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Composition Measurements of the LAW ALG Glasses

M. C. Hsieh

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REVIEWS AND APPROVALS

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EXECUTIVE SUMMARY

This report provides the results from the chemical analyses of glass compositions for the Low-Activity Waste Algorithm study glasses, a series of simulated nuclear waste glasses designed and fabricated at Pacific Northwest National Laboratory. These data will be used in the development, validation, and implementation of enhanced property/composition models for waste glass vitrification at Hanford.

Chemical analyses were performed on a representative sample of each of the quenched glasses to allow for comparisons with targeted compositions. The relative differences between the targeted and measured concentrations of SO_3 for most of the glasses were greater than 10%. The relative differences between the targeted and measured concentration of F^- was greater than 10% for one glass. The relative differences between the targeted and measured concentration of SnO_2 was greater than 10% for one glass. These results can be used in further characterization of this series of glasses, including the normalization of Product Consistency Test results.

Revision 1 of this report includes updated target compositions (revised Section 3.1.4; revised Table A-4; revised Exhibits A-1 and A-3).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

BDL	below detection limit
DOE	Department of Energy
IC	ion chromatography
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
KH	potassium hydroxide fusion
LAW	low-activity waste
LAW ALG	Low-Activity Waste Algorithm
LM	lithium metaborate fusion
LRM	low-activity test reference material
ORP	Office of River Protection
PF	sodium peroxide fusion
PNNL	Pacific Northwest National Laboratory
seq.	sequence
SRNL	Savannah River National Laboratory
TTQAP	Task Technical and Quality Assurance Plan
wt.%	weight percent
WTP	Hanford Waste Treatment and Immobilization Plant

1.0 Introduction

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

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

This report provides results from the chemical analyses of the baseline (quenched) versions of a series of simulated nuclear waste glasses fabricated at Pacific Northwest National Laboratory (PNNL). The glasses were selected as part of a broader study of the influence of glass composition on chemical durability, sulfur retention, and other properties.[3] The glasses were designated the Low-Activity Waste Algorithm (LAW ALG) study glasses. The resulting data will be used in the development, validation, and implementation of enhanced property/composition models for nuclear waste glasses.[1]

2.0 Experimental Procedure

2.1 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.[4] Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-03 The glasses provided by PNNL were fabricated following a Task Plan.[1]

2.2 Glasses Selected for Study

The baseline (quenched) glass compositions in this study were selected and fabricated by PNNL. Samples of the quenched baseline glasses were received at SRNL for chemical composition analysis. PNNL identifiers (IDs) for the glass samples and the associated SRNL sample identifiers are listed in Table 2-1.

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

Table 2-1. Identifiers for the LAW ALG Study Glasses

PNNL ID	Lab ID
LAWALG-00	S-13049
LAWALG-01	S-13050
LAWALG-02	S-13051
LAWALG-03	S-13052
LAWALG-04	S-13053
LAWALG-05-1	S-13054
LAWALG-06	S-13055
LAWALG-07	S-13056
LAWALG-08	S-13057
LAWALG-09	S-13058
LAWALG-10	S-13059
LAWALG-11	S-13060
LAWALG-12	S-13061
LAWALG-13	S-13062
LAWALG-14	S-13063
LAWALG-15	S-13064
LAWALG-16	S-13065
LAWALG-17	S-13066

2.3 Glass Composition Analysis

Chemical analyses were performed under the auspices of an analytical plan[5] on a representative sample of each of the glasses listed in Table 2-1 to allow for comparisons with the targeted compositions. Three dissolution techniques were used for preparing each of the glass samples, in duplicate, for analysis (potassium hydroxide fusion (KH), lithium metaborate fusion (LM), and sodium peroxide fusion (PF)).[6-8] Note that for some analytes, the analytical plan specified more than one preparation method for analysis. The results were reviewed and, in general, the method that provided better recovery of the analyte was selected for reporting.

Each of the duplicate samples was analyzed twice for each element of interest by inductively coupled plasma – optical emission spectroscopy (ICP-OES)[9] or ion chromatography (IC),[10] for a total of four measurements per element per glass. Glass standards were also intermittently measured to assess the performance of the ICP-OES and IC instruments over the course of these analyses. Specifically, several samples of the low-activity test reference material (LRM) were included as part of the analytical plans. The LRM composition reported as the "Consensus Average" is used as the reference composition of this glass.[11] The preparation and measurement methods used for each of the reported glass components are listed in Table 2-2.

Table 2-2. Preparation and Measurement Methods Used in Reporting the Analyte Concentrations of the Study Glasses

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

3.0 Results and Discussion

JMP® Version 14.3.0 (SAS Institute, Inc.)[12] was used to support these analyses.

3.1 Review and Evaluation of the Quenched Glass Composition Measurements

Table A-1, Table A-2, and Table A-3 in Appendix A provide the elemental concentration measurements in weight percent (wt.%) from glasses prepared using KH, LM, and PF methods, respectively. Elemental measurements for samples of the LRM glass are also included in these tables of Appendix A. These unprocessed data are provided so that the values are readily available should they be of interest for future reviews.

3.1.1 Treatment of Detection Limits

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

3.1.2 Composition Measurements by Glass Identifier

Exhibit A-1 in Appendix A provides plots of the oxide concentration measurements by the PNNL Glass ID (including the LRM glasses) by Lab ID grouped by targeted concentration. Different symbols and colors are used to represent the different glasses. These plots show the individual measurements across the

duplicates of each preparation method and the two instrument calibrations for each glass. Plotting the data in this format provides an opportunity to review the values for each individual glass as a function of the duplicate preparations and duplicate measurements. A review of the plots presented in these exhibits reveals the repeatability of the four individual values for each oxide for each glass. There were no indications of errors in preparation or measurement that had to be addressed in treatment of the data.

3.1.3 Results for the LRM Standard Glass

Exhibit A-2 in Appendix A provides a comparison of the LRM results to their acceptability limits utilized by SRNL.[9] The review is in the form of plots of the measurements arranged by preparation method and element, framed by upper and lower acceptability limits for the concentration of each element of interest. The results show that all measurements of the LRM elements of interest were within the acceptability limits during the execution of these analyses.

3.1.4 Measured versus Target Compositions

All measurements for each oxide for each glass (Table A-1, Table A-2, and Table A-3 in Appendix A) were used in calculating oxide values, which were then averaged to determine a representative chemical composition for each glass. A sum of oxides was also computed for each glass based upon the averaged oxide values. Exhibit A-3 in Appendix A provides plots showing the result for each glass for each oxide to allow PNNL to draw comparisons between the measured and targeted values.

Table A-4 in Appendix A provides a summary of the average compositions, targeted compositions and some associated differences and relative differences. The measured sums of oxides for all glasses fall within the interval of 97.9 wt.% to 101 wt. %, indicating acceptable recovery of the glass components.[13] Entries in Table A-4 show the relative differences between the measured and targeted values for the analytes with measured and targeted values above 1 wt.%. The relative differences were shaded if they are 10% or more and are summarized below.

- F^- relative difference was greater than 10% for LAWALG-12.
- SnO_2 relative difference was greater than 10% for LAWALG-09.
- SO_3 relative differences were 10% or more for LAWALG-01, LAWALG-02, LAWALG-03, LAWALG-05-1, LAWALG-06, LAWALG-07, LAWALG-08, LAWALG-12, LAWALG-13, and LAWALG-14.

4.0 Summary

Chemical analyses were performed on a representative sample of each of the LAW ALG quenched glasses to allow for comparisons with the targeted compositions. The relative differences between the targeted and measured concentrations of SO_3 for most of the glasses were greater than 10%. The relative difference between the targeted and measured concentration of F^- was greater than 10% for one glass. The relative differences between the targeted and measured concentration of SnO_2 was greater than 10% for one glass. These results can be used in further characterization of this series of glasses, including the normalization of Product Consistency Test results.

5.0 References

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Appendix A. Tables and Exhibits Supporting the LAW ALG Glass Composition Measurements

Table A-1. KH Measurements (wt.%) of the Study Glasses

PNNL ID	Block	Sub – Block	Seq	Lab ID	Cl^-	F^-
LRM	1	1	1	LRMKH111	<0.0250	0.842
LAWALG-17	1	1	2	S-13066KH21	0.500	0.268
LAWALG-03	1	1	3	S-13052KH21	0.0645	0.301
LAWALG-08	1	1	4	S-13057KH21	0.0448	0.0583
LAWALG-00	1	1	5	S-13049KH21	<0.0250	0.903
LAWALG-11	1	1	6	S-13060KH21	0.0676	0.0924
LAWALG-01	1	1	7	S-13050KH11	0.0597	0.431
LAWALG-16	1	1	8	S-13065KH21	0.0853	0.0638
LAWALG-03	1	1	9	S-13052KH11	0.0618	0.301
LRM	1	1	10	LRMKH112	<0.0250	0.845
LAWALG-01	1	1	11	S-13050KH21	0.0593	0.442
LAWALG-02	1	1	12	S-13051KH11	0.0975	0.0880
LAWALG-16	1	1	13	S-13065KH11	0.0822	0.0617
LAWALG-13	1	1	14	S-13062KH11	0.0641	0.258
LAWALG-11	1	1	15	S-13060KH11	0.0723	0.0905
LAWALG-08	1	1	16	S-13057KH11	0.0462	0.0568
LAWALG-00	1	1	17	S-13049KH11	<0.0250	0.875
LAWALG-17	1	1	18	S-13066KH11	0.527	0.278
LAWALG-02	1	1	19	S-13051KH21	0.0981	0.0827
LAWALG-13	1	1	20	S-13062KH21	0.0595	0.283
LRM	1	1	21	LRMKH113	<0.0250	0.850
LRM	1	2	1	LRMKH121	<0.0250	0.854
LAWALG-02	1	2	2	S-13051KH12	0.0989	0.0894
LAWALG-00	1	2	3	S-13049KH22	<0.0250	0.883
LAWALG-01	1	2	4	S-13050KH22	0.0633	0.444
LAWALG-13	1	2	5	S-13062KH22	0.0554	0.253
LAWALG-02	1	2	6	S-13051KH22	0.0951	0.0818
LAWALG-11	1	2	7	S-13060KH22	0.0696	0.0946
LAWALG-16	1	2	8	S-13065KH22	0.0815	0.0649
LAWALG-03	1	2	9	S-13052KH22	0.0668	0.304
LRM	1	2	10	LRMKH122	<0.0250	0.848
LAWALG-13	1	2	11	S-13062KH12	0.0700	0.269
LAWALG-17	1	2	12	S-13066KH12	0.551	0.290
LAWALG-00	1	2	13	S-13049KH12	<0.0250	0.865
LAWALG-16	1	2	14	S-13065KH12	0.0856	0.0665
LAWALG-11	1	2	15	S-13060KH12	0.0741	0.0962
LAWALG-01	1	2	16	S-13050KH12	0.0630	0.450
LAWALG-08	1	2	17	S-13057KH22	0.0481	0.0625
LAWALG-03	1	2	18	S-13052KH12	0.0667	0.319
LAWALG-08	1	2	19	S-13057KH12	0.0469	0.0621
LAWALG-17	1	2	20	S-13066KH22	0.543	0.286
LRM	1	2	21	LRMKH123	<0.0250	0.899
LRM	2	1	1	LRMKH211	<0.0250	0.858
LAWALG-05-1	2	1	2	S-13054KH21	0.0786	0.476
LAWALG-09	2	1	3	S-13058KH11	0.0520	0.314
LAWALG-14	2	1	4	S-13063KH21	0.0953	0.145
LAWALG-07	2	1	5	S-13056KH21	0.0274	0.256

Table A-1. KH Measurements (wt.%) of the Study Glasses (continued)

PNNL ID	Block	Sub – Block	Seq	Lab ID	Cl^-	F^-
LAWALG-09	2	1	6	S-13058KH21	0.0503	0.316
LAWALG-05-1	2	1	7	S-13054KH11	0.0708	0.488
LAWALG-06	2	1	8	S-13055KH21	0.0594	0.0641
LAWALG-07	2	1	9	S-13056KH11	0.0275	0.261
LRM	2	1	10	LRMKH212	<0.0250	0.879
LAWALG-15	2	1	11	S-13064KH11	0.118	0.0520
LAWALG-04	2	1	12	S-13053KH21	0.139	0.0289
LAWALG-12	2	1	13	S-13061KH11	0.0445	1.01
LAWALG-10	2	1	14	S-13059KH11	0.0561	0.0569
LAWALG-12	2	1	15	S-13061KH21	0.0426	1.01
LAWALG-04	2	1	16	S-13053KH11	0.132	0.0288
LAWALG-14	2	1	17	S-13063KH11	0.0932	0.142
LAWALG-06	2	1	18	S-13055KH11	0.0595	0.0623
LAWALG-15	2	1	19	S-13064KH21	0.118	0.0496
LAWALG-10	2	1	20	S-13059KH21	0.0566	0.0570
LRM	2	1	21	LRMKH213	<0.0250	0.873
LRM	2	2	1	LRMKH221	<0.0250	0.877
LAWALG-04	2	2	2	S-13053KH22	0.139	0.0283
LAWALG-07	2	2	3	S-13056KH12	0.0269	0.260
LAWALG-09	2	2	4	S-13058KH22	0.0467	0.319
LAWALG-12	2	2	5	S-13061KH22	0.0434	1.01
LAWALG-04	2	2	6	S-13053KH12	0.139	0.0283
LAWALG-07	2	2	7	S-13056KH22	0.0265	0.257
LAWALG-06	2	2	8	S-13055KH12	0.0563	0.0631
LAWALG-12	2	2	9	S-13061KH12	0.0434	1.02
LRM	2	2	10	LRMKH222	<0.0250	0.848
LAWALG-10	2	2	11	S-13059KH12	0.0563	0.0559
LAWALG-15	2	2	12	S-13064KH22	0.117	0.0490
LAWALG-14	2	2	13	S-13063KH22	0.0959	0.145
LAWALG-05-1	2	2	14	S-13054KH22	0.0823	0.501
LAWALG-10	2	2	15	S-13059KH22	0.0584	0.0576
LAWALG-06	2	2	16	S-13055KH22	0.0569	0.0630
LAWALG-09	2	2	17	S-13058KH12	0.0493	0.314
LAWALG-15	2	2	18	S-13064KH12	0.117	0.0517
LAWALG-14	2	2	19	S-13063KH12	0.0935	0.142
LAWALG-05-1	2	2	20	S-13054KH12	0.0689	0.498
LRM	2	2	21	LRMKH223	<0.0250	0.848

Table A-2. LM Measurements (wt.%) of the Study Glasses

PNNL ID	Block	Sub – Block	Seq	Lab ID	Al	Ca	Cr	Fe	K	Mg	Na	S	Sn	Ti	V	Zn
LRM	1	1	1	LRMLM111	5.21	0.345	0.129	0.939	1.19	0.0615	16.1	0.0828	<0.100	0.0597	<0.100	<0.100
LAWALG-16	1	1	2	S-13065LM21	4.67	5.52	0.376	0.0811	0.0554	0.0754	17.8	0.0593	3.30	0.0805	<0.100	<0.100
LAWALG-00	1	1	3	S-13049LM21	5.16	0.352	0.118	0.925	1.21	0.0608	15.6	0.0833	<0.100	0.0576	<0.100	<0.100
LAWALG-15	1	1	4	S-13064LM21	4.97	5.79	0.0340	0.0897	0.133	0.0692	18.3	0.338	3.34	0.0981	<0.100	<0.100
LAWALG-05-1	1	1	5	S-13054LM21	1.92	8.83	0.0287	0.0843	0.108	0.109	7.09	0.399	<0.100	<0.0500	2.25	<0.100
LAWALG-00	1	1	6	S-13049LM11	5.04	0.345	0.116	0.859	1.28	0.0570	15.0	0.0825	<0.100	0.0555	<0.100	<0.100
LAWALG-06	1	1	7	S-13055LM21	3.52	6.80	0.0505	0.0925	0.110	0.0890	16.8	0.318	1.11	0.0717	2.35	<0.100
LAWALG-16	1	1	8	S-13065LM11	5.16	6.09	0.355	0.0780	0.0577	0.0702	19.2	0.0611	3.54	0.0762	<0.100	<0.100
LAWALG-09	1	1	9	S-13058LM11	5.00	6.04	0.121	0.0908	0.169	0.0762	17.7	0.107	3.11	0.0821	<0.100	<0.100
LRM	1	1	10	LRMLM112	5.29	0.349	0.127	0.918	1.18	0.0602	16.1	0.0809	<0.100	0.0580	<0.100	<0.100
LAWALG-08	1	1	11	S-13057LM11	2.00	9.22	0.0169	0.101	0.0536	0.117	7.92	0.337	<0.100	<0.0500	2.39	<0.100
LAWALG-14	1	1	12	S-13063LM21	1.98	8.95	0.0293	0.0911	0.0786	0.117	12.1	0.567	<0.100	<0.0500	2.33	<0.100
LAWALG-10	1	1	13	S-13059LM11	4.97	5.88	0.104	0.0857	0.0593	0.0850	17.9	0.0741	3.49	0.0794	<0.100	<0.100
LAWALG-14	1	1	14	S-13063LM11	2.09	9.44	0.0276	0.0887	0.078	0.116	12.3	0.552	<0.100	<0.0500	2.42	<0.100
LAWALG-09	1	1	15	S-13058LM21	5.10	6.18	0.121	0.0936	0.171	0.0761	17.9	0.107	3.18	0.0825	<0.100	<0.100
LAWALG-15	1	1	16	S-13064LM11	4.78	5.66	0.0355	0.0984	0.138	0.0779	17.9	0.353	3.38	0.106	<0.100	<0.100
LAWALG-08	1	1	17	S-13057LM21	1.97	9.07	0.0174	0.0967	0.0591	0.116	7.75	0.355	<0.100	<0.0500	2.34	<0.100
LAWALG-10	1	1	18	S-13059LM21	4.73	5.68	0.103	0.0798	0.0520	0.0740	18.0	0.0726	3.30	0.0760	<0.100	<0.100
LAWALG-06	1	1	19	S-13055LM11	3.55	6.91	0.0449	0.109	0.119	0.107	16.5	0.325	1.22	0.0800	2.37	<0.100
LAWALG-05-1	1	1	20	S-13054LM11	1.93	9.01	0.0304	0.0875	0.103	0.116	7.13	0.423	<0.100	<0.0500	2.32	<0.100
LRM	1	1	21	LRMLM113	5.22	0.343	0.129	0.932	1.20	0.0610	16.0	0.0859	<0.100	0.0592	<0.100	<0.100
LRM	1	2	1	LRMLM121	5.29	0.345	0.132	0.963	1.24	0.0643	15.9	0.0853	<0.100	0.0610	<0.100	<0.100
LAWALG-06	1	2	2	S-13055LM22	3.29	6.36	0.0511	0.0947	0.117	0.0938	15.2	0.327	1.05	0.0732	2.20	<0.100
LAWALG-00	1	2	3	S-13049LM22	5.05	0.362	0.119	0.936	1.23	0.0628	15.3	0.0834	<0.100	0.0581	<0.100	<0.100
LAWALG-05-1	1	2	4	S-13054LM22	1.91	8.85	0.0293	0.0878	0.114	0.116	6.89	0.407	<0.100	<0.0500	2.24	<0.100
LAWALG-15	1	2	5	S-13064LM12	4.70	5.52	0.0358	0.101	0.142	0.0815	17.4	0.351	3.32	0.109	<0.100	<0.100
LAWALG-08	1	2	6	S-13057LM22	1.87	8.63	0.0174	0.0995	0.0623	0.121	7.21	0.352	<0.100	<0.0500	2.21	<0.100
LAWALG-00	1	2	7	S-13049LM12	5.08	0.358	0.117	0.881	1.20	0.0597	15.3	0.0822	<0.100	0.0570	<0.100	<0.100
LAWALG-16	1	2	8	S-13065LM12	4.52	5.41	0.363	0.0813	0.0625	0.0740	16.9	0.0639	3.18	0.0785	<0.100	<0.100
LAWALG-06	1	2	9	S-13055LM12	3.30	6.38	0.0449	0.110	0.122	0.110	15.1	0.317	1.15	0.0808	2.19	<0.100
LRM	1	2	10	LRMLM122	5.23	0.337	0.132	0.970	1.24	0.0649	15.6	0.0814	<0.100	0.0619	<0.100	<0.100
LAWALG-16	1	2	11	S-13065LM22	4.72	5.64	0.377	0.0821	0.0574	0.0778	17.4	0.0613	3.37	0.0816	<0.100	<0.100
LAWALG-09	1	2	12	S-13058LM12	4.77	5.80	0.121	0.0925	0.174	0.0788	16.8	0.107	2.98	0.0835	<0.100	<0.100
LAWALG-05-1	1	2	13	S-13054LM12	1.88	8.68	0.0306	0.0898	0.108	0.122	6.74	0.430	<0.100	<0.0500	2.23	<0.100
LAWALG-15	1	2	14	S-13064LM22	4.67	5.50	0.0346	0.0914	0.138	0.0723	17.2	0.342	3.22	0.101	<0.100	<0.100
LAWALG-10	1	2	15	S-13059LM22	4.61	5.50	0.105	0.0821	0.0557	0.0779	17.2	0.0721	3.28	0.0786	<0.100	<0.100
LAWALG-14	1	2	16	S-13063LM22	1.88	8.48	0.0293	0.0930	0.0830	0.122	11.2	0.569	<0.100	<0.0500	2.20	<0.100
LAWALG-08	1	2	17	S-13057LM12	1.87	8.63	0.0171	0.104	0.0583	0.123	7.26	0.347	<0.100	<0.0500	2.22	<0.100
LAWALG-10	1	2	18	S-13059LM12	4.56	5.42	0.106	0.0878	0.0632	0.0886	17.1	0.0724	3.28	0.0815	<0.100	<0.100
LAWALG-09	1	2	19	S-13058LM22	4.68	5.69	0.124	0.0969	0.180	0.0804	16.6	0.111	2.91	0.0856	<0.100	<0.100
LAWALG-14	1	2	20	S-13063LM12	1.88	8.59	0.0277	0.0911	0.0822	0.122	11.0	0.555	<0.100	<0.0500	2.17	<0.100
LRM	1	2	21	LRMLM123	5.31	0.345	0.132	0.970	1.26	0.065	15.6	0.0871	<0.100	0.0621	<0.100	<0.100
LRM	2	1	1	LRMLM211	5.23	0.334	0.131	0.946	1.19	0.0631	15.0	0.0858	<0.100	0.0604	<0.100	<0.100
LAWALG-13	2	1	2	S-13062LM11	1.92	8.70	0.0227	0.0762	<0.0500	0.12	10.0	0.422	<0.100	<0.0500	2.29	<0.100
LAWALG-04	2	1	3	S-13053LM11	4.70	5.54	0.0153	0.0642	0.303	0.0695	17.1	0.0527	3.38	0.0510	<0.100	<0.100
LAWALG-12	2	1	4	S-13061LM11	1.92	7.90	0.0336	0.0763	0.0517	0.108	12.7	0.438	<0.100	<0.0500	2.31	<0.100
LAWALG-01	2	1	5	S-13050LM11	1.88	8.52	0.0532	0.0802	0.192	0.118	10.7	0.600	<0.100	<0.0500	2.27	<0.100

Table A-2. LM Measurements (wt.%) of the Study Glasses (continued)

PNNL ID	Block	Sub – Block	Seq	Lab ID	Al	Ca	Cr	Fe	K	Mg	Na	S	Sn	Ti	V	Zn
LAWALG-11	2	1	6	S-13060LM11	4.67	5.31	0.0347	0.0939	2.39	0.0746	15.7	0.197	3.49	0.0972	<0.100	3.18
LAWALG-07	2	1	7	S-13056LM21	3.18	5.90	0.0395	0.0652	0.0679	0.0785	16.7	0.306	3.54	<0.0500	0.522	<0.100
LAWALG-13	2	1	8	S-13062LM21	1.88	8.59	0.0218	0.0759	<0.0500	0.118	9.65	0.423	<0.100	<0.0500	2.26	<0.100
LAWALG-17	2	1	9	S-13066LM21	4.86	5.59	0.0517	0.0987	0.458	0.0711	16.6	0.263	3.38	0.0964	<0.100	<0.100
LRM	2	1	10	LRMLM212	5.25	0.333	0.131	0.941	1.20	0.0628	14.8	0.0842	<0.100	0.0599	<0.100	<0.100
LAWALG-04	2	1	11	S-13053LM21	4.93	5.80	0.0151	0.0609	0.301	0.0678	17.8	0.0520	3.56	<0.0500	<0.100	<0.100
LAWALG-03	2	1	12	S-13052LM11	3.01	6.07	0.0514	0.0769	0.0694	0.0815	16.1	0.405	3.42	0.0583	1.41	<0.100
LAWALG-12	2	1	13	S-13061LM21	1.92	7.89	0.0333	0.0755	0.0513	0.107	12.4	0.433	<0.100	<0.0500	2.29	<0.100
LAWALG-02	2	1	14	S-13051LM11	2.92	6.91	0.0411	0.0881	0.0940	0.0951	13.9	0.545	<0.100	0.0672	2.28	<0.100
LAWALG-03	2	1	15	S-13052LM21	2.99	6.05	0.0525	0.0779	0.0689	0.0815	16.1	0.401	3.44	0.0584	1.40	<0.100
LAWALG-17	2	1	16	S-13066LM11	4.87	5.59	0.0548	0.0979	0.451	0.0768	16.6	0.273	3.50	0.102	<0.100	<0.100
LAWALG-07	2	1	17	S-13056LM11	3.20	5.94	0.0392	0.0650	0.0681	0.0787	16.6	0.314	3.54	<0.0500	0.523	<0.100
LAWALG-01	2	1	18	S-13050LM21	1.91	8.67	0.0523	0.0819	0.180	0.117	10.7	0.616	<0.100	<0.0500	2.29	<0.100
LAWALG-02	2	1	19	S-13051LM21	2.93	7.02	0.0370	0.0886	0.0956	0.0953	14.0	0.564	<0.100	0.0675	2.30	<0.100
LAWALG-11	2	1	20	S-13060LM21	4.87	5.50	0.0286	0.0991	2.62	0.0737	15.8	0.203	3.54	0.0965	<0.100	3.27
LRM	2	1	21	LRMLM213	5.26	0.337	0.129	0.928	1.19	0.0620	14.5	0.0859	<0.100	0.0587	<0.100	<0.100
LRM	2	2	1	LRMLM221	5.25	0.347	0.133	0.958	1.24	0.0641	15.4	0.0861	<0.100	0.0618	<0.100	<0.100
LAWALG-12	2	2	2	S-13061LM12	1.90	8.06	0.0337	0.0765	0.0520	0.108	13.1	0.427	<0.100	<0.0500	2.25	<0.100
LAWALG-02	2	2	3	S-13051LM12	2.89	7.06	0.0414	0.0892	0.0972	0.0961	14.5	0.538	<0.100	0.0688	2.24	<0.100
LAWALG-17	2	2	4	S-13066LM12	4.66	5.54	0.0558	0.0992	0.468	0.0780	16.9	0.273	3.41	0.105	<0.100	<0.100
LAWALG-03	2	2	5	S-13052LM22	2.89	6.01	0.0521	0.0779	0.0684	0.0817	16.3	0.390	3.32	0.0591	1.35	<0.100
LAWALG-17	2	2	6	S-13066LM22	4.70	5.55	0.0516	0.0995	0.463	0.0714	16.8	0.258	3.32	0.0979	<0.100	<0.100
LAWALG-03	2	2	7	S-13052LM12	2.87	5.95	0.0515	0.0770	0.0687	0.0812	16.4	0.392	3.31	0.0585	1.34	<0.100
LAWALG-04	2	2	8	S-13053LM22	4.56	5.52	0.0153	0.0608	0.301	0.0677	17.0	0.0474	3.29	0.0501	<0.100	<0.100
LAWALG-11	2	2	9	S-13060LM22	4.64	5.41	0.0288	0.0994	2.45	0.0738	15.9	0.192	3.40	0.0974	<0.100	3.08
LRM	2	2	10	LRMLM222	5.23	0.342	0.130	0.934	1.16	0.0625	15.3	0.0782	<0.100	0.0597	<0.100	<0.100
LAWALG-07	2	2	11	S-13056LM22	2.95	5.65	0.0381	0.0629	0.0637	0.0759	15.7	0.291	3.33	<0.0500	0.512	<0.100
LAWALG-11	2	2	12	S-13060LM12	4.50	5.25	0.0337	0.0921	2.28	0.0731	15.4	0.190	3.32	0.0958	<0.100	3.05
LAWALG-07	2	2	13	S-13056LM12	3.00	5.77	0.0388	0.0635	0.0659	0.0770	16.2	0.302	3.38	<0.0500	0.520	<0.100
LAWALG-04	2	2	14	S-13053LM12	4.61	5.58	0.0152	0.0627	0.289	0.0676	17.0	0.0487	3.32	<0.0500	<0.100	<0.100
LAWALG-02	2	2	15	S-13051LM22	2.85	6.97	0.0365	0.0869	0.0916	0.0934	14.1	0.541	<0.100	0.0664	2.22	<0.100
LAWALG-01	2	2	16	S-13050LM22	1.84	8.57	0.0516	0.0812	0.178	0.115	10.8	0.598	<0.100	<0.0500	2.21	<0.100
LAWALG-13	2	2	17	S-13062LM12	1.86	8.59	0.0222	0.0736	<0.0500	0.117	9.72	0.401	<0.100	<0.0500	2.20	<0.100
LAWALG-12	2	2	18	S-13061LM22	1.84	7.80	0.0328	0.0742	<0.0500	0.105	12.3	0.422	<0.100	<0.0500	2.20	<0.100
LAWALG-13	2	2	19	S-13062LM22	1.87	8.73	0.0220	0.0745	<0.0500	0.116	9.78	0.408	<0.100	<0.0500	2.22	<0.100
LAWALG-01	2	2	20	S-13050LM12	1.84	8.56	0.0523	0.0784	0.189	0.116	10.7	0.579	<0.100	<0.0500	2.20	<0.100
LRM	2	2	21	LRMLM223	5.21	0.342	0.129	0.926	1.19	0.0616	14.8	0.0812	<0.100	0.0590	<0.100	<0.100

Table A-3. PF Measurements (wt.%) of the Study Glasses

PNNL ID	Block	Sub – Block	Seq	Lab ID	B	Li	P	Si	Zr
LRM	1	1	1	LRMPF111	2.41	<0.100	0.231	25.2	0.687
LAWALG-04	1	1	2	S-13053PF11	2.69	<0.100	<0.100	18.7	4.42
LAWALG-12	1	1	3	S-13061PF21	4.04	<0.100	0.950	20.5	1.53
LAWALG-07	1	1	4	S-13056PF11	2.53	<0.100	0.725	19.0	4.05
LAWALG-13	1	1	5	S-13062PF21	4.29	0.529	0.415	22.1	1.49
LAWALG-12	1	1	6	S-13061PF11	4.22	<0.100	0.991	21.4	1.58
LAWALG-03	1	1	7	S-13052PF21	2.20	<0.100	1.32	18.6	4.53
LAWALG-01	1	1	8	S-13050PF21	2.57	1.29	0.240	22.4	1.43
LAWALG-15	1	1	9	S-13064PF21	2.64	<0.100	0.158	18.2	4.00
LRM	1	1	10	LRMPF112	2.37	<0.100	0.227	25.1	0.755
LAWALG-13	1	1	11	S-13062PF11	4.28	0.543	0.413	22.2	1.45
LAWALG-06	1	1	12	S-13055PF11	3.36	<0.100	0.117	18.5	3.97
LAWALG-11	1	1	13	S-13060PF21	1.82	<0.100	<0.100	17.5	4.72
LAWALG-15	1	1	14	S-13064PF11	2.82	<0.100	0.164	19.4	4.30
LAWALG-07	1	1	15	S-13056PF21	2.61	<0.100	0.776	19.1	4.30
LAWALG-01	1	1	16	S-13050PF11	2.66	1.30	0.247	22.8	1.51
LAWALG-06	1	1	17	S-13055PF21	3.45	<0.100	0.112	19.0	4.07
LAWALG-04	1	1	18	S-13053PF21	2.66	<0.100	<0.100	18.7	4.52
LAWALG-03	1	1	19	S-13052PF11	2.08	<0.100	1.27	17.9	4.34
LAWALG-11	1	1	20	S-13060PF11	1.82	<0.100	<0.100	17.5	4.73
LRM	1	1	21	LRMPF113	2.33	<0.100	0.225	24.9	0.773
LRM	1	2	1	LRMPF121	2.42	<0.100	0.211	25.2	0.688
LAWALG-12	1	2	2	S-13061PF12	3.92	<0.100	0.903	19.9	1.44
LAWALG-13	1	2	3	S-13062PF12	4.15	0.536	0.386	21.4	1.40
LAWALG-12	1	2	4	S-13061PF22	3.97	<0.100	0.901	20.3	1.47
LAWALG-15	1	2	5	S-13064PF12	2.59	<0.100	0.132	17.7	3.83
LAWALG-07	1	2	6	S-13056PF22	2.45	<0.100	0.692	17.7	3.94
LAWALG-06	1	2	7	S-13055PF12	3.34	<0.100	<0.100	18.2	3.92
LAWALG-01	1	2	8	S-13050PF22	2.58	1.29	0.213	22.2	1.46
LAWALG-03	1	2	9	S-13052PF12	2.11	<0.100	1.19	17.7	4.24
LRM	1	2	10	LRMPF122	2.37	<0.100	0.225	24.9	0.718
LAWALG-11	1	2	11	S-13060PF12	1.80	<0.100	<0.100	16.8	4.49
LAWALG-03	1	2	12	S-13052PF22	2.09	<0.100	1.19	17.5	4.25
LAWALG-04	1	2	13	S-13053PF22	2.65	<0.100	<0.100	18.4	4.41
LAWALG-11	1	2	14	S-13060PF22	1.80	<0.100	<0.100	16.8	4.51
LAWALG-04	1	2	15	S-13053PF12	2.67	<0.100	<0.100	18.5	4.42
LAWALG-01	1	2	16	S-13050PF12	2.58	1.28	0.216	21.8	1.49
LAWALG-15	1	2	17	S-13064PF22	2.68	<0.100	0.137	18.3	4.02
LAWALG-07	1	2	18	S-13056PF12	2.51	<0.100	0.670	18.8	4.04
LAWALG-06	1	2	19	S-13055PF22	3.30	<0.100	0.101	18.1	3.89
LAWALG-13	1	2	20	S-13062PF22	4.16	0.532	0.356	21.4	1.47
LRM	1	2	21	LRMPF123	2.40	<0.100	0.203	25.1	0.728
LRM	2	1	1	LRMPF211	2.37	<0.100	0.224	24.9	0.682
LAWALG-10	2	1	2	S-13059PF11	2.63	<0.100	0.151	18.4	4.11
LAWALG-02	2	1	3	S-13051PF21	3.96	<0.100	0.143	19.4	2.69
LAWALG-17	2	1	4	S-13066PF11	2.54	<0.100	<0.100	18.1	4.47
LAWALG-08	2	1	5	S-13057PF21	4.17	0.735	<0.100	23.3	1.45

Table A-3. PF Measurements (wt.%) of the Study Glasses (continued)

PNNL ID	Block	Sub – Block	Seq	Lab ID	B	Li	P	Si	Zr
LAWALG-17	2	1	6	S-13066PF21	2.54	<0.100	<0.100	18.0	4.51
LAWALG-02	2	1	7	S-13051PF11	3.87	<0.100	0.141	19.1	2.63
LAWALG-00	2	1	8	S-13049PF21	2.43	<0.100	0.238	25.6	0.745
LAWALG-16	2	1	9	S-13065PF21	2.55	<0.100	0.248	18.8	4.09
LRM	2	1	10	LRMPF212	2.36	<0.100	0.219	25.0	0.705
LAWALG-05-1	2	1	11	S-13054PF11	4.29	0.765	0.123	24.1	1.47
LAWALG-09	2	1	12	S-13058PF21	2.63	<0.100	1.47	17.1	4.63
LAWALG-08	2	1	13	S-13057PF11	4.19	0.747	<0.100	23.4	1.44
LAWALG-05-1	2	1	14	S-13054PF21	4.15	0.731	0.125	23.4	1.46
LAWALG-09	2	1	15	S-13058PF11	2.58	<0.100	1.47	16.8	4.59
LAWALG-14	2	1	16	S-13063PF21	4.21	0.304	<0.100	21.6	1.47
LAWALG-16	2	1	17	S-13065PF11	2.61	<0.100	0.249	19.2	4.12
LAWALG-00	2	1	18	S-13049PF11	2.38	<0.100	0.228	25.4	0.746
LAWALG-10	2	1	19	S-13059PF21	2.61	<0.100	0.154	18.4	4.12
LAWALG-14	2	1	20	S-13063PF11	4.02	0.289	<0.100	20.7	1.40
LRM	2	1	21	LRMPF213	2.33	<0.100	0.218	24.7	0.705
LRM	2	2	1	LRMPF221	2.39	<0.100	0.217	24.9	0.681
LAWALG-10	2	2	2	S-13059PF12	2.64	<0.100	0.140	18.3	4.07
LAWALG-05-1	2	2	3	S-13054PF12	4.05	0.760	0.118	22.6	1.38
LAWALG-14	2	2	4	S-13063PF22	4.00	0.340	<0.100	20.3	1.37
LAWALG-08	2	2	5	S-13057PF12	4.09	0.757	<0.100	22.7	1.39
LAWALG-09	2	2	6	S-13058PF12	2.52	<0.100	1.42	16.1	4.38
LAWALG-14	2	2	7	S-13063PF12	4.06	0.348	<0.100	20.6	1.39
LAWALG-00	2	2	8	S-13049PF22	2.34	<0.100	0.210	24.4	0.687
LAWALG-10	2	2	9	S-13059PF22	2.63	<0.100	0.144	18.2	4.06
LRM	2	2	10	LRMPF222	2.36	<0.100	0.217	24.6	0.689
LAWALG-09	2	2	11	S-13058PF22	2.48	<0.100	1.36	15.9	4.23
LAWALG-16	2	2	12	S-13065PF12	2.45	<0.100	0.237	17.9	3.81
LAWALG-02	2	2	13	S-13051PF12	3.85	<0.100	0.136	18.8	2.58
LAWALG-08	2	2	14	S-13057PF22	4.09	0.751	<0.100	22.8	1.41
LAWALG-17	2	2	15	S-13066PF12	2.48	<0.100	<0.100	17.5	4.33
LAWALG-05-1	2	2	16	S-13054PF22	4.05	0.750	0.108	22.7	1.42
LAWALG-17	2	2	17	S-13066PF22	2.47	<0.100	<0.100	17.4	4.31
LAWALG-02	2	2	18	S-13051PF22	3.82	<0.100	0.142	18.7	2.58
LAWALG-16	2	2	19	S-13065PF22	2.44	<0.100	0.230	17.8	3.84
LAWALG-00	2	2	20	S-13049PF12	2.32	<0.100	0.233	24.3	0.683
LRM	2	2	21	LRMPF223	2.35	<0.100	0.231	24.6	0.687

Table A-4. Comparison of Measured versus Target Compositions

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LRM	Al_2O_3	9.92	9.51	0.407	4%
LRM	B_2O_3	7.64	7.85	-0.214	-3%
LRM	CaO	0.478	0.54	-0.062	
LRM	Cl^-	<0.025	0		
LRM	Cr_2O_3	0.190	0.19	0.001	
LRM	F^-	0.86	0.86	0.000	
LRM	Fe_2O_3	1.35	1.38	-0.031	-2%
LRM	K_2O	1.45	1.48	-0.026	-2%
LRM	Li_2O	<0.215	0.11	0.105	
LRM	MgO	0.104	0.1	0.004	
LRM	Na_2O	20.8	20.0	0.763	4%
LRM	P_2O_5	0.506	0.54	-0.034	
LRM	SiO_2	53.3	54.2	-0.878	-2%
LRM	SnO_2	<0.127	0		
LRM	SO_3	0.209	0.3	-0.091	
LRM	TiO_2	0.100	0.1	0.000	
LRM	V_2O_5	<0.179	0		
LRM	ZnO	<0.124	0		
LRM	ZrO_2	0.957	0.93	0.027	
LRM	**Sum of Oxides**	**98.5**	**98.1**	**0.425**	**0%**
LAWALG-00	Al_2O_3	9.60	9.51	0.093	1%
LAWALG-00	B_2O_3	7.62	7.85	-0.227	-3%
LAWALG-00	CaO	0.496	0.54	-0.044	
LAWALG-00	Cl^-	<0.025	0		
LAWALG-00	Cr_2O_3	0.172	0.19	-0.018	
LAWALG-00	F^-	0.882	0.86	0.022	
LAWALG-00	Fe_2O_3	1.29	1.38	-0.093	-7%
LAWALG-00	K_2O	1.48	1.48	0.002	0%
LAWALG-00	Li_2O	<0.215	0.11	0.105	
LAWALG-00	MgO	0.0996	0.1	0.000	
LAWALG-00	Na_2O	20.6	20.0	0.594	3%
LAWALG-00	P_2O_5	0.521	0.54	-0.019	
LAWALG-00	SiO_2	53.3	54.2	-0.878	-2%
LAWALG-00	SnO_2	<0.127	0		
LAWALG-00	SO_3	0.207	0.3	-0.093	
LAWALG-00	TiO_2	0.0952	0.1	-0.005	
LAWALG-00	V_2O_5	<0.179	0		
LAWALG-00	ZnO	<0.124	0		
LAWALG-00	ZrO_2	0.966	0.93	0.036	
LAWALG-00	**Sum of Oxides**	**98.0**	**98.1**	**-0.120**	**0%**
LAWALG-01	Al_2O_3	3.53	3.567	-0.038	-1%
LAWALG-01	B_2O_3	8.36	8.513	-0.149	-2%
LAWALG-01	CaO	12.0	12.26	-0.259	-2%
LAWALG-01	Cl^-	0.0613	0.068	-0.007	
LAWALG-01	Cr_2O_3	0.0765	0.083	-0.006	
LAWALG-01	F^-	0.442	0.583	-0.141	

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-01	Fe_2O_3	0.115	0.12	-0.005	
LAWALG-01	K_2O	0.223	0.236	-0.013	
LAWALG-01	Li_2O	2.78	2.741	0.036	1%
LAWALG-01	MgO	0.193	0.18	0.013	
LAWALG-01	Na_2O	14.5	14.9	-0.446	-3%
LAWALG-01	P_2O_5	0.525	0.555	-0.03	
LAWALG-01	SiO_2	47.7	48.33	-0.62	-1%
LAWALG-01	SnO_2	<0.127	0	0.127	
LAWALG-01	SO_3	1.49	1.705	-0.211	-12%
LAWALG-01	TiO_2	<0.0834	0.069	0.014	
LAWALG-01	V_2O_5	4.00	4.047	-0.044	-1%
LAWALG-01	ZnO	<0.124	0	0.124	
LAWALG-01	ZrO_2	1.99	2.025	-0.036	-2%
LAWALG-01	**Sum of Oxides**	**98.3**	**100**	**-1.691**	**-2%**
LAWALG-02	Al_2O_3	5.47	5.405	0.07	1%
LAWALG-02	B_2O_3	12.5	13.01	-0.529	-4%
LAWALG-02	CaO	9.78	9.751	0.029	0%
LAWALG-02	Cl^-	0.0974	0.119	-0.022	
LAWALG-02	Cr_2O_3	0.0570	0.055	0.002	
LAWALG-02	F^-	0.0855	0.115	-0.03	
LAWALG-02	Fe_2O_3	0.126	0.133	-0.007	
LAWALG-02	K_2O	0.114	0.128	-0.014	
LAWALG-02	Li_2O	<0.215	0	0.215	
LAWALG-02	MgO	0.157	0.145	0.012	
LAWALG-02	Na_2O	19.0	19.6	-0.56	-3%
LAWALG-02	P_2O_5	0.322	0.308	0.014	
LAWALG-02	SiO_2	40.6	41.71	-1.062	-3%
LAWALG-02	SnO_2	<0.127	0	0.127	
LAWALG-02	SO_3	1.37	1.556	-0.19	-12%
LAWALG-02	TiO_2	0.113	0.128	-0.015	
LAWALG-02	V_2O_5	4.03	4.047	-0.012	0%
LAWALG-02	ZnO	<0.124	0	0.124	
LAWALG-02	ZrO_2	3.54	3.783	-0.244	-6%
LAWALG-02	**Sum of Oxides**	**97.9**	**100**	**-2.091**	**-2%**
LAWALG-03	Al_2O_3	5.56	5.469	0.086	2%
LAWALG-03	B_2O_3	6.83	6.968	-0.142	-2%
LAWALG-03	CaO	8.42	8.323	0.1	1%
LAWALG-03	Cl^-	0.0650	0.093	-0.028	
LAWALG-03	Cr_2O_3	0.0758	0.082	-0.006	
LAWALG-03	F^-	0.306	0.382	-0.076	
LAWALG-03	Fe_2O_3	0.111	0.118	-0.007	
LAWALG-03	K_2O	0.0829	0.098	-0.015	
LAWALG-03	Li_2O	<0.215	0	0.215	
LAWALG-03	MgO	0.135	0.124	0.011	
LAWALG-03	Na_2O	21.9	22.32	-0.45	-2%
LAWALG-03	P_2O_5	2.85	3.117	-0.27	-9%
LAWALG-03	SiO_2	38.3	38.35	-0.002	0%

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-03	SnO_2	4.28	4.372	-0.09	-2%
LAWALG-03	SO_3	0.991	1.195	-0.204	-17%
LAWALG-03	TiO_2	0.0977	0.116	-0.018	
LAWALG-03	V_2O_5	2.45	2.473	-0.018	-1%
LAWALG-03	ZnO	<0.124	0	0.124	
LAWALG-03	ZrO_2	5.86	6.386	-0.524	-8%
LAWALG-03	**Sum of Oxides**	**98.7**	**100**	**-1.313**	**-1%**
LAWALG-04	Al_2O_3	8.88	8.642	0.239	3%
LAWALG-04	B_2O_3	8.59	8.757	-0.168	-2%
LAWALG-04	CaO	7.85	7.666	0.184	2%
LAWALG-04	Cl^-	0.137	0.191	-0.054	
LAWALG-04	Cr_2O_3	0.0223	0.026	-0.004	
LAWALG-04	F^-	0.0286	0.036	-0.007	
LAWALG-04	Fe_2O_3	0.0889	0.103	-0.014	
LAWALG-04	K_2O	0.360	0.375	-0.015	
LAWALG-04	Li_2O	<0.215	0	0.215	
LAWALG-04	MgO	0.113	0.114	-0.001	
LAWALG-04	Na_2O	23.2	23.42	-0.203	-1%
LAWALG-04	P_2O_5	<0.229	0.08	0.149	
LAWALG-04	SiO_2	39.7	39.68	0.058	0%
LAWALG-04	SnO_2	4.30	4.377	-0.076	-2%
LAWALG-04	SO_3	0.125	0.126	-0.001	
LAWALG-04	TiO_2	<0.0839	0.097	-0.013	
LAWALG-04	V_2O_5	<0.179	0	0.179	
LAWALG-04	ZnO	<0.124	0	0.124	
LAWALG-04	ZrO_2	6.00	6.298	-0.297	-5%
LAWALG-04	**Sum of Oxides**	**100**	**100**	**0.295**	**0%**
LAWALG-05-1	Al_2O_3	3.61	3.56	0.049	1%
LAWALG-05-1	B_2O_3	13.3	13.62	-0.307	-2%
LAWALG-05-1	CaO	12.4	12.32	0.05	0%
LAWALG-05-1	Cl^-	0.0752	0.109	-0.034	
LAWALG-05-1	Cr_2O_3	0.0435	0.048	-0.005	
LAWALG-05-1	F^-	0.491	0.751	-0.26	
LAWALG-05-1	Fe_2O_3	0.125	0.127	-0.002	
LAWALG-05-1	K_2O	0.130	0.15	-0.02	
LAWALG-05-1	Li_2O	1.62	1.675	-0.057	-3%
LAWALG-05-1	MgO	0.192	0.181	0.011	
LAWALG-05-1	Na_2O	9.39	9.072	0.313	3%
LAWALG-05-1	P_2O_5	0.272	0.258	0.014	
LAWALG-05-1	SiO_2	49.6	50.29	-0.654	-1%
LAWALG-05-1	SnO_2	<0.127	0	0.127	
LAWALG-05-1	SO_3	1.04	1.668	-0.632	-38%
LAWALG-05-1	TiO_2	<0.0834	0.083	0	
LAWALG-05-1	V_2O_5	4.03	4.054	-0.019	0%
LAWALG-05-1	ZnO	<0.124	0	0.124	
LAWALG-05-1	ZrO_2	1.94	2.019	-0.084	-4%
LAWALG-05-1	**Sum of Oxides**	**98.6**	**100**	**-1.385**	**-1%**

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-06	Al_2O_3	6.45	6.266	0.187	3%
LAWALG-06	B_2O_3	10.8	11.09	-0.264	-2%
LAWALG-06	CaO	9.25	8.993	0.259	3%
LAWALG-06	Cl^-	0.0580	0.181	-0.123	
LAWALG-06	Cr_2O_3	0.0699	0.068	0.002	
LAWALG-06	F^-	0.0631	0.088	-0.025	
LAWALG-06	Fe_2O_3	0.145	0.133	0.012	
LAWALG-06	K_2O	0.141	0.148	-0.007	
LAWALG-06	Li_2O	<0.215	0	0.215	
LAWALG-06	MgO	0.166	0.134	0.032	
LAWALG-06	Na_2O	21.4	21.01	0.426	2%
LAWALG-06	P_2O_5	<0.246	0.224	0.022	
LAWALG-06	SiO_2	39.5	39.03	0.438	1%
LAWALG-06	SnO_2	1.44	1.396	0.042	3%
LAWALG-06	SO_3	0.803	1.42	-0.617	-43%
LAWALG-06	TiO_2	0.127	0.136	-0.009	
LAWALG-06	V_2O_5	4.07	4.041	0.025	1%
LAWALG-06	ZnO	<0.124	0	0.124	
LAWALG-06	ZrO_2	5.35	5.63	-0.277	-5%
LAWALG-06	**Sum of Oxides**	**100**	**100**	**0.463**	**0%**
LAWALG-07	Al_2O_3	5.82	5.75	0.074	1%
LAWALG-07	B_2O_3	8.13	8.314	-0.184	-2%
LAWALG-07	CaO	8.14	8.023	0.113	1%
LAWALG-07	Cl^-	0.0271	0.055	-0.028	
LAWALG-07	Cr_2O_3	0.0569	0.063	-0.006	
LAWALG-07	F^-	0.259	0.346	-0.087	
LAWALG-07	Fe_2O_3	0.0917	0.103	-0.011	
LAWALG-07	K_2O	0.0800	0.096	-0.016	
LAWALG-07	Li_2O	<0.215	0	0.215	
LAWALG-07	MgO	0.129	0.119	0.01	
LAWALG-07	Na_2O	22.0	22.86	-0.889	-4%
LAWALG-07	P_2O_5	1.64	1.739	-0.099	-6%
LAWALG-07	SiO_2	39.9	40.1	-0.199	0%
LAWALG-07	SnO_2	4.38	4.371	0.006	0%
LAWALG-07	SO_3	0.757	1.154	-0.397	-34%
LAWALG-07	TiO_2	<0.0834	0.091	-0.008	
LAWALG-07	V_2O_5	0.927	0.971	-0.044	
LAWALG-07	ZnO	<0.124	0	0.124	
LAWALG-07	ZrO_2	5.51	5.833	-0.318	-5%
LAWALG-07	**Sum of Oxides**	**98.2**	**100**	**-1.743**	**-2%**
LAWALG-08	Al_2O_3	3.64	3.574	0.068	2%
LAWALG-08	B_2O_3	13.3	13.68	-0.363	-3%
LAWALG-08	CaO	12.4	12.36	0.072	1%
LAWALG-08	Cl^-	0.0465	0.076	-0.03	
LAWALG-08	Cr_2O_3	0.0251	0.025	0	
LAWALG-08	F^-	0.0599	0.096	-0.036	
LAWALG-08	Fe_2O_3	0.143	0.132	0.011	

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-08	K_2O	0.0703	0.088	-0.018	
LAWALG-08	Li_2O	1.61	1.671	-0.062	-4%
LAWALG-08	MgO	0.198	0.182	0.016	
LAWALG-08	Na_2O	10.2	9.905	0.252	3%
LAWALG-08	P_2O_5	<0.229	0.16	0.069	
LAWALG-08	SiO_2	49.3	50.15	-0.839	-2%
LAWALG-08	SnO_2	<0.127	0	0.127	
LAWALG-08	SO_3	0.868	1.702	-0.834	-49%
LAWALG-08	TiO_2	<0.0834	0.092	-0.009	
LAWALG-08	V_2O_5	4.09	4.072	0.016	0%
LAWALG-08	ZnO	<0.124	0	0.124	
LAWALG-08	ZrO_2	1.92	2.019	-0.097	-5%
LAWALG-08	**Sum of Oxides**	**98.5**	**100**	**-1.53**	**-2%**
LAWALG-09	Al_2O_3	9.23	8.988	0.247	3%
LAWALG-09	B_2O_3	8.22	8.504	-0.285	-3%
LAWALG-09	CaO	8.29	8.058	0.236	3%
LAWALG-09	Cl^-	0.0496	0.086	-0.036	
LAWALG-09	Cr_2O_3	0.178	0.197	-0.019	
LAWALG-09	F^-	0.316	0.407	-0.091	
LAWALG-09	Fe_2O_3	0.134	0.139	-0.005	
LAWALG-09	K_2O	0.209	0.217	-0.008	
LAWALG-09	Li_2O	<0.215	0	0.215	
LAWALG-09	MgO	0.129	0.121	0.008	
LAWALG-09	Na_2O	23.3	22.77	0.48	2%
LAWALG-09	P_2O_5	3.28	3.529	-0.252	-7%
LAWALG-09	SiO_2	35.2	35.56	-0.312	-1%
LAWALG-09	SnO_2	3.87	4.374	-0.508	-12%
LAWALG-09	SO_3	0.270	0.345	-0.075	
LAWALG-09	TiO_2	0.139	0.163	-0.024	
LAWALG-09	V_2O_5	<0.179	0	0.179	
LAWALG-09	ZnO	<0.124	0	0.124	
LAWALG-09	ZrO_2	6.02	6.529	-0.508	-8%
LAWALG-09	**Sum of Oxides**	**99.4**	**100**	**-0.636**	**-1%**
LAWALG-10	Al_2O_3	8.91	8.78	0.134	2%
LAWALG-10	B_2O_3	8.46	8.724	-0.264	-3%
LAWALG-10	CaO	7.86	7.71	0.154	2%
LAWALG-10	Cl^-	0.0569	0.078	-0.021	
LAWALG-10	Cr_2O_3	0.153	0.169	-0.016	
LAWALG-10	F^-	0.0569	0.068	-0.011	
LAWALG-10	Fe_2O_3	0.120	0.125	-0.005	
LAWALG-10	K_2O	0.0693	0.072	-0.003	
LAWALG-10	Li_2O	<0.215	0	0.215	
LAWALG-10	MgO	0.135	0.116	0.019	
LAWALG-10	Na_2O	23.7	23.48	0.178	1%
LAWALG-10	P_2O_5	0.337	0.314	0.023	
LAWALG-10	SiO_2	39.2	39.76	-0.558	-1%
LAWALG-10	SnO_2	4.24	4.381	-0.144	-3%

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-10	SO_3	0.182	0.192	-0.01	
LAWALG-10	TiO_2	0.132	0.141	-0.009	
LAWALG-10	V_2O_5	<0.179	0	0.179	
LAWALG-10	ZnO	<0.124	0	0.124	
LAWALG-10	ZrO_2	5.52	5.878	-0.353	-6%
LAWALG-10	**Sum of Oxides**	**99.6**	**100**	**-0.369**	**0%**
LAWALG-11	Al_2O_3	8.82	8.687	0.137	2%
LAWALG-11	B_2O_3	5.83	6.163	-0.335	-5%
LAWALG-11	CaO	7.51	7.441	0.069	1%
LAWALG-11	Cl^-	0.0709	0.273	-0.202	
LAWALG-11	Cr_2O_3	0.0460	0.045	0.001	
LAWALG-11	F^-	0.0934	0.106	-0.013	
LAWALG-11	Fe_2O_3	0.137	0.143	-0.006	
LAWALG-11	K_2O	2.93	3.156	-0.223	-7%
LAWALG-11	Li_2O	<0.215	0	0.215	
LAWALG-11	MgO	0.122	0.113	0.009	
LAWALG-11	Na_2O	21.2	22.04	-0.873	-4%
LAWALG-11	P_2O_5	<0.229	0.13	0.099	
LAWALG-11	SiO_2	36.7	36.17	0.515	1%
LAWALG-11	SnO_2	4.36	4.378	-0.014	0%
LAWALG-11	SO_3	0.488	0.572	-0.084	
LAWALG-11	TiO_2	0.161	0.18	-0.019	
LAWALG-11	V_2O_5	<0.179	0	0.179	
LAWALG-11	ZnO	3.91	3.843	0.072	2%
LAWALG-11	ZrO_2	6.23	6.548	-0.317	-5%
LAWALG-11	**Sum of Oxides**	**99.2**	**100**	**-0.789**	**-1%**
LAWALG-12	Al_2O_3	3.58	3.56	0.021	1%
LAWALG-12	B_2O_3	13.0	12.92	0.081	1%
LAWALG-12	CaO	11.1	11.02	0.047	0%
LAWALG-12	Cl^-	0.0435	0.06	-0.017	
LAWALG-12	Cr_2O_3	0.0487	0.052	-0.003	
LAWALG-12	F^-	1.01	1.362	-0.35	-26%
LAWALG-12	Fe_2O_3	0.108	0.116	-0.008	
LAWALG-12	K_2O	<0.0617	0.081	-0.019	
LAWALG-12	Li_2O	<0.215	0	0.215	
LAWALG-12	MgO	0.177	0.162	0.015	
LAWALG-12	Na_2O	17.0	17.24	-0.218	-1%
LAWALG-12	P_2O_5	2.15	2.172	-0.027	-1%
LAWALG-12	SiO_2	43.9	43.48	0.433	1%
LAWALG-12	SnO_2	<0.127	0	0.127	
LAWALG-12	SO_3	1.07	1.63	-0.556	-34%
LAWALG-12	TiO_2	<0.0834	0.078	0.005	
LAWALG-12	V_2O_5	4.04	4.032	0.007	0%
LAWALG-12	ZnO	<0.124	0	0.124	
LAWALG-12	ZrO_2	2.03	2.024	0.009	0%
LAWALG-12	**Sum of Oxides**	**99.9**	**100**	**-0.112**	**0%**
LAWALG-13	Al_2O_3	3.56	3.582	-0.025	-1%

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-13	B_2O_3	13.6	13.61	-0.026	0%
LAWALG-13	CaO	12.1	12.32	-0.214	-2%
LAWALG-13	Cl^-	0.0623	0.079	-0.017	
LAWALG-13	Cr_2O_3	0.0324	0.035	-0.003	
LAWALG-13	F^-	0.266	0.404	-0.138	
LAWALG-13	Fe_2O_3	0.107	0.116	-0.009	
LAWALG-13	K_2O	<0.0602	0.073	-0.013	
LAWALG-13	Li_2O	1.15	1.139	0.013	1%
LAWALG-13	MgO	0.195	0.18	0.015	
LAWALG-13	Na_2O	13.2	13.48	-0.283	-2%
LAWALG-13	P_2O_5	0.899	0.925	-0.026	
LAWALG-13	SiO_2	46.6	46.19	0.397	1%
LAWALG-13	SnO_2	<0.127	0	0.127	
LAWALG-13	SO_3	1.03	1.717	-0.685	-40%
LAWALG-13	TiO_2	<0.0834	0.061	0.022	
LAWALG-13	V_2O_5	4.00	4.053	-0.05	-1%
LAWALG-13	ZnO	<0.124	0	0.124	
LAWALG-13	ZrO_2	1.96	2.024	-0.062	-3%
LAWALG-13	**Sum of Oxides**	**99.2**	**100**	**-0.851**	**-1%**
LAWALG-14	Al_2O_3	3.70	3.572	0.127	4%
LAWALG-14	B_2O_3	13.1	13.63	-0.512	-4%
LAWALG-14	CaO	12.4	12.15	0.251	2%
LAWALG-14	Cl^-	0.0945	0.12	-0.026	
LAWALG-14	Cr_2O_3	0.0416	0.047	-0.005	
LAWALG-14	F^-	0.144	0.211	-0.068	
LAWALG-14	Fe_2O_3	0.130	0.128	0.002	
LAWALG-14	K_2O	0.0969	0.112	-0.015	
LAWALG-14	Li_2O	0.689	0.815	-0.126	
LAWALG-14	MgO	0.198	0.179	0.019	
LAWALG-14	Na_2O	15.7	15.2	0.502	3%
LAWALG-14	P_2O_5	<0.229	0.162	0.067	
LAWALG-14	SiO_2	44.5	45.79	-1.294	-3%
LAWALG-14	SnO_2	<0.127	0	0.127	
LAWALG-14	SO_3	1.40	1.702	-0.302	-18%
LAWALG-14	TiO_2	<0.0834	0.087	-0.004	
LAWALG-14	V_2O_5	4.07	4.058	0.012	0%
LAWALG-14	ZnO	<0.124	0	0.124	
LAWALG-14	ZrO_2	1.90	2.023	-0.122	-6%
LAWALG-14	**Sum of Oxides**	**98.7**	**100**	**-1.24**	**-1%**
LAWALG-15	Al_2O_3	9.03	8.855	0.177	2%
LAWALG-15	B_2O_3	8.64	8.766	-0.129	-1%
LAWALG-15	CaO	7.86	7.714	0.146	2%
LAWALG-15	Cl^-	0.118	0.145	-0.028	
LAWALG-15	Cr_2O_3	0.0511	0.058	-0.007	
LAWALG-15	F^-	0.0506	0.05	0.001	
LAWALG-15	Fe_2O_3	0.136	0.153	-0.017	
LAWALG-15	K_2O	0.166	0.167	-0.001	

Table A-4. Comparison of Measured versus Target Compositions (continued)

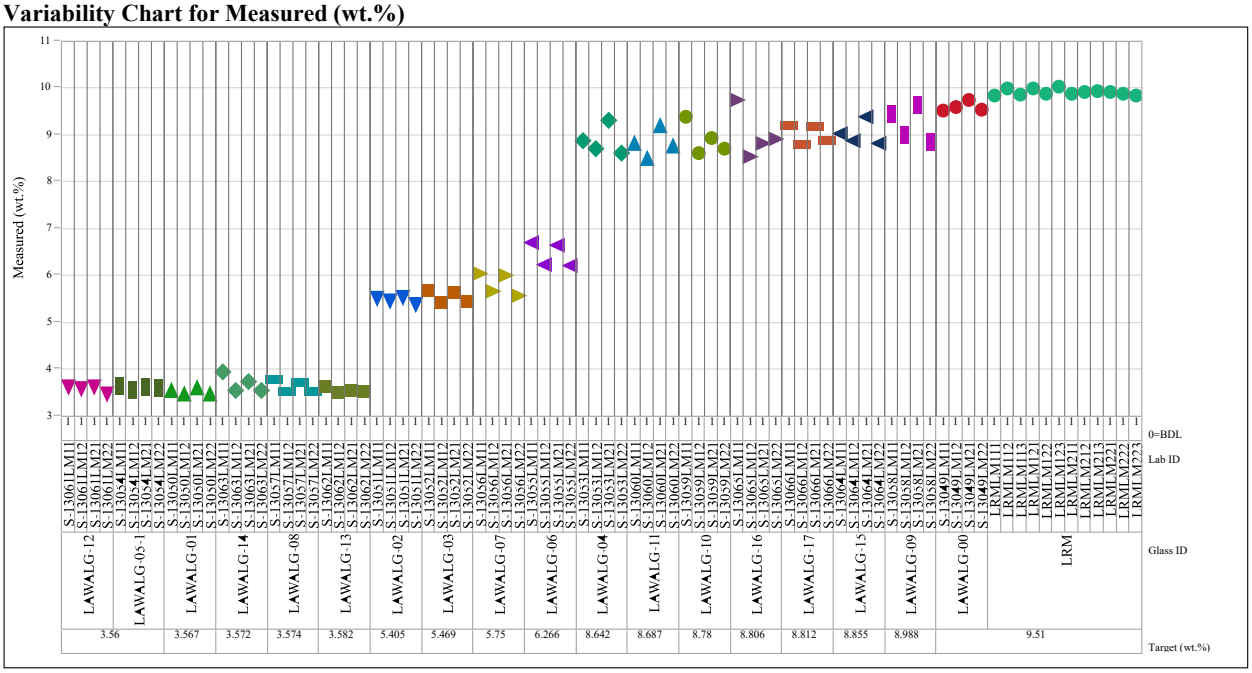
PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-15	Li_2O	<0.215	0	0.215	
LAWALG-15	MgO	0.125	0.118	0.007	
LAWALG-15	Na_2O	23.9	23.38	0.485	2%
LAWALG-15	P_2O_5	0.339	0.316	0.023	
LAWALG-15	SiO_2	39.4	38.94	0.42	1%
LAWALG-15	SnO_2	4.21	4.382	-0.173	-4%
LAWALG-15	SO_3	0.864	0.991	-0.127	
LAWALG-15	TiO_2	0.173	0.196	-0.023	
LAWALG-15	V_2O_5	<0.179	0	0.179	
LAWALG-15	ZnO	<0.124	0	0.124	
LAWALG-15	ZrO_2	5.45	5.759	-0.305	-5%
LAWALG-15	**Sum of Oxides**	**101**	**100**	**0.966**	**1%**
LAWALG-16	Al_2O_3	9.01	8.806	0.202	2%
LAWALG-16	B_2O_3	8.09	8.321	-0.231	-3%
LAWALG-16	CaO	7.93	7.731	0.195	3%
LAWALG-16	Cl^-	0.0837	0.113	-0.029	
LAWALG-16	Cr_2O_3	0.538	0.607	-0.069	
LAWALG-16	F^-	0.0642	0.071	-0.007	
LAWALG-16	Fe_2O_3	0.115	0.128	-0.013	
LAWALG-16	K_2O	0.0702	0.077	-0.007	
LAWALG-16	Li_2O	<0.215	0	0.215	
LAWALG-16	MgO	0.123	0.117	0.006	
LAWALG-16	Na_2O	24.0	23.43	0.596	3%
LAWALG-16	P_2O_5	0.552	0.541	0.011	
LAWALG-16	SiO_2	39.4	39.68	-0.267	-1%
LAWALG-16	SnO_2	4.25	4.381	-0.131	-3%
LAWALG-16	SO_3	0.153	0.163	-0.01	
LAWALG-16	TiO_2	0.132	0.146	-0.014	
LAWALG-16	V_2O_5	<0.179	0	0.179	
LAWALG-16	ZnO	<0.124	0	0.124	
LAWALG-16	ZrO_2	5.36	5.671	-0.315	-6%
LAWALG-16	**Sum of Oxides**	**100**	**100**	**0.436**	**0%**
LAWALG-17	Al_2O_3	9.02	8.812	0.206	2%
LAWALG-17	B_2O_3	8.07	8.326	-0.252	-3%
LAWALG-17	CaO	7.79	7.676	0.114	1%
LAWALG-17	Cl^-	0.530	0.797	-0.267	
LAWALG-17	Cr_2O_3	0.0782	0.088	-0.01	
LAWALG-17	F^-	0.281	0.32	-0.039	
LAWALG-17	Fe_2O_3	0.141	0.15	-0.009	
LAWALG-17	K_2O	0.554	0.585	-0.031	
LAWALG-17	Li_2O	<0.215	0	0.215	
LAWALG-17	MgO	0.123	0.117	0.006	
LAWALG-17	Na_2O	22.5	23.06	-0.517	-2%
LAWALG-17	P_2O_5	<0.229	0.159	0.07	
LAWALG-17	SiO_2	38.0	38.29	-0.317	-1%
LAWALG-17	SnO_2	4.32	4.361	-0.041	-1%
LAWALG-17	SO_3	0.666	0.772	-0.106	

Table A-4. Comparison of Measured versus Target Compositions (continued)

PNNL ID	Oxide	Mean Measurement (wt.%)	Target (wt.%)	Difference of Measured versus Target	% Difference Measured versus Target
LAWALG-17	TiO_2	0.167	0.189	-0.022	
LAWALG-17	V_2O_5	<0.179	0	0.179	
LAWALG-17	ZnO	<0.124	0	0.124	
LAWALG-17	ZrO_2	5.95	6.283	-0.333	-5%
LAWALG-17	**Sum of Oxides**	**99.0**	**100**	**-1.029**	**-1%**

Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations

Oxide=Al_2O_3, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=B_2O_3, Prep Method=PF
Variability Chart for Measured (wt.%)

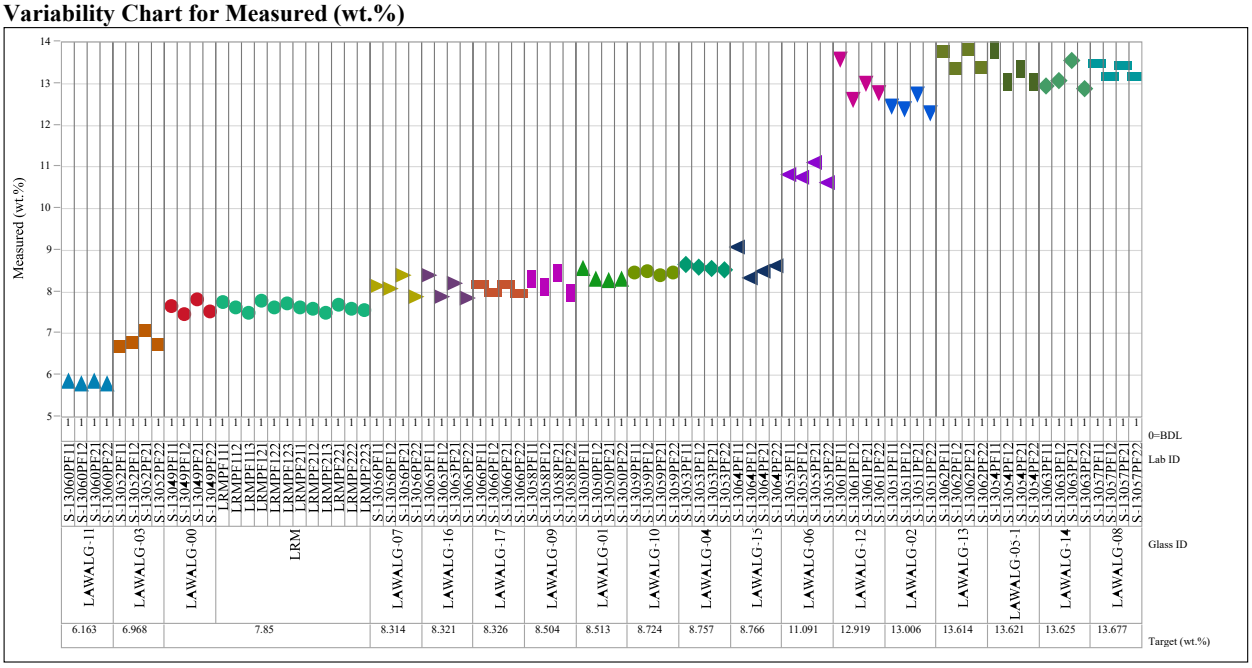
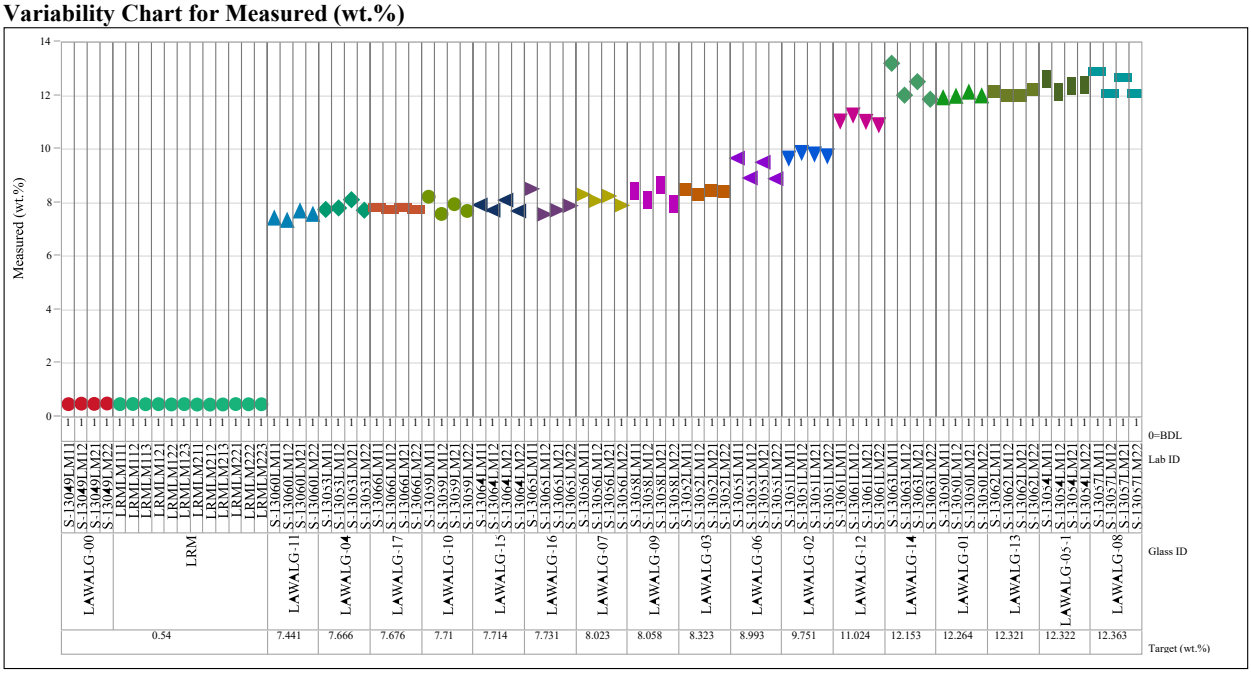


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=CaO, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=Cl⁻, Prep Method=KH
Variability Chart for Measured (wt.%)

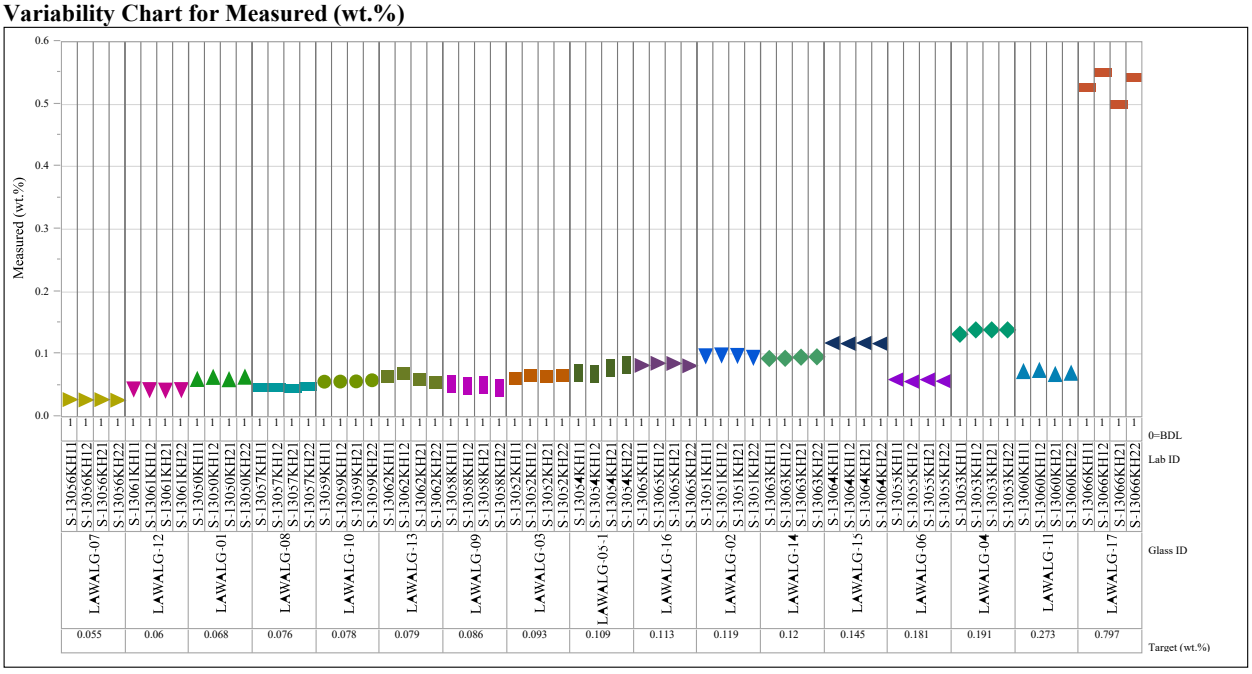
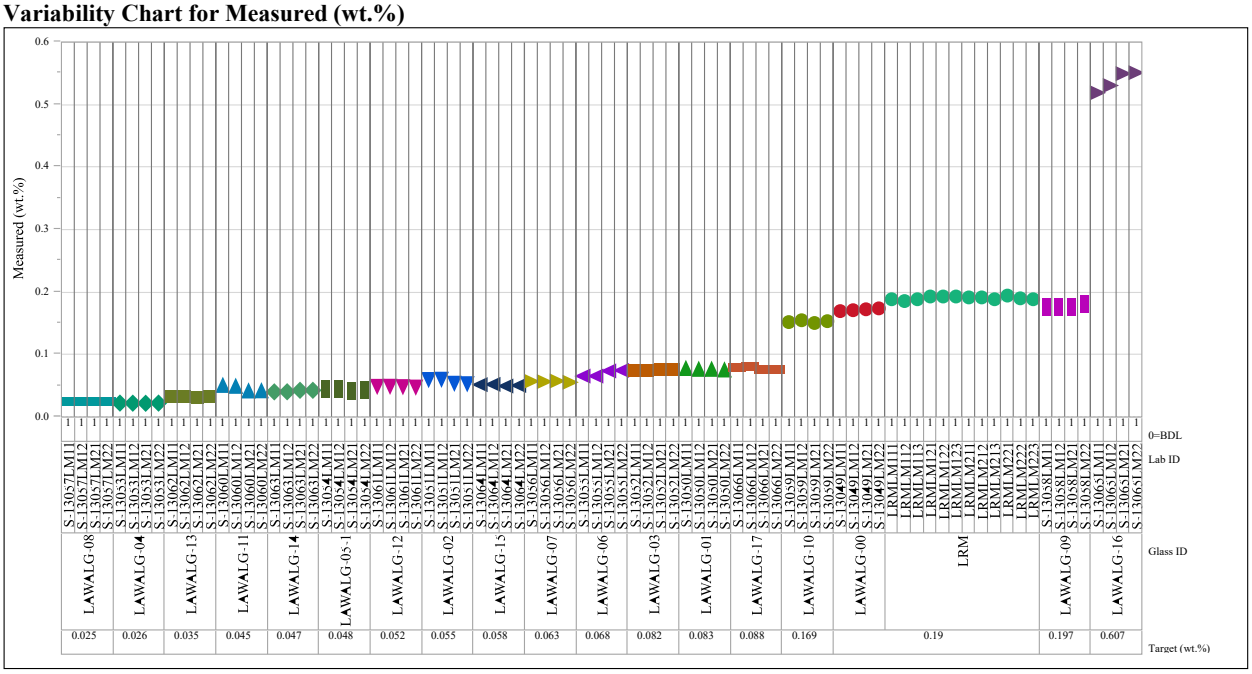


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=Cr_2O_3, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=F^-, Prep Method=KH
Variability Chart for Measured (wt.%)

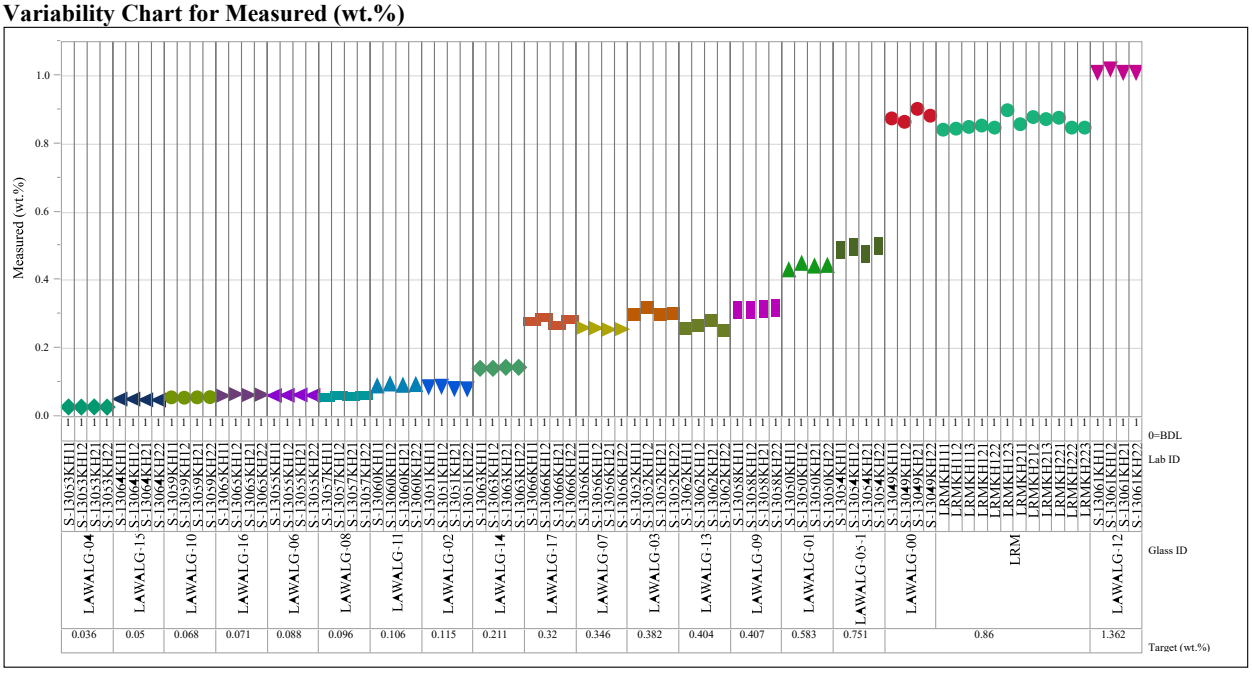
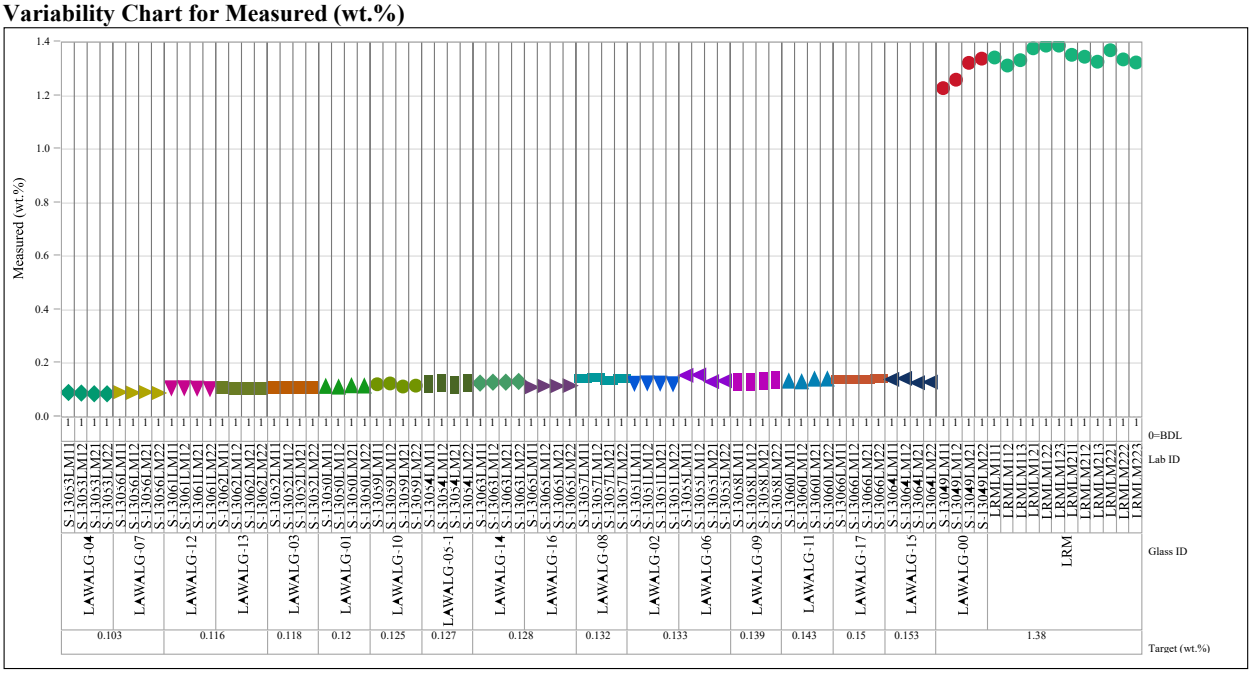


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=Fe_2O_3, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=K_2O, Prep Method=LM
Variability Chart for Measured (wt.%)

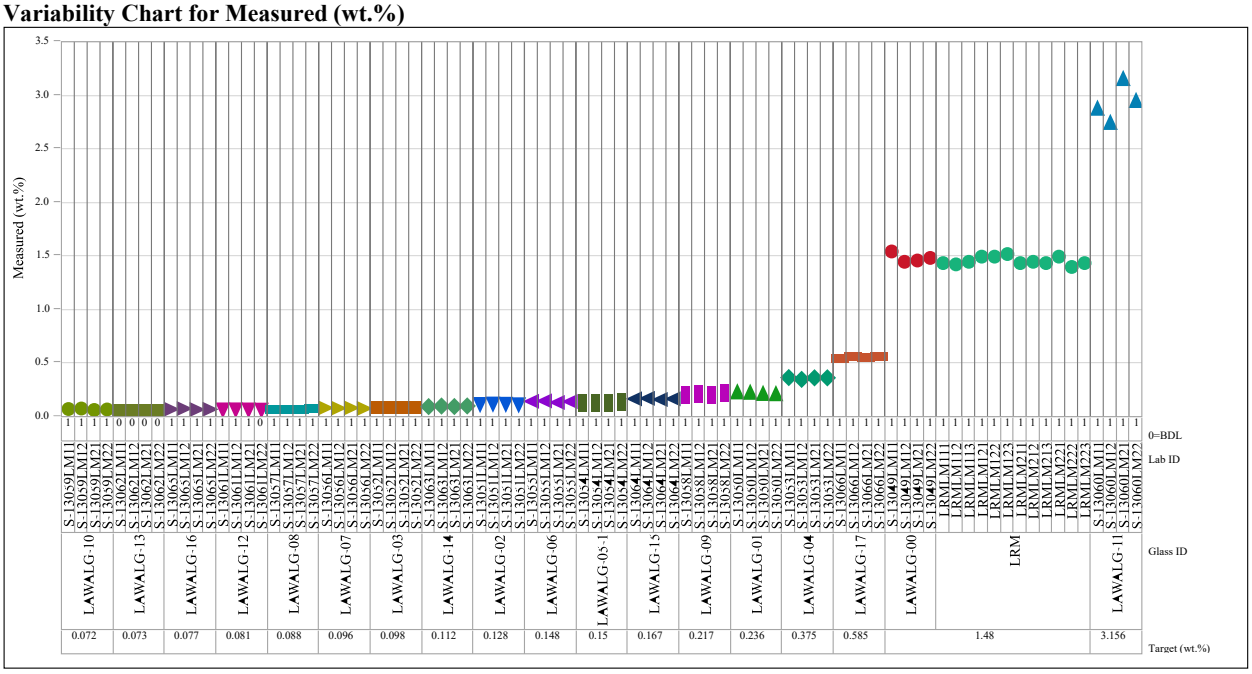
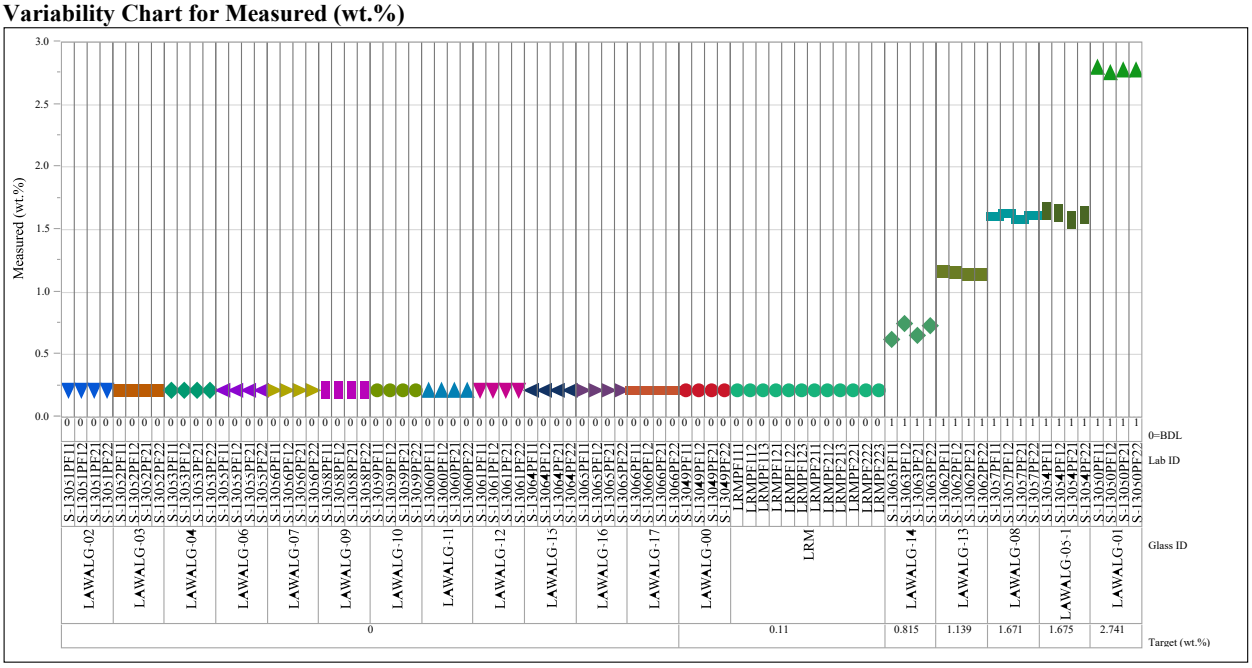


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=Li_2O, Prep Method=PF
Variability Chart for Measured (wt.%)



Oxide=MgO, Prep Method=LM
Variability Chart for Measured (wt.%)

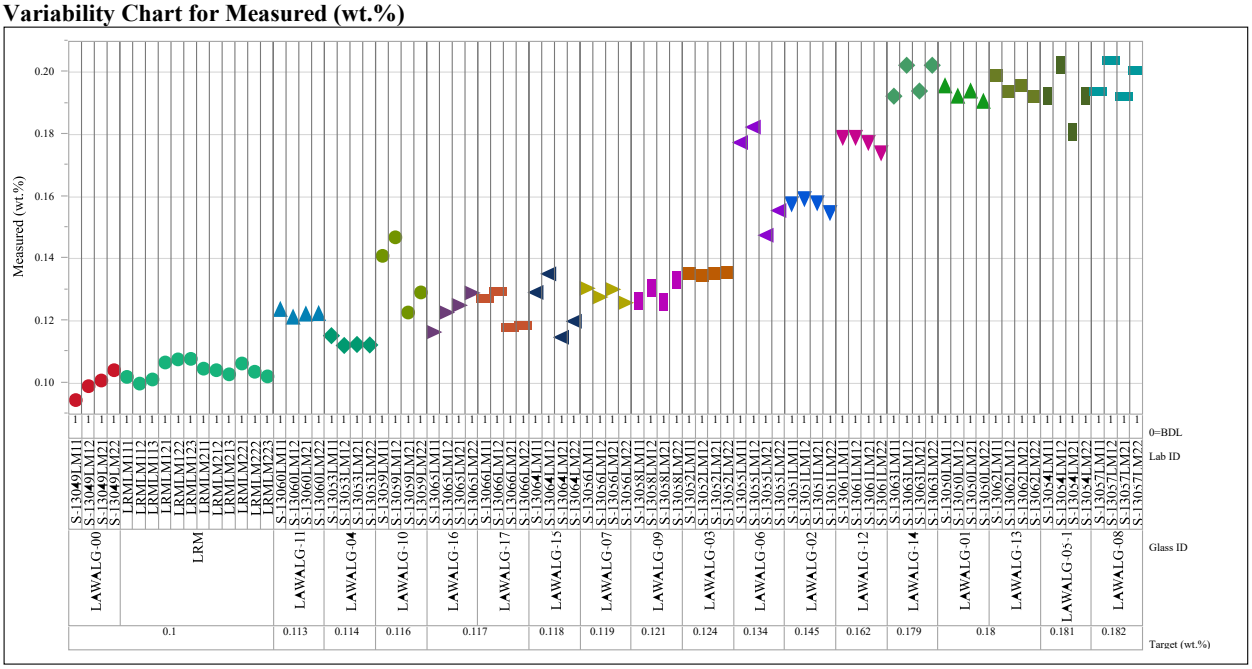
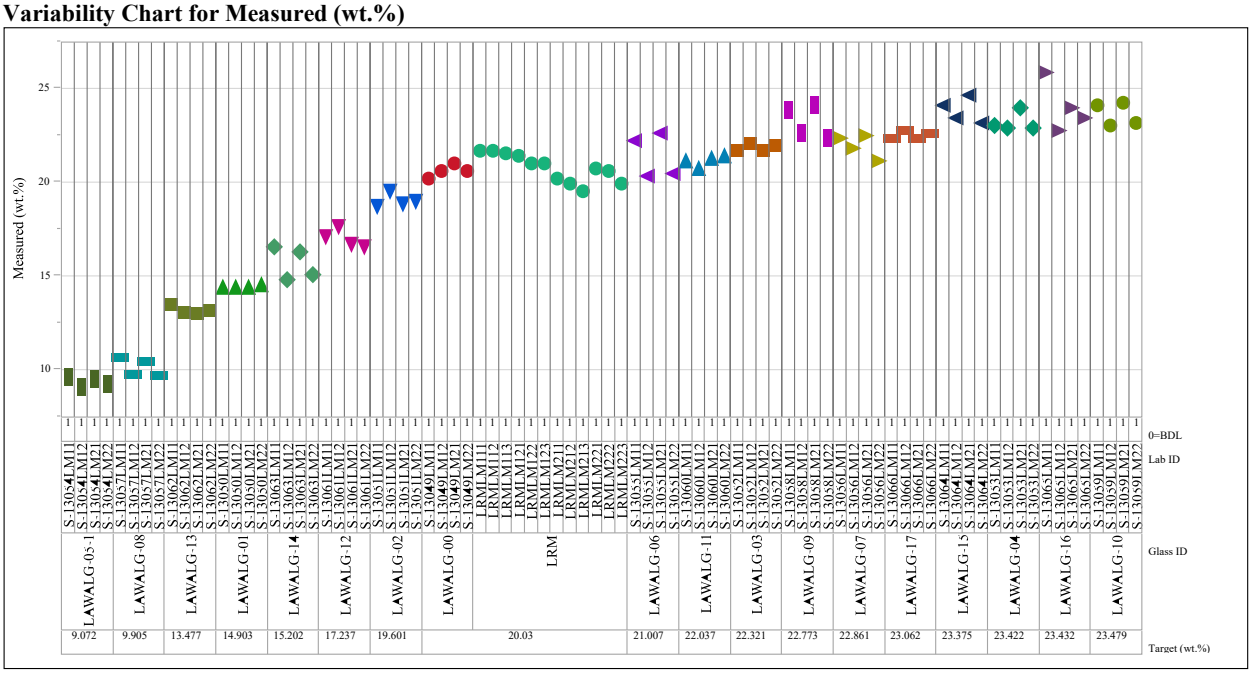


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=Na_2O, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=P_2O_5, Prep Method=PF
Variability Chart for Measured (wt.%)

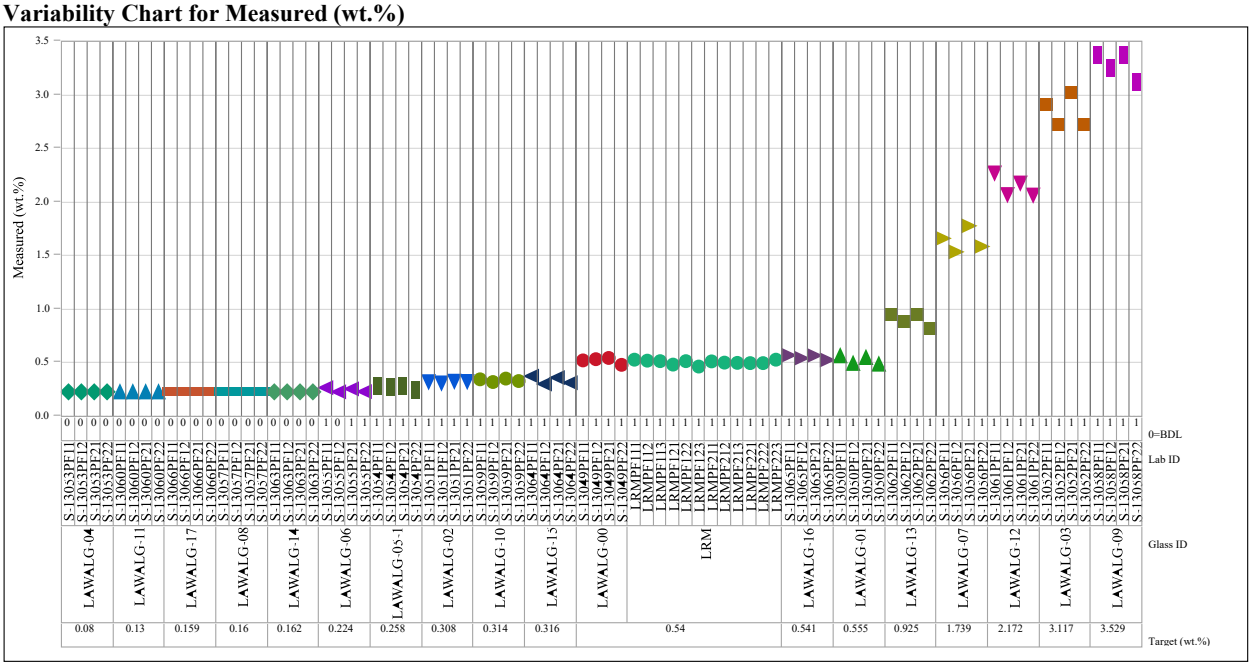
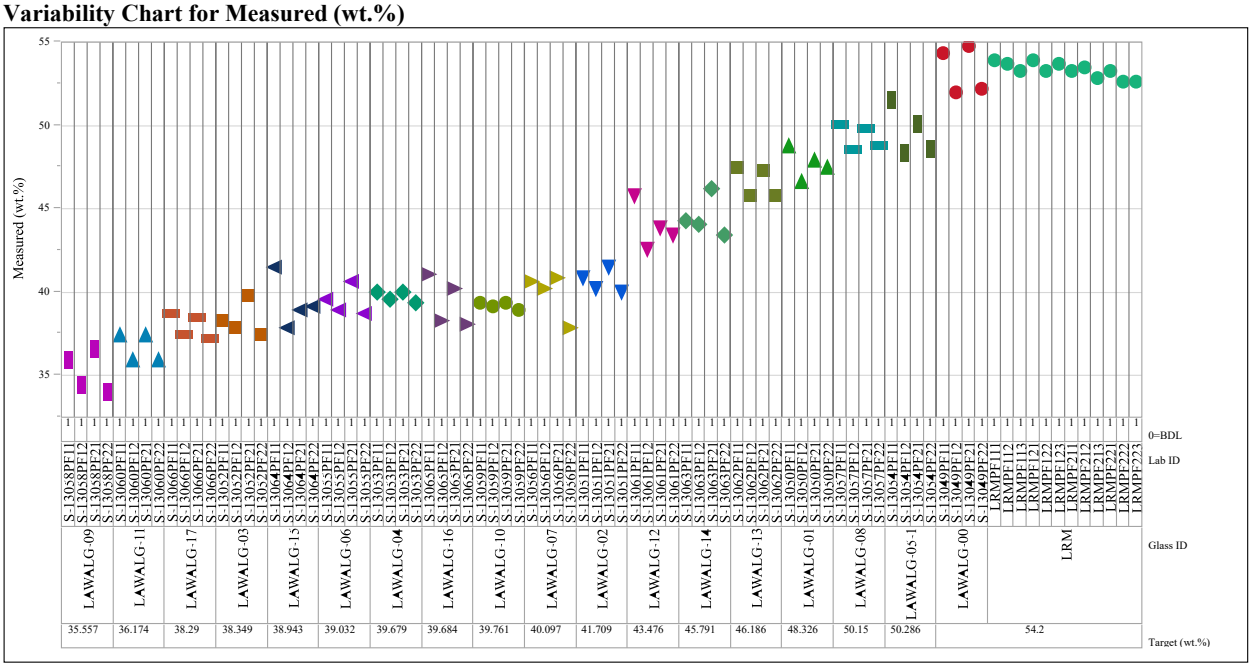


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=SiO_2, Prep Method=PF
Variability Chart for Measured (wt.%)



Oxide=SnO_2, Prep Method=LM
Variability Chart for Measured (wt.%)

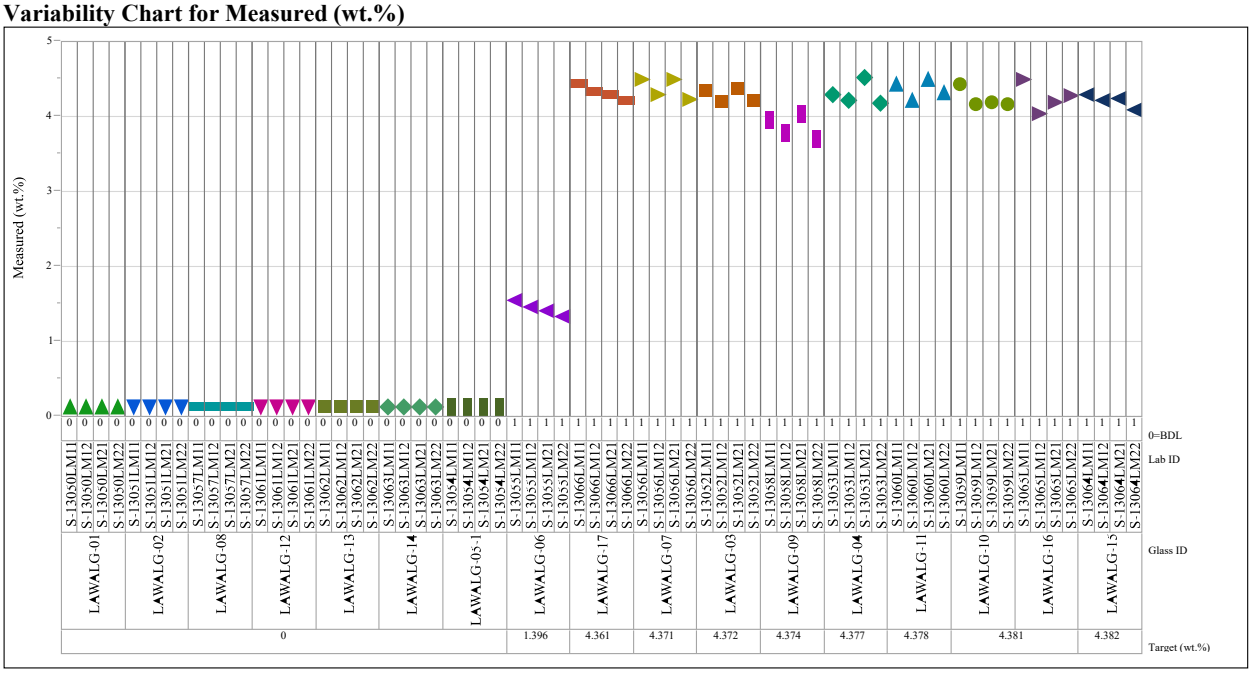
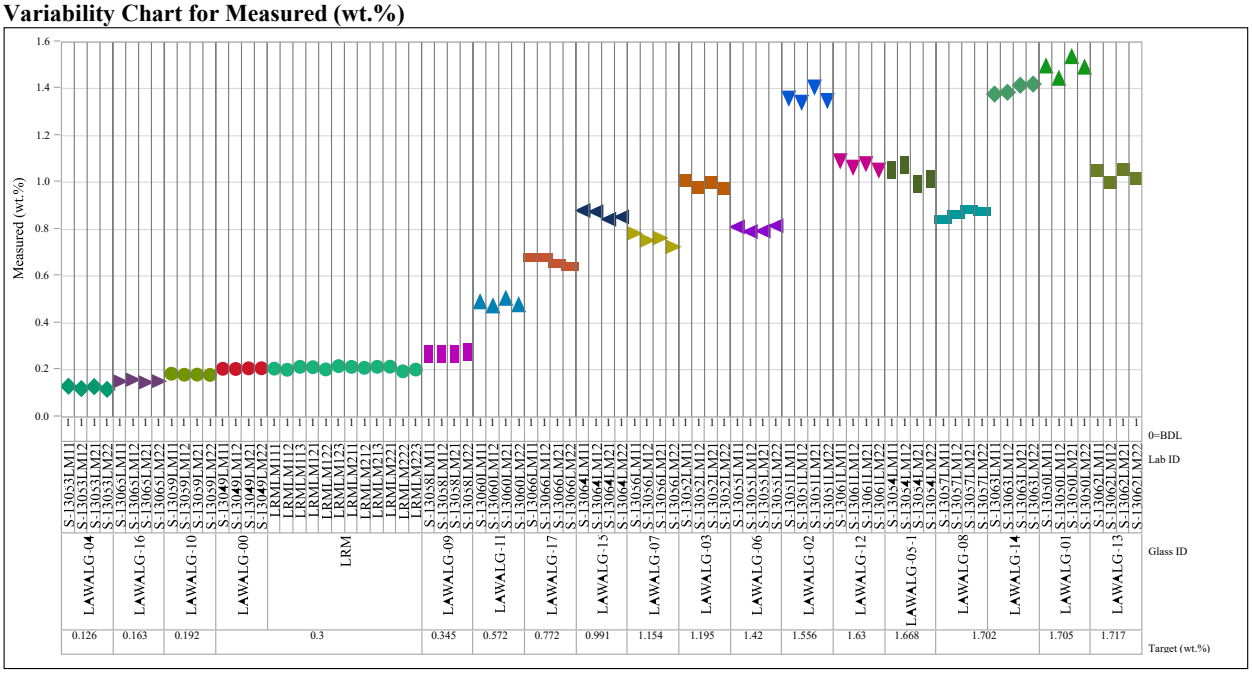


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=SO_3, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=TiO_2, Prep Method=LM
Variability Chart for Measured (wt.%)

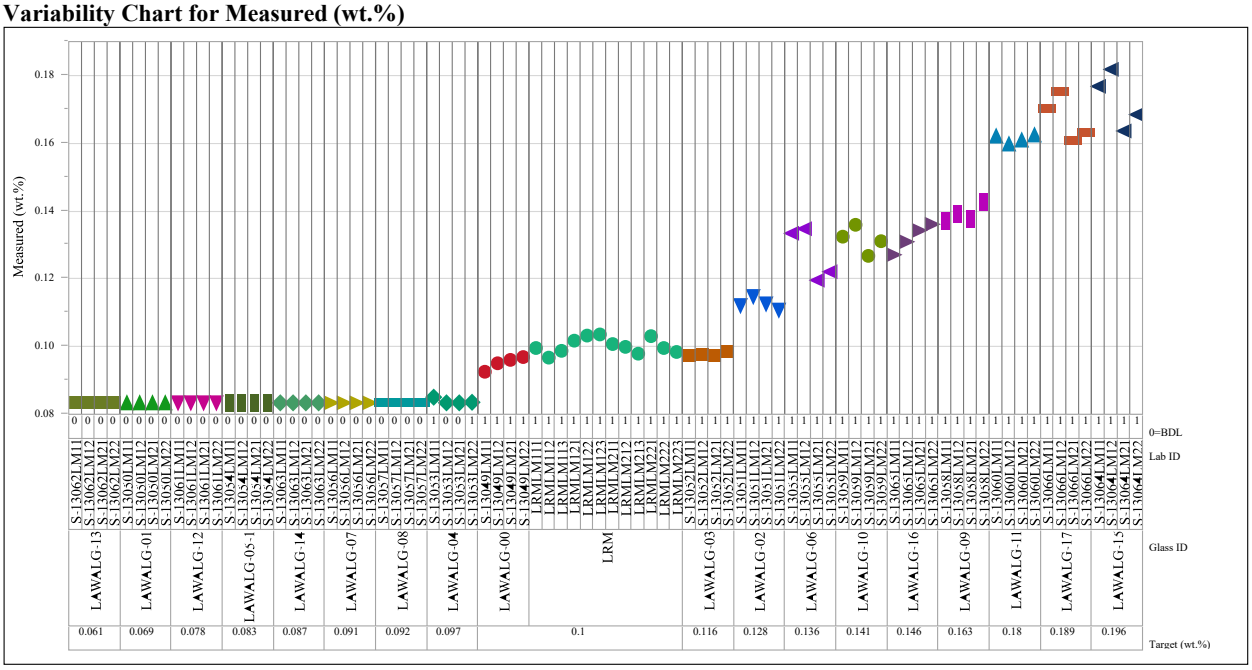
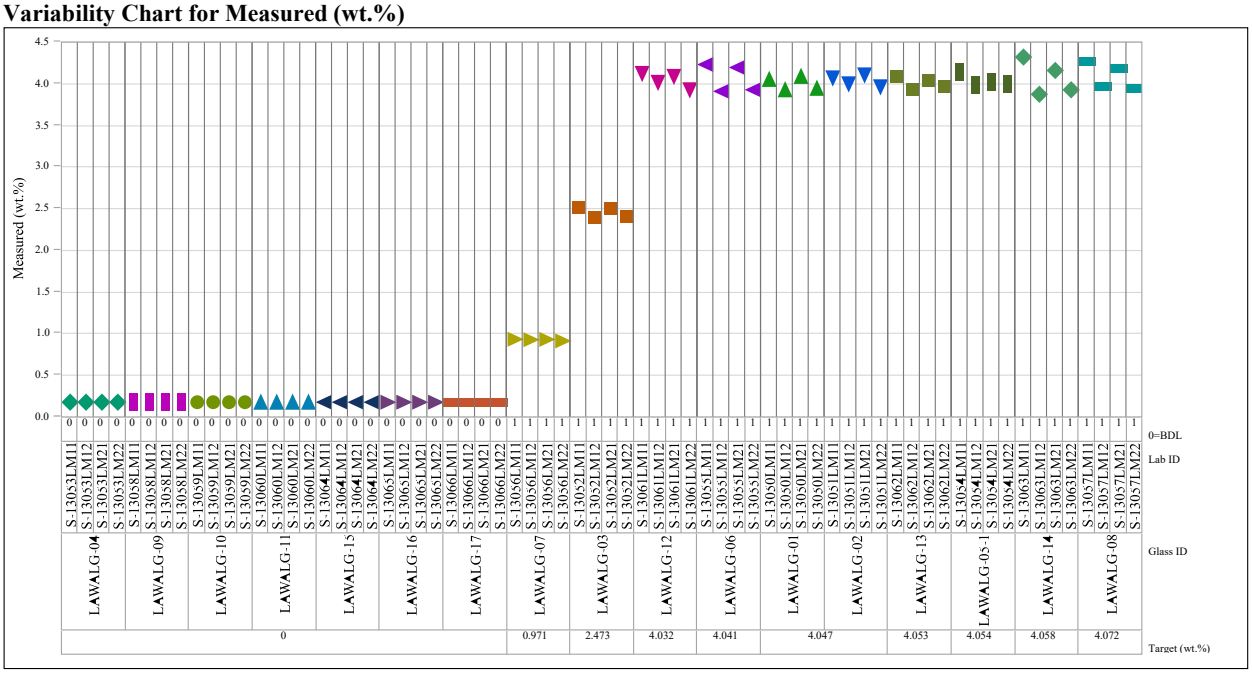


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=V_2O_5, Prep Method=LM
Variability Chart for Measured (wt.%)



Oxide=ZnO, Prep Method=LM
Variability Chart for Measured (wt.%)

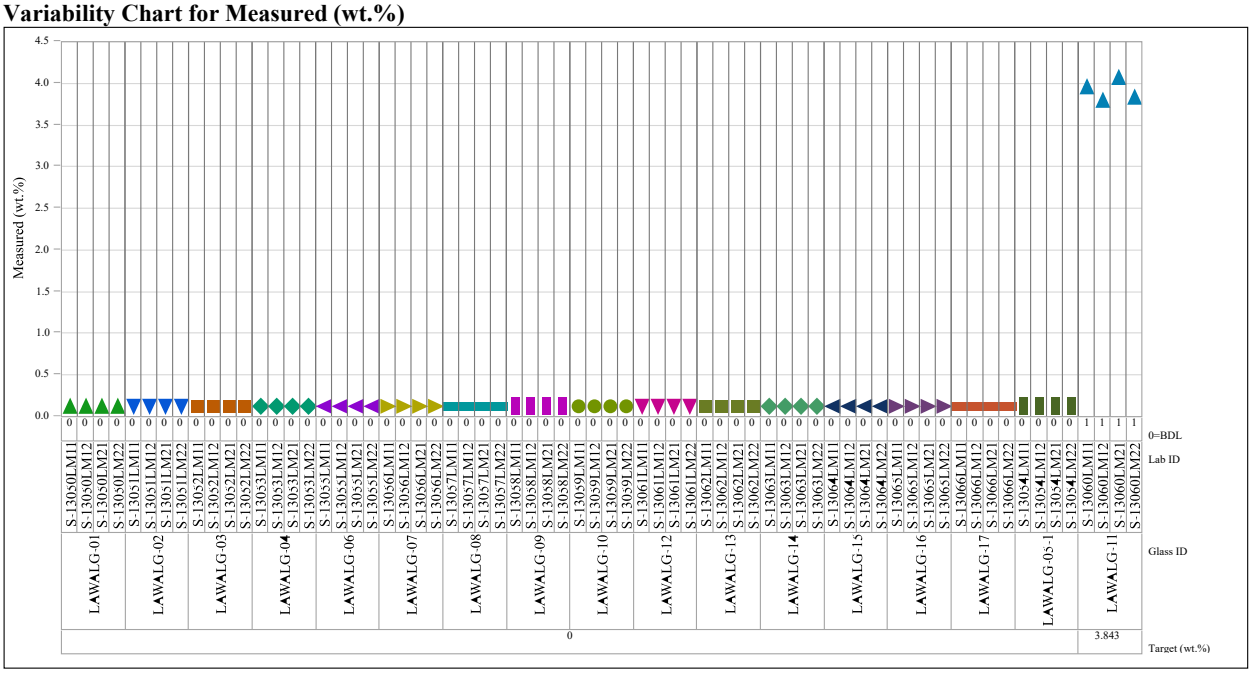


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=ZrO_2, Prep Method=PF
Variability Chart for Measured (wt.%)

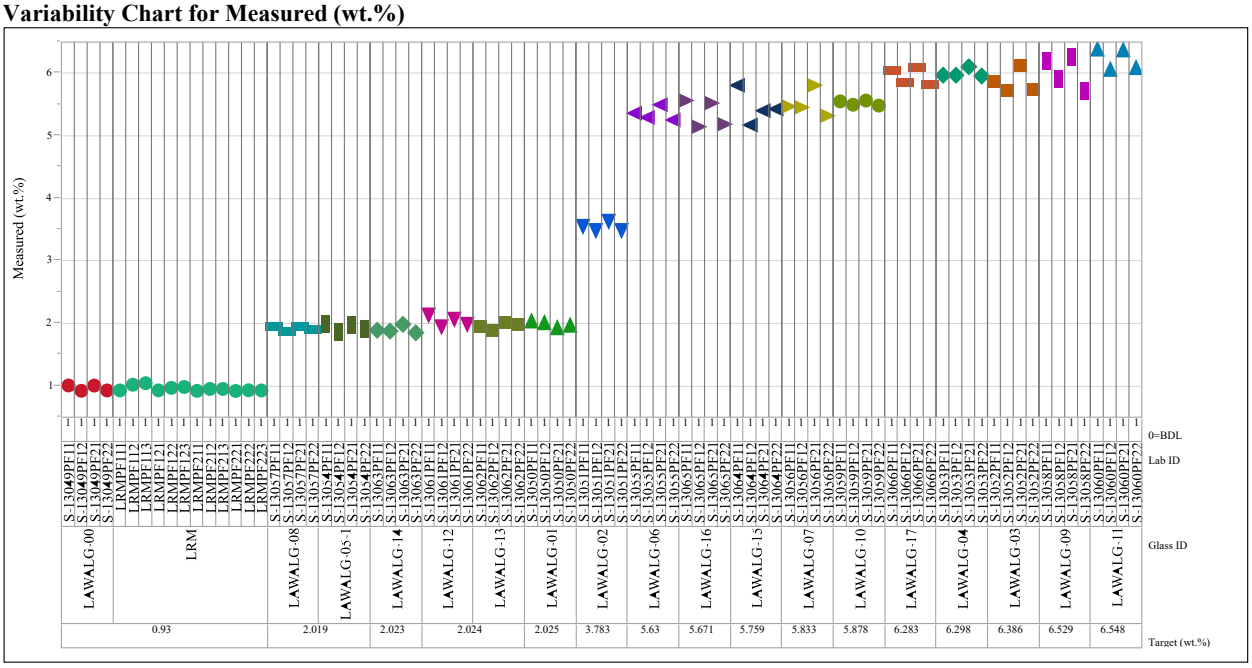
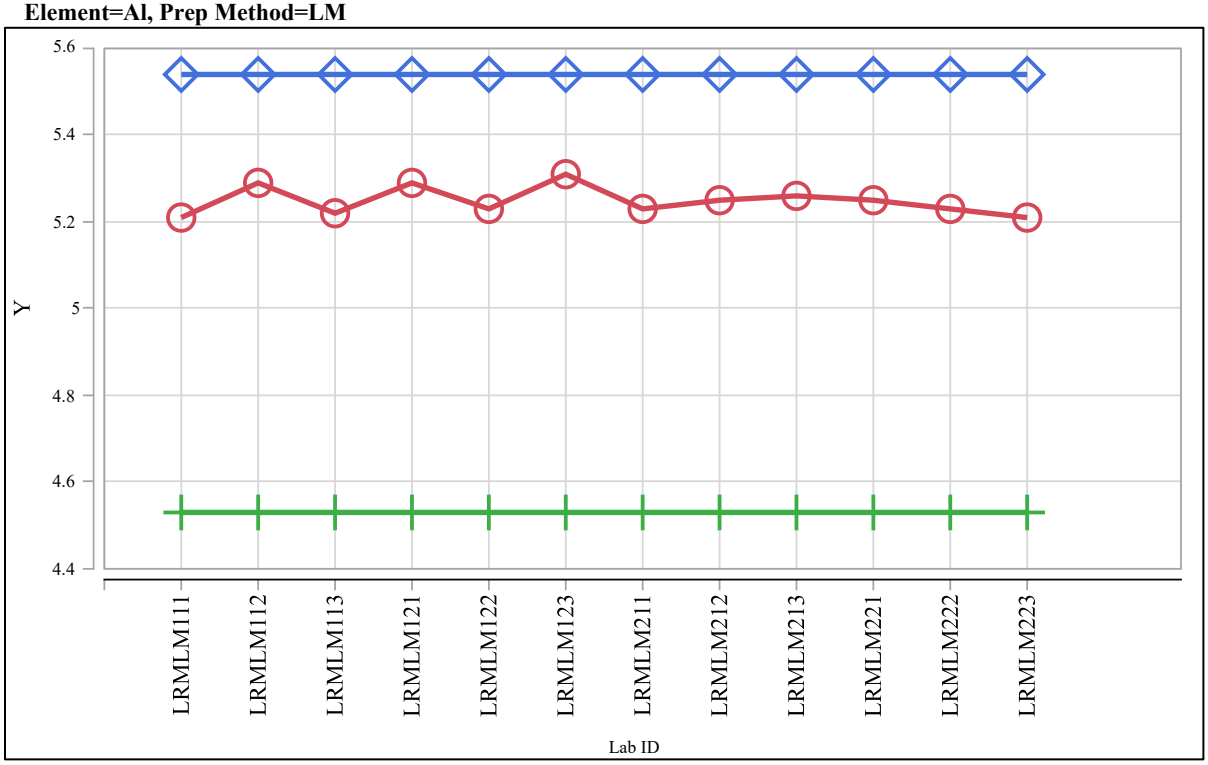


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass

Element=Al, Prep Method=LM



Element=B, Prep Method=PF

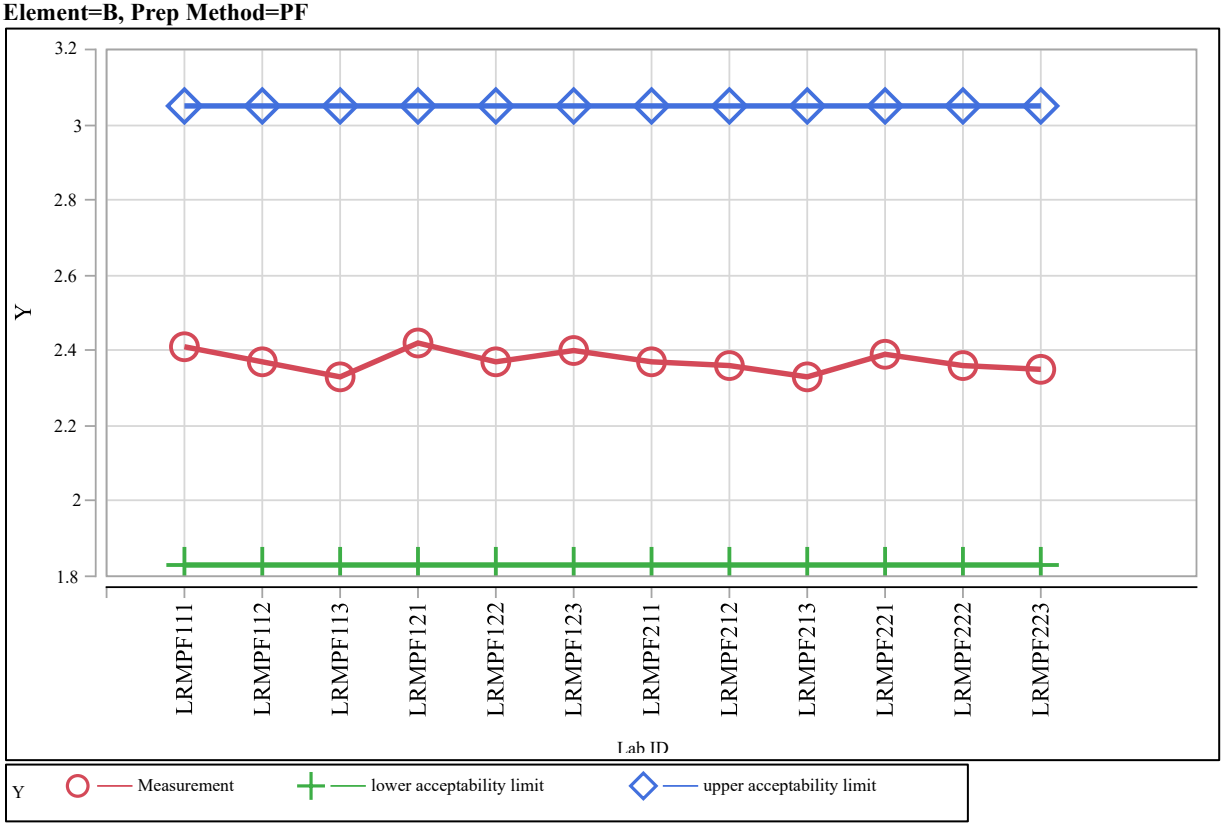
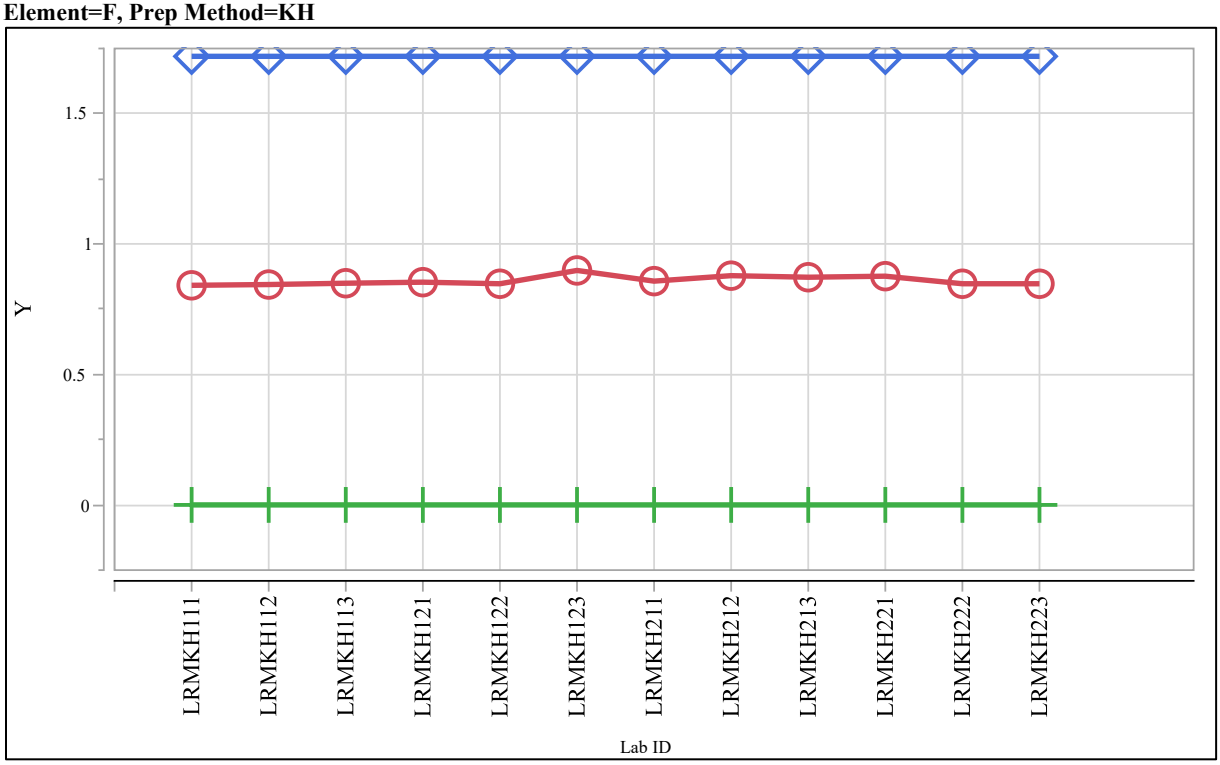


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=F, Prep Method=KH



Element=Fe, Prep Method=LM

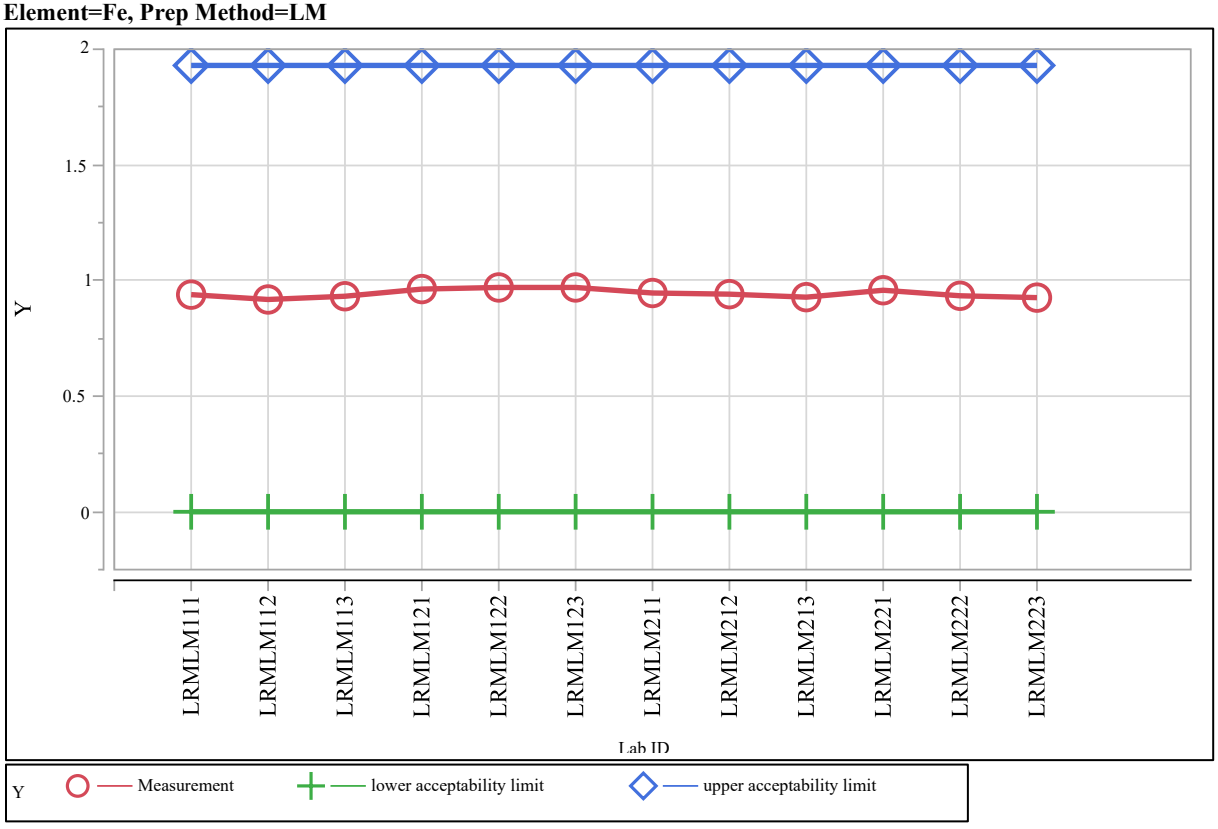
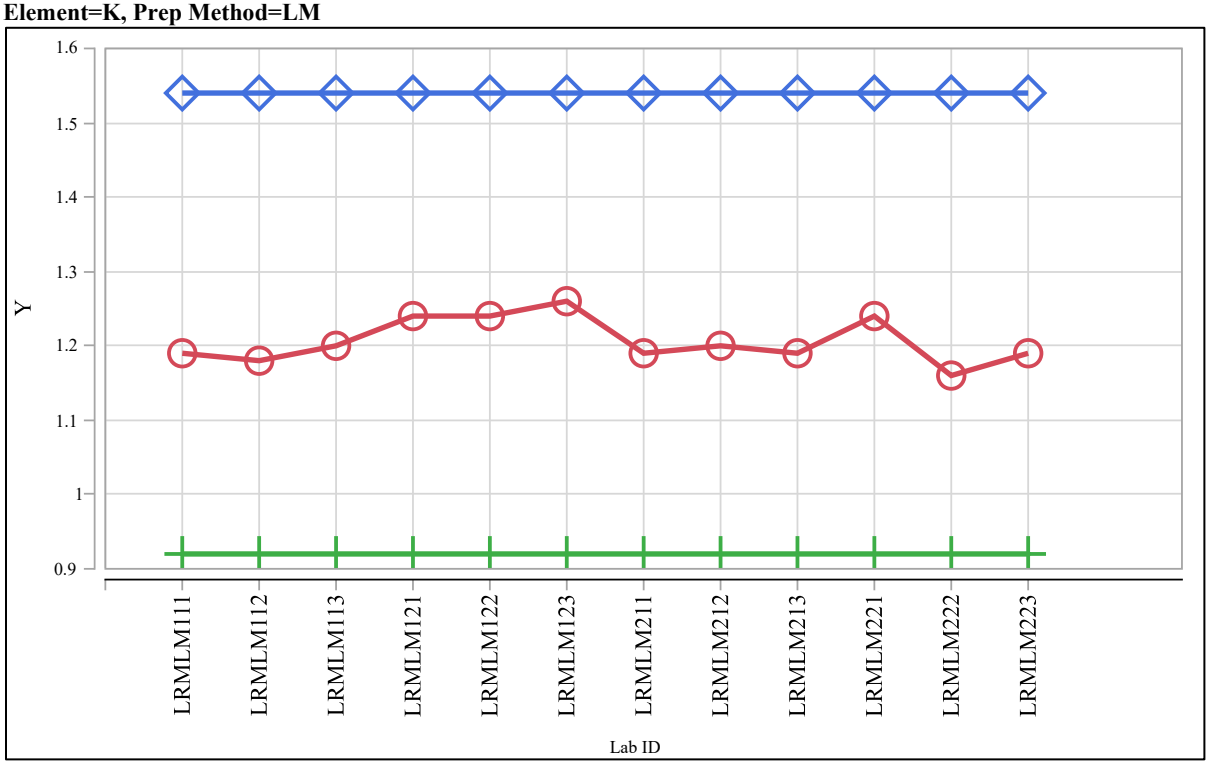


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=K, Prep Method=LM



Element=Na, Prep Method=LM

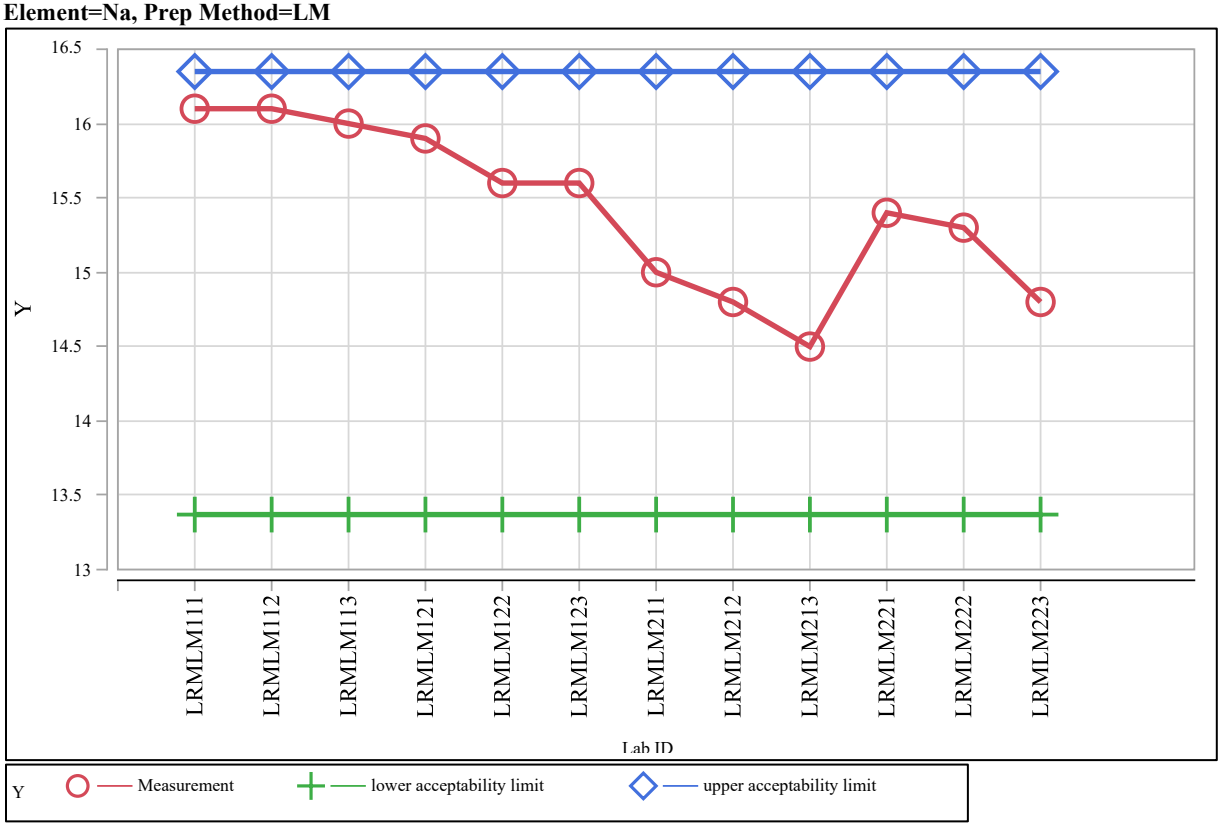
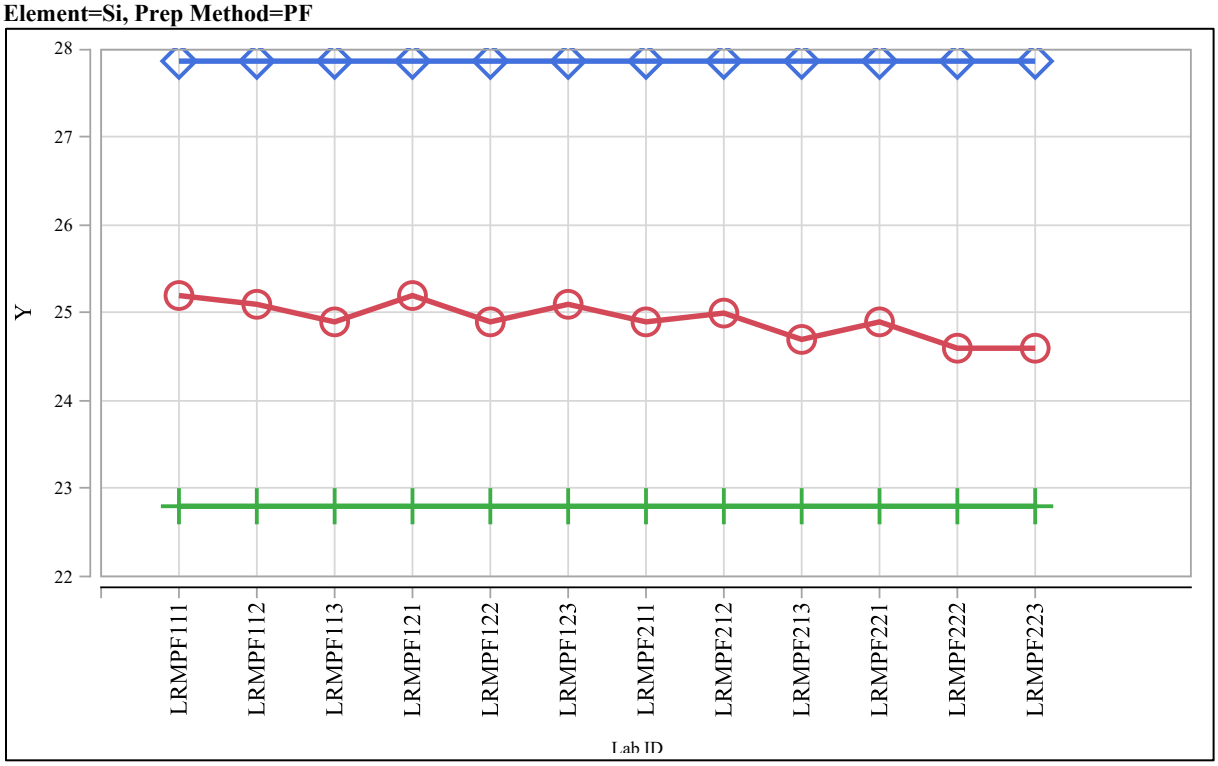


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=Si, Prep Method=PF



Element=Zr, Prep Method=PF

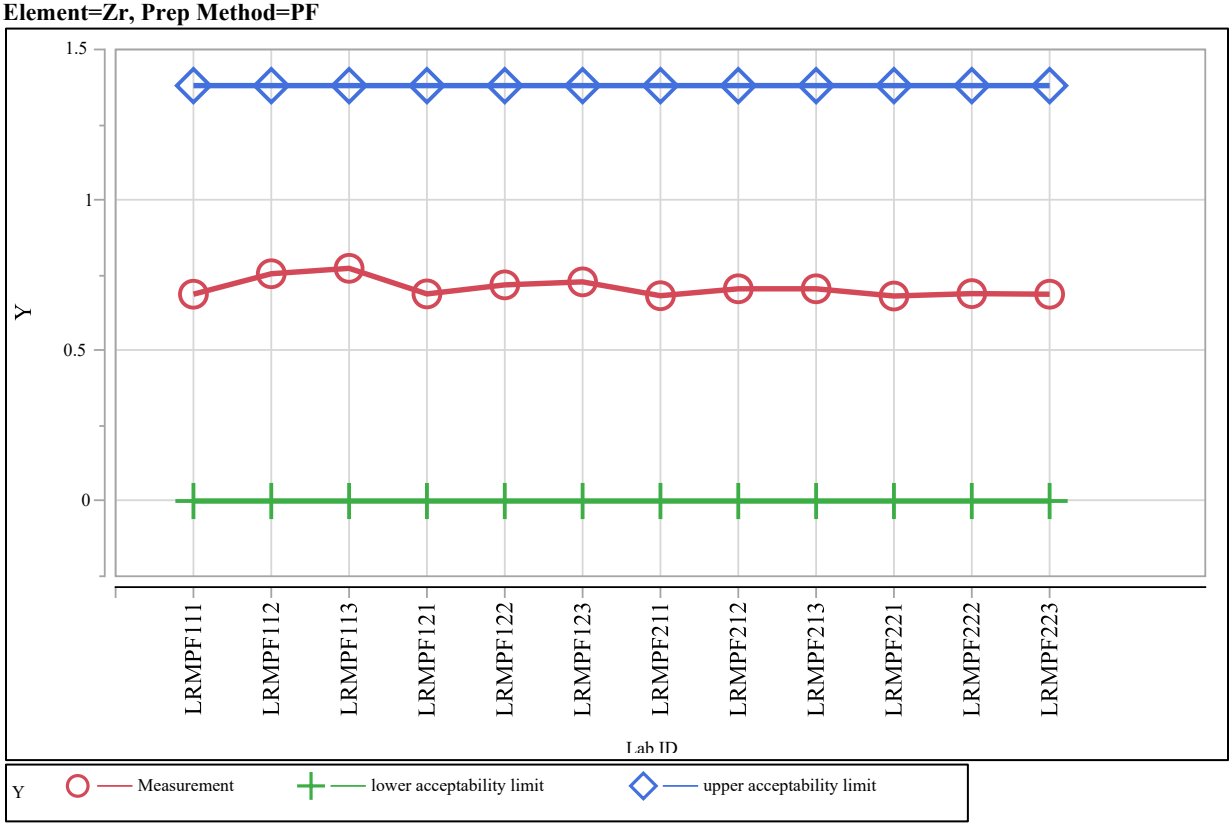
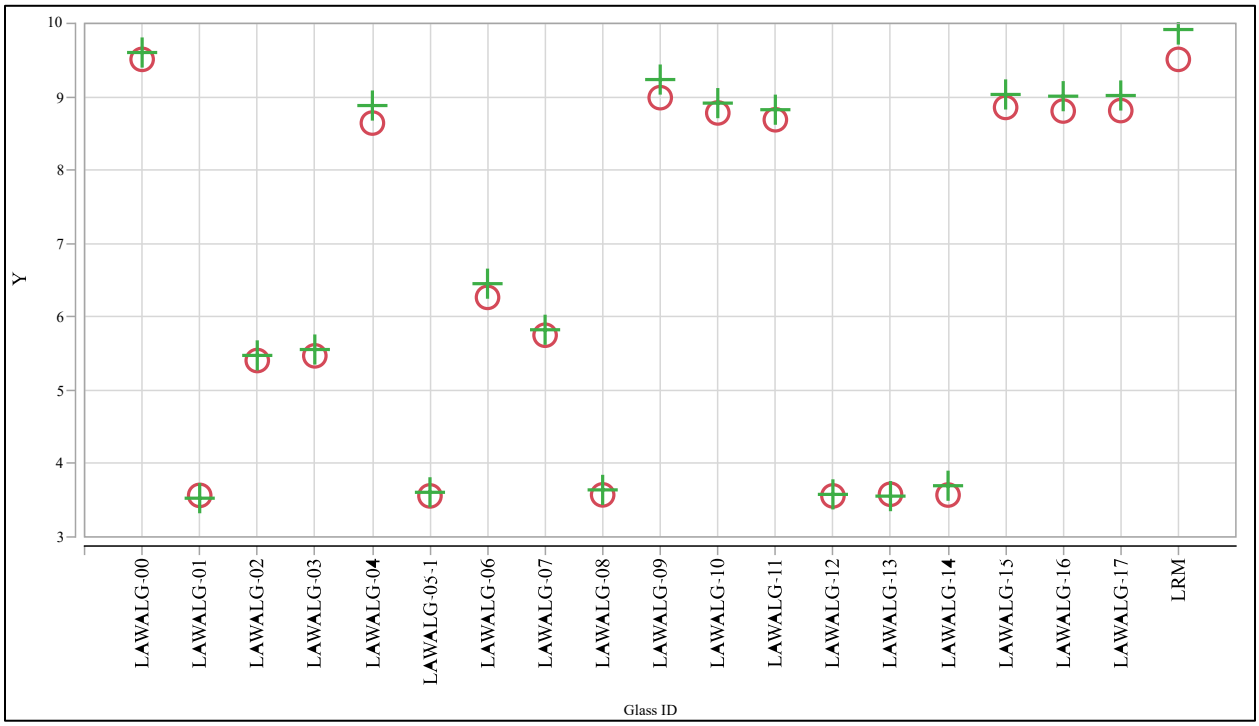
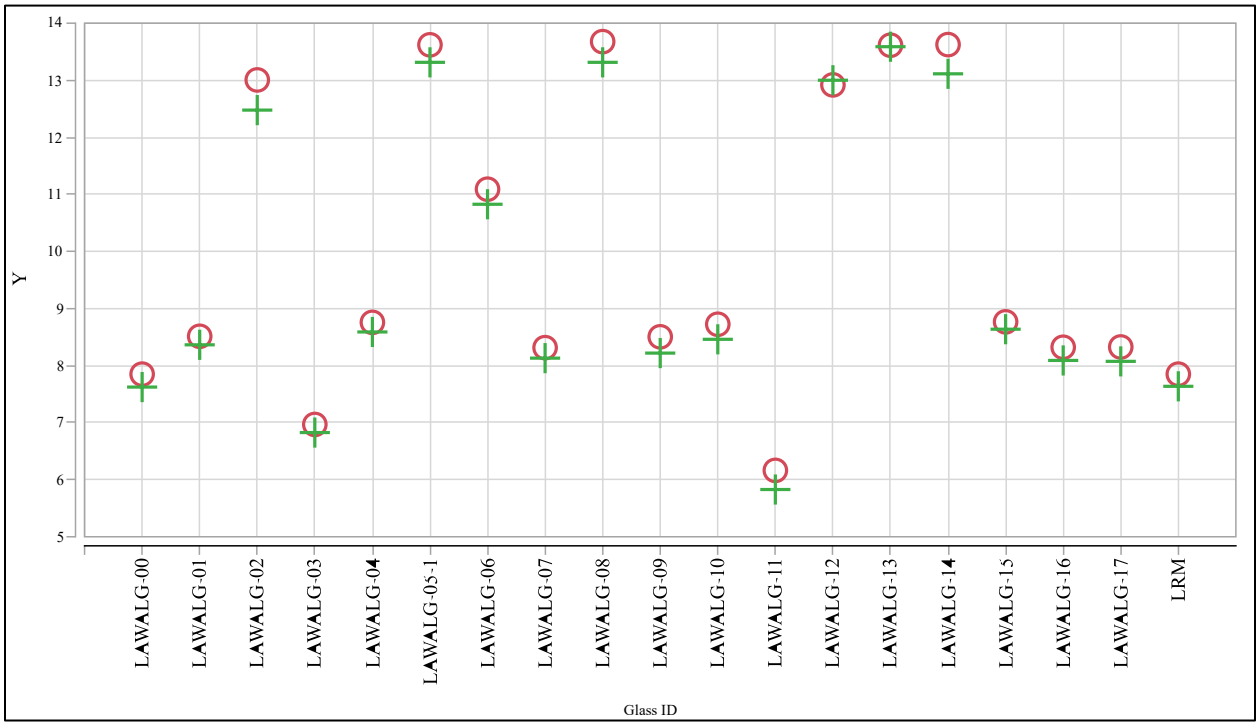


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide

Oxide=Al_2O_3



Oxide=B_2O_3



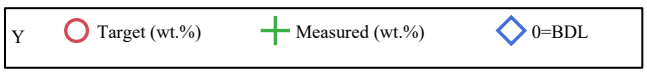
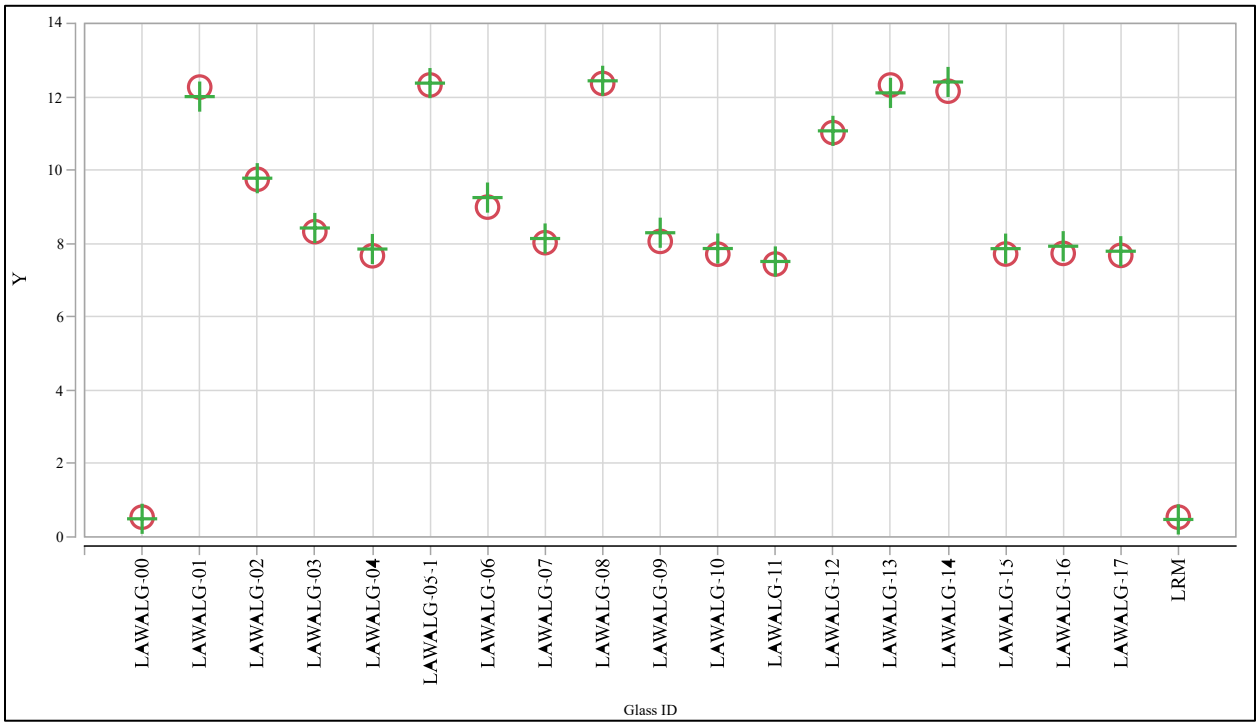
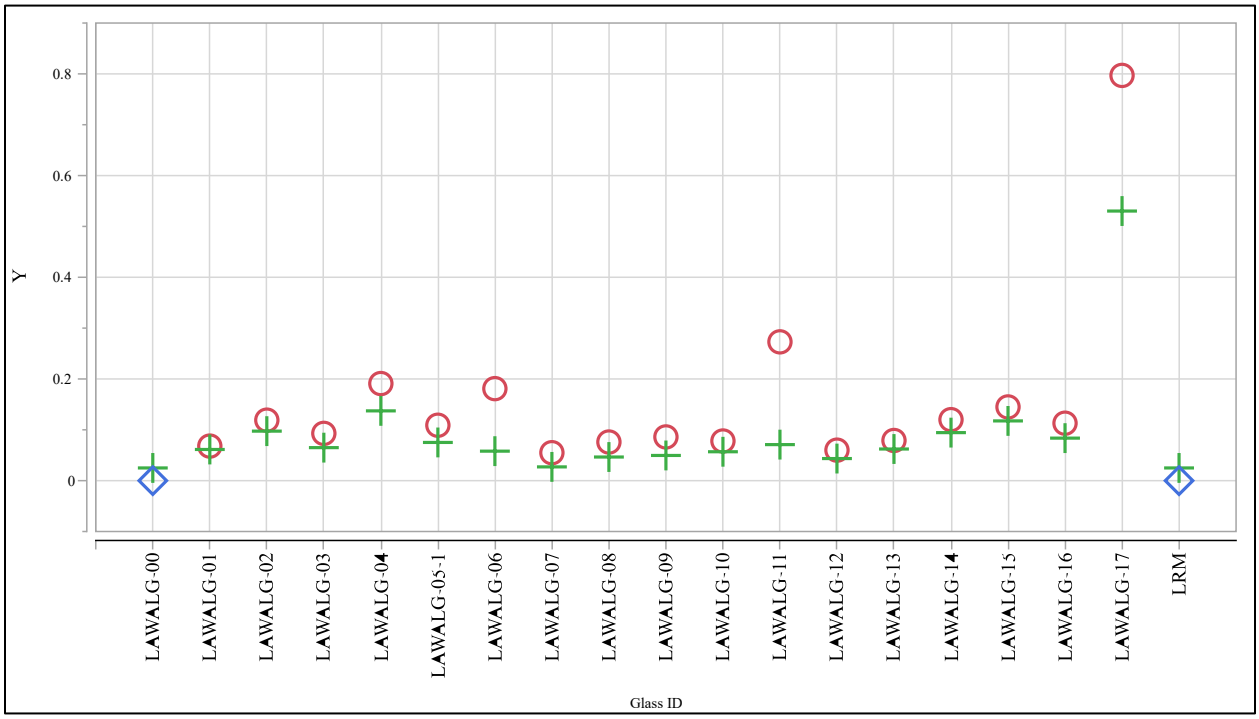


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=CaO



Oxide=Cl⁻



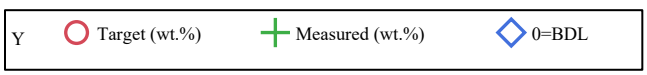
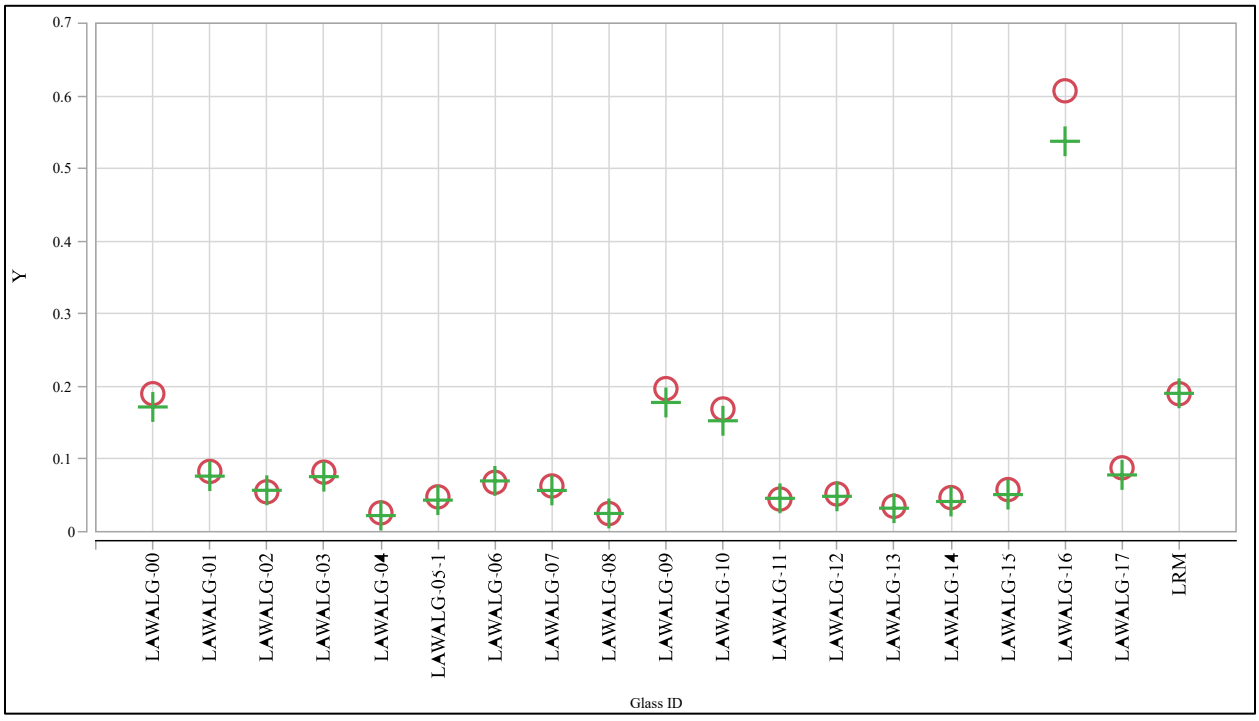
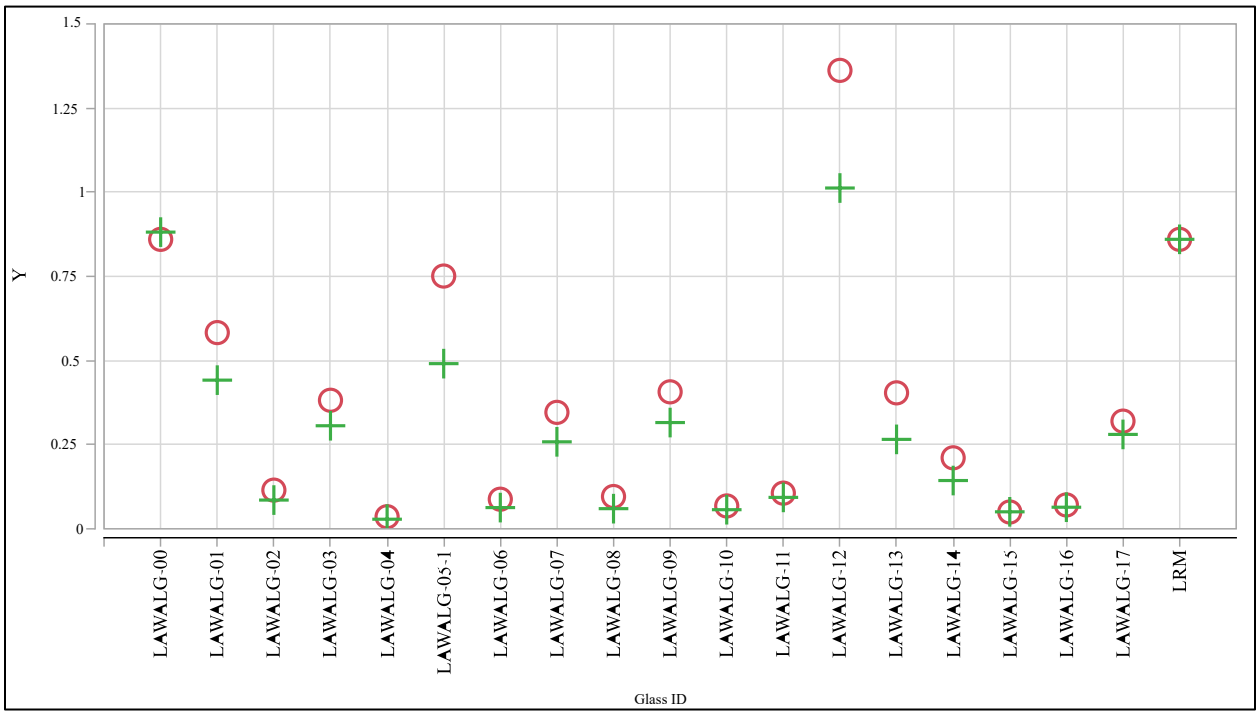


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Cr_2O_3



Oxide=F^-



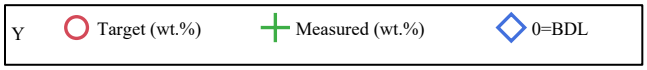
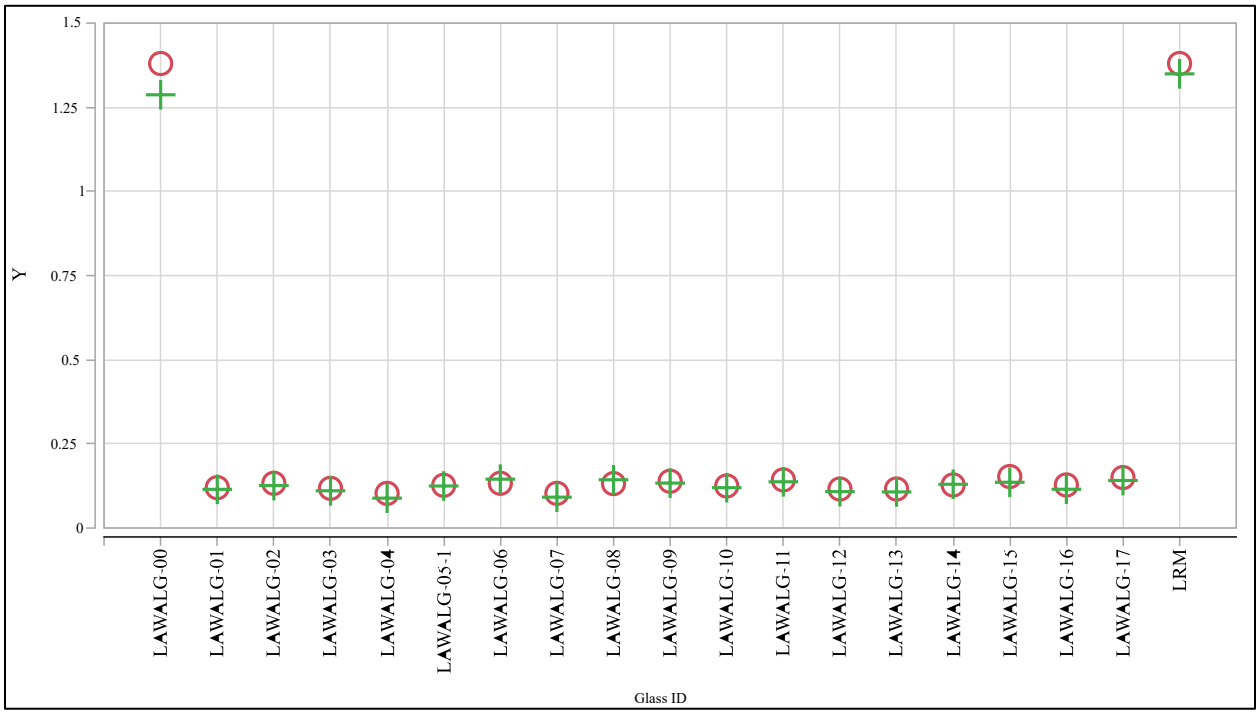
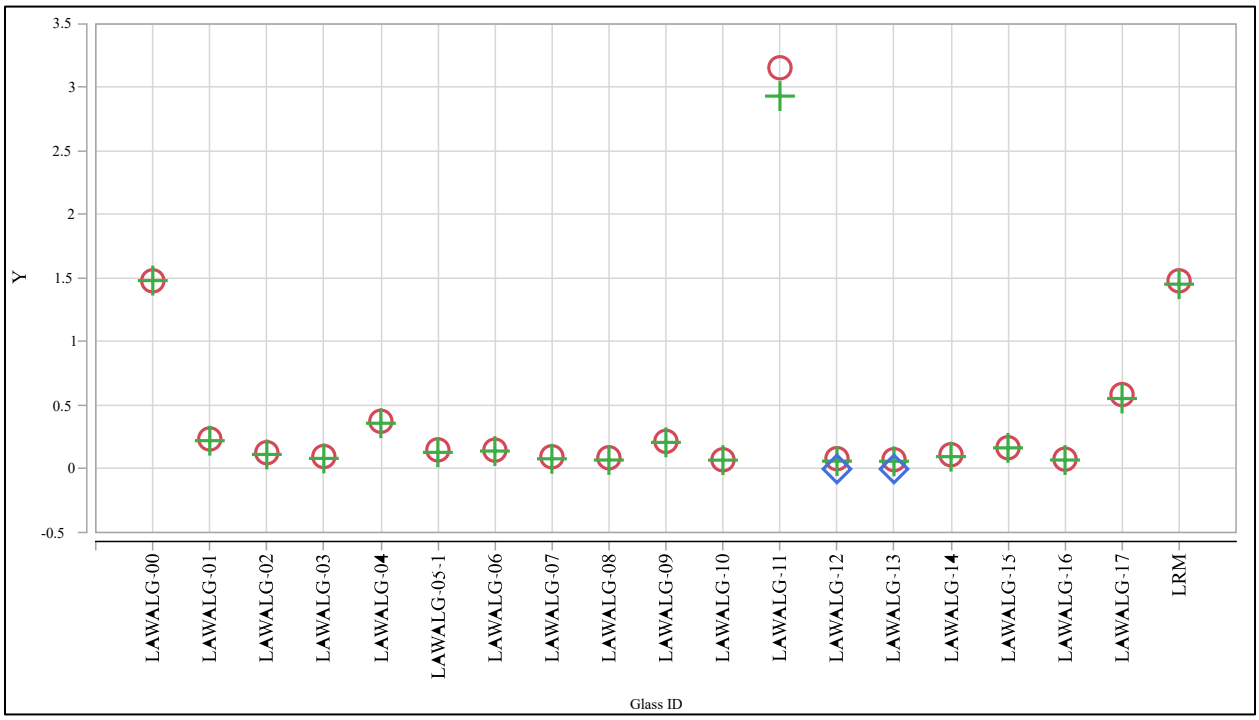


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Fe_2O_3



Oxide=K_2O



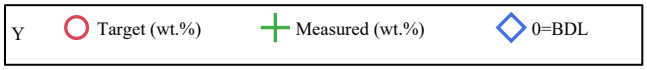
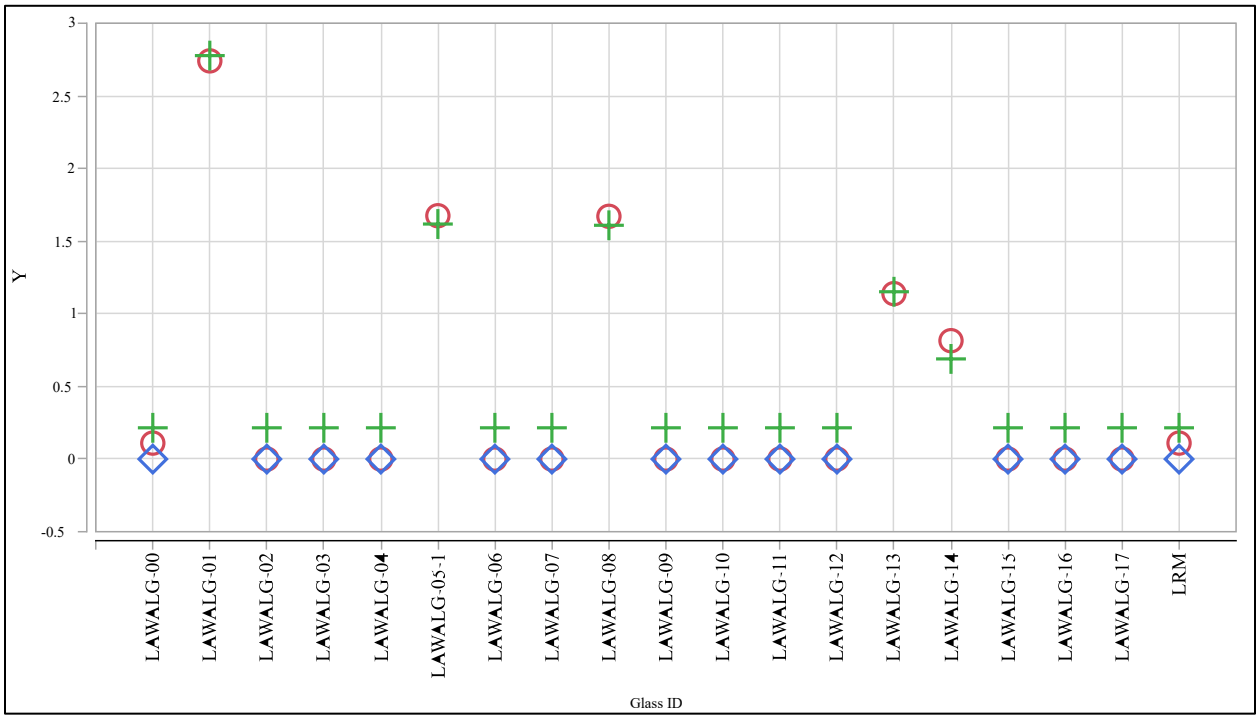
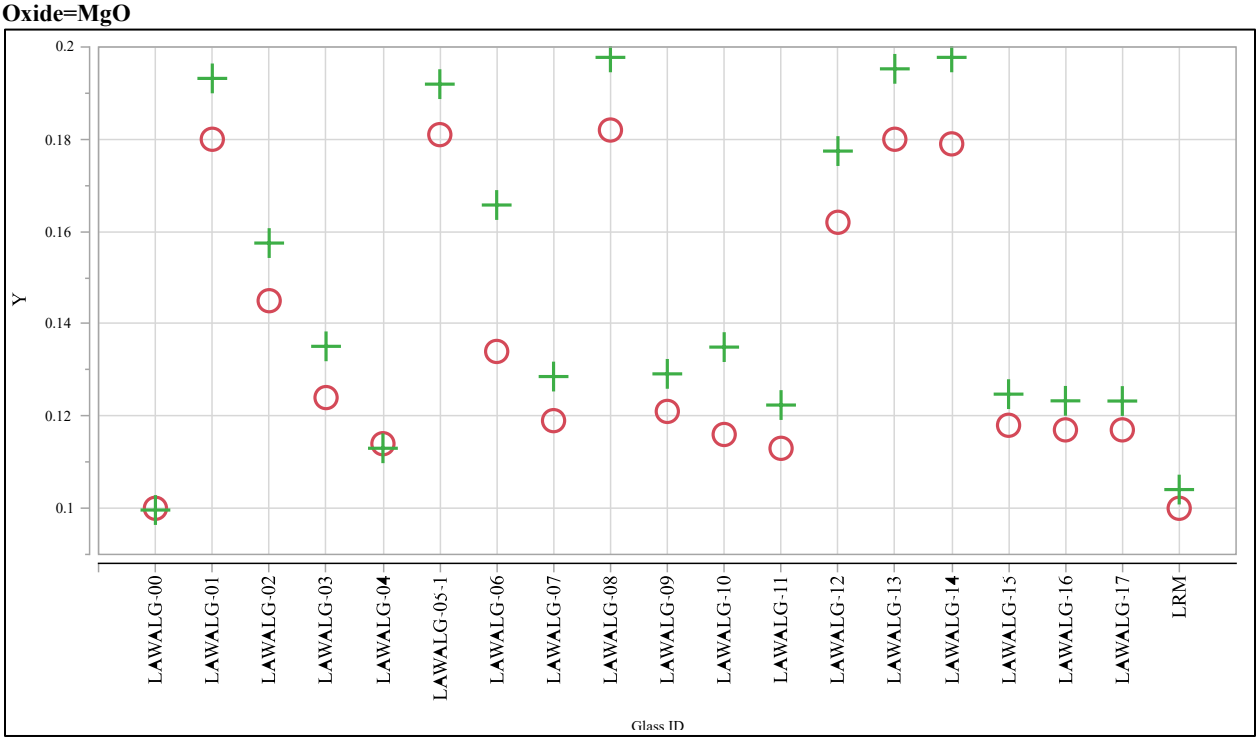


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Li_2O



Oxide=MgO



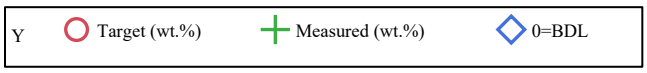
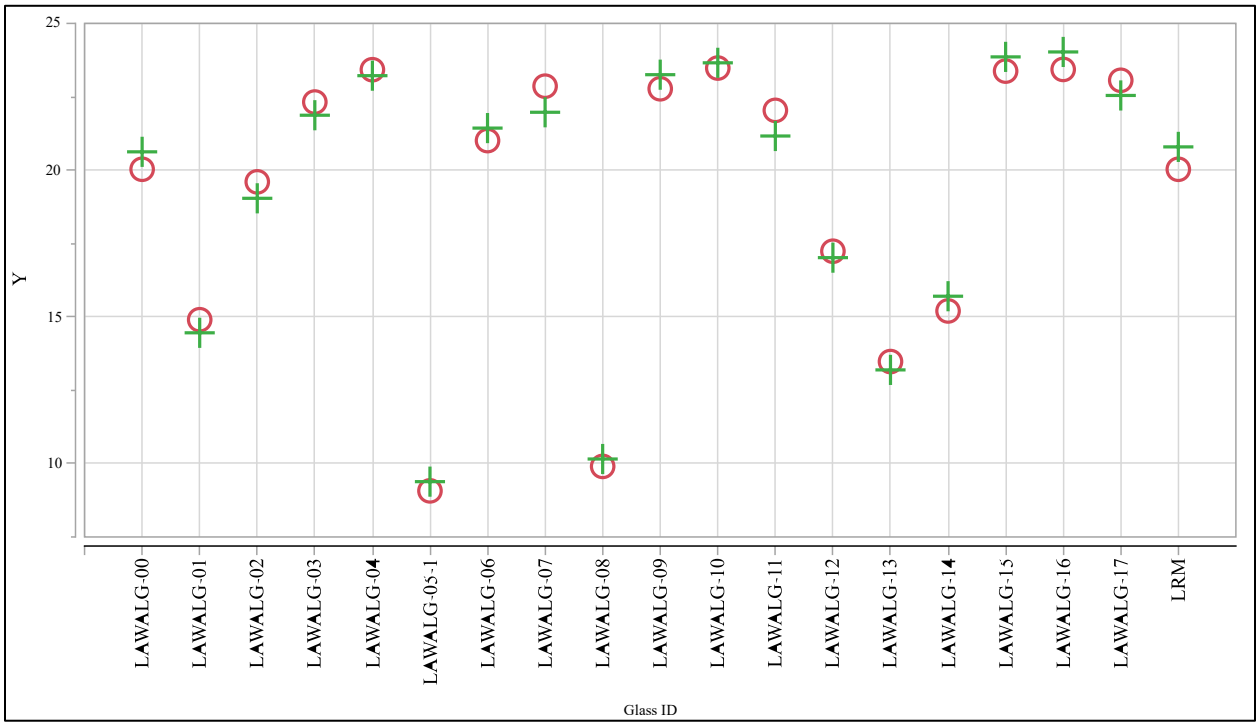
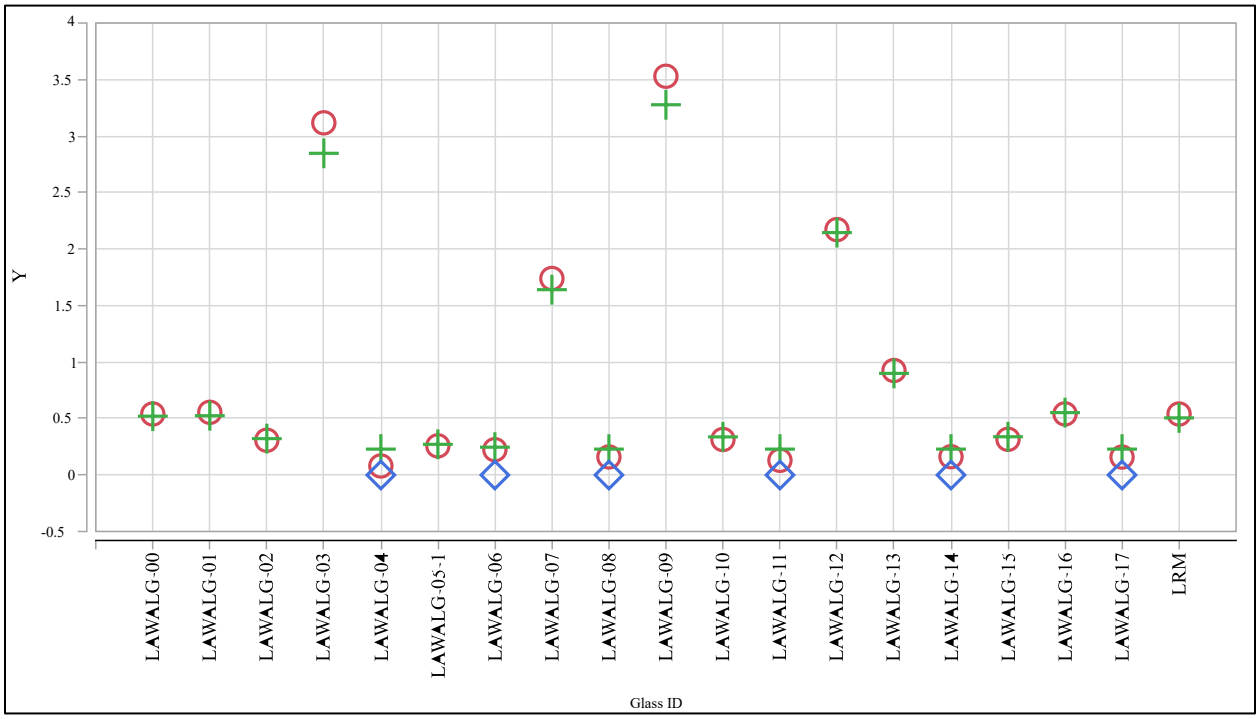


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Na_2O



Oxide=P_2O_5



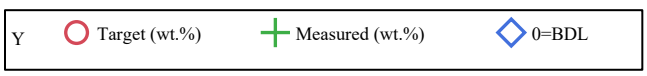
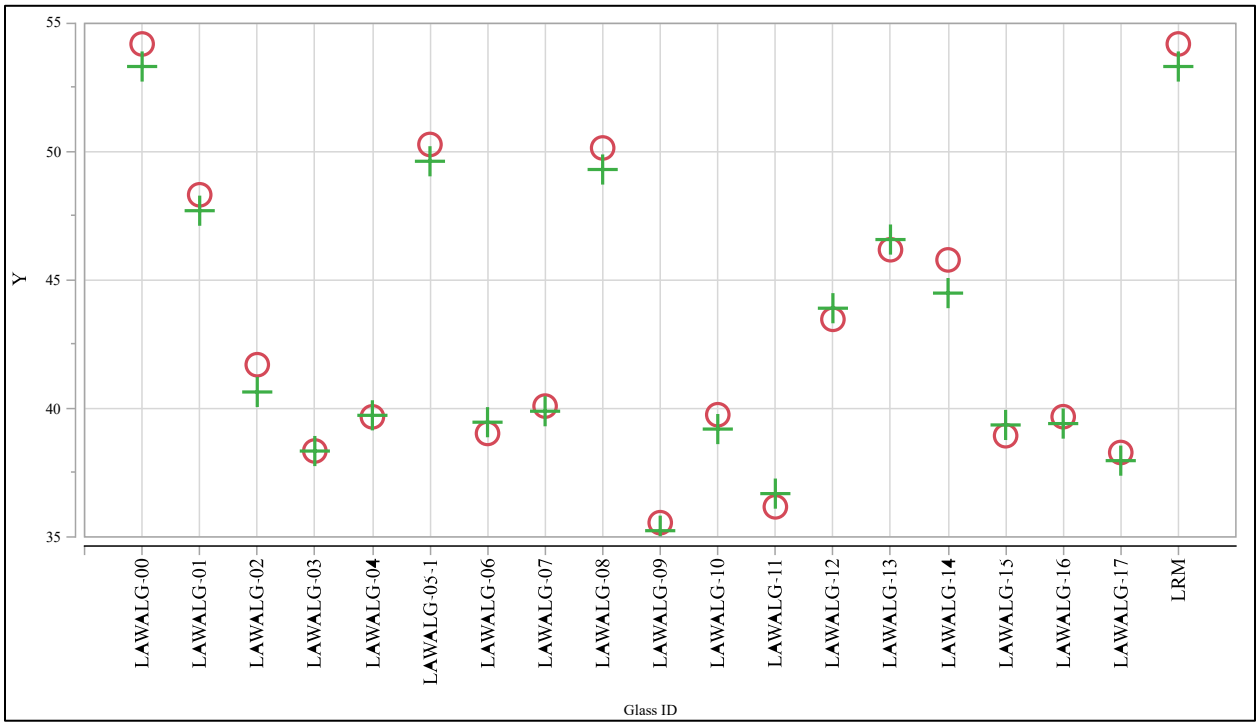
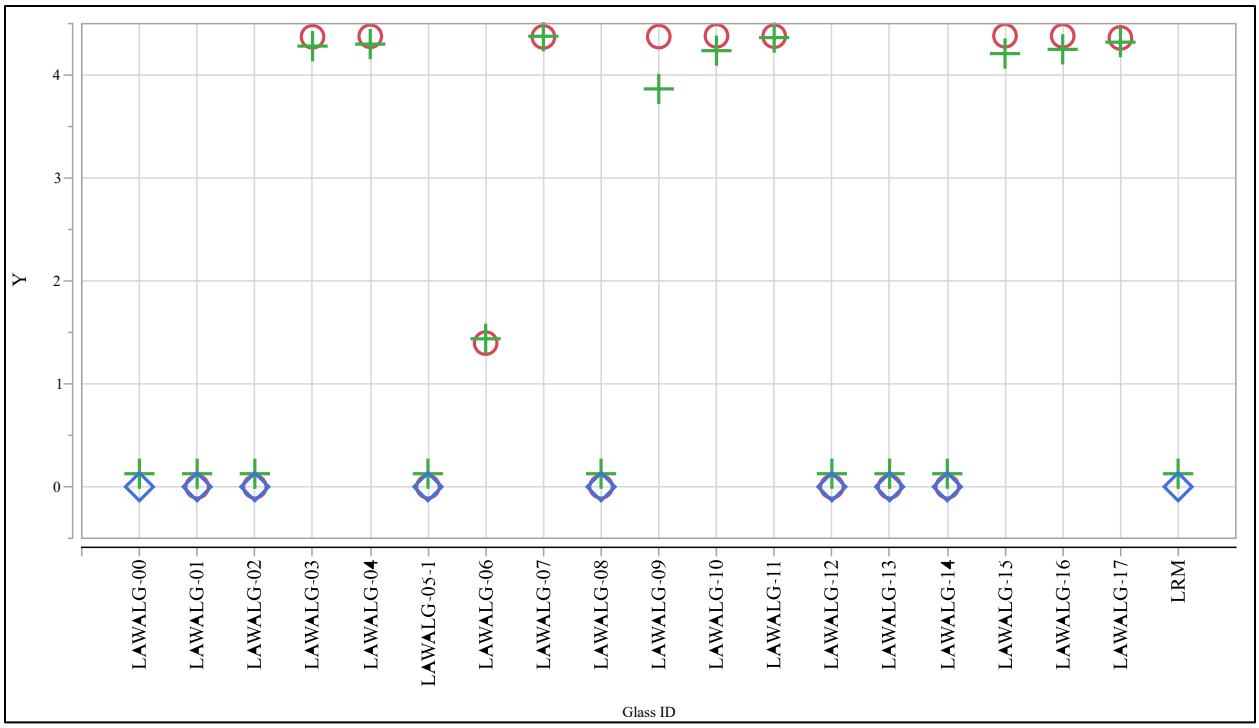


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=SiO_2



Oxide=SnO_2



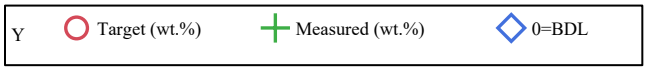
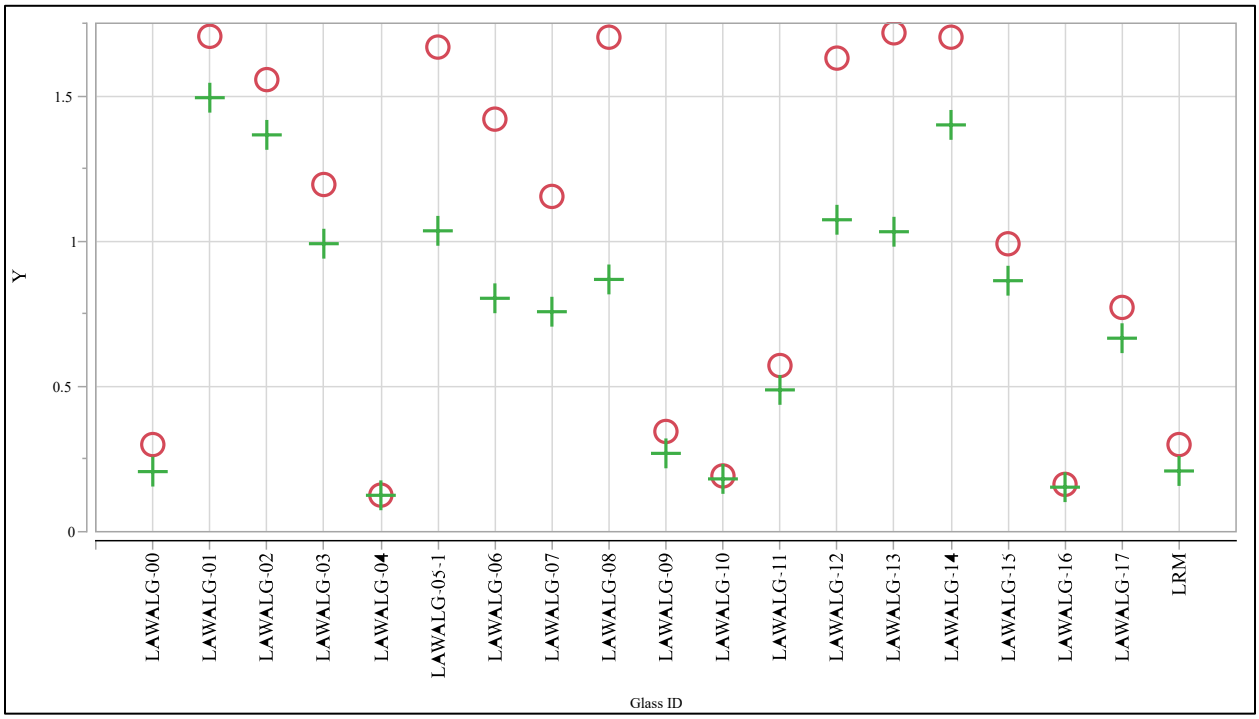
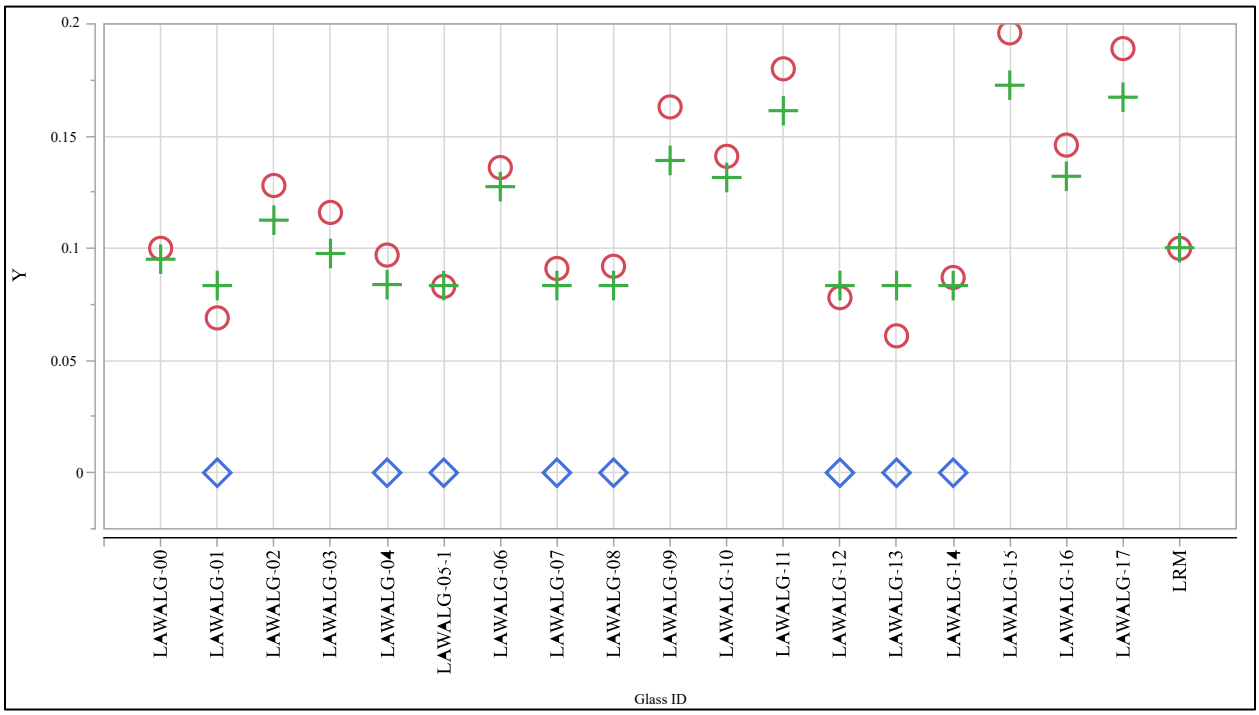


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=SO_3



Oxide=TiO_2



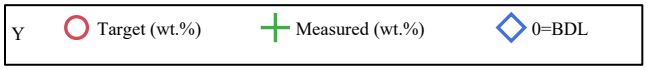
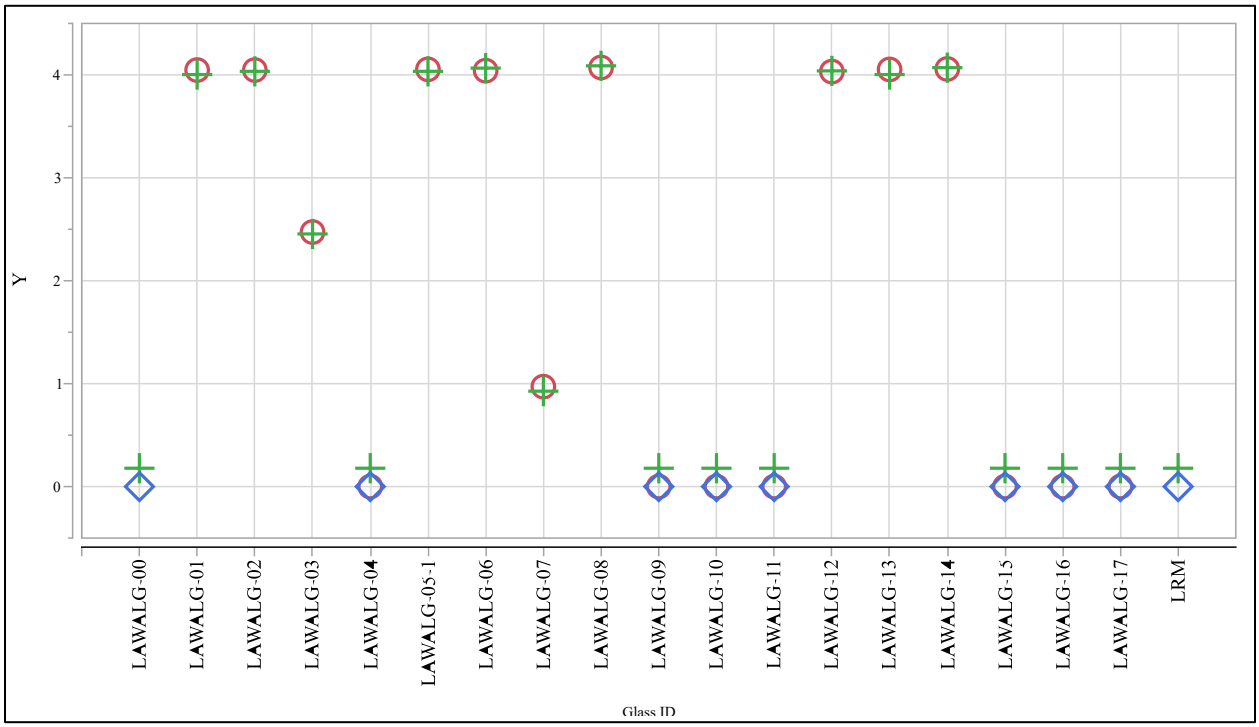
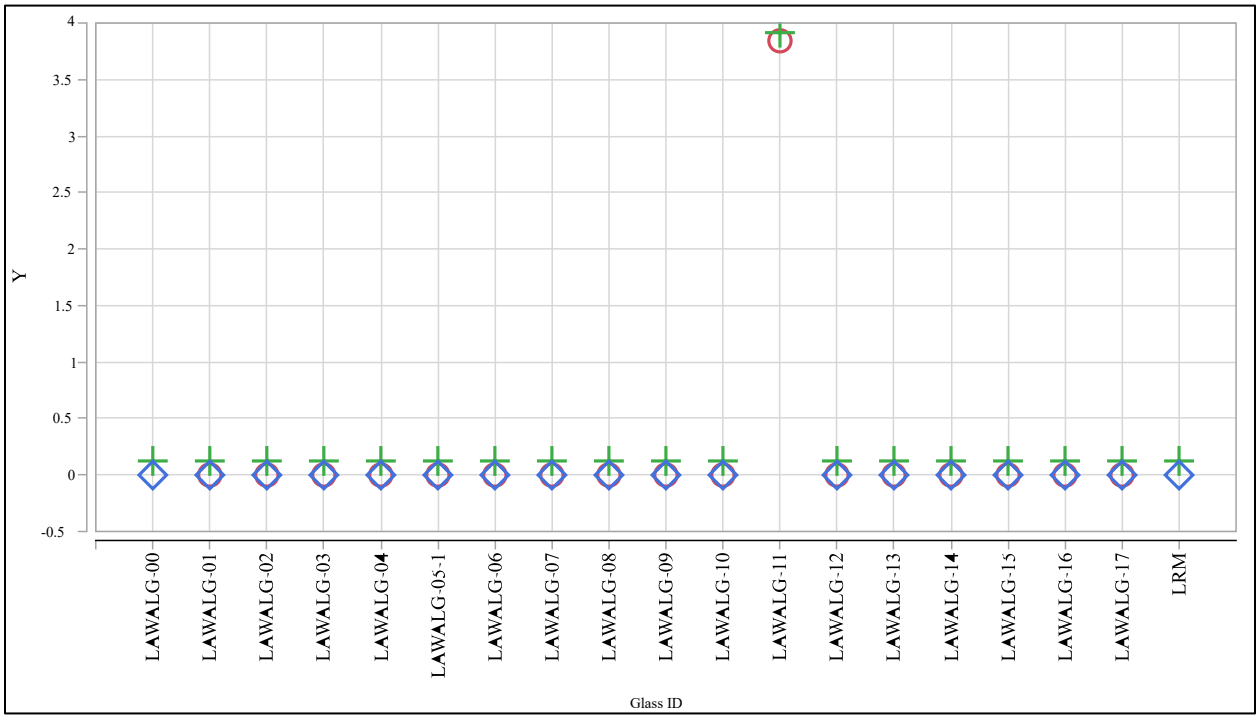


Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=V_2O_5



Oxide=ZnO



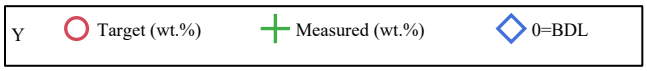
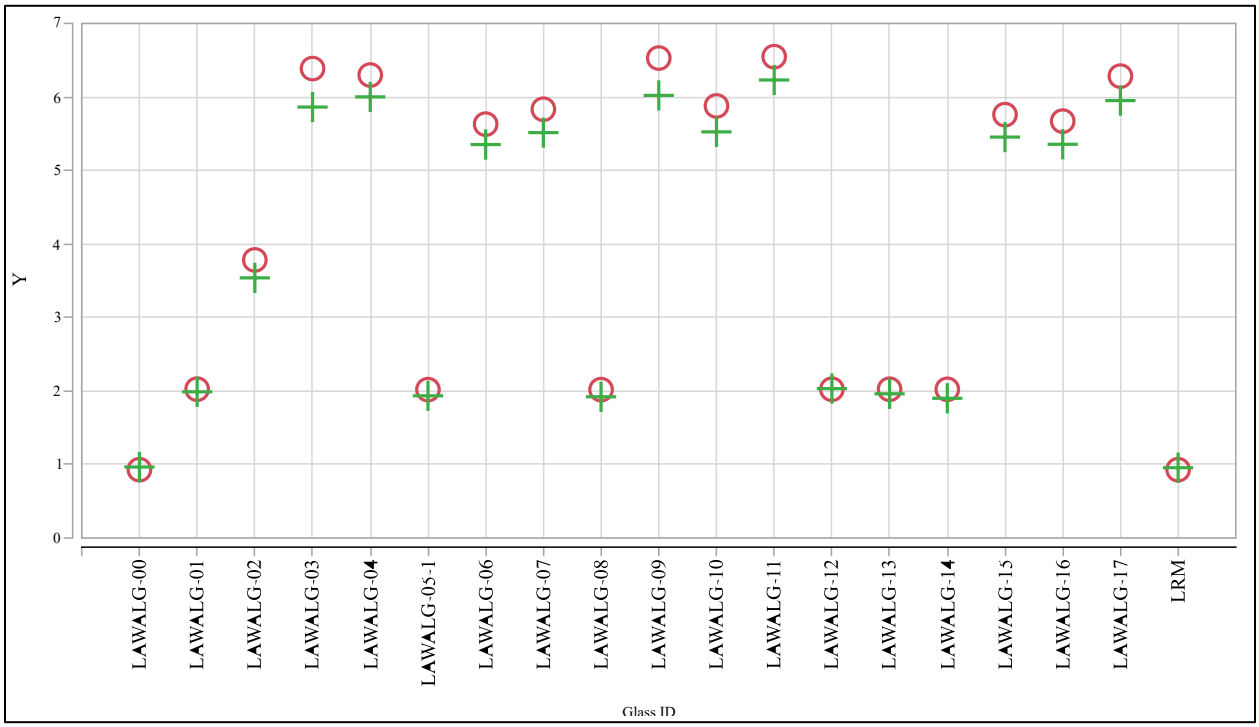
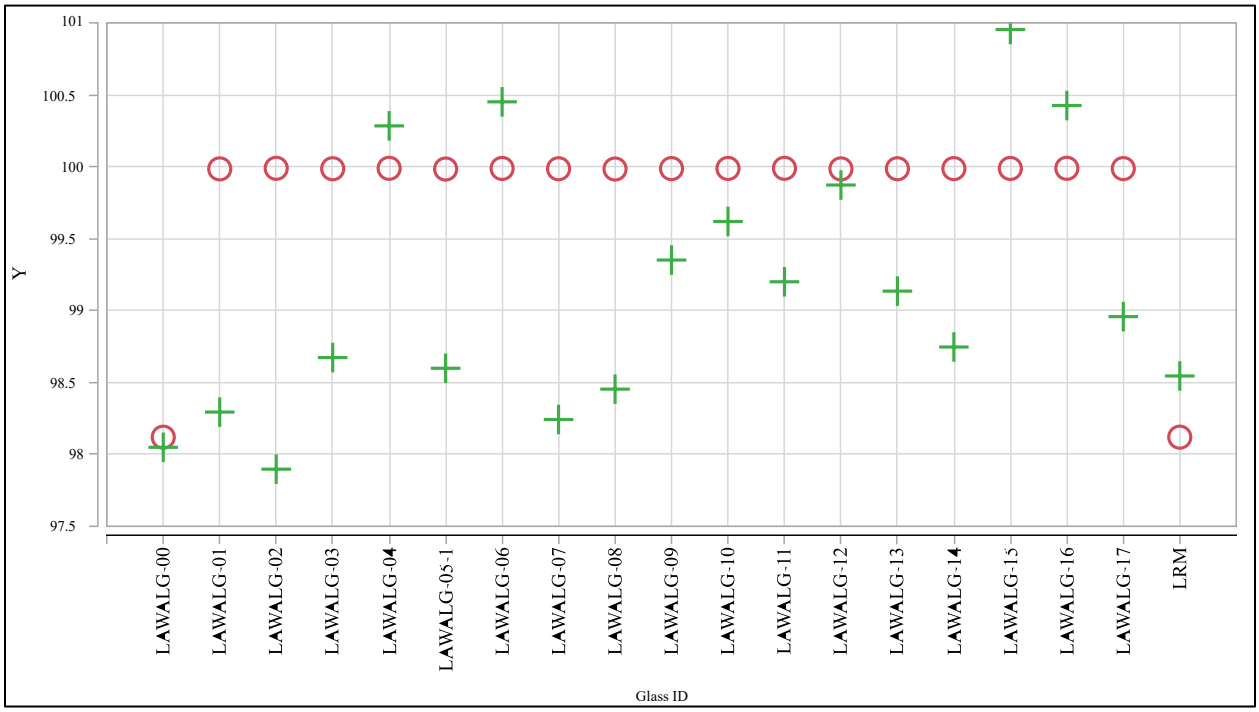


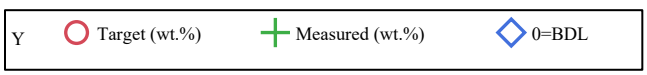
Exhibit A-3. Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=ZrO_2



Oxide=Sum of Oxides





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