMPOSITION ANALYSIS

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Table C.1: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Lithium Metaborate (LM)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Bi	Ca	Cd	Ce	Cr	Fe	K	La	Mg	Mn	Na	Nd	Ni	P	Pb	S	Si	Sr	Th	Ti	U	Zn	Zr
BCHLM111	Batch 1	1	1	1	2.51	<0.01	0.897	<0.01	<0.01	0.069	8.94	2.83	<0.01	0.869	1.32	6.90	0.106	0.570	<0.01	<0.01	<0.01	23.6	<0.01	<0.100	0.394	<0.10	<0.01	0.062
USTLM111	Ustd	1	1	2	1.97	<0.01	0.909	<0.01	<0.01	0.150	8.70	2.36	<0.01	0.687	1.98	8.42	<0.01	0.727	<0.01	<0.01	<0.01	22.8	<0.01	<0.100	0.535	1.98	<0.01	<0.01
H02LM11	SPA-28	1	1	3	5.23	<0.01	0.365	0.774	0.366	0.523	9.48	3.96	0.211	<0.01	2.28	9.49	0.101	0.370	0.065	0.250	0.071	16.0	0.386	<0.100	<0.01	<0.10	1.55	0.971
H33LM21	SPA-10	1	1	4	4.65	3.35	0.712	<0.01	0.328	0.419	8.71	2.33	0.157	<0.01	1.13	10.3	0.076	0.289	0.384	0.205	0.128	19.4	0.137	<0.100	<0.01	<0.10	<0.01	0.626
H13LM21	SPA-35	1	1	5	4.22	<0.01	0.020	0.879	0.368	0.532	4.82	4.00	0.214	<0.01	0.800	12.8	0.108	0.384	0.222	0.258	0.074	17.0	1.75	<0.100	0.719	<0.10	1.58	0.724
H44LM11	SPA-32	1	1	6	3.24	0.017	0.019	<0.01	0.368	0.204	4.79	3.90	0.211	<0.01	2.30	13.0	0.101	0.387	0.554	0.254	0.068	19.8	<0.01	<0.100	<0.01	<0.10	1.55	0.746
H44LM21	SPA-32	1	1	7	3.27	<0.01	0.023	<0.01	0.370	0.207	4.92	3.98	0.214	<0.01	2.33	13.2	0.102	0.428	0.560	0.256	0.064	20.1	<0.01	<0.100	<0.01	<0.10	1.57	0.740
H32LM11	SPA-30	1	1	8	3.25	4.51	1.52	<0.01	0.372	0.499	7.95	2.31	0.216	<0.01	0.803	12.4	0.103	1.10	0.227	0.258	0.075	16.5	<0.01	<0.100	<0.01	<0.10	1.13	0.713
H14LM11	SPA-23	1	1	9	5.21	4.47	0.049	<0.01	0.369	0.557	4.86	3.95	0.212	<0.01	2.32	13.3	0.113	1.50	0.479	0.255	0.072	16.2	<0.01	<0.100	1.18	<0.10	<0.01	0.624
H33LM11	SPA-10	1	1	10	4.64	3.34	0.721	<0.01	0.325	0.411	8.72	2.38	0.155	<0.01	1.12	10.4	0.076	0.287	0.401	0.202	0.134	19.5	0.139	<0.100	<0.01	<0.10	<0.01	0.652
H29LM21	SPA-27	1	1	11	3.40	4.42	0.018	<0.01	0.365	0.521	4.79	3.95	0.211	<0.01	0.792	12.5	0.113	0.397	0.209	0.255	0.070	17.5	1.72	<0.100	1.16	<0.10	<0.01	0.698
BCHLM112	Batch 1	1	1	12	2.49	<0.01	0.897	<0.01	<0.01	0.067	8.73	2.84	<0.01	0.870	1.32	6.84	0.106	0.561	<0.01	<0.01	<0.01	23.4	<0.01	<0.100	0.396	<0.10	<0.01	0.062
USTLM112	Ustd	1	1	13	1.93	<0.01	0.891	<0.01	<0.01	0.145	8.54	2.37	<0.01	0.673	1.94	8.37	<0.01	0.709	<0.01	<0.01	<0.01	22.6	<0.01	<0.100	0.528	1.95	<0.01	<0.01
H32LM21	SPA-30	1	1	14	3.25	4.50	1.52	<0.01	0.373	0.490	7.95	2.26	0.214	<0.01	0.791	12.4	0.103	1.08	0.235	0.251	0.081	16.4	<0.01	<0.100	<0.01	<0.10	1.12	0.746
H14LM21	SPA-23	1	1	15	5.18	4.41	0.025	<0.01	0.365	0.546	4.82	3.95	0.209	<0.01	2.25	13.1	0.110	1.47	0.497	0.248	0.083	16.3	<0.01	<0.100	1.17	<0.10	<0.01	0.664
H29LM11	SPA-27	1	1	16	3.41	4.45	0.016	<0.01	0.369	0.524	4.83	3.96	0.212	<0.01	0.797	12.5	0.113	0.385	0.215	0.257	0.069	17.6	1.72	<0.100	1.17	<0.10	<0.01	0.712
H13LM11	SPA-35	1	1	17	4.23	<0.01	0.025	0.877	0.369	0.527	4.84	3.98	0.213	<0.01	0.796	12.9	0.109	0.395	0.215	0.254	0.076	17.3	1.75	<0.100	0.725	<0.10	1.58	0.727
H38LM11	SPA-18	1	1	18	3.21	<0.01	1.50	<0.01	0.367	0.202	9.52	3.37	0.211	<0.01	0.793	12.0	0.104	0.388	0.237	0.252	0.071	16.6	1.25	<0.100	<0.01	<0.10	0.783	2.11
H38LM21	SPA-18	1	1	19	3.22	<0.01	1.50	<0.01	0.365	0.201	9.49	3.36	0.211	<0.01	0.791	12.0	0.104	0.384	0.229	0.254	0.084	16.6	1.25	<0.100	<0.01	<0.10	0.778	2.08
H16LM21	SPA-02	1	1	20	7.77	<0.01	0.247	1.76	0.372	0.005	9.03	4.98	0.216	<0.01	2.81	8.34	0.108	0.230	0.959	0.254	0.074	13.8	<0.01	<0.100	0.725	<0.10	0.588	<0.01
H02LM21	SPA-28	1	1	21	5.21	<0.01	0.349	0.778	0.361	0.512	9.52	3.95	0.209	<0.01	2.26	9.50	0.100	0.372	0.095	0.253	0.096	16.0	0.379	<0.100	<0.01	<0.10	1.54	1.03
H16LM11	SPA-02	1	1	22	7.81	<0.01	0.248	1.76	0.375	0.005	9.10	4.98	0.217	<0.01	2.82	8.39	0.109	0.230	0.977	0.258	0.068	14.0	<0.01	<0.100	0.728	<0.10	0.590	0.033
BCHLM113	Batch 1	1	1	23	2.49	<0.01	0.895	<0.01	<0.01	0.068	8.98	2.82	<0.01	0.873	1.32	6.86	0.106	0.561	<0.01	<0.01	<0.01	23.4	<0.01	<0.100	0.394	<0.10	<0.01	0.062
USTLM113	Ustd	1	1	24	1.96	<0.01	0.907	<0.01	<0.01	0.149	8.57	2.33	<0.01	0.689	1.99	8.29	<0.01	0.729	<0.01	<0.01	<0.01	22.5	<0.01	<0.100	0.529	1.98	<0.01	<0.01
BCHLM121	Batch 1	1	2	1	2.52	<0.01	0.894	<0.01	<0.01	0.064	9.04	2.81	<0.01	0.869	1.33	6.98	0.104	0.573	<0.01	<0.01	<0.01	24.2	<0.01	<0.100	0.403	<0.10	<0.01	0.061
USTLM121	Ustd	1	2	2	1.96	<0.01	0.895	<0.01	<0.01	0.145	8.69	2.29	<0.01	0.677	1.97	8.50	<0.01	0.725	<0.01	<0.01	<0.01	23.2	<0.01	<0.100	0.531	1.95	<0.01	<0.01
H02LM22	SPA-28	1	2	3	5.27	<0.01	0.353	0.777	0.370	0.520	9.68	3.93	0.210	<0.01	2.31	9.68	0.100	0.374	<0.01	0.248	0.044	16.5	0.393	<0.100	<0.01	<0.10	1.58	1.07
H13LM12	SPA-35	1	2	4	4.25	<0.01	0.023	0.877	0.372	0.533	4.70	3.77	0.211	<0.01	0.802	12.7	0.107	0.405	0.212	0.254	0.049	17.3	1.76	<0.100	0.732	<0.10	1.59	0.731
H02LM12	SPA-28	1	2	5	5.27	<0.01	0.390	0.777	0.366	0.529	9.80	3.99	0.208	<0.01	2.30	9.77	0.099	0.372	0.111	0.247	0.040	16.6	0.402	<0.100	<0.01	<0.10	1.58	1.09
H32LM12	SPA-30	1	2	6	3.22	4.48	1.48	<0.01	0.372	0.503	8.16	2.25	0.212	<0.01	0.803	12.7	0.100	1.10	0.223	0.251	0.039	17.0	<0.01	<0.100	<0.01	<0.10	1.12	0.724
H38LM22	SPA-18	1	2	7	3.23	<0.01	1.47	<0.01	0.365	0.200	9.68	3.33	0.208	<0.01	0.793	12.3	0.101	0.385	0.217	0.247	0.039	17.1	1.24	<0.100	<0.01	<0.10	0.780	2.12
H33LM12	SPA-10	1	2	8	4.69	3.33	0.708	<0.01	0.326	0.413	8.87	2.29	0.152	<0.01	1.12	10.6	0.073	0.291	0.393	0.195	0.096	20.0	0.140	<0.100	<0.01	<0.10	<0.01	0.656
H44LM12	SPA-32	1	2	9	3.28	0.015	0.017	<0.01	0.369	0.203	4.90	3.88	0.210	<0.01	2.32	13.2	0.100	0.388	0.577	0.249	0.047	20.3	<0.01	<0.100	<0.01	<0.10	1.56	0.805
H38LM12	SPA-18	1	2	10	3.25	<0.01	1.49	<0.01	0.370	0.202	9.69	3.35	0.211	<0.01	0.803	12.3	0.103	0.383	0.241	0.252	0.051	17.1	1.26	<0.100	<0.01	<0.10	0.788	2.16
H29LM22	SPA-27	1	2	11	3.44	4.42	0.012	<0.01	0.368	0.527	4.81	3.79	0.210	<0.01	0.801	12.3	0.111	0.388	0.212	0.248	0.040	17.6	1.73	<0.100	1.18	<0.10	<0.01	0.719
BCHLM122	Batch 1	1	2	12	2.50	<0.01	0.936	<0.01	<0.01	0.065	8.82	2.82	<0.01	0.878	1.34	7.00	0.104	0.569	<0.01	<0.01	<0.01	24.2	<0.01	<0.100	0.402	<0.10	<0.01	0.061
USTLM122	Ustd	1	2	13	1.99	<0.01	0.922	<0.01	<0.01	0.149	8.64	2.29	<0.01	0.695	2.02	8.46	<0.01	0.738	<0.01	<0.01	<0.01	23.1	<0.01	<0.100	0.544	1.98	<0.01	<0.01
H33LM22	SPA-10	1	2	14	4.67	3.37	0.705	<0.01	0.328	0.420	8.90	2.26	0.155	<0.01	1.15	10.5	0.075	0.292	0.382	0.201	0.088	20.1	0.138	<0.100	<0.01	<0.10	<0.01	0.642
H13LM22	SPA-35	1	2	15	4.24	<0.01	0.014	0.885	0.373	0.540	4.91	4.03	0.213	<0.01	0.809	13.4	0.108	0.386	0.212	0.254	0.046	17.6	1.76	<0.100	0.735	<0.10	1.60	0.720
H16LM22	SPA-02	1	2	16	7.81	<0.01	0.244	1.78	0.377	0.000	9.08	5.08	0.216	<0.01	2.87	8.61	0.107	0.233	0.951	0.252	0.033	14.1	<0.01	<0.100	0.740	<0.10	0.593	<0.01
H14LM12	SPA-23	1	2	17	5.25	4.47	0.058	<0.01	0.373	0.564	4.89	4.00	0.212	<0.01	2.34	13.7	0.112	1.52	0.485	0.255	0.059	16.7	<0.01	<0.100	1.19	<0.10	<0.01	0.667
H32LM22	SPA-30	1	2	18	3.25	4.50	1.49	<0.01	0.375	0.502	7.97	2.26	0.214	<0.01	0.809	12.8	0.102	1.10	0.224	0.251	0.041	16.8	<0.01	<0.100	<0.01	<0.10	1.14	0.722
H14LM22	SPA-23	1	2	19	5.21	4.41	0.022	<0.01	0.368	0.559	4.80	3.97	0.210	<0.01	2.31	13.4	0.111	1.50	0.488	0.246	0.049	16.7	<0.01	<0.100	1.18	<0.10	<0.01	0.652
H16LM12	SPA-02	1	2	20	7.95	<0.01	0.249	1.796	0.380	<0.01	9.16	5.07	0.217	<0.01	2.89	8.59	0.108	0.234	0.956	0.252	0.056	14.3	<0.01	<0.100	0.742	<0.10	0.599	<0.01
H29LM12	SPA-27	1	2	21	3.45	4.49	0.015	<0.01	0.375	0.537	4.91	3.97	0.213	<0.01	0.814	12.8	0.114	0.397	0.214	0.253	0.047	18.0	1.72	<0.100	1.20	<0.10	<0.01	0.730
H44LM22	SPA-32	1	2	22	3.28	<0.01	0.017	<0.01	0.378	0.208	4.91	3.98	0.215	<0.01	2.38	13.4	0.103	0.465	0.587	0.254	0.051	20.6	<0.01	<0.100	<0.01	<0.10	1.60	0.809
BCHLM123	Batch 1	1	2	23	2.52	<0.01	0.900	<0.01	<0.01	0.066	9.04	2.84	<0.01	0.889	1.35	6.97	0.104	0.573	<0.01	<0.01	<0.01	24.1	<0.01	<0.100	0.401	<0.10	<0.01	0.060
USTLM123	Ustd	1	2	24	1.98	<0.01	0.914	<0.01	<0.01	0.150	8.56	2.33	<0.01	0.700	2.03	8.47	<0.01	0.739	<0.01	<0.01	<0.01	23.1	<0.01	<0.100	0.543	2.00	<0.01	<0.01

Table C.1: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Lithium Metaborate (LM) (continued)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Bi	Ca	Cd	Ce	Cr	Fe	K	La	Mg	Mn	Na	Nd	Ni	P	Pb	S	Si	Sr	Th	Ti	U	Zn	Zr
BCHLM211	Batch 1	2	1	1	2.50	<0.01	0.900	<0.01	<0.01	0.067	9.01	2.78	<0.01	0.871	1.32	6.84	0.104	0.570	<0.01	<0.01	<0.01	23.7	<0.01	<0.10	0.396	<0.10	<0.01	0.063
USTLM211	Ustd	2	1	2	1.98	<0.01	0.918	<0.01	<0.01	0.153	8.81	2.29	<0.01	0.686	1.99	8.29	<0.01	0.744	<0.01	<0.01	<0.01	22.8	<0.01	<0.10	0.539	1.97	<0.01	<0.01
H24LM21	SPA-37	2	1	3	3.90	2.37	0.879	0.646	0.370	0.290	6.71	1.74	0.211	<0.01	1.77	10.4	0.112	1.00	0.433	0.253	0.058	17.0	1.35	<0.10	0.913	<0.10	0.599	2.19
H23LM11	SPA-20	2	1	4	5.16	4.42	1.48	<0.01	0.367	0.205	5.82	3.82	0.210	<0.01	0.791	12.9	0.113	0.378	0.223	0.249	0.040	16.0	<0.01	<0.10	1.18	<0.10	<0.01	2.11
H35LM11	SPA-07	2	1	5	6.71	<0.01	2.27	1.67	0.358	0.857	6.63	<0.01	0.206	<0.01	1.46	11.0	0.096	0.232	<0.01	0.255	0.058	13.5	0.550	<0.10	<0.01	<0.10	1.56	1.03
H24LM11	SPA-37	2	1	6	3.88	2.35	0.871	0.644	0.368	0.280	6.60	1.71	0.209	<0.01	1.74	10.4	0.111	0.973	0.429	0.252	0.052	17.0	1.34	<0.10	0.904	<0.10	0.592	2.19
H35LM21	SPA-07	2	1	7	6.69	<0.01	2.24	1.70	0.362	0.868	6.66	<0.01	0.208	<0.01	1.49	11.0	0.098	0.237	<0.01	0.268	0.052	13.6	0.544	<0.10	<0.01	<0.10	1.57	1.04
H37LM21	SPA-13	2	1	8	5.26	<0.01	0.018	<0.01	0.375	0.508	8.29	0.95	0.215	<0.01	1.89	11.8	0.111	1.18	0.520	0.258	0.048	17.2	<0.01	<0.10	0.889	<0.10	<0.01	0.713
H23LM21	SPA-20	2	1	9	5.20	4.40	1.49	<0.01	0.367	0.205	5.86	3.75	0.209	<0.01	0.789	12.8	0.113	0.379	0.235	0.248	0.053	16.1	<0.01	<0.10	1.17	<0.10	<0.01	2.12
H40LM11	SPA-17	2	1	10	3.23	<0.01	0.015	0.877	0.374	0.200	5.37	3.75	0.213	<0.01	0.802	12.0	0.116	1.54	0.211	0.253	0.048	17.8	<0.01	<0.10	1.19	<0.10	1.58	2.13
H40LM21	SPA-17	2	1	11	3.23	<0.01	0.013	0.865	0.369	0.196	5.37	3.84	0.212	<0.01	0.794	12.4	0.115	1.51	0.205	0.250	0.048	17.9	<0.01	<0.10	1.17	<0.10	1.57	2.11
BCHLM212	Batch 1	2	1	12	2.52	<0.01	0.893	<0.01	<0.01	0.067	9.19	2.69	<0.01	0.872	1.32	6.78	0.104	0.562	<0.01	<0.01	<0.01	23.8	<0.01	<0.10	0.398	<0.10	<0.01	0.063
USTLM212	Ustd	2	1	13	1.97	<0.01	0.916	<0.01	<0.01	0.149	9.05	2.25	<0.01	0.688	1.99	8.31	<0.01	0.731	<0.01	<0.01	<0.01	23.1	<0.01	<0.10	0.541	1.97	<0.01	<0.01
H37LM11	SPA-13	2	1	14	5.27	<0.01	0.036	<0.01	0.356	0.496	8.25	0.93	0.205	<0.01	1.82	11.8	0.105	1.13	0.484	0.245	0.053	17.1	<0.01	<0.10	0.864	<0.10	<0.01	0.673
H12LM11	SPA-03	2	1	15	7.86	3.62	0.019	0.027	0.332	<0.01	8.70	<0.01	0.191	<0.01	0.071	10.1	0.091	0.365	0.039	0.248	0.054	17.6	<0.01	<0.10	0.017	<0.10	<0.01	0.017
H45LM11	SPA-29	2	1	16	3.28	4.44	1.49	<0.01	0.368	0.515	9.30	0.90	0.212	<0.01	0.790	9.50	0.101	0.722	0.208	0.247	0.054	17.1	1.74	<0.10	<0.01	<0.10	1.09	0.706
H42LM21	SPA-16	2	1	17	3.25	4.46	0.011	0.850	0.371	0.525	5.29	0.92	0.213	<0.01	2.30	11.2	0.101	1.01	0.546	0.253	0.045	22.0	1.64	<0.10	<0.01	<0.10	<0.01	0.735
H42LM11	SPA-16	2	1	18	3.23	4.46	0.009	0.853	0.374	0.522	5.10	0.92	0.214	<0.01	2.29	11.2	0.102	1.01	0.527	0.252	0.043	22.0	1.60	<0.10	<0.01	<0.10	<0.01	0.711
H12LM21	SPA-03	2	1	19	7.88	3.64	0.018	0.027	0.368	<0.01	8.71	<0.01	0.212	<0.01	0.071	10.1	0.100	0.366	0.033	0.252	0.051	17.6	<0.01	<0.10	0.017	<0.10	<0.01	<0.01
H19LM21	SPA-39	2	1	20	1.39	<0.01	0.245	<0.01	<0.01	0.187	10.8	0.908	<0.01	0.293	2.32	8.11	<0.01	0.048	<0.01	<0.01	<0.01	23.5	<0.01	<0.10	0.360	<0.10	<0.01	<0.01
H19LM11	SPA-39	2	1	21	1.37	<0.01	0.228	<0.01	<0.01	0.184	10.7	0.896	<0.01	0.291	2.28	7.99	<0.01	0.040	<0.01	0.001	0.025	23.1	<0.01	<0.10	0.356	<0.10	<0.01	0.014
H45LM21	SPA-29	2	1	22	3.28	4.46	1.49	<0.01	0.369	0.510	9.22	0.90	0.213	<0.01	0.793	9.54	0.101	0.726	0.209	0.249	0.064	17.0	1.74	<0.10	<0.01	<0.10	1.10	0.712
BCHLM213	Batch 1	2	1	23	2.51	<0.01	0.916	<0.01	<0.01	0.067	9.28	2.66	<0.01	0.874	1.32	6.79	0.104	0.564	<0.01	<0.01	<0.01	24.1	<0.01	<0.10	0.401	<0.10	<0.01	0.064
USTLM213	Ustd	2	1	24	1.97	<0.01	0.926	<0.01	<0.01	0.150	9.13	2.20	<0.01	0.691	1.99	8.24	<0.01	0.730	<0.01	<0.01	<0.01	23.1	<0.01	<0.10	0.539	1.99	<0.01	<0.01
BCHLM221	Batch 1	2	2	1	2.51	<0.01	0.931	<0.01	<0.01	0.066	8.95	2.82	<0.01	0.869	1.32	6.89	0.106	0.566	<0.01	<0.01	<0.01	23.6	<0.01	<0.10	0.397	<0.10	<0.01	0.063
USTLM221	Ustd	2	2	2	1.96	<0.01	0.926	<0.01	<0.01	0.148	8.71	2.32	<0.01	0.682	1.98	8.34	<0.01	0.726	<0.01	<0.01	<0.01	22.6	<0.01	<0.10	0.538	1.96	<0.01	<0.01
H45LM22	SPA-29	2	2	3	3.27	4.42	1.48	<0.01	0.367	0.503	8.88	1.00	0.210	<0.01	0.786	9.69	0.103	0.720	0.208	0.246	0.051	16.8	1.73	<0.10	<0.01	<0.10	1.11	0.712
H42LM12	SPA-16	2	2	4	3.19	4.40	0.012	0.836	0.371	0.515	4.87	1.01	0.211	<0.01	2.27	11.3	0.103	1.00	0.518	0.249	0.050	21.5	1.59	<0.10	<0.01	<0.10	<0.01	0.710
H24LM12	SPA-37	2	2	5	3.88	2.36	0.878	0.637	0.369	0.277	6.50	1.77	0.210	<0.01	1.75	10.5	0.113	0.971	0.439	0.248	0.048	16.9	1.36	<0.10	0.902	<0.10	0.590	2.22
H37LM12	SPA-13	2	2	6	5.28	<0.01	0.042	<0.01	0.361	0.496	7.96	1.01	0.206	<0.01	1.82	11.8	0.108	1.14	0.504	0.247	0.053	16.8	<0.01	<0.10	0.861	<0.10	<0.01	0.721
H40LM21	SPA-17	2	2	7	3.22	<0.01	0.014	0.853	0.369	0.193	5.25	3.96	0.210	<0.01	0.790	12.4	0.116	1.50	0.208	0.244	0.052	17.8	<0.01	<0.10	1.17	<0.10	1.55	2.13
H19LM12	SPA-39	2	2	8	1.36	<0.01	0.230	<0.01	<0.01	0.181	10.31	1.01	<0.01	0.288	2.27	8.18	0.004	0.040	<0.01	<0.01	<0.01	22.8	<0.01	<0.10	0.353	<0.10	<0.01	<0.01
H42LM22	SPA-16	2	2	9	3.23	4.41	0.014	0.834	0.369	0.519	5.15	1.01	0.211	<0.01	2.28	11.3	0.102	0.998	0.557	0.249	0.049	21.5	1.62	<0.10	<0.01	<0.10	<0.01	0.744
H40LM12	SPA-17	2	2	10	3.21	<0.01	0.018	0.859	0.373	0.197	5.23	3.93	0.211	<0.01	0.795	12.3	0.117	1.53	0.211	0.251	0.051	17.7	<0.01	<0.10	1.18	<0.10	1.56	2.13
H12LM12	SPA-03	2	2	11	7.87	3.62	0.027	0.029	0.334	<0.01	8.33	<0.01	0.191	<0.01	0.069	10.2	0.093	0.365	0.034	0.244	0.043	17.3	<0.01	<0.10	0.017	<0.10	0.012	<0.01
BCHLM222	Batch 1	2	2	12	2.52	<0.01	0.926	<0.01	<0.01	0.066	8.93	2.83	<0.01	0.867	1.32	6.91	0.105	0.563	<0.01	<0.01	<0.01	23.6	<0.01	<0.10	0.397	<0.10	<0.01	0.063
USTLM222	Ustd	2	2	13	1.96	<0.01	0.924	<0.01	<0.01	0.147	8.77	2.32	<0.01	0.673	1.97	8.35	<0.01	0.720	<0.01	<0.01	<0.01	22.7	<0.01	<0.10	0.533	1.95	<0.01	<0.01
H35LM12	SPA-07	2	2	14	6.66	0.010	2.25	1.668	0.355	0.845	6.53	<0.01	0.204	<0.01	1.45	11.2	0.098	0.229	<0.01	0.253	0.056	13.4	0.547	<0.10	<0.01	<0.10	1.54	1.03
H19LM22	SPA-39	2	2	15	1.37	<0.01	0.242	<0.01	<0.01	0.183	10.53	1.00	<0.01	0.288	2.28	8.20	0.005	0.047	<0.01	<0.01	<0.01	23.1	<0.01	<0.10	0.358	<0.10	<0.01	<0.01
H45LM12	SPA-29	2	2	16	3.27	4.39	1.48	<0.01	0.365	0.507	8.93	0.99	0.209	<0.01	0.780	9.64	0.101	0.715	0.203	0.245	0.052	16.8	1.74	<0.10	<0.01	<0.10	1.09	0.704
H35LM22	SPA-07	2	2	17	6.69	0.010	2.23	1.666	0.362	0.859	6.51	<0.01	0.206	<0.01	1.47	11.2	0.099	0.235	<0.01	0.261	0.049	13.4	0.547	<0.10	<0.01	<0.10	1.55	1.04
H37LM22	SPA-13	2	2	18	5.23	<0.01	0.017	<0.01	0.371	0.501	8.01	1.02	0.211	<0.01	1.87	11.8	0.111	1.17	0.515	0.252	0.046	16.9	<0.01	<0.10	0.881	<0.10	<0.01	0.709
H12LM22	SPA-03	2	2	19	7.84	3.59	0.019	0.029	0.365	<0.01	8.43	<0.01	0.208	<0.01	0.068	10.3	0.101	0.360	0.032	0.248	0.036	17.3	<0.01	<0.10	0.017	<0.10	0.011	<0.01
H23LM12	SPA-20	2	2	20	5.16	4.38	1.48	<0.01	0.367	0.201	5.64	3.84	0.207	<0.01	0.778	13.0	0.113	0.371	0.223	0.244	0.044	15.8	<0.01	<0.10	1.16	<0.10	<0.01	2.11
H24LM22	SPA-37	2	2	21	3.88	2.35	0.875	0.632	0.369	0.284	6.56	1.78	0.209	<0.01	1.75	10.5	0.113	0.988	0.429	0.250	0.046	16.9	1.35	<0.10	0.901	<0.10	0.588	2.19
H23LM22	SPA-20	2	2	22	5.17	4.35	1.48	<0.01	0.365	0.200	5.65	3.86	0.207	<0.01	0.777	13.0	0.113	0.372	0.232	0.241	0.051	15.8	<0.01	<0.10	1.16	<0.10	<0.01	2.11
BCHLM223	Batch 1	2	2	23	2.50	<0.01	0.902	<0.01	<0.01	0.065	8.92	2.82	<0.01	0.853	1.31	6.93	0.105	0.560	<0.01	<0.01	<0.01	23.5	<0.01	<0.10	0.394	<0.10	<0.01	0.063
USTLM223	Ustd	2	2	24	1.97	<0.01	0.902	<0.01	<0.01	0.144	8.74	2.33	<0.01	0.668	1.95	8.34	<0.01	0.710	<0.01	<0.01	<0.01	22.5	<0.01	<0.10	0.532	1.95	<0.01	<0.01

Table C.1: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Lithium Metaborate (LM) (continued)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Bi	Ca	Cd	Ce	Cr	Fe	K	La	Mg	Mn	Na	Nd	Ni	P	Pb	S	Si	Sr	Th	Ti	U	Zn	Zr
BCHLM311	Batch 1	3	1	1	2.50	<0.01	0.909	<0.01	<0.01	0.064	8.90	2.86	<0.01	0.863	1.31	6.92	0.104	0.561	<0.01	<0.01	<0.01	23.5	<0.01	<0.10	0.397	<0.10	<0.01	0.062
USTLM311	Ustd	3	1	2	1.98	<0.01	0.922	<0.01	<0.01	0.147	8.66	2.36	<0.01	0.682	1.98	8.36	<0.01	0.727	<0.01	<0.01	<0.01	22.5	<0.01	<0.10	0.538	1.97	<0.01	<0.01
H18LM11	SPA-08	3	1	3	3.64	6.06	2.26	1.67	0.364	0.006	3.09	<0.01	0.207	<0.01	4.31	7.57	0.116	0.223	1.02	0.243	0.058	12.9	<0.01	<0.10	1.74	<0.10	1.53	1.89
H34LM11	SPA-31	3	1	4	5.00	4.27	0.008	<0.01	0.366	0.194	9.51	1.01	0.210	<0.01	0.784	12.0	0.100	0.834	0.433	0.249	0.041	16.7	1.70	<0.10	<0.01	<0.10	<0.01	0.708
H21LM11	SPA-04	3	1	5	4.84	1.36	0.020	<0.01	0.353	<0.01	10.76	5.39	0.203	<0.01	<0.01	9.14	0.107	0.218	1.05	0.243	0.037	15.4	3.46	<0.10	1.18	<0.10	1.51	<0.01
H28LM11	SPA-24	3	1	6	5.27	0.186	1.52	0.834	0.369	0.534	5.85	3.94	0.208	<0.01	2.26	9.80	0.113	0.376	0.214	0.246	0.044	17.1	1.74	<0.10	1.17	<0.10	<0.01	2.13
H30LM21	SPA-36	3	1	7	3.86	2.36	0.877	0.643	0.368	0.316	6.53	1.79	0.209	<0.01	1.74	10.4	0.111	1.00	0.377	0.501	0.051	16.5	1.33	<0.10	0.893	<0.10	0.598	2.11
H10LM11	SPA-22	3	1	8	3.25	2.54	0.077	0.857	0.370	0.197	5.24	3.98	0.211	<0.01	0.790	11.5	0.108	1.11	0.213	0.252	0.044	18.5	<0.01	<0.10	0.527	<0.10	<0.01	2.13
H18LM21	SPA-08	3	1	9	3.60	6.07	2.23	1.64	0.365	<0.01	3.18	<0.01	0.207	<0.01	4.31	7.53	0.116	0.224	1.02	0.240	0.054	12.7	<0.01	<0.10	1.74	<0.10	1.52	1.916
H17LM11	SPA-06	3	1	10	3.80	6.24	2.22	1.70	0.371	0.059	3.27	5.43	0.210	<0.01	<0.01	7.66	0.111	0.229	1.08	0.248	0.064	13.8	3.44	<0.10	0.073	<0.10	<0.01	5.40
H08LM21	SPA-05	3	1	11	2.92	<0.01	2.24	<0.01	0.366	0.138	2.13	4.43	0.205	<0.01	4.27	7.59	0.108	1.79	0.994	0.239	0.056	12.8	3.46	<0.10	<0.01	<0.10	<0.01	5.09
BCHLM312	Batch 1	3	1	12	2.50	<0.01	0.917	<0.01	<0.01	0.064	8.76	2.84	<0.01	0.854	1.30	6.82	0.103	0.557	<0.01	<0.01	<0.01	23.3	<0.01	<0.10	0.387	<0.10	<0.01	0.060
USTLM312	Ustd	3	1	13	1.96	<0.01	0.922	<0.01	<0.01	0.149	8.62	2.34	<0.01	0.671	1.95	8.24	<0.01	0.732	<0.01	<0.01	<0.01	22.4	<0.01	<0.10	0.532	1.96	<0.01	<0.01
H21LM21	SPA-04	3	1	14	4.84	1.39	0.072	<0.01	0.363	<0.01	10.27	5.35	0.208	<0.01	<0.01	9.00	0.109	0.226	1.05	0.249	0.029	15.3	3.38	<0.10	1.22	<0.10	1.53	<0.01
H08LM11	SPA-05	3	1	15	2.90	<0.01	2.18	<0.01	0.371	0.140	2.06	4.48	0.206	<0.01	4.32	7.64	0.108	1.83	1.01	0.244	0.048	11.9	3.37	<0.10	<0.01	<0.10	<0.01	5.14
H17LM21	SPA-06	3	1	16	3.79	6.22	2.21	1.67	0.370	0.055	3.18	5.43	0.209	<0.01	<0.01	7.69	0.110	0.228	1.06	0.246	0.041	13.6	3.42	<0.10	0.073	<0.10	<0.01	5.39
H28LM21	SPA-24	3	1	17	5.22	0.185	1.49	0.830	0.368	0.525	5.70	3.97	0.207	<0.01	2.25	9.75	0.113	0.376	0.204	0.246	0.039	16.8	1.74	<0.10	1.17	<0.10	<0.01	2.11
H15LM11	SPA-34	3	1	18	3.26	<0.01	1.50	0.806	0.360	0.487	7.62	4.01	0.206	<0.01	2.20	10.9	0.101	1.41	0.492	0.243	0.055	16.2	0.34	<0.10	0.142	<0.10	1.50	2.03
H15LM21	SPA-34	3	1	19	3.20	<0.01	1.50	0.837	0.369	0.500	7.62	4.00	0.210	<0.01	2.25	10.9	0.104	1.46	0.501	0.250	0.052	16.2	0.34	<0.10	0.147	<0.10	1.54	2.08
H34LM21	SPA-31	3	1	20	4.97	4.21	0.011	<0.01	0.360	0.189	9.40	1.03	0.206	<0.01	0.766	12.1	0.098	0.818	0.435	0.243	0.043	16.7	1.69	<0.10	<0.01	<0.10	<0.01	0.691
H10LM21	SPA-22	3	1	21	3.22	2.49	0.046	0.842	0.360	0.193	5.12	4.00	0.206	<0.01	0.773	11.4	0.105	1.08	0.202	0.243	0.042	18.3	<0.01	<0.10	0.516	<0.10	<0.01	2.09
H30LM11	SPA-36	3	1	22	3.91	2.37	0.870	0.641	0.368	0.318	6.39	1.81	0.209	<0.01	1.75	10.4	0.109	1.01	0.218	0.504	0.039	16.5	1.34	<0.10	0.898	<0.10	0.598	1.72
BCHLM313	Batch 1	3	1	23	2.50	<0.01	0.907	<0.01	<0.01	0.063	8.71	2.88	<0.01	0.843	1.29	6.85	0.103	0.552	<0.01	<0.01	<0.01	23.2	<0.01	<0.10	0.391	<0.10	<0.01	0.060
USTLM313	Ustd	3	1	24	1.95	<0.01	0.919	<0.01	<0.01	0.144	8.46	2.36	<0.01	0.664	1.94	8.23	<0.01	0.713	<0.01	<0.01	<0.01	22.2	<0.01	<0.10	0.526	1.94	<0.01	<0.01
BCHLM321	Batch 1	3	2	1	2.51	<0.01	0.913	<0.01	<0.01	0.066	8.88	2.91	<0.01	0.868	1.32	6.98	0.106	0.564	<0.01	<0.01	<0.01	23.7	<0.01	<0.10	0.397	<0.10	<0.01	0.06
USTLM321	Ustd	3	2	2	1.95	<0.01	0.907	<0.01	<0.01	0.149	8.79	2.38	<0.01	0.681	1.98	8.40	<0.01	0.726	<0.01	<0.01	<0.01	22.7	<0.01	<0.10	0.532	1.96	<0.01	<0.01
H18LM22	SPA-08	3	2	3	3.61	6.13	2.20	1.70	0.368	<0.01	3.09	<0.01	0.211	<0.01	4.43	7.65	0.119	0.229	1.03	0.245	0.048	12.9	<0.01	<0.10	1.76	<0.10	1.55	1.95
H17LM22	SPA-06	3	2	4	3.77	6.32	2.20	1.76	0.373	0.059	3.22	5.45	0.215	<0.01	<0.01	7.95	0.114	0.236	1.08	0.254	0.051	13.9	3.39	<0.10	0.076	<0.10	<0.01	5.53
H15LM22	SPA-34	3	2	5	3.21	<0.01	1.49	0.878	0.374	0.521	7.85	4.03	0.216	<0.01	2.34	11.1	0.107	1.51	0.517	0.258	0.049	16.5	0.332	<0.10	0.151	<0.10	1.60	2.16
H34LM12	SPA-31	3	2	6	5.08	4.37	0.011	<0.01	0.372	0.202	9.44	1.05	0.216	<0.01	0.82	12.2	0.103	0.862	0.447	0.260	0.056	16.7	1.70	<0.10	<0.01	<0.10	<0.01	0.718
H08LM22	SPA-05	3	2	7	2.92	<0.01	2.21	<0.01	0.369	0.145	2.04	4.50	0.210	<0.01	4.43	7.69	0.111	1.86	1.01	0.246	0.065	12.9	3.42	<0.10	<0.01	<0.10	<0.01	5.19
H10LM22	SPA-22	3	2	8	3.24	2.56	0.043	0.889	0.368	0.204	5.24	4.03	0.215	<0.01	0.813	11.5	0.110	1.13	0.213	0.256	0.046	18.5	<0.01	<0.10	0.532	<0.10	<0.01	2.16
H30LM12	SPA-36	3	2	9	3.90	2.42	0.892	0.682	0.374	0.336	6.47	1.82	0.216	<0.01	1.83	10.5	0.114	1.05	0.214	0.528	0.048	16.6	1.32	<0.10	0.922	<0.10	0.627	1.76
H21LM12	SPA-04	3	2	10	4.88	1.39	0.020	<0.01	0.359	<0.01	10.62	5.44	0.209	<0.01	<0.01	9.11	0.110	0.227	1.05	0.247	0.044	15.4	3.45	<0.10	1.20	<0.10	1.56	<0.01
H34LM22	SPA-31	3	2	11	5.09	4.33	0.015	<0.01	0.372	0.201	9.40	1.04	0.215	<0.01	0.805	12.1	0.103	0.855	0.442	0.257	0.051	16.6	1.71	<0.10	<0.01	<0.10	<0.01	0.712
BCHLM322	Batch 1	3	2	12	2.52	<0.01	0.913	<0.01	<0.01	0.069	8.74	2.87	<0.01	0.896	1.35	6.88	0.107	0.576	<0.01	<0.01	<0.01	23.3	<0.01	<0.10	0.400	<0.10	<0.01	0.062
USTLM322	Ustd	3	2	13	1.97	<0.01	0.904	<0.01	<0.01	0.154	8.61	2.40	<0.01	0.714	2.06	8.35	<0.01	0.754	<0.01	<0.01	<0.01	22.4	<0.01	<0.10	0.544	1.99	<0.01	<0.01
H21LM22	SPA-04	3	2	14	4.90	1.43	0.017	<0.01	0.375	<0.01	10.23	5.45	0.218	<0.01	<0.01	9.15	0.115	0.239	1.09	0.264	0.058	15.4	3.39	<0.10	1.26	<0.10	1.63	<0.01
H08LM12	SPA-05	3	2	15	2.95	<0.01	2.21	<0.01	0.382	0.149	2.01	4.48	0.216	<0.01	4.55	7.63	0.114	1.92	1.04	0.258	0.057	11.8	3.40	<0.10	<0.01	<0.10	<0.01	5.38
H10LM12	SPA-22	3	2	16	3.28	2.60	0.042	0.902	0.377	0.207	5.15	4.04	0.218	<0.01	0.825	11.5	0.112	1.15	0.218	0.260	0.050	18.4	<0.01	<0.10	0.543	<0.10	<0.01	2.21
H28LM12	SPA-24	3	2	17	5.28	0.187	1.51	0.880	0.377	0.556	5.68	4.04	0.216	<0.01	2.36	9.84	0.118	0.390	0.212	0.253	0.049	17.0	1.75	<0.10	1.19	<0.10	<0.01	2.20
H17LM12	SPA-06	3	2	18	3.82	6.37	2.23	1.76	0.379	0.063	3.15	5.57	0.218	<0.01	<0.01	7.75	0.115	0.238	1.10	0.257	0.052	13.6	3.44	<0.10	0.077	<0.10	<0.01	5.59
H30LM22	SPA-36	3	2	19	3.86	2.40	0.881	0.674	0.376	0.330	6.42	1.83	0.215	<0.01	1.81	10.4	0.114	1.03	0.379	0.521	0.048	16.4	1.33	<0.10	0.919	<0.10	0.620	2.18
H28LM22	SPA-24	3	2	20	5.31	0.189	1.51	0.876	0.378	0.549	5.81	4.01	0.216	<0.01	2.36	9.80	0.117	0.392	0.220	0.256	0.055	17.1	1.74	<0.10	1.20	<0.10	<0.01	2.21
H15LM12	SPA-34	3	2	21	3.26	<0.01	1.51	0.851	0.370	0.509	7.88	4.06	0.213	<0.01	2.28	11.0	0.106	1.46	0.506	0.252	0.060	16.5	0.342	<0.10	0.149	<0.10	1.56	2.11
H18LM12	SPA-08	3	2	22	3.67	6.19	2.25	1.74	0.370	<0.01	3.15	<0.01	0.212	<0.01	4.44	7.64	0.119	0.231	1.03	0.247	0.053	13.0	<0.01	<0.10	1.77	<0.10	1.59	1.95
BCHLM323	Batch 1	3	2	23	2.53	<0.01	0.921	<0.01	<0.01	0.068	9.02	2.86	<0.01	0.889	1.36	6.87	0.109	0.575	<0.01	<0.01	<0.01	23.6	<0.01	<0.10	0.404	<0.10	<0.01	0.063
USTLM323	Ustd	3	2	24	1.98	<0.01	0.911	<0.01	<0.01	0.153	8.85	2.36	<0.01	0.702	2.04	8.31	<0.01	0.746	<0.01	<0.01	<0.01	22.6	<0.01	<0.10	0.548	1.99	<0.01	<0.01

Table C.1: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Lithium Metaborate (LM) (continued)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Bi	Ca	Cd	Ce	Cr	Fe	K	La	Mg	Mn	Na	Nd	Ni	P	Pb	S	Si	Sr	Th	Ti	U	Zn	Zr
BCHLM411	Batch 1	4	1	1	2.50	<0.01	0.887	<0.01	<0.01	0.068	8.86	2.82	<0.01	0.860	1.31	6.80	0.105	0.557	<0.01	<0.01	<0.01	23.5	<0.01	<0.10	0.392	<0.10	<0.01	0.063
USTLM411	Ustd	4	1	2	1.96	<0.01	0.921	<0.01	<0.01	0.148	8.75	2.38	<0.01	0.678	1.95	8.29	<0.01	0.723	<0.01	<0.01	<0.01	22.7	<0.01	<0.10	0.533	1.97	<0.01	<0.01
H11LM21	SPA-15	4	1	3	5.21	4.42	0.018	0.832	0.368	0.497	9.61	1.79	0.212	<0.01	2.26	11.2	0.102	0.365	0.528	0.249	0.053	16.1	<0.01	<0.10	<0.01	<0.10	<0.01	0.711
H26LM21	SPA-09	4	1	4	5.16	<0.01	1.48	<0.01	0.365	0.495	8.65	1.06	0.207	<0.01	2.22	10.4	0.110	0.363	0.500	0.245	0.059	16.2	1.73	<0.10	1.15	<0.10	<0.01	0.639
H04LM21	SPA-01	4	1	5	4.03	6.19	0.017	<0.01	0.376	0.440	6.98	2.66	0.213	<0.01	3.68	8.76	0.101	0.924	<0.01	0.254	0.038	16.8	<0.01	<0.10	<0.01	<0.10	0.667	<0.01
H05LM21	SPA-21	4	1	6	3.68	4.37	1.48	0.819	0.369	0.562	6.78	3.93	0.208	<0.01	2.25	9.26	0.102	0.389	0.214	0.242	0.041	18.1	<0.01	<0.10	<0.01	<0.10	1.53	1.93
H07LM11	SPA-33	4	1	7	3.37	4.41	1.49	0.843	0.372	0.452	9.37	1.07	0.212	<0.01	2.23	9.94	0.102	0.348	0.231	0.245	0.049	16.3	0.136	<0.10	<0.01	<0.10	<0.01	0.712
H39LM21	SPA-19	4	1	8	4.58	3.35	1.26	<0.01	0.363	0.197	5.00	1.05	0.209	<0.01	2.22	12.4	0.101	1.10	0.206	0.243	0.050	17.2	0.755	<0.10	<0.01	<0.10	1.38	0.706
H04LM11	SPA-01	4	1	9	4.03	6.06	0.026	<0.01	0.365	0.432	6.90	2.73	0.208	<0.01	3.59	8.85	0.098	0.897	0.013	0.245	0.038	16.7	<0.01	<0.10	<0.01	<0.10	0.655	0.013
H25LM21	SPA-14	4	1	10	3.22	<0.01	1.54	<0.01	0.361	0.194	9.56	1.10	0.205	<0.01	2.18	12.5	0.110	1.39	0.477	0.236	0.054	16.0	<0.01	<0.10	1.14	<0.10	1.51	1.76
H26LM11	SPA-09	4	1	11	5.20	<0.01	1.49	<0.01	0.365	0.490	8.47	1.06	0.209	<0.01	2.22	10.2	0.110	0.354	0.489	0.244	0.054	16.0	1.76	<0.10	1.15	<0.10	<0.01	0.620
BCHLM412	Batch 1	4	1	12	2.52	<0.01	0.912	<0.01	<0.01	0.068	8.88	2.88	<0.01	0.864	1.31	6.72	0.105	0.564	<0.01	<0.01	<0.01	23.4	<0.01	<0.10	0.399	<0.10	<0.01	0.063
USTLM412	Ustd	4	1	13	1.96	<0.01	0.909	<0.01	<0.01	0.150	8.72	2.38	<0.01	0.684	1.97	8.14	<0.01	0.723	<0.01	<0.01	<0.01	22.6	<0.01	<0.10	0.535	1.96	<0.01	<0.01
H07LM21	SPA-33	4	1	14	3.40	4.41	1.49	0.853	0.372	0.485	9.41	1.06	0.212	<0.01	2.27	9.84	0.102	0.375	0.225	0.249	0.045	16.4	0.135	<0.10	<0.01	<0.10	<0.01	0.713
H39LM11	SPA-19	4	1	15	4.59	3.36	1.22	<0.01	0.367	0.201	4.97	1.03	0.211	<0.01	2.25	12.1	0.101	1.11	0.218	0.247	0.045	17.2	0.746	<0.10	<0.01	<0.10	1.39	0.718
H05LM11	SPA-21	4	1	16	3.64	4.30	1.47	0.805	0.361	0.549	6.62	3.86	0.205	<0.01	2.22	8.98	0.100	0.385	0.224	0.235	0.045	18.0	<0.01	<0.10	<0.01	<0.10	1.51	1.92
H27LM21	SPA-38	4	1	17	4.20	<0.01	0.791	0.566	0.059	0.140	8.43	<0.01	0.217	0.345	0.278	11.8	0.138	0.384	0.182	0.140	0.090	21.4	0.014	<0.10	0.020	<0.10	<0.01	1.28
H11LM11	SPA-15	4	1	18	5.17	4.39	0.032	0.829	0.366	0.497	9.41	1.79	0.211	<0.01	2.26	10.8	0.101	0.364	0.522	0.248	0.058	16.1	<0.01	<0.10	<0.01	<0.10	<0.01	0.713
H20LM21	SPA-26	4	1	19	5.02	0.010	1.43	<0.01	0.351	0.513	4.65	3.79	0.202	<0.01	0.757	11.6	0.106	0.042	0.197	0.239	0.044	15.6	1.68	<0.10	0.763	<0.10	0.585	2.03
H20LM11	SPA-26	4	1	20	5.26	0.010	1.51	<0.01	0.360	0.531	4.83	3.95	0.207	<0.01	0.779	11.9	0.108	0.043	0.208	0.243	0.049	16.2	1.78	<0.10	0.783	<0.10	0.609	2.10
H27LM11	SPA-38	4	1	21	4.22	<0.01	0.773	0.594	0.061	0.147	8.38	<0.01	0.224	0.360	0.290	11.7	0.142	0.401	0.189	0.147	0.081	21.3	0.015	<0.10	0.022	<0.10	0.029	1.32
H25LM11	SPA-14	4	1	22	3.22	<0.01	1.52	<0.01	0.364	0.200	9.26	1.05	0.209	<0.01	2.25	12.0	0.112	1.44	0.489	0.245	0.051	15.9	<0.01	<0.10	1.16	<0.10	1.56	1.80
BCHLM413	Batch 1	4	1	23	2.51	<0.01	0.892	<0.01	<0.01	0.069	8.58	2.86	<0.01	0.881	1.33	6.57	0.106	0.570	<0.01	<0.01	<0.01	23.4	<0.01	<0.10	0.403	<0.10	<0.01	0.064
USTLM413	Ustd	4	1	24	1.98	<0.01	0.920	<0.01	<0.01	0.158	8.51	2.38	<0.01	0.698	2.02	7.97	<0.01	0.759	<0.01	<0.01	<0.01	22.5	<0.01	<0.10	0.545	1.99	<0.01	<0.01
BCHLM421	Batch 1	4	2	1	2.49	<0.01	0.910	<0.01	<0.01	0.066	8.90	2.82	<0.01	0.860	1.31	6.85	0.106	0.562	<0.01	<0.01	<0.01	24.0	<0.01	<0.10	0.395	<0.10	<0.01	0.062
USTLM421	Ustd	4	2	2	1.95	<0.01	0.904	<0.01	<0.01	0.146	8.79	2.36	<0.01	0.675	1.96	8.43	<0.01	0.723	<0.01	<0.01	<0.01	23.2	<0.01	<0.10	0.531	1.95	<0.01	0.012
H05LM12	SPA-21	4	2	3	3.60	4.29	1.46	0.815	0.361	0.556	6.80	3.89	0.204	<0.01	2.25	9.38	0.100	0.388	0.211	0.237	0.033	18.2	<0.01	<0.10	<0.01	<0.10	1.53	1.90
H25LM22	SPA-14	4	2	4	3.22	<0.01	1.53	<0.01	0.360	0.197	9.74	1.06	0.206	<0.01	2.24	12.8	0.110	1.43	0.480	0.243	0.056	16.3	<0.01	<0.10	1.16	<0.10	1.55	1.78
H04LM12	SPA-01	4	2	5	3.98	6.12	0.022	<0.01	0.367	0.447	6.99	2.68	0.210	<0.01	3.72	8.99	0.098	0.925	<0.01	0.251	0.036	17.1	<0.01	<0.10	<0.01	<0.10	0.672	0.024
H20LM22	SPA-26	4	2	6	5.02	<0.01	1.43	<0.01	0.352	0.521	4.78	3.73	0.202	<0.01	0.770	12.1	0.106	0.041	0.198	0.240	0.043	15.8	1.67	<0.10	0.767	<0.10	0.595	2.05
H25LM12	SPA-14	4	2	7	3.19	<0.01	1.50	<0.01	0.363	0.197	9.59	1.04	0.207	<0.01	2.24	12.6	0.111	1.43	0.484	0.243	0.055	16.3	<0.01	<0.10	1.16	<0.10	1.55	1.79
H39LM12	SPA-19	4	2	8	4.58	3.37	1.22	<0.01	0.366	0.202	4.99	1.02	0.212	<0.01	2.29	12.6	0.101	1.12	0.216	0.249	0.051	17.4	0.740	<0.10	<0.01	<0.10	1.42	0.716
H07LM22	SPA-33	4	2	9	3.36	4.41	1.48	0.859	0.370	0.487	9.56	1.03	0.210	<0.01	2.29	10.1	0.101	0.374	0.224	0.250	0.051	16.6	0.137	<0.10	<0.01	<0.10	<0.01	0.710
H27LM12	SPA-38	4	2	10	4.19	<0.01	0.770	0.583	0.061	0.144	8.67	<0.01	0.221	0.354	0.286	12.3	0.141	0.398	0.190	0.145	0.082	21.8	0.019	<0.10	0.020	<0.10	0.029	1.31
H11LM12	SPA-15	4	2	11	5.20	4.40	0.033	0.832	0.365	0.500	9.69	1.79	0.210	<0.01	2.27	11.3	0.100	0.364	0.533	0.249	0.050	16.3	<0.01	<0.10	<0.01	<0.10	<0.01	0.704
BCHLM422	Batch 1	4	2	12	2.50	<0.01	0.903	<0.01	<0.01	0.066	8.83	2.82	<0.01	0.865	1.31	6.81	0.105	0.561	<0.01	<0.01	<0.01	23.8	<0.01	<0.10	0.397	<0.10	<0.01	0.061
USTLM422	Ustd	4	2	13	1.95	<0.01	0.894	<0.01	<0.01	0.152	8.67	2.35	<0.01	0.691	2.01	8.33	<0.01	0.739	<0.01	<0.01	<0.01	22.9	<0.01	<0.10	0.538	1.95	<0.01	<0.01
H26LM22	SPA-09	4	2	14	5.15	<0.01	1.46	<0.01	0.365	0.508	8.49	1.01	0.209	<0.01	2.28	10.3	0.110	0.368	0.506	0.253	0.045	16.1	1.71	<0.10	1.16	<0.10	<0.01	0.640
H04LM22	SPA-01	4	2	15	4.02	6.26	0.017	<0.01	0.377	0.452	6.98	2.68	0.215	<0.01	3.79	8.98	0.101	0.948	<0.01	0.263	0.037	17.2	<0.01	<0.10	<0.01	<0.10	0.686	0.016
H26LM12	SPA-09	4	2	16	5.18	<0.01	1.47	<0.01	0.365	0.497	8.47	1.02	0.208	<0.01	2.26	10.3	0.110	0.357	0.491	0.249	0.043	16.1	1.73	<0.10	1.16	<0.10	<0.01	0.626
H20LM12	SPA-26	4	2	17	5.24	<0.01	1.51	<0.01	0.359	0.529	4.95	4.01	0.206	<0.01	0.778	12.8	0.108	0.042	0.207	0.243	0.050	16.4	1.78	<0.10	0.779	<0.10	0.603	2.10
H07LM12	SPA-33	4	2	18	3.38	4.44	1.48	0.862	0.373	0.461	9.36	1.04	0.213	<0.01	2.28	10.0	0.101	0.354	0.227	0.250	0.047	16.5	0.137	<0.10	<0.01	<0.10	<0.01	0.714
H05LM22	SPA-21	4	2	19	3.64	4.40	1.46	0.851	0.368	0.580	6.73	3.86	0.210	<0.01	2.34	9.29	0.102	0.399	0.220	0.251	0.048	18.1	<0.01	<0.10	<0.01	<0.10	1.58	1.95
H11LM22	SPA-15	4	2	20	5.22	4.48	0.019	0.865	0.371	0.516	9.53	1.76	0.215	<0.01	2.34	11.1	0.103	0.376	0.535	0.255	0.053	16.2	<0.01	<0.10	<0.01	<0.10	<0.01	0.716
H27LM22	SPA-38	4	2	21	4.22	<0.01	0.780	0.593	0.060	0.144	8.45	<0.01	0.221	0.359	0.287	11.9	0.138	0.396	0.192	0.144	0.089	21.4	0.018	<0.10	0.019	<0.10	0.031	1.31
H39LM22	SPA-19	4	2	22	4.60	3.37	1.24	<0.01	0.367	0.205	4.98	1.02	0.213	<0.01	2.32	12.5	0.101	1.14	0.211	0.252	0.045	17.4	0.740	<0.10	<0.01	<0.10	1.44	0.712
BCHLM423	Batch 1	4	2	23	2.50	<0.01	0.898	<0.01	<0.01	0.068	8.81	2.85	<0.01	0.889	1.35	6.83	0.106	0.572	<0.01	<0.01	<0.01	23.7	<0.01	<0.10	0.402	<0.10	<0.01	0.062
USTLM423	Ustd	4	2	24	1.95	<0.01	0.895	<0.01	<0.01	0.152	8.66	2.38	<0.01	0.697	2.01	8.32	<0.01	0.740	<0.01	<0.01	<0.01	22.9	<0.01	<0.10	0.542	1.97	<0.01	<0.01

Table C.1: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Lithium Metaborate (LM) (continued)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Al	Bi	Ca	Cd	Ce	Cr	Fe	K	La	Mg	Mn	Na	Nd	Ni	P	Pb	S	Si	Sr	Th	Ti	U	Zn	Zr
BCHLM511	Batch 1	5	1	1	2.50	<0.01	0.885	<0.01	<0.01	0.069	8.90	2.84	<0.01	0.870	1.33	6.92	0.110	0.564	<0.01	<0.01	<0.01	23.9	<0.01	<0.10	0.401	<0.10	<0.01	0.064
USTLM511	Ustd	5	1	2	1.96	<0.01	0.905	<0.01	<0.01	0.150	8.79	2.36	<0.01	0.686	1.99	8.43	<0.01	0.726	<0.01	<0.01	<0.01	23.1	<0.01	<0.10	0.541	1.95	<0.01	<0.01
H01LM11	SPA-25	5	1	3	5.54	<0.01	0.015	<0.01	0.380	0.369	8.57	1.02	0.217	<0.01	2.32	9.85	0.105	0.379	0.539	0.256	0.053	21.8	1.73	<0.10	0.016	<0.10	1.57	0.900
H36LM21	SPA-41	5	1	4	5.29	<0.01	0.018	0.826	0.378	0.351	5.06	3.99	0.221	<0.01	0.812	9.85	0.103	1.43	0.537	0.265	0.045	19.4	<0.01	0.706	<0.01	1.76	<0.01	0.762
H41LM21	SPA-43	5	1	5	3.11	0.091	0.025	0.005	0.352	0.482	6.02	1.36	0.209	<0.01	2.20	11.3	0.107	0.376	0.500	0.254	0.053	15.6	1.68	1.77	0.974	6.63	1.48	1.92
H41LM11	SPA-43	5	1	6	3.21	0.090	0.018	0.005	0.361	0.494	6.20	1.38	0.214	<0.01	2.25	11.6	0.110	0.382	0.507	0.260	0.061	16.0	1.75	1.83	1.01	6.80	1.51	1.96
H09LM11	SPA-11	5	1	7	5.29	4.35	0.013	<0.01	0.368	0.174	9.11	1.02	0.215	<0.01	2.25	9.89	0.101	0.336	0.222	0.247	0.062	17.8	<0.01	<0.10	<0.01	<0.10	1.53	0.714
H06LM11	SPA-12	5	1	8	5.24	0.011	1.51	<0.01	0.378	0.532	7.65	1.02	0.215	<0.01	2.07	12.3	0.112	1.30	0.230	0.254	0.059	18.1	<0.01	<0.10	0.897	<0.10	<0.01	0.718
H22LM11	SPA-44	5	1	9	3.22	0.010	0.301	<0.01	0.365	0.456	7.64	3.93	0.211	<0.01	1.12	13.1	0.100	0.371	0.519	0.250	0.054	16.1	<0.01	1.70	<0.01	1.68	<0.01	2.08
H22LM21	SPA-44	5	1	10	3.24	0.011	0.294	<0.01	0.369	0.461	7.78	3.98	0.224	<0.01	1.13	13.3	0.102	0.378	0.517	0.254	0.066	16.2	<0.01	1.72	<0.01	1.69	<0.01	2.10
H36LM11	SPA-41	5	1	11	5.34	<0.01	0.031	0.812	0.372	0.345	5.13	4.03	0.218	<0.01	0.802	9.89	0.102	1.40	0.543	0.262	0.061	19.6	<0.01	0.696	<0.01	1.71	<0.01	0.763
BCHLM512	Batch 1	5	1	12	2.49	<0.01	0.889	<0.01	<0.01	0.069	8.70	2.71	<0.01	0.870	1.33	6.70	0.110	0.564	<0.01	<0.01	<0.01	23.3	<0.01	<0.10	0.400	<0.10	<0.01	0.064
USTLM512	Ustd	5	1	13	1.96	<0.01	0.900	<0.01	<0.01	0.150	8.66	2.30	<0.01	0.684	1.99	8.28	<0.01	0.731	<0.01	<0.01	<0.01	22.8	<0.01	<0.10	0.540	1.95	<0.01	<0.01
H31LM21	SPA-40	5	1	14	8.39	<0.01	0.088	1.29	0.075	0.080	9.43	<0.01	0.291	0.070	0.903	15.7	0.032	0.630	0.119	0.026	0.033	16.1	1.44	<0.10	0.012	<0.10	0.040	1.31
H31LM11	SPA-40	5	1	15	8.36	<0.01	0.089	1.31	0.076	0.080	9.56	<0.01	0.295	0.071	0.911	16.1	0.032	0.624	0.119	0.029	0.036	16.4	1.44	<0.10	0.012	<0.10	0.040	1.33
H03LM11	SPA-42	5	1	16	3.41	4.47	0.015	0.876	0.372	0.369	5.15	1.01	0.216	<0.01	0.788	9.89	0.101	0.988	0.213	0.258	0.052	19.4	1.76	1.02	<0.01	2.27	<0.01	0.716
H01LM21	SPA-25	5	1	17	5.24	<0.01	0.020	<0.01	0.382	0.377	8.69	1.01	0.219	<0.01	2.33	9.93	0.106	0.385	0.503	0.258	0.055	21.2	1.74	<0.10	0.015	<0.10	1.59	0.685
H06LM21	SPA-12	5	1	18	5.26	0.010	1.51	<0.01	0.379	0.530	7.70	1.01	0.215	<0.01	2.07	12.3	0.111	1.30	0.232	0.254	0.064	18.2	<0.01	<0.10	0.903	<0.10	<0.01	0.726
H09LM21	SPA-11	5	1	19	5.29	4.42	0.016	<0.01	0.377	0.191	9.26	1.00	0.218	<0.01	2.30	9.77	0.103	0.372	0.216	0.253	0.054	17.7	<0.01	<0.10	<0.01	<0.10	1.56	0.721
H03LM21	SPA-42	5	1	20	3.39	4.43	0.029	0.872	0.369	0.368	5.22	1.03	0.213	<0.01	0.785	9.83	0.099	0.983	0.217	0.254	0.052	19.3	1.75	1.01	<0.01	2.23	<0.01	0.711
H43LM21	SPA-45	5	1	21	3.59	4.30	1.52	0.841	0.355	0.181	5.18	1.06	0.207	<0.01	0.765	12.5	0.100	1.17	0.208	0.236	0.053	17.6	<0.01	1.58	0.456	1.64	1.27	0.689
H43LM11	SPA-45	5	1	22	3.61	4.48	1.51	0.884	0.374	0.188	5.25	1.01	0.217	<0.01	0.801	12.6	0.106	1.26	0.223	0.255	0.052	17.8	<0.01	1.57	0.479	1.75	1.33	0.734
BCHLM513	Batch 1	5	1	23	2.60	<0.01	0.926	<0.01	<0.01	0.087	9.62	2.80	<0.01	0.890	1.36	6.86	0.112	0.580	<0.01	<0.01	<0.01	23.8	<0.01	<0.10	0.412	<0.10	<0.01	0.065
USTLM513	Ustd	5	1	24	1.99	<0.01	0.907	<0.01	<0.01	0.151	8.60	2.32	<0.01	0.685	2.00	8.31	<0.01	0.730	<0.01	<0.01	<0.01	22.8	<0.01	<0.10	0.544	1.97	<0.01	<0.01
BCHLM521	Batch 1	5	2	1	2.48	<0.01	0.884	<0.01	<0.01	0.067	8.78	2.78	<0.01	0.864	1.31	6.78	0.105	0.561	<0.01	<0.01	<0.01	23.4	<0.01	<0.10	0.395	<0.10	<0.01	0.061
USTLM521	Ustd	5	2	2	1.94	<0.01	0.894	<0.01	<0.01	0.147	8.56	2.31	<0.01	0.680	1.98	8.23	<0.01	0.721	<0.01	<0.01	<0.01	22.5	<0.01	<0.10	0.534	1.92	<0.01	<0.01
H22LM22	SPA-44	5	2	3	3.21	<0.01	0.289	<0.01	0.361	0.455	7.67	3.95	0.217	<0.01	1.12	13.3	0.097	0.372	0.513	0.247	0.043	16.0	<0.01	1.71	<0.01	1.66	<0.01	2.08
H03LM22	SPA-42	5	2	4	3.36	4.40	0.028	0.858	0.361	0.365	5.20	1.03	0.209	<0.01	0.781	9.81	0.094	0.980	0.210	0.249	0.036	19.1	1.74	1.01	<0.01	2.22	<0.01	0.712
H41LM22	SPA-43	5	2	5	3.08	0.087	0.024	0.006	0.344	0.476	5.93	1.35	0.204	<0.01	2.18	11.2	0.102	0.371	0.487	0.255	0.045	15.4	1.67	1.76	0.964	6.56	1.44	1.89
H43LM12	SPA-45	5	2	6	3.53	4.42	1.48	0.863	0.364	0.184	5.09	1.00	0.210	<0.01	0.788	12.3	0.099	1.244	0.208	0.246	0.043	17.2	<0.01	1.56	0.468	1.71	1.31	0.709
H31LM12	SPA-40	5	2	7	8.40	<0.01	0.086	1.291	0.071	0.078	9.27	<0.01	0.289	<0.01	0.905	15.7	0.027	0.623	0.119	0.026	0.026	16.0	1.44	<0.10	<0.01	<0.10	0.039	1.32
H06LM22	SPA-12	5	2	8	5.22	<0.01	1.51	<0.01	0.373	0.528	7.69	1.01	0.211	<0.01	2.06	12.2	0.107	1.30	0.237	0.247	0.050	17.9	<0.01	<0.10	0.888	<0.10	<0.01	0.741
H31LM22	SPA-40	5	2	9	8.30	<0.01	0.086	1.263	0.070	0.078	9.22	<0.01	0.284	<0.01	0.892	15.6	0.027	0.626	0.114	0.026	0.018	15.9	1.43	<0.10	<0.01	<0.10	0.039	1.31
H09LM12	SPA-11	5	2	10	5.26	4.31	0.010	<0.01	0.361	0.170	8.90	1.01	0.208	<0.01	2.23	9.78	0.096	0.329	0.211	0.241	0.042	17.4	<0.01	<0.10	<0.01	<0.10	1.51	0.705
H36LM22	SPA-41	5	2	11	5.27	<0.01	0.027	0.806	0.370	0.346	4.95	3.99	0.214	<0.01	0.802	9.75	0.098	1.41	0.543	0.257	0.037	19.2	<0.01	0.697	<0.01	1.74	<0.01	0.762
BCHLM522	Batch 1	5	2	12	2.58	<0.01	0.918	<0.01	<0.01	0.085	8.72	2.81	<0.01	0.880	1.34	6.84	0.106	0.573	<0.01	<0.01	<0.01	23.4	<0.01	<0.10	0.405	<0.10	<0.01	0.061
USTLM522	Ustd	5	2	13	1.95	<0.01	0.899	<0.01	<0.01	0.148	8.57	2.31	<0.01	0.675	1.97	8.23	<0.01	0.731	<0.01	<0.01	<0.01	22.5	<0.01	0.056	0.534	1.93	<0.01	<0.01
H01LM12	SPA-25	5	2	14	5.53	<0.01	0.012	<0.01	0.373	0.364	8.44	1.01	0.213	<0.01	2.30	9.75	0.099	0.375	0.534	0.249	0.035	21.4	1.72	<0.10	0.011	<0.10	1.54	0.903
H01LM22	SPA-25	5	2	15	5.27	<0.01	0.017	<0.01	0.374	0.372	8.47	1.01	0.214	<0.01	2.31	9.77	0.099	0.381	0.498	0.252	0.036	20.6	1.73	<0.10	0.010	<0.10	1.56	0.675
H36LM12	SPA-41	5	2	16	5.31	<0.01	0.022	0.789	0.364	0.339	4.99	4.08	0.212	<0.01	0.788	9.75	0.096	1.38	0.536	0.254	0.043	19.3	<0.01	0.691	<0.01	1.71	<0.01	0.753
H03LM12	SPA-42	5	2	17	3.37	4.42	0.013	0.858	0.363	0.366	5.01	1.01	0.209	<0.01	0.78	9.64	0.095	0.981	0.207	0.250	0.034	19.0	1.74	1.01	<0.01	2.22	<0.01	0.708
H09LM22	SPA-11	5	2	18	5.26	4.37	0.013	<0.01	0.367	0.187	9.17	1.02	0.212	<0.01	2.28	9.77	0.097	0.367	0.217	0.246	0.038	17.5	<0.01	<0.10	<0.01	<0.10	1.51	0.717
H43LM22	SPA-45	5	2	19	3.56	4.27	1.52	0.815	0.348	0.178	5.17	1.07	0.201	<0.01	0.75	12.4	0.094	1.16	0.201	0.232	0.038	17.2	<0.01	1.57	0.448	1.62	1.25	0.683
H06LM12	SPA-12	5	2	20	5.20	<0.01	1.49	<0.01	0.365	0.517	7.39	1.03	0.206	<0.01	2.03	12.2	0.104	1.26	0.223	0.243	0.042	17.7	<0.01	<0.10	0.872	<0.10	<0.01	0.702
H41LM12	SPA-43	5	2	21	3.19	0.088	0.017	0.006	0.352	0.485	6.07	1.42	0.208	<0.01	2.21	11.6	0.103	0.377	0.499	0.254	0.042	15.7	1.75	1.81	0.989	6.68	1.48	1.93
H22LM12	SPA-44	5	2	22	3.17	<0.01	0.298	<0.01	0.354	0.445	7.48	3.93	0.203	<0.01	1.10	12.8	0.094	0.364	0.507	0.241	0.041	15.6	<0.01	1.67	<0.01	1.64	<0.01	2.05
BCHLM523	Batch 1	5	2	23	2.51	<0.01	0.894	<0.01	<0.01	0.067	9.15	2.84	<0.01	0.852	1.31	6.79	0.104	0.554	<0.01	<0.01	<0.01	23.2	<0.01	<0.10	0.397	<0.10	<0.01	0.061
USTLM523	Ustd	5	2	24	1.95	<0.01	0.907	<0.01	<0.01	0.147	8.37	2.33	<0.01	0.671	1.96	8.16	<0.01	0.717	<0.01	<0.01	<0.01	22.2	<0.01	<0.10	0.530	1.94	<0.01	<0.01

Table C.2: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Sodium Peroxide (SP)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li
BCHSP111	Batch 1	1	1	1	2.51	2.08
UGSP111	Ustd	1	1	2	2.72	1.29
H02SP11	SPA-28	1	1	3	1.70	2.02
H33SP21	SPA-10	1	1	4	1.75	1.37
H13SP21	SPA-35	1	1	5	3.73	1.03
H44SP11	SPA-32	1	1	6	3.07	0.675
H44SP21	SPA-32	1	1	7	3.13	0.684
H32SP11	SPA-30	1	1	8	3.66	0.671
H14SP11	SPA-23	1	1	9	1.53	2.02
H33SP11	SPA-10	1	1	10	1.76	1.36
H29SP21	SPA-27	1	1	11	3.58	0.676
BCHSP112	Batch 1	1	1	12	2.48	2.08
UGSP112	Ustd	1	1	13	2.81	1.32
H32SP21	SPA-30	1	1	14	3.69	0.676
H14SP21	SPA-23	1	1	15	1.59	2.03
H29SP11	SPA-27	1	1	16	3.62	0.671
H13SP11	SPA-35	1	1	17	3.79	1.05
H38SP11	SPA-18	1	1	18	2.61	1.73
H38SP21	SPA-18	1	1	19	2.58	1.72
H16SP21	SPA-02	1	1	20	3.83	0.112
H02SP21	SPA-28	1	1	21	1.78	2.10
H16SP11	SPA-02	1	1	22	3.82	0.114
BCHSP113	Batch 1	1	1	23	2.52	2.10
UGSP113	Ustd	1	1	24	2.80	1.33
BCHSP121	Batch 1	1	2	1	2.51	2.03
UGSP121	Ustd	1	2	2	2.68	1.28
H02SP22	SPA-28	1	2	3	1.71	2.01
H13SP12	SPA-35	1	2	4	3.66	1.01
H02SP12	SPA-28	1	2	5	1.68	1.99
H32SP12	SPA-30	1	2	6	3.48	0.667
H38SP22	SPA-18	1	2	7	2.46	1.66
H33SP12	SPA-10	1	2	8	1.72	1.33
H44SP12	SPA-32	1	2	9	2.95	0.68
H38SP12	SPA-18	1	2	10	2.48	1.67
H29SP22	SPA-27	1	2	11	3.51	0.675
BCHSP122	Batch 1	1	2	12	2.39	2.02
UGSP122	Ustd	1	2	13	2.71	1.27
H33SP22	SPA-10	1	2	14	1.73	1.34
H13SP22	SPA-35	1	2	15	3.57	1.01
H16SP22	SPA-02	1	2	16	3.75	0.13
H14SP12	SPA-23	1	2	17	1.55	2.00
H32SP22	SPA-30	1	2	18	3.54	0.672
H14SP22	SPA-23	1	2	19	1.56	1.99
H16SP12	SPA-02	1	2	20	3.77	0.13
H29SP12	SPA-27	1	2	21	3.59	0.68
H44SP22	SPA-32	1	2	22	3.03	0.69
BCHSP123	Batch 1	1	2	23	2.49	2.07
UGSP123	Ustd	1	2	24	2.71	1.30
BCHSP211	Batch 1	2	1	1	2.50	2.00
UGSP211	Ustd	2	1	2	2.67	1.22
H24SP21	SPA-37	2	1	3	2.87	0.989
H23SP11	SPA-20	2	1	4	1.52	1.94
H35SP11	SPA-07	2	1	5	4.67	1.75
H24SP11	SPA-37	2	1	6	2.90	0.994
H35SP21	SPA-07	2	1	7	4.65	1.74
H37SP21	SPA-13	2	1	8	2.98	1.89
H23SP21	SPA-20	2	1	9	1.55	1.96
H40SP11	SPA-17	2	1	10	3.54	0.655
H40SP21	SPA-17	2	1	11	3.63	0.661
BCHSP212	Batch 1	2	1	12	2.50	2.01
UGSP212	Ustd	2	1	13	2.64	1.23
H37SP11	SPA-13	2	1	14	3.05	1.93
H12SP11	SPA-03	2	1	15	3.60	1.28
H45SP11	SPA-29	2	1	16	3.03	2.01
H42SP21	SPA-16	2	1	17	1.61	0.667
H42SP11	SPA-16	2	1	18	1.62	0.679
H12SP21	SPA-03	2	1	19	3.49	1.25
H19SP21	SPA-39	2	1	20	3.02	2.64
H19SP11	SPA-39	2	1	21	3.10	2.68
H45SP21	SPA-29	2	1	22	2.98	1.96
BCHSP213	Batch 1	2	1	23	2.48	2.01
UGSP213	Ustd	2	1	24	2.69	1.23

Table C.2: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Sodium Peroxide (SP) *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li
BCHSP221	Batch 1	2	2	1	2.48	2.02
UGSP221	Ustd	2	2	2	2.66	1.23
H45SP22	SPA-29	2	2	3	2.90	1.98
H42SP12	SPA-16	2	2	4	1.61	0.680
H24SP12	SPA-37	2	2	5	2.91	1.02
H37SP12	SPA-13	2	2	6	2.89	1.90
H40SP21	SPA-17	2	2	7	3.63	0.667
H19SP12	SPA-39	2	2	8	3.09	2.72
H42SP22	SPA-16	2	2	9	1.57	0.662
H40SP12	SPA-17	2	2	10	3.55	0.652
H12SP12	SPA-03	2	2	11	3.56	1.29
BCHSP222	Batch 1	2	2	12	2.43	2.02
UGSP222	Ustd	2	2	13	2.76	1.24
H35SP12	SPA-07	2	2	14	4.67	1.75
H19SP22	SPA-39	2	2	15	3.08	2.69
H45SP12	SPA-29	2	2	16	3.01	2.00
H35SP22	SPA-07	2	2	17	4.59	1.73
H37SP22	SPA-13	2	2	18	2.94	1.88
H12SP22	SPA-03	2	2	19	3.55	1.25
H23SP12	SPA-20	2	2	20	1.61	2.00
H24SP22	SPA-37	2	2	21	2.87	0.989
H23SP22	SPA-20	2	2	22	1.52	1.95
BCHSP223	Batch 1	2	2	23	2.34	1.97
UGSP223	Ustd	2	2	24	2.53	1.18
BCHSP311	Batch 1	3	1	1	2.45	2.09
UGSP311	Ustd	3	1	2	2.75	1.25
H18SP11	SPA-08	3	1	3	5.32	1.50
H34SP11	SPA-31	3	1	4	1.71	1.76
H21SP11	SPA-04	3	1	5	3.23	0.111
H28SP11	SPA-24	3	1	6	1.69	2.03
H30SP21	SPA-36	3	1	7	3.06	1.07
H10SP11	SPA-22	3	1	8	3.08	1.79
H18SP21	SPA-08	3	1	9	5.26	1.54
H17SP11	SPA-06	3	1	10	2.27	2.28
H08SP21	SPA-05	3	1	11	5.86	0.114
BCHSP312	Batch 1	3	1	12	2.46	2.04
UGSP312	Ustd	3	1	13	2.59	1.27
H21SP21	SPA-04	3	1	14	3.00	0.109
H08SP11	SPA-05	3	1	15	5.51	0.112
H17SP21	SPA-06	3	1	16	2.24	2.25
H28SP21	SPA-24	3	1	17	1.64	2.05
H15SP11	SPA-34	3	1	18	2.06	2.03
H15SP21	SPA-34	3	1	19	2.03	2.00
H34SP21	SPA-31	3	1	20	1.61	1.76
H10SP21	SPA-22	3	1	21	3.06	1.81
H30SP11	SPA-36	3	1	22	3.01	1.09
BCHSP313	Batch 1	3	1	23	2.40	2.01
UGSP313	Ustd	3	1	24	2.56	1.24
BCHSP321	Batch 1	3	2	1	2.52	2.06
UGSP321	Ustd	3	2	2	2.68	1.26
H18SP22	SPA-08	3	2	3	5.20	1.49
H17SP22	SPA-06	3	2	4	2.29	2.27
H15SP22	SPA-34	3	2	5	1.99	1.97
H34SP12	SPA-31	3	2	6	1.53	1.73
H08SP22	SPA-05	3	2	7	5.63	0.102
H10SP22	SPA-22	3	2	8	3.03	1.77
H30SP12	SPA-36	3	2	9	2.88	1.03
H21SP12	SPA-04	3	2	10	3.14	0.100
H34SP22	SPA-31	3	2	11	1.60	1.75
BCHSP322	Batch 1	3	2	12	2.48	2.03
UGSP322	Ustd	3	2	13	2.67	1.26
H21SP22	SPA-04	3	2	14	2.96	0.097
H08SP12	SPA-05	3	2	15	5.50	0.101
H10SP12	SPA-22	3	2	16	2.97	1.73
H28SP12	SPA-24	3	2	17	1.54	1.96
H17SP12	SPA-06	3	2	18	2.22	2.25
H30SP22	SPA-36	3	2	19	2.88	1.03
H28SP22	SPA-24	3	2	20	1.56	2.00
H15SP12	SPA-34	3	2	21	2.01	2.02
H18SP12	SPA-08	3	2	22	5.27	1.52
BCHSP323	Batch 1	3	2	23	2.56	2.05
UGSP323	Ustd	3	2	24	2.69	1.25

Table C.2: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Sodium Peroxide (SP) ***(continued)***

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li
BCHSP411	Batch 1	4	1	1	2.38	2.00
UGSP411	Ustd	4	1	2	2.65	1.26
H11SP21	SPA-15	4	1	3	1.60	2.03
H26SP21	SPA-09	4	1	4	2.67	1.95
H04SP21	SPA-01	4	1	5	4.37	0.124
H05SP21	SPA-21	4	1	6	2.09	0.710
H07SP11	SPA-33	4	1	7	3.64	0.673
H39SP21	SPA-19	4	1	8	2.07	1.97
H04SP11	SPA-01	4	1	9	4.45	0.125
H25SP21	SPA-14	4	1	10	1.53	1.94
H26SP11	SPA-09	4	1	11	2.54	1.95
BCHSP412	Batch 1	4	1	12	2.31	1.96
UGSP412	Ustd	4	1	13	2.52	1.22
H07SP21	SPA-33	4	1	14	3.52	0.658
H39SP11	SPA-19	4	1	15	1.97	1.94
H05SP11	SPA-21	4	1	16	2.04	0.702
H27SP21	SPA-38	4	1	17	2.17	1.32
H11SP11	SPA-15	4	1	18	1.60	1.96
H20SP21	SPA-26	4	1	19	2.51	1.94
H20SP11	SPA-26	4	1	20	2.42	1.91
H27SP11	SPA-38	4	1	21	2.09	1.31
H25SP11	SPA-14	4	1	22	1.52	1.98
BCHSP413	Batch 1	4	1	23	2.33	1.97
UGSP413	Ustd	4	1	24	2.62	1.26
BCHSP421	Batch 1	4	2	1	2.64	2.07
UGSP421	Ustd	4	2	2	2.87	1.31
H05SP12	SPA-21	4	2	3	1.98	0.702
H25SP22	SPA-14	4	2	4	1.51	2.00
H04SP12	SPA-01	4	2	5	4.54	0.126
H20SP22	SPA-26	4	2	6	2.59	1.98
H25SP12	SPA-14	4	2	7	1.59	2.01
H39SP12	SPA-19	4	2	8	2.07	2.02
H07SP22	SPA-33	4	2	9	3.65	0.678
H27SP12	SPA-38	4	2	10	2.05	1.31
H11SP12	SPA-15	4	2	11	1.49	1.96
BCHSP422	Batch 1	4	2	12	2.35	2.02
UGSP422	Ustd	4	2	13	2.86	1.34
H26SP22	SPA-09	4	2	14	2.61	1.92
H04SP22	SPA-01	4	2	15	4.56	0.122
H26SP12	SPA-09	4	2	16	2.71	1.97
H20SP12	SPA-26	4	2	17	2.48	1.89
H07SP12	SPA-33	4	2	18	3.77	0.670
H05SP22	SPA-21	4	2	19	2.03	0.694
H11SP22	SPA-15	4	2	20	1.64	2.10
H27SP22	SPA-38	4	2	21	2.20	1.36
H39SP22	SPA-19	4	2	22	1.96	1.99
BCHSP423	Batch 1	4	2	23	2.49	2.06
UGSP423	Ustd	4	2	24	2.81	1.32
BCHSP511	Batch 1	5	1	1	2.44	2.02
USTSP511	Ustd	5	1	2	2.60	1.25
H01SP11	SPA-25	5	1	3	1.45	0.655
H36SP21	SPA-41	5	1	4	3.00	0.689
H41SP21	SPA-43	5	1	5	1.52	0.885
H41SP11	SPA-43	5	1	6	1.53	0.891
H09SP11	SPA-11	5	1	7	2.47	0.824
H06SP11	SPA-12	5	1	8	2.46	1.12
H22SP11	SPA-44	5	1	9	3.51	0.689
H22SP21	SPA-44	5	1	10	3.51	0.676
H36SP11	SPA-41	5	1	11	3.06	0.692
BCHSP512	Batch 1	5	1	12	2.47	2.04
UGSP512	Ustd	5	1	13	2.70	1.29
H31SP21	SPA-40	5	1	14	1.69	0.639
H31SP11	SPA-40	5	1	15	1.62	0.623
H03SP11	SPA-42	5	1	16	2.41	1.97
H01SP21	SPA-25	5	1	17	1.50	0.667
H06SP21	SPA-12	5	1	18	2.43	1.13
H09SP21	SPA-11	5	1	19	2.50	0.843
H03SP21	SPA-42	5	1	20	2.52	2.04
H43SP21	SPA-45	5	1	21	1.52	1.96
H43SP11	SPA-45	5	1	22	1.53	1.98
BCHSP513	Batch 1	5	1	23	2.46	2.07
UGSP513	Ustd	5	1	24	2.61	1.27

Table C.2: Measured Elemental Concentrations (wt%) for the SPA Glasses Prepared Using Peroxide Fusion ***(continued)***

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	B	Li
BCHSP521	Batch 1	5	2	1	2.41	1.96
UGSP521	Ustd	5	2	2	2.71	1.27
H22SP22	SPA-44	5	2	3	3.72	0.667
H03SP22	SPA-42	5	2	4	2.55	2.02
H41SP22	SPA-43	5	2	5	1.64	0.894
H43SP12	SPA-45	5	2	6	1.64	2.01
H31SP12	SPA-40	5	2	7	1.74	0.611
H06SP22	SPA-12	5	2	8	2.54	1.14
H31SP22	SPA-40	5	2	9	1.72	0.605
H09SP12	SPA-11	5	2	10	2.55	0.827
H36SP22	SPA-41	5	2	11	3.19	0.667
BCHSP522	Batch 1	5	2	12	2.47	2.00
UGSP522	Ustd	5	2	13	2.71	1.26
H01SP12	SPA-25	5	2	14	1.54	0.646
H01SP22	SPA-25	5	2	15	1.58	0.671
H36SP12	SPA-41	5	2	16	3.27	0.694
H03SP12	SPA-42	5	2	17	2.58	2.04
H09SP22	SPA-11	5	2	18	2.70	0.879
H43SP22	SPA-45	5	2	19	1.64	2.05
H06SP12	SPA-12	5	2	20	2.57	1.15
H41SP12	SPA-43	5	2	21	1.58	0.887
H22SP12	SPA-44	5	2	22	3.73	0.682
BCHSP523	Batch 1	5	2	23	2.46	2.01
UGSP523	Ustd	5	2	24	2.78	1.29

Table C.3: Measured Anion Concentrations (wt%)
for the SPA Glasses Prepared Using Potassium Hydroxide (PH)

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Cl-	F-
LRMPH111	LRM	1	1	1	<0.200	0.900
H29PH11	SPA-27	1	1	2	<0.200	0.410
H21PH11	SPA-04	1	1	3	<0.200	0.010
H17PH11	SPA-06	1	1	4	<0.200	1.77
H38PH11	SPA-18	1	1	5	<0.200	1.43
H35PH11	SPA-07	1	1	6	<0.200	1.50
H39PH11	SPA-19	1	1	7	<0.200	1.42
H15PH11	SPA-34	1	1	8	<0.200	0.420
H45PH11	SPA-29	1	1	9	<0.200	0.420
H34PH11	SPA-31	1	1	10	<0.200	1.35
H40PH11	SPA-17	1	1	11	<0.200	1.33
H44PH11	SPA-32	1	1	12	<0.200	1.35
LRMPH112	LRM	1	1	13	<0.200	0.940
H16PH11	SPA-02	1	1	14	<0.200	1.46
H26PH11	SPA-09	1	1	15	<0.200	0.430
H31PH11	SPA-40	1	1	16	<0.200	0.010
H24PH11	SPA-37	1	1	17	<0.200	0.650
H19PH11	SPA-39	1	1	18	<0.200	0.020
H42PH11	SPA-16	1	1	19	<0.200	1.35
H13PH11	SPA-35	1	1	20	<0.200	1.28
H25PH11	SPA-14	1	1	21	<0.200	1.39
H28PH11	SPA-24	1	1	22	<0.200	1.34
H14PH11	SPA-23	1	1	23	<0.200	0.380
H08PH11	SPA-05	1	1	24	<0.200	1.74
H30PH11	SPA-36	1	1	25	<0.200	0.720
LRMPH113	LRM	1	1	26	<0.200	0.900
LRMPH121	LRM	1	2	1	<0.200	0.860
H13PH12	SPA-35	1	2	2	<0.200	1.28
H44PH12	SPA-32	1	2	3	<0.200	1.34
H26PH12	SPA-09	1	2	4	<0.200	0.390
H29PH12	SPA-27	1	2	5	<0.200	0.420
H38PH12	SPA-18	1	2	6	<0.200	1.36
H34PH12	SPA-31	1	2	7	<0.200	1.33
H24PH12	SPA-37	1	2	8	<0.200	0.610
H35PH12	SPA-07	1	2	9	<0.200	1.56
H31PH12	SPA-40	1	2	10	<0.200	0.020
H15PH12	SPA-34	1	2	11	<0.200	0.390
H45PH12	SPA-29	1	2	12	<0.200	0.390
LRMPH122	LRM	1	2	13	<0.200	0.870
H16PH12	SPA-02	1	2	14	<0.200	1.50
H39PH12	SPA-19	1	2	15	<0.200	1.41
H17PH12	SPA-06	1	2	16	<0.200	1.73
H14PH12	SPA-23	1	2	17	<0.200	0.430
H42PH12	SPA-16	1	2	18	<0.200	1.33
H08PH12	SPA-05	1	2	19	<0.200	1.68
H40PH12	SPA-17	1	2	20	<0.200	1.39
H21PH12	SPA-04	1	2	21	<0.200	0.010
H30PH12	SPA-36	1	2	22	<0.200	0.670
H25PH12	SPA-14	1	2	23	<0.200	1.34
H28PH12	SPA-24	1	2	24	<0.200	1.32
H19PH12	SPA-39	1	2	25	<0.200	0.010
LRMPH123	LRM	1	2	26	<0.200	0.840

Table C.3: Measured Anion Concentrations (wt%) for the SPA Glasses Prepared Using Potassium Hydroxide (PH) *(continued)*

SRTC-ML ID	Glass ID	Block	Sub-Block	Analytical Sequence	Cl-	F-
LRMPH211	LRM	2	1	1	<0.200	0.900
H11PH11	SPA-15	2	1	2	<0.200	1.35
H27PH11	SPA-38	2	1	3	<0.200	0.090
H05PH11	SPA-21	2	1	4	<0.200	0.390
H12PH11	SPA-03	2	1	5	<0.200	1.70
H07PH11	SPA-33	2	1	6	<0.200	1.27
H02PH11	SPA-28	2	1	7	<0.200	0.400
H37PH11	SPA-13	2	1	8	<0.200	1.33
H41*PH11	SPA-43	2	1	9	<0.200	0.420
H18PH11	SPA-08	2	1	10	<0.200	0.010
H43*PH11	SPA-45	2	1	11	<0.200	1.41
H01PH11	SPA-25	2	1	12	<0.200	1.26
LRMPH212	LRM	2	1	13	<0.200	0.920
H20PH11	SPA-26	2	1	14	<0.200	1.26
H23PH11	SPA-20	2	1	15	<0.200	0.380
H32PH11	SPA-30	2	1	16	<0.200	0.380
H04PH11	SPA-01	2	1	17	<0.200	0.010
H36*PH11	SPA-41	2	1	18	<0.200	1.25
H10PH11	SPA-22	2	1	19	<0.200	1.43
H03*PH11	SPA-42	2	1	20	<0.200	1.38
H06PH11	SPA-12	2	1	21	<0.200	1.33
H22*PH11	SPA-44	2	1	22	<0.200	0.420
H09PH11	SPA-11	2	1	23	<0.200	1.28
H33PH11	SPA-10	2	1	24	<0.200	0.330
LRMPH213	LRM	2	1	25	<0.200	0.900
LRMPH221	LRM	2	2	1	<0.200	0.850
H09PH12	SPA-11	2	2	2	<0.200	1.28
H04PH12	SPA-01	2	2	3	<0.200	0.010
H33PH12	SPA-10	2	2	4	<0.200	0.320
H41*PH12	SPA-43	2	2	5	<0.200	0.420
H11PH12	SPA-15	2	2	6	<0.200	1.38
H05PH12	SPA-21	2	2	7	<0.200	0.410
H27PH12	SPA-38	2	2	8	<0.200	0.050
H23PH12	SPA-20	2	2	9	<0.200	0.380
H10PH12	SPA-22	2	2	10	<0.200	1.43
H07PH12	SPA-33	2	2	11	<0.200	1.30
H01PH12	SPA-25	2	2	12	<0.200	1.28
LRMPH222	LRM	2	2	13	<0.200	0.960
H20PH12	SPA-26	2	2	14	<0.200	1.27
H37PH12	SPA-13	2	2	15	<0.200	1.33
H06PH12	SPA-12	2	2	16	<0.200	1.33
H32PH12	SPA-30	2	2	17	<0.200	0.400
H03*PH12	SPA-42	2	2	18	<0.200	1.38
H02PH12	SPA-28	2	2	19	<0.200	0.390
H43*PH12	SPA-45	2	2	20	<0.200	1.39
H12PH12	SPA-03	2	2	21	<0.200	1.70
H36*PH12	SPA-41	2	2	22	<0.200	1.23
H22*PH12	SPA-44	2	2	23	<0.200	0.430
H18PH12	SPA-08	2	2	24	<0.200	0.020
LRMPH223	LRM	2	2	25	<0.200	0.980

Table C.6: Average Measured and Bias-Corrected Chemical Compositions Versus Targeted Compositions by Oxide/Anion by Glass Number

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
0	Al_2O_3	4.7445	4.8661	4.8770	-2.7%	-0.2%
0	B_2O_3	7.9113	7.7871	7.7770	1.7%	0.1%
0	Bi_2O_3	0.0056	0.0056	0.0000		
0	CaO	1.2670	1.2237	1.2200	3.9%	0.3%
0	CdO	0.0057	0.0057	0.0000		
0	Ce_2O_3	0.0059	0.0059	0.0000		
0	Cl-	0.0000	0.0000	0.0000		
0	Cr_2O_3	0.0994	0.1070	0.1070	-7.1%	0.0%
0	F-	0.0000	0.0000	0.0000		
0	Fe_2O_3	12.7515	12.8252	12.8390	-0.7%	-0.1%
0	K_2O	3.3974	3.3328	3.3270	2.1%	0.2%
0	La_2O_3	0.0059	0.0059	0.0000		
0	Li_2O	4.3682	4.4768	4.4290	-1.4%	1.1%
0	MgO	1.4432	1.4206	1.4190	1.7%	0.1%
0	MnO	1.7095	1.7238	1.7260	-1.0%	-0.1%
0	Na_2O	9.2329	9.0198	9.0030	2.6%	0.2%
0	Nd_2O_3	0.1232	0.1232	0.1470	-16.2%	-16.2%
0	NiO	0.7193	0.7475	0.7510	-4.2%	-0.5%
0	P_2O_5	0.0115	0.0115	0.0000		
0	PbO	0.0054	0.0054	0.0000		
0	SO_3^-	0.0125	0.0125	0.0000		
0	SiO_2	50.5303	50.1897	50.2200	0.6%	-0.1%
0	SrO	0.0059	0.0059	0.0000		
0	ThO_2	0.0569	0.0569	0.0000		
0	TiO_2	0.6643	0.6759	0.6770	-1.9%	-0.2%
0	U_3O_8	0.0590	0.0609	0.0000		
0	ZnO	0.0062	0.0062	0.0000		
0	ZrO_2	0.0840	0.0840	0.0980	-14.3%	-14.3%
0	sum of oxides	99.2264	98.7854	98.6170	0.6%	0.2%
1	Al_2O_3	7.5863	7.8220	7.6500	-0.8%	2.2%
1	B_2O_3	14.4252	14.4243	15.0500	-4.2%	-4.2%
1	Bi_2O_3	6.8644	6.8644	7.0000	-1.9%	-1.9%
1	CaO	0.0287	0.0278	0.0000		
1	CdO	0.0057	0.0057	0.0000		
1	Ce_2O_3	0.4348	0.4348	0.4360	-0.3%	-0.3%
1	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
1	Cr_2O_3	0.6471	0.7021	0.7000	-7.6%	0.3%
1	F-	0.0100	0.0109	0.0000		
1	Fe_2O_3	9.9543	10.1466	10.3100	-3.5%	-1.6%
1	K_2O	3.2374	3.1465	3.1500	2.8%	-0.1%
1	La_2O_3	0.2480	0.2480	0.2580	-3.9%	-3.9%
1	Li_2O	0.2675	0.1533	0.1500	78.3%	2.2%
1	MgO	0.0083	0.0082	0.0000		
1	MnO	4.7710	4.8313	5.0100	-4.8%	-3.6%
1	Na_2O	11.9905	11.8405	11.7000	2.5%	1.2%
1	Nd_2O_3	0.1161	0.1161	0.0810	43.3%	43.3%
1	NiO	1.1752	1.2290	1.2600	-6.7%	-2.5%
1	P_2O_5	0.0160	0.0160	0.0000		
1	PbO	0.2728	0.2728	0.2900	-5.9%	-5.9%
1	SO_3^-	0.0930	0.0930	0.0900	3.3%	3.3%
1	SiO_2	36.2611	36.0172	35.6600	1.7%	1.0%
1	SrO	0.0059	0.0059	0.0000		
1	ThO_2	0.0569	0.0569	0.0000		
1	TiO_2	0.0083	0.0085	0.0000		
1	U_3O_8	0.0590	0.0612	0.0000		
1	ZnO	0.8340	0.8340	0.8600	-3.0%	-3.0%
1	ZrO_2	0.0196	0.0196	0.0000		
1	sum of oxides	99.4971	99.4967	99.6630	-0.2%	-0.2%
2	Al_2O_3	14.8042	15.2539	14.7500	0.4%	3.4%
2	B_2O_3	12.2115	11.8768	12.3500	-1.1%	-3.8%
2	Bi_2O_3	0.0056	0.0056	0.0000		

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
2	CaO	0.3456	0.3337	0.3300	4.7%	1.1%
2	CdO	2.0264	2.0264	2.0000	1.3%	1.3%
2	Ce_2O_3	0.4404	0.4404	0.4360	1.0%	1.0%
2	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
2	Cr_2O_3	0.0055	0.0060	0.0000		
2	F-	1.4800	1.6748	2.0000	-26.0%	-16.3%
2	Fe_2O_3	12.9995	13.0801	13.2400	-1.8%	-1.2%
2	K_2O	6.0561	5.9175	5.5600	8.9%	6.4%
2	La_2O_3	0.2539	0.2539	0.2580	-1.6%	-1.6%
2	Li_2O	0.2616	0.0000	0.0000		
2	MgO	0.0083	0.0081	0.0000		
2	MnO	3.6767	3.6952	3.6700	0.2%	0.7%
2	Na_2O	11.4344	11.0274	10.9400	4.5%	0.8%
2	Nd_2O_3	0.1260	0.1260	0.0810	55.5%	55.5%
2	NiO	0.2949	0.3065	0.3000	-1.7%	2.2%
2	P_2O_5	2.2015	2.2015	2.1700	1.4%	1.4%
2	PbO	0.2736	0.2736	0.2900	-5.7%	-5.7%
2	SO_3^-	0.1442	0.1442	0.0900	60.2%	60.2%
2	SiO_2	30.0572	29.6277	29.2400	2.8%	1.3%
2	SrO	0.0059	0.0059	0.0000		
2	ThO_2	0.0569	0.0569	0.0000		
2	TiO_2	1.2239	1.2471	1.2100	1.1%	3.1%
2	U_3O_8	0.0590	0.0610	0.0000		
2	ZnO	0.7375	0.7375	0.7400	-0.3%	-0.3%
2	ZrO_2	0.0162	0.0162	0.0000		
2	sum of oxides	101.3065	100.5038	99.6630	1.6%	0.8%
3	Al_2O_3	14.8562	15.2771	15.0000	-1.0%	1.8%
3	B_2O_3	11.4306	11.2488	11.3900	0.4%	-1.2%
3	Bi_2O_3	4.0328	4.0328	4.2000	-4.0%	-4.0%
3	CaO	0.0290	0.0278	0.0000		
3	CdO	0.0320	0.0320	0.0000		
3	Ce_2O_3	0.4097	0.4097	0.4360	-6.0%	-6.0%
3	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
3	Cr_2O_3	0.0073	0.0081	0.0000		
3	F-	1.7000	1.8515	2.0000	-15.0%	-7.4%
3	Fe_2O_3	12.2132	12.1225	12.1300	0.7%	-0.1%
3	K_2O	0.0060	0.0060	0.0000		
3	La_2O_3	0.2351	0.2351	0.2580	-8.9%	-8.9%
3	Li_2O	2.7288	2.9961	2.9200	-6.5%	2.6%
3	MgO	0.0083	0.0082	0.0000		
3	MnO	0.0901	0.0913	0.0000		
3	Na_2O	13.7159	13.3601	13.4300	2.1%	-0.5%
3	Nd_2O_3	0.1123	0.1123	0.0810	38.6%	38.6%
3	NiO	0.4632	0.4845	0.4900	-5.5%	-1.1%
3	P_2O_5	0.0791	0.0791	0.0000		
3	PbO	0.2671	0.2671	0.2900	-7.9%	-7.9%
3	SO_3^-	0.1149	0.1149	0.0900	27.6%	27.6%
3	SiO_2	37.3308	36.9498	36.9400	1.1%	0.0%
3	SrO	0.0059	0.0059	0.0000		
3	ThO_2	0.0569	0.0569	0.0000		
3	TiO_2	0.0284	0.0290	0.0000		
3	U_3O_8	0.0590	0.0612	0.0000		
3	ZnO	0.0103	0.0103	0.0000		
3	ZrO_2	0.0108	0.0108	0.0000		
3	sum of oxides	100.1335	99.9886	99.6630	0.5%	0.3%
4	Al_2O_3	9.1924	9.4528	9.2800	-0.9%	1.9%
4	B_2O_3	9.9253	9.6773	10.1900	-2.6%	-5.0%
4	Bi_2O_3	1.5524	1.5524	1.6000	-3.0%	-3.0%
4	CaO	0.0451	0.0431	0.0000		
4	CdO	0.0057	0.0057	0.0000		
4	Ce_2O_3	0.4246	0.4246	0.4360	-2.6%	-2.6%
4	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
4	Cr_2O_3	0.0073	0.0082	0.0000		
4	F-	0.0100	0.0113	0.0000		
4	Fe_2O_3	14.9690	15.2157	15.1400	-1.1%	0.5%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
4	K_2O	6.5139	6.2685	6.0000	8.6%	4.5%
4	La_2O_3	0.2457	0.2457	0.2580	-4.8%	-4.8%
4	Li_2O	0.2244	0.0000	0.0000		
4	MgO	0.0083	0.0082	0.0000		
4	MnO	0.0065	0.0065	0.0000		
4	Na_2O	12.2668	11.8965	12.1500	1.0%	-2.1%
4	Nd_2O_3	0.1286	0.1286	0.0810	58.8%	58.8%
4	NiO	0.2895	0.3028	0.3000	-3.5%	0.9%
4	P_2O_5	2.4289	2.4289	2.5000	-2.8%	-2.8%
4	PbO	0.2701	0.2701	0.2900	-6.9%	-6.9%
4	SO_3^-	0.1049	0.1049	0.0900	16.5%	16.5%
4	SiO_2	32.8917	32.9505	33.2500	-1.1%	-0.9%
4	SrO	4.0445	4.0445	4.0000	1.1%	1.1%
4	ThO_2	0.0569	0.0569	0.0000		
4	TiO_2	2.0266	2.0771	2.0900	-3.0%	-0.6%
4	U_3O_8	0.0590	0.0611	0.0000		
4	ZnO	1.9388	1.9388	2.0000	-3.1%	-3.1%
4	ZrO_2	0.0068	0.0068	0.0000		
4	sum of oxides	99.7436	99.2874	99.6630	0.1%	-0.4%
5	Al_2O_3	5.5221	5.6785	5.4100	2.1%	5.0%
5	B_2O_3	18.1119	17.6594	19.0400	-4.9%	-7.3%
5	Bi_2O_3	0.0056	0.0056	0.0000		
5	CaO	3.0922	2.9521	3.0000	3.1%	-1.6%
5	CdO	0.0057	0.0057	0.0000		
5	Ce_2O_3	0.4357	0.4357	0.4360	-0.1%	-0.1%
5	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
5	Cr_2O_3	0.2090	0.2330	0.2100	-0.5%	11.0%
5	F-	1.7100	1.9331	2.0000	-14.5%	-3.3%
5	Fe_2O_3	2.9452	2.9939	3.0000	-1.8%	-0.2%
5	K_2O	5.3876	5.1847	4.9900	8.0%	3.9%
5	La_2O_3	0.2454	0.2454	0.2580	-4.9%	-4.9%
5	Li_2O	0.2309	0.0000	0.0000		
5	MgO	0.0083	0.0082	0.0000		
5	MnO	5.6716	5.7357	6.0000	-5.5%	-4.4%
5	Na_2O	10.2954	9.9846	10.0000	3.0%	-0.2%
5	Nd_2O_3	0.1286	0.1286	0.0810	58.8%	58.8%
5	NiO	2.3541	2.4624	2.4700	-4.7%	-0.3%
5	P_2O_5	2.3223	2.3223	2.5000	-7.1%	-7.1%
5	PbO	0.2658	0.2658	0.2900	-8.3%	-8.3%
5	SO_3^-	0.1411	0.1411	0.0900	56.7%	56.7%
5	SiO_2	26.4204	26.4678	28.2000	-6.3%	-6.1%
5	SrO	4.0356	4.0356	4.0000	0.9%	0.9%
5	ThO_2	0.0569	0.0569	0.0000		
5	TiO_2	0.0083	0.0085	0.0000		
5	U_3O_8	0.0590	0.0611	0.0000		
5	ZnO	0.0062	0.0062	0.0000		
5	ZrO_2	7.0242	7.0242	7.6800	-8.5%	-8.5%
5	sum of oxides	96.7990	96.1361	99.6630	-2.9%	-3.5%
6	Al_2O_3	7.1707	7.3739	7.0200	2.1%	5.0%
6	B_2O_3	7.2609	7.0782	7.0300	3.3%	0.7%
6	Bi_2O_3	7.0093	7.0093	7.0000	0.1%	0.1%
6	CaO	3.0992	2.9587	3.0000	3.3%	-1.4%
6	CdO	1.9676	1.9676	2.0000	-1.6%	-1.6%
6	Ce_2O_3	0.4372	0.4372	0.4360	0.3%	0.3%
6	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
6	Cr_2O_3	0.0862	0.0961	0.0900	-4.2%	6.8%
6	F-	1.7500	1.9787	2.0000	-12.5%	-1.1%
6	Fe_2O_3	4.5822	4.6578	4.6700	-1.9%	-0.3%
6	K_2O	6.5892	6.3409	6.0000	9.8%	5.7%
6	La_2O_3	0.2498	0.2498	0.2580	-3.2%	-3.2%
6	Li_2O	4.8709	4.9956	4.9700	-2.0%	0.5%
6	MgO	0.0083	0.0082	0.0000		
6	MnO	0.0065	0.0065	0.0000		
6	Na_2O	10.4639	10.1477	10.0000	4.6%	1.5%
6	Nd_2O_3	0.1312	0.1312	0.0810	62.0%	62.0%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
6	NiO	0.2962	0.3098	0.3000	-1.3%	3.3%
6	P_2O_5	2.4747	2.4747	2.5000	-1.0%	-1.0%
6	PbO	0.2706	0.2706	0.2900	-6.7%	-6.7%
6	SO_3^-	0.1298	0.1298	0.0900	44.3%	44.3%
6	SiO_2	29.3619	29.4144	29.8000	-1.5%	-1.3%
6	SrO	4.0474	4.0474	4.0000	1.2%	1.2%
6	ThO_2	0.0569	0.0569	0.0000		
6	TiO_2	0.1247	0.1278	0.1200	3.9%	6.5%
6	U_3O_8	0.0590	0.0611	0.0000		
6	ZnO	0.0062	0.0062	0.0000		
6	ZrO_2	7.3990	7.3990	8.0000	-7.5%	-7.5%
6	sum of oxides	100.0095	99.8354	99.6630	0.3%	0.2%
7	Al_2O_3	12.6360	12.9940	12.8100	-1.4%	1.4%
7	B_2O_3	14.9564	14.7174	15.1100	-1.0%	-2.6%
7	Bi_2O_3	0.0084	0.0084	0.0000		
7	CaO	3.1447	3.0091	3.0000	4.8%	0.3%
7	CdO	1.9145	1.9145	2.0000	-4.3%	-4.3%
7	Ce_2O_3	0.4208	0.4208	0.4360	-3.5%	-3.5%
7	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
7	Cr_2O_3	1.2530	1.3829	1.2000	4.4%	15.2%
7	F-	1.5300	1.7317	2.0000	-23.5%	-13.4%
7	Fe_2O_3	9.4110	9.3422	9.1700	2.6%	1.9%
7	K_2O	0.0060	0.0060	0.0300	-79.9%	-79.9%
7	La_2O_3	0.2416	0.2416	0.2580	-6.4%	-6.4%
7	Li_2O	3.7514	4.0734	3.9700	-5.5%	2.6%
7	MgO	0.0083	0.0082	0.0000		
7	MnO	1.8948	1.9213	1.8900	0.3%	1.7%
7	Na_2O	14.9628	14.5745	14.5800	2.6%	0.0%
7	Nd_2O_3	0.1140	0.1140	0.0810	40.8%	40.8%
7	NiO	0.2968	0.3105	0.3000	-1.1%	3.5%
7	P_2O_5	0.0115	0.0115	0.0000		
7	PbO	0.2793	0.2793	0.2900	-3.7%	-3.7%
7	SO_3^-	0.1342	0.1342	0.0900	49.1%	49.1%
7	SiO_2	28.8271	28.5334	28.3700	1.6%	0.6%
7	SrO	0.6469	0.6469	0.6100	6.0%	6.0%
7	ThO_2	0.0569	0.0569	0.0000		
7	TiO_2	0.0083	0.0085	0.0000		
7	U_3O_8	0.0590	0.0612	0.0000		
7	ZnO	1.9357	1.9357	2.0000	-3.2%	-3.2%
7	ZrO_2	1.3981	1.3981	1.4600	-4.2%	-4.2%
7	sum of oxides	100.0074	99.9359	99.6630	0.3%	0.3%
8	Al_2O_3	6.8589	7.0532	6.7600	1.5%	4.3%
8	B_2O_3	16.9447	16.5198	16.9000	0.3%	-2.2%
8	Bi_2O_3	6.8142	6.8142	7.0000	-2.7%	-2.7%
8	CaO	3.1272	2.9855	3.0000	4.2%	-0.5%
8	CdO	1.9276	1.9276	2.0000	-3.6%	-3.6%
8	Ce_2O_3	0.4296	0.4296	0.4360	-1.5%	-1.5%
8	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
8	Cr_2O_3	0.0077	0.0086	0.0000		
8	F-	0.0150	0.0163	0.0000		
8	Fe_2O_3	4.4714	4.5450	4.5000	-0.6%	1.0%
8	K_2O	0.0060	0.0058	0.3200	-98.1%	-98.2%
8	La_2O_3	0.2454	0.2454	0.2580	-4.9%	-4.9%
8	Li_2O	3.2563	3.3472	3.3300	-2.2%	0.5%
8	MgO	0.0083	0.0082	0.0000		
8	MnO	5.6458	5.7104	6.0000	-5.9%	-4.8%
8	Na_2O	10.2414	9.9322	10.0000	2.4%	-0.7%
8	Nd_2O_3	0.1371	0.1371	0.0810	69.2%	69.2%
8	NiO	0.2885	0.3018	0.3000	-3.8%	0.6%
8	P_2O_5	2.3487	2.3487	2.5000	-6.1%	-6.1%
8	PbO	0.2626	0.2626	0.2900	-9.5%	-9.5%
8	SO_3^-	0.1330	0.1330	0.0900	47.7%	47.7%
8	SiO_2	27.5435	27.5922	28.0100	-1.7%	-1.5%
8	SrO	0.0059	0.0059	0.0000		
8	ThO_2	0.0569	0.0569	0.0000		

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
8	TiO_2	2.9232	2.9962	3.0500	-4.2%	-1.8%
8	U_3O_8	0.0590	0.0611	0.0000		
8	ZnO	1.9263	1.9263	2.0000	-3.7%	-3.7%
8	ZrO_2	2.6023	2.6023	2.8300	-8.0%	-8.0%
8	sum of oxides	98.3864	98.0731	99.6630	-1.3%	-1.6%
9	Al_2O_3	9.7734	10.0771	10.0000	-2.3%	0.8%
9	B_2O_3	8.4764	8.4773	8.7200	-2.8%	-2.8%
9	Bi_2O_3	0.0056	0.0056	0.0000		
9	CaO	2.0638	1.9988	2.0000	3.2%	-0.1%
9	CdO	0.0057	0.0057	0.0000		
9	Ce_2O_3	0.4275	0.4275	0.4360	-1.9%	-1.9%
9	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
9	Cr_2O_3	0.7271	0.7888	0.8000	-9.1%	-1.4%
9	F-	0.4100	0.4630	0.5000	-18.0%	-7.4%
9	Fe_2O_3	12.1810	12.4168	12.5900	-3.2%	-1.4%
9	K_2O	1.2498	1.2146	1.5000	-16.7%	-19.0%
9	La_2O_3	0.2442	0.2442	0.2580	-5.3%	-5.3%
9	Li_2O	4.1928	4.5996	4.5000	-6.8%	2.2%
9	MgO	0.0083	0.0082	0.0000		
9	MnO	2.8987	2.9354	3.0000	-3.4%	-2.2%
9	Na_2O	13.8844	13.7122	13.7900	0.7%	-0.6%
9	Nd_2O_3	0.1283	0.1283	0.0810	58.4%	58.4%
9	NiO	0.4587	0.4797	0.5000	-8.3%	-4.1%
9	P_2O_5	1.1377	1.1377	1.2500	-9.0%	-9.0%
9	PbO	0.2669	0.2669	0.2900	-8.0%	-8.0%
9	SO_3^-	0.1255	0.1255	0.0900	39.4%	39.4%
9	SiO_2	34.4427	34.2144	34.3500	0.3%	-0.4%
9	SrO	2.0489	2.0489	2.0000	2.4%	2.4%
9	ThO_2	0.0569	0.0569	0.0000		
9	TiO_2	1.9265	1.9647	2.0000	-3.7%	-1.8%
9	U_3O_8	0.0590	0.0612	0.0000		
9	ZnO	0.0062	0.0062	0.0000		
9	ZrO_2	0.8527	0.8527	1.0000	-14.7%	-14.7%
9	sum of oxides	98.1588	98.8180	99.6630	-1.5%	-0.8%
10	Al_2O_3	8.8098	9.0774	10.0000	-11.9%	-9.2%
10	B_2O_3	5.6026	5.4491	5.0000	12.1%	9.0%
10	Bi_2O_3	3.7318	3.7318	5.0000	-25.4%	-25.4%
10	CaO	0.9955	0.9612	0.0000		
10	CdO	0.0057	0.0057	0.0000		
10	Ce_2O_3	0.3827	0.3827	0.4360	-12.2%	-12.2%
10	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
10	Cr_2O_3	0.6077	0.6693	0.8000	-24.0%	-16.3%
10	F-	0.3250	0.3540	0.5000	-35.0%	-29.2%
10	Fe_2O_3	12.5814	12.6589	13.7300	-8.4%	-7.8%
10	K_2O	2.7886	2.7247	3.2700	-14.7%	-16.7%
10	La_2O_3	0.1815	0.1815	0.2580	-29.7%	-29.7%
10	Li_2O	2.9064	3.2607	3.2700	-11.1%	-0.3%
10	MgO	0.0083	0.0081	0.0000		
10	MnO	1.4591	1.4665	1.8700	-22.0%	-21.6%
10	Na_2O	14.0866	13.5856	13.7600	2.4%	-1.3%
10	Nd_2O_3	0.0875	0.0875	0.0810	8.0%	8.0%
10	NiO	0.3687	0.3832	0.5000	-26.3%	-23.4%
10	P_2O_5	0.8936	0.8936	1.2500	-28.5%	-28.5%
10	PbO	0.2162	0.2162	0.2900	-25.4%	-25.4%
10	SO_3^-	0.2784	0.2784	0.0900	209.3%	209.3%
10	SiO_2	42.2512	41.6447	38.3300	10.2%	8.6%
10	SrO	0.1638	0.1638	0.2200	-25.5%	-25.5%
10	ThO_2	0.0569	0.0569	0.0000		
10	TiO_2	0.0083	0.0085	0.0000		
10	U_3O_8	0.0590	0.0610	0.0000		
10	ZnO	0.0062	0.0062	0.0000		
10	ZrO_2	0.8699	0.8699	1.0000	-13.0%	-13.0%
10	sum of oxides	99.8325	99.2874	99.6630	0.2%	-0.4%
11	Al_2O_3	9.9671	10.0681	10.0000	-0.3%	0.7%
11	B_2O_3	8.2268	8.1595	8.2500	-0.3%	-1.1%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
11	Bi_2O_3	4.8633	4.8633	4.9100	-1.0%	-1.0%
11	CaO	0.0182	0.0179	0.0000		
11	CdO	0.0057	0.0057	0.0000		
11	Ce_2O_3	0.4313	0.4313	0.4360	-1.1%	-1.1%
11	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
11	Cr_2O_3	0.2638	0.2606	0.3000	-12.1%	-13.1%
11	F-	1.2800	1.3941	1.5000	-14.7%	-7.1%
11	Fe_2O_3	13.0246	12.9572	13.4500	-3.2%	-3.7%
11	K_2O	1.2197	1.2150	1.5000	-18.7%	-19.0%
11	La_2O_3	0.2501	0.2501	0.2580	-3.1%	-3.1%
11	Li_2O	1.8154	1.8563	1.8500	-1.9%	0.3%
11	MgO	0.0083	0.0082	0.0000		
11	MnO	2.9246	2.9210	3.0000	-2.5%	-2.6%
11	Na_2O	13.2138	13.0702	12.8100	3.2%	2.0%
11	Nd_2O_3	0.1158	0.1158	0.0810	42.9%	42.9%
11	NiO	0.4466	0.4549	0.5000	-10.7%	-9.0%
11	P_2O_5	0.4961	0.4961	0.5000	-0.8%	-0.8%
11	PbO	0.2658	0.2658	0.2900	-8.3%	-8.3%
11	SO_3^-	0.1223	0.1223	0.0900	35.9%	35.9%
11	SiO_2	37.6517	37.4979	36.9300	2.0%	1.5%
11	SrO	0.0059	0.0059	0.0000		
11	ThO_2	0.0569	0.0569	0.0000		
11	TiO_2	0.0083	0.0084	0.0000		
11	U_3O_8	0.0590	0.0602	0.0000		
11	ZnO	1.9014	1.9014	2.0000	-4.9%	-4.9%
11	ZrO_2	0.9648	0.9648	1.0000	-3.5%	-3.5%
11	sum of oxides	99.7074	99.5288	99.6630	0.0%	-0.1%
12	Al_2O_3	9.8821	9.9823	10.0000	-1.2%	-0.2%
12	B_2O_3	8.0498	7.9835	8.1400	-1.1%	-1.9%
12	Bi_2O_3	0.0086	0.0086	0.0000		
12	CaO	2.1058	2.0728	2.0000	5.3%	3.6%
12	CdO	0.0057	0.0057	0.0000		
12	Ce_2O_3	0.4378	0.4378	0.4360	0.4%	0.4%
12	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
12	Cr_2O_3	0.7699	0.7606	0.8000	-3.8%	-4.9%
12	F-	1.3300	1.4485	1.5000	-11.3%	-3.4%
12	Fe_2O_3	10.8764	10.8201	10.9600	-0.8%	-1.3%
12	K_2O	1.2257	1.2210	1.5000	-18.3%	-18.6%
12	La_2O_3	0.2483	0.2483	0.2580	-3.7%	-3.7%
12	Li_2O	2.4435	2.5587	2.5500	-4.2%	0.3%
12	MgO	0.0083	0.0082	0.0000		
12	MnO	2.6566	2.6534	2.6700	-0.5%	-0.6%
12	Na_2O	16.5130	16.3334	15.9800	3.3%	2.2%
12	Nd_2O_3	0.1266	0.1266	0.0810	56.2%	56.2%
12	NiO	1.6415	1.6718	1.7100	-4.0%	-2.2%
12	P_2O_5	0.5282	0.5282	0.5000	5.6%	5.6%
12	PbO	0.2688	0.2688	0.2900	-7.3%	-7.3%
12	SO_3^-	0.1342	0.1342	0.0900	49.1%	49.1%
12	SiO_2	38.4539	38.2967	37.6900	2.0%	1.6%
12	SrO	0.0059	0.0059	0.0000		
12	ThO_2	0.0569	0.0569	0.0000		
12	TiO_2	1.4845	1.4874	1.5000	-1.0%	-0.8%
12	U_3O_8	0.0590	0.0602	0.0000		
12	ZnO	0.0062	0.0062	0.0000		
12	ZrO_2	0.9749	0.9749	1.0000	-2.5%	-2.5%
12	sum of oxides	100.4022	100.2607	99.6630	0.7%	0.6%
13	Al_2O_3	9.9388	10.2203	10.0000	-0.6%	2.2%
13	B_2O_3	9.5470	9.3924	9.5300	0.2%	-1.4%
13	Bi_2O_3	0.0056	0.0056	0.0000		
13	CaO	0.0395	0.0378	0.0000		
13	CdO	0.0057	0.0057	0.0000		
13	Ce_2O_3	0.4284	0.4284	0.4360	-1.7%	-1.7%
13	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
13	Cr_2O_3	0.7312	0.8070	0.8000	-8.6%	0.9%
13	F-	1.3300	1.4485	1.5000	-11.3%	-3.4%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
13	Fe_2O_3	11.6199	11.5338	11.6700	-0.4%	-1.2%
13	K_2O	1.1775	1.1750	1.5000	-21.5%	-21.7%
13	La_2O_3	0.2454	0.2454	0.2580	-4.9%	-4.9%
13	Li_2O	4.0905	4.3915	4.2800	-4.4%	2.6%
13	MgO	0.0083	0.0082	0.0000		
13	MnO	2.3887	2.4221	2.4400	-2.1%	-0.7%
13	Na_2O	15.9064	15.4947	15.6400	1.7%	-0.9%
13	Nd_2O_3	0.1268	0.1268	0.0810	56.6%	56.6%
13	NiO	1.4697	1.5375	1.5900	-7.6%	-3.3%
13	P_2O_5	1.1589	1.1589	1.2200	-5.0%	-5.0%
13	PbO	0.2698	0.2698	0.2900	-7.0%	-7.0%
13	SO_3^-	0.1248	0.1248	0.0900	38.7%	38.7%
13	SiO_2	36.3681	35.9969	35.8400	1.5%	0.4%
13	SrO	0.0059	0.0059	0.0000		
13	ThO_2	0.0569	0.0569	0.0000		
13	TiO_2	1.4574	1.4894	1.4900	-2.2%	0.0%
13	U_3O_8	0.0590	0.0612	0.0000		
13	ZnO	0.0062	0.0062	0.0000		
13	ZrO_2	0.9510	0.9510	1.0000	-4.9%	-4.9%
13	sum of oxides	99.6175	99.5017	99.6630	0.0%	-0.2%
14	Al_2O_3	6.0700	6.2586	6.0000	1.2%	4.3%
14	B_2O_3	4.9506	4.9515	5.0000	-1.0%	-1.0%
14	Bi_2O_3	0.0056	0.0056	0.0000		
14	CaO	2.1303	2.0631	2.0000	6.5%	3.2%
14	CdO	0.0057	0.0057	0.0000		
14	Ce_2O_3	0.4240	0.4240	0.4360	-2.7%	-2.7%
14	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
14	Cr_2O_3	0.2879	0.3123	0.3000	-4.0%	4.1%
14	F-	1.3650	1.5431	1.5000	-9.0%	2.9%
14	Fe_2O_3	13.6358	13.8987	14.0000	-2.6%	-0.7%
14	K_2O	1.2799	1.2439	1.5000	-14.7%	-17.1%
14	La_2O_3	0.2425	0.2425	0.2580	-6.0%	-6.0%
14	Li_2O	4.2681	4.5996	4.5000	-5.2%	2.2%
14	MgO	0.0083	0.0082	0.0000		
14	MnO	2.8761	2.9126	3.0000	-4.1%	-2.9%
14	Na_2O	16.8163	16.6047	16.8100	0.0%	-1.2%
14	Nd_2O_3	0.1292	0.1292	0.0810	59.5%	59.5%
14	NiO	1.8101	1.8930	2.0000	-9.5%	-5.3%
14	P_2O_5	1.1056	1.1056	1.2500	-11.6%	-11.6%
14	PbO	0.2604	0.2604	0.2900	-10.2%	-10.2%
14	SO_3^-	0.1348	0.1348	0.0900	49.8%	49.8%
14	SiO_2	34.4962	34.2644	34.0000	1.5%	0.8%
14	SrO	0.0059	0.0059	0.0000		
14	ThO_2	0.0569	0.0569	0.0000		
14	TiO_2	1.9265	1.9647	2.0000	-3.7%	-1.8%
14	U_3O_8	0.0590	0.0612	0.0000		
14	ZnO	1.9201	1.9201	2.0000	-4.0%	-4.0%
14	ZrO_2	2.4078	2.4078	2.6400	-8.8%	-8.8%
14	sum of oxides	98.7787	99.3781	99.6630	-0.9%	-0.3%
15	Al_2O_3	9.8254	10.1308	10.0000	-1.7%	1.3%
15	B_2O_3	5.0955	5.0995	5.0000	1.9%	2.0%
15	Bi_2O_3	4.9302	4.9302	5.0000	-1.4%	-1.4%
15	CaO	0.0357	0.0346	0.0000		
15	CdO	0.9590	0.9590	1.0000	-4.1%	-4.1%
15	Ce_2O_3	0.4305	0.4305	0.4360	-1.3%	-1.3%
15	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
15	Cr_2O_3	0.7345	0.7968	0.7700	-4.6%	3.5%
15	F-	1.3650	1.4864	1.5000	-9.0%	-0.9%
15	Fe_2O_3	13.6679	13.9319	14.0000	-2.4%	-0.5%
15	K_2O	2.1472	2.0869	2.2600	-5.0%	-7.7%
15	La_2O_3	0.2486	0.2486	0.2580	-3.6%	-3.6%
15	Li_2O	4.3327	4.5996	4.5000	-3.7%	2.2%
15	MgO	0.0083	0.0082	0.0000		
15	MnO	2.9472	2.9845	3.0000	-1.8%	-0.5%
15	Na_2O	14.9628	14.7759	14.7200	1.6%	0.4%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
15	Nd_2O_3	0.1184	0.1184	0.0810	46.2%	46.2%
15	NiO	0.4673	0.4887	0.5000	-6.5%	-2.3%
15	P_2O_5	1.2133	1.2133	1.2500	-2.9%	-2.9%
15	PbO	0.2696	0.2696	0.2900	-7.0%	-7.0%
15	SO_3^-	0.1336	0.1336	0.0900	48.4%	48.4%
15	SiO_2	34.6032	34.3724	34.0000	1.8%	1.1%
15	SrO	0.0059	0.0059	0.0000		
15	ThO_2	0.0569	0.0569	0.0000		
15	TiO_2	0.0083	0.0085	0.0000		
15	U_3O_8	0.0590	0.0612	0.0000		
15	ZnO	0.0062	0.0062	0.0000		
15	ZrO_2	0.9604	0.9604	1.0000	-4.0%	-4.0%
15	sum of oxides	99.6925	100.2985	99.6630	0.0%	0.6%
16	Al_2O_3	6.0936	6.2663	6.0000	1.6%	4.4%
16	B_2O_3	5.1599	5.0771	5.0000	3.2%	1.5%
16	Bi_2O_3	4.9414	4.9414	5.0000	-1.2%	-1.2%
16	CaO	0.0161	0.0154	0.0000		
16	CdO	0.9632	0.9632	1.0000	-3.7%	-3.7%
16	Ce_2O_3	0.4348	0.4348	0.4360	-0.3%	-0.3%
16	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
16	Cr_2O_3	0.7604	0.8392	0.8000	-5.0%	4.9%
16	F-	1.3400	1.5153	1.5000	-10.7%	1.0%
16	Fe_2O_3	7.2950	7.2409	7.0000	4.2%	3.4%
16	K_2O	1.1624	1.1598	1.5000	-22.5%	-22.7%
16	La_2O_3	0.2489	0.2489	0.2580	-3.5%	-3.5%
16	Li_2O	1.4467	1.5391	1.5000	-3.6%	2.6%
16	MgO	0.0083	0.0082	0.0000		
16	MnO	2.9504	2.9916	3.0000	-1.7%	-0.3%
16	Na_2O	15.1650	14.7720	14.8000	2.5%	-0.2%
16	Nd_2O_3	0.1190	0.1190	0.0810	46.9%	46.9%
16	NiO	1.2782	1.3371	1.3300	-3.9%	0.5%
16	P_2O_5	1.2305	1.2305	1.2500	-1.6%	-1.6%
16	PbO	0.2701	0.2701	0.2900	-6.9%	-6.9%
16	SO_3^-	0.1167	0.1167	0.0900	29.7%	29.7%
16	SiO_2	46.5298	46.0540	45.9900	1.2%	0.1%
16	SrO	1.9069	1.9069	1.8300	4.2%	4.2%
16	ThO_2	0.0569	0.0569	0.0000		
16	TiO_2	0.0083	0.0085	0.0000		
16	U_3O_8	0.0590	0.0612	0.0000		
16	ZnO	0.0062	0.0062	0.0000		
16	ZrO_2	0.9793	0.9793	1.0000	-2.1%	-2.1%
16	sum of oxides	100.6473	100.2598	99.6630	1.0%	0.6%
17	Al_2O_3	6.0889	6.2614	6.0000	1.5%	4.4%
17	B_2O_3	11.5514	11.3675	11.6900	-1.2%	-2.8%
17	Bi_2O_3	0.0056	0.0056	0.0000		
17	CaO	0.0210	0.0201	0.0000		
17	CdO	0.9864	0.9864	1.0000	-1.4%	-1.4%
17	Ce_2O_3	0.4348	0.4348	0.4360	-0.3%	-0.3%
17	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
17	Cr_2O_3	0.2872	0.3170	0.3000	-4.3%	5.7%
17	F-	1.3600	1.5394	1.5000	-9.3%	2.6%
17	Fe_2O_3	7.5846	7.5288	7.4400	1.9%	1.2%
17	K_2O	4.6618	4.6539	4.5000	3.6%	3.4%
17	La_2O_3	0.2480	0.2480	0.2580	-3.9%	-3.9%
17	Li_2O	1.4182	1.5391	1.5000	-5.5%	2.6%
17	MgO	0.0083	0.0082	0.0000		
17	MnO	1.0268	1.0412	1.0000	2.7%	4.1%
17	Na_2O	16.5467	16.1176	16.4700	0.5%	-2.1%
17	Nd_2O_3	0.1353	0.1353	0.0810	67.0%	67.0%
17	NiO	1.9342	2.0234	2.0000	-3.3%	1.2%
17	P_2O_5	0.4783	0.4783	0.5000	-4.3%	-4.3%
17	PbO	0.2688	0.2688	0.2900	-7.3%	-7.3%
17	SO_3^-	0.1242	0.1242	0.0900	38.0%	38.0%
17	SiO_2	38.0795	37.6923	37.6000	1.3%	0.2%
17	SrO	0.0059	0.0059	0.0000		

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
17	ThO_2	0.0569	0.0569	0.0000		
17	TiO_2	1.9641	2.0071	2.0000	-1.8%	0.4%
17	U_3O_8	0.0590	0.0612	0.0000		
17	ZnO	1.9481	1.9481	2.0000	-2.6%	-2.6%
17	ZrO_2	2.8705	2.8705	3.0000	-4.3%	-4.3%
17	sum of oxides	100.2545	99.8409	99.6630	0.6%	0.2%
18	Al_2O_3	6.0984	6.2836	6.0000	1.6%	4.7%
18	B_2O_3	8.1544	7.9299	8.1800	-0.3%	-3.1%
18	Bi_2O_3	0.0056	0.0056	0.0000		
18	CaO	2.0848	2.0129	2.0000	4.2%	0.6%
18	CdO	0.0057	0.0057	0.0000		
18	Ce_2O_3	0.4296	0.4296	0.4360	-1.5%	-1.5%
18	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
18	Cr_2O_3	0.2941	0.3240	0.3000	-2.0%	8.0%
18	F-	1.3950	1.5766	1.5000	-7.0%	5.1%
18	Fe_2O_3	13.7180	13.8025	14.0000	-2.0%	-1.4%
18	K_2O	4.0384	3.9459	3.8900	3.8%	1.4%
18	La_2O_3	0.2466	0.2466	0.2580	-4.4%	-4.4%
18	Li_2O	3.6492	3.7793	3.7900	-3.7%	-0.3%
18	MgO	0.0083	0.0081	0.0000		
18	MnO	1.0265	1.0317	1.0000	2.7%	3.2%
18	Na_2O	16.3782	15.7954	15.8900	3.1%	-0.6%
18	Nd_2O_3	0.1201	0.1201	0.0810	48.3%	48.3%
18	NiO	0.4899	0.5092	0.5000	-2.0%	1.8%
18	P_2O_5	0.5293	0.5293	0.5000	5.9%	5.9%
18	PbO	0.2706	0.2706	0.2900	-6.7%	-6.7%
18	SO_3^-	0.1529	0.1529	0.0900	69.9%	69.9%
18	SiO_2	36.0472	35.5300	35.5400	1.4%	0.0%
18	SrO	1.4783	1.4783	1.4200	4.1%	4.1%
18	ThO_2	0.0569	0.0569	0.0000		
18	TiO_2	0.0083	0.0085	0.0000		
18	U_3O_8	0.0590	0.0610	0.0000		
18	ZnO	0.9737	0.9737	0.9900	-1.6%	-1.6%
18	ZrO_2	2.8603	2.8603	3.0000	-4.7%	-4.7%
18	sum of oxides	100.6794	99.8283	99.6630	1.0%	0.2%
19	Al_2O_3	8.6681	8.9375	8.8200	-1.7%	1.3%
19	B_2O_3	6.4961	6.4993	6.5700	-1.1%	-1.1%
19	Bi_2O_3	3.7485	3.7485	3.8200	-1.9%	-1.9%
19	CaO	1.7280	1.6735	1.6400	5.4%	2.0%
19	CdO	0.0057	0.0057	0.0000		
19	Ce_2O_3	0.4284	0.4284	0.4360	-1.7%	-1.7%
19	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
19	Cr_2O_3	0.2941	0.3191	0.3000	-2.0%	6.4%
19	F-	1.4150	1.6003	1.5000	-5.7%	6.7%
19	Fe_2O_3	7.1271	7.2649	7.3200	-2.6%	-0.8%
19	K_2O	1.2407	1.2059	1.5000	-17.3%	-19.6%
19	La_2O_3	0.2478	0.2478	0.2580	-4.0%	-4.0%
19	Li_2O	4.2627	4.5996	4.5000	-5.3%	2.2%
19	MgO	0.0083	0.0082	0.0000		
19	MnO	2.9310	2.9681	3.0000	-2.3%	-1.1%
19	Na_2O	16.7152	16.5059	17.0800	-2.1%	-3.4%
19	Nd_2O_3	0.1178	0.1178	0.0810	45.4%	45.4%
19	NiO	1.4220	1.4871	1.5000	-5.2%	-0.9%
19	P_2O_5	0.4875	0.4875	0.5000	-2.5%	-2.5%
19	PbO	0.2669	0.2669	0.2900	-8.0%	-8.0%
19	SO_3^-	0.1192	0.1192	0.0900	32.5%	32.5%
19	SiO_2	37.0099	36.7628	36.8100	0.5%	-0.1%
19	SrO	0.8813	0.8813	0.8400	4.9%	4.9%
19	ThO_2	0.0569	0.0569	0.0000		
19	TiO_2	0.0083	0.0085	0.0000		
19	U_3O_8	0.0590	0.0612	0.0000		
19	ZnO	1.7521	1.7521	1.8000	-2.7%	-2.7%
19	ZrO_2	0.9631	0.9631	1.0000	-3.7%	-3.7%
19	sum of oxides	98.5608	99.0770	99.6630	-1.1%	-0.6%
20	Al_2O_3	9.7734	10.0503	10.0000	-2.3%	0.5%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
20	B_2O_3	4.9908	4.9121	5.0000	-0.2%	-1.8%
20	Bi_2O_3	4.8912	4.8912	0.2000	2345.6%	2345.6%
20	CaO	2.0743	1.9848	2.0000	3.7%	-0.8%
20	CdO	0.0057	0.0057	1.0000	-99.4%	-99.4%
20	Ce_2O_3	0.4293	0.4293	0.4360	-1.5%	-1.5%
20	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
20	Cr_2O_3	0.2963	0.3270	0.8000	-63.0%	-59.1%
20	F-	0.3800	0.4139	1.5000	-74.7%	-72.4%
20	Fe_2O_3	8.2101	8.1493	8.4600	-3.0%	-3.7%
20	K_2O	4.5986	4.5918	4.5000	2.2%	2.0%
20	La_2O_3	0.2442	0.2442	0.2580	-5.3%	-5.3%
20	Li_2O	4.2251	4.6172	4.5000	-6.1%	2.6%
20	MgO	0.0083	0.0082	0.0000		
20	MnO	1.0120	1.0261	3.0000	-66.3%	-65.8%
20	Na_2O	17.4229	16.9712	12.9300	34.7%	31.3%
20	Nd_2O_3	0.1318	0.1318	0.0810	62.7%	62.7%
20	NiO	0.4772	0.4992	0.5000	-4.6%	-0.2%
20	P_2O_5	0.5230	0.5230	0.5000	4.6%	4.6%
20	PbO	0.2645	0.2645	0.2900	-8.8%	-8.8%
20	SO_3^-	0.1174	0.1174	0.0900	30.4%	30.4%
20	SiO_2	34.0684	33.7208	36.6100	-6.9%	-7.9%
20	SrO	0.0059	0.0059	2.0000	-99.7%	-99.7%
20	ThO_2	0.0569	0.0569	0.0000		
20	TiO_2	1.9474	1.9901	2.0000	-2.6%	-0.5%
20	U_3O_8	0.0590	0.0612	0.0000		
20	ZnO	0.0062	0.0062	0.0000		
20	ZrO_2	2.8536	2.8536	3.0000	-4.9%	-4.9%
20	sum of oxides	99.1733	98.9527	99.6630	-0.5%	-0.7%
21	Al_2O_3	6.8778	7.0914	6.9000	-0.3%	2.8%
21	B_2O_3	6.5525	6.5584	6.7300	-2.6%	-2.5%
21	Bi_2O_3	4.8382	4.8382	5.0000	-3.2%	-3.2%
21	CaO	2.0533	1.9886	2.0000	2.7%	-0.6%
21	CdO	0.9395	0.9395	1.0000	-6.0%	-6.0%
21	Ce_2O_3	0.4272	0.4272	0.4360	-2.0%	-2.0%
21	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
21	Cr_2O_3	0.8211	0.8907	0.7500	9.5%	18.8%
21	F-	0.4000	0.4355	0.5000	-20.0%	-12.9%
21	Fe_2O_3	9.6255	9.8114	9.9100	-2.9%	-1.0%
21	K_2O	4.6799	4.5486	4.5000	4.0%	1.1%
21	La_2O_3	0.2425	0.2425	0.2580	-6.0%	-6.0%
21	Li_2O	1.5113	1.6354	1.6000	-5.5%	2.2%
21	MgO	0.0083	0.0082	0.0000		
21	MnO	2.9246	2.9616	3.0000	-2.5%	-1.3%
21	Na_2O	12.4387	12.2830	12.5000	-0.5%	-1.7%
21	Nd_2O_3	0.1178	0.1178	0.0810	45.4%	45.4%
21	NiO	0.4966	0.5193	0.5000	-0.7%	3.9%
21	P_2O_5	0.4978	0.4978	0.5000	-0.4%	-0.4%
21	PbO	0.2599	0.2599	0.2900	-10.4%	-10.4%
21	SO_3^-	0.1042	0.1042	0.0900	15.8%	15.8%
21	SiO_2	38.7213	38.4637	38.3500	1.0%	0.3%
21	SrO	0.0059	0.0059	0.0000		
21	ThO_2	0.0569	0.0569	0.0000		
21	TiO_2	0.0083	0.0085	0.0000		
21	U_3O_8	0.0590	0.0612	0.0000		
21	ZnO	1.9139	1.9139	2.0000	-4.3%	-4.3%
21	ZrO_2	2.6003	2.6003	2.7600	-5.8%	-5.8%
21	sum of oxides	99.2823	99.3697	99.6630	-0.4%	-0.3%
22	Al_2O_3	6.1362	6.3100	6.0000	2.3%	5.2%
22	B_2O_3	9.7724	9.5284	9.7100	0.6%	-1.9%
22	Bi_2O_3	2.8400	2.8400	2.8600	-0.7%	-0.7%
22	CaO	0.0728	0.0695	0.0000		
22	CdO	0.9967	0.9967	1.0000	-0.3%	-0.3%
22	Ce_2O_3	0.4319	0.4319	0.4360	-0.9%	-0.9%
22	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
22	Cr_2O_3	0.2927	0.3263	0.3000	-2.4%	8.8%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
22	F-	1.4300	1.5574	1.5000	-4.7%	3.8%
22	Fe_2O_3	7.4166	7.5386	7.5600	-1.9%	-0.3%
22	K_2O	4.8335	4.6514	4.5000	7.4%	3.4%
22	La_2O_3	0.2492	0.2492	0.2580	-3.4%	-3.4%
22	Li_2O	3.8214	3.9302	3.9100	-2.3%	0.5%
22	MgO	0.0083	0.0082	0.0000		
22	MnO	1.0333	1.0449	1.0000	3.3%	4.5%
22	Na_2O	15.4683	15.0014	15.1100	2.4%	-0.7%
22	Nd_2O_3	0.1268	0.1268	0.0810	56.6%	56.6%
22	NiO	1.4220	1.4874	1.4600	-2.6%	1.9%
22	P_2O_5	0.4846	0.4846	0.5000	-3.1%	-3.1%
22	PbO	0.2723	0.2723	0.2900	-6.1%	-6.1%
22	SO_3^-	0.1136	0.1136	0.0900	26.2%	26.2%
22	SiO_2	39.4166	39.4871	39.2100	0.5%	0.7%
22	SrO	0.0059	0.0059	0.0000		
22	ThO_2	0.0569	0.0569	0.0000		
22	TiO_2	0.8832	0.9052	0.8800	0.4%	2.9%
22	U_3O_8	0.0590	0.0611	0.0000		
22	ZnO	0.0062	0.0062	0.0000		
22	ZrO_2	2.9008	2.9008	3.0000	-3.3%	-3.3%
22	sum of oxides	100.6510	100.4921	99.6630	1.0%	0.8%
23	Al_2O_3	9.8490	10.1483	10.0000	-1.5%	1.5%
23	B_2O_3	5.0150	4.8778	5.0000	0.3%	-2.4%
23	Bi_2O_3	4.9497	4.9497	5.0000	-1.0%	-1.0%
23	CaO	0.0539	0.0520	0.0000		
23	CdO	0.0057	0.0057	0.0000		
23	Ce_2O_3	0.4319	0.4319	0.4360	-0.9%	-0.9%
23	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
23	Cr_2O_3	0.8134	0.8961	0.8000	1.7%	12.0%
23	F-	0.4050	0.4590	0.5000	-19.0%	-8.2%
23	Fe_2O_3	6.9233	6.9663	7.0000	-1.1%	-0.5%
23	K_2O	4.7793	4.6698	4.5000	6.2%	3.8%
23	La_2O_3	0.2472	0.2472	0.2580	-4.2%	-4.2%
23	Li_2O	4.3273	4.4873	4.5000	-3.8%	-0.3%
23	MgO	0.0083	0.0081	0.0000		
23	MnO	2.9762	2.9913	3.0000	-0.8%	-0.3%
23	Na_2O	18.0295	17.3878	17.5000	3.0%	-0.6%
23	Nd_2O_3	0.1301	0.1301	0.0810	60.6%	60.6%
23	NiO	1.9056	1.9805	2.0000	-4.7%	-1.0%
23	P_2O_5	1.1165	1.1165	1.2500	-10.7%	-10.7%
23	PbO	0.2704	0.2704	0.2900	-6.8%	-6.8%
23	SO_3^-	0.1642	0.1642	0.0900	82.4%	82.4%
23	SiO_2	35.2450	34.7399	34.4500	2.3%	0.8%
23	SrO	0.0059	0.0059	0.0000		
23	ThO_2	0.0569	0.0569	0.0000		
23	TiO_2	1.9682	2.0056	2.0000	-1.6%	0.3%
23	U_3O_8	0.0590	0.0610	0.0000		
23	ZnO	0.0062	0.0062	0.0000		
23	ZrO_2	0.8804	0.8804	1.0000	-12.0%	-12.0%
23	sum of oxides	100.7229	100.0956	99.6630	1.1%	0.4%
24	Al_2O_3	9.9577	10.2397	10.0000	-0.4%	2.4%
24	B_2O_3	5.1760	5.0488	5.0000	3.5%	1.0%
24	Bi_2O_3	0.2082	0.2082	5.0000	-95.8%	-95.8%
24	CaO	2.1093	2.0137	2.0000	5.5%	0.7%
24	CdO	0.9767	0.9767	0.0000		
24	Ce_2O_3	0.4369	0.4369	0.4360	0.2%	0.2%
24	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
24	Cr_2O_3	0.7907	0.8818	0.3000	163.6%	193.9%
24	F-	1.3300	1.5040	0.5000	166.0%	200.8%
24	Fe_2O_3	8.2351	8.3707	8.2000	0.4%	2.1%
24	K_2O	4.8064	4.6253	4.5000	6.8%	2.8%
24	La_2O_3	0.2483	0.2483	0.2580	-3.7%	-3.7%
24	Li_2O	4.3273	4.5232	4.5000	-3.8%	0.5%
24	MgO	0.0083	0.0082	0.0000		
24	MnO	2.9794	3.0131	1.0000	197.9%	201.3%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
24	Na_2O	13.2070	12.8084	17.5000	-24.5%	-26.8%
24	Nd_2O_3	0.1344	0.1344	0.0810	66.0%	66.0%
24	NiO	0.4880	0.5105	0.5000	-2.4%	2.1%
24	P_2O_5	0.4869	0.4869	0.5000	-2.6%	-2.6%
24	PbO	0.2696	0.2696	0.2900	-7.0%	-7.0%
24	SO_3^-	0.1167	0.1167	0.0900	29.7%	29.7%
24	SiO_2	36.3681	36.4329	34.0000	7.0%	7.2%
24	SrO	2.0607	2.0607	0.0000		
24	ThO_2	0.0569	0.0569	0.0000		
24	TiO_2	1.9724	2.0216	2.0000	-1.4%	1.1%
24	U_3O_8	0.0590	0.0611	0.0000		
24	ZnO	0.0062	0.0062	0.0000		
24	ZrO_2	2.9211	2.9211	3.0000	-2.6%	-2.6%
24	sum of oxides	99.8373	100.0856	99.6630	0.2%	0.4%
25	Al_2O_3	10.1939	10.2967	10.0000	1.9%	3.0%
25	B_2O_3	4.8862	4.8462	5.0000	-2.3%	-3.1%
25	Bi_2O_3	0.0056	0.0056	0.0000		
25	CaO	0.0224	0.0220	0.0000		
25	CdO	0.0057	0.0057	0.0000		
25	Ce_2O_3	0.4419	0.4419	0.4360	1.3%	1.3%
25	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
25	Cr_2O_3	0.5415	0.5350	0.5700	-5.0%	-6.1%
25	F-	1.2700	1.3830	1.5000	-15.3%	-7.8%
25	Fe_2O_3	12.2132	12.1499	12.3700	-1.3%	-1.8%
25	K_2O	1.2197	1.2150	1.5000	-18.7%	-19.0%
25	La_2O_3	0.2530	0.2530	0.2580	-1.9%	-1.9%
25	Li_2O	1.4204	1.5051	1.5000	-5.3%	0.3%
25	MgO	0.0083	0.0082	0.0000		
25	MnO	2.9891	2.9855	3.0000	-0.4%	-0.5%
25	Na_2O	13.2441	13.0997	12.7400	4.0%	2.8%
25	Nd_2O_3	0.1193	0.1193	0.0810	47.2%	47.2%
25	NiO	0.4836	0.4924	0.5000	-3.3%	-1.5%
25	P_2O_5	1.1881	1.1881	1.2500	-5.0%	-5.0%
25	PbO	0.2733	0.2733	0.2900	-5.7%	-5.7%
25	SO_3^-	0.1117	0.1117	0.0900	24.2%	24.2%
25	SiO_2	45.4601	45.2738	43.5700	4.3%	3.9%
25	SrO	2.0459	2.0459	2.0000	2.3%	2.3%
25	ThO_2	0.0569	0.0569	0.0000		
25	TiO_2	0.0217	0.0217	0.0000		
25	U_3O_8	0.0590	0.0602	0.0000		
25	ZnO	1.9481	1.9481	2.0000	-2.6%	-2.6%
25	ZrO_2	1.0681	1.0681	1.0000	6.8%	6.8%
25	sum of oxides	101.6507	101.5122	99.6630	2.0%	1.9%
26	Al_2O_3	9.7026	10.0041	10.0000	-3.0%	0.0%
26	B_2O_3	8.0498	8.0497	7.9300	1.5%	1.5%
26	Bi_2O_3	0.0084	0.0084	0.0000		
26	CaO	2.0568	1.9920	2.0000	2.8%	-0.4%
26	CdO	0.0057	0.0057	0.0000		
26	Ce_2O_3	0.4164	0.4164	0.4360	-4.5%	-4.5%
26	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
26	Cr_2O_3	0.7651	0.8300	0.8000	-4.4%	3.8%
26	F-	1.2650	1.3776	1.5000	-15.7%	-8.2%
26	Fe_2O_3	6.8661	6.9985	7.2100	-4.8%	-2.9%
26	K_2O	4.6618	4.5310	4.5000	3.6%	0.7%
26	La_2O_3	0.2395	0.2395	0.2580	-7.2%	-7.2%
26	Li_2O	4.1551	4.4361	4.3400	-4.3%	2.2%
26	MgO	0.0083	0.0082	0.0000		
26	MnO	0.9955	1.0081	1.0000	-0.4%	0.8%
26	Na_2O	16.3108	16.1039	16.6100	-1.8%	-3.0%
26	Nd_2O_3	0.1248	0.1248	0.0810	54.1%	54.1%
26	NiO	0.0534	0.0559	0.5000	-89.3%	-88.8%
26	P_2O_5	0.4640	0.4640	0.5000	-7.2%	-7.2%
26	PbO	0.2599	0.2599	0.2900	-10.4%	-10.4%
26	SO_3^-	0.1161	0.1161	0.0900	29.0%	29.0%
26	SiO_2	34.2288	34.0001	34.4800	-0.7%	-1.4%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
26	SrO	2.0429	2.0429	2.0000	2.1%	2.1%
26	ThO_2	0.0569	0.0569	0.0000		
26	TiO_2	1.2894	1.3149	1.3400	-3.8%	-1.9%
26	U_3O_8	0.0590	0.0612	0.0000		
26	ZnO	0.7444	0.7444	0.7900	-5.8%	-5.8%
26	ZrO_2	2.7962	2.7962	3.0000	-6.8%	-6.8%
26	sum of oxides	97.8427	98.1465	99.6630	-1.8%	-1.5%
27	Al_2O_3	6.4715	6.6681	6.4200	0.8%	3.9%
27	B_2O_3	11.5111	11.1958	12.0000	-4.1%	-6.7%
27	Bi_2O_3	4.9553	4.9553	5.0000	-0.9%	-0.9%
27	CaO	0.0213	0.0206	0.0000		
27	CdO	0.0057	0.0057	0.0000		
27	Ce_2O_3	0.4325	0.4325	0.4360	-0.8%	-0.8%
27	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
27	Cr_2O_3	0.7706	0.8490	0.8000	-3.7%	6.1%
27	F-	0.4150	0.4696	0.5000	-17.0%	-6.1%
27	Fe_2O_3	6.9126	6.9554	7.0000	-1.2%	-0.6%
27	K_2O	4.7190	4.6109	4.5000	4.9%	2.5%
27	La_2O_3	0.2480	0.2480	0.2580	-3.9%	-3.9%
27	Li_2O	1.4543	1.4958	1.5000	-3.0%	-0.3%
27	MgO	0.0083	0.0081	0.0000		
27	MnO	1.0343	1.0395	1.0000	3.4%	3.9%
27	Na_2O	16.8837	16.2843	16.4400	2.7%	-0.9%
27	Nd_2O_3	0.1315	0.1315	0.0810	62.4%	62.4%
27	NiO	0.4985	0.5181	0.5000	-0.3%	3.6%
27	P_2O_5	0.4869	0.4869	0.5000	-2.6%	-2.6%
27	PbO	0.2728	0.2728	0.2900	-5.9%	-5.9%
27	SO_3^-	0.1411	0.1411	0.0900	56.7%	56.7%
27	SiO_2	37.8121	37.2738	37.3400	1.3%	-0.2%
27	SrO	2.0370	2.0370	2.0000	1.9%	1.9%
27	ThO_2	0.0569	0.0569	0.0000		
27	TiO_2	1.9641	2.0012	2.0000	-1.8%	0.1%
27	U_3O_8	0.0590	0.0610	0.0000		
27	ZnO	0.0062	0.0062	0.0000		
27	ZrO_2	0.9655	0.9655	1.0000	-3.5%	-3.5%
27	sum of oxides	100.3749	99.2906	99.6630	0.7%	-0.4%
28	Al_2O_3	9.9104	10.2115	10.0000	-0.9%	2.1%
28	B_2O_3	5.5302	5.3784	5.5600	-0.5%	-3.3%
28	Bi_2O_3	0.0056	0.0056	0.0000		
28	CaO	0.5097	0.4920	0.4600	10.8%	7.0%
28	CdO	0.8870	0.8870	1.0000	-11.3%	-11.3%
28	Ce_2O_3	0.4284	0.4284	0.4360	-1.7%	-1.7%
28	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
28	Cr_2O_3	0.7615	0.8389	0.8000	-4.8%	4.9%
28	F-	0.3950	0.4303	0.5000	-21.0%	-13.9%
28	Fe_2O_3	13.7537	13.8383	14.0000	-1.8%	-1.2%
28	K_2O	4.7672	4.6580	4.5000	5.9%	3.5%
28	La_2O_3	0.2457	0.2457	0.2580	-4.8%	-4.8%
28	Li_2O	4.3704	4.4873	4.5000	-2.9%	-0.3%
28	MgO	0.0083	0.0081	0.0000		
28	MnO	2.9536	2.9686	3.0000	-1.5%	-1.0%
28	Na_2O	12.9543	12.4933	12.5000	3.6%	-0.1%
28	Nd_2O_3	0.1166	0.1166	0.0810	44.0%	44.0%
28	NiO	0.4734	0.4920	0.5000	-5.3%	-1.6%
28	P_2O_5	0.1581	0.1581	1.2500	-87.4%	-87.4%
28	PbO	0.2688	0.2688	0.2900	-7.3%	-7.3%
28	SO_3^-	0.1567	0.1567	0.0900	74.1%	74.1%
28	SiO_2	34.8171	34.3165	34.4700	1.0%	-0.4%
28	SrO	0.4612	0.4612	0.4600	0.3%	0.3%
28	ThO_2	0.0569	0.0569	0.0000		
28	TiO_2	0.0083	0.0085	0.0000		
28	U_3O_8	0.0590	0.0610	0.0000		
28	ZnO	1.9450	1.9450	2.0000	-2.8%	-2.8%
28	ZrO_2	1.4052	1.4052	3.0000	-53.2%	-53.2%
28	sum of oxides	97.5072	96.9177	99.6630	-2.2%	-2.8%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
29	Al_2O_3	6.1881	6.3634	6.1300	0.9%	3.8%
29	B_2O_3	9.5953	9.4412	9.6800	-0.9%	-2.5%
29	Bi_2O_3	4.9358	4.9358	5.0000	-1.3%	-1.3%
29	CaO	2.0778	1.9882	2.0000	3.9%	-0.6%
29	CdO	0.0057	0.0057	0.0000		
29	Ce_2O_3	0.4302	0.4302	0.4360	-1.3%	-1.3%
29	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
29	Cr_2O_3	0.7436	0.8207	0.8000	-7.1%	2.6%
29	F-	0.4050	0.4576	0.5000	-19.0%	-8.5%
29	Fe_2O_3	12.9853	12.8887	12.9300	0.4%	-0.3%
29	K_2O	1.1414	1.1387	1.5000	-23.9%	-24.1%
29	La_2O_3	0.2475	0.2475	0.2580	-4.1%	-4.1%
29	Li_2O	4.2789	4.6172	4.5000	-4.9%	2.6%
29	MgO	0.0083	0.0082	0.0000		
29	MnO	1.0165	1.0307	1.0000	1.6%	3.1%
29	Na_2O	12.9307	12.5953	12.8000	1.0%	-1.6%
29	Nd_2O_3	0.1184	0.1184	0.0810	46.2%	46.2%
29	NiO	0.9172	0.9594	0.9700	-5.4%	-1.1%
29	P_2O_5	0.4743	0.4743	0.5000	-5.1%	-5.1%
29	PbO	0.2658	0.2658	0.2900	-8.3%	-8.3%
29	SO_3^-	0.1380	0.1380	0.0900	53.3%	53.3%
29	SiO_2	36.2077	35.8384	35.7600	1.3%	0.2%
29	SrO	2.0548	2.0548	2.0000	2.7%	2.7%
29	ThO_2	0.0569	0.0569	0.0000		
29	TiO_2	0.0083	0.0085	0.0000		
29	U_3O_8	0.0590	0.0612	0.0000		
29	ZnO	1.3662	1.3662	1.4300	-4.5%	-4.5%
29	ZrO_2	0.9570	0.9570	1.0000	-4.3%	-4.3%
29	sum of oxides	99.7133	99.3678	99.6630	0.1%	-0.3%
30	Al_2O_3	6.1267	6.3130	6.0000	2.1%	5.2%
30	B_2O_3	11.5675	11.2492	12.0000	-3.6%	-6.3%
30	Bi_2O_3	5.0138	5.0138	5.0000	0.3%	0.3%
30	CaO	2.1023	2.0299	2.0000	5.1%	1.5%
30	CdO	0.0057	0.0057	0.0000		
30	Ce_2O_3	0.4369	0.4369	0.4360	0.2%	0.2%
30	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
30	Cr_2O_3	0.7286	0.8027	0.8000	-8.9%	0.3%
30	F-	0.3900	0.4246	0.5000	-22.0%	-15.1%
30	Fe_2O_3	11.4483	11.5190	11.4400	0.1%	0.7%
30	K_2O	2.7344	2.6718	2.7600	-0.9%	-3.2%
30	La_2O_3	0.2510	0.2510	0.2580	-2.7%	-2.7%
30	Li_2O	1.4457	1.4958	1.5000	-3.6%	-0.3%
30	MgO	0.0083	0.0081	0.0000		
30	MnO	1.0349	1.0402	1.0000	3.5%	4.0%
30	Na_2O	16.9511	16.3477	16.2600	4.3%	0.5%
30	Nd_2O_3	0.1190	0.1190	0.0810	46.9%	46.9%
30	NiO	1.3934	1.4482	1.4400	-3.2%	0.6%
30	P_2O_5	0.5207	0.5207	0.5000	4.1%	4.1%
30	PbO	0.2723	0.2723	0.2900	-6.1%	-6.1%
30	SO_3^-	0.1473	0.1473	0.0900	63.7%	63.7%
30	SiO_2	35.6728	35.1617	34.8700	2.3%	0.8%
30	SrO	0.0059	0.0059	0.0000		
30	ThO_2	0.0569	0.0569	0.0000		
30	TiO_2	0.0083	0.0085	0.0000		
30	U_3O_8	0.0590	0.0610	0.0000		
30	ZnO	1.4035	1.4035	1.4300	-1.9%	-1.9%
30	ZrO_2	0.9810	0.9810	1.0000	-1.9%	-1.9%
30	sum of oxides	100.9853	99.8952	99.6630	1.3%	0.2%
31	Al_2O_3	9.5136	9.7829	9.6600	-1.5%	1.3%
31	B_2O_3	5.1921	5.0640	5.0000	3.8%	1.3%
31	Bi_2O_3	4.7881	4.7881	4.8300	-0.9%	-0.9%
31	CaO	0.0157	0.0150	0.0000		
31	CdO	0.0057	0.0057	0.0000		
31	Ce_2O_3	0.4305	0.4305	0.4360	-1.3%	-1.3%
31	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
31	Cr_2O_3	0.2872	0.3202	0.3000	-4.3%	6.7%
31	F-	1.3400	1.5153	1.5000	-10.7%	1.0%
31	Fe_2O_3	13.4928	13.7150	13.7600	-1.9%	-0.3%
31	K_2O	1.2437	1.1969	1.5000	-17.1%	-20.2%
31	La_2O_3	0.2483	0.2483	0.2580	-3.7%	-3.7%
31	Li_2O	3.7676	3.9503	3.9300	-4.1%	0.5%
31	MgO	0.0083	0.0082	0.0000		
31	MnO	1.0249	1.0365	1.0000	2.5%	3.6%
31	Na_2O	16.3108	15.8184	15.9300	2.4%	-0.7%
31	Nd_2O_3	0.1178	0.1178	0.0810	45.4%	45.4%
31	NiO	1.0718	1.1211	1.1200	-4.3%	0.1%
31	P_2O_5	1.0065	1.0065	1.0400	-3.2%	-3.2%
31	PbO	0.2717	0.2717	0.2900	-6.3%	-6.3%
31	SO_3^-	0.1192	0.1192	0.0900	32.5%	32.5%
31	SiO_2	35.6728	35.7371	35.9300	-0.7%	-0.5%
31	SrO	2.0104	2.0104	2.0000	0.5%	0.5%
31	ThO_2	0.0569	0.0569	0.0000		
31	TiO_2	0.0083	0.0085	0.0000		
31	U_3O_8	0.0590	0.0611	0.0000		
31	ZnO	0.0062	0.0062	0.0000		
31	ZrO_2	0.9554	0.9554	1.0000	-4.5%	-4.5%
31	sum of oxides	99.1254	99.4672	99.6630	-0.5%	-0.2%
32	Al_2O_3	6.1739	6.3615	6.0500	2.0%	5.1%
32	B_2O_3	9.8046	9.5352	10.0900	-2.8%	-5.5%
32	Bi_2O_3	0.0117	0.0117	0.0000		
32	CaO	0.0266	0.0257	0.0000		
32	CdO	0.0057	0.0057	0.0000		
32	Ce_2O_3	0.4348	0.4348	0.4360	-0.3%	-0.3%
32	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
32	Cr_2O_3	0.3004	0.3308	0.3000	0.1%	10.3%
32	F-	1.3450	1.5212	1.5000	-10.3%	1.4%
32	Fe_2O_3	6.9769	7.0201	7.0000	-0.3%	0.3%
32	K_2O	4.7401	4.6315	4.5000	5.3%	2.9%
32	La_2O_3	0.2492	0.2492	0.2580	-3.4%	-3.4%
32	Li_2O	1.4688	1.4958	1.5000	-2.1%	-0.3%
32	MgO	0.0083	0.0081	0.0000		
32	MnO	3.0117	3.0270	3.0000	0.4%	0.9%
32	Na_2O	17.7936	17.1611	17.5000	1.7%	-1.9%
32	Nd_2O_3	0.1184	0.1184	0.0810	46.2%	46.2%
32	NiO	0.5306	0.5515	0.5000	6.1%	10.3%
32	P_2O_5	1.3050	1.3050	1.2500	4.4%	4.4%
32	PbO	0.2728	0.2728	0.2900	-5.9%	-5.9%
32	SO_3^-	0.1436	0.1436	0.0900	59.5%	59.5%
32	SiO_2	43.2139	42.5954	42.2700	2.2%	0.8%
32	SrO	0.0059	0.0059	0.0000		
32	ThO_2	0.0569	0.0569	0.0000		
32	TiO_2	0.0083	0.0085	0.0000		
32	U_3O_8	0.0590	0.0610	0.0000		
32	ZnO	1.9543	1.9543	2.0000	-2.3%	-2.3%
32	ZrO_2	1.0469	1.0469	1.0400	0.7%	0.7%
32	sum of oxides	101.1670	100.0394	99.6630	1.5%	0.4%
33	Al_2O_3	6.3818	6.5801	6.3300	0.8%	4.0%
33	B_2O_3	11.7365	11.7350	12.0000	-2.2%	-2.2%
33	Bi_2O_3	4.9246	4.9246	5.0000	-1.5%	-1.5%
33	CaO	2.0778	2.0123	2.0000	3.9%	0.6%
33	CdO	0.9758	0.9758	1.0000	-2.4%	-2.4%
33	Ce_2O_3	0.4354	0.4354	0.4360	-0.1%	-0.1%
33	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
33	Cr_2O_3	0.6888	0.7472	0.7300	-5.6%	2.4%
33	F-	1.2850	1.3993	1.5000	-14.3%	-6.7%
33	Fe_2O_3	13.4749	13.7353	13.7700	-2.1%	-0.3%
33	K_2O	1.2648	1.2293	1.5000	-15.7%	-18.0%
33	La_2O_3	0.2483	0.2483	0.2580	-3.7%	-3.7%
33	Li_2O	1.4419	1.5332	1.5000	-3.9%	2.2%
33	MgO	0.0083	0.0082	0.0000		

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
33	MnO	2.9278	2.9649	3.0000	-2.4%	-1.2%
33	Na_2O	13.4396	13.2718	13.2600	1.4%	0.1%
33	Nd_2O_3	0.1184	0.1184	0.0810	46.2%	46.2%
33	NiO	0.4616	0.4827	0.5000	-7.7%	-3.5%
33	P_2O_5	0.5196	0.5196	0.5000	3.9%	3.9%
33	PbO	0.2677	0.2677	0.2900	-7.7%	-7.7%
33	SO_3^-	0.1199	0.1199	0.0900	33.2%	33.2%
33	SiO_2	35.1915	34.9564	34.7500	1.3%	0.6%
33	SrO	0.1611	0.1611	0.1600	0.7%	0.7%
33	ThO_2	0.0569	0.0569	0.0000		
33	TiO_2	0.0083	0.0085	0.0000		
33	U_3O_8	0.0590	0.0612	0.0000		
33	ZnO	0.0062	0.0062	0.0000		
33	ZrO_2	0.9621	0.9621	1.0000	-3.8%	-3.8%
33	sum of oxides	99.3437	99.6214	99.6630	-0.3%	0.0%
34	Al_2O_3	6.1078	6.2809	6.0000	1.8%	4.7%
34	B_2O_3	6.5122	6.3496	6.4400	1.1%	-1.4%
34	Bi_2O_3	0.0056	0.0056	0.0000		
34	CaO	2.0988	2.0037	2.0000	4.9%	0.2%
34	CdO	0.9630	0.9630	1.0000	-3.7%	-3.7%
34	Ce_2O_3	0.4313	0.4313	0.4360	-1.1%	-1.1%
34	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
34	Cr_2O_3	0.7370	0.8219	0.8000	-7.9%	2.7%
34	F-	0.4050	0.4576	0.5000	-19.0%	-8.5%
34	Fe_2O_3	11.0695	11.2508	11.3800	-2.7%	-1.1%
34	K_2O	4.8485	4.6659	4.5000	7.7%	3.7%
34	La_2O_3	0.2478	0.2478	0.2580	-4.0%	-4.0%
34	Li_2O	4.3166	4.5232	4.5000	-4.1%	0.5%
34	MgO	0.0083	0.0082	0.0000		
34	MnO	2.9278	2.9611	3.0000	-2.4%	-1.3%
34	Na_2O	14.7943	14.3475	14.3500	3.1%	0.0%
34	Nd_2O_3	0.1219	0.1219	0.0810	50.5%	50.5%
34	NiO	1.8579	1.9434	2.0000	-7.1%	-2.8%
34	P_2O_5	1.1549	1.1549	1.2500	-7.6%	-7.6%
34	PbO	0.2701	0.2701	0.2900	-6.9%	-6.9%
34	SO_3^-	0.1348	0.1348	0.0900	49.8%	49.8%
34	SiO_2	34.9776	35.0390	35.1500	-0.5%	-0.3%
34	SrO	0.4003	0.4003	0.3800	5.3%	5.3%
34	ThO_2	0.0569	0.0569	0.0000		
34	TiO_2	0.2456	0.2517	0.2500	-1.8%	0.7%
34	U_3O_8	0.0590	0.0611	0.0000		
34	ZnO	1.9294	1.9294	2.0000	-3.5%	-3.5%
34	ZrO_2	2.8299	2.8299	3.0000	-5.7%	-5.7%
34	sum of oxides	99.6116	99.6113	99.6630	-0.1%	-0.1%
35	Al_2O_3	8.0020	8.2452	7.9900	0.2%	3.2%
35	B_2O_3	11.8734	11.5470	12.0000	-1.1%	-3.8%
35	Bi_2O_3	0.0056	0.0056	0.0000		
35	CaO	0.0287	0.0277	0.0000		
35	CdO	1.0047	1.0047	1.0000	0.5%	0.5%
35	Ce_2O_3	0.4340	0.4340	0.4360	-0.5%	-0.5%
35	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
35	Cr_2O_3	0.7790	0.8582	0.8000	-2.6%	7.3%
35	F-	1.2800	1.4478	1.5000	-14.7%	-3.5%
35	Fe_2O_3	6.8876	6.9304	7.0000	-1.6%	-1.0%
35	K_2O	4.7521	4.6432	4.5000	5.6%	3.2%
35	La_2O_3	0.2495	0.2495	0.2580	-3.3%	-3.3%
35	Li_2O	2.2067	2.2835	2.2900	-3.6%	-0.3%
35	MgO	0.0083	0.0081	0.0000		
35	MnO	1.0352	1.0405	1.0000	3.5%	4.0%
35	Na_2O	17.4566	16.8360	17.0200	2.6%	-1.1%
35	Nd_2O_3	0.1260	0.1260	0.0810	55.5%	55.5%
35	NiO	0.4995	0.5191	0.5000	-0.1%	3.8%
35	P_2O_5	0.4932	0.4932	0.5000	-1.4%	-1.4%
35	PbO	0.2747	0.2747	0.2900	-5.3%	-5.3%
35	SO_3^-	0.1529	0.1529	0.0900	69.9%	69.9%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
35	SiO_2	37.0099	36.4822	36.1900	2.3%	0.8%
35	SrO	2.0755	2.0755	2.0000	3.8%	3.8%
35	ThO_2	0.0569	0.0569	0.0000		
35	TiO_2	1.2139	1.2369	1.2100	0.3%	2.2%
35	U_3O_8	0.0590	0.0610	0.0000		
35	ZnO	1.9761	1.9761	2.0000	-1.2%	-1.2%
35	ZrO_2	0.9800	0.9800	1.0000	-2.0%	-2.0%
35	sum of oxides	101.0209	100.0958	99.6630	1.4%	0.4%
36	Al_2O_3	7.3360	7.5439	7.2900	0.6%	3.5%
36	B_2O_3	9.5229	9.2873	9.5200	0.0%	-2.4%
36	Bi_2O_3	2.6616	2.6616	2.6800	-0.7%	-0.7%
36	CaO	1.2313	1.1755	1.1500	7.1%	2.2%
36	CdO	0.7539	0.7539	0.7700	-2.1%	-2.1%
36	Ce_2O_3	0.4351	0.4351	0.4360	-0.2%	-0.2%
36	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
36	Cr_2O_3	0.4750	0.5297	0.4600	3.3%	15.1%
36	F-	0.6950	0.7852	0.7700	-9.7%	2.0%
36	Fe_2O_3	9.2251	9.3771	9.5200	-3.1%	-1.5%
36	K_2O	2.1833	2.1011	2.3000	-5.1%	-8.6%
36	La_2O_3	0.2489	0.2489	0.2580	-3.5%	-3.5%
36	Li_2O	2.2713	2.3119	2.3000	-1.2%	0.5%
36	MgO	0.0083	0.0082	0.0000		
36	MnO	2.3016	2.3276	2.3000	0.1%	1.2%
36	Na_2O	14.0529	13.6287	13.8300	1.6%	-1.5%
36	Nd_2O_3	0.1306	0.1306	0.0810	61.3%	61.3%
36	NiO	1.3011	1.3610	1.3400	-2.9%	1.6%
36	P_2O_5	0.6805	0.6805	0.9600	-29.1%	-29.1%
36	PbO	0.5531	0.5531	0.2900	90.7%	90.7%
36	SO_3^-	0.1161	0.1161	0.0900	29.0%	29.0%
36	SiO_2	35.2985	35.3618	36.4000	-3.0%	-2.9%
36	SrO	1.5729	1.5729	1.5400	2.1%	2.1%
36	ThO_2	0.0569	0.0569	0.0000		
36	TiO_2	1.5145	1.5523	1.5400	-1.7%	0.8%
36	U_3O_8	0.0590	0.0611	0.0000		
36	ZnO	0.7603	0.7603	0.7700	-1.3%	-1.3%
36	ZrO_2	2.6239	2.6239	3.0600	-14.3%	-14.3%
36	sum of oxides	98.1697	98.1063	99.6630	-1.5%	-1.6%
37	Al_2O_3	7.3407	7.5487	7.2900	0.7%	3.5%
37	B_2O_3	9.2975	9.1494	9.5200	-2.3%	-3.9%
37	Bi_2O_3	2.6281	2.6281	2.6800	-1.9%	-1.9%
37	CaO	1.2253	1.1725	1.1500	6.6%	2.0%
37	CdO	0.7308	0.7308	0.7700	-5.1%	-5.1%
37	Ce_2O_3	0.4322	0.4322	0.4360	-0.9%	-0.9%
37	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
37	Cr_2O_3	0.4133	0.4561	0.4600	-10.2%	-0.8%
37	F-	0.6300	0.7119	0.7700	-18.2%	-7.5%
37	Fe_2O_3	9.4253	9.3564	9.5200	-1.0%	-1.7%
37	K_2O	2.1081	2.1047	2.3000	-8.3%	-8.5%
37	La_2O_3	0.2460	0.2460	0.2580	-4.7%	-4.7%
37	Li_2O	2.1486	2.3599	2.3000	-6.6%	2.6%
37	MgO	0.0083	0.0082	0.0000		
37	MnO	2.2628	2.2944	2.3000	-1.6%	-0.2%
37	Na_2O	14.0866	13.7215	13.8300	1.9%	-0.8%
37	Nd_2O_3	0.1309	0.1309	0.0810	61.6%	61.6%
37	NiO	1.2509	1.3085	1.3400	-6.7%	-2.3%
37	P_2O_5	0.9910	0.9910	0.9600	3.2%	3.2%
37	PbO	0.2701	0.2701	0.2900	-6.9%	-6.9%
37	SO_3^-	0.1273	0.1273	0.0900	41.5%	41.5%
37	SiO_2	36.2611	35.8923	36.4000	-0.4%	-1.4%
37	SrO	1.5965	1.5965	1.5400	3.7%	3.7%
37	ThO_2	0.0569	0.0569	0.0000		
37	TiO_2	1.5095	1.5426	1.5400	-2.0%	0.2%
37	U_3O_8	0.0590	0.0612	0.0000		
37	ZnO	0.7372	0.7372	0.7700	-4.3%	-4.3%
37	ZrO_2	2.9684	2.9684	3.0600	-3.0%	-3.0%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
37	sum of oxides	99.0425	98.7039	99.6630	-0.6%	-1.0%
38	Al_2O_3	7.9501	8.1971	8.0009	-0.6%	2.5%
38	B_2O_3	6.8503	6.8536	7.0008	-2.1%	-2.1%
38	Bi_2O_3	0.0056	0.0056	0.0000		
38	CaO	1.0893	1.0549	1.0001	8.9%	5.5%
38	CdO	0.6671	0.6671	0.7001	-4.7%	-4.7%
38	Ce_2O_3	0.0706	0.0706	0.0668	5.7%	5.7%
38	Cl-	0.1000	0.1000	0.0100	899.9%	899.9%
38	Cr_2O_3	0.2101	0.2279	0.2200	-4.5%	3.6%
38	F-	0.0700	0.0765	0.0600	16.7%	27.5%
38	Fe_2O_3	12.1274	12.3615	12.5014	-3.0%	-1.1%
38	K_2O	0.0060	0.0059	0.2800	-97.8%	-97.9%
38	La_2O_3	0.2589	0.2589	0.2720	-4.8%	-4.8%
38	Li_2O	2.8526	3.0668	3.0003	-4.9%	2.2%
38	MgO	0.5878	0.5783	0.6001	-2.0%	-3.6%
38	MnO	0.3683	0.3730	0.3600	2.3%	3.6%
38	Na_2O	16.0749	15.8732	15.7317	2.2%	0.9%
38	Nd_2O_3	0.1630	0.1630	0.1820	-10.4%	-10.4%
38	NiO	0.5023	0.5253	0.5201	-3.4%	1.0%
38	P_2O_5	0.4314	0.4314	0.4601	-6.2%	-6.2%
38	PbO	0.1551	0.1551	0.1720	-9.8%	-9.8%
38	SO_3^-	0.2135	0.2135	0.1920	11.2%	11.2%
38	SiO_2	45.9415	45.6347	46.0050	-0.1%	-0.8%
38	SrO	0.0195	0.0195	0.0300	-35.0%	-35.0%
38	ThO_2	0.0569	0.0569	0.0000		
38	TiO_2	0.0338	0.0344	0.0300	12.6%	14.8%
38	U_3O_8	0.0590	0.0612	0.0000		
38	ZnO	0.0293	0.0293	0.0400	-26.9%	-26.9%
38	ZrO_2	1.7628	1.7628	1.8502	-4.7%	-4.7%
38	sum of oxides	98.6569	98.8579	99.2856	-0.6%	-0.4%
39	Al_2O_3	2.5933	2.6668	2.5000	3.7%	6.7%
39	B_2O_3	9.8931	9.7361	9.9900	-1.0%	-2.5%
39	Bi_2O_3	0.0056	0.0056	0.0000		
39	CaO	0.3306	0.3163	0.3000	10.2%	5.4%
39	CdO	0.0057	0.0057	0.0000		
39	Ce_2O_3	0.0059	0.0059	0.0000		
39	Cl-	0.1000	0.1000	0.0000		
39	Cr_2O_3	0.2686	0.2964	0.3000	-10.5%	-1.2%
39	F-	0.0150	0.0168	0.0000		
39	Fe_2O_3	15.1334	15.0216	14.9900	1.0%	0.2%
39	K_2O	1.1486	1.1458	1.5000	-23.4%	-23.6%
39	La_2O_3	0.0059	0.0059	0.0000		
39	Li_2O	5.7752	6.1460	5.9900	-3.6%	2.6%
39	MgO	0.4808	0.4743	0.5000	-3.8%	-5.1%
39	MnO	2.9536	2.9948	3.0000	-1.5%	-0.2%
39	Na_2O	10.9458	10.6617	10.9900	-0.4%	-3.0%
39	Nd_2O_3	0.0055	0.0055	0.0000		
39	NiO	0.0557	0.0582	0.0500	11.3%	16.5%
39	P_2O_5	0.0115	0.0115	0.0000		
39	PbO	0.0043	0.0043	0.0000		
39	SO_3^-	0.0250	0.0250	0.0000		
39	SiO_2	49.4713	48.9667	49.2000	0.6%	-0.5%
39	SrO	0.0059	0.0059	0.0000		
39	ThO_2	0.0569	0.0569	0.0000		
39	TiO_2	0.5951	0.6081	0.6000	-0.8%	1.4%
39	U_3O_8	0.0590	0.0612	0.0000		
39	ZnO	0.0062	0.0062	0.0000		
39	ZrO_2	0.0098	0.0098	0.0000		
39	sum of oxides	99.9671	99.4191	99.9100	0.1%	-0.5%
40	Al_2O_3	15.8009	15.9608	16.0011	-1.3%	-0.3%
40	B_2O_3	5.4497	5.4048	5.6004	-2.7%	-3.5%
40	Bi_2O_3	0.0056	0.0056	0.0000		
40	CaO	0.1221	0.1201	0.1000	22.1%	20.1%
40	CdO	1.4719	1.4719	1.5301	-3.8%	-3.8%
40	Ce_2O_3	0.0855	0.0855	0.0820	4.3%	4.3%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
40	Cl-	0.1000	0.1000	0.0570	75.4%	75.4%
40	Cr_2O_3	0.1155	0.1141	0.1200	-3.8%	-4.9%
40	F-	0.0150	0.0171	0.0100	50.0%	71.5%
40	Fe_2O_3	13.3963	13.3266	13.5609	-1.2%	-1.7%
40	K_2O	0.0060	0.0060	0.0300	-79.9%	-80.0%
40	La_2O_3	0.3398	0.3398	0.3520	-3.5%	-3.5%
40	Li_2O	1.3337	1.4049	1.4001	-4.7%	0.3%
40	MgO	0.0626	0.0612	0.1370	-54.3%	-55.3%
40	MnO	1.1656	1.1642	1.1601	0.5%	0.4%
40	Na_2O	21.2647	21.0325	21.0014	1.3%	0.1%
40	Nd_2O_3	0.0344	0.0344	0.0240	43.4%	43.4%
40	NiO	0.7963	0.8109	0.8701	-8.5%	-6.8%
40	P_2O_5	0.2698	0.2698	0.2800	-3.6%	-3.6%
40	PbO	0.0288	0.0288	0.0310	-7.1%	-7.1%
40	SO_3^-	0.0705	0.0705	0.0290	143.2%	143.2%
40	SiO_2	34.4427	34.3019	33.9422	1.5%	1.1%
40	SrO	1.7000	1.7000	1.6601	2.4%	2.4%
40	ThO_2	0.0569	0.0569	0.0000		
40	TiO_2	0.0142	0.0142	0.0100	41.8%	42.2%
40	U_3O_8	0.0590	0.0602	0.0000		
40	ZnO	0.0492	0.0492	0.0500	-1.7%	-1.7%
40	ZrO_2	1.7797	1.7797	1.8601	-4.3%	-4.3%
40	sum of oxides	100.0363	99.7917	99.8986	0.1%	-0.1%
41	Al_2O_3	10.0191	10.1205	10.0000	0.2%	1.2%
41	B_2O_3	10.0783	9.9961	10.0600	0.2%	-0.6%
41	Bi_2O_3	0.0056	0.0056	0.0000		
41	CaO	0.0343	0.0337	0.0000		
41	CdO	0.9233	0.9233	1.0000	-7.7%	-7.7%
41	Ce_2O_3	0.4346	0.4346	0.4360	-0.3%	-0.3%
41	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
41	Cr_2O_3	0.5046	0.4985	0.8000	-36.9%	-37.7%
41	F-	1.2400	1.3506	1.5000	-17.3%	-10.0%
41	Fe_2O_3	7.1950	7.1576	7.9400	-9.4%	-9.9%
41	K_2O	4.8455	4.8269	4.5000	7.7%	7.3%
41	La_2O_3	0.2536	0.2536	0.2580	-1.7%	-1.7%
41	Li_2O	1.4758	1.5051	1.5000	-1.6%	0.3%
41	MgO	0.0083	0.0082	0.0000		
41	MnO	1.0343	1.0330	1.0000	3.4%	3.3%
41	Na_2O	13.2239	13.0798	12.5000	5.8%	4.6%
41	Nd_2O_3	0.1163	0.1163	0.0810	43.6%	43.6%
41	NiO	1.7879	1.8208	2.0000	-10.6%	-9.0%
41	P_2O_5	1.2368	1.2368	1.2500	-1.1%	-1.1%
41	PbO	0.2795	0.2795	0.2900	-3.6%	-3.6%
41	SO_3^-	0.1161	0.1161	0.0900	29.0%	29.0%
41	SiO_2	41.4489	41.2800	40.7200	1.8%	1.4%
41	SrO	0.0059	0.0059	0.0000		
41	ThO_2	0.7937	0.7937	0.7300	8.7%	8.7%
41	TiO_2	0.0083	0.0084	0.0000		
41	U_3O_8	2.0400	2.0838	2.0000	2.0%	4.2%
41	ZnO	0.0062	0.0062	0.0000		
41	ZrO_2	1.0266	1.0266	1.0000	2.7%	2.7%
41	sum of oxides	100.2423	100.1013	99.6630	0.6%	0.4%
42	Al_2O_3	6.3912	6.4561	6.3200	1.1%	2.2%
42	B_2O_3	8.0980	8.0312	8.1800	-1.0%	-1.8%
42	Bi_2O_3	4.9386	4.9386	5.0000	-1.2%	-1.2%
42	CaO	0.0297	0.0293	0.0000		
42	CdO	0.9892	0.9892	1.0000	-1.1%	-1.1%
42	Ce_2O_3	0.4290	0.4290	0.4360	-1.6%	-1.6%
42	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
42	Cr_2O_3	0.5364	0.5300	0.7300	-26.5%	-27.4%
42	F-	1.3800	1.5030	1.5000	-8.0%	0.2%
42	Fe_2O_3	7.3558	7.3178	7.3200	0.5%	0.0%
42	K_2O	1.2287	1.2240	1.5000	-18.1%	-18.4%
42	La_2O_3	0.2483	0.2483	0.2580	-3.7%	-3.7%
42	Li_2O	4.3435	4.5153	4.5000	-3.5%	0.3%

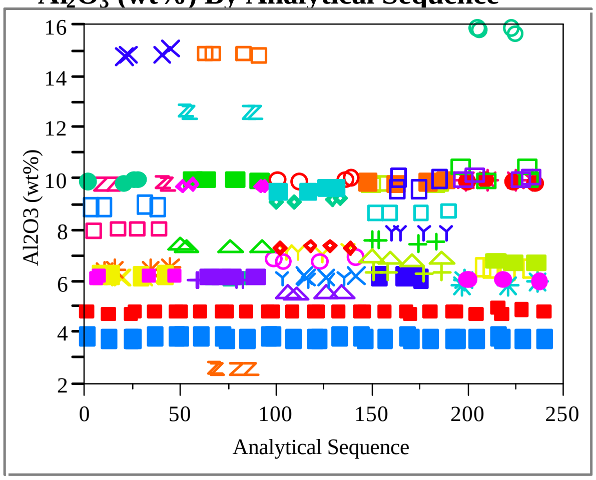
Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
42	MgO	0.0083	0.0082	0.0000		
42	MnO	1.0117	1.0104	1.0000	1.2%	1.0%
42	Na_2O	13.2003	13.0563	12.7800	3.3%	2.2%
42	Nd_2O_3	0.1134	0.1134	0.0810	40.0%	40.0%
42	NiO	1.2509	1.2738	1.3500	-7.3%	-5.6%
42	P_2O_5	0.4852	0.4852	0.5000	-3.0%	-3.0%
42	PbO	0.2723	0.2723	0.2900	-6.1%	-6.1%
42	SO_3^-	0.1086	0.1086	0.0900	20.7%	20.7%
42	SiO_2	41.0746	40.9069	40.0700	2.5%	2.1%
42	SrO	2.0666	2.0666	2.0000	3.3%	3.3%
42	ThO_2	1.1521	1.1521	1.1400	1.1%	1.1%
42	TiO_2	0.0083	0.0084	0.0000		
42	U_3O_8	2.6355	2.6923	2.6100	1.0%	3.2%
42	ZnO	0.0062	0.0062	0.0000		
42	ZrO_2	0.9614	0.9614	1.0000	-3.9%	-3.9%
42	sum of oxides	100.4239	100.4339	99.6630	0.8%	0.8%
43	Al_2O_3	5.9472	6.0075	6.0000	-0.9%	0.1%
43	B_2O_3	5.0472	5.0058	5.0000	0.9%	0.1%
43	Bi_2O_3	0.0992	0.0992	0.0000		
43	CaO	0.0294	0.0289	0.0000		
43	CdO	0.0063	0.0063	0.0000		
43	Ce_2O_3	0.4126	0.4126	0.4360	-5.4%	-5.4%
43	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
43	Cr_2O_3	0.7078	0.6993	0.8000	-11.5%	-12.6%
43	F-	0.4200	0.4574	0.5000	-16.0%	-8.5%
43	Fe_2O_3	8.6568	8.6120	9.4900	-8.8%	-9.3%
43	K_2O	1.6593	1.6530	1.9300	-14.0%	-14.4%
43	La_2O_3	0.2448	0.2448	0.2580	-5.1%	-5.1%
43	Li_2O	1.9145	1.9667	1.9600	-2.3%	0.3%
43	MgO	0.0083	0.0082	0.0000		
43	MnO	2.8536	2.8501	3.0000	-4.9%	-5.0%
43	Na_2O	15.4009	15.2337	15.4700	-0.4%	-1.5%
43	Nd_2O_3	0.1231	0.1231	0.0810	51.9%	51.9%
43	NiO	0.4791	0.4879	0.5000	-4.2%	-2.4%
43	P_2O_5	1.1417	1.1417	1.2500	-8.7%	-8.7%
43	PbO	0.2755	0.2755	0.2900	-5.0%	-5.0%
43	SO_3^-	0.1255	0.1255	0.0900	39.4%	39.4%
43	SiO_2	33.5335	33.3966	34.0000	-1.4%	-1.8%
43	SrO	2.0252	2.0252	2.0000	1.3%	1.3%
43	ThO_2	2.0397	2.0397	2.0000	2.0%	2.0%
43	TiO_2	1.6417	1.6449	1.7300	-5.1%	-4.9%
43	U_3O_8	7.8623	8.0317	8.0000	-1.7%	0.4%
43	ZnO	1.8392	1.8392	2.0000	-8.0%	-8.0%
43	ZrO_2	2.6003	2.6003	2.8700	-9.4%	-9.4%
43	sum of oxides	97.1946	97.1167	99.6630	-2.5%	-2.6%
44	Al_2O_3	6.0653	6.1269	6.0000	1.1%	2.1%
44	B_2O_3	11.6480	11.5528	11.9500	-2.5%	-3.3%
44	Bi_2O_3	0.0086	0.0086	0.0000		
44	CaO	0.4135	0.4070	0.3700	11.7%	10.0%
44	CdO	0.0057	0.0057	0.0000		
44	Ce_2O_3	0.4243	0.4243	0.4360	-2.7%	-2.7%
44	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
44	Cr_2O_3	0.6639	0.6559	0.8000	-17.0%	-18.0%
44	F-	0.4250	0.4628	0.5000	-15.0%	-7.4%
44	Fe_2O_3	10.9265	10.8699	11.1700	-2.2%	-2.7%
44	K_2O	4.7552	4.7368	4.5000	5.7%	5.3%
44	La_2O_3	0.2507	0.2507	0.2580	-2.8%	-2.8%
44	Li_2O	1.4607	1.5051	1.5000	-2.6%	0.3%
44	MgO	0.0083	0.0082	0.0000		
44	MnO	1.4429	1.4411	1.4600	-1.2%	-1.3%
44	Na_2O	17.6925	17.4998	17.5000	1.1%	0.0%
44	Nd_2O_3	0.1146	0.1146	0.0810	41.5%	41.5%
44	NiO	0.4724	0.4811	0.5000	-5.5%	-3.8%
44	P_2O_5	1.1778	1.1778	1.2500	-5.8%	-5.8%
44	PbO	0.2671	0.2671	0.2900	-7.9%	-7.9%

Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
44	SO_3^-	0.1273	0.1273	0.0900	41.5%	41.5%
44	SiO_2	34.1753	34.0354	34.0000	0.5%	0.1%
44	SrO	0.0059	0.0059	0.0000		
44	ThO_2	1.9344	1.9344	2.0000	-3.3%	-3.3%
44	TiO_2	0.0083	0.0084	0.0000		
44	U_3O_8	1.9663	2.0088	2.0000	-1.7%	0.4%
44	ZnO	0.0062	0.0062	0.0000		
44	ZrO_2	2.8063	2.8063	3.0000	-6.5%	-6.5%
44	sum of oxides	99.3532	99.0292	99.6630	-0.3%	-0.6%
45	Al_2O_3	6.7502	6.8189	6.6900	0.9%	1.9%
45	B_2O_3	5.0955	5.0541	5.0000	1.9%	1.1%
45	Bi_2O_3	4.8689	4.8689	5.0000	-2.6%	-2.6%
45	CaO	2.1093	2.0762	2.0000	5.5%	3.8%
45	CdO	0.9718	0.9718	1.0000	-2.8%	-2.8%
45	Ce_2O_3	0.4220	0.4220	0.4360	-3.2%	-3.2%
45	Cl-	0.1000	0.1000	0.0080	1150.0%	1150.0%
45	Cr_2O_3	0.2671	0.2639	0.3000	-11.0%	-12.0%
45	F-	1.4000	1.5249	1.5000	-6.7%	1.7%
45	Fe_2O_3	7.3951	7.3569	7.5000	-1.4%	-1.9%
45	K_2O	1.2468	1.2420	1.5000	-16.9%	-17.2%
45	La_2O_3	0.2448	0.2448	0.2580	-5.1%	-5.1%
45	Li_2O	4.3058	4.3849	4.3700	-1.5%	0.3%
45	MgO	0.0083	0.0082	0.0000		
45	MnO	1.0020	1.0007	1.0000	0.2%	0.1%
45	Na_2O	16.7826	16.5994	16.3900	2.4%	1.3%
45	Nd_2O_3	0.1163	0.1163	0.0810	43.6%	43.6%
45	NiO	1.5378	1.5661	1.6600	-7.4%	-5.7%
45	P_2O_5	0.4812	0.4812	0.5000	-3.8%	-3.8%
45	PbO	0.2610	0.2610	0.2900	-10.0%	-10.0%
45	SO_3^-	0.1161	0.1161	0.0900	29.0%	29.0%
45	SiO_2	37.3308	37.1774	36.7300	1.6%	1.2%
45	SrO	0.0059	0.0059	0.0000		
45	ThO_2	1.7865	1.7865	1.9100	-6.5%	-6.5%
45	TiO_2	0.7719	0.7734	0.7800	-1.0%	-0.9%
45	U_3O_8	1.9811	2.0238	2.0000	-0.9%	1.2%
45	ZnO	1.6058	1.6058	1.6700	-3.8%	-3.8%
45	ZrO_2	0.9506	0.9506	1.0000	-4.9%	-4.9%
45	sum of oxides	99.9151	99.8017	99.6630	0.3%	0.1%
100	Al_2O_3	3.7091	3.8043	4.1000	-9.5%	-7.2%
100	B_2O_3	8.6680	8.5328	9.2090	-5.9%	-7.3%
100	Bi_2O_3	0.0056	0.0056	0.0000		
100	CaO	1.2728	1.2294	1.3010	-2.2%	-5.5%
100	CdO	0.0057	0.0057	0.0000		
100	Ce_2O_3	0.0059	0.0059	0.0000		
100	Cl-	0.0000	0.0000	0.0000		
100	Cr_2O_3	0.2180	0.2351	0.0000		
100	F-	0.0000	0.0000	0.0000		
100	Fe_2O_3	12.4169	12.4894	13.1960	-5.9%	-5.4%
100	K_2O	2.8123	2.7589	2.9990	-6.2%	-8.0%
100	La_2O_3	0.0059	0.0059	0.0000		
100	Li_2O	2.7263	3.0900	3.0570	-10.8%	1.1%
100	MgO	1.1345	1.1167	1.2100	-6.2%	-7.7%
100	MnO	2.5635	2.5849	2.8920	-11.4%	-10.6%
100	Na_2O	11.2059	10.9473	11.7950	-5.0%	-7.2%
100	Nd_2O_3	0.0058	0.0058	0.0000		
100	NiO	0.9285	0.9648	1.1200	-17.1%	-13.9%
100	P_2O_5	0.0115	0.0115	0.0000		
100	PbO	0.0054	0.0054	0.0000		
100	SO_3^-	0.0125	0.0125	0.0000		
100	SiO_2	48.6049	48.2774	45.3530	7.2%	6.4%
100	SrO	0.0059	0.0059	0.0000		
100	ThO_2	0.0571	0.0571	0.0000		
100	TiO_2	0.8951	0.9108	1.0490	-14.7%	-13.2%
100	U_3O_8	2.3148	2.3930	2.4060	-3.8%	-0.5%
100	ZnO	0.0062	0.0062	0.0000		

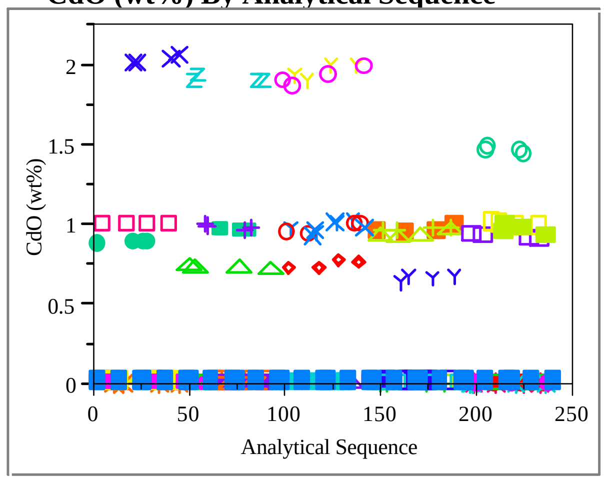
Glass #	(wt%)	Measured (wt%)	Measured Bias-Corrected (wt%)	Targeted (wt%)	% Diff of Measured	% Diff of Meas BC
100	ZrO_2	0.0071	0.0071	0.0000		
100	sum of oxides	99.6050	99.4693	99.6870	-0.1%	-0.2%

Exhibit C.1: SRTC-ML Measurements for Samples Prepared Using the LM Method

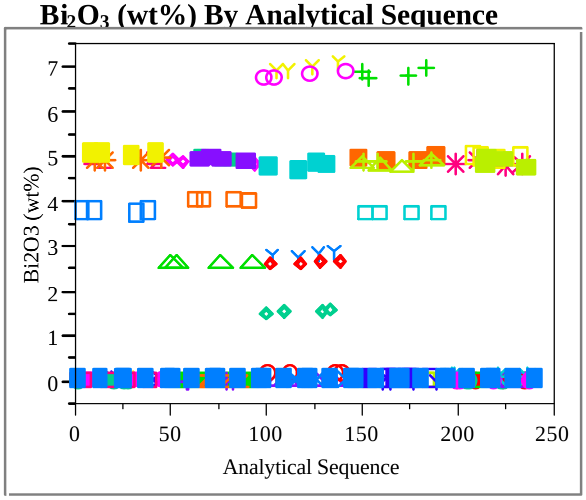
Al_2O_3 (wt%) By Analytical Sequence



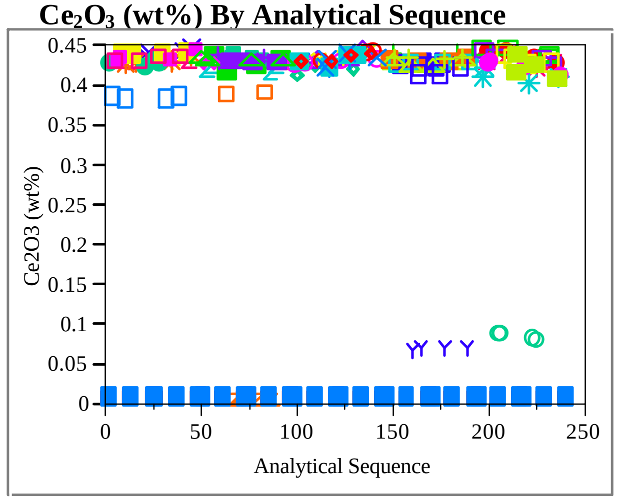
CdO (wt%) By Analytical Sequence



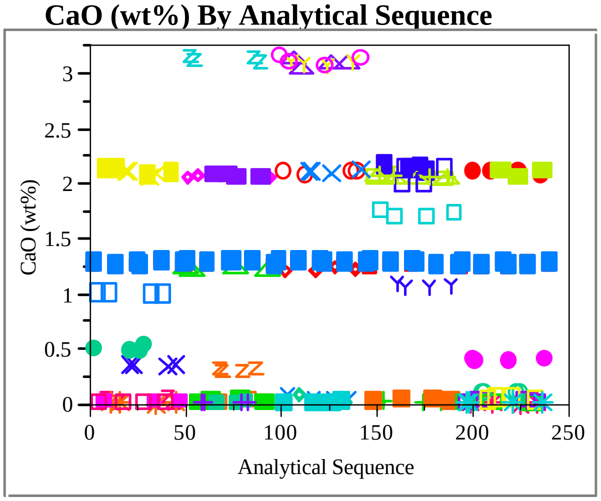
Bi_2O_3 (wt%) By Analytical Sequence



Ce_2O_3 (wt%) By Analytical Sequence



CaO (wt%) By Analytical Sequence



Cr_2O_3 (wt%) By Analytical Sequence

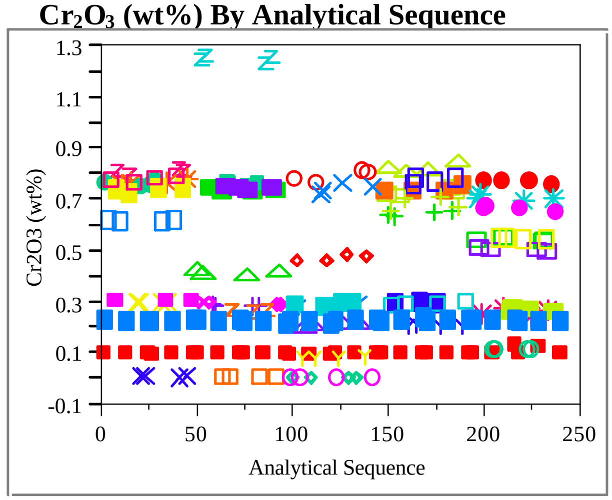
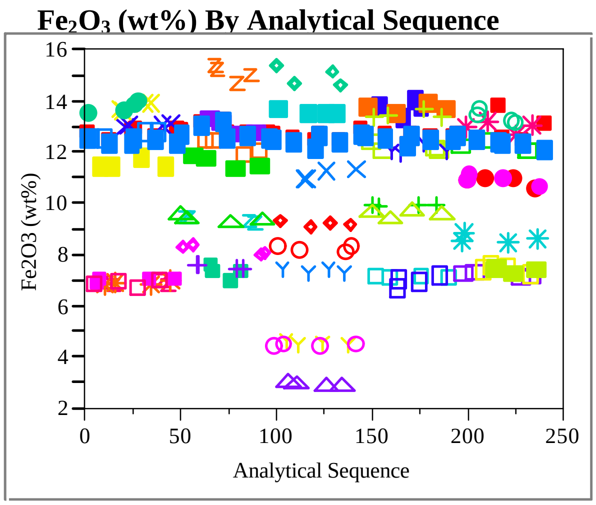
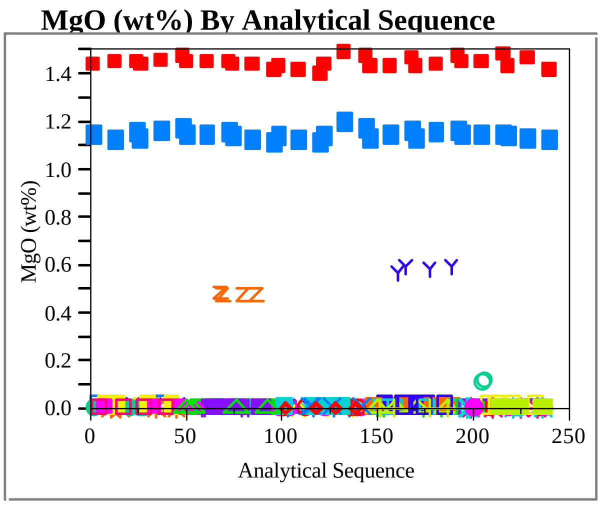
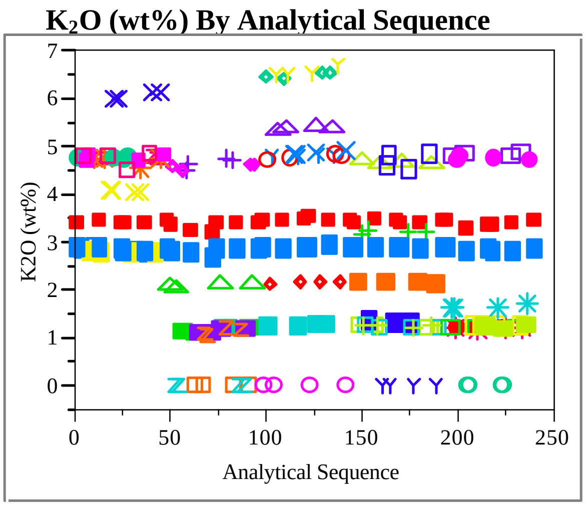
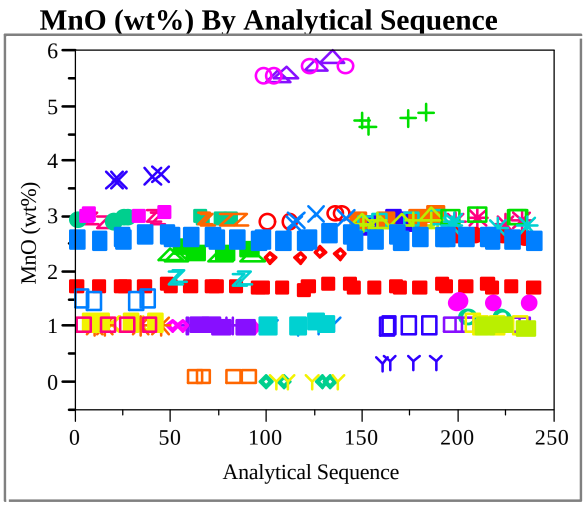


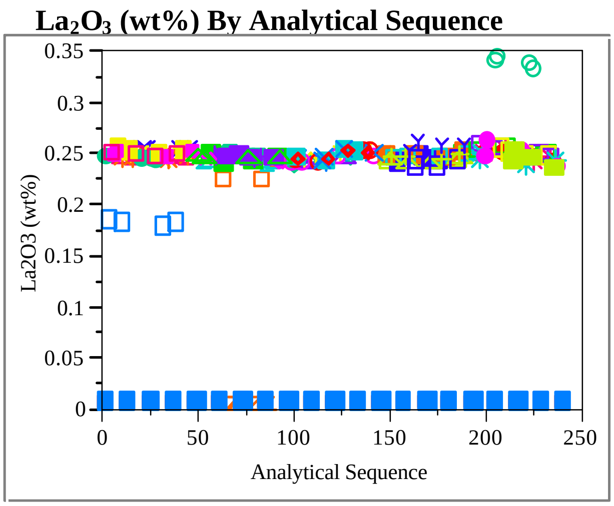
Exhibit C.1: SRTC-ML Measurements for Samples Prepared Using the LM Method
(continued)











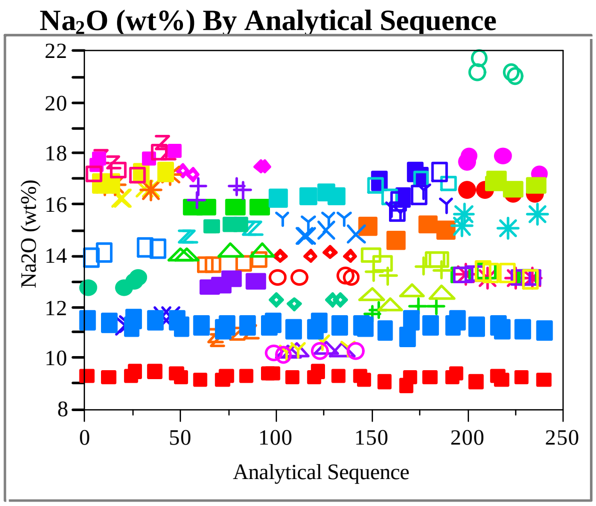
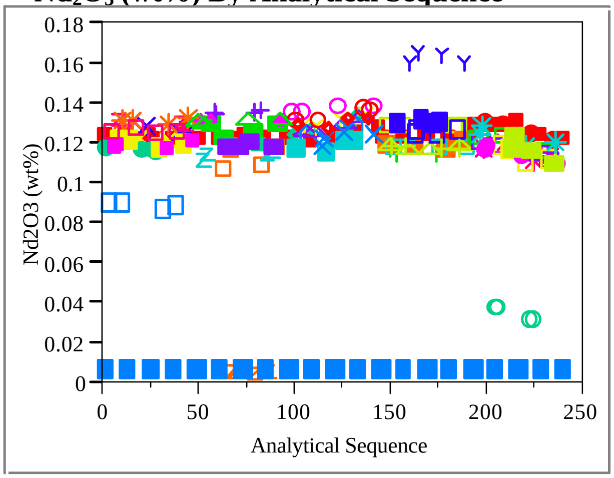
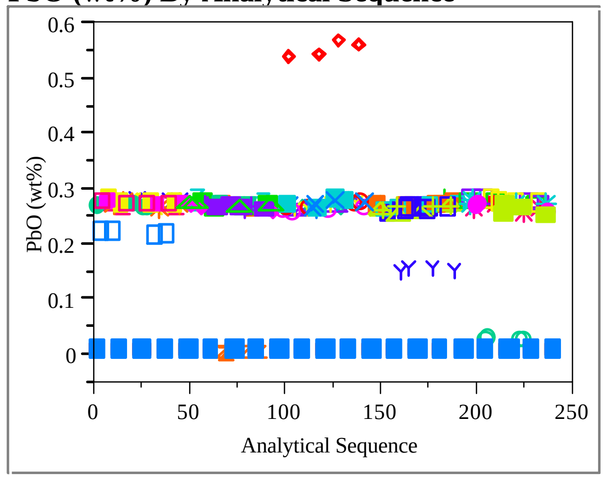


Exhibit C.1: SRTC-ML Measurements for Samples Prepared Using the LM Method
(continued)

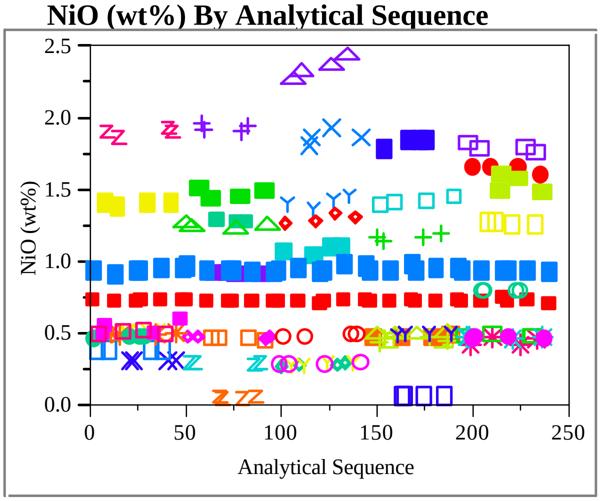
Nd_2O_3 (wt%) By Analytical Sequence



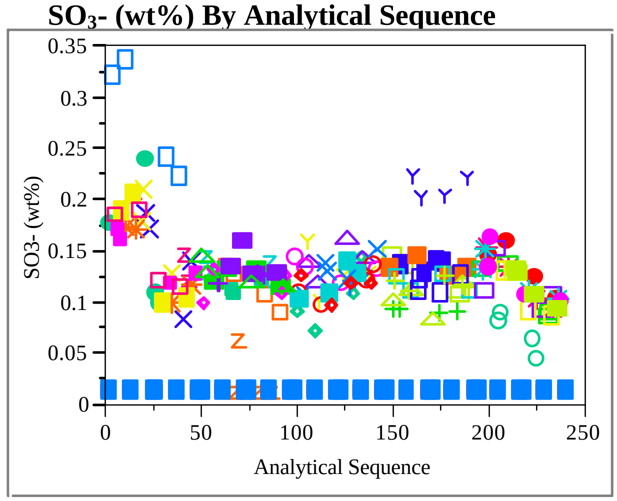
PbO (wt%) By Analytical Sequence



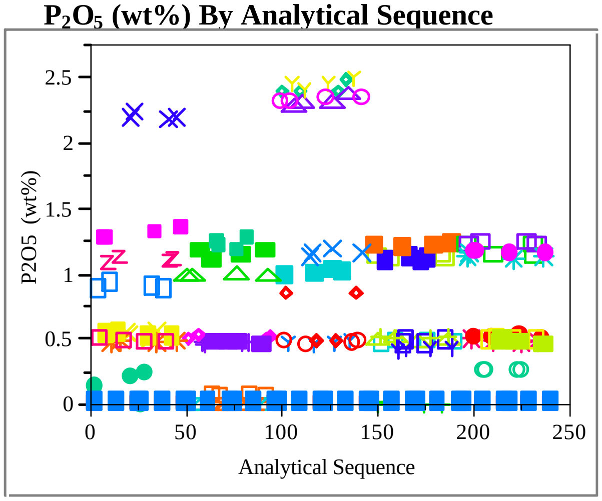
NiO (wt%) By Analytical Sequence



SO_3- (wt%) By Analytical Sequence



P_2O_5 (wt%) By Analytical Sequence



SiO_2 (wt%) By Analytical Sequence

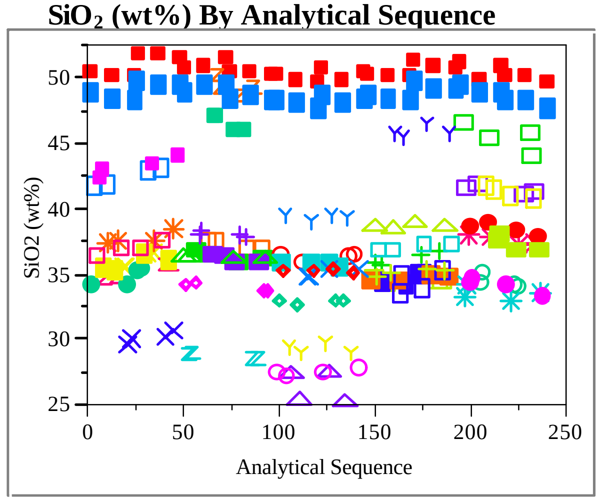
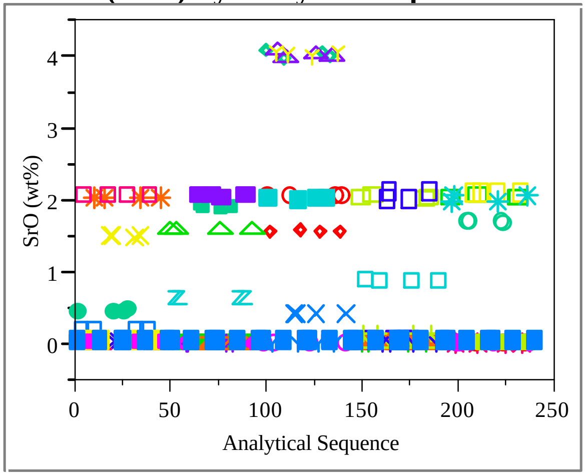
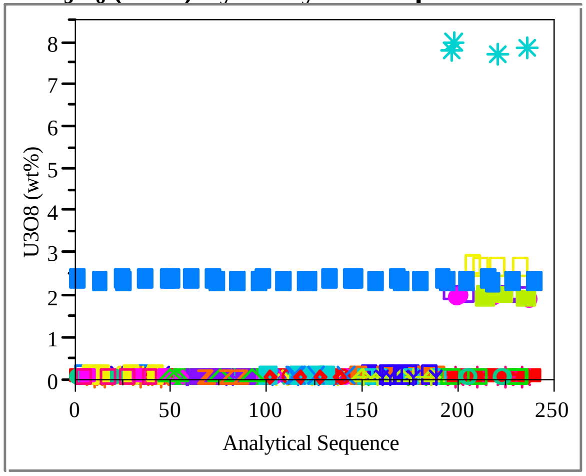


Exhibit C.1: SRTC-ML Measurements for Samples Prepared Using the LM Method
(continued)

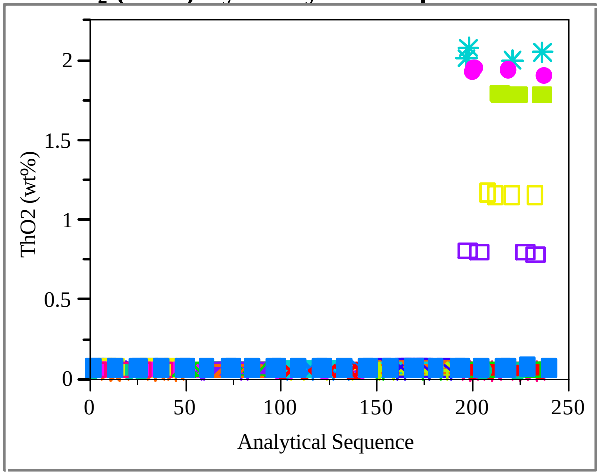
SrO (wt%) By Analytical Sequence



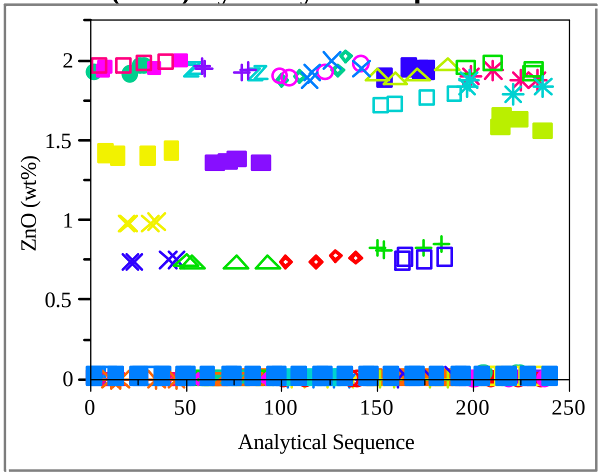
U_3O_8 (wt%) By Analytical Sequence



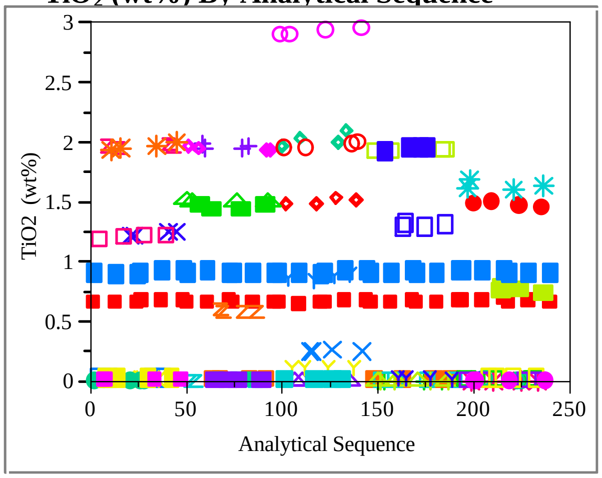
ThO_2 (wt%) By Analytical Sequence



ZnO (wt%) By Analytical Sequence



TiO_2 (wt%) By Analytical Sequence



ZrO_2 (wt%) By Analytical Sequence

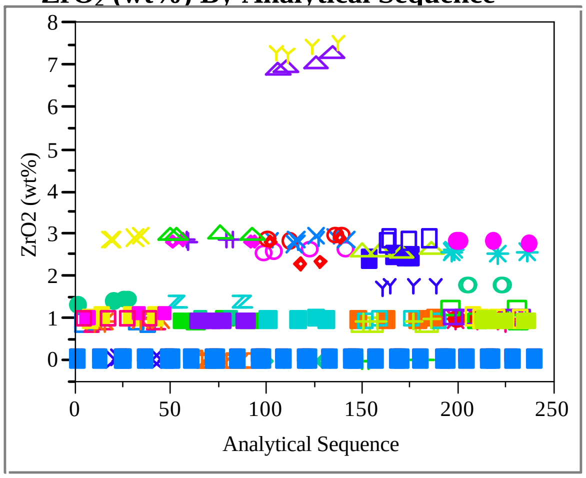
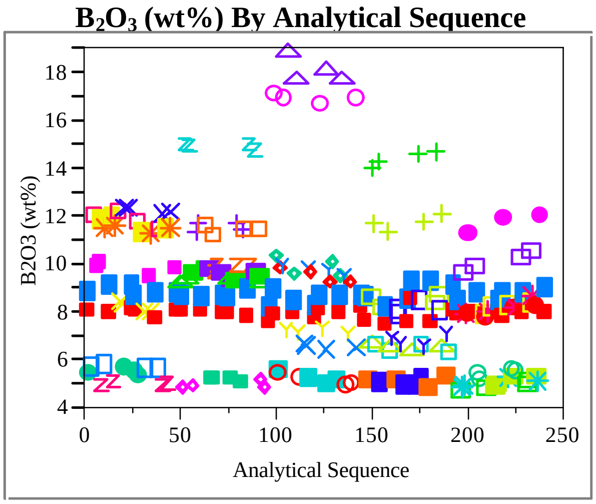


Exhibit C.2: SRTC-ML Measurements for Samples Prepared Using the SP Method



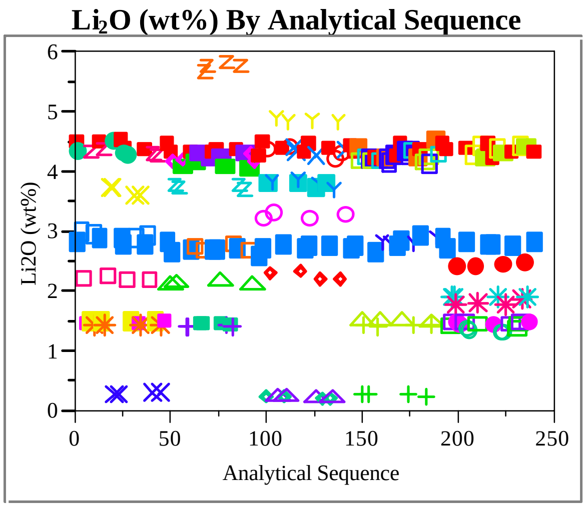
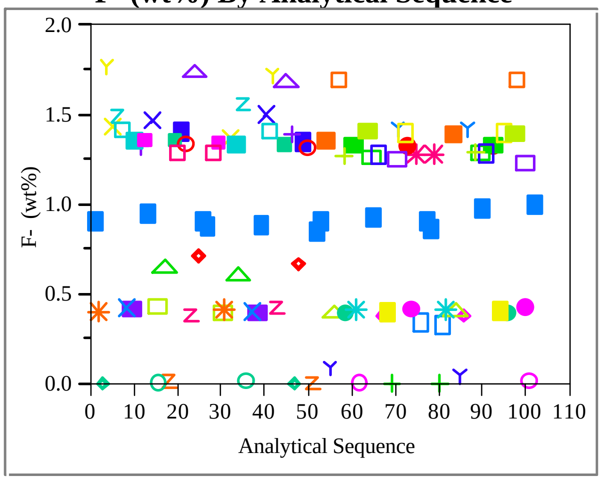


Exhibit C.3: SRTC-ML Measurements for Samples Prepared Using the PH Method

F- (wt%) By Analytical Sequence



Cl- (wt%) By Analytical Sequence

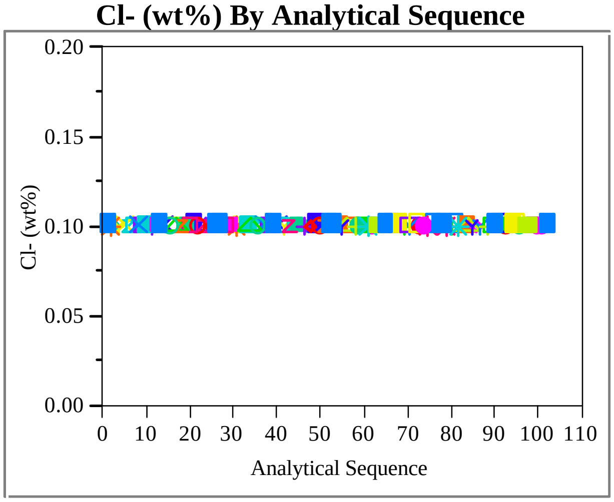
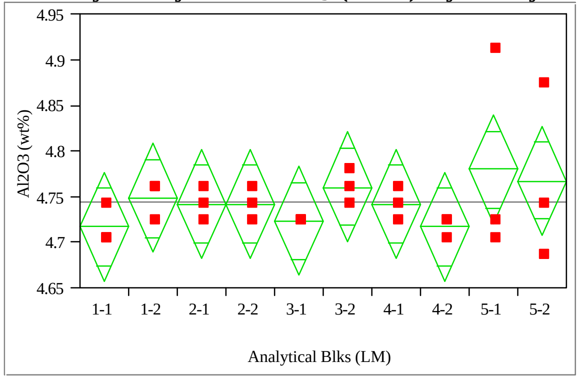


Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method

Oneway Analysis of Al_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.19481
Root Mean Square Error	0.05011
Mean of Response	4.744535
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.01215062	0.001350	0.5377	0.8301
Error	20	0.05022096	0.002511		
C. Total	29	0.06237157			

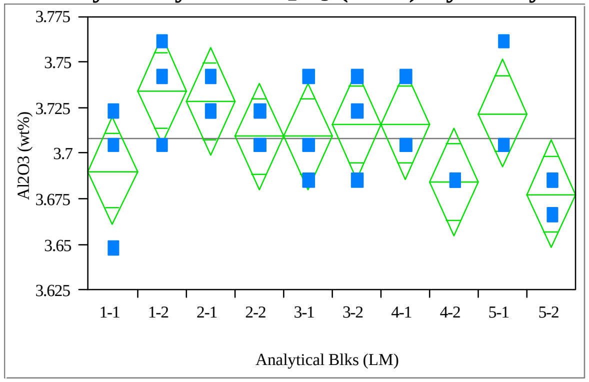
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.71745	0.02893	4.6571	4.7778
1-2	3	4.74894	0.02893	4.6886	4.8093
2-1	3	4.74264	0.02893	4.6823	4.8030
2-2	3	4.74264	0.02893	4.6823	4.8030
3-1	3	4.72375	0.02893	4.6634	4.7841
3-2	3	4.76154	0.02893	4.7012	4.8219
4-1	3	4.74264	0.02893	4.6823	4.8030
4-2	3	4.71745	0.02893	4.6571	4.7778
5-1	3	4.78044	0.02893	4.7201	4.8408
5-2	3	4.76784	0.02893	4.7075	4.8282

Std Error uses a pooled estimate of error variance

U std – reference value 4.1 wt%

Oneway Analysis of Al_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.447208
Root Mean Square Error	0.024393
Mean of Response	3.709088
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00962767	0.001070	1.7978	0.1316
Error	20	0.01190070	0.000595		
C. Total	29	0.02152837			

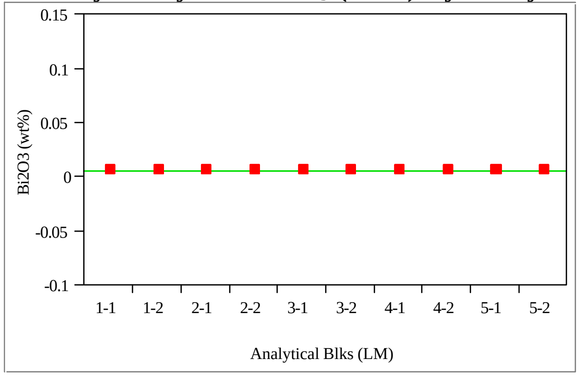
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	3.69082	0.01408	3.6614	3.7202
1-2	3	3.73491	0.01408	3.7055	3.7643
2-1	3	3.72861	0.01408	3.6992	3.7580
2-2	3	3.70972	0.01408	3.6803	3.7391
3-1	3	3.70972	0.01408	3.6803	3.7391
3-2	3	3.71602	0.01408	3.6866	3.7454
4-1	3	3.71602	0.01408	3.6866	3.7454
4-2	3	3.68452	0.01408	3.6551	3.7139
5-1	3	3.72232	0.01408	3.6929	3.7517
5-2	3	3.67823	0.01408	3.6488	3.7076

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0 wt%
Oneway Analysis of Bi_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005574
Observations (or Sum Wgts)	30

Analysis of Variance

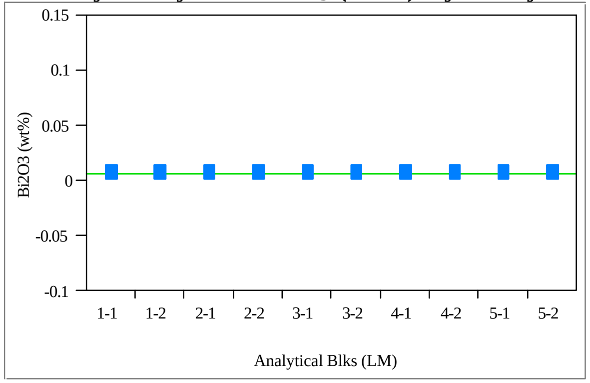
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005574	0	0.00557	0.00557
1-2	3	0.005574	0	0.00557	0.00557
2-1	3	0.005574	0	0.00557	0.00557
2-2	3	0.005574	0	0.00557	0.00557
3-1	3	0.005574	0	0.00557	0.00557
3-2	3	0.005574	0	0.00557	0.00557
4-1	3	0.005574	0	0.00557	0.00557
4-2	3	0.005574	0	0.00557	0.00557
5-1	3	0.005574	0	0.00557	0.00557
5-2	3	0.005574	0	0.00557	0.00557

Std Error uses a pooled estimate of error variance

U std – reference value 0 wt%
Oneway Analysis of Bi_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005574
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

Means for Oneway Anova

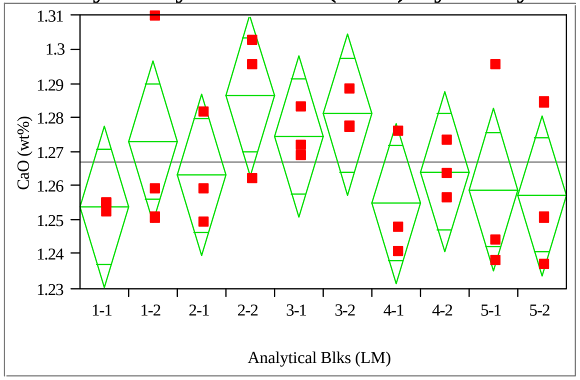
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005574	0	0.00557	0.00557
1-2	3	0.005574	0	0.00557	0.00557
2-1	3	0.005574	0	0.00557	0.00557
2-2	3	0.005574	0	0.00557	0.00557
3-1	3	0.005574	0	0.00557	0.00557
3-2	3	0.005574	0	0.00557	0.00557
4-1	3	0.005574	0	0.00557	0.00557
4-2	3	0.005574	0	0.00557	0.00557
5-1	3	0.005574	0	0.00557	0.00557
5-2	3	0.005574	0	0.00557	0.00557

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 1.22 wt%

Oneway Analysis of CaO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.312251
Root Mean Square Error	0.019657
Mean of Response	1.266976
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00350863	0.000390	1.0089	0.4650
Error	20	0.00772793	0.000386		
C. Total	29	0.01123657			

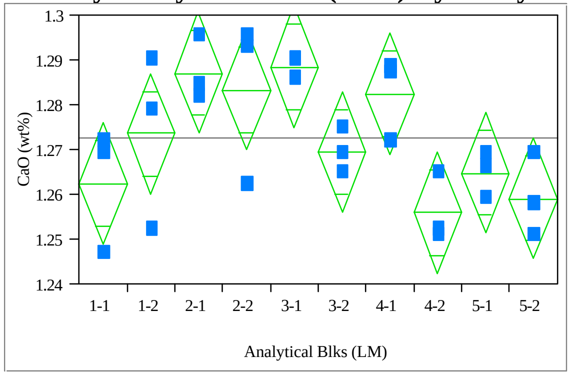
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.25415	0.01135	1.2305	1.2778
1-2	3	1.27327	0.01135	1.2496	1.2969
2-1	3	1.26348	0.01135	1.2398	1.2872
2-2	3	1.28680	0.01135	1.2631	1.3105
3-1	3	1.27467	0.01135	1.2510	1.2983
3-2	3	1.28120	0.01135	1.2575	1.3049
4-1	3	1.25508	0.01135	1.2314	1.2788
4-2	3	1.26441	0.01135	1.2407	1.2881
5-1	3	1.25928	0.01135	1.2356	1.2830
5-2	3	1.25741	0.01135	1.2337	1.2811

Std Error uses a pooled estimate of error variance

U std – reference value 1.301 wt%

Oneway Analysis of CaO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.611358
Root Mean Square Error	0.011202
Mean of Response	1.272806
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00394815	0.000439	3.4957	0.0095
Error	20	0.00250985	0.000125		
C. Total	29	0.00645800			

Means for Oneway Anova

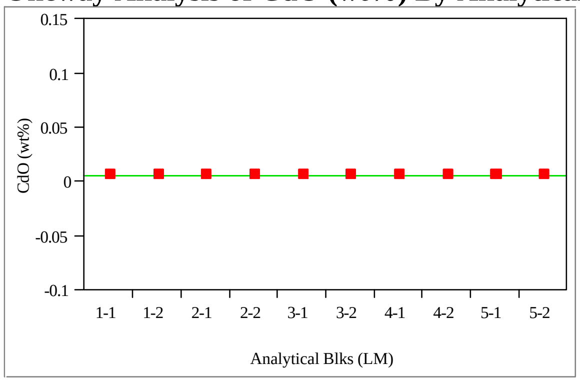
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.26254	0.00647	1.2491	1.2760
1-2	3	1.27374	0.00647	1.2602	1.2872
2-1	3	1.28726	0.00647	1.2738	1.3008
2-2	3	1.28353	0.00647	1.2700	1.2970
3-1	3	1.28866	0.00647	1.2752	1.3022
3-2	3	1.26954	0.00647	1.2560	1.2830
4-1	3	1.28260	0.00647	1.2691	1.2961
4-2	3	1.25602	0.00647	1.2425	1.2695
5-1	3	1.26488	0.00647	1.2514	1.2784
5-2	3	1.25928	0.00647	1.2458	1.2728

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0 wt%

Oneway Analysis of CdO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005711
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

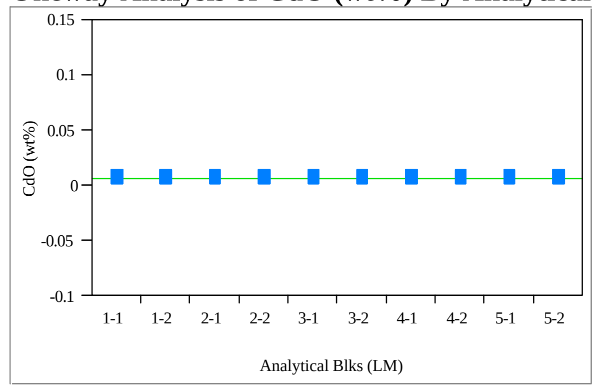
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005712	0	0.00571	0.00571
1-2	3	0.005712	0	0.00571	0.00571
2-1	3	0.005712	0	0.00571	0.00571
2-2	3	0.005712	0	0.00571	0.00571
3-1	3	0.005712	0	0.00571	0.00571
3-2	3	0.005712	0	0.00571	0.00571
4-1	3	0.005712	0	0.00571	0.00571
4-2	3	0.005712	0	0.00571	0.00571
5-1	3	0.005712	0	0.00571	0.00571
5-2	3	0.005712	0	0.00571	0.00571

Std Error uses a pooled estimate of error variance

U std – reference value 0 wt%

Oneway Analysis of CdO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005711
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

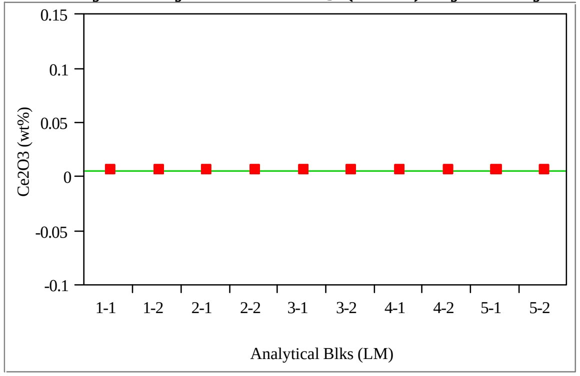
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005712	0	0.00571	0.00571
1-2	3	0.005712	0	0.00571	0.00571
2-1	3	0.005712	0	0.00571	0.00571
2-2	3	0.005712	0	0.00571	0.00571
3-1	3	0.005712	0	0.00571	0.00571
3-2	3	0.005712	0	0.00571	0.00571
4-1	3	0.005712	0	0.00571	0.00571
4-2	3	0.005712	0	0.00571	0.00571
5-1	3	0.005712	0	0.00571	0.00571
5-2	3	0.005712	0	0.00571	0.00571

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0 wt%
Oneway Analysis of Ce_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	30

Analysis of Variance

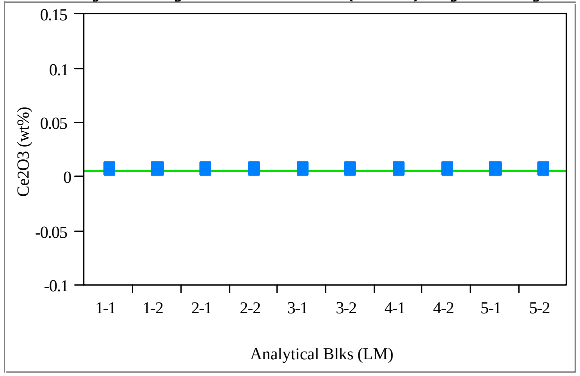
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

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
3-1	3	0.005857	0	0.00586	0.00586
3-2	3	0.005857	0	0.00586	0.00586
4-1	3	0.005857	0	0.00586	0.00586
4-2	3	0.005857	0	0.00586	0.00586
5-1	3	0.005857	0	0.00586	0.00586
5-2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

U std – reference value 0 wt%
Oneway Analysis of Ce_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Adj Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005857
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

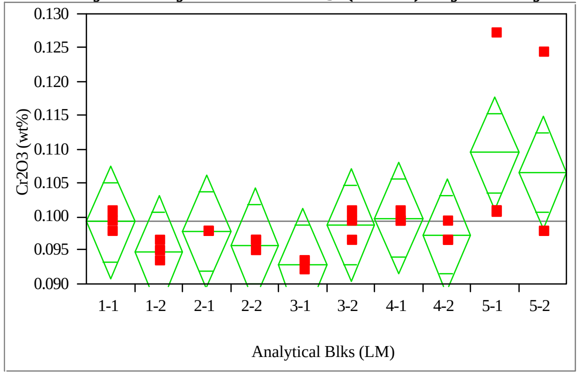
Means for Oneway Anova

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
3-1	3	0.005857	0	0.00586	0.00586
3-2	3	0.005857	0	0.00586	0.00586
4-1	3	0.005857	0	0.00586	0.00586
4-2	3	0.005857	0	0.00586	0.00586
5-1	3	0.005857	0	0.00586	0.00586
5-2	3	0.005857	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 0.107 wt%
Oneway Analysis of Cr_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.426117
Mean of Response	0.099389
Observations (or Sum Wgts)	30

Analysis of Variance

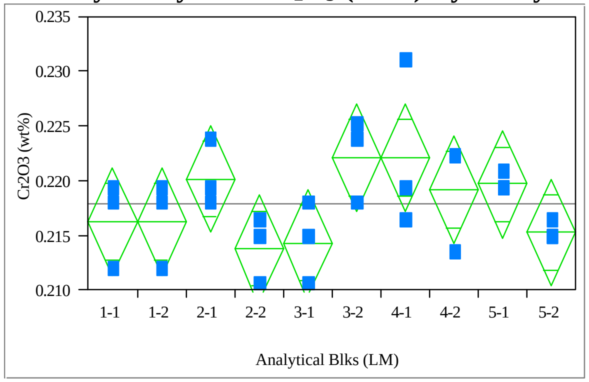
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00070639	0.000078	1.6500	0.1679
Error	20	0.00095135	0.000048		
C. Total	29	0.00165775			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.099389	0.00398	0.09108	0.10769
1-2	3	0.095004	0.00398	0.08670	0.10331
2-1	3	0.097927	0.00398	0.08962	0.10623
2-2	3	0.095978	0.00398	0.08767	0.10428
3-1	3	0.093055	0.00398	0.08475	0.10136
3-2	3	0.098902	0.00398	0.09060	0.10721
4-1	3	0.099876	0.00398	0.09157	0.10818
4-2	3	0.097440	0.00398	0.08913	0.10575
5-1	3	0.109620	0.00398	0.10131	0.11793
5-2	3	0.106697	0.00398	0.09839	0.11500

Std Error uses a pooled estimate of error variance

U std – reference value no defined
Oneway Analysis of Cr_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.443369
Root Mean Square Error	0.004047
Mean of Response	0.217973
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00026091	0.000029	1.7700	0.1378
Error	20	0.00032756	0.000016		
C. Total	29	0.00058847			

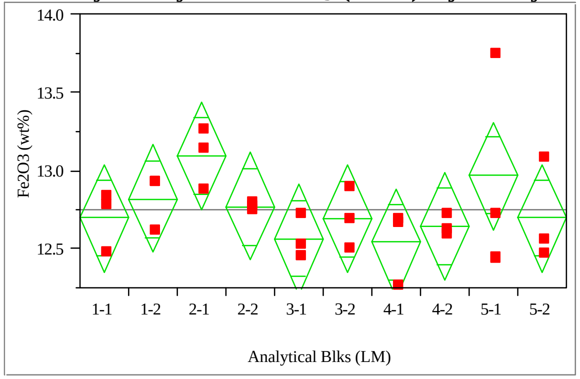
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.216317	0.00234	0.21144	0.22119
1-2	3	0.216317	0.00234	0.21144	0.22119
2-1	3	0.220214	0.00234	0.21534	0.22509
2-2	3	0.213881	0.00234	0.20901	0.21875
3-1	3	0.214368	0.00234	0.20949	0.21924
3-2	3	0.222163	0.00234	0.21729	0.22704
4-1	3	0.222163	0.00234	0.21729	0.22704
4-2	3	0.219240	0.00234	0.21437	0.22411
5-1	3	0.219727	0.00234	0.21485	0.22460
5-2	3	0.215342	0.00234	0.21047	0.22022

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 12.839 wt%
Oneway Analysis of Fe_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.329586
Root Mean Square Error	0.286416
Mean of Response	12.75149
Observations (or Sum Wgts)	30

Analysis of Variance

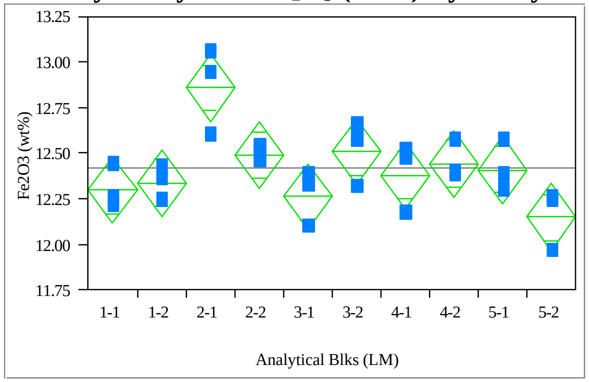
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.8065858	0.089621	1.0925	0.4105
Error	20	1.6406845	0.082034		
C. Total	29	2.4472703			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.7005	0.16536	12.356	13.045
1-2	3	12.8196	0.16536	12.475	13.165
2-1	3	13.0961	0.16536	12.751	13.441
2-2	3	12.7720	0.16536	12.427	13.117
3-1	3	12.5671	0.16536	12.222	12.912
3-2	3	12.6957	0.16536	12.351	13.041
4-1	3	12.5432	0.16536	12.198	12.888
4-2	3	12.6481	0.16536	12.303	12.993
5-1	3	12.9721	0.16536	12.627	13.317
5-2	3	12.7005	0.16536	12.356	13.045

Std Error uses a pooled estimate of error variance

U std – reference value 13.196 wt%
Oneway Analysis of Fe_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.683495
Root Mean Square Error	0.150922
Mean of Response	12.41694
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.9837634	0.109307	4.7989	0.0017
Error	20	0.4555488	0.022777		
C. Total	29	1.4393122			

Means for Oneway Anova

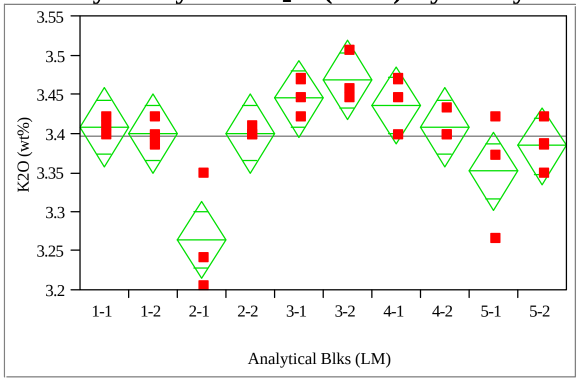
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	12.3002	0.08713	12.118	12.482
1-2	3	12.3383	0.08713	12.157	12.520
2-1	3	12.8625	0.08713	12.681	13.044
2-2	3	12.4956	0.08713	12.314	12.677
3-1	3	12.2668	0.08713	12.085	12.449
3-2	3	12.5099	0.08713	12.328	12.692
4-1	3	12.3812	0.08713	12.199	12.563
4-2	3	12.4479	0.08713	12.266	12.630
5-1	3	12.4146	0.08713	12.233	12.596
5-2	3	12.1525	0.08713	11.971	12.334

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 3.327 wt%

Oneway Analysis of K_2O (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.7162
Root Mean Square Error	0.041612
Mean of Response	3.397374
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.08739741	0.009711	5.6080	0.0007
Error	20	0.03463199	0.001732		
C. Total	29	0.12202941			

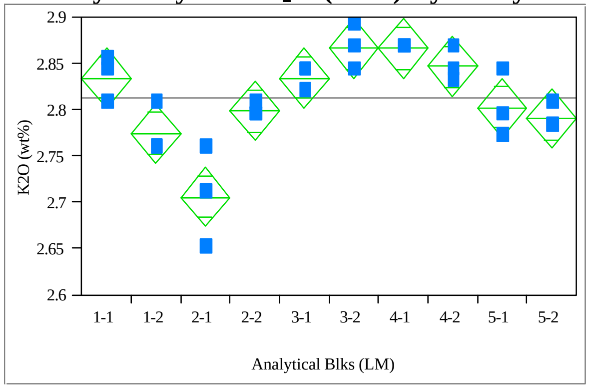
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	3.40902	0.02402	3.3589	3.4591
1-2	3	3.40099	0.02402	3.3509	3.4511
2-1	3	3.26447	0.02402	3.2144	3.3146
2-2	3	3.40099	0.02402	3.3509	3.4511
3-1	3	3.44516	0.02402	3.3950	3.4953
3-2	3	3.46925	0.02402	3.4191	3.5194
4-1	3	3.43713	0.02402	3.3870	3.4872
4-2	3	3.40902	0.02402	3.3589	3.4591
5-1	3	3.35280	0.02402	3.3027	3.4029
5-2	3	3.38493	0.02402	3.3348	3.4350

Std Error uses a pooled estimate of error variance

U std – reference value 2.999 wt%

Oneway Analysis of K_2O (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.820903
Root Mean Square Error	0.026574
Mean of Response	2.812339
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.06473668	0.007193	10.1857	<.0001
Error	20	0.01412366	0.000706		
C. Total	29	0.07886034			

Means for Oneway Anova

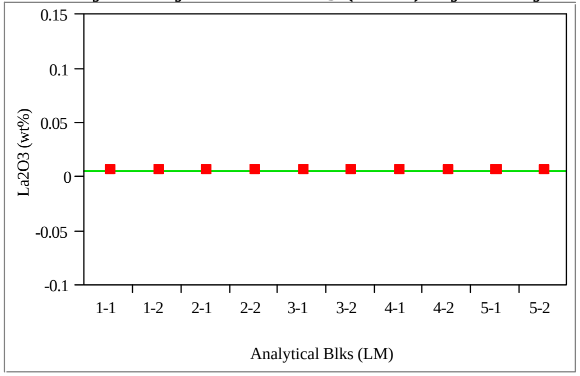
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.83483	0.01534	2.8028	2.8668
1-2	3	2.77460	0.01534	2.7426	2.8066
2-1	3	2.70633	0.01534	2.6743	2.7383
2-2	3	2.79869	0.01534	2.7667	2.8307
3-1	3	2.83483	0.01534	2.8028	2.8668
3-2	3	2.86695	0.01534	2.8349	2.8990
4-1	3	2.86695	0.01534	2.8349	2.8990
4-2	3	2.84687	0.01534	2.8149	2.8789
5-1	3	2.80270	0.01534	2.7707	2.8347
5-2	3	2.79066	0.01534	2.7587	2.8227

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 0 wt%

Oneway Analysis of La_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

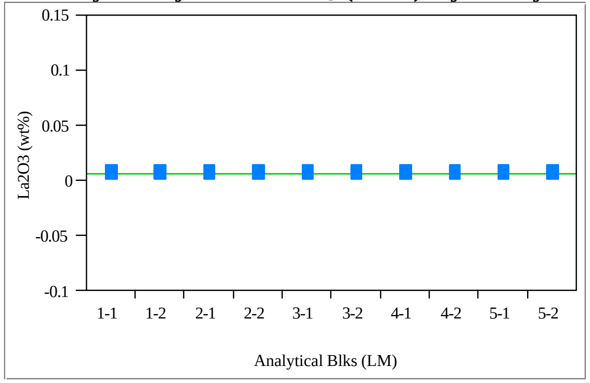
Means for Oneway Anova

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
3-1	3	0.005864	0	0.00586	0.00586
3-2	3	0.005864	0	0.00586	0.00586
4-1	3	0.005864	0	0.00586	0.00586
4-2	3	0.005864	0	0.00586	0.00586
5-1	3	0.005864	0	0.00586	0.00586
5-2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

U std – reference value 0 wt%

Oneway Analysis of La_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005864
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

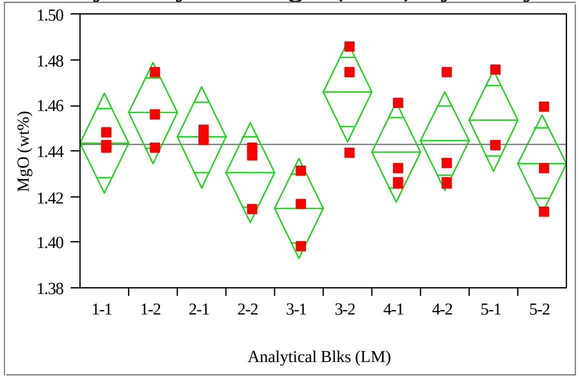
Means for Oneway Anova

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
3-1	3	0.005864	0	0.00586	0.00586
3-2	3	0.005864	0	0.00586	0.00586
4-1	3	0.005864	0	0.00586	0.00586
4-2	3	0.005864	0	0.00586	0.00586
5-1	3	0.005864	0	0.00586	0.00586
5-2	3	0.005864	0	0.00586	0.00586

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 1.419 wt%
Oneway Analysis of MgO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.462205
Root Mean Square Error	0.018095
Mean of Response	1.44321
Observations (or Sum Wgts)	30

Analysis of Variance

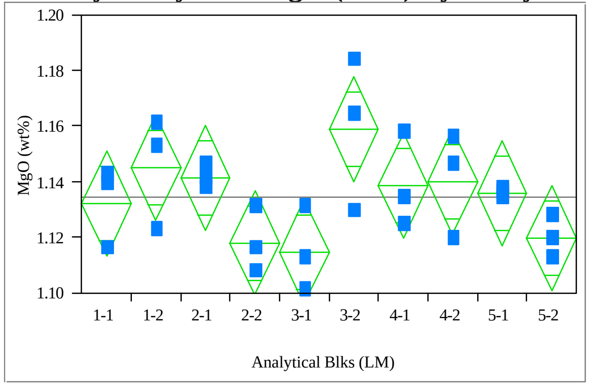
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00562836	0.000625	1.9099	0.1094
Error	20	0.00654882	0.000327		
C. Total	29	0.01217718			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.44365	0.01045	1.4219	1.4654
1-2	3	1.45692	0.01045	1.4351	1.4787
2-1	3	1.44642	0.01045	1.4246	1.4682
2-2	3	1.43094	0.01045	1.4091	1.4527
3-1	3	1.41491	0.01045	1.3931	1.4367
3-2	3	1.46631	0.01045	1.4445	1.4881
4-1	3	1.43978	0.01045	1.4180	1.4616
4-2	3	1.44476	0.01045	1.4230	1.4666
5-1	3	1.45360	0.01045	1.4318	1.4754
5-2	3	1.43481	0.01045	1.4130	1.4566

Std Error uses a pooled estimate of error variance

U std – reference value 1.21 wt%
Oneway Analysis of MgO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.507153
Root Mean Square Error	0.015698
Mean of Response	1.134527
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00507163	0.000564	2.2867	0.0593
Error	20	0.00492857	0.000246		
C. Total	29	0.01000020			

Means for Oneway Anova

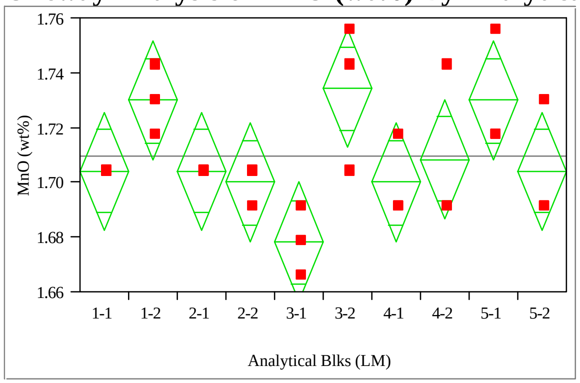
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.13248	0.00906	1.1136	1.1514
1-2	3	1.14519	0.00906	1.1263	1.1641
2-1	3	1.14133	0.00906	1.1224	1.1602
2-2	3	1.11811	0.00906	1.0992	1.1370
3-1	3	1.11480	0.00906	1.0959	1.1337
3-2	3	1.15901	0.00906	1.1401	1.1779
4-1	3	1.13856	0.00906	1.1197	1.1575
4-2	3	1.14022	0.00906	1.1213	1.1591
5-1	3	1.13580	0.00906	1.1169	1.1547
5-2	3	1.11977	0.00906	1.1009	1.1387

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 1.726 wt%

Oneway Analysis of MnO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.556575
Root Mean Square Error	0.017953
Mean of Response	1.709549
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00809146	0.000899	2.7893	0.0269
Error	20	0.00644650	0.000322		
C. Total	29	0.01453796			

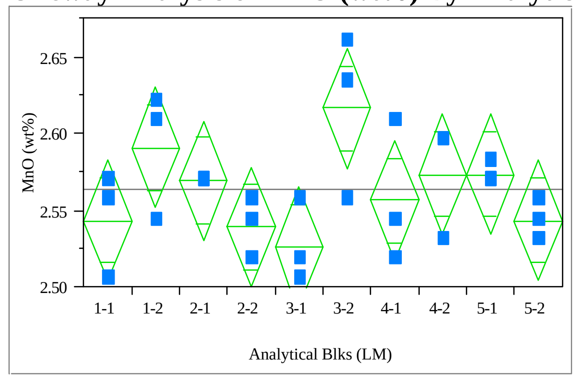
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	1.70438	0.01037	1.6828	1.7260
1-2	3	1.73021	0.01037	1.7086	1.7518
2-1	3	1.70438	0.01037	1.6828	1.7260
2-2	3	1.70008	0.01037	1.6785	1.7217
3-1	3	1.67856	0.01037	1.6569	1.7002
3-2	3	1.73451	0.01037	1.7129	1.7561
4-1	3	1.70008	0.01037	1.6785	1.7217
4-2	3	1.70869	0.01037	1.6871	1.7303
5-1	3	1.73021	0.01037	1.7086	1.7518
5-2	3	1.70438	0.01037	1.6828	1.7260

Std Error uses a pooled estimate of error variance

U std – reference value 2.892 wt%

Oneway Analysis of MnO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.482759
Root Mean Square Error	0.032665
Mean of Response	2.563462
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.01991745	0.002213	2.0741	0.0836
Error	20	0.02134013	0.001067		
C. Total	29	0.04125758			

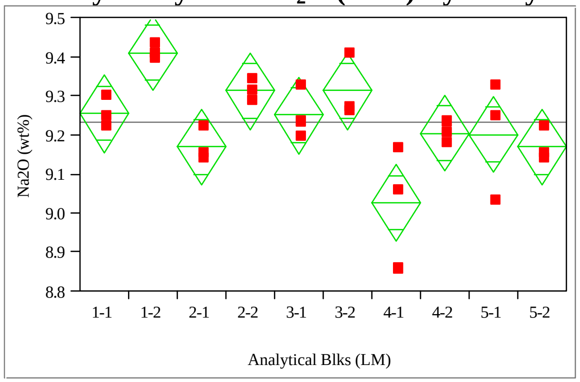
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.54366	0.01886	2.5043	2.5830
1-2	3	2.59101	0.01886	2.5517	2.6303
2-1	3	2.56949	0.01886	2.5301	2.6088
2-2	3	2.53936	0.01886	2.5000	2.5787
3-1	3	2.52645	0.01886	2.4871	2.5658
3-2	3	2.61683	0.01886	2.5775	2.6562
4-1	3	2.55658	0.01886	2.5172	2.5959
4-2	3	2.57379	0.01886	2.5345	2.6131
5-1	3	2.57379	0.01886	2.5345	2.6131
5-2	3	2.54366	0.01886	2.5043	2.5830

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 9.003 wt%
Oneway Analysis of Na_2O (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.687782
Root Mean Square Error	0.081922
Mean of Response	9.232901
Observations (or Sum Wgts)	30

Analysis of Variance

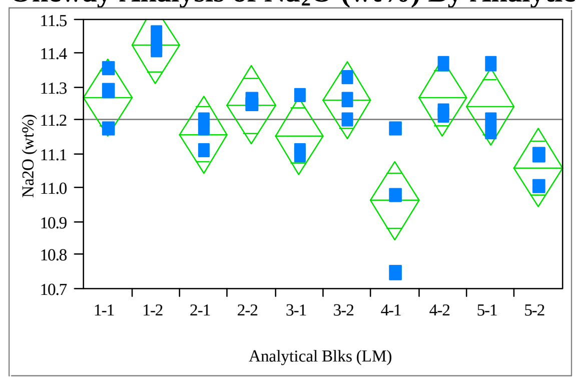
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.29567916	0.032853	4.8953	0.0015
Error	20	0.13422342	0.006711		
C. Total	29	0.42990258			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	9.25627	0.04730	9.1576	9.3549
1-2	3	9.41353	0.04730	9.3149	9.5122
2-1	3	9.17089	0.04730	9.0722	9.2696
2-2	3	9.31468	0.04730	9.2160	9.4133
3-1	3	9.25177	0.04730	9.1531	9.3504
3-2	3	9.31468	0.04730	9.2160	9.4133
4-1	3	9.02711	0.04730	8.9284	9.1258
4-2	3	9.20684	0.04730	9.1082	9.3055
5-1	3	9.20235	0.04730	9.1037	9.3010
5-2	3	9.17089	0.04730	9.0722	9.2696

Std Error uses a pooled estimate of error variance

U std – reference value 11.795 wt%
Oneway Analysis of Na_2O (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.704638
Root Mean Square Error	0.095888
Mean of Response	11.20592
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.43870342	0.048745	5.3015	0.0009
Error	20	0.18389092	0.009195		
C. Total	29	0.62259434			

Means for Oneway Anova

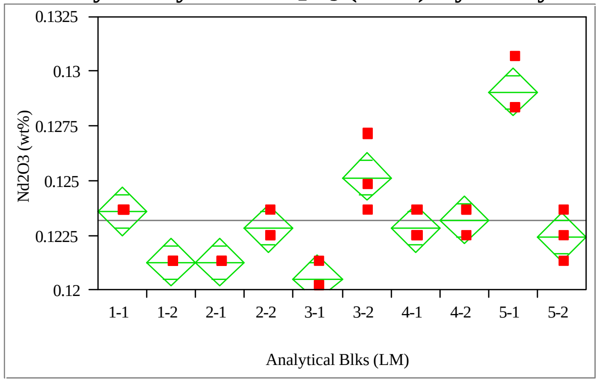
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	11.2693	0.05536	11.154	11.385
1-2	3	11.4265	0.05536	11.311	11.542
2-1	3	11.1614	0.05536	11.046	11.277
2-2	3	11.2468	0.05536	11.131	11.362
3-1	3	11.1569	0.05536	11.041	11.272
3-2	3	11.2603	0.05536	11.145	11.376
4-1	3	10.9637	0.05536	10.848	11.079
4-2	3	11.2693	0.05536	11.154	11.385
5-1	3	11.2423	0.05536	11.127	11.358
5-2	3	11.0626	0.05536	10.947	11.178

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0.147 wt%

Oneway Analysis of Nd_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.908163
Root Mean Square Error	0.000903
Mean of Response	0.12325
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00016144	0.000018	21.9753	<.0001
Error	20	0.00001633	0.000001		
C. Total	29	0.00017777			

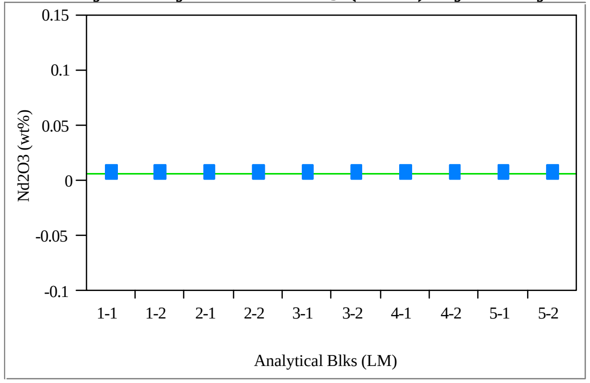
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.123638	0.00052	0.12255	0.12473
1-2	3	0.121306	0.00052	0.12022	0.12239
2-1	3	0.121306	0.00052	0.12022	0.12239
2-2	3	0.122861	0.00052	0.12177	0.12395
3-1	3	0.120528	0.00052	0.11944	0.12162
3-2	3	0.125194	0.00052	0.12411	0.12628
4-1	3	0.122861	0.00052	0.12177	0.12395
4-2	3	0.123250	0.00052	0.12216	0.12434
5-1	3	0.129082	0.00052	0.12799	0.13017
5-2	3	0.122472	0.00052	0.12138	0.12356

Std Error uses a pooled estimate of error variance

U std – reference value 0 wt%

Oneway Analysis of Nd_2O_3 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.005832
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

Means for Oneway Anova

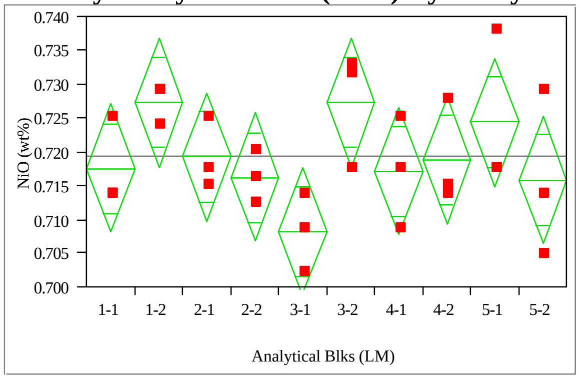
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005832	0	0.00583	0.00583
1-2	3	0.005832	0	0.00583	0.00583
2-1	3	0.005832	0	0.00583	0.00583
2-2	3	0.005832	0	0.00583	0.00583
3-1	3	0.005832	0	0.00583	0.00583
3-2	3	0.005832	0	0.00583	0.00583
4-1	3	0.005832	0	0.00583	0.00583
4-2	3	0.005832	0	0.00583	0.00583
5-1	3	0.005832	0	0.00583	0.00583
5-2	3	0.005832	0	0.00583	0.00583

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference 0.751 wt%

Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.426475
Root Mean Square Error	0.007848
Mean of Response	0.719344
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00091591	0.000102	1.6524	0.1672
Error	20	0.00123171	0.000062		
C. Total	29	0.00214762			

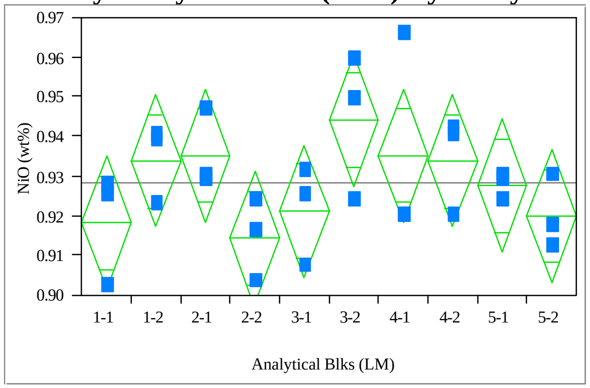
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.717690	0.00453	0.70824	0.72714
1-2	3	0.727446	0.00453	0.71799	0.73690
2-1	3	0.719387	0.00453	0.70994	0.72884
2-2	3	0.716417	0.00453	0.70697	0.72587
3-1	3	0.708358	0.00453	0.69891	0.71781
3-2	3	0.727446	0.00453	0.71799	0.73690
4-1	3	0.717266	0.00453	0.70781	0.72672
4-2	3	0.718962	0.00453	0.70951	0.72841
5-1	3	0.724477	0.00453	0.71503	0.73393
5-2	3	0.715993	0.00453	0.70654	0.72544

Std Error uses a pooled estimate of error variance

U std – reference value 1.12 wt%

Oneway Analysis of NiO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.389494
Root Mean Square Error	0.013914
Mean of Response	0.928458
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00247039	0.000274	1.4177	0.2456
Error	20	0.00387218	0.000194		
C. Total	29	0.00634257			

Means for Oneway Anova

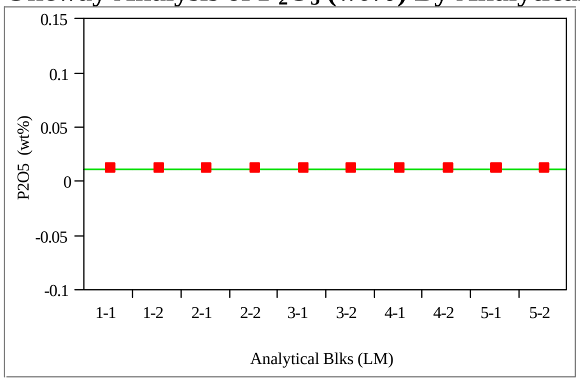
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.918321	0.00803	0.90156	0.93508
1-2	3	0.934015	0.00803	0.91726	0.95077
2-1	3	0.935287	0.00803	0.91853	0.95204
2-2	3	0.914503	0.00803	0.89775	0.93126
3-1	3	0.921290	0.00803	0.90453	0.93805
3-2	3	0.944195	0.00803	0.92744	0.96095
4-1	3	0.935287	0.00803	0.91853	0.95204
4-2	3	0.934015	0.00803	0.91726	0.95077
5-1	3	0.927652	0.00803	0.91090	0.94441
5-2	3	0.920018	0.00803	0.90326	0.93677

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value ~0 wt%

Oneway Analysis of P_2O_5 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.011457
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	3.6111e-34	4.012e-35	.	.
Error	20	0	0		
C. Total	29	3.6111e-34			

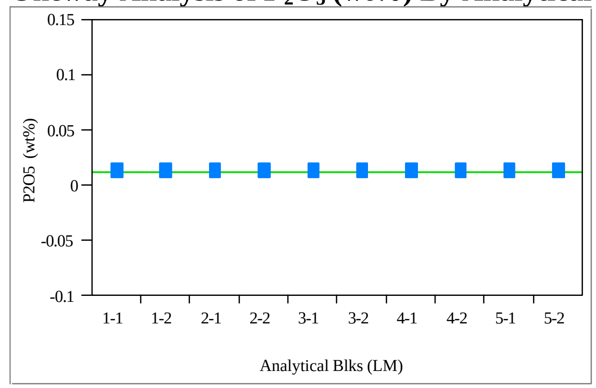
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.011457	0	0.01146	0.01146
1-2	3	0.011457	0	0.01146	0.01146
2-1	3	0.011457	0	0.01146	0.01146
2-2	3	0.011457	0	0.01146	0.01146
3-1	3	0.011457	0	0.01146	0.01146
3-2	3	0.011457	0	0.01146	0.01146
4-1	3	0.011457	0	0.01146	0.01146
4-2	3	0.011457	0	0.01146	0.01146
5-1	3	0.011457	0	0.01146	0.01146
5-2	3	0.011457	0	0.01146	0.01146

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

Oneway Analysis of P_2O_5 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.011457
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	3.6111e-34	4.012e-35	.	.
Error	20	0	0		
C. Total	29	3.6111e-34			

Means for Oneway Anova

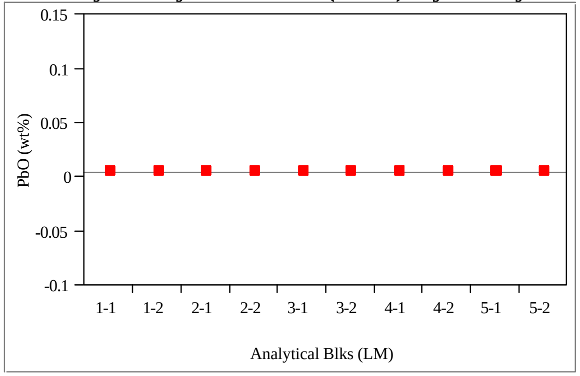
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.011457	0	0.01146	0.01146
1-2	3	0.011457	0	0.01146	0.01146
2-1	3	0.011457	0	0.01146	0.01146
2-2	3	0.011457	0	0.01146	0.01146
3-1	3	0.011457	0	0.01146	0.01146
3-2	3	0.011457	0	0.01146	0.01146
4-1	3	0.011457	0	0.01146	0.01146
4-2	3	0.011457	0	0.01146	0.01146
5-1	3	0.011457	0	0.01146	0.01146
5-2	3	0.011457	0	0.01146	0.01146

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	4
Root Mean Square Error	.
Mean of Response	0.005386
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	9.0278e-35	1.003e-35	-2.9630	-1.0000
Error	20	-6.771e-35	-3.39e-36		
C. Total	29	2.2569e-35			

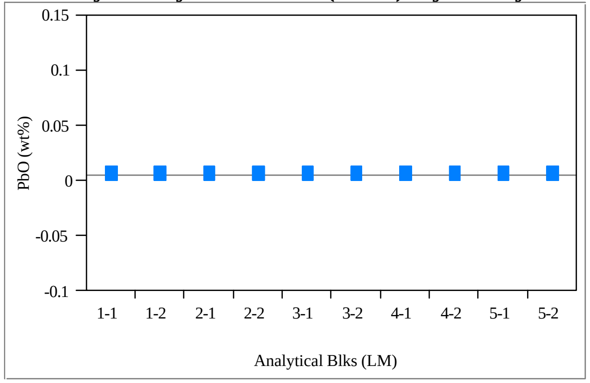
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	.	.	.
1-2	3	0.005386	.	.	.
2-1	3	0.005386	.	.	.
2-2	3	0.005386	.	.	.
3-1	3	0.005386	.	.	.
3-2	3	0.005386	.	.	.
4-1	3	0.005386	.	.	.
4-2	3	0.005386	.	.	.
5-1	3	0.005386	.	.	.
5-2	3	0.005386	.	.	.

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

Oneway Analysis of PbO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	4
Root Mean Square Error	.
Mean of Response	0.005386
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	9.0278e-35	1.003e-35	-2.9630	-1.0000
Error	20	-6.771e-35	-3.39e-36		
C. Total	29	2.2569e-35			

Means for Oneway Anova

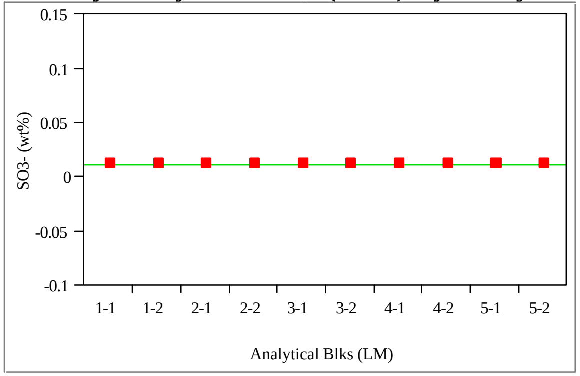
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005386	.	.	.
1-2	3	0.005386	.	.	.
2-1	3	0.005386	.	.	.
2-2	3	0.005386	.	.	.
3-1	3	0.005386	.	.	.
3-2	3	0.005386	.	.	.
4-1	3	0.005386	.	.	.
4-2	3	0.005386	.	.	.
5-1	3	0.005386	.	.	.
5-2	3	0.005386	.	.	.

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value ~0 wt%

Oneway Analysis of SO_3- (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.012485
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	9.0278e-35	1.003e-35	.	.
Error	20	0	0		
C. Total	29	9.0278e-35			

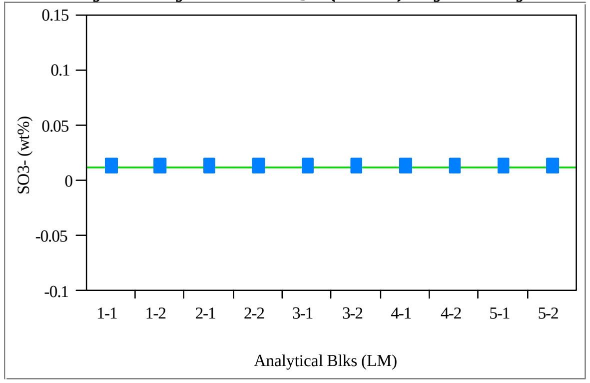
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.012485	0	0.01248	0.01248
1-2	3	0.012485	0	0.01248	0.01248
2-1	3	0.012485	0	0.01248	0.01248
2-2	3	0.012485	0	0.01248	0.01248
3-1	3	0.012485	0	0.01248	0.01248
3-2	3	0.012485	0	0.01248	0.01248
4-1	3	0.012485	0	0.01248	0.01248
4-2	3	0.012485	0	0.01248	0.01248
5-1	3	0.012485	0	0.01248	0.01248
5-2	3	0.012485	0	0.01248	0.01248

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

Oneway Analysis of SO_3- (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.012485
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	9.0278e-35	1.003e-35	.	.
Error	20	0	0		
C. Total	29	9.0278e-35			

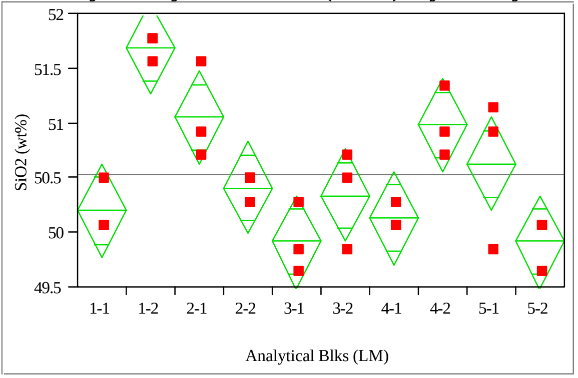
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.012485	0	0.01248	0.01248
1-2	3	0.012485	0	0.01248	0.01248
2-1	3	0.012485	0	0.01248	0.01248
2-2	3	0.012485	0	0.01248	0.01248
3-1	3	0.012485	0	0.01248	0.01248
3-2	3	0.012485	0	0.01248	0.01248
4-1	3	0.012485	0	0.01248	0.01248
4-2	3	0.012485	0	0.01248	0.01248
5-1	3	0.012485	0	0.01248	0.01248
5-2	3	0.012485	0	0.01248	0.01248

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 50.22 wt %
Oneway Analysis of SiO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.778498
Root Mean Square Error	0.353686
Mean of Response	50.53027
Observations (or Sum Wgts)	30

Analysis of Variance

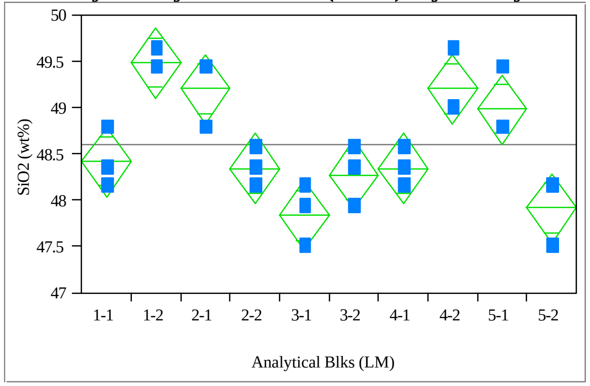
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	8.793183	0.977020	7.8103	<.0001
Error	20	2.501877	0.125094		
C. Total	29	11.295060			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	50.2022	0.20420	49.776	50.628
1-2	3	51.6997	0.20420	51.274	52.126
2-1	3	51.0580	0.20420	50.632	51.484
2-2	3	50.4162	0.20420	49.990	50.842
3-1	3	49.9170	0.20420	49.491	50.343
3-2	3	50.3449	0.20420	49.919	50.771
4-1	3	50.1309	0.20420	49.705	50.557
4-2	3	50.9866	0.20420	50.561	51.413
5-1	3	50.6301	0.20420	50.204	51.056
5-2	3	49.9170	0.20420	49.491	50.343

Std Error uses a pooled estimate of error variance

U std – reference value 45.353 wt%
Oneway Analysis of SiO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.81982
Root Mean Square Error	0.312465
Mean of Response	48.6049
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	8.884715	0.987191	10.1111	<.0001
Error	20	1.952685	0.097634		
C. Total	29	10.837399			

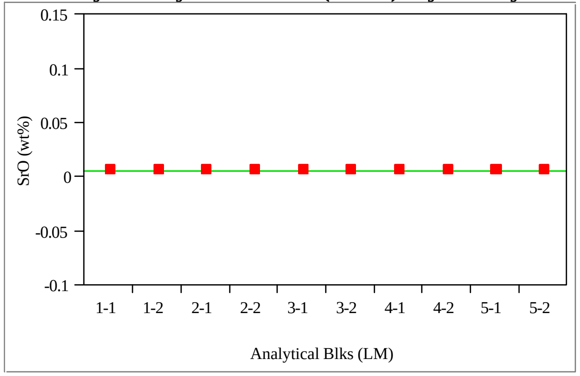
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	48.4195	0.18040	48.043	48.796
1-2	3	49.4891	0.18040	49.113	49.865
2-1	3	49.2039	0.18040	48.828	49.580
2-2	3	48.3482	0.18040	47.972	48.724
3-1	3	47.8490	0.18040	47.473	48.225
3-2	3	48.2769	0.18040	47.901	48.653
4-1	3	48.3482	0.18040	47.972	48.724
4-2	3	49.2039	0.18040	48.828	49.580
5-1	3	48.9900	0.18040	48.614	49.366
5-2	3	47.9203	0.18040	47.544	48.297

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value ~0 wt%
Oneway Analysis of SrO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005913
Observations (or Sum Wgts)	30

Analysis of Variance

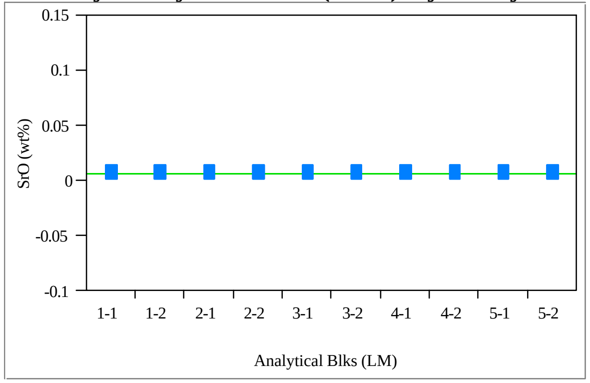
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0	0	.	.
Error	20	0	0		
C. Total	29	0			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005913	0	0.00591	0.00591
1-2	3	0.005913	0	0.00591	0.00591
2-1	3	0.005913	0	0.00591	0.00591
2-2	3	0.005913	0	0.00591	0.00591
3-1	3	0.005913	0	0.00591	0.00591
3-2	3	0.005913	0	0.00591	0.00591
4-1	3	0.005913	0	0.00591	0.00591
4-2	3	0.005913	0	0.00591	0.00591
5-1	3	0.005913	0	0.00591	0.00591
5-2	3	0.005913	0	0.00591	0.00591

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%
Oneway Analysis of SrO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.005913
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0	0	.	.
Error	20	0	0		
C. Total	29	0			

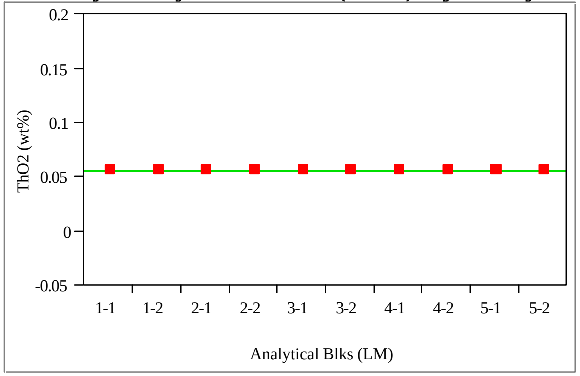
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.005913	0	0.00591	0.00591
1-2	3	0.005913	0	0.00591	0.00591
2-1	3	0.005913	0	0.00591	0.00591
2-2	3	0.005913	0	0.00591	0.00591
3-1	3	0.005913	0	0.00591	0.00591
3-2	3	0.005913	0	0.00591	0.00591
4-1	3	0.005913	0	0.00591	0.00591
4-2	3	0.005913	0	0.00591	0.00591
5-1	3	0.005913	0	0.00591	0.00591
5-2	3	0.005913	0	0.00591	0.00591

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value ~0 wt%
Oneway Analysis of ThO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	.
Root Mean Square Error	0
Mean of Response	0.056895
Observations (or Sum Wgts)	30

Analysis of Variance

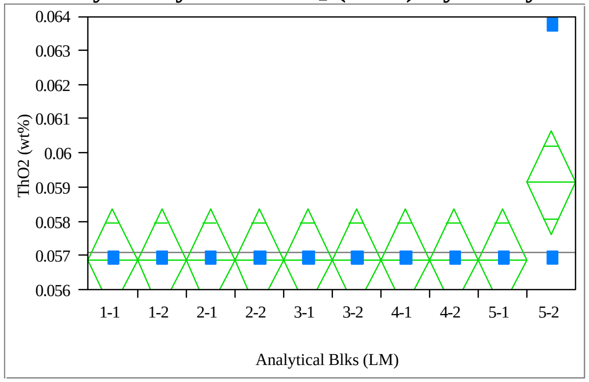
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0	0	.	.
Error	20	0	0		
C. Total	29	0			

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
3-1	3	0.056895	0	0.05690	0.05690
3-2	3	0.056895	0	0.05690	0.05690
4-1	3	0.056895	0	0.05690	0.05690
4-2	3	0.056895	0	0.05690	0.05690
5-1	3	0.056895	0	0.05690	0.05690
5-2	3	0.056895	0	0.05690	0.05690

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%
Oneway Analysis of ThO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.310345
Root Mean Square Error	0.001247
Mean of Response	0.057123
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00001398	0.0000016	1.0000	0.4711
Error	20	0.00003108	0.0000016		
C. Total	29	0.00004506			

Means for Oneway Anova

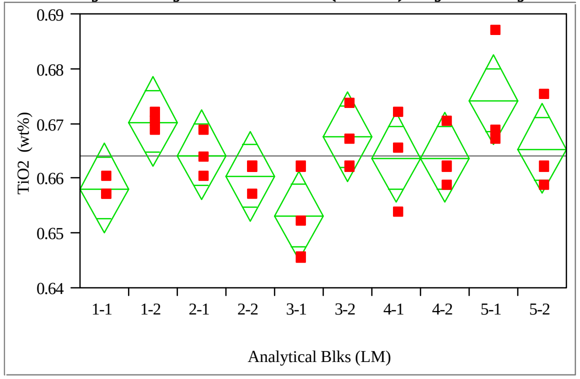
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.056895	0.00072	0.05539	0.05840
1-2	3	0.056895	0.00072	0.05539	0.05840
2-1	3	0.056895	0.00072	0.05539	0.05840
2-2	3	0.056895	0.00072	0.05539	0.05840
3-1	3	0.056895	0.00072	0.05539	0.05840
3-2	3	0.056895	0.00072	0.05539	0.05840
4-1	3	0.056895	0.00072	0.05539	0.05840
4-2	3	0.056895	0.00072	0.05539	0.05840
5-1	3	0.056895	0.00072	0.05539	0.05840
5-2	3	0.059171	0.00072	0.05767	0.06067

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0.677 wt%

Oneway Analysis of TiO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.515146
Root Mean Square Error	0.006789
Mean of Response	0.664253
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00097944	0.000109	2.3611	0.0526
Error	20	0.00092184	0.000046		
C. Total	29	0.00190128			

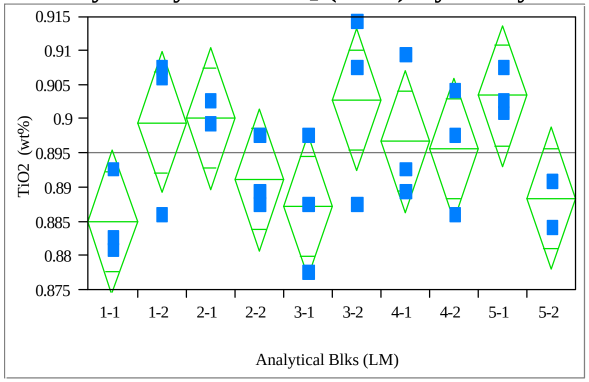
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.658304	0.00392	0.65013	0.66648
1-2	3	0.670536	0.00392	0.66236	0.67871
2-1	3	0.664420	0.00392	0.65624	0.67260
2-2	3	0.660528	0.00392	0.65235	0.66870
3-1	3	0.653300	0.00392	0.64512	0.66148
3-2	3	0.667756	0.00392	0.65958	0.67593
4-1	3	0.663864	0.00392	0.65569	0.67204
4-2	3	0.663864	0.00392	0.65569	0.67204
5-1	3	0.674428	0.00392	0.66625	0.68260
5-2	3	0.665532	0.00392	0.65736	0.67371

Std Error uses a pooled estimate of error variance

U std – reference value 1.049 wt%

Oneway Analysis of TiO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.447085
Root Mean Square Error	0.008597
Mean of Response	0.895104
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00119534	0.000133	1.7969	0.1318
Error	20	0.00147829	0.000074		
C. Total	29	0.00267362			

Means for Oneway Anova

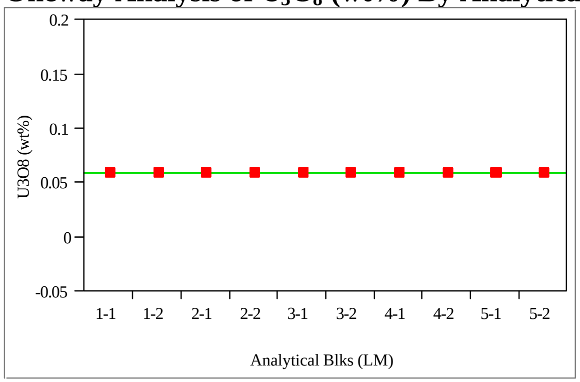
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.885152	0.00496	0.87480	0.89551
1-2	3	0.899608	0.00496	0.88925	0.90996
2-1	3	0.900164	0.00496	0.88981	0.91052
2-2	3	0.891268	0.00496	0.88091	0.90162
3-1	3	0.887376	0.00496	0.87702	0.89773
3-2	3	0.902944	0.00496	0.89259	0.91330
4-1	3	0.896828	0.00496	0.88647	0.90718
4-2	3	0.895716	0.00496	0.88536	0.90607
5-1	3	0.903500	0.00496	0.89315	0.91385
5-2	3	0.888488	0.00496	0.87813	0.89884

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method ***(continued)***

Batch 1 – reference value 0 wt%

Oneway Analysis of U_3O_8 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.05896
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	5.7778e-33	6.42e-34	.	.
Error	20	0	0		
C. Total	29	5.7778e-33			

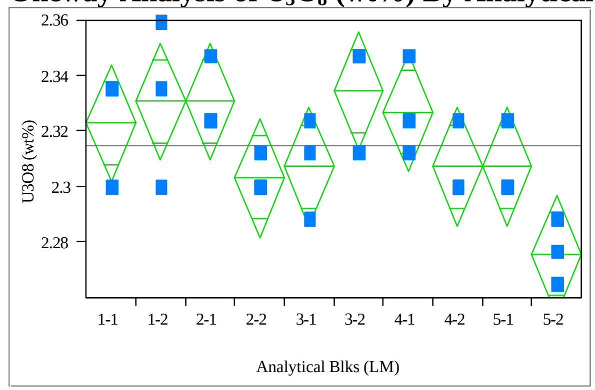
Means for Oneway Anova

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
3-1	3	0.058960	0	0.05896	0.05896
3-2	3	0.058960	0	0.05896	0.05896
4-1	3	0.058960	0	0.05896	0.05896
4-2	3	0.058960	0	0.05896	0.05896
5-1	3	0.058960	0	0.05896	0.05896
5-2	3	0.058960	0	0.05896	0.05896

Std Error uses a pooled estimate of error variance

U std – reference value 2.406 wt%

Oneway Analysis of U_3O_8 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.587565
Root Mean Square Error	0.017622
Mean of Response	2.31477
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00884830	0.000983	3.1658	0.0152
Error	20	0.00621096	0.000311		
C. Total	29	0.01505925			

Means for Oneway Anova

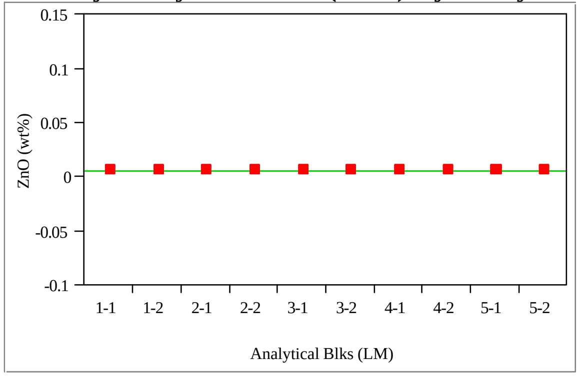
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.32302	0.01017	2.3018	2.3442
1-2	3	2.33089	0.01017	2.3097	2.3521
2-1	3	2.33089	0.01017	2.3097	2.3521
2-2	3	2.30337	0.01017	2.2821	2.3246
3-1	3	2.30730	0.01017	2.2861	2.3285
3-2	3	2.33482	0.01017	2.3136	2.3560
4-1	3	2.32695	0.01017	2.3057	2.3482
4-2	3	2.30730	0.01017	2.2861	2.3285
5-1	3	2.30730	0.01017	2.2861	2.3285
5-2	3	2.27586	0.01017	2.2546	2.2971

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value ~0 wt%

Oneway Analysis of ZnO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

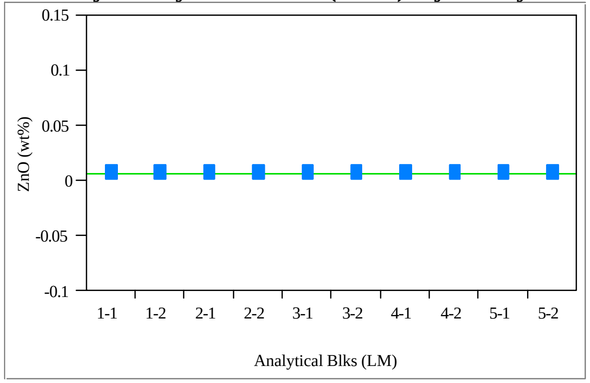
Means for Oneway Anova

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
3-1	3	0.006224	0	0.00622	0.00622
3-2	3	0.006224	0	0.00622	0.00622
4-1	3	0.006224	0	0.00622	0.00622
4-2	3	0.006224	0	0.00622	0.00622
5-1	3	0.006224	0	0.00622	0.00622
5-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%

Oneway Analysis of ZnO (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	1
Root Mean Square Error	0
Mean of Response	0.006224
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	2.2569e-35	2.508e-36	.	.
Error	20	0	0		
C. Total	29	2.2569e-35			

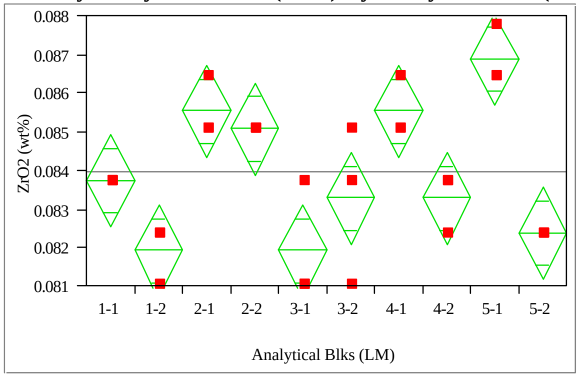
Means for Oneway Anova

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
3-1	3	0.006224	0	0.00622	0.00622
3-2	3	0.006224	0	0.00622	0.00622
4-1	3	0.006224	0	0.00622	0.00622
4-2	3	0.006224	0	0.00622	0.00622
5-1	3	0.006224	0	0.00622	0.00622
5-2	3	0.006224	0	0.00622	0.00622

Std Error uses a pooled estimate of error variance

Exhibit C.4: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the LM Method *(continued)*

Batch 1 – reference value 0.098 wt%
Oneway Analysis of ZrO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.803077
Root Mean Square Error	0.000986
Mean of Response	0.083975
Observations (or Sum Wgts)	30

Analysis of Variance

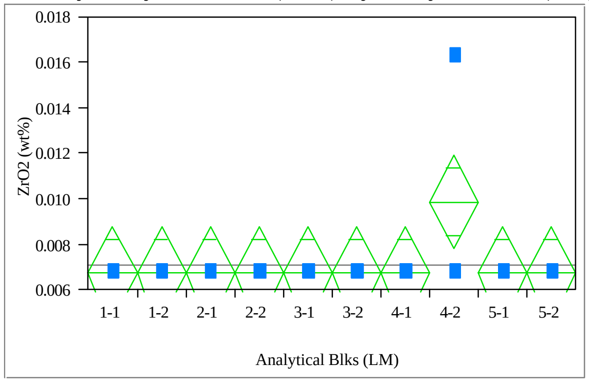
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00007937	0.0000088	9.0625	<.0001
Error	20	0.00001946	9.7315e-7		
C. Total	29	0.00009884			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.083750	0.00057	0.08256	0.08494
1-2	3	0.081949	0.00057	0.08076	0.08314
2-1	3	0.085551	0.00057	0.08436	0.08674
2-2	3	0.085100	0.00057	0.08391	0.08629
3-1	3	0.081949	0.00057	0.08076	0.08314
3-2	3	0.083299	0.00057	0.08211	0.08449
4-1	3	0.085551	0.00057	0.08436	0.08674
4-2	3	0.083299	0.00057	0.08211	0.08449
5-1	3	0.086901	0.00057	0.08571	0.08809
5-2	3	0.082399	0.00057	0.08121	0.08359

Std Error uses a pooled estimate of error variance

U std – reference value ~0 wt%
Oneway Analysis of ZrO_2 (wt%) By Analytical Blks (LM)



Summary of Fit

Rsquare	0.310345
Root Mean Square Error	0.001726
Mean of Response	0.007069
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Blks (LM)	9	0.00002682	0.000003	1.0000	0.4711
Error	20	0.00005961	0.000003		
C. Total	29	0.00008643			

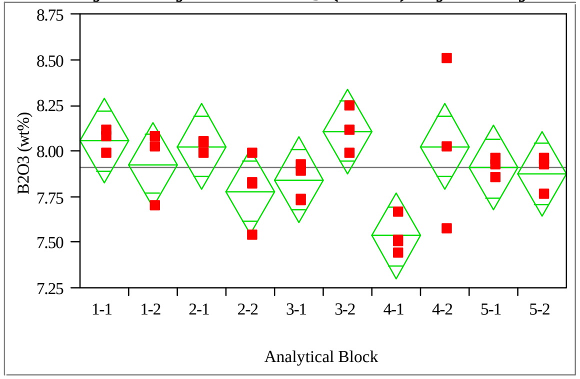
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.006754	0.00100	0.00467	0.00883
1-2	3	0.006754	0.00100	0.00467	0.00883
2-1	3	0.006754	0.00100	0.00467	0.00883
2-2	3	0.006754	0.00100	0.00467	0.00883
3-1	3	0.006754	0.00100	0.00467	0.00883
3-2	3	0.006754	0.00100	0.00467	0.00883
4-1	3	0.006754	0.00100	0.00467	0.00883
4-2	3	0.009906	0.00100	0.00783	0.01198
5-1	3	0.006754	0.00100	0.00467	0.00883
5-2	3	0.006754	0.00100	0.00467	0.00883

Std Error uses a pooled estimate of error variance

Exhibit C.5: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the SP Method

Batch 1 – reference value 7.777 wt%
Oneway Analysis of B_2O_3 (wt%) By Analytical Block



Summary of Fit

Rsquare	0.506732
Root Mean Square Error	0.193105
Mean of Response	7.911294
Observations (or Sum Wgts)	30

Analysis of Variance

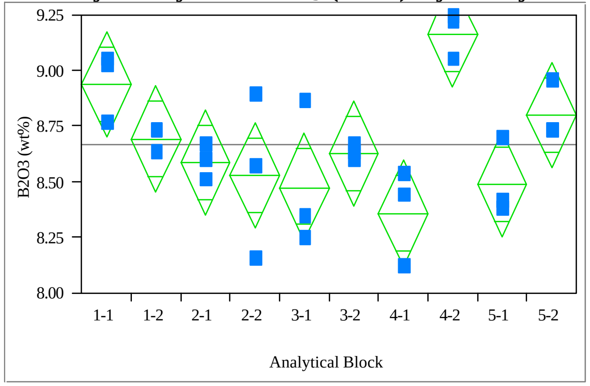
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	9	0.7661426	0.085127	2.2829	0.0596
Error	20	0.7457872	0.037289		
C. Total	29	1.5119299			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	8.06048	0.11149	7.8279	8.2930
1-2	3	7.93169	0.11149	7.6991	8.1642
2-1	3	8.02828	0.11149	7.7957	8.2608
2-2	3	7.78143	0.11149	7.5489	8.0140
3-1	3	7.84582	0.11149	7.6133	8.0784
3-2	3	8.11415	0.11149	7.8816	8.3467
4-1	3	7.53457	0.11149	7.3020	7.7671
4-2	3	8.02828	0.11149	7.7957	8.2608
5-1	3	7.91022	0.11149	7.6777	8.1428
5-2	3	7.87802	0.11149	7.6455	8.1106

Std Error uses a pooled estimate of error variance

U std – reference value 9.209 wt%
Oneway Analysis of B_2O_3 (wt%) By Analytical Block



Summary of Fit

Rsquare	0.670876
Root Mean Square Error	0.197265
Mean of Response	8.667971
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	9	1.5864049	0.176267	4.5297	0.0024
Error	20	0.7782729	0.038914		
C. Total	29	2.3646778			

Means for Oneway Anova

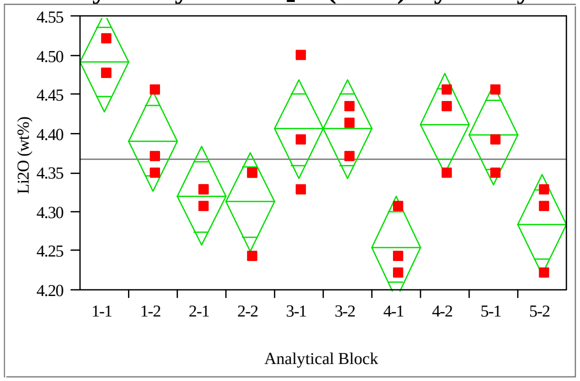
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	8.94059	0.11389	8.7030	9.1782
1-2	3	8.69373	0.11389	8.4562	8.9313
2-1	3	8.58640	0.11389	8.3488	8.8240
2-2	3	8.53274	0.11389	8.2952	8.7703
3-1	3	8.47907	0.11389	8.2415	8.7166
3-2	3	8.62933	0.11389	8.3918	8.8669
4-1	3	8.36101	0.11389	8.1234	8.5986
4-2	3	9.16598	0.11389	8.9284	9.4036
5-1	3	8.48980	0.11389	8.2522	8.7274
5-2	3	8.80106	0.11389	8.5635	9.0386

Std Error uses a pooled estimate of error variance

Exhibit C.5: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the SP Method *(continued)*

Batch 1 – reference value 4.429 wt%

Oneway Analysis of Li_2O (wt%) By Analytical Block



Summary of Fit

Rsquare	0.715878
Root Mean Square Error	0.052881
Mean of Response	4.368234
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	9	0.14091879	0.015658	5.5991	0.0007
Error	20	0.05592874	0.002796		
C. Total	29	0.19684753			

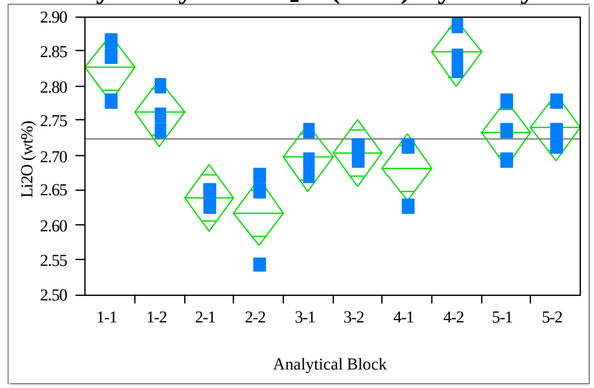
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	4.49238	0.03053	4.4287	4.5561
1-2	3	4.39192	0.03053	4.3282	4.4556
2-1	3	4.32015	0.03053	4.2565	4.3838
2-2	3	4.31298	0.03053	4.2493	4.3767
3-1	3	4.40627	0.03053	4.3426	4.4700
3-2	3	4.40627	0.03053	4.3426	4.4700
4-1	3	4.25557	0.03053	4.1919	4.3193
4-2	3	4.41344	0.03053	4.3498	4.4771
5-1	3	4.39909	0.03053	4.3354	4.4628
5-2	3	4.28427	0.03053	4.2206	4.3480

Std Error uses a pooled estimate of error variance

U std – reference value 3.057 wt%

Oneway Analysis of Li_2O (wt%) By Analytical Block



Summary of Fit

Rsquare	0.822439
Root Mean Square Error	0.039698
Mean of Response	2.726289
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	9	0.14598637	0.016221	10.2930	<.0001
Error	20	0.03151785	0.001576		
C. Total	29	0.17750422			

Means for Oneway Anova

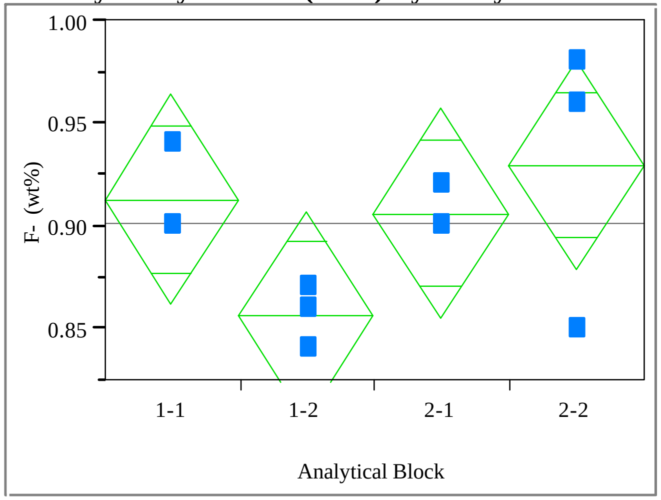
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	2.82748	0.02292	2.7797	2.8753
1-2	3	2.76289	0.02292	2.7151	2.8107
2-1	3	2.64089	0.02292	2.5931	2.6887
2-2	3	2.61936	0.02292	2.5716	2.6672
3-1	3	2.69830	0.02292	2.6505	2.7461
3-2	3	2.70548	0.02292	2.6577	2.7533
4-1	3	2.68395	0.02292	2.6361	2.7318
4-2	3	2.84900	0.02292	2.8012	2.8968
5-1	3	2.73418	0.02292	2.6864	2.7820
5-2	3	2.74136	0.02292	2.6936	2.7892

Std Error uses a pooled estimate of error variance

Exhibit C.6: SRTC-ML Measurements by Analytical Block for Samples of the Standard Glasses Prepared Using the PF Method

LRM – reference value 1 wt%

Oneway Analysis of F- (wt%) By Analytical Block



Summary of Fit

Rsquare	0.435981
Root Mean Square Error	0.038079
Mean of Response	0.901667
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0.00896667	0.002989	2.0613	0.1839
Error	8	0.01160000	0.001450		
C. Total	11	0.02056667			

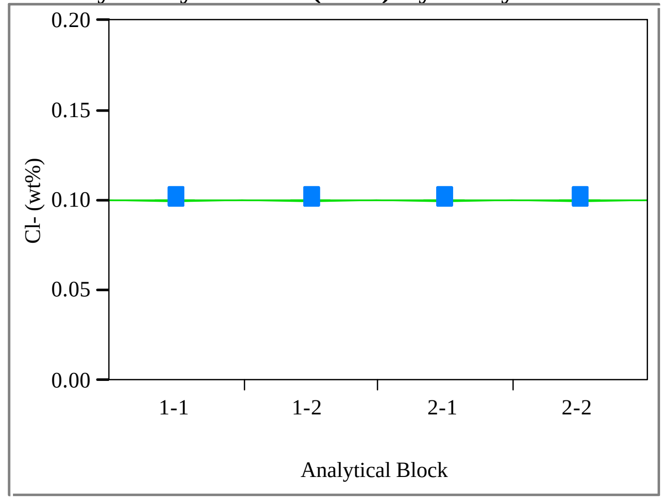
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.913333	0.02198	0.86264	0.96403
1-2	3	0.856667	0.02198	0.80597	0.90736
2-1	3	0.906667	0.02198	0.85597	0.95736
2-2	3	0.930000	0.02198	0.87930	0.98070

Std Error uses a pooled estimate of error variance

LRM – reference value 0.8 wt%

Oneway Analysis of Cl- (wt%) By Analytical Block



Summary of Fit

Rsquare	0
Root Mean Square Error	1.7e-17
Mean of Response	0.1
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Analytical Block	3	0	0	0.0000	1.0000
Error	8	2.3111e-33	2.889e-34		
C. Total	11	2.3111e-33			

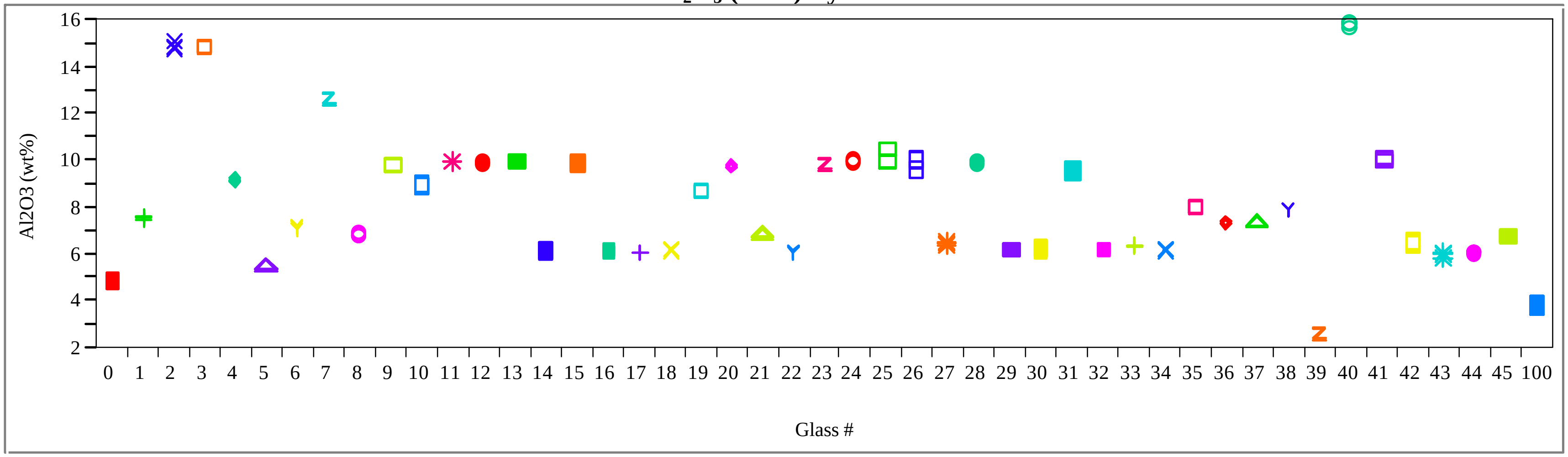
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1-1	3	0.100000	9.813e-18	0.10000	0.10000
1-2	3	0.100000	9.813e-18	0.10000	0.10000
2-1	3	0.100000	9.813e-18	0.10000	0.10000
2-2	3	0.100000	9.813e-18	0.10000	0.10000

Std Error uses a pooled estimate of error variance

Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method
(with 0 – Batch 1 and 100 – U std)

Al_2O_3 (wt%) By Glass #



Al_2O_3 bc (wt%) By Glass #

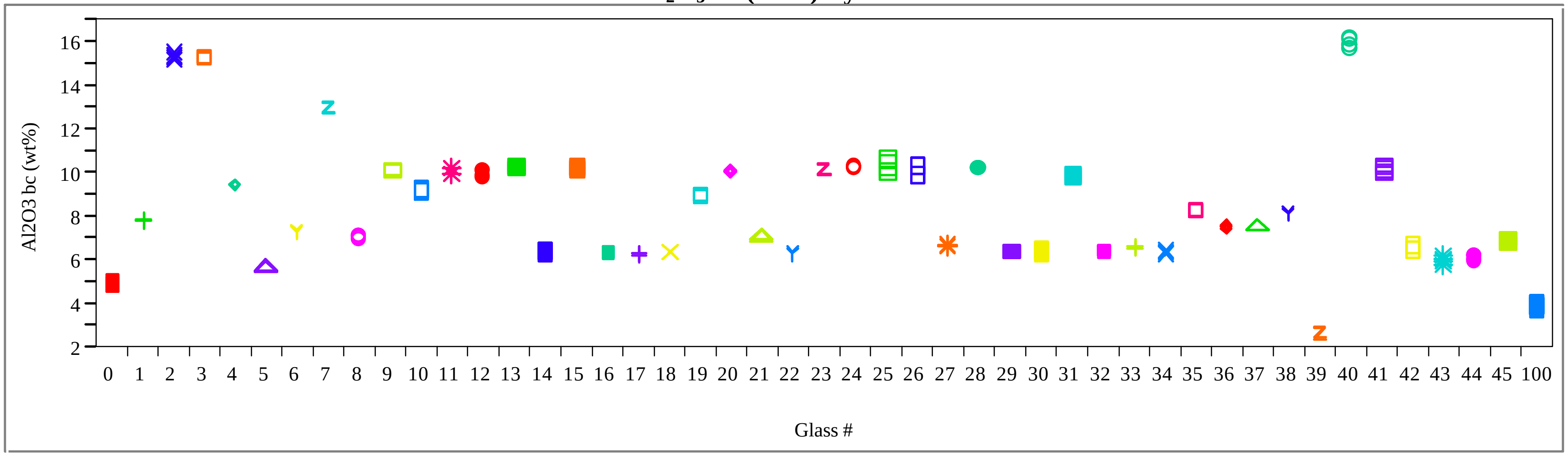
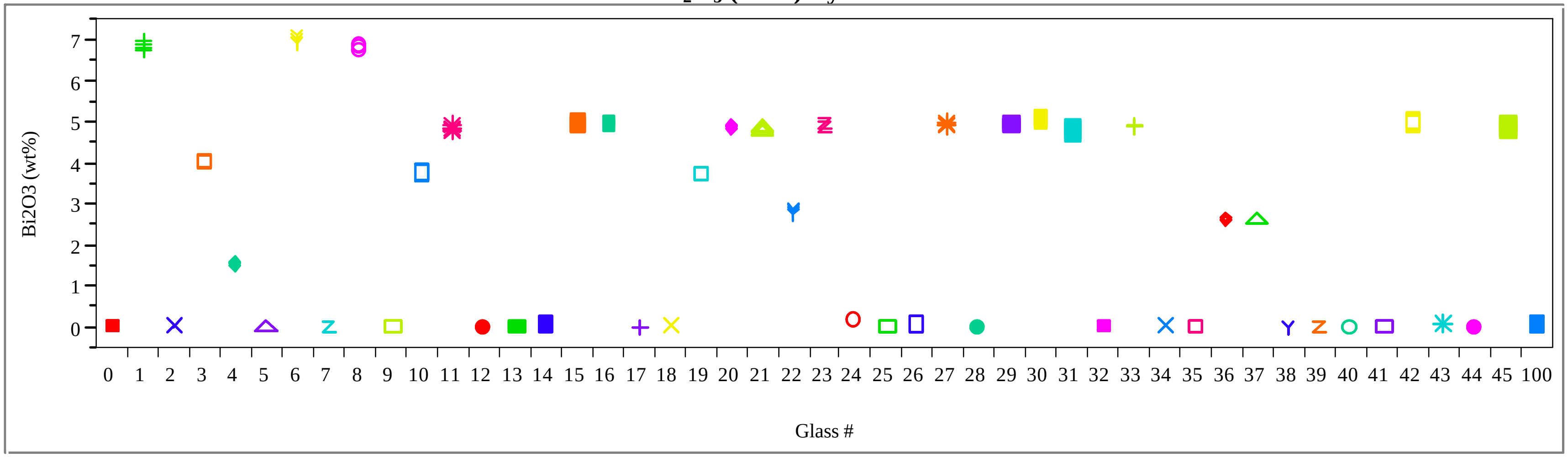


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Bi_2O_3 (wt%) By Glass #



Bi_2O_3 bc (wt%) By Glass #

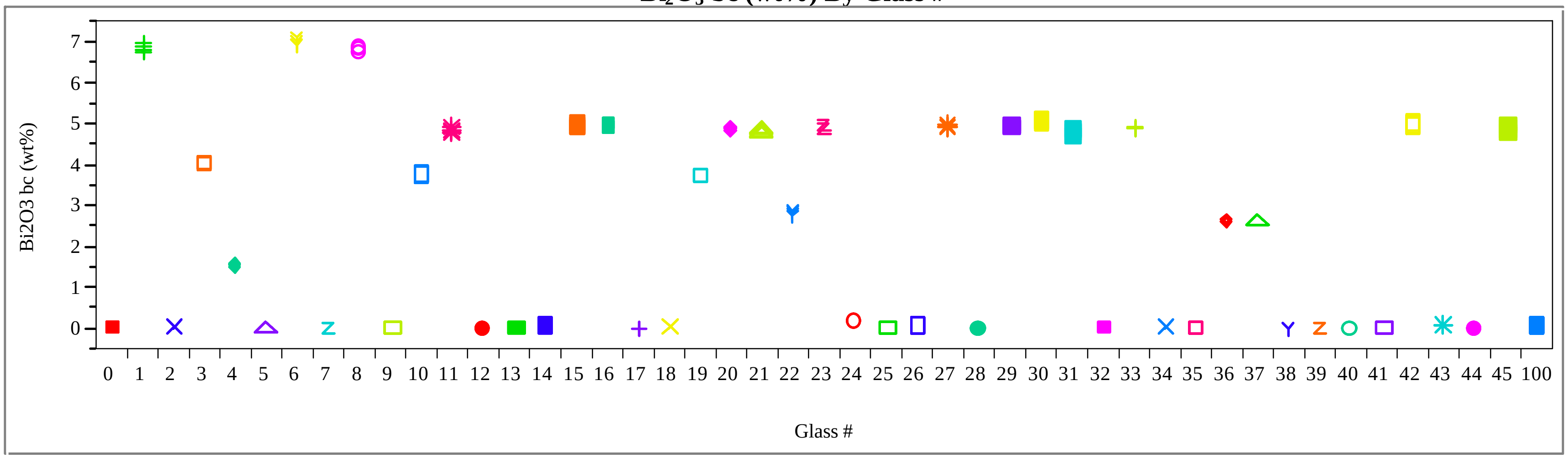
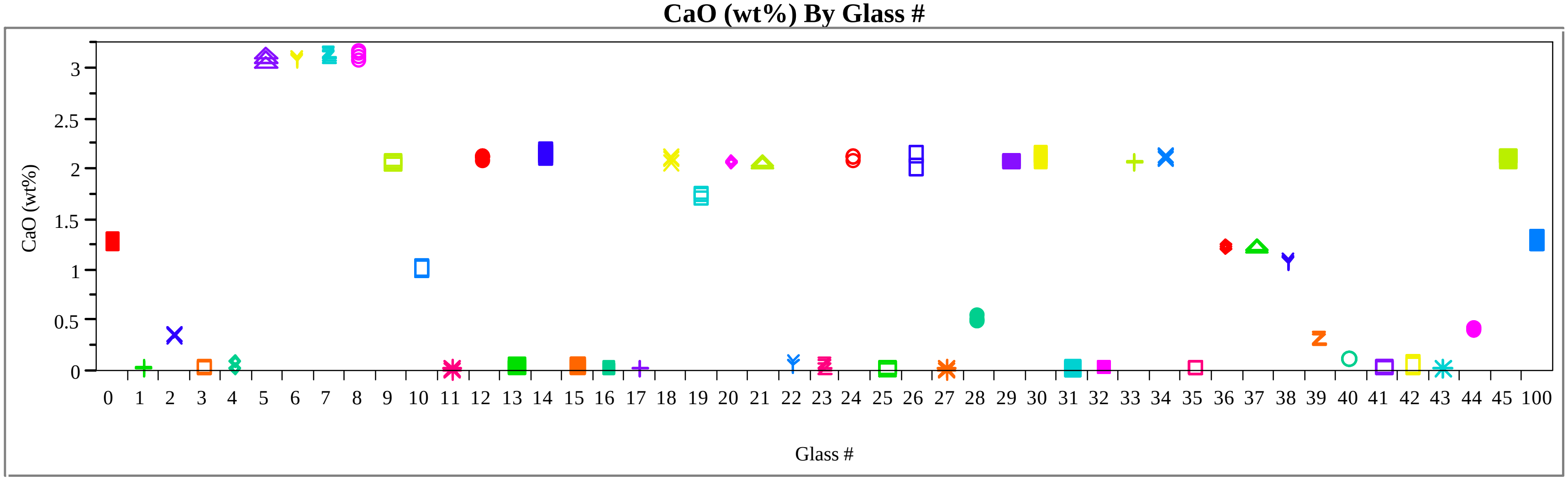


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)



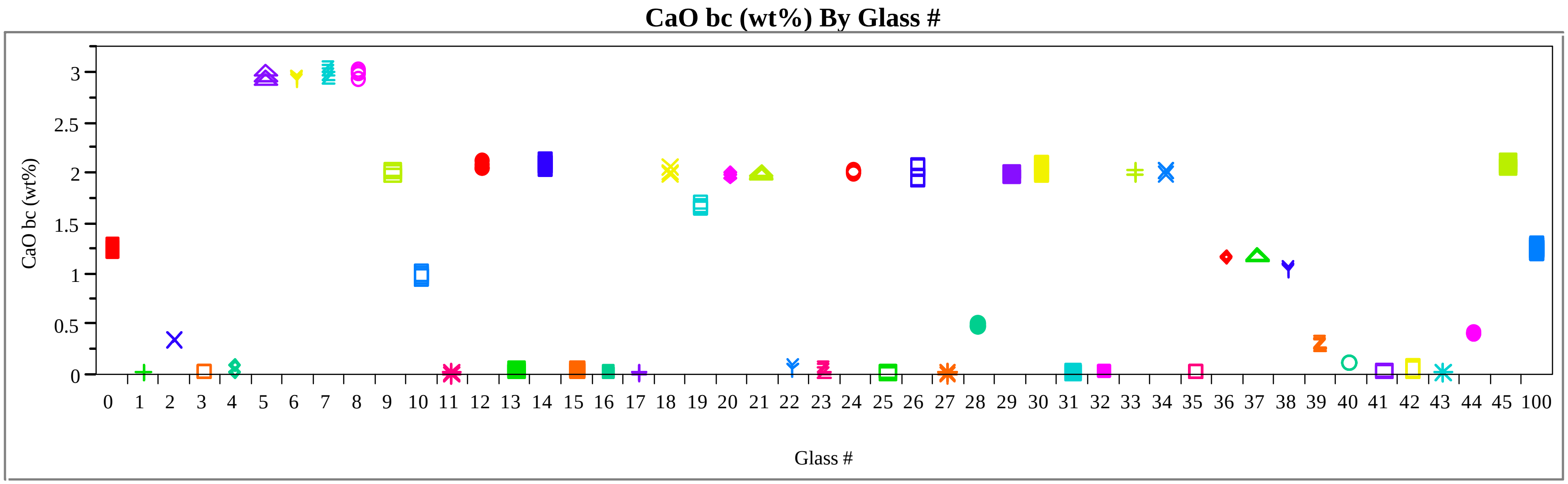
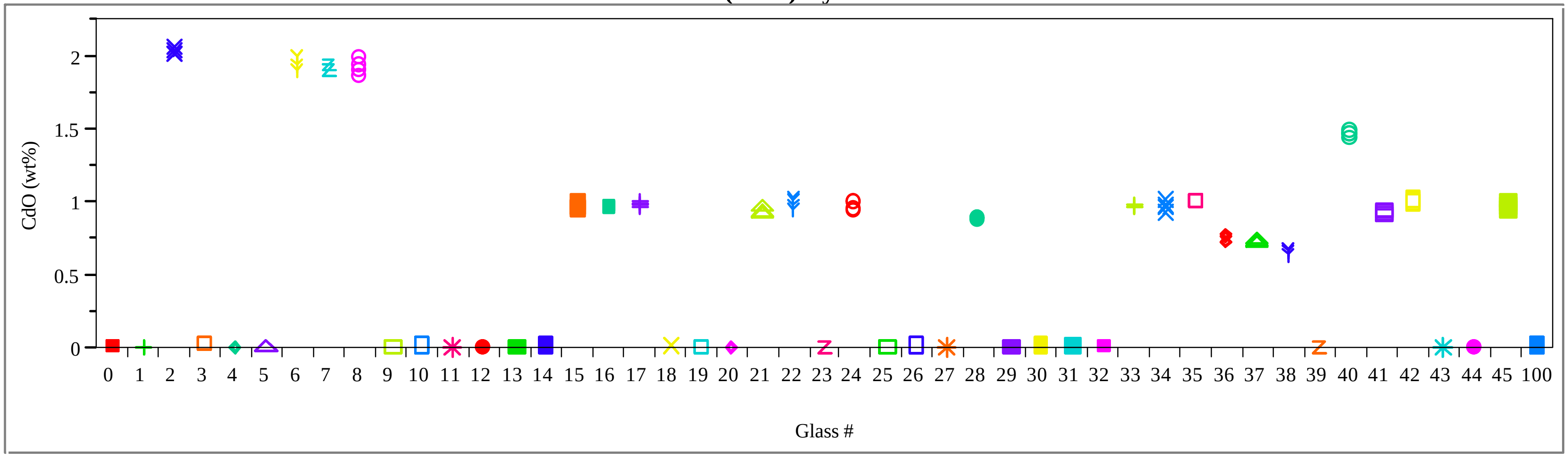


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

CdO (wt%) By Glass #



CdO bc (wt%) By Glass #

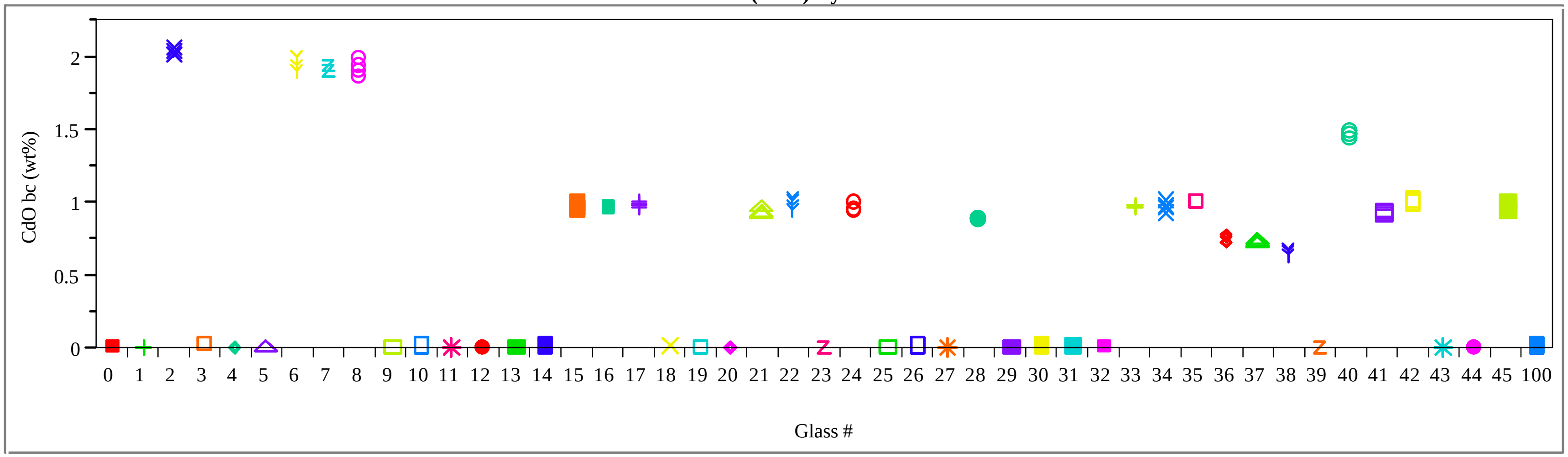
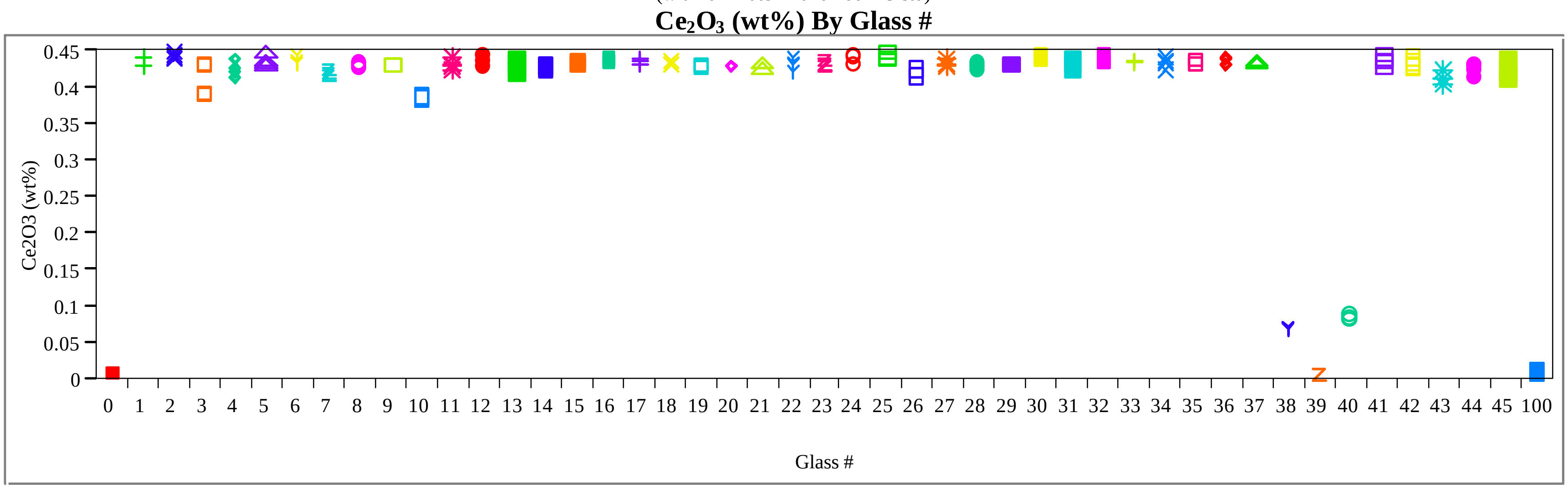


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)



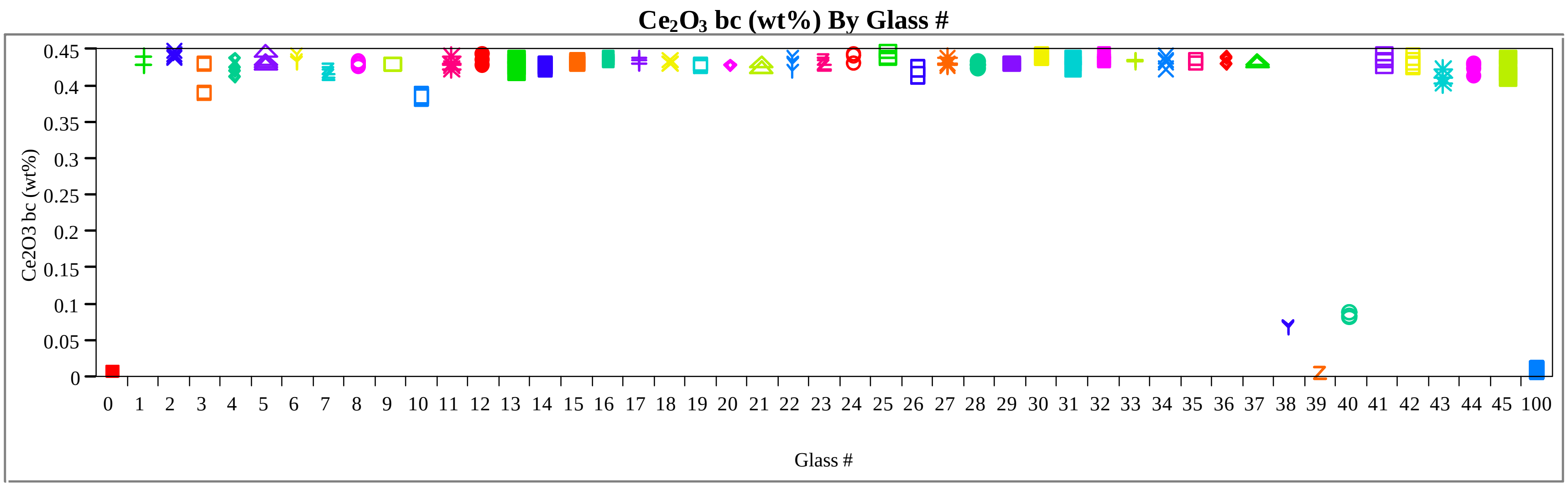
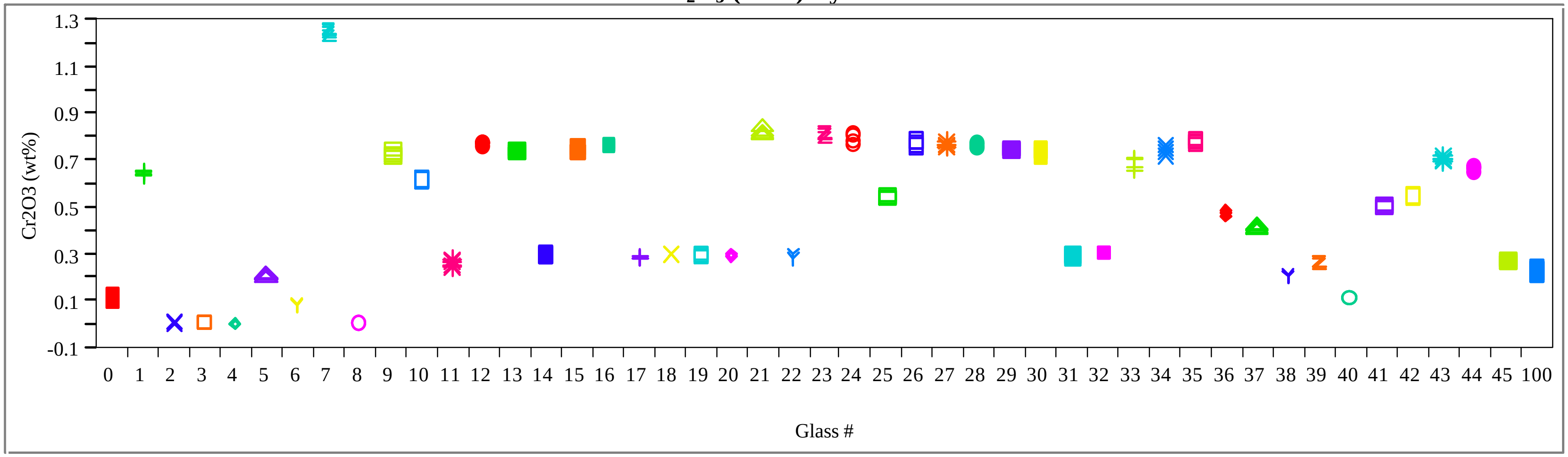


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Cr_2O_3 (wt%) By Glass #



Cr_2O_3 bc (wt%) By Glass #

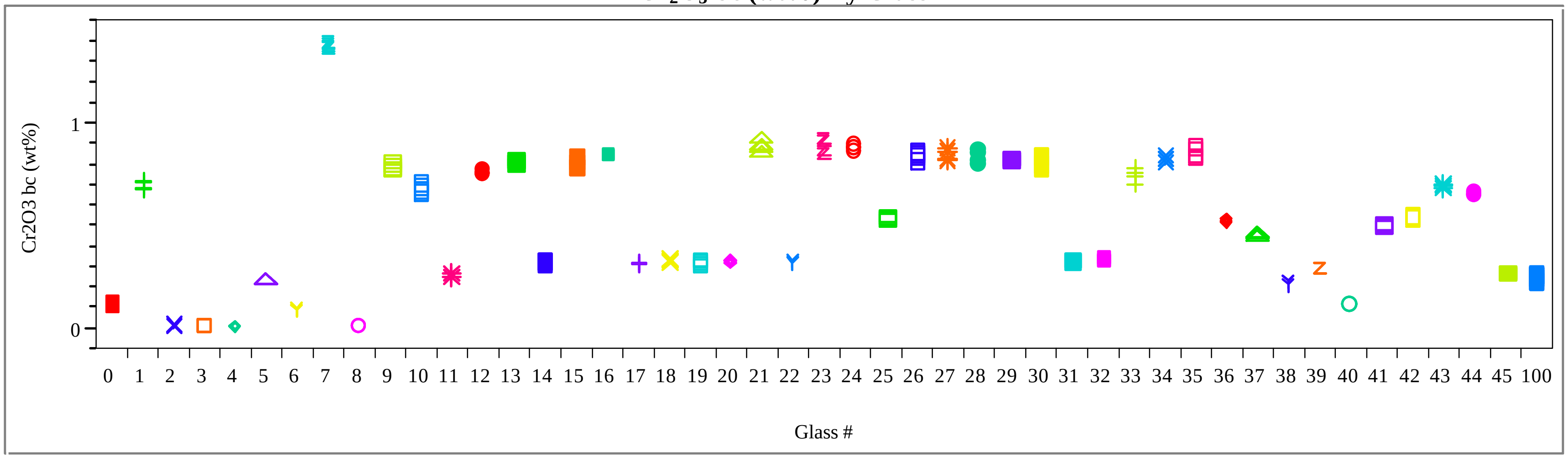
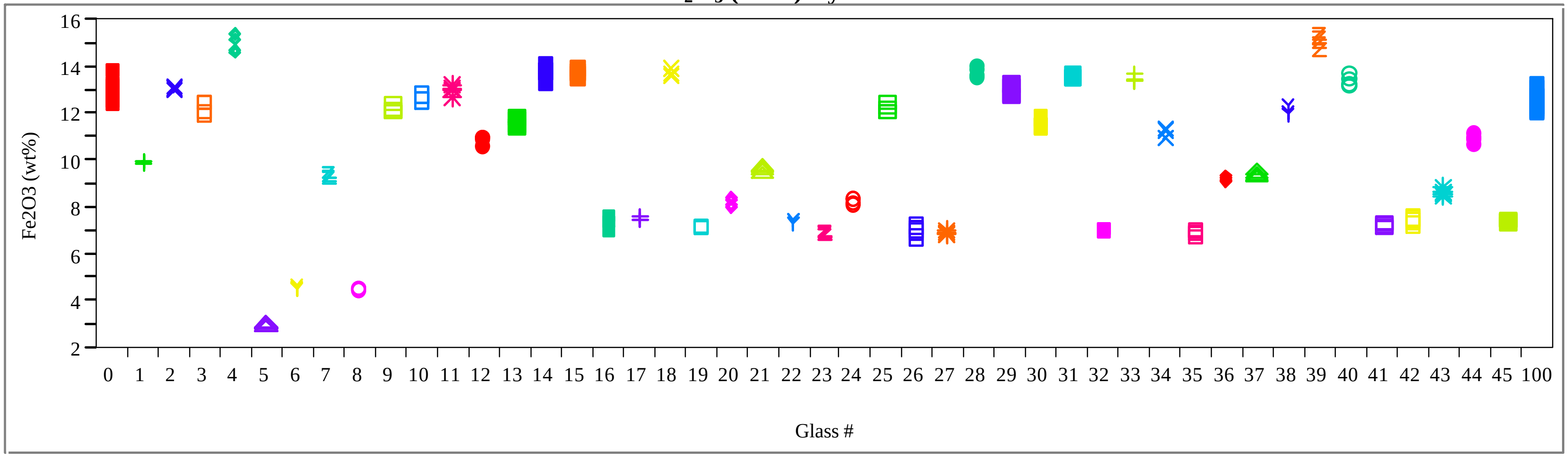


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Fe_2O_3 (wt%) By Glass #



Fe_2O_3 bc (wt%) By Glass #

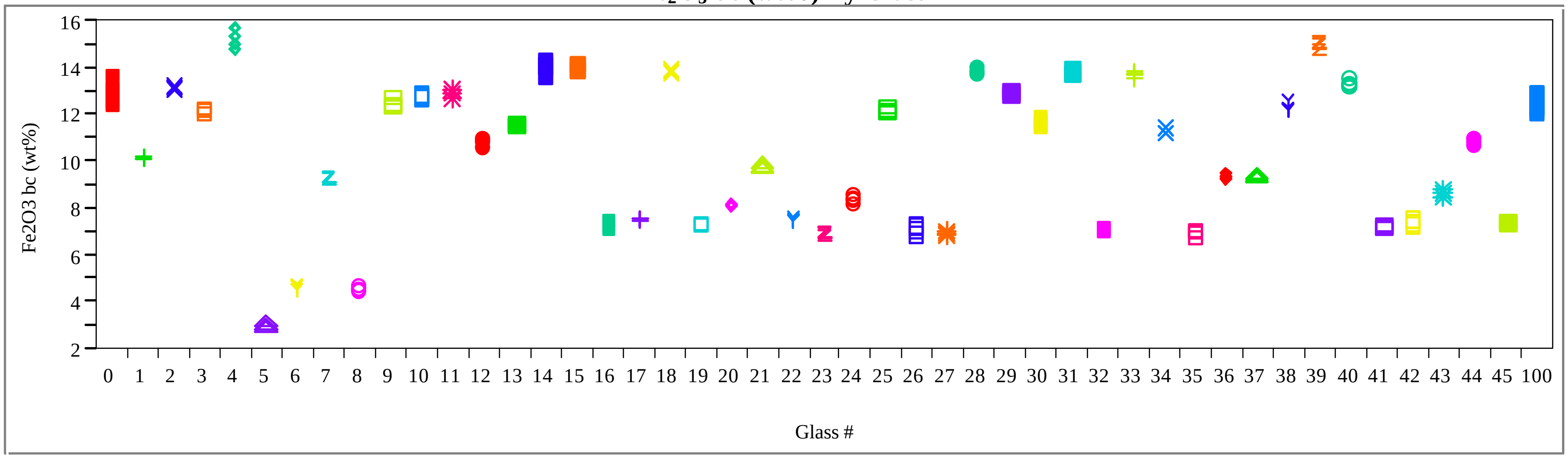
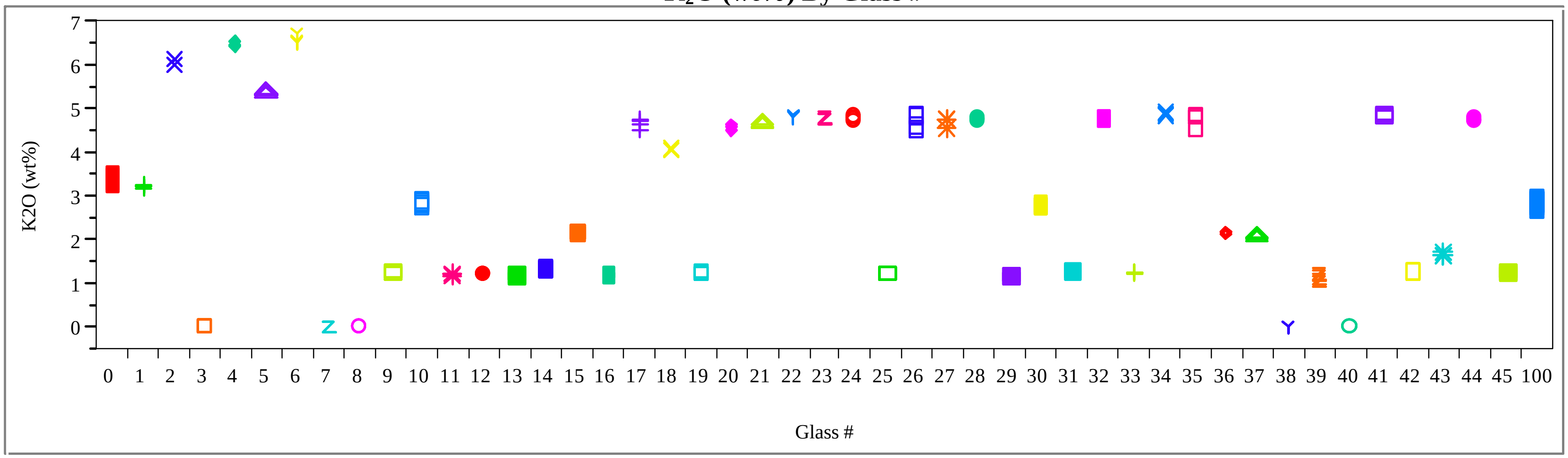


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

K_2O (wt%) By Glass #



K_2O bc (wt%) By Glass #

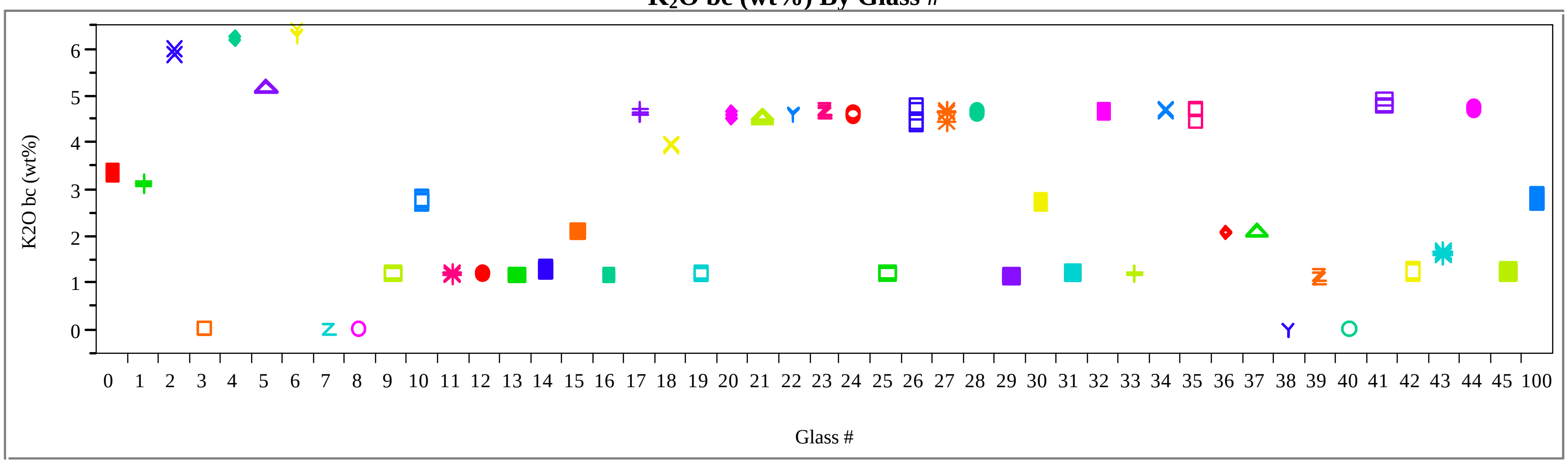
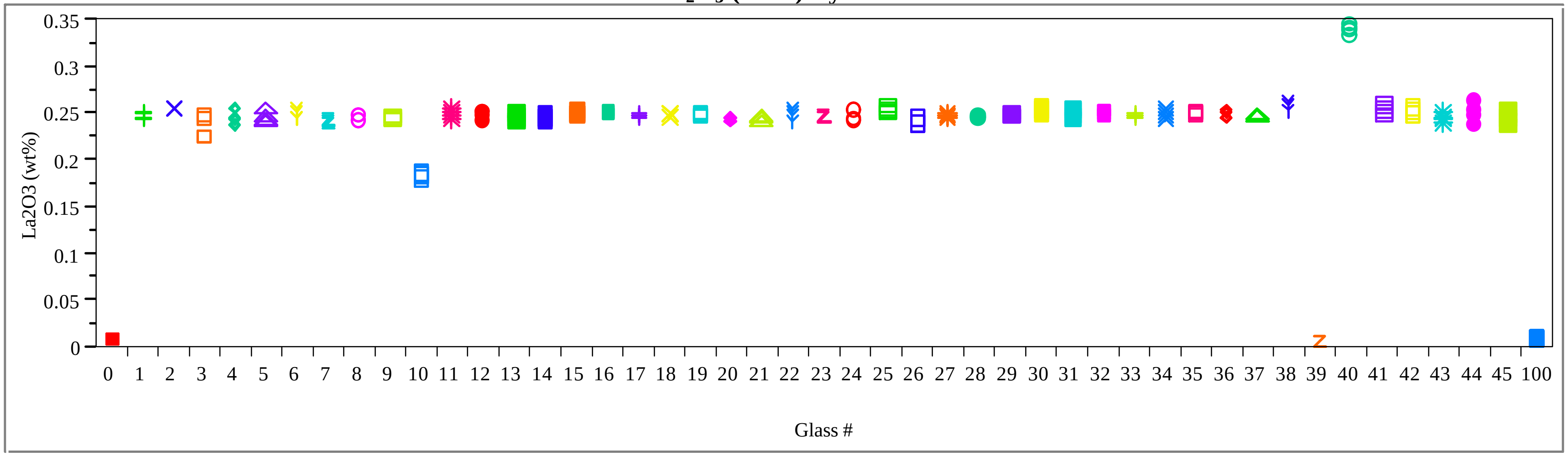


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

La_2O_3 (wt%) By Glass #



La_2O_3 bc (wt%) By Glass #

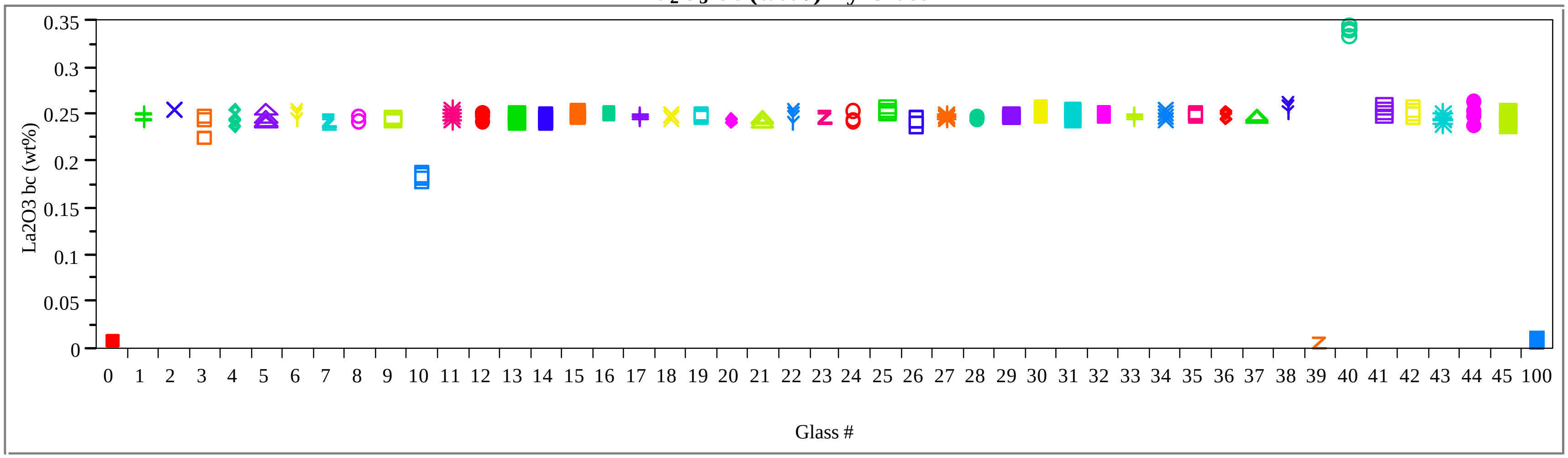
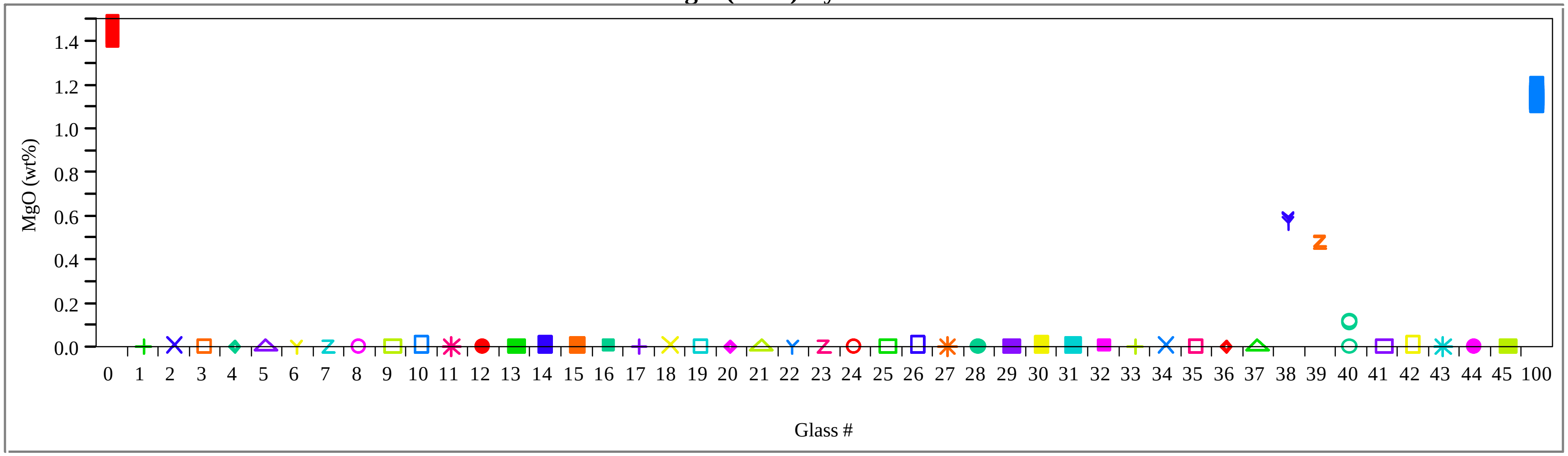


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method *(continued)*

(with 0 – Batch 1 and 100 – U std)

MgO (wt%) By Glass #



MgO bc (wt%) By Glass #

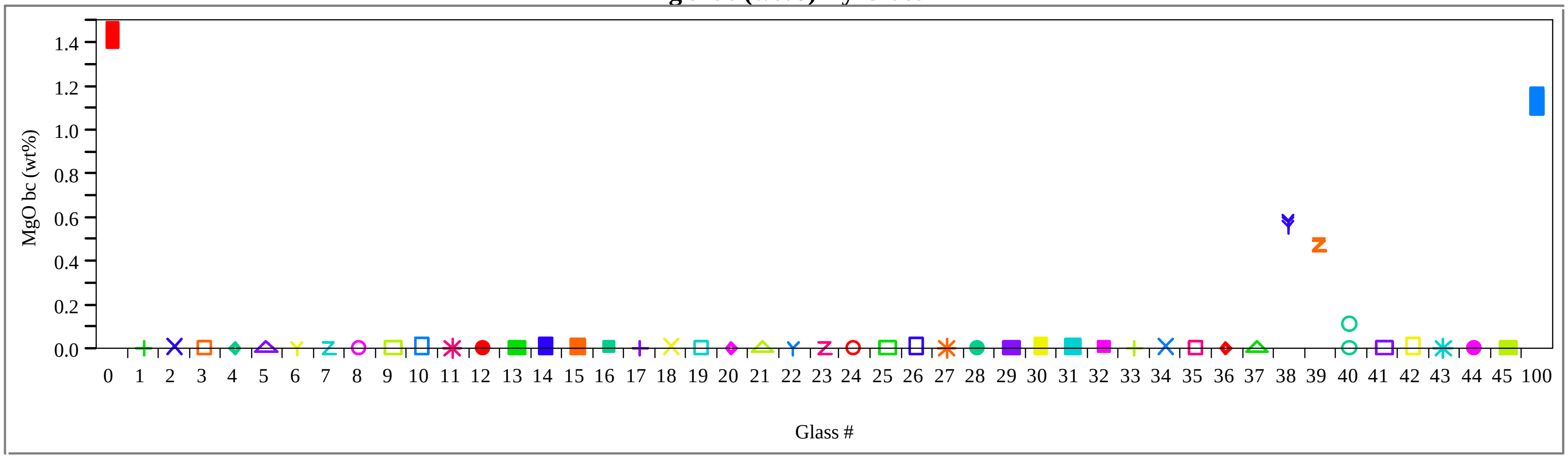
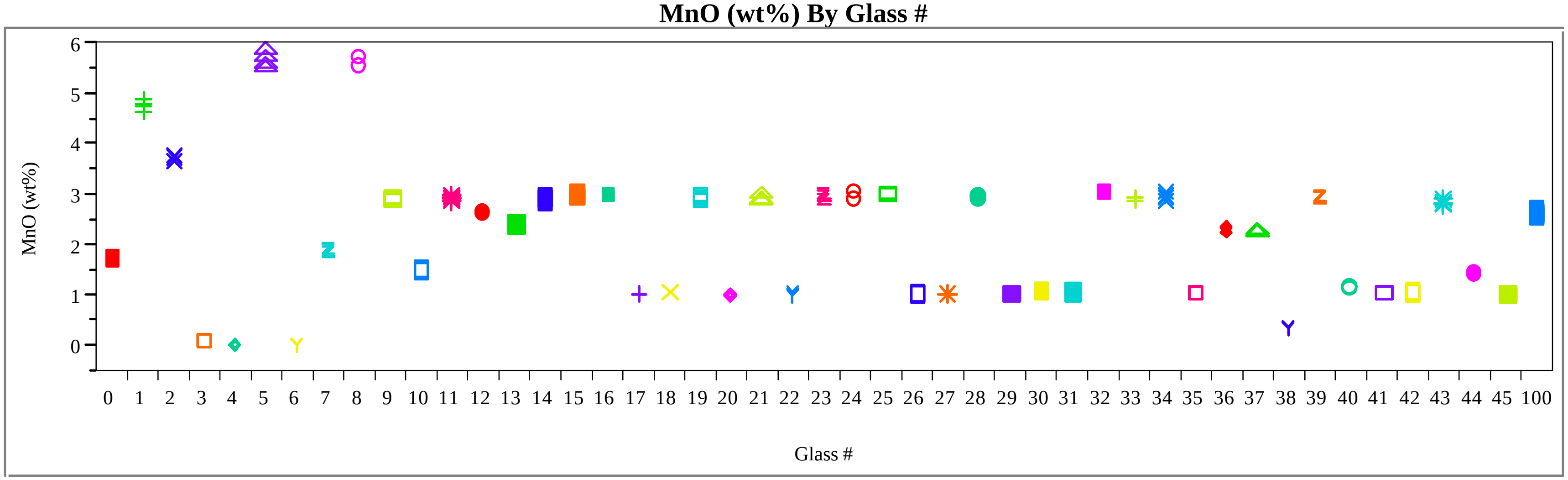


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)



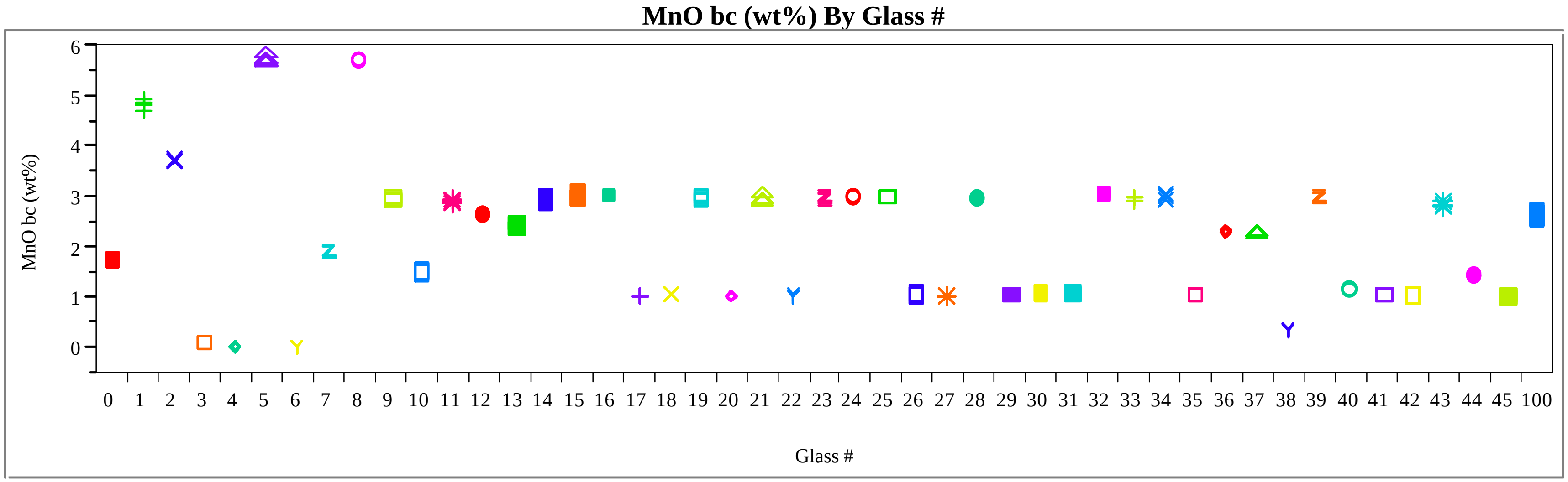
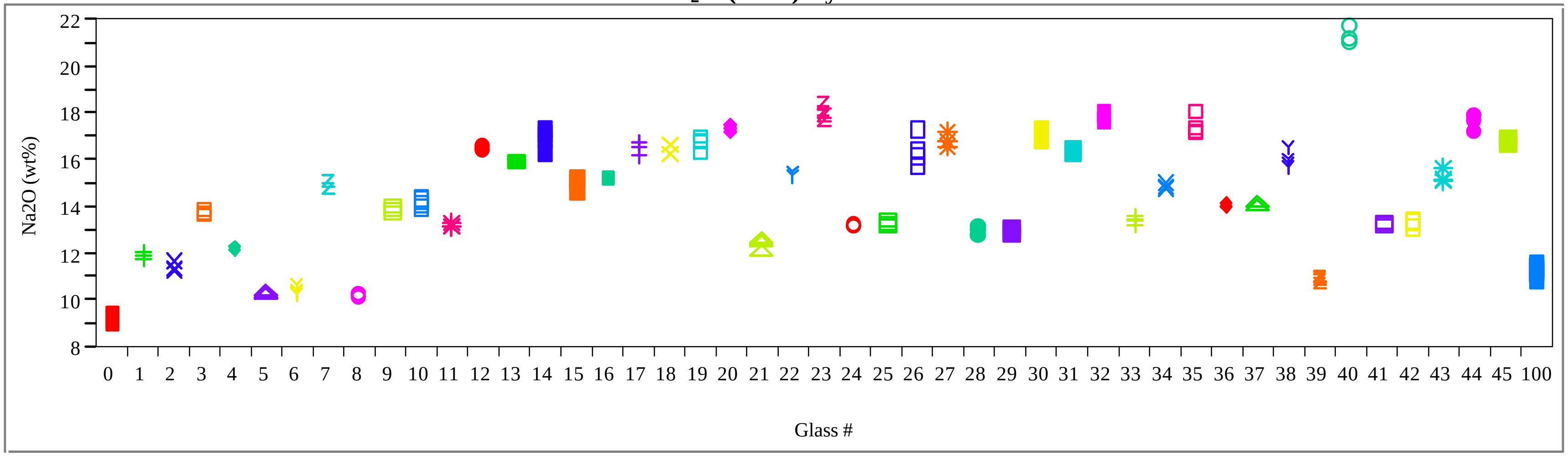


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Na_2O (wt%) By Glass #



Na_2O bc (wt%) By Glass #

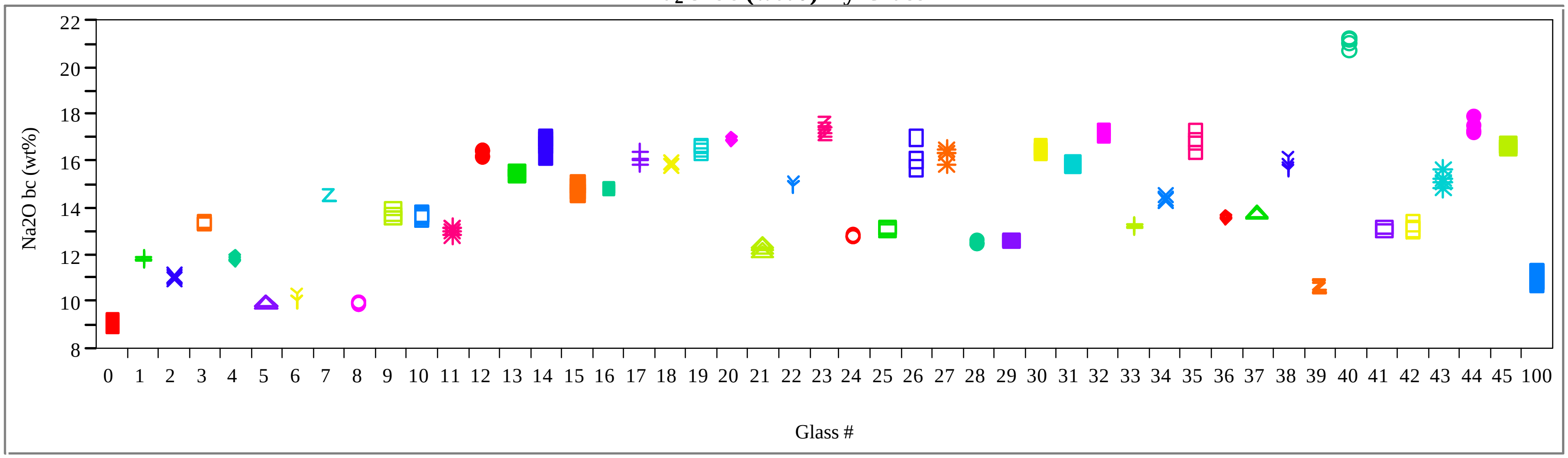
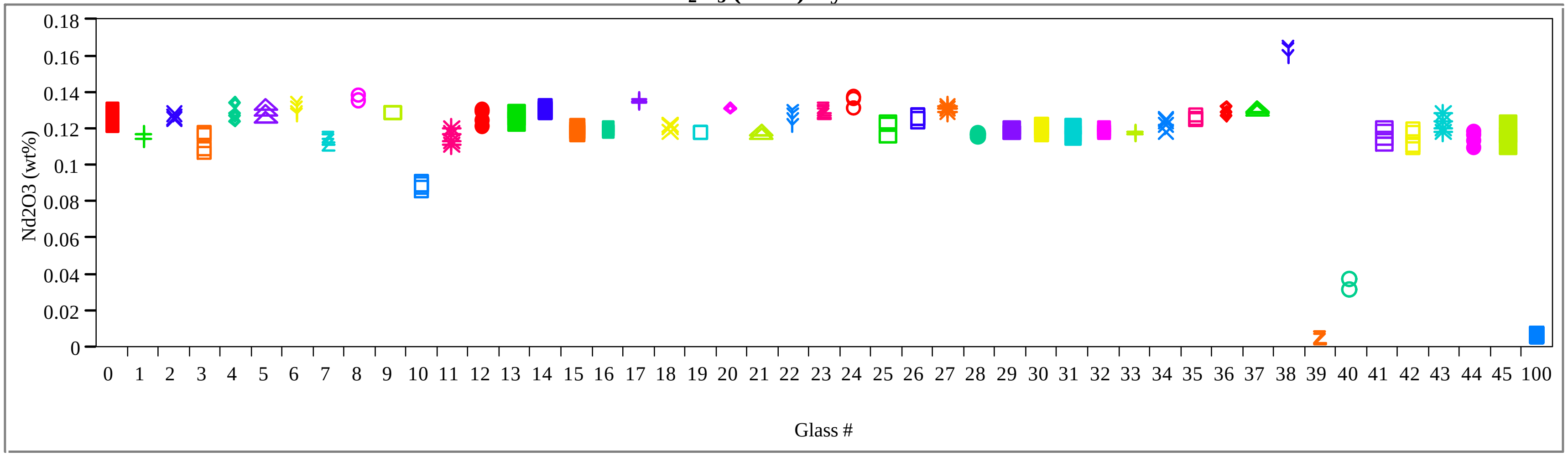


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Nd_2O_3 (wt%) By Glass #



Nd_2O_3 bc (wt%) By Glass #

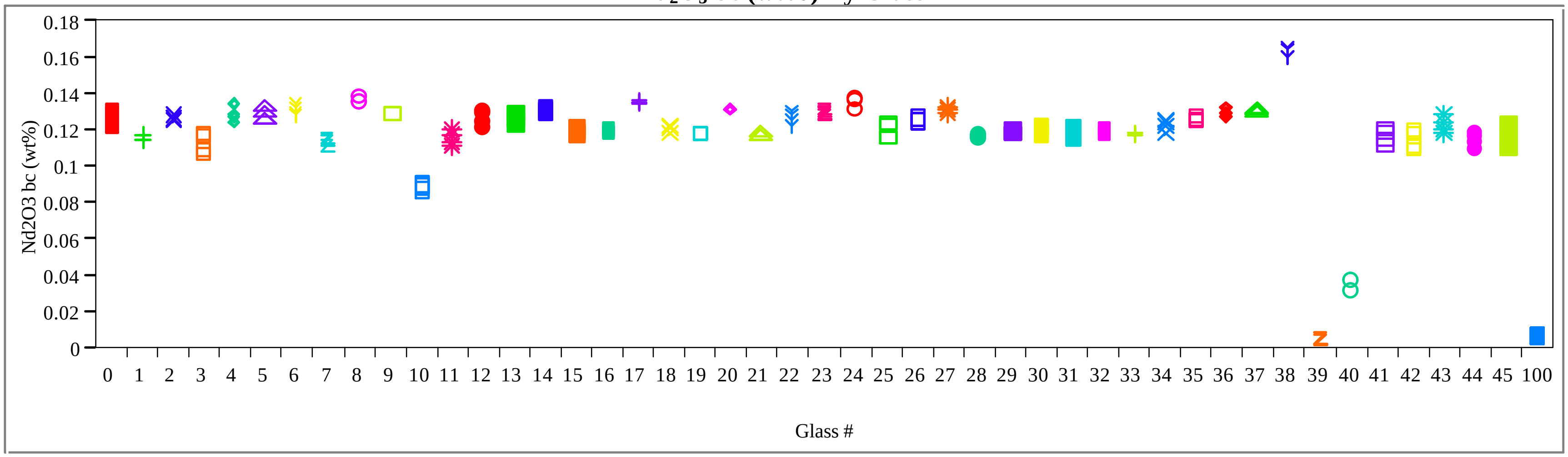
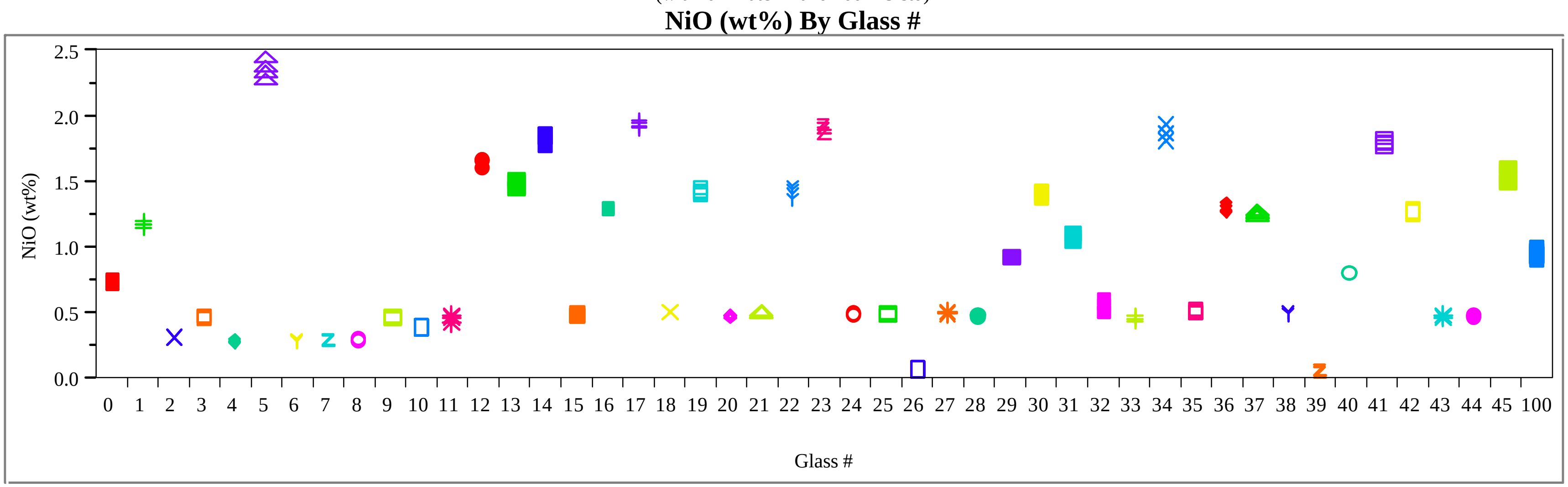


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)



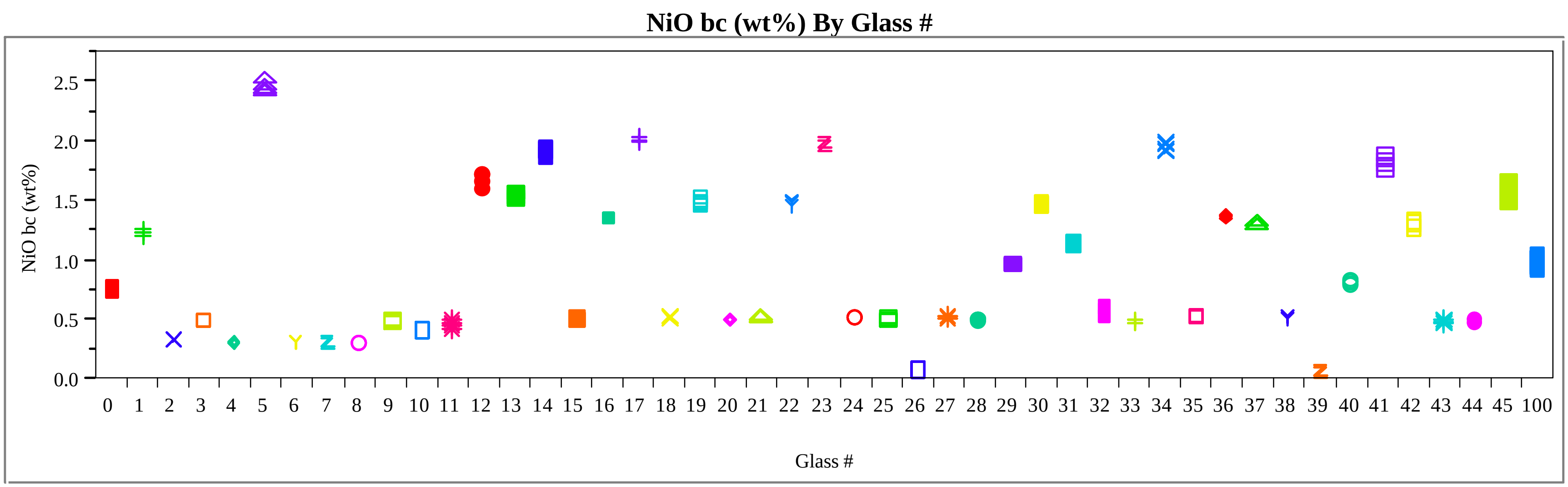
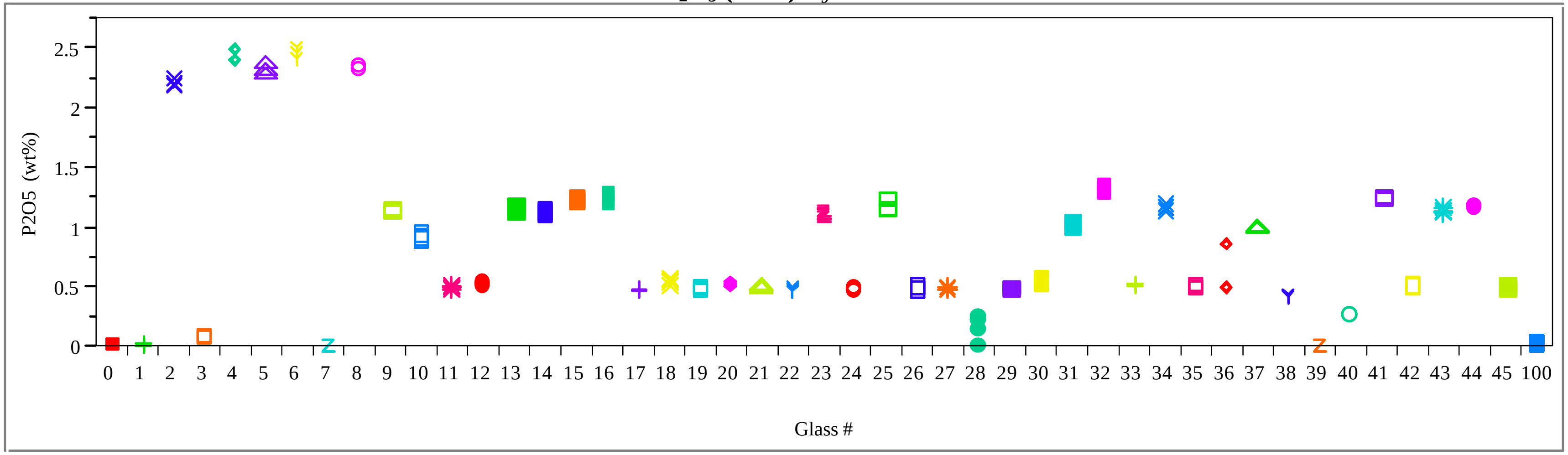


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

P_2O_5 (wt%) By Glass #



P_2O_5 bc (wt%) By Glass #

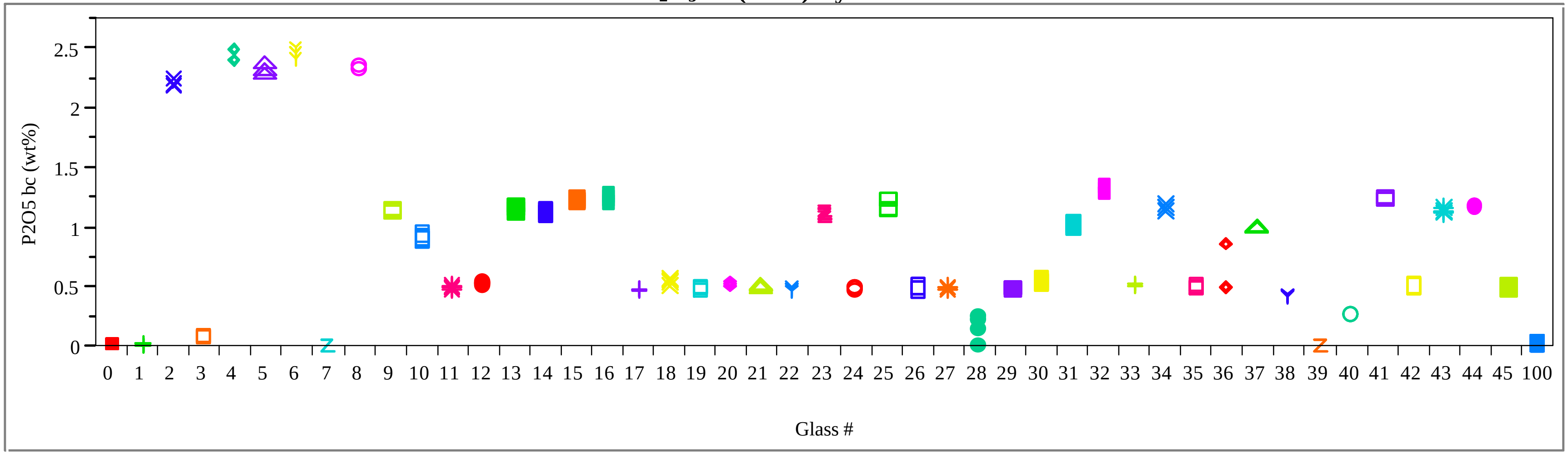
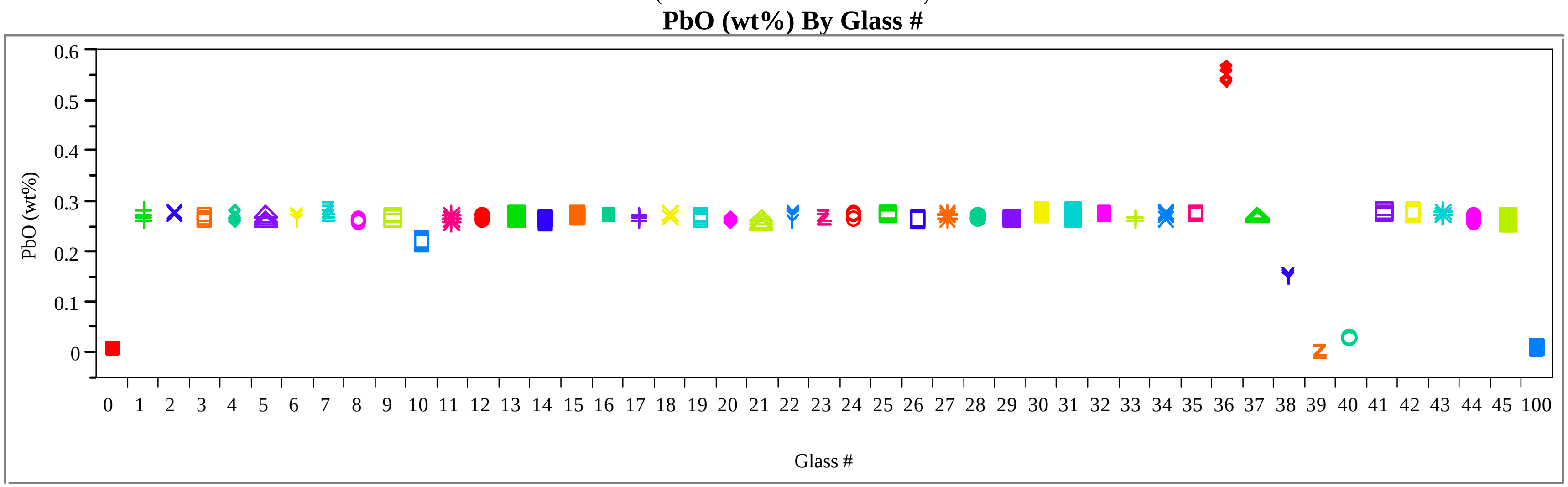


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)



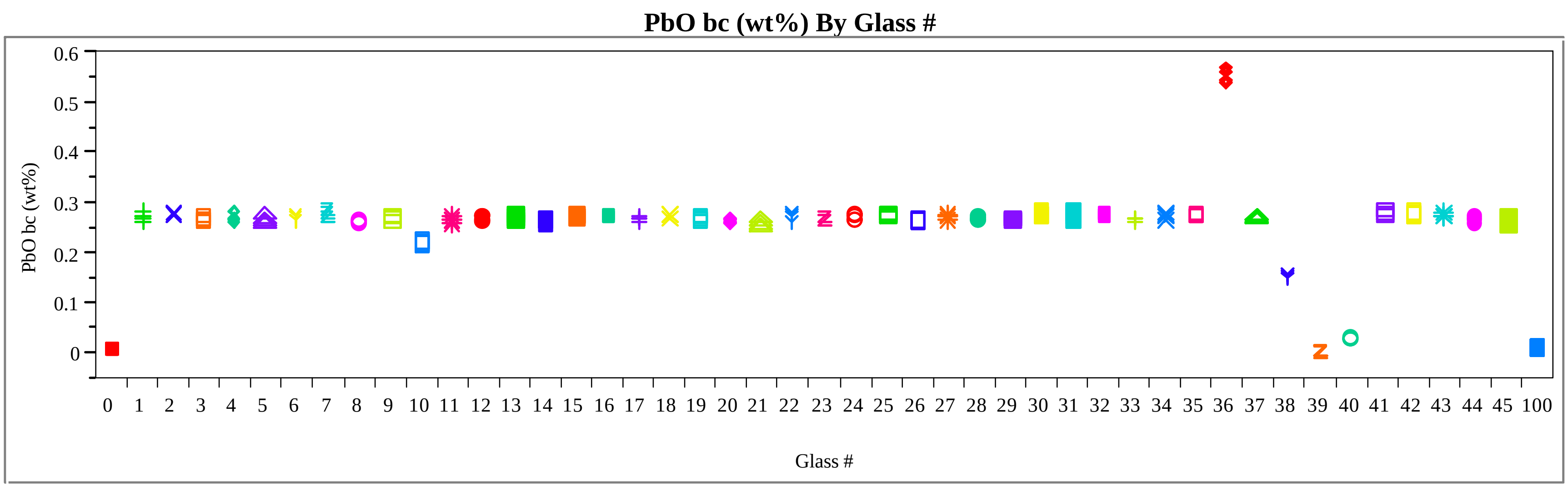
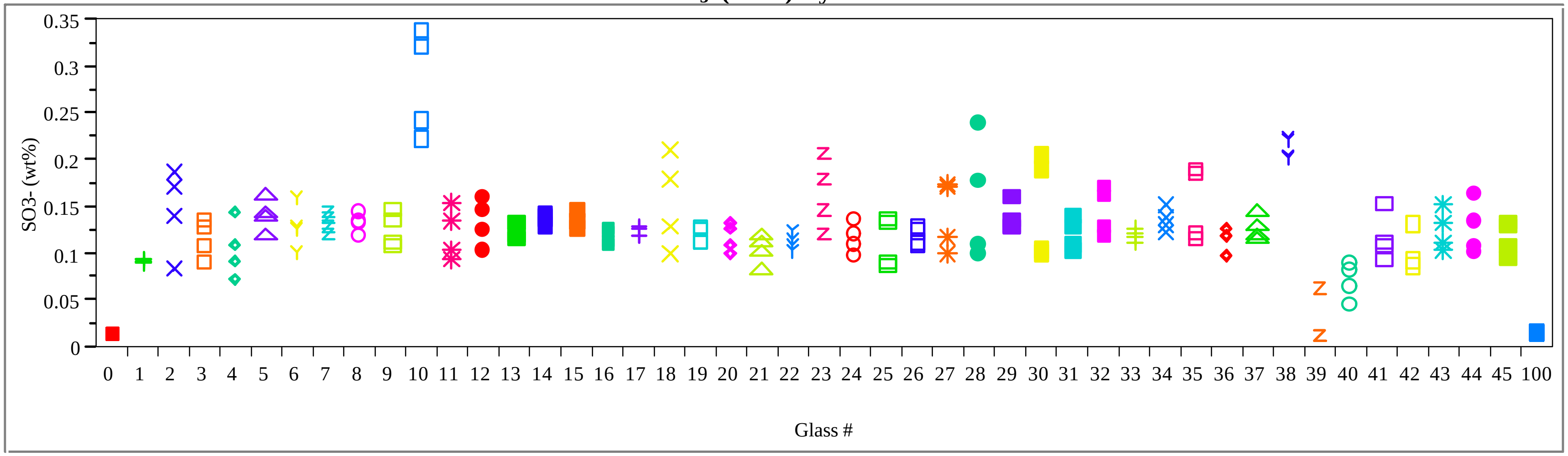


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

SO_3^- (wt%) By Glass #



SO_3^- bc (wt%) By Glass #

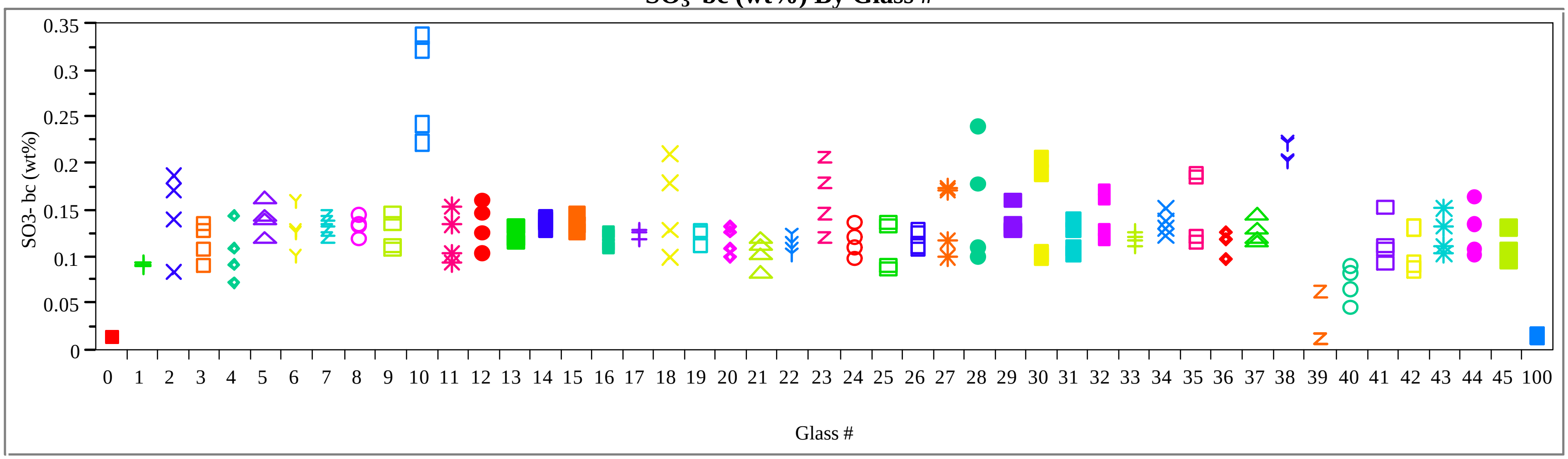
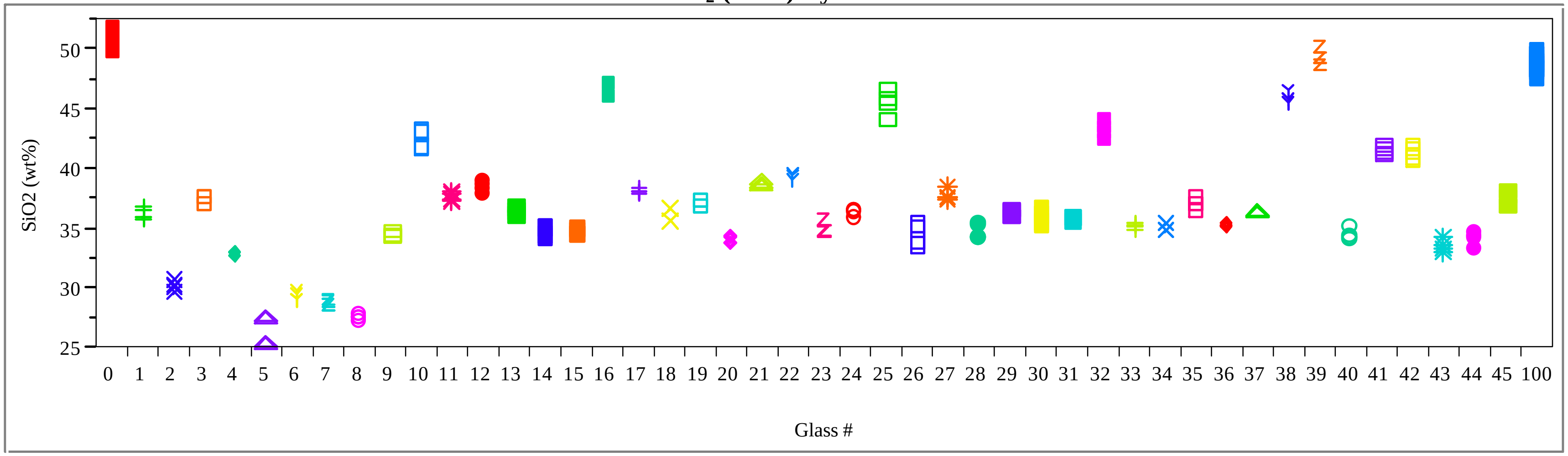


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

SiO_2 (wt%) By Glass #



SiO_2 bc (wt%) By Glass #

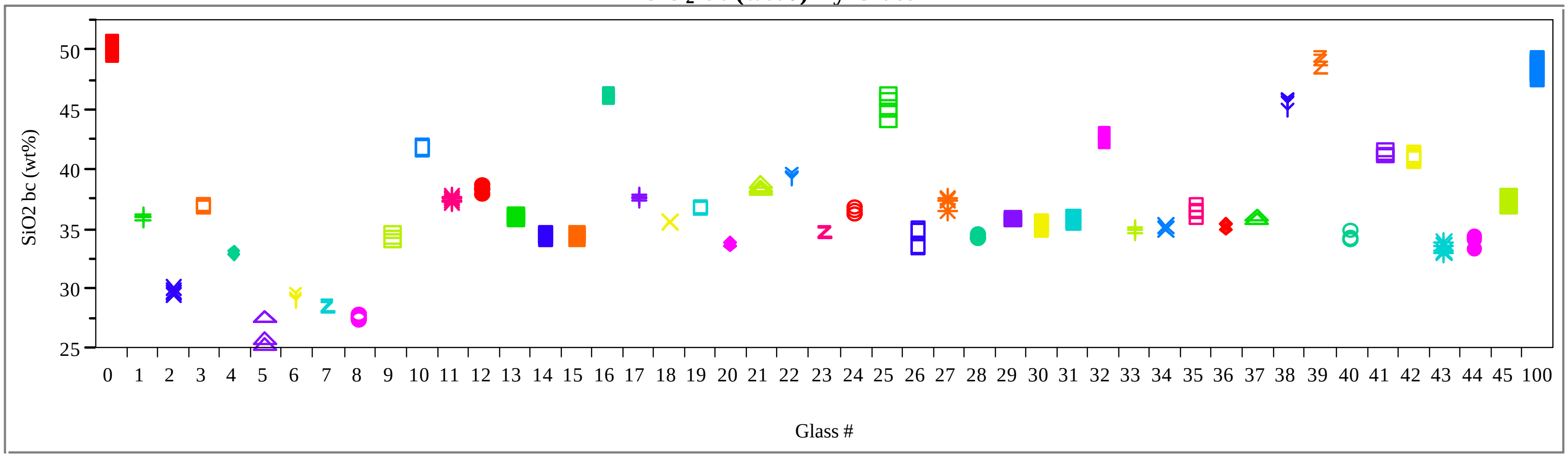
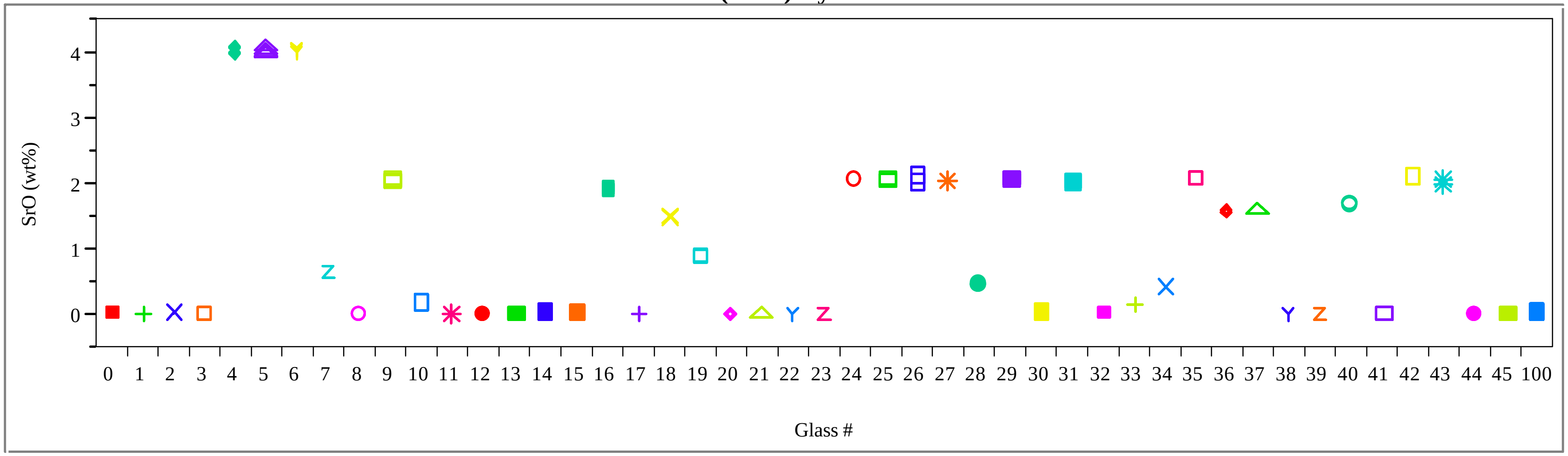


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

SrO (wt%) By Glass #



SrO bc (wt%) By Glass #

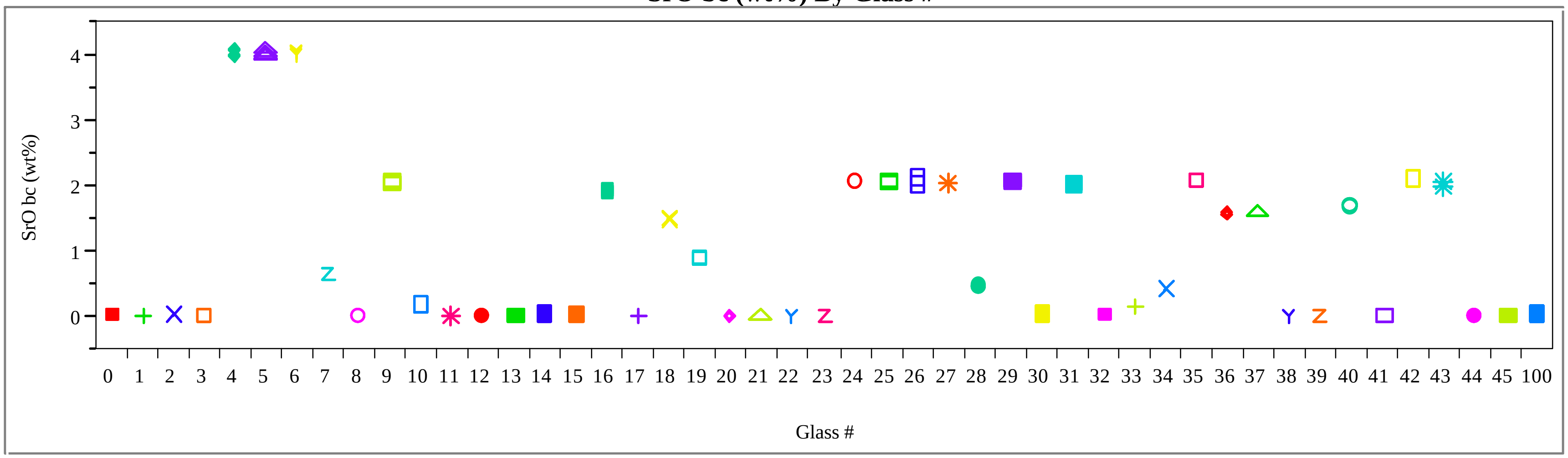
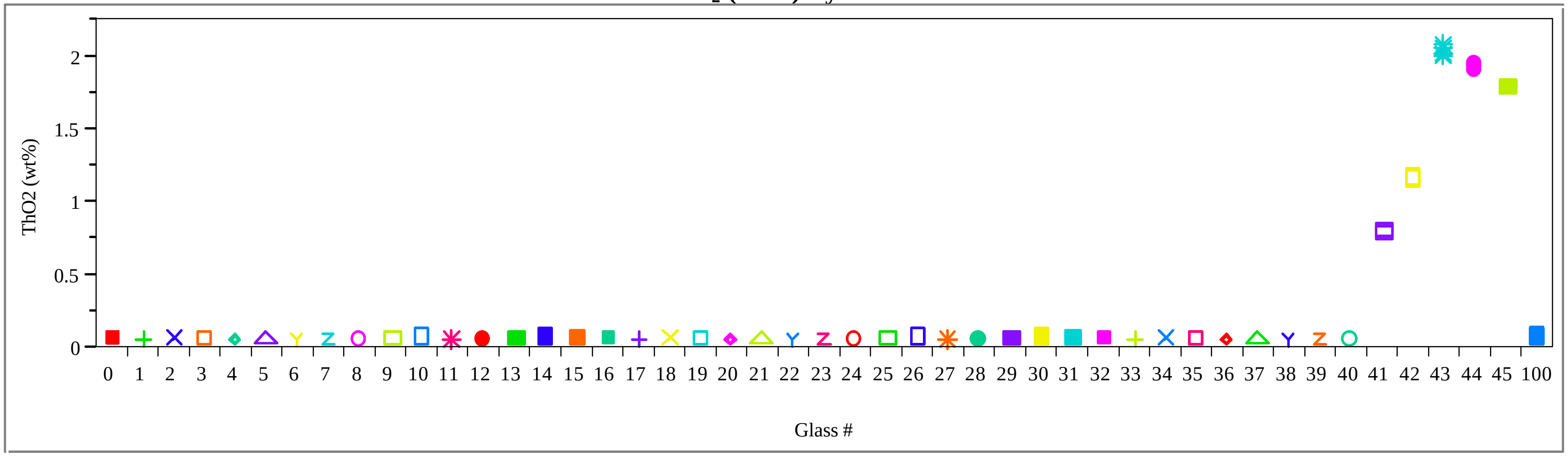


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

ThO_2 (wt%) By Glass #



ThO_2 bc (wt%) By Glass #

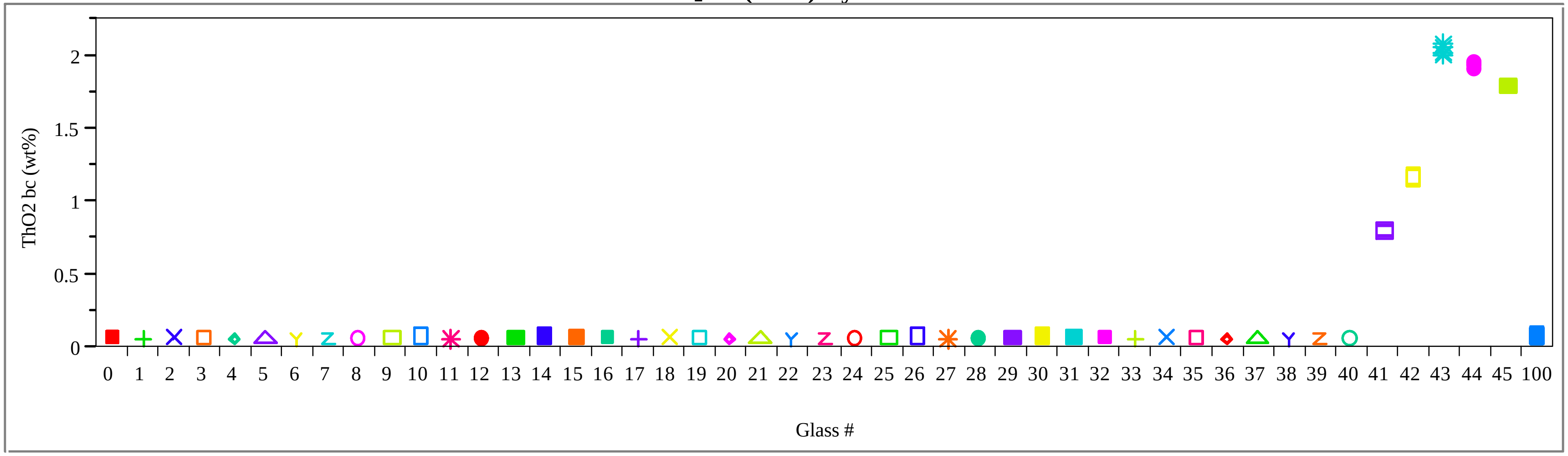
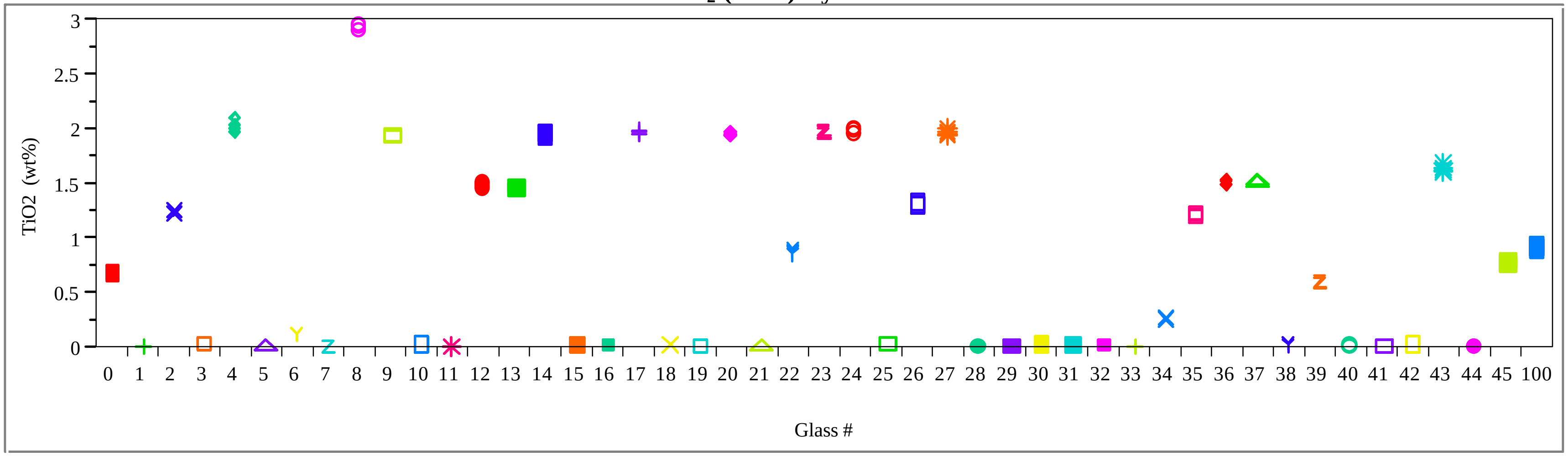


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

TiO_2 (wt%) By Glass #



TiO_2 bc (wt%) By Glass #

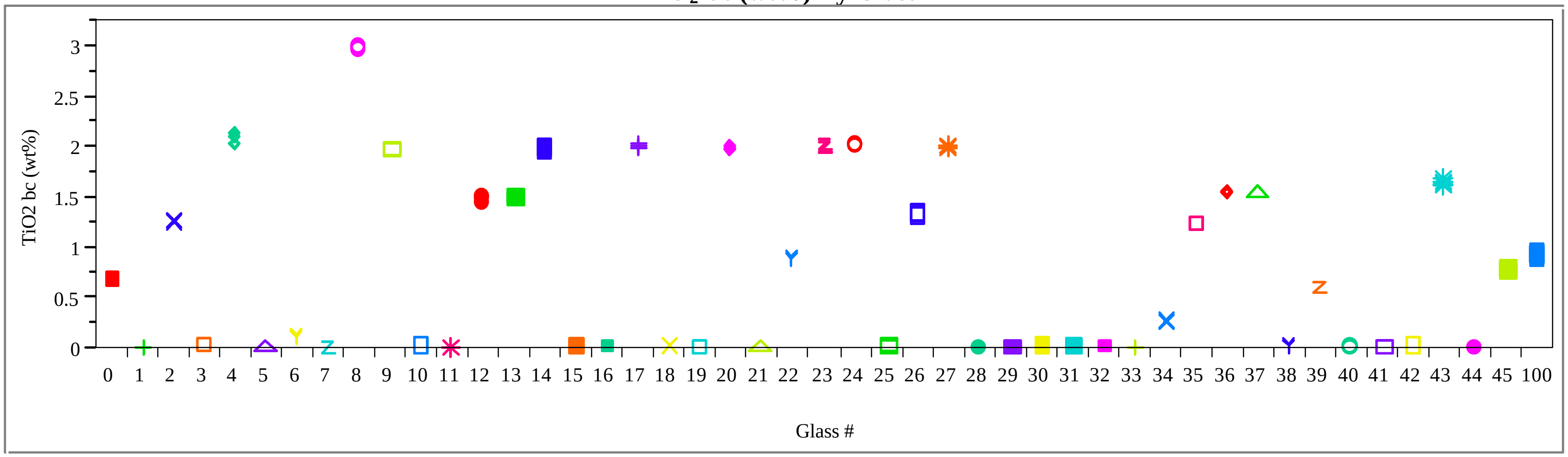
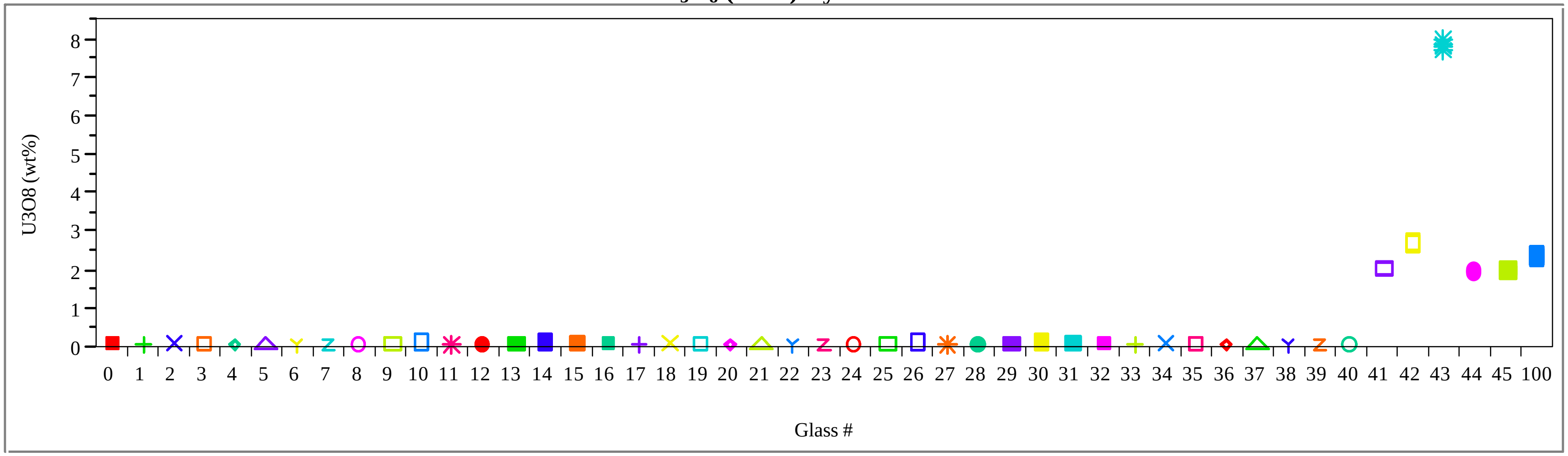


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

U_3O_8 (wt%) By Glass #



U_3O_8 bc (wt%) By Glass #

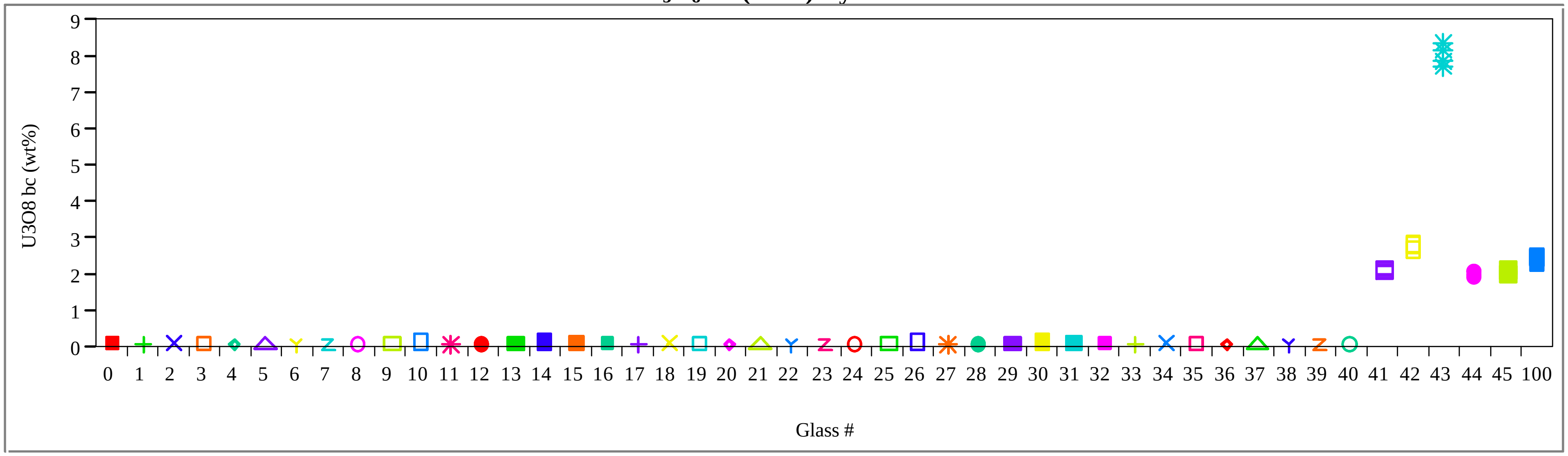
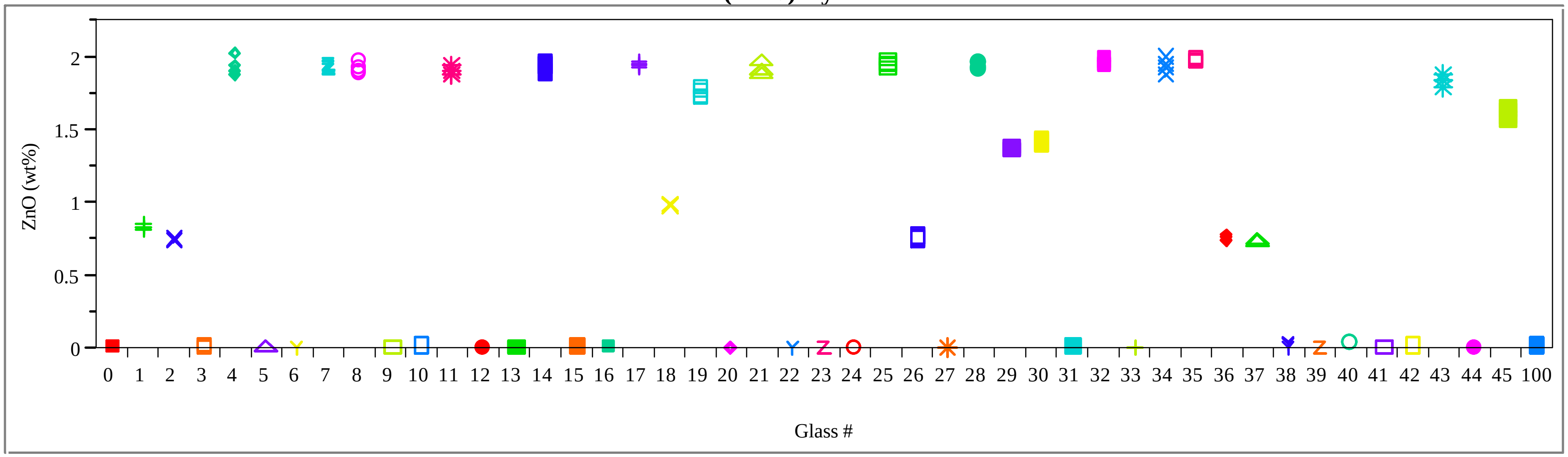


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

ZnO (wt%) By Glass #



ZnO bc (wt%) By Glass #

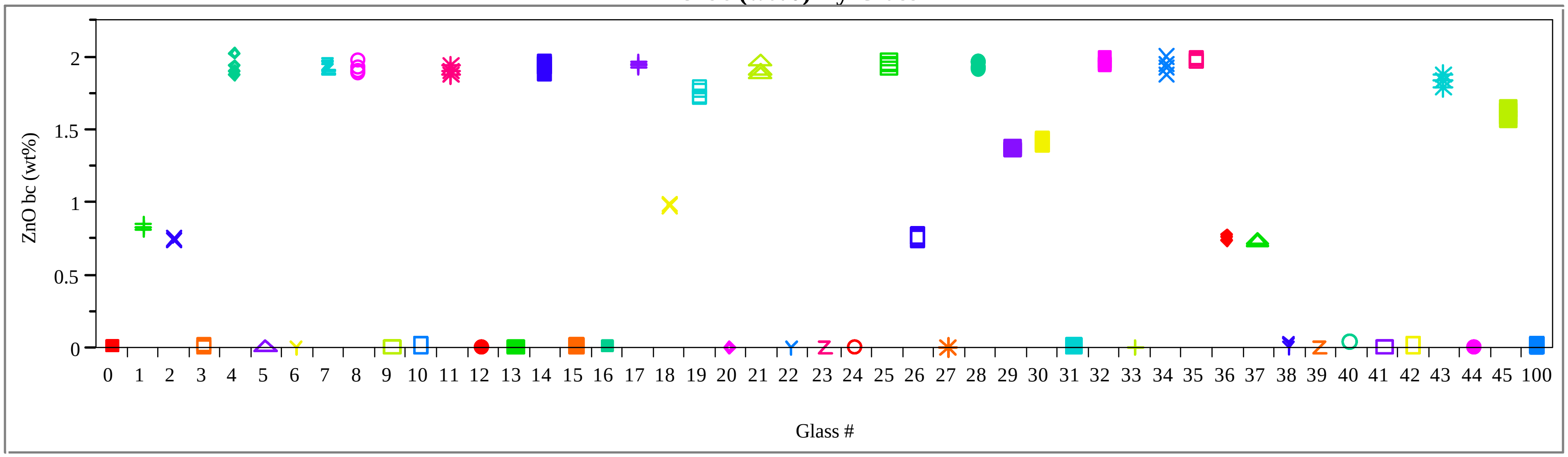
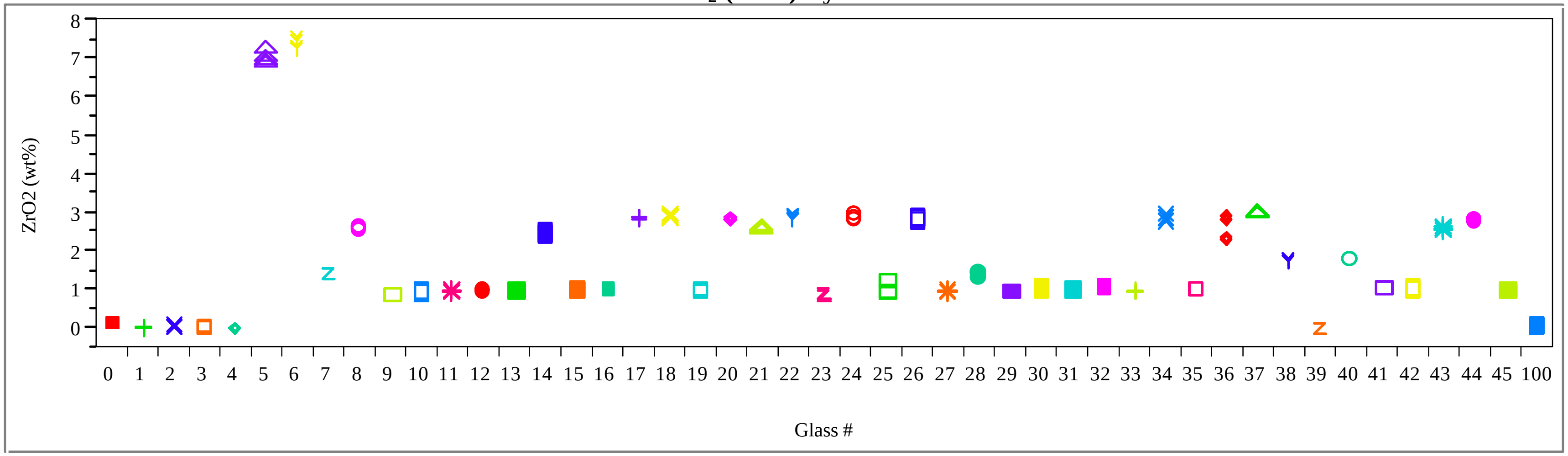


Exhibit C.7: SRTC-ML Measurements by Glass Number for Samples Prepared Using the LM Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

ZrO_2 (wt%) By Glass #



ZrO_2 bc (wt%) By Glass #

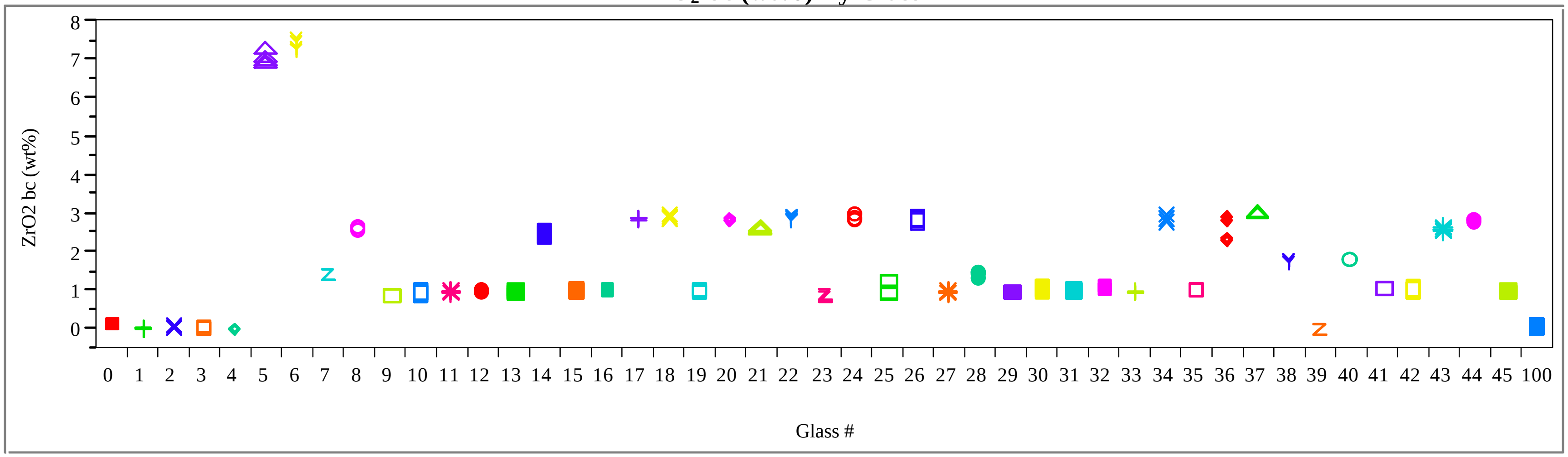
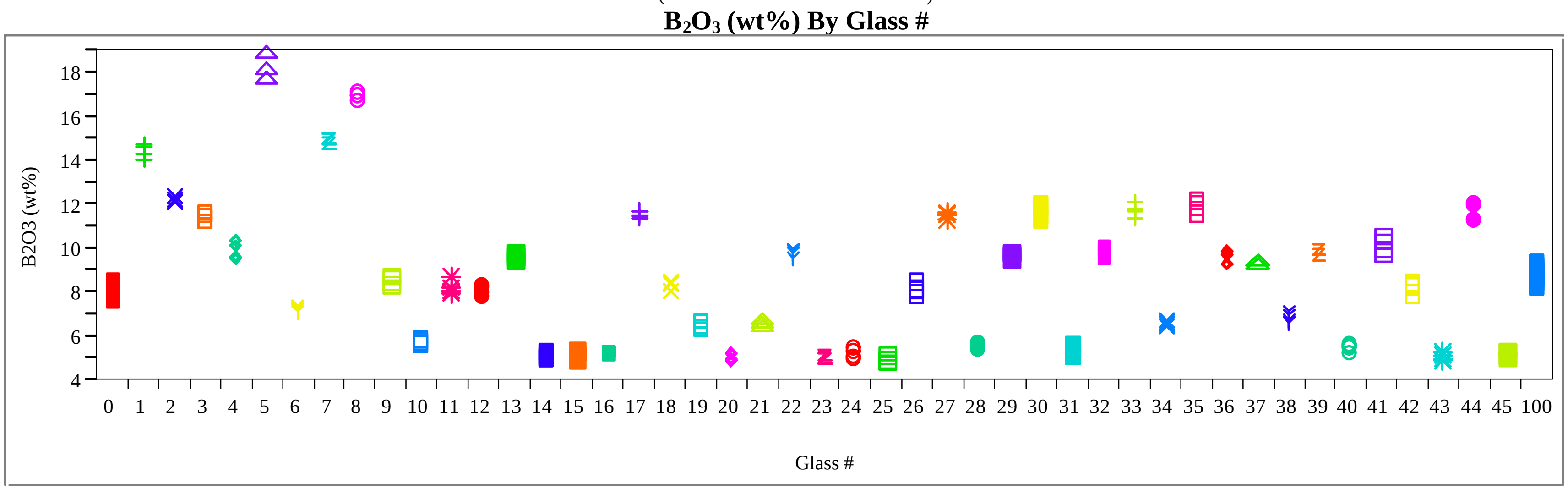


Exhibit C.8: SRTC-ML Measurements by Glass Number for Samples Prepared Using the SP Method

(with 0 – Batch 1 and 100 – U std)



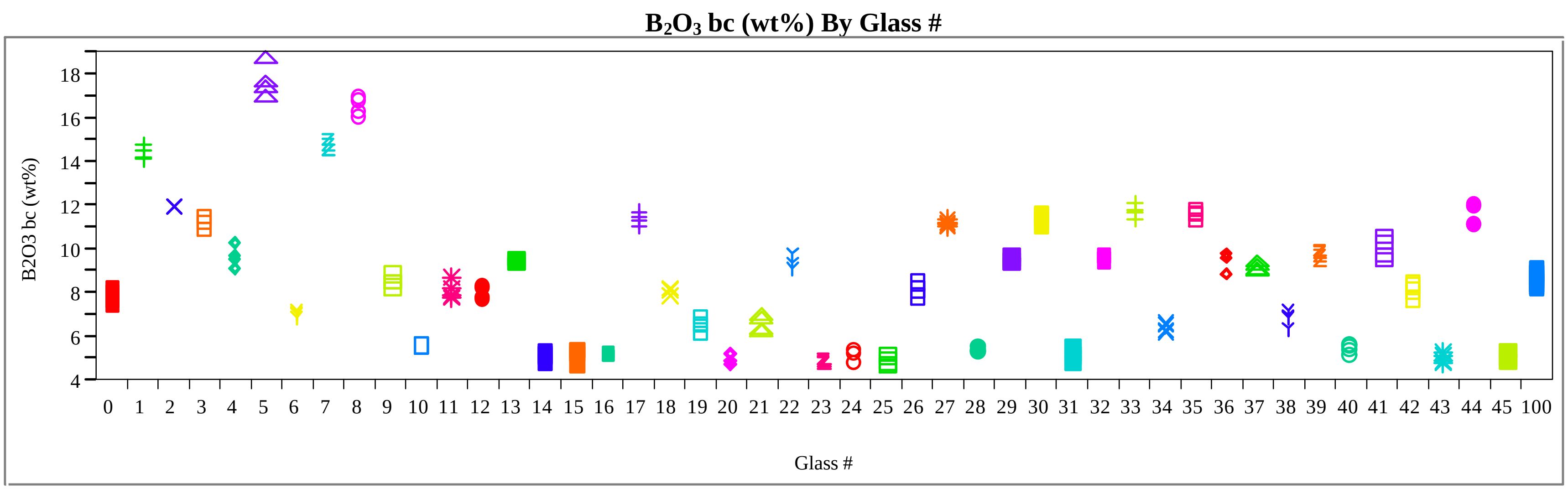
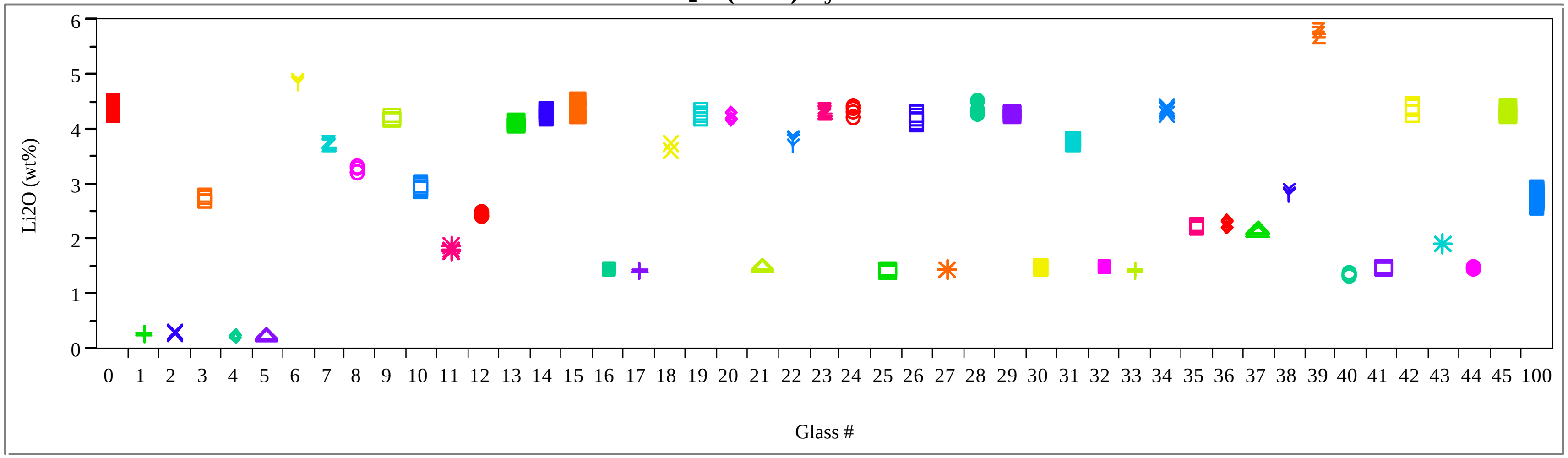


Exhibit C.8: SRTC-ML Measurements by Glass Number for Samples Prepared Using the SP Method ***(continued)***

(with 0 – Batch 1 and 100 – U std)

Li_2O (wt%) By Glass #



Li_2O bc (wt%) By Glass #

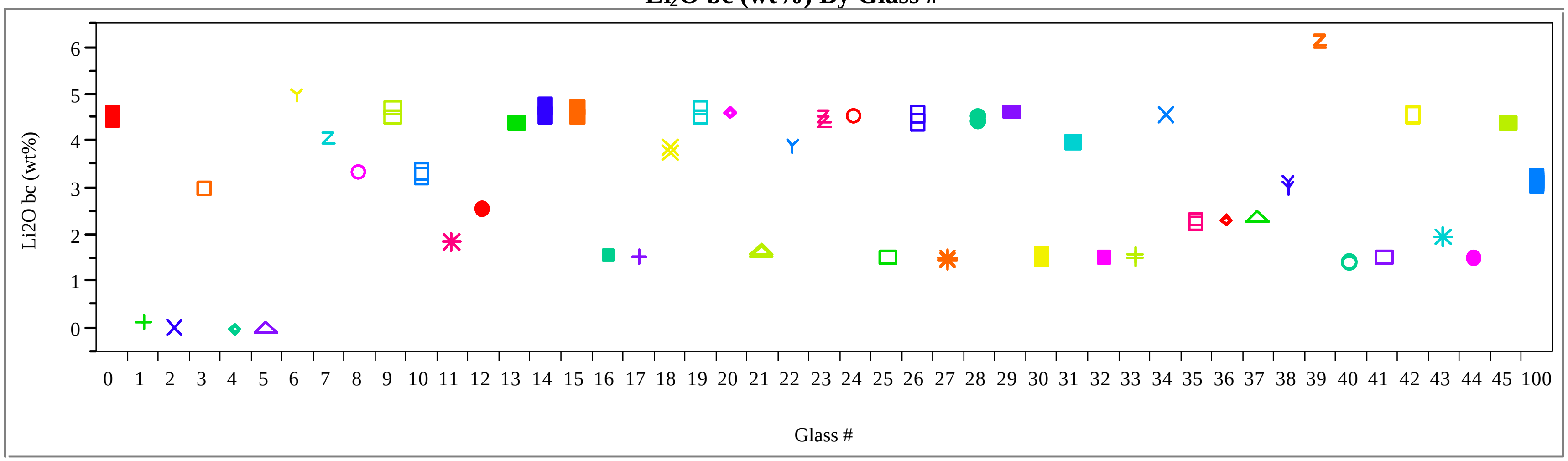
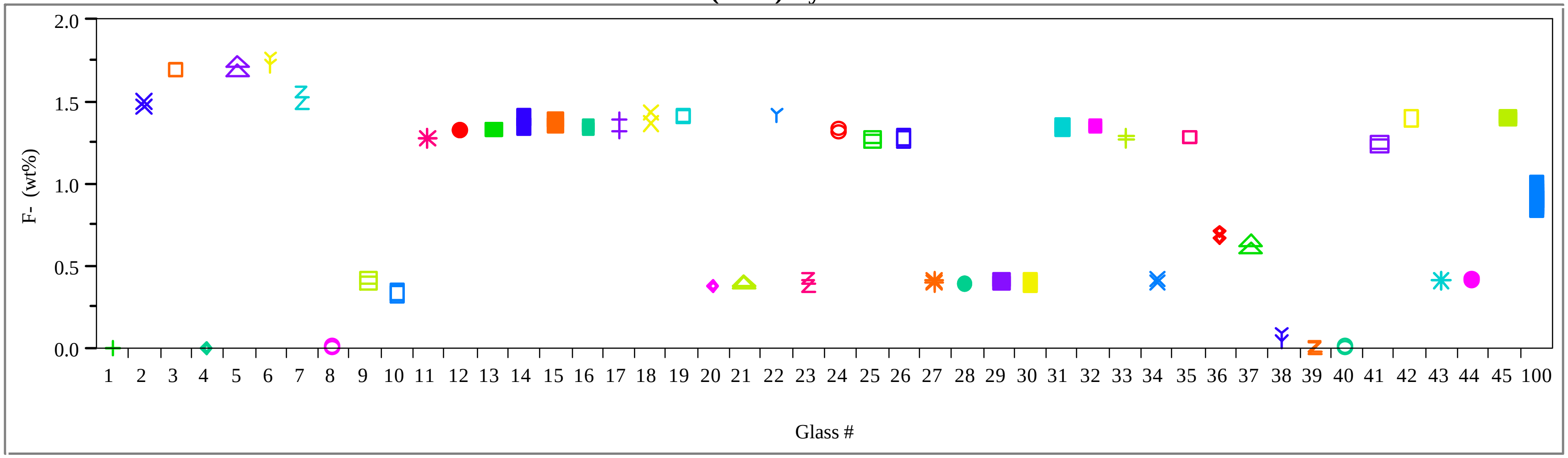


Exhibit C.9: SRTC-ML Measurements by Glass Number for Samples Prepared Using the PF Method

(with 100 – LRM)

F^- (wt%) By Glass #



F^- bc (wt%) By Glass #

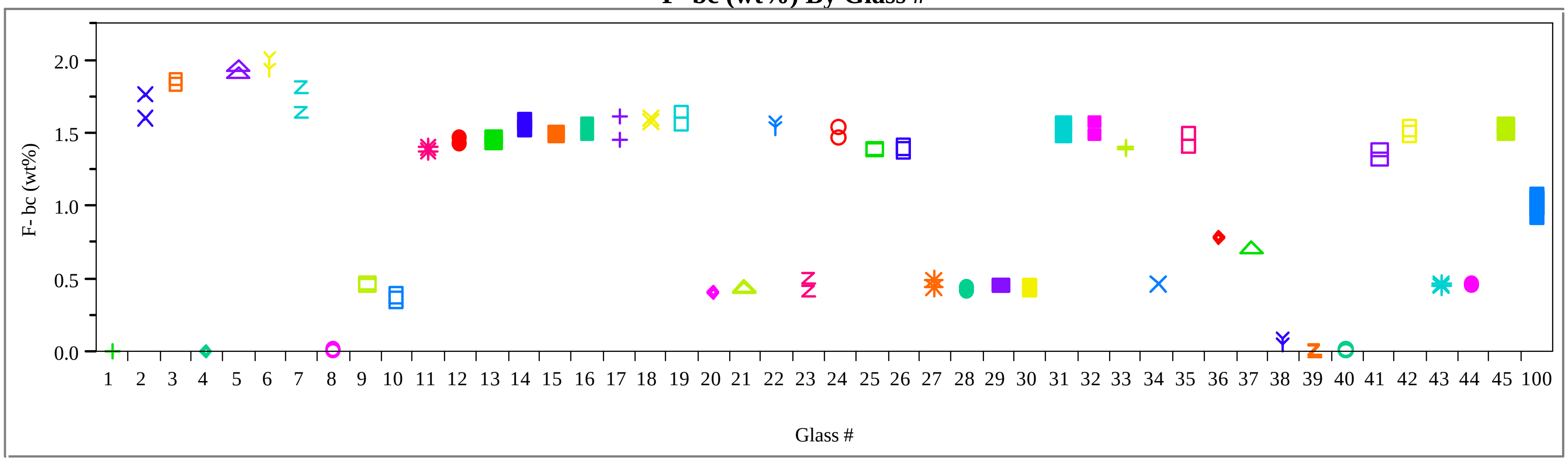
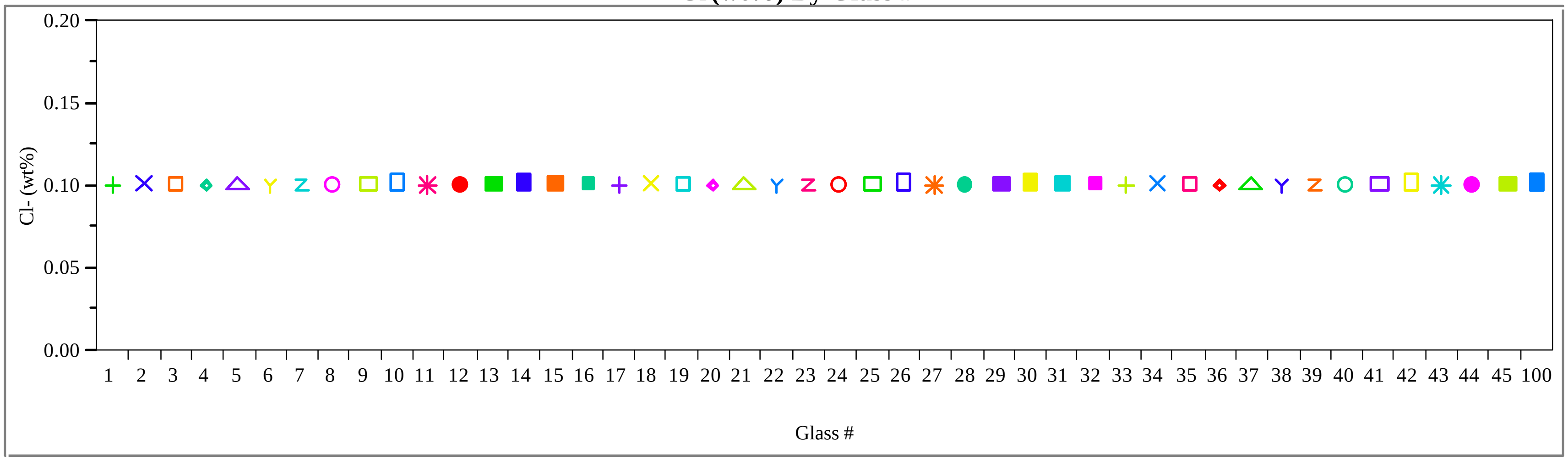


Exhibit C.9: SRTC-ML Measurements by Glass Number for Samples Prepared Using the PF Method ***(continued)***
(with 100 – LRM)

Cl⁻(wt%) By Glass #



Cl⁻ bc (wt%) By Glass #

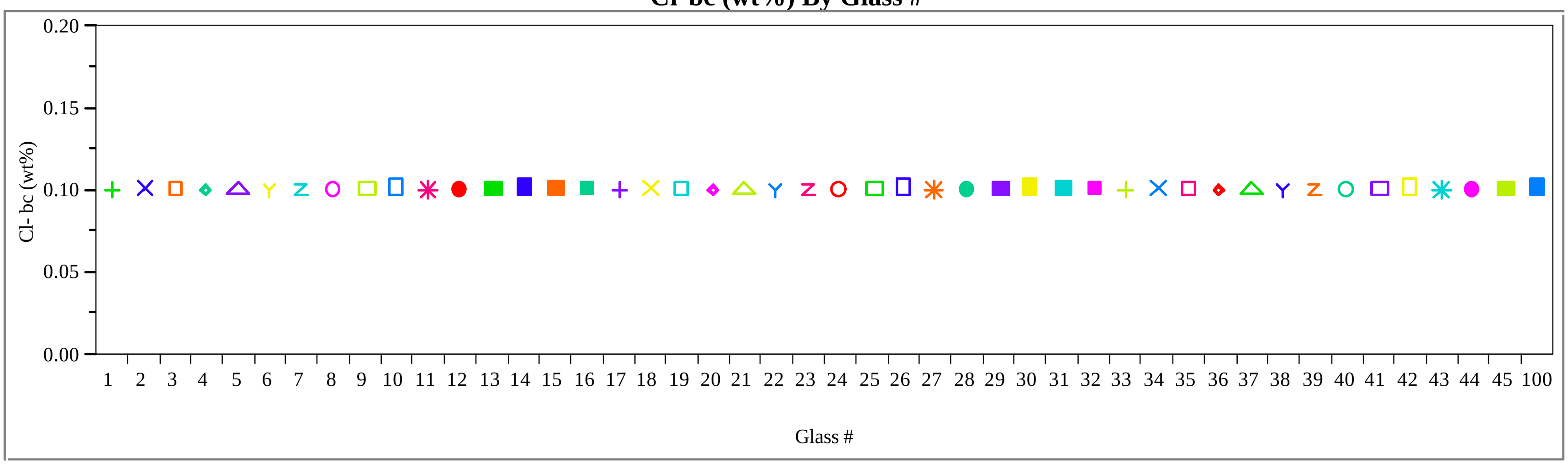
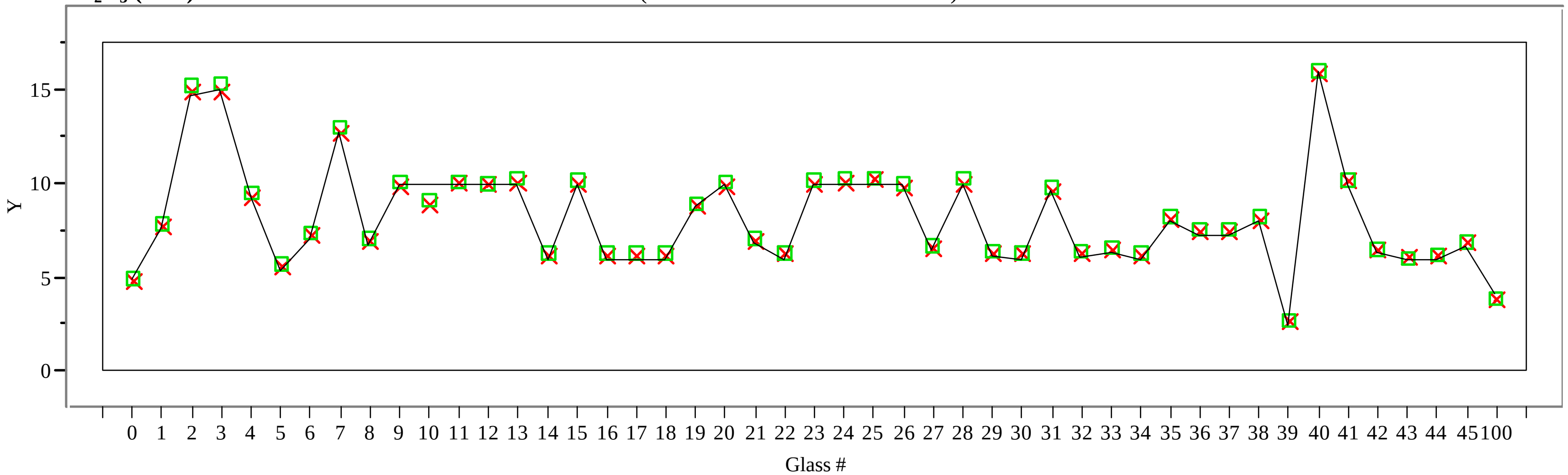


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide

Oxide=Al_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=B_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)

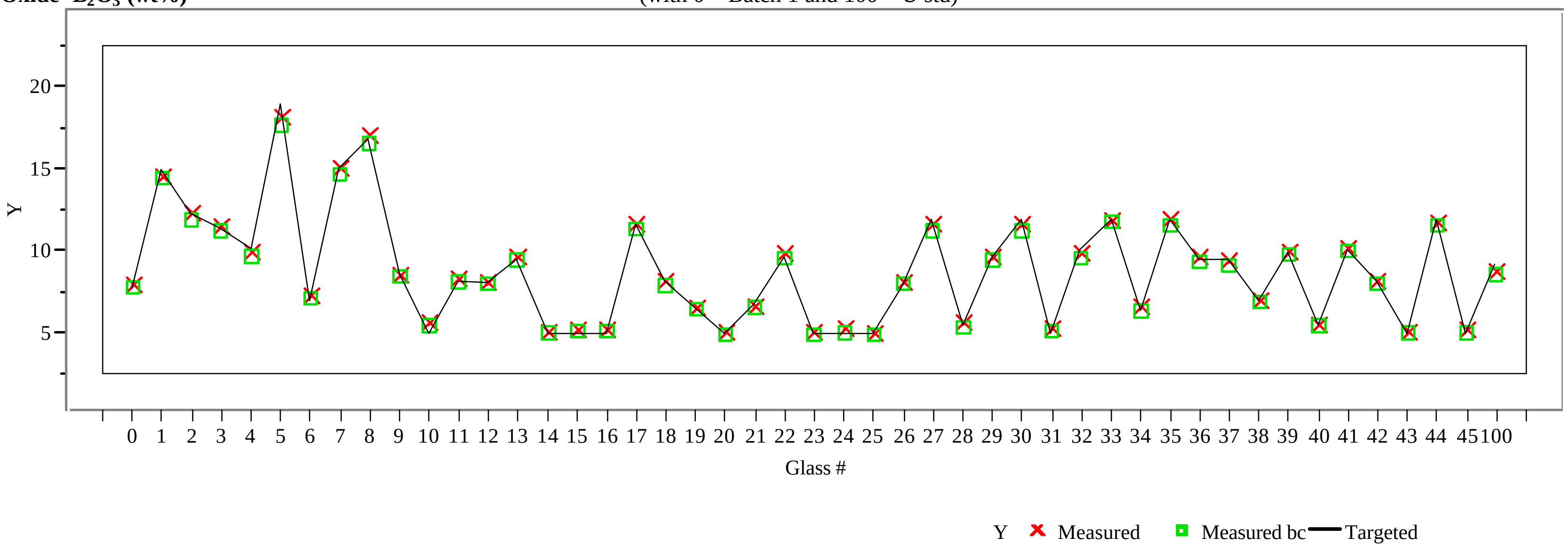
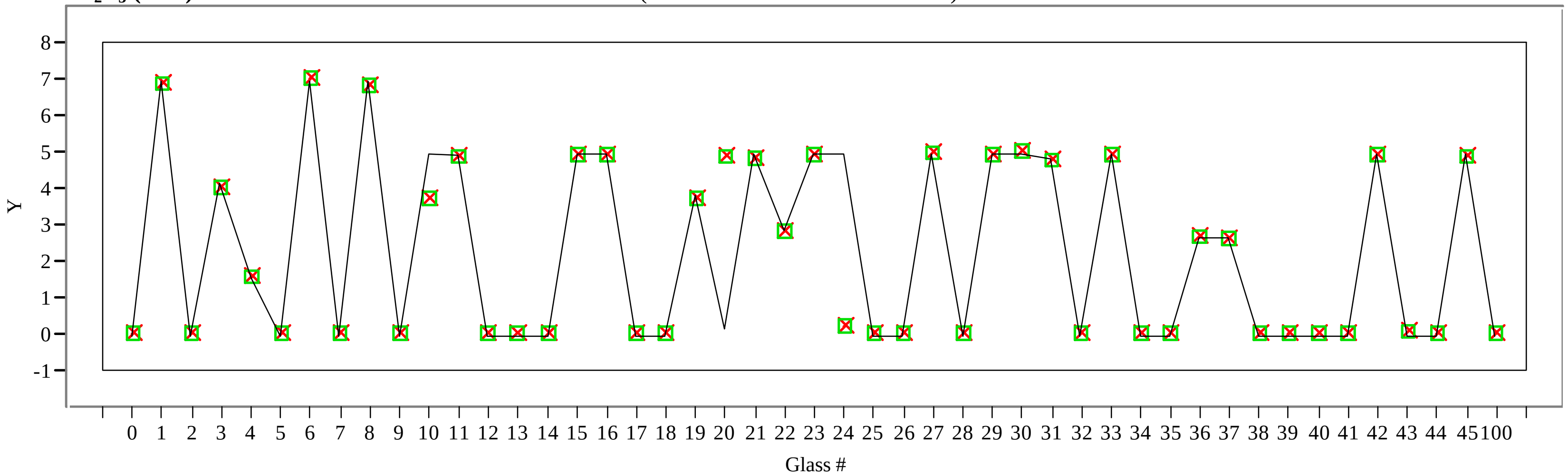


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=Bi_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=CaO (wt%) (with 0 – Batch 1 and 100 – U std)

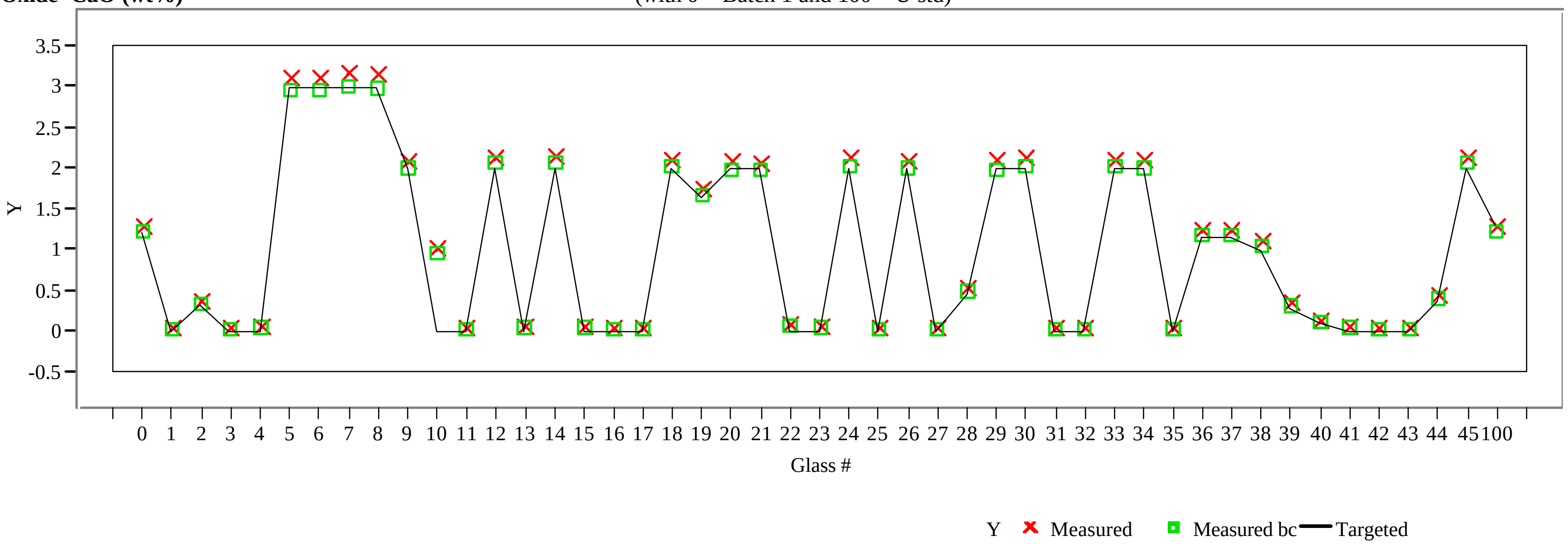
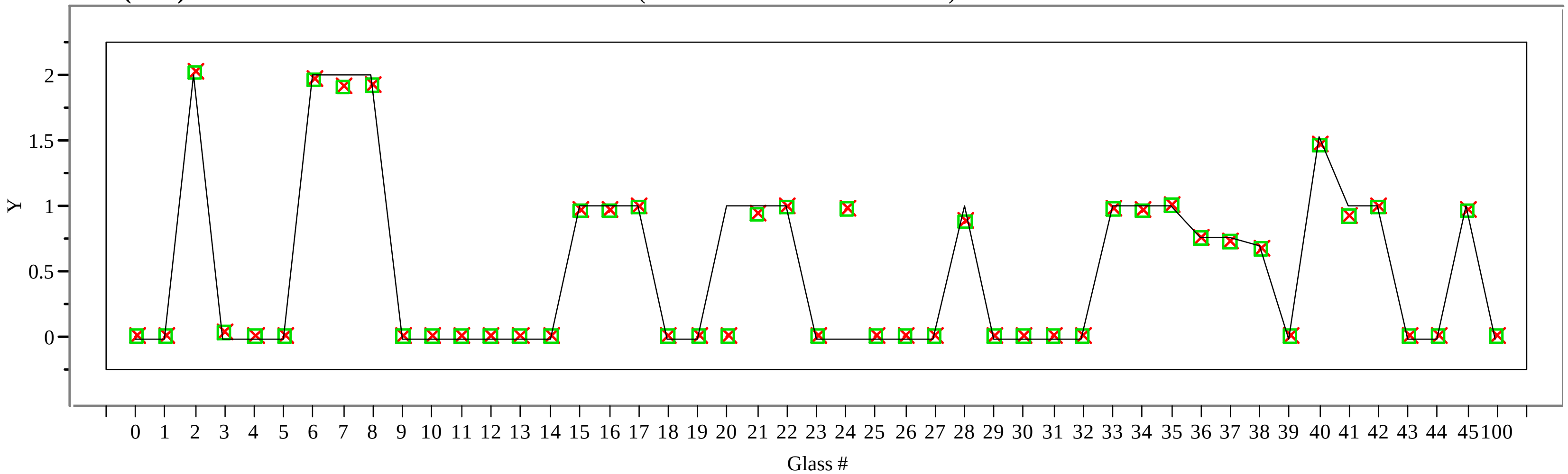


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=CdO (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=Ce_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)

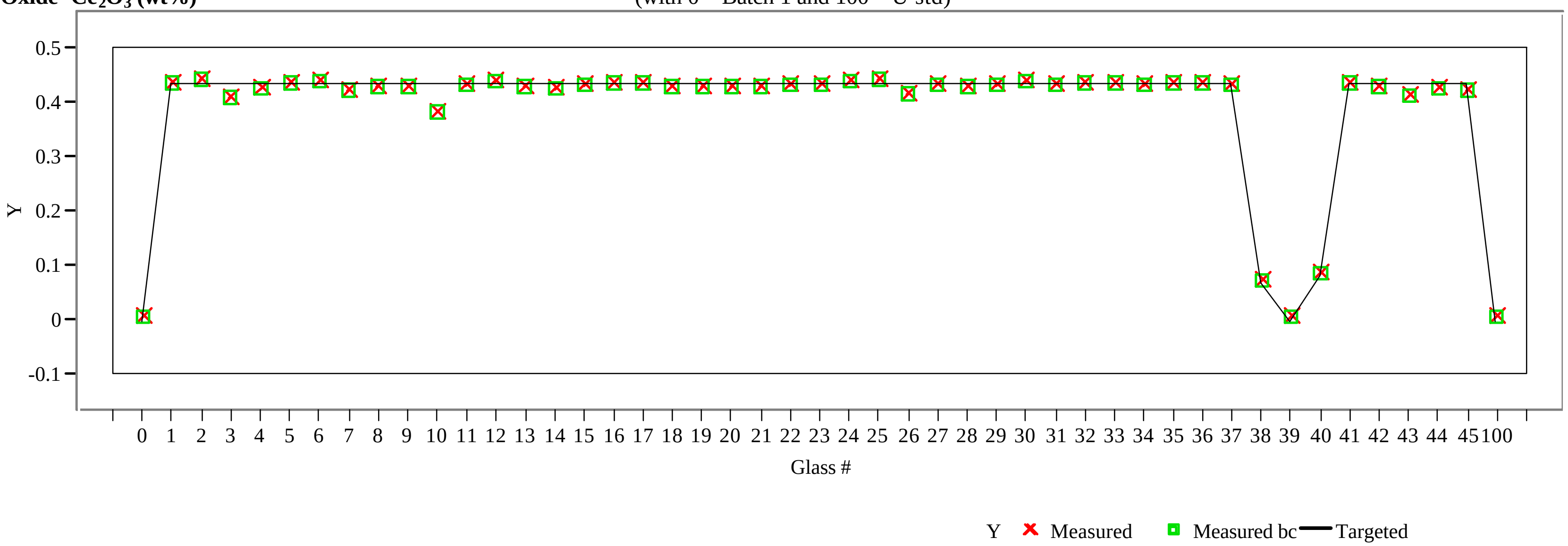
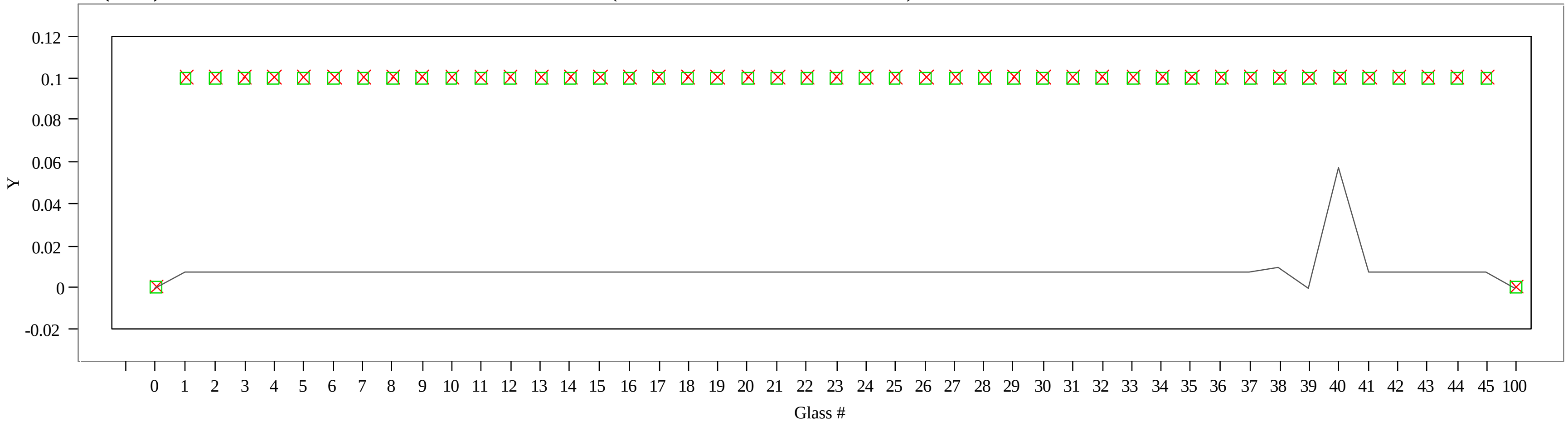


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide *(continued)*

Oxide=Cl- (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=Cr_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)

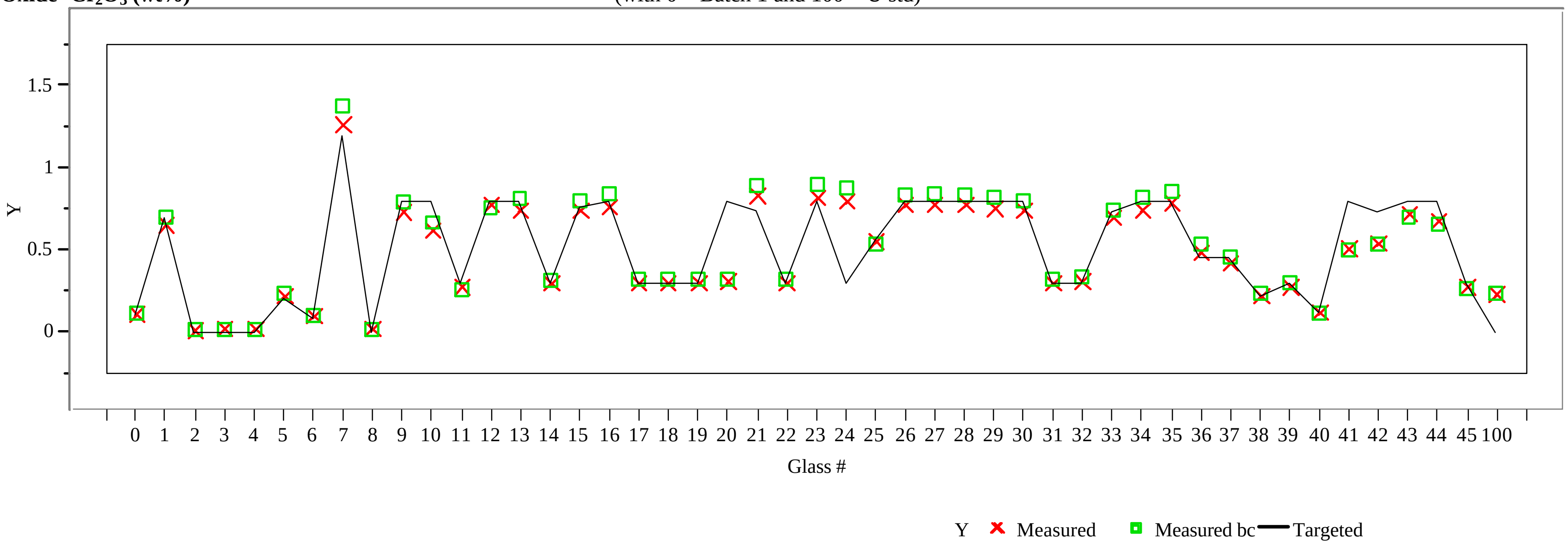
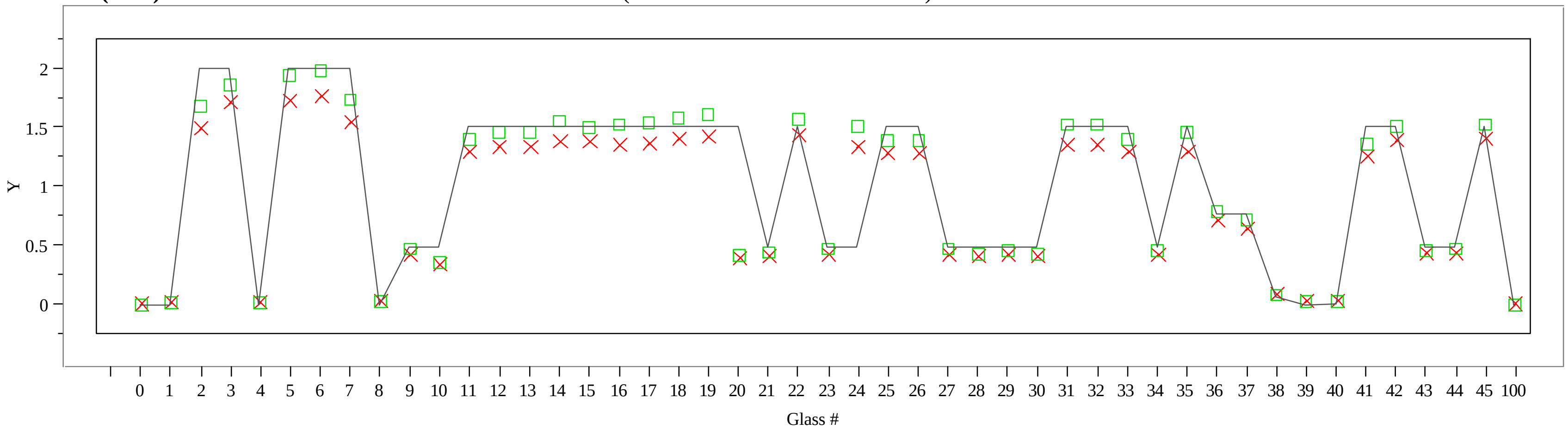


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=F- (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=Fe_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)

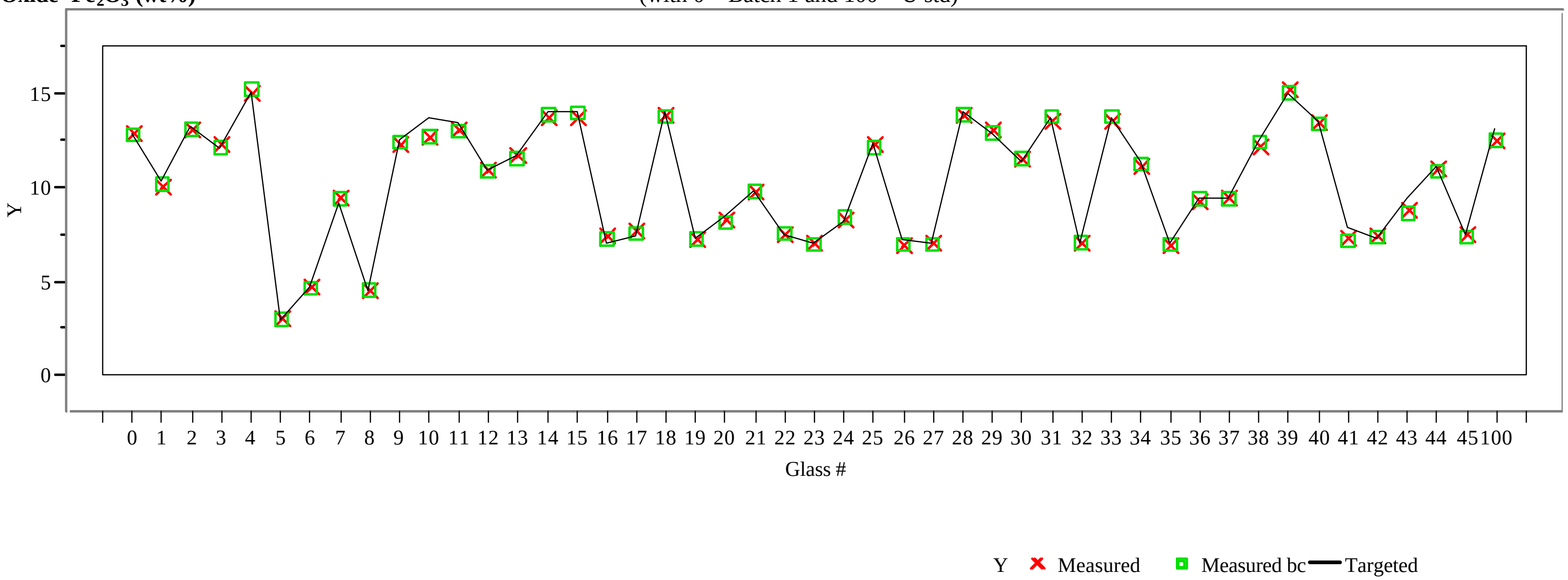
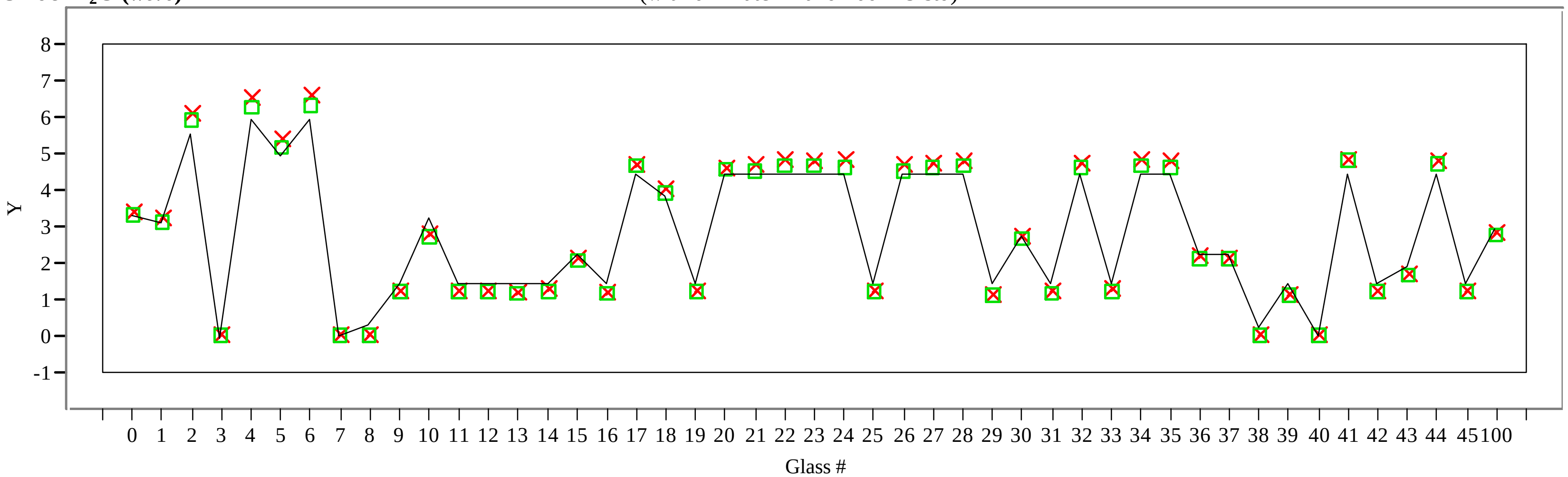


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=K_2O (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=La_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)

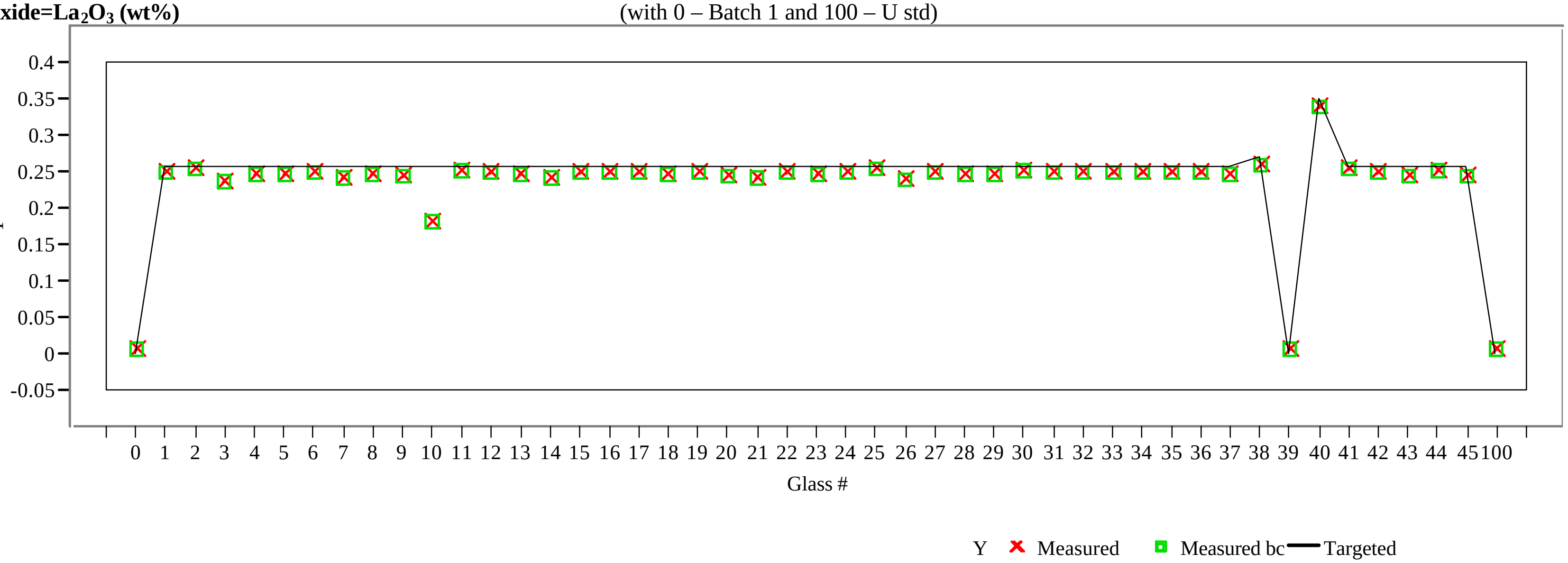
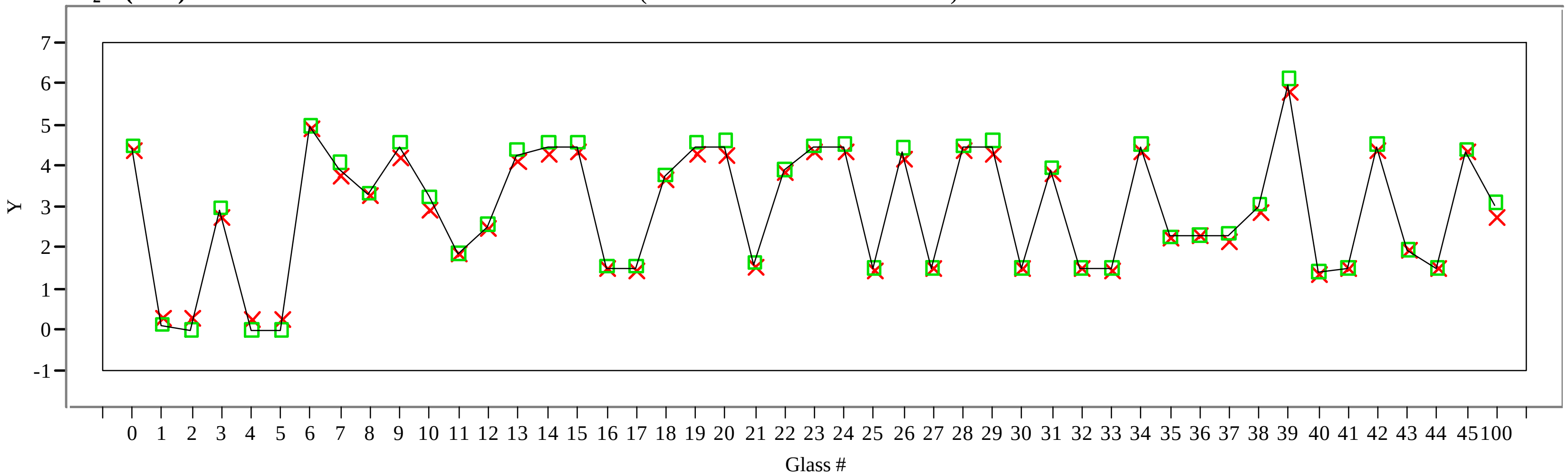


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=Li_2O (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=MgO (wt%) (with 0 – Batch 1 and 100 – U std)

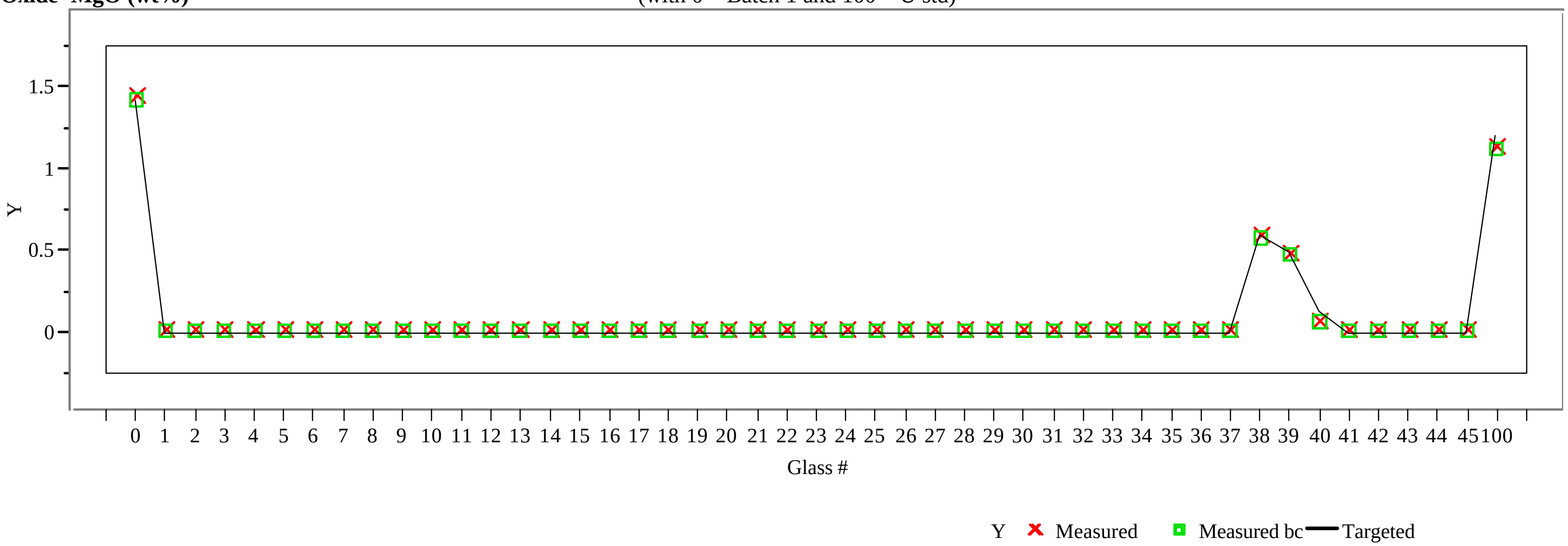
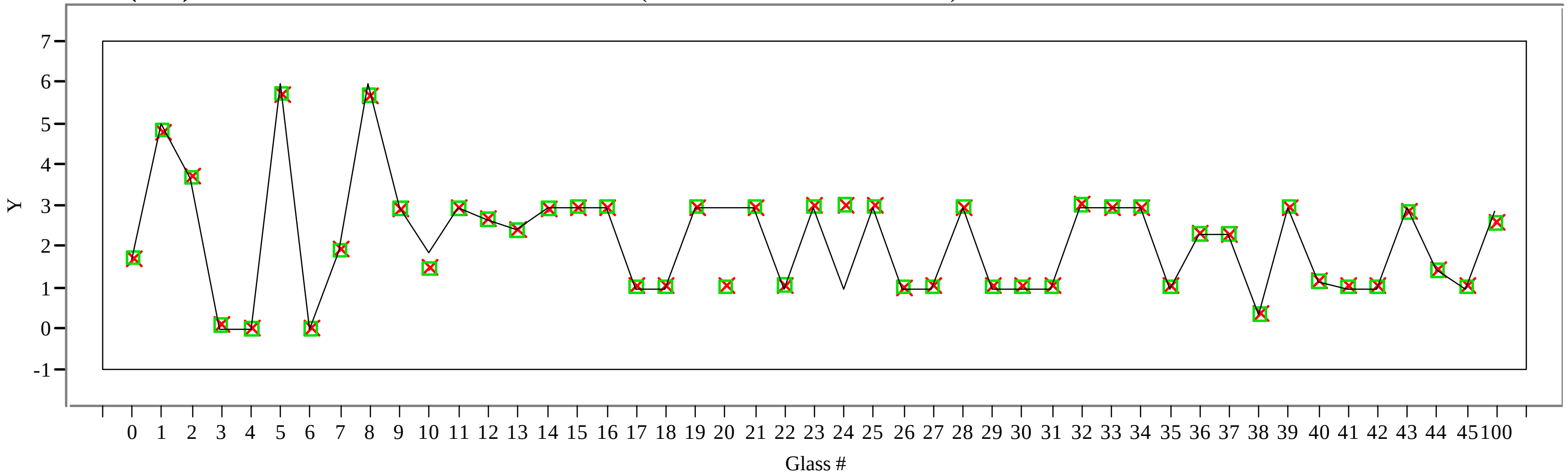


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=MnO (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=Na_2O (wt%) (with 0 – Batch 1 and 100 – U std)

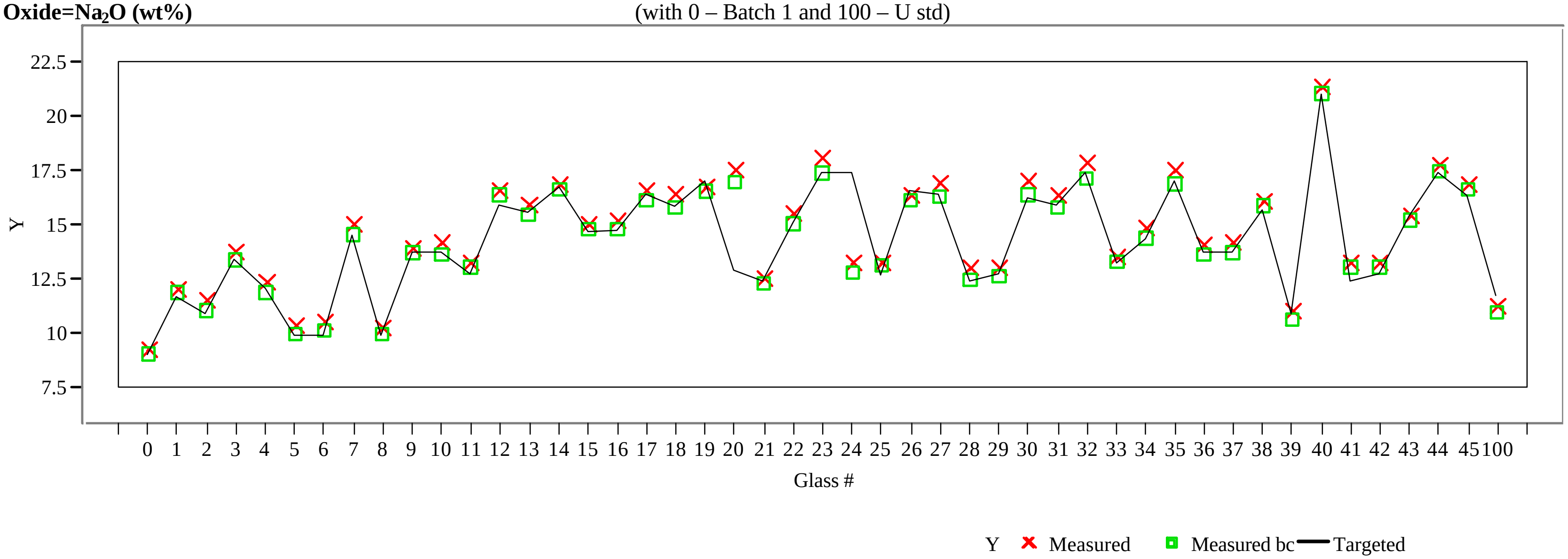
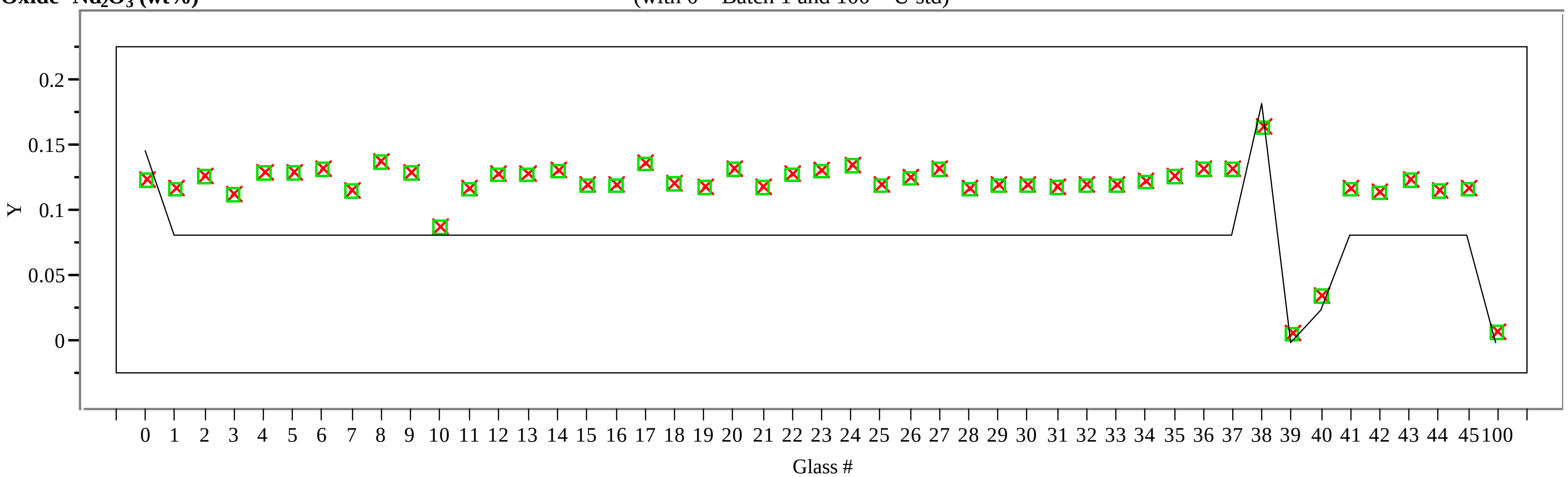


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=Nd_2O_3 (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=NiO (wt%) (with 0 – Batch 1 and 100 – U std)

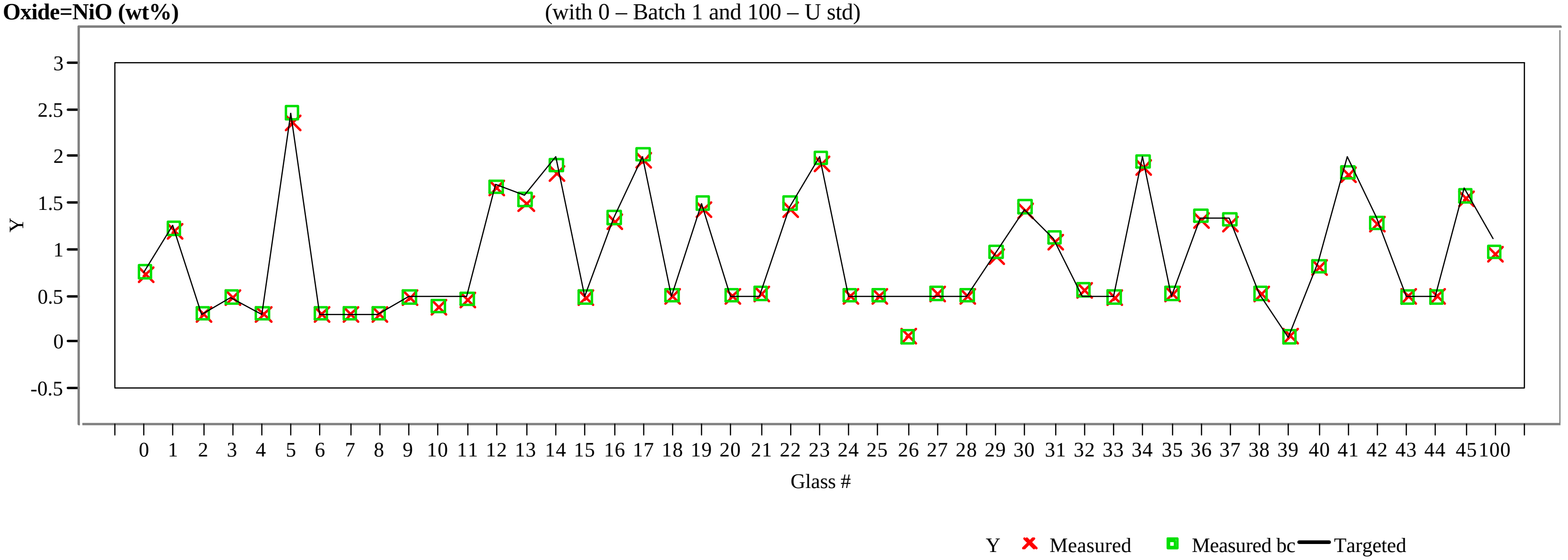
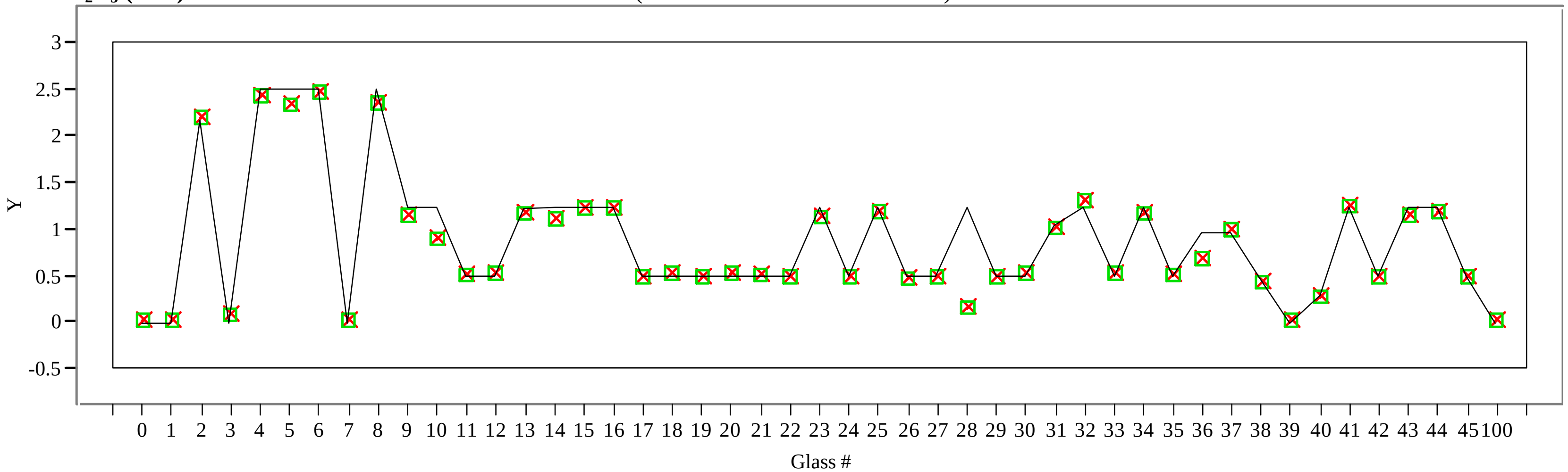


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=P_2O_5 (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=PbO (wt%) (with 0 – Batch 1 and 100 – U std)

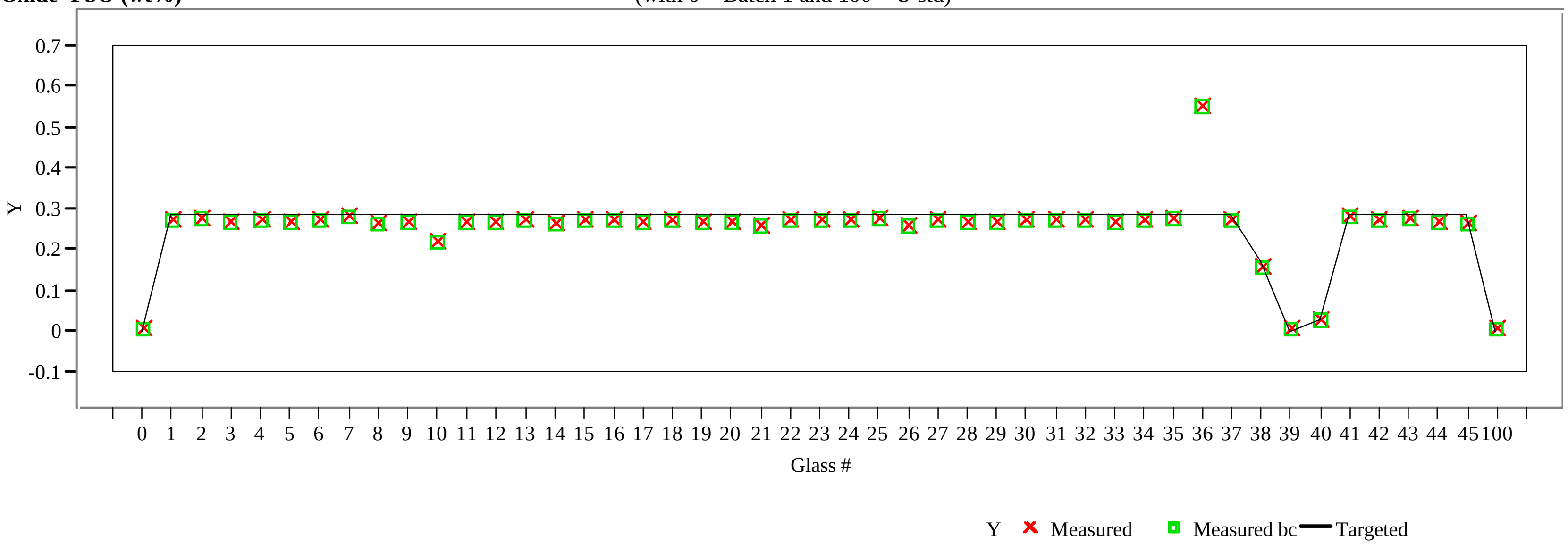
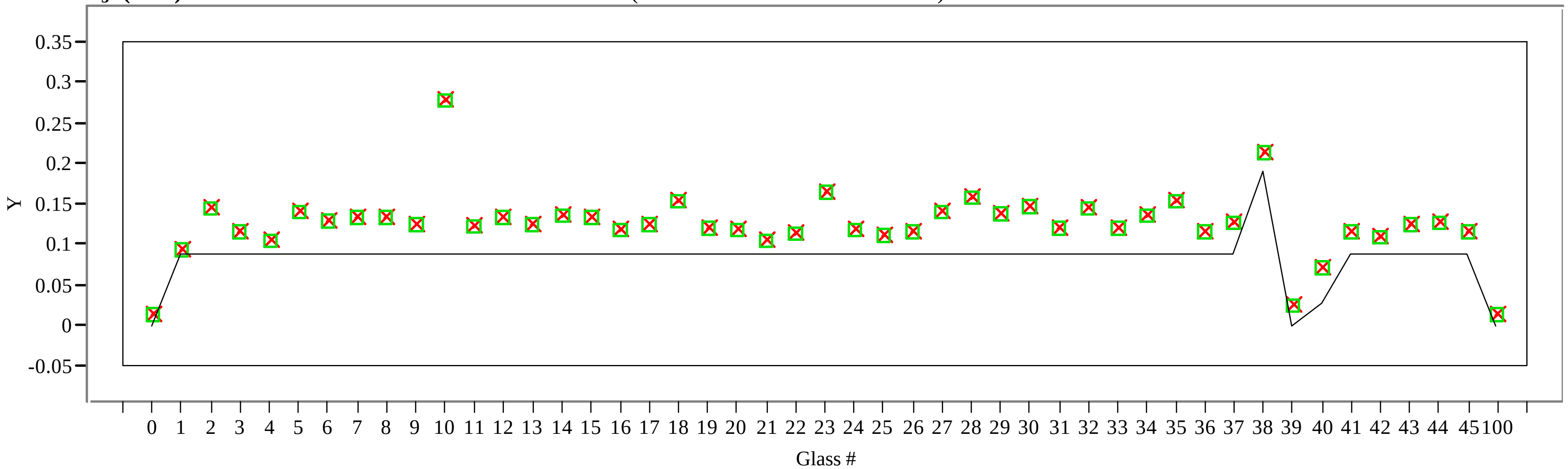


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=SO_3- (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=SiO_2 (wt%) (with 0 – Batch 1 and 100 – U std)

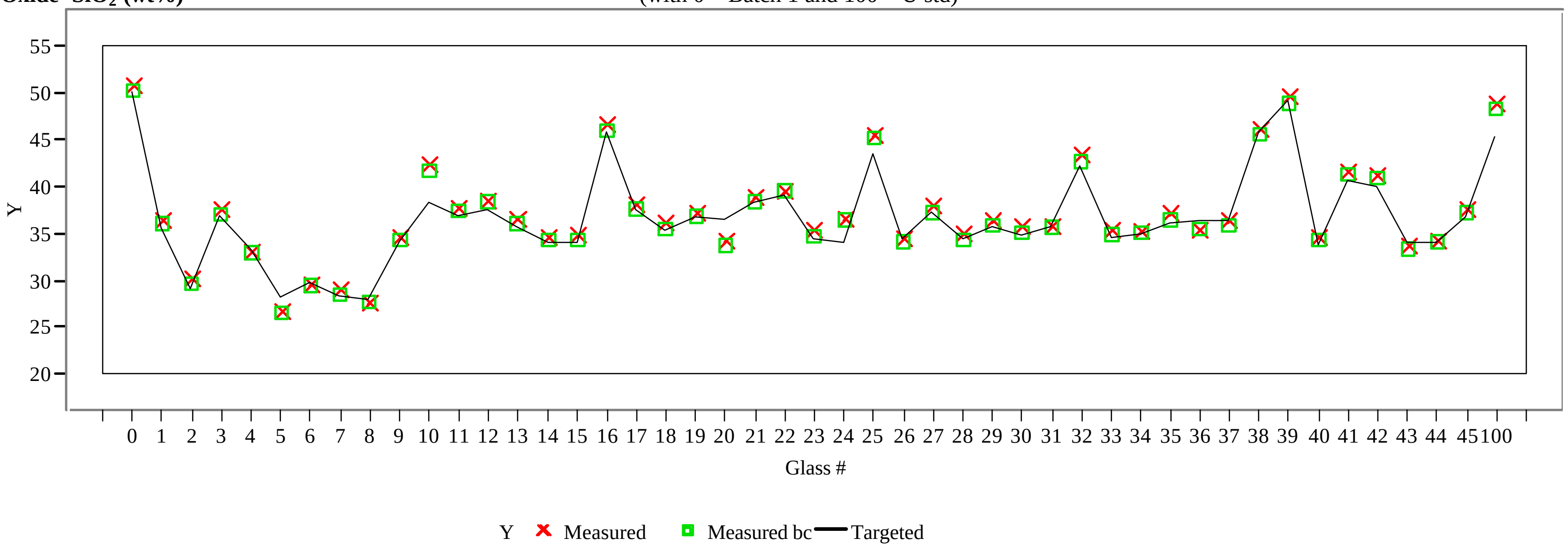
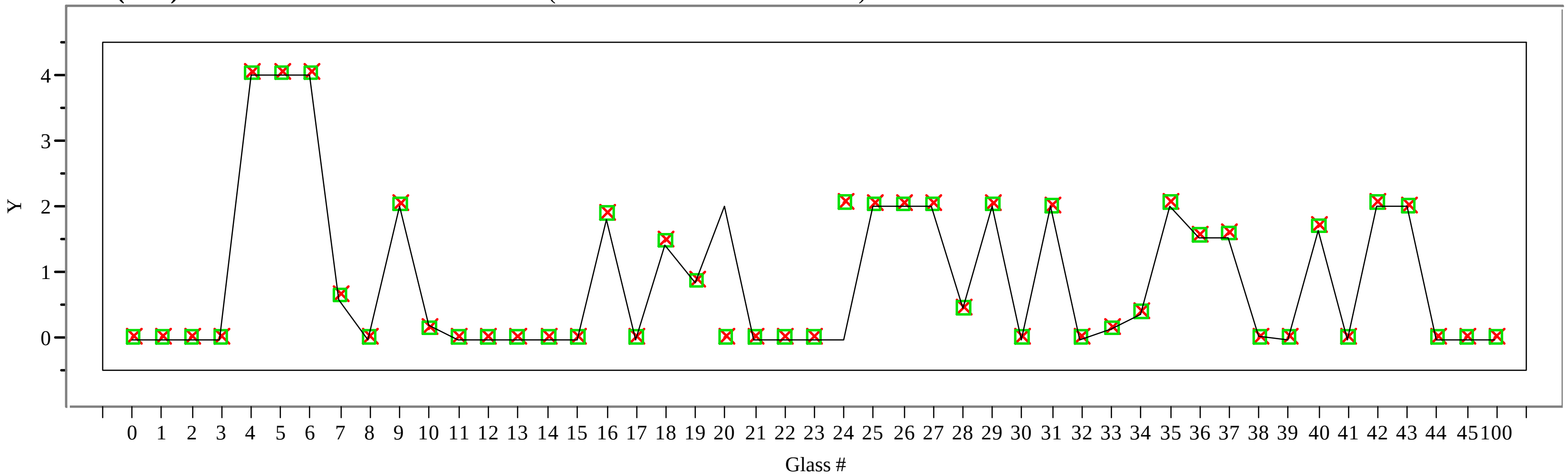


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=SrO (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=ThO_2 (wt%) (with 0 – Batch 1 and 100 – U std)

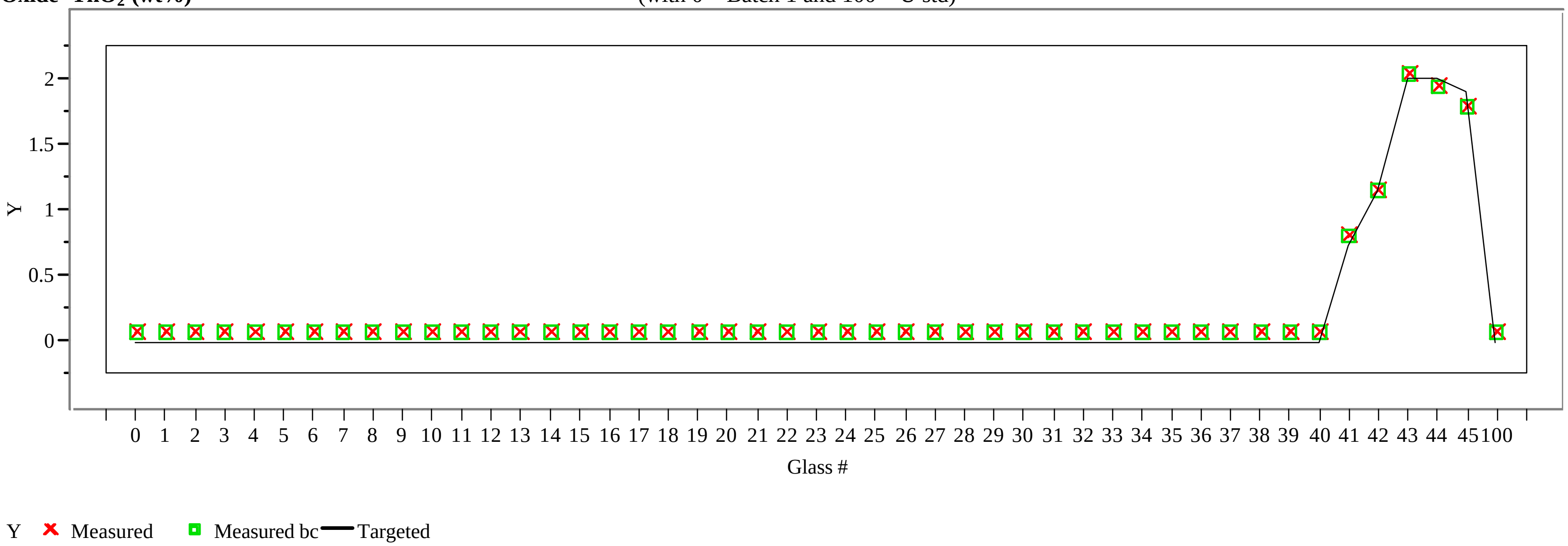
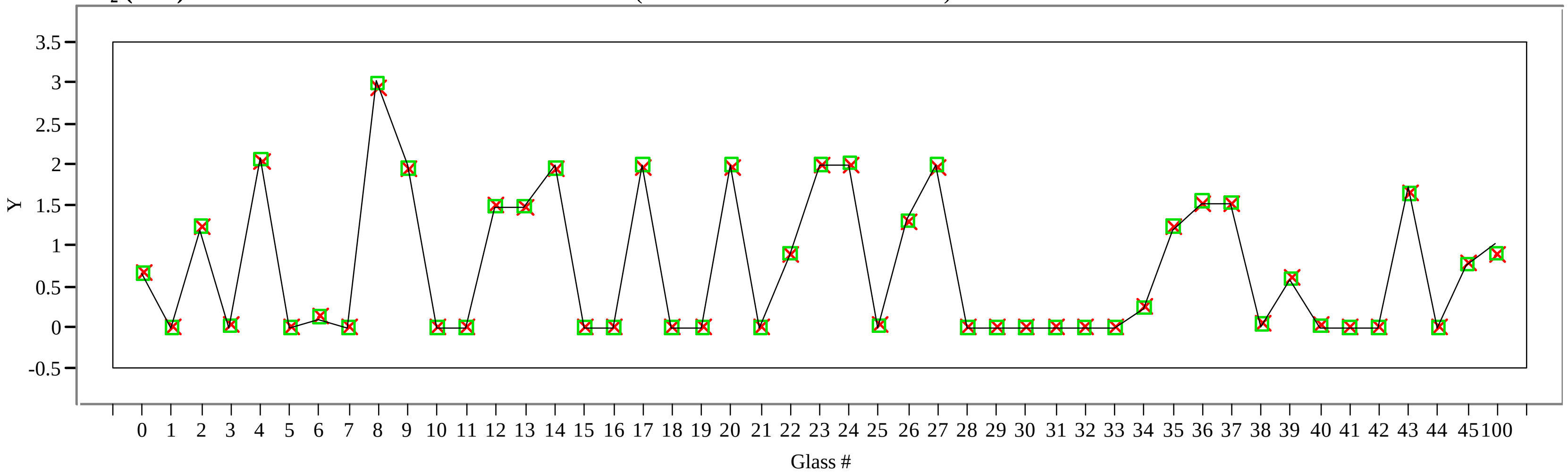


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=TiO_2 (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=U_3O_8 (wt%) (with 0 – Batch 1 and 100 – U std)

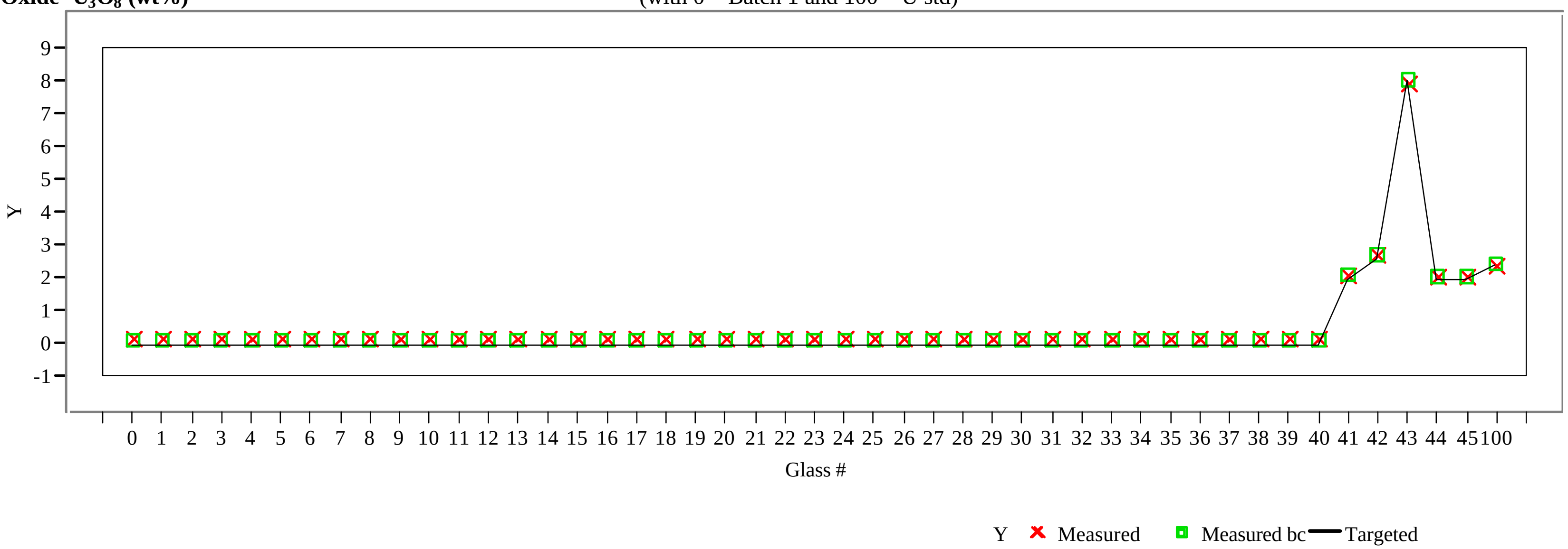
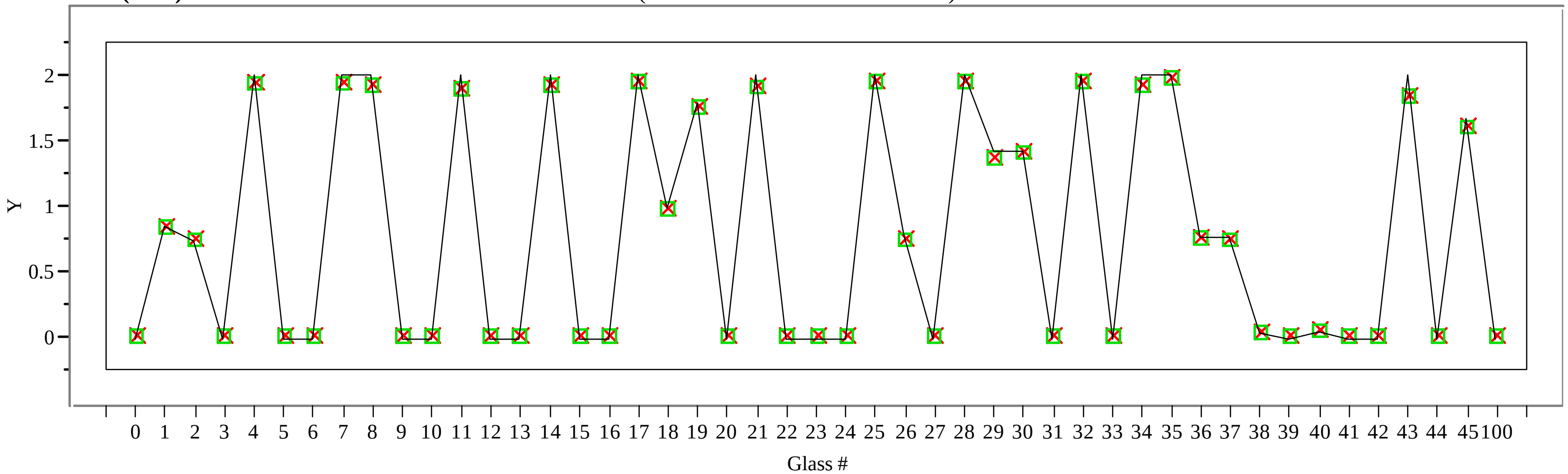


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide=ZnO (wt%) (with 0 – Batch 1 and 100 – U std)



Oxide=ZrO_2 (wt%) (with 0 – Batch 1 and 100 – U std)

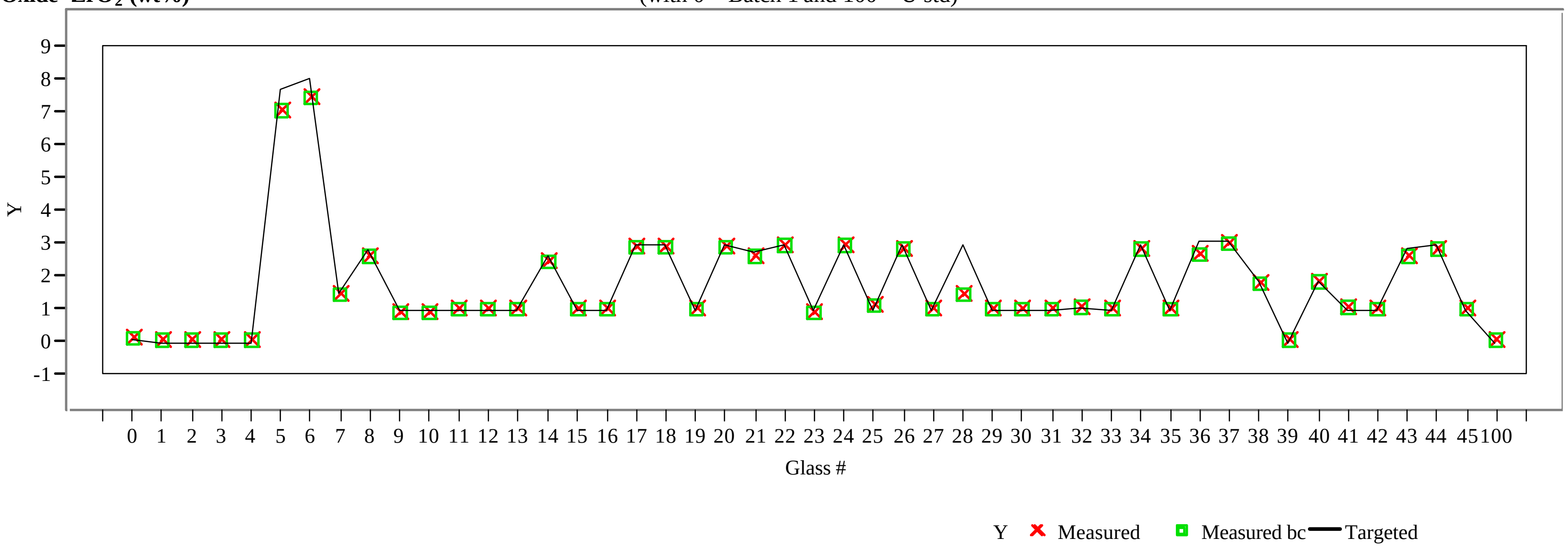
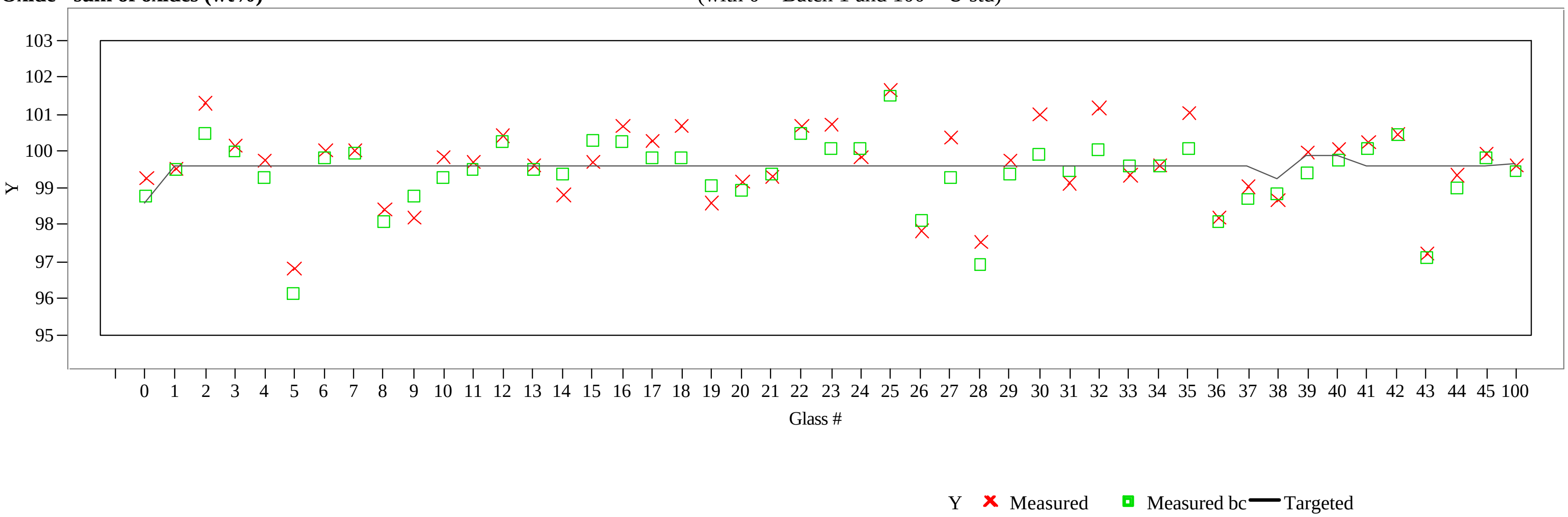


Exhibit C.10: Average Measured and Bias-Corrected (bc) Versus Targeted Compositions by Glass by Oxide ***(continued)***

Oxide= sum of oxides (wt%) (with 0 – Batch 1 and 100 – U std)



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SRS Distribution

E.W. Holtzscheiter, 773-A
R.H. Spires, 773-A
S.L. Marra, 999-W
R.C. Tuckfield, 773-42A
D.A. Crowley, 773-43A
D.F. Bickford, 999-W
C.M. Jantzen, 773-A
N.E. Bibler, 773-A
T.K. Snyder, 773-42A
D.R. Best, 773-41A
K.G. Brown, 773-42A
A.D. Cozzi, 999-W
T.B. Edwards, 773-42A
J.C. George, 773-43A
C.C. Herman, 773-43A
S. Owens, 999-W
D.K. Peeler, 999-W
I.A. Reamer, 773-A
D.C. Witt, 999-W
R.J. Workman, 999-W
Records (4)
VT QA File

PNNL Distribution

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