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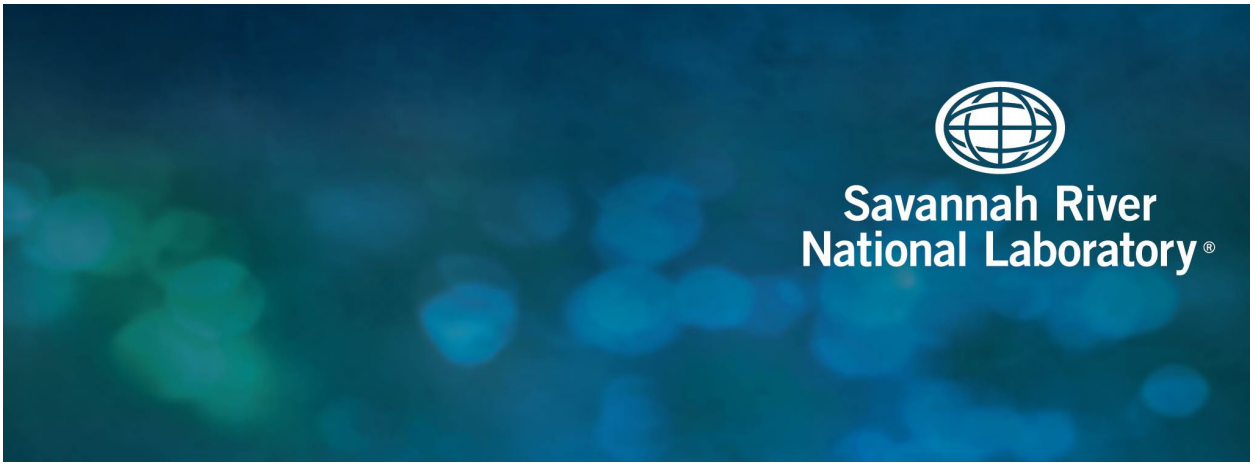

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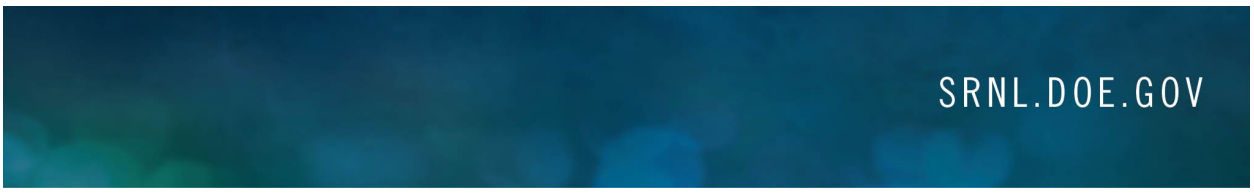
Composition Measurements of the LAW HPVR Glasses

M. C. Hsieh

June 2022

SRNL-STI-2022-00265, Revision 0



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EXECUTIVE SUMMARY

This report provides the results from the chemical analyses of the glass compositions of the Low-Activity Waste High PCT and VHT Response 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 Cl^-, K_2O, Na_2O, and ZrO_2 for several of the glasses were greater than 10%. These results can be used in further characterization of this series of glasses, including the normalization of Product Consistency Test results.

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LIST OF ABBREVIATIONS

BDL	below detection limit
DOE	U. S. Department of Energy
IC	ion chromatography
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
HPVR	High PCT and VHT Response Glass
KH	potassium hydroxide fusion
LAW	low-activity waste
LM	lithium metaborate fusion
LRM	low-activity test reference material
ORP	Office of River Protection
PCT	Product Consistency Test
PF	sodium peroxide fusion
PNNL	Pacific Northwest National Laboratory
Q	quenched
seq.	sequence
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
TTQAP	Task Technical and Quality Assurance Plan
VHT	Vapor Hydration Test
wt.%	weight percent
WTP	Waste Treatment and Immobilization Plant

1.0 Introduction

The U.S. Department of Energy (DOE) is responsible for building the Hanford Waste Treatment and Immobilization Plant (WTP) at the Hanford site in Washington to remediate 56 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) version of a series of simulated nuclear waste glasses designed and 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 High PCT and VHT Response (LAW HPVR) 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 Savannah River Site (SRS) Manual E7, Procedure 2.60.[4] SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011.[5] Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-05. The glasses provided by PNNL were designed and 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 (Q) baseline glasses were received at SRNL for chemical composition analysis. PNNL identifiers (IDs) for the glass samples and the associated SRNL sample IDs 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 HPVR Study Glasses

PNNL ID	Lab ID
LAW-HPVR-01-1	S-13662
LAW-HPVR-02-1	S-13663
LAW-HPVR-03-1	S-13664
LAW-HPVR-04-1	S-13665
LAW-HPVR-05	S-13666
LAW-HPVR-06	S-13667
LAW-HPVR-07	S-13668
LAW-HPVR-08	S-13669
LAW-HPVR-09	S-13670
LAW-HPVR-10	S-13671
LAW-HPVR-11	S-13672
LAW-HPVR-12	S-13673
LAW-HPVR-13	S-13674
LAW-HPVR-14	S-13675
LAW-HPVR-15	S-13676
LAW-HPVR-16	S-13677
LAW-HPVR-17	S-13678
LAW-HPVR-18	S-13679
LAW-HPVR-19	S-13680
LAW-HPVR-20	S-13681
LAW-HPVR-21	S-13682
LAW-HPVR-22	S-13683
LAW-HPVR-23	S-13684
LAW-HPVR-24	S-13685
LAW-HPVR-25	S-13686
LAW-HPVR-26	S-13687

2.3 Glass Composition Analysis

Chemical analyses were performed under the direction of an analytical plan[6] 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)).[7-9] 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 the 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)[10] or ion chromatography (IC),[11] 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 measurements over the course of these analyses. Specifically, several samples of the low-activity test reference material (LRM) were included as part of the analytical plan. The LRM composition reported as the "Consensus Average" is used as the reference composition of this glass.[12] The preparation and measurement methods used for each of the reported glass components are listed in Table 2-2.

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

Analyte	Measurement Method	Preparation Method
Al	ICP-OES	PF
B	ICP-OES	PF
Ca	ICP-OES	LM
Cl	IC	KH
Cr	ICP-OES	LM
F	IC	KH
Fe	ICP-OES	LM
K	ICP-OES	PF
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 16.0.0 (SAS Institute, Inc.)[13] 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.

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 calculation the sum of oxides for each glass in Table A-4 in Appendix A. 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 the 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.[10] The review is in the form of plots of the measurements arranged by 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 the 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 the calculations of 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 sum of oxides for all glasses fall within the interval of 95.0 wt.% and 100 wt.%, indicating acceptable recovery of the glass components.[14] 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.%. All Cl^- relative differences are given as well. The relative differences were shaded if they are 10% or more and are summarized below.

- Cl^- relative differences were above 10% for all study glasses except LAW-HPVR-04-1. The Cl^- relative differences for these glasses ranged from 62% to 3956%. The difference between measured and targeted composition values ranged from 0.03 wt.% to 1.42 wt.%.
- K_2O relative differences were 10% or greater for LAW-HPVR-03-1, LAW-HPVR-07, LAW-HPVR-11, LAW-HPVR-13, LAW-HPVR-15, LAW-HPVR-21, LAW-HPVR-22, and LAW-HPVR-25.
- Na_2O relative differences were 10% or greater for LAW-HPVR-07, LAW-HPVR-25, and LAW-HPVR-26.
- ZrO_2 relative differences were 10% or greater for LAW-HPVR-02-1, LAW-HPVR-05, LAW-HPVR-09, LAW-HPVR-10, LAW-HPVR-11, LAW-HPVR-12, LAW-HPVR-13, LAW-HPVR-14, LAW-HPVR-15, LAW-HPVR-17, LAW-HPVR-18, LAW-HPVR-19, LAW-HPVR-21, and LAW-HPVR-23.

4.0 Summary

Chemical analyses were performed on a representative sample of each of the LAW HPVR quenched glasses to allow for comparisons with targeted compositions. The relative differences between the targeted and measured concentrations of Cl^-, K_2O, Na_2O, and ZrO_2 for several of the glasses were greater than 10%. 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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10. "Calibration, Verification, and Operation of the Agilent 5110 ICP-OES Inductively Coupled Plasma-Optical Emission Spectrometer," Savannah River National Laboratory, Aiken, SC, Manual L33, Procedure 0242, Rev. 1, 2021.

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12. W.L. Ebert and S.F. Wolf, "Round-Robin Testing of a Reference Glass for Low-Activity Waste Forms," Argonne National Laboratory, Argonne, IL, ANL-99/22, Revision 0, 1999.

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14. C.M. Jantzen, N.E. Bibler, D.C. Beam, C.L. Crawford, and M.A. Pickett, "Characterization of the Defense Waste Processing Facility (DWPF) Environmental Assessment (EA) Glass Standard Reference Material," Westinghouse Savannah River Company, Aiken, SC, WSRC-TR-92-346, Revision 1, 1993.

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

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Cl^-	F^-
LRM	LRMKH111	1	1	1	<0.0250	0.876
LAW-HPVR-04-1	S-13665KH11	1	1	2	0.112	0.172
LAW-HPVR-12	S-13673KH11	1	1	3	0.860	0.0600
LAW-HPVR-01-1	S-13662KH11	1	1	4	1.44	0.0540
LAW-HPVR-14	S-13675KH21	1	1	5	1.45	0.0740
LAW-HPVR-08	S-13669KH21	1	1	6	1.29	0.0945
LAW-HPVR-26	S-13687KH11	1	1	7	1.02	0.122
LAW-HPVR-12	S-13673KH21	1	1	8	0.866	0.0589
LAW-HPVR-26	S-13687KH21	1	1	9	1.00	0.122
LAW-HPVR-08	S-13669KH11	1	1	10	1.29	0.0928
LRM	LRMKH112	1	1	11	<0.0250	0.874
LAW-HPVR-04-1	S-13665KH21	1	1	12	0.104	0.167
LAW-HPVR-02-1	S-13663KH21	1	1	13	0.671	0.0879
LAW-HPVR-24	S-13685KH21	1	1	14	0.809	0.136
LAW-HPVR-18	S-13679KH21	1	1	15	0.924	0.146
LAW-HPVR-14	S-13675KH11	1	1	16	1.45	0.0725
LAW-HPVR-01-1	S-13662KH21	1	1	17	1.43	0.0512
LAW-HPVR-24	S-13685KH11	1	1	18	0.808	0.135
LAW-HPVR-02-1	S-13663KH11	1	1	19	0.677	0.0880
LAW-HPVR-18	S-13679KH11	1	1	20	0.933	0.146
LRM	LRMKH113	1	1	21	<0.0250	0.876
LRM	LRMKH121	1	2	1	<0.0250	0.872
LAW-HPVR-08	S-13669KH12	1	2	2	1.25	0.0896
LAW-HPVR-04-1	S-13665KH12	1	2	3	0.0977	0.165
LAW-HPVR-01-1	S-13662KH12	1	2	4	1.39	0.0488
LAW-HPVR-02-1	S-13663KH12	1	2	5	0.648	0.0837
LAW-HPVR-18	S-13679KH22	1	2	6	0.888	0.140
LAW-HPVR-12	S-13673KH22	1	2	7	0.825	0.0541
LAW-HPVR-14	S-13675KH12	1	2	8	1.39	0.0683
LAW-HPVR-26	S-13687KH22	1	2	9	0.956	0.114
LAW-HPVR-08	S-13669KH22	1	2	10	1.24	0.0869
LRM	LRMKH122	1	2	11	<0.0250	0.884
LAW-HPVR-24	S-13685KH22	1	2	12	0.774	0.128
LAW-HPVR-04-1	S-13665KH22	1	2	13	0.0905	0.157
LAW-HPVR-18	S-13679KH12	1	2	14	0.880	0.137
LAW-HPVR-01-1	S-13662KH22	1	2	15	1.36	0.0467
LAW-HPVR-02-1	S-13663KH22	1	2	16	0.640	0.0809
LAW-HPVR-14	S-13675KH22	1	2	17	1.37	0.0666
LAW-HPVR-26	S-13687KH12	1	2	18	0.957	0.112
LAW-HPVR-12	S-13673KH12	1	2	19	0.808	0.0535
LAW-HPVR-24	S-13685KH12	1	2	20	0.759	0.126
LRM	LRMKH123	1	2	21	<0.0250	0.854
LRM	LRMKH211	2	1	1	<0.0250	0.896
LAW-HPVR-21	S-13682KH21	2	1	2	0.810	0.137
LAW-HPVR-10	S-13671KH11	2	1	3	0.793	0.0711
LAW-HPVR-11	S-13672KH21	2	1	4	1.44	0.0551
LAW-HPVR-25	S-13686KH11	2	1	5	0.700	0.165

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Cl^-	F^-
LAW-HPVR-13	S-13674KH21	2	1	6	1.14	0.108
LAW-HPVR-13	S-13674KH11	2	1	7	1.08	0.102
LAW-HPVR-21	S-13682KH11	2	1	8	0.805	0.139
LAW-HPVR-07	S-13668KH21	2	1	9	0.736	0.0974
LAW-HPVR-16	S-13677KH11	2	1	10	1.15	0.111
LRM	LRMKH212	2	1	11	<0.0250	0.893
LAW-HPVR-16	S-13677KH21	2	1	12	1.13	0.109
LAW-HPVR-25	S-13686KH21	2	1	13	0.707	0.168
LAW-HPVR-15	S-13676KH21	2	1	14	0.972	0.0643
LAW-HPVR-10	S-13671KH21	2	1	15	0.790	0.0682
LAW-HPVR-07	S-13668KH11	2	1	16	0.740	0.0962
LAW-HPVR-09	S-13670KH11	2	1	17	0.693	0.0784
LAW-HPVR-11	S-13672KH11	2	1	18	1.43	0.0564
LAW-HPVR-15	S-13676KH11	2	1	19	0.977	0.0626
LAW-HPVR-09	S-13670KH21	2	1	20	0.687	0.0778
LRM	LRMKH213	2	1	21	<0.0250	0.900
LRM	LRMKH221	2	2	1	<0.0250	0.899
LAW-HPVR-15	S-13676KH22	2	2	2	0.973	0.0640
LAW-HPVR-25	S-13686KH22	2	2	3	0.703	0.168
LAW-HPVR-21	S-13682KH22	2	2	4	0.813	0.139
LAW-HPVR-15	S-13676KH12	2	2	5	0.998	0.0643
LAW-HPVR-13	S-13674KH12	2	2	6	1.11	0.105
LAW-HPVR-09	S-13670KH22	2	2	7	0.704	0.0801
LAW-HPVR-25	S-13686KH12	2	2	8	0.720	0.171
LAW-HPVR-13	S-13674KH22	2	2	9	1.16	0.111
LAW-HPVR-16	S-13677KH12	2	2	10	1.18	0.115
LRM	LRMKH222	2	2	11	<0.0250	0.911
LAW-HPVR-11	S-13672KH22	2	2	12	1.48	0.0570
LAW-HPVR-16	S-13677KH22	2	2	13	1.18	0.113
LAW-HPVR-10	S-13671KH22	2	2	14	0.815	0.0704
LAW-HPVR-09	S-13670KH12	2	2	15	0.720	0.0813
LAW-HPVR-21	S-13682KH12	2	2	16	0.833	0.144
LAW-HPVR-07	S-13668KH12	2	2	17	0.768	0.100
LAW-HPVR-11	S-13672KH12	2	2	18	1.49	0.0592
LAW-HPVR-10	S-13671KH12	2	2	19	0.822	0.0749
LAW-HPVR-07	S-13668KH22	2	2	20	0.766	0.102
LRM	LRMKH223	2	2	21	<0.0250	0.908
LRM	LRMKH311	3	1	1	<0.0250	0.869
LAW-HPVR-06	S-13667KH11	3	1	2	0.764	0.0587
LAW-HPVR-17	S-13678KH11	3	1	3	0.764	0.141
LAW-HPVR-06	S-13667KH21	3	1	4	0.754	0.0589
LAW-HPVR-17	S-13678KH21	3	1	5	0.763	0.141
LAW-HPVR-23	S-13684KH11	3	1	6	1.26	0.107
LAW-HPVR-19	S-13680KH21	3	1	7	0.642	0.0546
LAW-HPVR-22	S-13683KH21	3	1	8	0.778	0.129
LAW-HPVR-05	S-13666KH11	3	1	9	1.33	0.155
LRM	LRMKH312	3	1	10	<0.0250	0.871

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

Glass ID	Lab ID		Block	Sub-Blk	Seq.	Cl^-	F^-
LAW-HPVR-20	S-13681KH21		3	1	11	1.00	0.132
LAW-HPVR-20	S-13681KH11		3	1	12	0.997	0.134
LAW-HPVR-05	S-13666KH21		3	1	13	1.33	0.153
LAW-HPVR-19	S-13680KH11		3	1	14	0.659	0.0567
LAW-HPVR-03-1	S-13664KH21		3	1	15	0.0767	0.0774
LAW-HPVR-22	S-13683KH11		3	1	16	0.799	0.135
LAW-HPVR-03-1	S-13664KH11		3	1	17	0.0784	0.0885
LAW-HPVR-23	S-13684KH21		3	1	18	1.26	0.107
LRM	LRMKH313		3	1	19	<0.0250	0.891
LRM	LRMKH321		3	2	1	<0.0250	0.883
LAW-HPVR-03-1	S-13664KH22		3	2	2	0.0744	0.0777
LAW-HPVR-17	S-13678KH12		3	2	3	0.802	0.148
LAW-HPVR-06	S-13667KH22		3	2	4	0.790	0.0620
LAW-HPVR-05	S-13666KH12		3	2	5	1.37	0.162
LAW-HPVR-20	S-13681KH12		3	2	6	1.03	0.140
LAW-HPVR-20	S-13681KH22		3	2	7	1.04	0.139
LAW-HPVR-17	S-13678KH22		3	2	8	0.805	0.149
LAW-HPVR-19	S-13680KH22		3	2	9	0.672	0.0584
LRM	LRMKH322		3	2	10	<0.0250	0.886
LAW-HPVR-22	S-13683KH12		3	2	11	0.813	0.137
LAW-HPVR-05	S-13666KH22		3	2	12	1.38	0.160
LAW-HPVR-23	S-13684KH12		3	2	13	1.26	0.106
LAW-HPVR-22	S-13683KH22		3	2	14	0.812	0.136
LAW-HPVR-03-1	S-13664KH12		3	2	15	0.0822	0.0849
LAW-HPVR-23	S-13684KH22		3	2	16	1.26	0.106
LAW-HPVR-06	S-13667KH12		3	2	17	0.802	0.0634
LAW-HPVR-19	S-13680KH12		3	2	18	0.674	0.0594
LRM	LRMKH323		3	2	19	<0.0250	0.888

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Ca	Cr	Fe	Mg	Na	S	Sn	Ti	V	Zn
LRM	LRMLM111	1	1	1	0.384	0.126	0.939	0.0638	15.8	0.0871	<0.100	0.0592	<0.0500	<0.100
LAW-HPVR-14	S-13675LM11	1	1	2	6.62	0.0516	0.0821	0.0489	18.8	0.171	3.55	0.826	<0.0500	0.260
LAW-HPVR-01-1	S-13662LM21	1	1	3	4.81	0.0381	0.0690	0.0387	13.3	0.127	1.77	1.06	1.88	0.211
LAW-HPVR-05	S-13666LM11	1	1	4	4.64	0.104	0.159	0.0482	12.5	0.279	0.699	0.262	1.06	0.537
LAW-HPVR-23	S-13684LM21	1	1	5	5.22	0.0722	0.108	0.0459	16.8	0.229	2.83	0.815	0.726	0.352
LAW-HPVR-23	S-13684LM11	1	1	6	5.39	0.0711	0.108	0.0464	17.0	0.230	2.91	0.814	0.726	0.356
LAW-HPVR-03-1	S-13664LM11	1	1	7	4.74	0.0511	0.0800	0.0392	12.1	0.169	3.43	0.608	1.93	0.254
LAW-HPVR-12	S-13673LM11	1	1	8	5.56	0.0413	0.0774	0.0415	17.1	0.133	1.68	0.598	1.08	0.199
LAW-HPVR-03-1	S-13664LM21	1	1	9	4.79	0.0504	0.0809	0.0389	12.0	0.175	3.39	0.597	1.94	0.249
LAW-HPVR-12	S-13673LM21	1	1	10	5.61	0.0410	0.0792	0.0407	17.2	0.131	1.84	0.585	1.09	0.192
LRM	LRMLM112	1	1	11	0.397	0.126	0.933	0.0636	15.6	0.0920	<0.100	0.0590	<0.0500	<0.100
LAW-HPVR-22	S-13683LM21	1	1	12	5.33	0.0936	0.139	0.0475	15.2	0.290	4.04	1.93	2.32	0.462
LAW-HPVR-13	S-13674LM11	1	1	13	5.19	0.0734	0.117	0.0441	12.8	0.183	0.505	0.0564	1.35	0.376
LAW-HPVR-14	S-13675LM21	1	1	14	6.76	0.0513	0.0836	0.0478	19.9	0.173	3.63	0.813	<0.0500	0.253
LAW-HPVR-13	S-13674LM21	1	1	15	5.22	0.0855	0.119	0.0443	12.8	0.185	0.506	0.0568	1.36	0.379
LAW-HPVR-11	S-13672LM21	1	1	16	4.82	0.0398	0.0618	0.0352	16.8	0.145	3.09	1.85	1.55	0.192
LAW-HPVR-11	S-13672LM11	1	1	17	4.61	0.0387	0.0629	0.0352	16.8	0.141	3.08	1.85	1.55	0.193
LAW-HPVR-01-1	S-13662LM11	1	1	18	5.04	0.0376	0.117	0.0380	13.5	0.126	1.83	1.10	1.95	0.204
LAW-HPVR-05	S-13666LM21	1	1	19	4.89	0.105	0.159	0.0478	13.1	0.292	0.699	0.262	1.10	0.535
LAW-HPVR-22	S-13683LM11	1	1	20	5.39	0.110	0.140	0.0473	15.5	0.286	4.10	1.96	2.35	0.455
LRM	LRMLM113	1	1	21	0.405	0.127	0.937	0.0638	16.2	0.0958	<0.100	0.0594	<0.0500	<0.100
LRM	LRMLM121	1	2	1	0.365	0.128	0.952	0.0646	14.8	0.0848	<0.100	0.0603	<0.0500	<0.100
LAW-HPVR-23	S-13684LM22	1	2	2	5.15	0.0720	0.109	0.0458	15.7	0.231	2.54	0.817	0.727	0.353
LAW-HPVR-13	S-13674LM22	1	2	3	4.53	0.0847	0.119	0.0441	11.3	0.165	0.504	0.0570	1.19	0.381
LAW-HPVR-01-1	S-13662LM22	1	2	4	4.47	0.0376	0.0680	0.0381	12.1	0.121	1.57	0.952	1.73	0.208
LAW-HPVR-14	S-13675LM12	1	2	5	6.48	0.0497	0.0795	0.0473	18.1	0.161	3.37	0.794	<0.0500	0.252
LAW-HPVR-14	S-13675LM22	1	2	6	6.60	0.0499	0.0817	0.0466	18.4	0.159	3.42	0.786	<0.0500	0.251
LAW-HPVR-03-1	S-13664LM22	1	2	7	4.54	0.0505	0.0809	0.0387	11.6	0.162	3.27	0.596	1.79	0.252
LAW-HPVR-11	S-13672LM22	1	2	8	4.44	0.0385	0.0604	0.0343	15.5	0.132	2.75	1.62	1.37	0.188
LAW-HPVR-05	S-13666LM22	1	2	9	4.55	0.102	0.156	0.0469	12.3	0.278	0.681	0.256	0.949	0.532
LAW-HPVR-22	S-13683LM12	1	2	10	5.08	0.108	0.139	0.0467	14.5	0.263	3.51	1.76	2.12	0.454
LRM	LRMLM122	1	2	11	0.380	0.125	0.929	0.0631	15.0	0.0795	<0.100	0.0584	<0.0500	<0.100
LAW-HPVR-12	S-13673LM12	1	2	12	5.35	0.0409	0.0775	0.0413	16.1	0.124	1.63	0.596	1.01	0.198

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Ca	Cr	Fe	Mg	Na	S	Sn	Ti	V	Zn
LAW-HPVR-01-1	S-13662LM12	1	2	13	4.71	0.0373	0.117	0.0377	12.7	0.126	1.61	1.00	1.78	0.204
LAW-HPVR-23	S-13684LM12	1	2	14	5.25	0.0704	0.107	0.0460	16.2	0.224	2.69	0.808	0.720	0.355
LAW-HPVR-13	S-13674LM12	1	2	15	4.81	0.0731	0.117	0.0441	11.7	0.164	0.494	0.0563	1.21	0.378
LAW-HPVR-22	S-13683LM22	1	2	16	5.12	0.0933	0.139	0.0473	14.4	0.274	3.57	1.78	2.14	0.467
LAW-HPVR-12	S-13673LM22	1	2	17	5.39	0.0412	0.0799	0.0411	16.5	0.131	1.65	0.593	1.01	0.198
LAW-HPVR-11	S-13672LM12	1	2	18	4.35	0.0387	0.0625	0.0351	15.2	0.135	2.72	1.62	1.36	0.194
LAW-HPVR-03-1	S-13664LM12	1	2	19	4.75	0.0510	0.0795	0.0390	11.8	0.169	3.37	0.605	1.84	0.253
LAW-HPVR-05	S-13666LM12	1	2	20	4.65	0.103	0.156	0.0475	12.3	0.266	0.685	0.257	1.01	0.530
LRM	LRMLM123	1	2	21	0.374	0.125	0.923	0.0627	15.6	0.0855	<0.100	0.0579	<0.0500	<0.100
LRM	LRMLM211	2	1	1	0.366	0.129	0.956	0.0650	15.4	0.0888	<0.100	0.0613	<0.0500	<0.100
LAW-HPVR-06	S-13667LM21	2	1	2	8.61	0.0470	0.0780	0.0614	11.8	0.166	0.137	0.577	0.229	0.243
LAW-HPVR-18	S-13679LM21	2	1	3	5.92	0.107	0.157	0.0557	12.0	0.310	3.53	0.311	2.07	0.529
LAW-HPVR-08	S-13669LM11	2	1	4	4.93	0.0613	0.0983	0.0425	11.9	0.195	1.26	1.54	0.403	0.327
LAW-HPVR-24	S-13685LM21	2	1	5	5.63	0.0951	0.142	0.0527	11.6	0.308	2.05	1.75	1.70	0.470
LAW-HPVR-18	S-13679LM11	2	1	6	5.52	0.103	0.147	0.0521	10.9	0.300	3.34	0.291	1.93	0.496
LAW-HPVR-09	S-13670LM11	2	1	7	4.50	0.0556	0.0866	0.0390	13.7	0.188	0.309	1.73	0.627	0.275
LAW-HPVR-19	S-13680LM11	2	1	8	6.21	0.0438	0.0715	0.0472	15.3	0.150	0.339	0.507	2.25	0.220
LAW-HPVR-06	S-13667LM11	2	1	9	8.67	0.0467	0.0763	0.0627	11.9	0.165	0.134	0.570	0.227	0.247
LAW-HPVR-10	S-13671LM11	2	1	10	6.27	0.0552	0.0846	0.0484	16.4	0.169	2.57	<0.0500	0.953	0.256
LRM	LRMLM212	2	1	11	0.382	0.128	0.949	0.0647	15.7	0.0874	<0.100	0.0608	<0.0500	<0.100
LAW-HPVR-20	S-13681LM11	2	1	12	4.49	0.0955	0.142	0.0459	18.1	0.323	0.254	0.929	0.819	0.476
LAW-HPVR-21	S-13682LM21	2	1	13	4.43	0.104	0.154	0.0445	14.4	0.307	0.149	1.67	1.94	0.461
LAW-HPVR-10	S-13671LM21	2	1	14	6.29	0.0504	0.0828	0.0481	16.5	0.169	2.54	<0.0500	1.00	0.258
LAW-HPVR-20	S-13681LM21	2	1	15	4.49	0.0955	0.142	0.0458	18.1	0.327	0.261	0.930	0.820	0.479
LAW-HPVR-19	S-13680LM21	2	1	16	6.17	0.0426	0.0707	0.0471	15.6	0.148	0.332	0.502	2.26	0.220
LAW-HPVR-21	S-13682LM11	2	1	17	4.39	0.0931	0.144	0.0440	14.2	0.313	0.152	1.65	1.93	0.460
LAW-HPVR-08	S-13669LM21	2	1	18	4.97	0.0635	0.0956	0.0419	11.5	0.190	1.28	1.56	0.396	0.322
LAW-HPVR-09	S-13670LM21	2	1	19	4.45	0.0543	0.0837	0.0381	13.7	0.179	0.292	1.75	0.608	0.268
LAW-HPVR-24	S-13685LM11	2	1	20	5.69	0.0913	0.137	0.0510	11.9	0.297	2.04	1.75	1.71	0.455
LRM	LRMLM213	2	1	21	0.377	0.125	0.932	0.0636	16.0	0.0841	<0.100	0.0597	<0.0500	<0.100
LRM	LRMLM221	2	2	1	0.365	0.125	0.927	0.0619	15.2	0.0815	<0.100	0.0584	<0.0500	<0.100
LAW-HPVR-18	S-13679LM22	2	2	2	5.71	0.106	0.154	0.0537	12.1	0.300	3.37	0.303	1.99	0.514
LAW-HPVR-09	S-13670LM22	2	2	3	4.19	0.0540	0.0828	0.0368	13.4	0.174	0.293	1.62	0.595	0.261

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Ca	Cr	Fe	Mg	Na	S	Sn	Ti	V	Zn
LAW-HPVR-20	S-13681LM22	2	2	4	4.26	0.0949	0.140	0.0442	18.2	0.302	0.251	0.907	0.800	0.467
LAW-HPVR-18	S-13679LM12	2	2	5	5.25	0.102	0.143	0.0499	10.5	0.277	3.07	0.282	1.81	0.478
LAW-HPVR-08	S-13669LM22	2	2	6	4.72	0.063	0.0939	0.0404	11.1	0.178	1.19	1.46	0.386	0.313
LAW-HPVR-06	S-13667LM12	2	2	7	8.21	0.0470	0.0761	0.0614	10.9	0.162	0.134	0.566	0.225	0.242
LAW-HPVR-20	S-13681LM12	2	2	8	4.27	0.0959	0.142	0.0450	17.7	0.325	0.257	0.925	0.817	0.475
LAW-HPVR-24	S-13685LM12	2	2	9	5.42	0.0946	0.141	0.0513	11.0	0.305	1.84	1.64	1.59	0.464
LAW-HPVR-21	S-13682LM12	2	2	10	4.18	0.0946	0.144	0.0431	14.3	0.310	0.151	1.54	1.79	0.455
LRM	LRMLM222	2	2	11	0.361	0.130	0.956	0.0638	15.0	0.0888	<0.100	0.0610	<0.0500	<0.100
LAW-HPVR-19	S-13680LM12	2	2	12	5.88	0.0425	0.0694	0.0450	15.7	0.134	0.322	0.485	2.09	0.212
LAW-HPVR-10	S-13671LM12	2	2	13	6.03	0.0545	0.0828	0.0465	17.1	0.154	2.36	<0.0500	0.924	0.250
LAW-HPVR-19	S-13680LM22	2	2	14	5.84	0.0417	0.0682	0.0446	16.2	0.130	0.320	0.479	2.14	0.208
LAW-HPVR-06	S-13667LM22	2	2	15	8.54	0.0455	0.0753	0.0583	12.2	0.138	0.129	0.551	0.219	0.233
LAW-HPVR-10	S-13671LM22	2	2	16	6.04	0.0498	0.0808	0.0463	16.9	0.146	2.35	<0.0500	0.920	0.247
LAW-HPVR-09	S-13670LM12	2	2	17	4.28	0.0530	0.0822	0.0365	13.9	0.167	0.286	1.65	0.585	0.259
LAW-HPVR-08	S-13669LM12	2	2	18	4.78	0.0586	0.0942	0.0402	11.4	0.182	1.18	1.48	0.381	0.311
LAW-HPVR-24	S-13685LM22	2	2	19	5.47	0.0908	0.136	0.0497	11.3	0.289	1.88	1.67	1.62	0.446
LAW-HPVR-21	S-13682LM22	2	2	20	4.13	0.101	0.149	0.0423	14.5	0.277	0.145	1.55	1.80	0.439
LRM	LRMLM223	2	2	21	0.352	0.125	0.924	0.0617	15.5	0.0764	<0.100	0.0585	<0.0500	<0.100
LRM	LRMLM311	3	1	1	0.372	0.130	0.965	0.0660	14.2	0.0814	<0.100	0.0608	<0.0500	<0.100
LAW-HPVR-04-1	S-13665LM21	3	1	2	4.90	0.113	0.166	0.0508	12.0	0.373	0.875	1.63	2.11	0.562
LAW-HPVR-15	S-13676LM11	3	1	3	4.34	0.0459	0.0742	0.0363	10.8	0.142	3.06	0.0635	0.300	0.221
LAW-HPVR-17	S-13678LM21	3	1	4	6.18	0.0984	0.146	0.0542	12.3	0.333	0.663	0.126	0.369	0.502
LAW-HPVR-02-1	S-13663LM11	3	1	5	5.43	0.0671	0.105	0.0468	12.3	0.196	2.33	0.658	2.01	0.330
LAW-HPVR-02-1	S-13663LM21	3	1	6	5.55	0.0663	0.104	0.0471	12.5	0.194	2.48	0.660	2.04	0.332
LAW-HPVR-17	S-13678LM11	3	1	7	6.14	0.113	0.155	0.0581	12.2	0.350	0.682	0.132	0.384	0.530
LAW-HPVR-25	S-13686LM11	3	1	8	8.11	0.115	0.180	0.0717	16.5	0.385	1.38	1.18	0.128	0.610
LAW-HPVR-15	S-13676LM21	3	1	9	4.37	0.0469	0.0763	0.0377	10.8	0.156	3.07	0.0641	0.304	0.232
LRM	LRMLM312	3	1	10	0.373	0.131	0.988	0.0673	14.9	0.0794	<0.100	0.0596	<0.0500	<0.100
LAW-HPVR-26	S-13687LM21	3	1	11	4.41	0.0838	0.129	0.0440	11.3	0.278	1.32	0.505	0.156	0.432
LAW-HPVR-16	S-13677LM21	3	1	12	4.34	0.0771	0.124	0.0433	13.4	0.222	3.20	0.547	0.499	0.403
LAW-HPVR-07	S-13668LM21	3	1	13	6.92	0.0679	0.109	0.0587	13.8	0.207	1.56	0.150	2.23	0.357
LAW-HPVR-25	S-13686LM21	3	1	14	7.68	0.119	0.181	0.0713	15.8	0.374	1.46	1.14	0.126	0.599
LAW-HPVR-04-1	S-13665LM11	3	1	15	4.86	0.117	0.173	0.0529	11.9	0.389	0.859	1.63	2.11	0.586

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Ca	Cr	Fe	Mg	Na	S	Sn	Ti	V	Zn
LAW-HPVR-07	S-13668LM11	3	1	16	7.01	0.0682	0.109	0.0590	13.6	0.210	1.52	0.152	2.24	0.360
LAW-HPVR-26	S-13687LM11	3	1	17	4.56	0.0854	0.137	0.0448	12.0	0.287	1.36	0.512	0.161	0.441
LAW-HPVR-16	S-13677LM11	3	1	18	4.67	0.0776	0.125	0.0437	14.1	0.228	3.51	0.548	0.500	0.412
LRM	LRMLM313	3	1	19	0.366	0.135	1.02	0.0693	14.5	0.0903	<0.100	0.0611	<0.0500	<0.100
LRM	LRMLM321	3	2	1	0.346	0.133	0.983	0.0654	15.0	0.0809	<0.100	0.0605	<0.0500	<0.100
LAW-HPVR-02-1	S-13663LM22	3	2	2	5.07	0.0703	0.109	0.0474	12.0	0.202	2.22	0.679	1.88	0.343
LAW-HPVR-04-1	S-13665LM22	3	2	3	4.32	0.124	0.179	0.0534	11.9	0.378	0.902	1.52	1.98	0.599
LAW-HPVR-17	S-13678LM12	3	2	4	5.42	0.118	0.161	0.0583	12.0	0.357	0.676	0.134	0.394	0.547
LAW-HPVR-07	S-13668LM22	3	2	5	6.52	0.0730	0.114	0.0600	14.2	0.211	1.49	0.159	2.12	0.374
LAW-HPVR-25	S-13686LM22	3	2	6	7.51	0.127	0.188	0.0725	16.1	0.382	1.39	1.08	0.133	0.629
LAW-HPVR-15	S-13676LM22	3	2	7	4.18	0.0495	0.0788	0.0379	10.9	0.146	2.90	0.0663	0.315	0.240
LAW-HPVR-02-1	S-13663LM12	3	2	8	5.20	0.0735	0.112	0.0489	12.0	0.215	2.27	0.685	1.88	0.355
LAW-HPVR-26	S-13687LM22	3	2	9	4.21	0.0915	0.136	0.0454	12.2	0.295	1.35	0.530	0.166	0.460
LRM	LRMLM322	3	2	10	0.337	0.144	1.06	0.0704	14.9	0.0825	<0.100	0.0633	<0.0500	<0.100
LAW-HPVR-26	S-13687LM12	3	2	11	4.15	0.0917	0.144	0.0459	11.6	0.301	1.33	0.532	0.168	0.459
LAW-HPVR-15	S-13676LM12	3	2	12	3.94	0.0494	0.0798	0.0377	10.7	0.162	2.74	0.0648	0.309	0.236
LAW-HPVR-16	S-13677LM22	3	2	13	4.30	0.0808	0.128	0.0432	13.9	0.216	3.20	0.550	0.506	0.415
LAW-HPVR-04-1	S-13665LM12	3	2	14	4.61	0.124	0.178	0.0535	11.9	0.388	0.860	1.55	2.01	0.602
LAW-HPVR-17	S-13678LM22	3	2	15	5.82	0.109	0.159	0.0574	11.7	0.340	0.650	0.130	0.386	0.544
LAW-HPVR-16	S-13677LM12	3	2	16	4.00	0.0827	0.131	0.0445	13.1	0.226	3.04	0.560	0.515	0.427
LAW-HPVR-07	S-13668LM12	3	2	17	6.39	0.0732	0.115	0.0607	13.6	0.211	1.47	0.155	2.08	0.381
LAW-HPVR-25	S-13686LM12	3	2	18	7.42	0.119	0.185	0.0710	16.7	0.376	1.38	1.07	0.125	0.618
LRM	LRMLM323	3	2	19	0.336	0.141	1.05	0.0691	14.3	0.0941	<0.100	0.0608	<0.0500	<0.100

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	K	Li	P	Si	Zr
LRM	LRMPF111	1	1	1	5.25	2.50	1.37	0.0579	0.213	26.3	0.689
LAW-HPVR-13	S-13674PF11	1	1	2	1.95	2.15	2.96	0.936	0.223	23.3	4.10
LAW-HPVR-20	S-13681PF21	1	1	3	1.80	3.64	<0.100	0.122	0.255	20.2	2.13
LAW-HPVR-09	S-13670PF21	1	1	4	2.55	4.26	1.52	1.32	0.150	20.4	1.49
LAW-HPVR-08	S-13669PF21	1	1	5	4.44	4.12	2.81	1.62	0.186	16.8	3.57
LAW-HPVR-14	S-13675PF11	1	1	6	2.80	3.37	0.273	0.115	0.150	16.3	3.27
LAW-HPVR-19	S-13680PF11	1	1	7	2.60	2.93	0.464	0.887	0.120	20.2	1.32
LAW-HPVR-20	S-13681PF11	1	1	8	1.79	3.63	0.183	0.121	0.269	19.8	1.99
LAW-HPVR-12	S-13673PF21	1	1	9	2.26	1.93	0.255	0.847	0.119	22.5	1.91
LAW-HPVR-06	S-13667PF11	1	1	10	1.96	4.28	4.48	0.587	0.140	19.1	1.93
LRM	LRMPF112	1	1	11	5.23	2.39	1.35	0.0530	0.214	25.1	0.677
LAW-HPVR-10	S-13671PF21	1	1	12	1.86	3.78	1.91	0.163	0.153	18.7	1.75
LAW-HPVR-13	S-13674PF21	1	1	13	1.82	2.08	2.95	0.902	0.225	22.4	3.95
LAW-HPVR-06	S-13667PF21	1	1	14	1.97	4.27	4.59	0.596	0.126	19.1	1.93
LAW-HPVR-10	S-13671PF11	1	1	15	1.86	3.86	1.96	0.165	0.155	19.2	1.79
LAW-HPVR-19	S-13680PF21	1	1	16	2.74	2.96	0.609	0.914	0.119	20.2	1.33
LAW-HPVR-14	S-13675PF21	1	1	17	2.97	3.37	0.318	0.114	0.147	16.3	3.30
LAW-HPVR-09	S-13670PF11	1	1	18	2.62	4.13	1.53	1.34	0.152	19.9	1.55
LAW-HPVR-08	S-13669PF11	1	1	19	4.86	4.08	2.80	1.59	0.182	16.6	3.55
LAW-HPVR-12	S-13673PF11	1	1	20	2.30	1.90	0.309	0.828	0.127	22.2	1.89
LRM	LRMPF113	1	1	21	5.22	2.42	1.41	0.0533	0.205	25.4	0.695
LRM	LRMPF121	1	2	1	4.89	2.49	1.33	<0.0500	0.188	26.0	0.708
LAW-HPVR-12	S-13673PF12	1	2	2	2.29	1.90	0.194	0.839	0.104	22.1	1.94
LAW-HPVR-10	S-13671PF12	1	2	3	1.87	3.75	1.85	0.156	0.122	18.7	1.80
LAW-HPVR-08	S-13669PF12	1	2	4	4.94	4.21	2.89	1.67	0.160	16.9	3.77
LAW-HPVR-14	S-13675PF12	1	2	5	2.86	3.44	0.233	0.111	0.115	16.5	3.47
LAW-HPVR-10	S-13671PF22	1	2	6	1.95	3.90	1.90	0.165	0.136	19.3	1.88
LAW-HPVR-08	S-13669PF22	1	2	7	4.97	4.17	2.85	1.65	0.164	16.9	3.75
LAW-HPVR-06	S-13667PF22	1	2	8	1.90	4.33	4.72	0.598	0.124	19.3	2.02
LAW-HPVR-06	S-13667PF12	1	2	9	1.89	4.29	4.61	0.592	0.126	19.1	2.01
LAW-HPVR-13	S-13674PF12	1	2	10	1.92	2.10	2.76	0.871	0.188	22.7	4.15
LRM	LRMPF122	1	2	11	5.18	2.48	1.31	<0.0500	0.212	25.9	0.725
LAW-HPVR-19	S-13680PF12	1	2	12	2.74	2.96	0.418	0.917	0.106	20.4	1.39

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	K	Li	P	Si	Zr
LAW-HPVR-13	S-13674PF22	1	2	13	1.95	2.15	2.91	0.885	0.211	23.0	4.21
LAW-HPVR-20	S-13681PF12	1	2	14	1.81	3.70	0.120	0.111	0.254	20.2	2.100
LAW-HPVR-12	S-13673PF22	1	2	15	2.08	1.81	0.126	0.803	<0.100	21.1	1.86
LAW-HPVR-14	S-13675PF22	1	2	16	2.92	3.34	0.182	0.0979	0.124	16.1	3.37
LAW-HPVR-20	S-13681PF22	1	2	17	1.87	3.68	<0.100	0.108	0.280	20.3	2.11
LAW-HPVR-09	S-13670PF22	1	2	18	2.45	4.14	1.42	1.27	0.132	19.9	1.51
LAW-HPVR-19	S-13680PF22	1	2	19	2.65	2.91	0.360	0.868	0.124	19.9	1.34
LAW-HPVR-09	S-13670PF12	1	2	20	2.63	4.17	1.46	1.29	0.156	20.0	1.53
LRM	LRMPF123	1	2	21	4.98	2.29	1.21	<0.0500	0.188	24.1	0.676
LRM	LRMPF211	2	1	1	5.34	2.47	1.27	<0.0500	0.216	25.8	0.710
LAW-HPVR-05	S-13666PF21	2	1	2	1.99	3.27	0.683	1.82	0.312	20.2	4.26
LAW-HPVR-11	S-13672PF11	2	1	3	2.10	3.39	3.19	0.228	<0.100	16.5	4.44
LAW-HPVR-02-1	S-13663PF11	2	1	4	2.04	4.20	3.11	0.0692	0.181	19.3	1.44
LAW-HPVR-17	S-13678PF21	2	1	5	4.28	4.18	4.10	0.733	0.289	17.7	1.78
LAW-HPVR-21	S-13682PF11	2	1	6	4.58	3.86	4.55	<0.0500	0.253	15.7	1.73
LAW-HPVR-11	S-13672PF21	2	1	7	2.05	3.28	2.94	0.221	0.107	16.0	4.30
LAW-HPVR-23	S-13684PF21	2	1	8	2.77	2.17	1.07	0.416	0.206	18.9	3.57
LAW-HPVR-03-1	S-13664PF11	2	1	9	3.93	2.79	4.35	1.27	0.145	16.7	4.72
LAW-HPVR-15	S-13676PF21	2	1	10	2.27	3.25	3.85	1.38	0.131	21.1	2.27
LRM	LRMPF212	2	1	11	5.24	2.41	1.27	<0.0500	0.212	25.5	0.718
LAW-HPVR-18	S-13679PF11	2	1	12	2.22	3.97	1.01	1.26	0.288	18.1	2.07
LAW-HPVR-23	S-13684PF11	2	1	13	2.83	2.20	1.15	0.426	0.207	19.2	3.63
LAW-HPVR-03-1	S-13664PF21	2	1	14	3.91	2.76	4.39	1.26	0.146	16.5	4.67
LAW-HPVR-02-1	S-13663PF21	2	1	15	1.99	4.11	3.21	0.0718	0.177	18.9	1.42
LAW-HPVR-15	S-13676PF11	2	1	16	2.25	3.19	3.84	1.36	0.120	20.8	2.24
LAW-HPVR-17	S-13678PF11	2	1	17	4.07	3.97	3.86	0.685	0.260	16.8	1.71
LAW-HPVR-21	S-13682PF21	2	1	18	4.61	3.89	4.52	<0.0500	0.243	15.9	1.76
LAW-HPVR-05	S-13666PF11	2	1	19	1.98	3.22	0.658	1.72	0.307	20.0	4.24
LAW-HPVR-18	S-13679PF21	2	1	20	2.19	3.89	0.942	1.21	0.293	17.8	2.04
LRM	LRMPF213	2	1	21	5.15	2.38	1.21	<0.0500	0.209	25.1	0.714
LRM	LRMPF221	2	2	1	4.97	2.32	1.24	<0.0500	0.181	24.4	0.661
LAW-HPVR-11	S-13672PF22	2	2	2	1.97	3.21	2.91	0.218	<0.100	15.6	4.17
LAW-HPVR-15	S-13676PF22	2	2	3	2.16	3.06	3.75	1.33	0.108	19.9	2.12

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	K	Li	P	Si	Zr
LAW-HPVR-23	S-13684PF22	2	2	4	2.63	2.07	1.21	0.430	0.176	18.1	3.38
LAW-HPVR-18	S-13679PF22	2	2	5	2.08	3.74	0.950	1.19	0.266	17.3	1.93
LAW-HPVR-17	S-13678PF22	2	2	6	4.02	3.97	3.79	0.671	0.249	16.8	1.68
LAW-HPVR-23	S-13684PF12	2	2	7	2.64	2.07	1.08	0.415	0.182	18.1	3.37
LAW-HPVR-21	S-13682PF12	2	2	8	4.31	3.66	4.22	<0.0500	0.221	15.0	1.62
LAW-HPVR-17	S-13678PF12	2	2	9	3.93	3.88	3.68	0.665	0.244	16.4	1.65
LAW-HPVR-05	S-13666PF22	2	2	10	1.86	3.06	0.642	1.68	0.290	19.1	4.00
LRM	LRMPF222	2	2	11	4.89	2.27	1.19	<0.0500	0.176	24.0	0.671
LAW-HPVR-05	S-13666PF12	2	2	12	1.87	3.10	0.657	1.76	0.279	19.3	4.02
LAW-HPVR-02-1	S-13663PF22	2	2	13	1.86	3.84	3.03	0.0700	0.159	17.7	1.31
LAW-HPVR-03-1	S-13664PF22	2	2	14	3.63	2.58	4.04	1.17	0.124	15.6	4.34
LAW-HPVR-02-1	S-13663PF12	2	2	15	1.92	3.94	3.19	0.0747	0.155	18.1	1.34
LAW-HPVR-15	S-13676PF12	2	2	16	2.13	3.05	3.72	1.31	0.109	19.8	2.11
LAW-HPVR-03-1	S-13664PF12	2	2	17	3.54	2.53	4.04	1.17	0.115	15.3	4.27
LAW-HPVR-21	S-13682PF22	2	2	18	4.28	3.65	4.20	<0.0500	0.220	15.0	1.62
LAW-HPVR-18	S-13679PF12	2	2	19	2.05	3.66	0.985	1.17	0.266	16.9	1.91
LAW-HPVR-11	S-13672PF12	2	2	20	1.96	3.17	2.88	0.213	<0.100	15.5	4.14
LRM	LRMPF223	2	2	21	4.80	2.21	1.06	<0.0500	0.184	23.6	0.645
LRM	LRMPF311	3	1	1	5.33	2.40	1.17	0.0527	0.204	25.2	0.705
LAW-HPVR-07	S-13668PF21	3	1	2	2.19	2.18	2.91	0.493	0.160	17.6	4.62
LAW-HPVR-04-1	S-13665PF21	3	1	3	1.84	2.65	1.37	1.58	0.342	21.1	1.63
LAW-HPVR-01-1	S-13662PF11	3	1	4	1.92	3.83	2.10	1.26	<0.100	18.6	3.86
LAW-HPVR-25	S-13686PF21	3	1	5	1.83	2.04	1.56	0.228	0.307	18.4	3.28
LAW-HPVR-07	S-13668PF11	3	1	6	2.26	2.17	2.98	0.497	0.184	17.7	4.67
LAW-HPVR-24	S-13685PF21	3	1	7	1.96	2.13	4.61	1.35	0.261	19.6	1.86
LAW-HPVR-04-1	S-13665PF11	3	1	8	1.82	2.60	1.48	1.59	0.326	20.9	1.68
LAW-HPVR-22	S-13683PF11	3	1	9	2.93	2.34	2.69	0.779	0.245	16.6	3.09
LRM	LRMPF312	3	1	10	5.40	2.38	1.28	0.0506	0.193	25.4	0.7800
LAW-HPVR-24	S-13685PF11	3	1	11	1.95	2.12	4.63	1.37	0.270	19.6	1.82
LAW-HPVR-01-1	S-13662PF21	3	1	12	1.85	3.81	2.17	1.24	<0.100	18.3	3.91
LAW-HPVR-26	S-13687PF21	3	1	13	6.35	4.23	2.69	1.70	0.249	16.6	2.44
LAW-HPVR-22	S-13683PF21	3	1	14	2.99	2.32	2.82	0.772	0.244	16.3	3.05
LAW-HPVR-16	S-13677PF21	3	1	15	3.39	3.74	2.19	0.598	0.242	17.9	3.45

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	K	Li	P	Si	Zr
LAW-HPVR-25	S-13686PF11	3	1	16	1.84	1.97	1.35	0.222	0.328	18.4	3.30
LAW-HPVR-26	S-13687PF11	3	1	17	6.04	4.18	2.54	1.67	0.250	16.7	2.48
LAW-HPVR-16	S-13677PF11	3	1	18	3.43	3.73	2.26	0.610	0.211	18.0	3.48
LRM	LRMPF313	3	1	19	5.42	2.32	1.35	<0.0500	0.222	25.4	0.799
LRM	LRMPF321	3	2	1	5.20	2.34	1.24	<0.0500	0.205	24.9	0.667
LAW-HPVR-22	S-13683PF22	3	2	2	3.06	2.32	2.58	0.720	0.271	16.3	2.91
LAW-HPVR-24	S-13685PF22	3	2	3	2.05	2.08	4.67	1.31	0.257	19.6	1.83
LAW-HPVR-24	S-13685PF12	3	2	4	2.05	2.09	4.66	1.31	0.274	19.5	1.78
LAW-HPVR-16	S-13677PF12	3	2	5	3.43	3.70	1.95	0.562	0.232	17.9	3.35
LAW-HPVR-16	S-13677PF22	3	2	6	3.38	3.71	2.08	0.556	0.244	17.8	3.29
LAW-HPVR-22	S-13683PF12	3	2	7	2.99	2.32	2.55	0.727	0.280	16.5	3.02
LAW-HPVR-26	S-13687PF12	3	2	8	5.98	4.20	2.38	1.64	0.266	16.9	2.42
LAW-HPVR-01-1	S-13662PF22	3	2	9	2.00	3.82	2.10	1.19	0.103	18.5	3.84
LRM	LRMPF322	3	2	10	5.28	2.34	1.36	<0.0500	0.235	25.3	0.705
LAW-HPVR-04-1	S-13665PF12	3	2	11	1.95	2.59	1.29	1.51	0.361	20.8	1.61
LAW-HPVR-26	S-13687PF22	3	2	12	6.35	4.21	2.64	1.66	0.266	16.9	2.39
LAW-HPVR-07	S-13668PF12	3	2	13	2.39	2.13	3.06	0.478	0.183	17.9	4.58
LAW-HPVR-04-1	S-13665PF22	3	2	14	1.96	2.60	1.39	1.54	0.350	21.2	1.61
LAW-HPVR-25	S-13686PF12	3	2	15	1.97	2.00	1.45	0.198	0.346	18.6	3.22
LAW-HPVR-07	S-13668PF22	3	2	16	2.37	2.15	2.94	0.475	0.205	17.9	4.64
LAW-HPVR-01-1	S-13662PF12	3	2	17	2.02	3.81	2.00	1.19	0.129	18.5	3.83
LAW-HPVR-25	S-13686PF22	3	2	18	1.98	2.03	1.49	0.203	0.352	18.7	3.28
LRM	LRMPF323	3	2	19	5.43	2.39	1.17	<0.0500	0.249	25.7	0.760

Table A-4. Comparison of Measured versus Target Compositions

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-01-1	Al_2O_3	3.68	3.79	-0.11	-3%
LAW-HPVR-01-1	B_2O_3	12.3	12.5	-0.208	-2%
LAW-HPVR-01-1	CaO	6.66	6.5	0.157	2%
LAW-HPVR-01-1	Cl^-	1.41	0.035	1.37	3914%
LAW-HPVR-01-1	Cr_2O_3	0.0550	0.06	-0.005	
LAW-HPVR-01-1	F^-	0.0502	0.07	-0.02	
LAW-HPVR-01-1	Fe_2O_3	0.133	0.08	0.053	
LAW-HPVR-01-1	K_2O	2.52	2.56	-0.039	-2%
LAW-HPVR-01-1	Li_2O	2.63	2.62	0.007	0%
LAW-HPVR-01-1	MgO	0.0632	0.01	0.053	
LAW-HPVR-01-1	Na_2O	17.4	18.2	-0.811	-4%
LAW-HPVR-01-1	P_2O_5	<0.247	0.26	-0.013	
LAW-HPVR-01-1	SiO_2	39.5	40.1	-0.576	-1%
LAW-HPVR-01-1	SnO_2	2.15	2.02	0.132	7%
LAW-HPVR-01-1	SO_3	0.312	0.346	-0.034	
LAW-HPVR-01-1	TiO_2	1.71	1.73	-0.015	-1%
LAW-HPVR-01-1	V_2O_5	3.28	3.26	0.016	0%
LAW-HPVR-01-1	ZnO	0.257	0.25	0.007	
LAW-HPVR-01-1	ZrO_2	5.21	5.64	-0.426	-8%
LAW-HPVR-01-1	**Sum of Oxides**	**99.6**	**100**	**-0.463**	**0%**
LAW-HPVR-02-1	Al_2O_3	3.69	3.86	-0.171	-4%
LAW-HPVR-02-1	B_2O_3	13.0	13.6	-0.648	-5%
LAW-HPVR-02-1	CaO	7.43	7.6	-0.167	-2%
LAW-HPVR-02-1	Cl^-	0.659	0.06	0.599	998%
LAW-HPVR-02-1	Cr_2O_3	0.101	0.102	-0.001	
LAW-HPVR-02-1	F^-	0.0851	0.12	-0.035	
LAW-HPVR-02-1	Fe_2O_3	0.154	0.137	0.017	
LAW-HPVR-02-1	K_2O	3.78	4.02	-0.244	-6%
LAW-HPVR-02-1	Li_2O	0.154	0.167	-0.013	
LAW-HPVR-02-1	MgO	0.0789	0.017	0.062	
LAW-HPVR-02-1	Na_2O	16.4	17.7	-1.254	-7%
LAW-HPVR-02-1	P_2O_5	0.385	0.444	-0.059	
LAW-HPVR-02-1	SiO_2	39.6	41.5	-1.923	-5%
LAW-HPVR-02-1	SnO_2	2.95	2.83	0.122	4%
LAW-HPVR-02-1	SO_3	0.504	0.589	-0.085	
LAW-HPVR-02-1	TiO_2	1.12	1.16	-0.042	-4%
LAW-HPVR-02-1	V_2O_5	3.49	3.57	-0.084	-2%
LAW-HPVR-02-1	ZnO	0.423	0.427	-0.004	
LAW-HPVR-02-1	ZrO_2	1.86	2.12	-0.259	-12%
LAW-HPVR-02-1	**Sum of Oxides**	**95.8**	**100**	**-4.189**	**-4%**
LAW-HPVR-03-1	Al_2O_3	7.09	7.59	-0.5	-7%
LAW-HPVR-03-1	B_2O_3	8.58	9.16	-0.579	-6%
LAW-HPVR-03-1	CaO	6.58	6.3	0.283	4%
LAW-HPVR-03-1	Cl^-	0.0779	0.048	0.03	62%
LAW-HPVR-03-1	Cr_2O_3	0.0742	0.082	-0.008	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-03-1	F-	0.0821	0.096	-0.014	
LAW-HPVR-03-1	Fe2O3	0.115	0.109	0.006	
LAW-HPVR-03-1	K2O	5.07	5.63	-0.565	-10%
LAW-HPVR-03-1	Li2O	2.62	2.86	-0.239	-8%
LAW-HPVR-03-1	MgO	0.0646	0.014	0.051	
LAW-HPVR-03-1	Na2O	16.0	16.1	-0.093	-1%
LAW-HPVR-03-1	P2O5	0.304	0.355	-0.051	
LAW-HPVR-03-1	SiO2	34.3	36.2	-1.918	-5%
LAW-HPVR-03-1	SnO2	4.27	4	0.272	7%
LAW-HPVR-03-1	SO3	0.421	0.471	-0.05	
LAW-HPVR-03-1	TiO2	1.00	1.09	-0.087	-8%
LAW-HPVR-03-1	V2O5	3.35	3.31	0.037	1%
LAW-HPVR-03-1	ZnO	0.314	0.341	-0.027	
LAW-HPVR-03-1	ZrO2	6.08	6.29	-0.211	-3%
LAW-HPVR-03-1	**Sum of Oxides**	**96.4**	**100**	**-3.661**	**-4%**
LAW-HPVR-04-1	Al_2O_3	3.58	3.71	-0.134	-4%
LAW-HPVR-04-1	B_2O_3	8.40	8.56	-0.156	-2%
LAW-HPVR-04-1	CaO	6.54	6.69	-0.152	-2%
LAW-HPVR-04-1	Cl^-	0.101	0.104	-0.003	-3%
LAW-HPVR-04-1	Cr_2O_3	0.175	0.178	-0.003	
LAW-HPVR-04-1	F^-	0.165	0.208	-0.043	
LAW-HPVR-04-1	Fe_2O_3	0.249	0.238	0.011	
LAW-HPVR-04-1	K_2O	1.67	1.61	0.055	3%
LAW-HPVR-04-1	Li_2O	3.35	3.36	-0.012	0%
LAW-HPVR-04-1	MgO	0.0873	0.03	0.057	
LAW-HPVR-04-1	Na_2O	16.1	17.2	-1.125	-7%
LAW-HPVR-04-1	P_2O_5	0.790	0.772	0.018	
LAW-HPVR-04-1	SiO_2	44.9	45.9	-0.975	-2%
LAW-HPVR-04-1	SnO_2	1.11	1.08	0.03	3%
LAW-HPVR-04-1	SO_3	0.954	1.02	-0.066	-6%
LAW-HPVR-04-1	TiO_2	2.64	2.7	-0.06	-2%
LAW-HPVR-04-1	V_2O_5	3.66	3.77	-0.106	-3%
LAW-HPVR-04-1	ZnO	0.731	0.742	-0.011	
LAW-HPVR-04-1	ZrO_2	2.21	2.16	0.045	2%
LAW-HPVR-04-1	**Sum of Oxides**	**97.4**	**100**	**-2.631**	**-3%**
LAW-HPVR-05	Al_2O_3	3.64	3.85	-0.213	-6%
LAW-HPVR-05	B_2O_3	10.2	10.7	-0.517	-5%
LAW-HPVR-05	CaO	6.55	6.2	0.352	6%
LAW-HPVR-05	Cl^-	1.35	0.098	1.255	1280%
LAW-HPVR-05	Cr_2O_3	0.151	0.169	-0.018	
LAW-HPVR-05	F^-	0.158	0.197	-0.04	
LAW-HPVR-05	Fe_2O_3	0.225	0.225	0	
LAW-HPVR-05	K_2O	0.795	0.818	-0.023	
LAW-HPVR-05	Li_2O	3.76	4.14	-0.383	-9%
LAW-HPVR-05	MgO	0.0789	0.028	0.051	
LAW-HPVR-05	Na_2O	16.9	17.7	-0.783	-4%
LAW-HPVR-05	P_2O_5	0.681	0.731	-0.05	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-05	SiO_2	42.0	43.9	-1.863	-4%
LAW-HPVR-05	SnO_2	0.877	0.842	0.035	
LAW-HPVR-05	SO_3	0.696	0.97	-0.274	
LAW-HPVR-05	TiO_2	0.432	0.452	-0.02	
LAW-HPVR-05	V_2O_5	1.84	1.82	0.018	1%
LAW-HPVR-05	ZnO	0.664	0.703	-0.039	
LAW-HPVR-05	ZrO_2	5.58	6.41	-0.831	-13%
LAW-HPVR-05	**Sum of Oxides**	**96.6**	**100**	**-3.342**	**-3%**
LAW-HPVR-06	Al_2O_3	3.65	3.72	-0.073	-2%
LAW-HPVR-06	B_2O_3	13.8	13.8	0.021	0%
LAW-HPVR-06	CaO	11.9	12.6	-0.7	-6%
LAW-HPVR-06	Cl^-	0.778	0.044	0.734	1667%
LAW-HPVR-06	Cr_2O_3	0.068	0.075	-0.007	
LAW-HPVR-06	F^-	0.0608	0.087	-0.026	
LAW-HPVR-06	Fe_2O_3	0.109	0.1	0.009	
LAW-HPVR-06	K_2O	5.54	5.87	-0.329	-6%
LAW-HPVR-06	Li_2O	1.28	1.27	0.007	1%
LAW-HPVR-06	MgO	0.101	0.012	0.089	
LAW-HPVR-06	Na_2O	15.8	15.9	-0.128	-1%
LAW-HPVR-06	P_2O_5	0.296	0.324	-0.028	
LAW-HPVR-06	SiO_2	41.0	41	-0.032	0%
LAW-HPVR-06	SnO_2	0.169	0.149	0.02	
LAW-HPVR-06	SO_3	0.394	0.43	-0.036	
LAW-HPVR-06	TiO_2	0.944	1	-0.056	-6%
LAW-HPVR-06	V_2O_5	0.402	0.421	-0.019	
LAW-HPVR-06	ZnO	0.300	0.311	-0.011	
LAW-HPVR-06	ZrO_2	2.66	2.93	-0.266	-9%
LAW-HPVR-06	**Sum of Oxides**	**99.2**	**100**	**-0.831**	**-1%**
LAW-HPVR-07	Al_2O_3	4.35	4.26	0.091	2%
LAW-HPVR-07	B_2O_3	6.95	7.07	-0.123	-2%
LAW-HPVR-07	CaO	9.39	9.88	-0.491	-5%
LAW-HPVR-07	Cl^-	0.753	0.061	0.692	1134%
LAW-HPVR-07	Cr_2O_3	0.103	0.105	-0.002	
LAW-HPVR-07	F^-	0.0989	0.123	-0.024	
LAW-HPVR-07	Fe_2O_3	0.160	0.141	0.019	
LAW-HPVR-07	K_2O	3.58	4.31	-0.729	-17%
LAW-HPVR-07	Li_2O	1.05	1	0.046	5%
LAW-HPVR-07	MgO	0.0988	0.018	0.081	
LAW-HPVR-07	Na_2O	18.6	21	-2.398	-11%
LAW-HPVR-07	P_2O_5	0.419	0.457	-0.038	
LAW-HPVR-07	SiO_2	38.0	37.9	0.126	0%
LAW-HPVR-07	SnO_2	1.92	1.83	0.087	5%
LAW-HPVR-07	SO_3	0.524	0.606	-0.082	
LAW-HPVR-07	TiO_2	0.257	0.247	0.01	
LAW-HPVR-07	V_2O_5	3.87	3.97	-0.101	-3%
LAW-HPVR-07	ZnO	0.458	0.439	0.019	
LAW-HPVR-07	ZrO_2	6.25	6.59	-0.339	-5%

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-07	**Sum of Oxides**	**96.8**	**100**	**-3.157**	**-3%**
LAW-HPVR-08	Al_2O_3	9.07	9.3	-0.226	-2%
LAW-HPVR-08	B_2O_3	13.3	13.1	0.246	2%
LAW-HPVR-08	CaO	6.79	6.85	-0.064	-1%
LAW-HPVR-08	Cl^-	1.27	0.058	1.21	2085%
LAW-HPVR-08	Cr_2O_3	0.0900	0.1	-0.01	
LAW-HPVR-08	F^-	0.0910	0.116	-0.025	
LAW-HPVR-08	Fe_2O_3	0.137	0.133	0.004	
LAW-HPVR-08	K_2O	3.42	3.66	-0.242	-7%
LAW-HPVR-08	Li_2O	3.51	3.5	0.015	0%
LAW-HPVR-08	MgO	0.0684	0.017	0.051	
LAW-HPVR-08	Na_2O	15.5	16.4	-0.932	-6%
LAW-HPVR-08	P_2O_5	0.396	0.433	-0.037	
LAW-HPVR-08	SiO_2	35.9	35.2	0.74	2%
LAW-HPVR-08	SnO_2	1.56	1.49	0.068	5%
LAW-HPVR-08	SO_3	0.465	0.574	-0.109	
LAW-HPVR-08	TiO_2	2.52	2.57	-0.051	-2%
LAW-HPVR-08	V_2O_5	0.699	0.731	-0.032	
LAW-HPVR-08	ZnO	0.396	0.416	-0.02	
LAW-HPVR-08	ZrO_2	4.94	5.41	-0.466	-9%
LAW-HPVR-08	**Sum of Oxides**	**100**	**100**	**0.121**	**0%**
LAW-HPVR-09	Al_2O_3	4.84	4.88	-0.038	-1%
LAW-HPVR-09	B_2O_3	13.4	13.6	-0.157	-1%
LAW-HPVR-09	CaO	6.09	6.12	-0.026	0%
LAW-HPVR-09	Cl^-	0.701	0.049	0.652	1331%
LAW-HPVR-09	Cr_2O_3	0.0793	0.084	-0.005	
LAW-HPVR-09	F^-	0.0794	0.098	-0.019	
LAW-HPVR-09	Fe_2O_3	0.12	0.112	0.008	
LAW-HPVR-09	K_2O	1.79	1.77	0.016	1%
LAW-HPVR-09	Li_2O	2.81	2.83	-0.02	-1%
LAW-HPVR-09	MgO	0.0624	0.014	0.048	
LAW-HPVR-09	Na_2O	18.4	19.1	-0.666	-3%
LAW-HPVR-09	P_2O_5	0.338	0.364	-0.026	
LAW-HPVR-09	SiO_2	42.9	43.5	-0.607	-1%
LAW-HPVR-09	SnO_2	0.375	0.352	0.023	
LAW-HPVR-09	SO_3	0.442	0.483	-0.041	
LAW-HPVR-09	TiO_2	2.81	2.92	-0.105	-4%
LAW-HPVR-09	V_2O_5	1.08	1.13	-0.052	-5%
LAW-HPVR-09	ZnO	0.331	0.35	-0.019	
LAW-HPVR-09	ZrO_2	2.05	2.27	-0.217	-10%
LAW-HPVR-09	**Sum of Oxides**	**98.8**	**100**	**-1.252**	**-1%**
LAW-HPVR-10	Al_2O_3	3.56	3.55	0.012	0%
LAW-HPVR-10	B_2O_3	12.3	12.3	0.008	0%
LAW-HPVR-10	CaO	8.62	8.88	-0.264	-3%
LAW-HPVR-10	Cl^-	0.805	0.047	0.758	1613%
LAW-HPVR-10	Cr_2O_3	0.0767	0.08	-0.003	
LAW-HPVR-10	F^-	0.0712	0.093	-0.022	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-10	Fe_2O_3	0.118	0.106	0.012	
LAW-HPVR-10	K_2O	2.29	2.27	0.025	1%
LAW-HPVR-10	Li_2O	0.349	0.338	0.011	
LAW-HPVR-10	MgO	0.0785	0.013	0.065	
LAW-HPVR-10	Na_2O	22.5	22.8	-0.255	-1%
LAW-HPVR-10	P_2O_5	0.324	0.346	-0.022	
LAW-HPVR-10	SiO_2	40.6	40.8	-0.207	-1%
LAW-HPVR-10	SnO_2	3.12	3	0.117	4%
LAW-HPVR-10	SO_3	0.398	0.459	-0.061	
LAW-HPVR-10	TiO_2	<0.0834	0.049	0.034	
LAW-HPVR-10	V_2O_5	1.69	1.78	-0.085	-5%
LAW-HPVR-10	ZnO	0.315	0.333	-0.018	
LAW-HPVR-10	ZrO_2	2.44	2.7	-0.262	-10%
LAW-HPVR-10	**Sum of Oxides**	**99.8**	**99.9**	**-0.156**	**0%**
LAW-HPVR-11	Al_2O_3	3.82	4.02	-0.203	-5%
LAW-HPVR-11	B_2O_3	10.5	11	-0.495	-5%
LAW-HPVR-11	CaO	6.37	6.06	0.313	5%
LAW-HPVR-11	Cl^-	1.46	0.036	1.424	3956%
LAW-HPVR-11	Cr_2O_3	0.0569	0.061	-0.004	
LAW-HPVR-11	F^-	0.0569	0.071	-0.014	
LAW-HPVR-11	Fe_2O_3	0.0885	0.081	0.007	
LAW-HPVR-11	K_2O	3.59	4.23	-0.64	-15%
LAW-HPVR-11	Li_2O	0.474	0.506	-0.032	
LAW-HPVR-11	MgO	0.0580	0.01	0.048	
LAW-HPVR-11	Na_2O	21.7	22.3	-0.631	-3%
LAW-HPVR-11	P_2O_5	<0.233	0.264	-0.031	
LAW-HPVR-11	SiO_2	34.0	35.4	-1.385	-4%
LAW-HPVR-11	SnO_2	3.69	3.39	0.305	9%
LAW-HPVR-11	SO_3	0.345	0.35	-0.005	
LAW-HPVR-11	TiO_2	2.89	2.82	0.074	3%
LAW-HPVR-11	V_2O_5	2.60	2.53	0.072	3%
LAW-HPVR-11	ZnO	0.239	0.254	-0.015	
LAW-HPVR-11	ZrO_2	5.76	6.55	-0.792	-12%
LAW-HPVR-11	**Sum of Oxides**	**97.9**	**99.9**	**-2.005**	**-2%**
LAW-HPVR-12	Al_2O_3	4.22	4.44	-0.222	-5%
LAW-HPVR-12	B_2O_3	6.07	6.16	-0.09	-1%
LAW-HPVR-12	CaO	7.66	7.41	0.254	3%
LAW-HPVR-12	Cl^-	0.840	0.036	0.804	2233%
LAW-HPVR-12	Cr_2O_3	0.0601	0.062	-0.002	
LAW-HPVR-12	F^-	0.0566	0.073	-0.016	
LAW-HPVR-12	Fe_2O_3	0.112	0.083	0.029	
LAW-HPVR-12	K_2O	0.266	0.09	0.176	
LAW-HPVR-12	Li_2O	1.79	1.81	-0.025	-1%
LAW-HPVR-12	MgO	0.0682	0.01	0.058	
LAW-HPVR-12	Na_2O	22.5	23.1	-0.555	-2%
LAW-HPVR-12	P_2O_5	<0.258	0.27	-0.012	
LAW-HPVR-12	SiO_2	47.0	48	-0.989	-2%

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-12	SnO_2	2.16	2.05	0.108	5%
LAW-HPVR-12	SO_3	0.324	0.358	-0.034	
LAW-HPVR-12	TiO_2	0.989	1.07	-0.081	-8%
LAW-HPVR-12	V_2O_5	1.87	1.86	0.01	1%
LAW-HPVR-12	ZnO	0.245	0.26	-0.015	
LAW-HPVR-12	ZrO_2	2.57	2.88	-0.313	-11%
LAW-HPVR-12	**Sum of Oxides**	**99.1**	**100**	**-0.915**	**-1%**
LAW-HPVR-13	Al_2O_3	3.61	3.57	0.039	1%
LAW-HPVR-13	B_2O_3	6.83	6.83	-0.004	0%
LAW-HPVR-13	CaO	6.91	6.6	0.309	5%
LAW-HPVR-13	Cl^-	1.12	0.069	1.054	1527%
LAW-HPVR-13	Cr_2O_3	0.116	0.118	-0.002	
LAW-HPVR-13	F^-	0.107	0.137	-0.031	
LAW-HPVR-13	Fe_2O_3	0.169	0.157	0.012	
LAW-HPVR-13	K_2O	3.49	3.91	-0.423	-11%
LAW-HPVR-13	Li_2O	1.93	1.93	0.004	0%
LAW-HPVR-13	MgO	0.0732	0.02	0.053	
LAW-HPVR-13	Na_2O	16.4	16.9	-0.522	-3%
LAW-HPVR-13	P_2O_5	0.485	0.509	-0.024	
LAW-HPVR-13	SiO_2	48.9	49	-0.117	0%
LAW-HPVR-13	SnO_2	0.638	0.591	0.047	
LAW-HPVR-13	SO_3	0.435	0.676	-0.241	
LAW-HPVR-13	TiO_2	0.0945	0.085	0.009	
LAW-HPVR-13	V_2O_5	2.28	2.23	0.051	2%
LAW-HPVR-13	ZnO	0.471	0.49	-0.019	
LAW-HPVR-13	ZrO_2	5.54	6.15	-0.608	-10%
LAW-HPVR-13	**Sum of Oxides**	**99.6**	**100**	**-0.413**	**0%**
LAW-HPVR-14	Al_2O_3	5.46	5.77	-0.314	-5%
LAW-HPVR-14	B_2O_3	10.9	11	-0.117	-1%
LAW-HPVR-14	CaO	9.26	9.12	0.136	1%
LAW-HPVR-14	Cl^-	1.42	0.047	1.368	2911%
LAW-HPVR-14	Cr_2O_3	0.0740	0.081	-0.007	
LAW-HPVR-14	F^-	0.0704	0.094	-0.024	
LAW-HPVR-14	Fe_2O_3	0.117	0.108	0.009	
LAW-HPVR-14	K_2O	0.303	0.138	0.165	
LAW-HPVR-14	Li_2O	0.236	0.23	0.006	
LAW-HPVR-14	MgO	0.0790	0.013	0.066	
LAW-HPVR-14	Na_2O	25.3	26.3	-0.958	-4%
LAW-HPVR-14	P_2O_5	0.307	0.351	-0.044	
LAW-HPVR-14	SiO_2	34.9	35.1	-0.229	-1%
LAW-HPVR-14	SnO_2	4.43	4.21	0.224	5%
LAW-HPVR-14	SO_3	0.414	0.465	-0.051	
LAW-HPVR-14	TiO_2	1.34	1.47	-0.128	-9%
LAW-HPVR-14	V_2O_5	<0.0893	0.064	0.025	
LAW-HPVR-14	ZnO	0.316	0.337	-0.021	
LAW-HPVR-14	ZrO_2	4.53	5.16	-0.631	-12%
LAW-HPVR-14	**Sum of Oxides**	**99.5**	**100**	**-0.524**	**-1%**

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-15	Al_2O_3	4.16	4.44	-0.278	-6%
LAW-HPVR-15	B_2O_3	10.1	10.6	-0.498	-5%
LAW-HPVR-15	CaO	5.89	6.06	-0.173	-3%
LAW-HPVR-15	Cl^-	0.980	0.04	0.94	2350%
LAW-HPVR-15	Cr_2O_3	0.0700	0.069	0.001	
LAW-HPVR-15	F^-	0.0638	0.08	-0.016	
LAW-HPVR-15	Fe_2O_3	0.110	0.092	0.018	
LAW-HPVR-15	K_2O	4.57	5.06	-0.495	-10%
LAW-HPVR-15	Li_2O	2.90	3.11	-0.214	-7%
LAW-HPVR-15	MgO	0.062	0.011	0.051	
LAW-HPVR-15	Na_2O	14.6	15.8	-1.242	-8%
LAW-HPVR-15	P_2O_5	0.268	0.298	-0.03	
LAW-HPVR-15	SiO_2	43.6	46	-2.358	-5%
LAW-HPVR-15	SnO_2	3.74	3.64	0.096	3%
LAW-HPVR-15	SO_3	0.378	0.395	-0.017	
LAW-HPVR-15	TiO_2	0.108	0.096	0.012	
LAW-HPVR-15	V_2O_5	0.548	0.56	-0.012	
LAW-HPVR-15	ZnO	0.289	0.286	0.003	
LAW-HPVR-15	ZrO_2	2.95	3.38	-0.429	-13%
LAW-HPVR-15	**Sum of Oxides**	**95.4**	**100**	**-4.64**	**-5%**
LAW-HPVR-16	Al_2O_3	6.44	6.54	-0.102	-2%
LAW-HPVR-16	B_2O_3	12.0	12.2	-0.222	-2%
LAW-HPVR-16	CaO	6.06	6.17	-0.115	-2%
LAW-HPVR-16	Cl^-	1.16	0.071	1.089	1534%
LAW-HPVR-16	Cr_2O_3	0.116	0.121	-0.005	
LAW-HPVR-16	F^-	0.112	0.141	-0.029	
LAW-HPVR-16	Fe_2O_3	0.182	0.162	0.02	
LAW-HPVR-16	K_2O	2.55	2.77	-0.216	-8%
LAW-HPVR-16	Li_2O	1.25	1.22	0.032	3%
LAW-HPVR-16	MgO	0.0724	0.02	0.052	
LAW-HPVR-16	Na_2O	18.4	19.9	-1.533	-8%
LAW-HPVR-16	P_2O_5	0.532	0.525	0.007	
LAW-HPVR-16	SiO_2	38.3	38.2	0.093	0%
LAW-HPVR-16	SnO_2	4.11	3.94	0.17	4%
LAW-HPVR-16	SO_3	0.557	0.697	-0.14	
LAW-HPVR-16	TiO_2	0.919	0.945	-0.026	
LAW-HPVR-16	V_2O_5	0.902	0.925	-0.023	
LAW-HPVR-16	ZnO	0.516	0.505	0.011	
LAW-HPVR-16	ZrO_2	4.58	4.94	-0.357	-7%
LAW-HPVR-16	**Sum of Oxides**	**98.7**	**100**	**-1.294**	**-1%**
LAW-HPVR-17	Al_2O_3	7.70	8.22	-0.52	-6%
LAW-HPVR-17	B_2O_3	12.9	13.6	-0.72	-5%
LAW-HPVR-17	CaO	8.24	8.74	-0.499	-6%
LAW-HPVR-17	Cl^-	0.784	0.092	0.692	752%
LAW-HPVR-17	Cr_2O_3	0.160	0.158	0.002	
LAW-HPVR-17	F^-	0.145	0.185	-0.04	
LAW-HPVR-17	Fe_2O_3	0.222	0.211	0.011	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-17	K_2O	4.65	5.09	-0.443	-9%
LAW-HPVR-17	Li_2O	1.48	1.59	-0.108	-7%
LAW-HPVR-17	MgO	0.0945	0.026	0.069	
LAW-HPVR-17	Na_2O	16.2	17.7	-1.457	-8%
LAW-HPVR-17	P_2O_5	0.597	0.686	-0.089	
LAW-HPVR-17	SiO_2	36.2	37.8	-1.592	-4%
LAW-HPVR-17	SnO_2	0.848	0.797	0.051	
LAW-HPVR-17	SO_3	0.861	0.911	-0.05	
LAW-HPVR-17	TiO_2	0.218	0.204	0.014	
LAW-HPVR-17	V_2O_5	0.684	0.693	-0.009	
LAW-HPVR-17	ZnO	0.661	0.66	0.001	
LAW-HPVR-17	ZrO_2	2.30	2.64	-0.337	-13%
LAW-HPVR-17	**Sum of Oxides**	**95.0**	**100**	**-5.026**	**-5%**
LAW-HPVR-18	Al_2O_3	4.03	4.28	-0.246	-6%
LAW-HPVR-18	B_2O_3	12.3	13	-0.716	-6%
LAW-HPVR-18	CaO	7.84	8.4	-0.564	-7%
LAW-HPVR-18	Cl^-	0.906	0.096	0.81	844%
LAW-HPVR-18	Cr_2O_3	0.153	0.165	-0.012	
LAW-HPVR-18	F^-	0.142	0.193	-0.051	
LAW-HPVR-18	Fe_2O_3	0.215	0.22	-0.005	
LAW-HPVR-18	K_2O	1.17	1.15	0.021	2%
LAW-HPVR-18	Li_2O	2.60	2.8	-0.2	-7%
LAW-HPVR-18	MgO	0.0876	0.028	0.06	
LAW-HPVR-18	Na_2O	15.3	16.3	-0.967	-6%
LAW-HPVR-18	P_2O_5	0.638	0.715	-0.077	
LAW-HPVR-18	SiO_2	37.5	39.5	-2.009	-5%
LAW-HPVR-18	SnO_2	4.22	4.28	-0.055	-1%
LAW-HPVR-18	SO_3	0.741	0.949	-0.208	
LAW-HPVR-18	TiO_2	0.495	0.533	-0.038	
LAW-HPVR-18	V_2O_5	3.48	3.73	-0.249	-7%
LAW-HPVR-18	ZnO	0.628	0.688	-0.06	
LAW-HPVR-18	ZrO_2	2.68	3.08	-0.395	-13%
LAW-HPVR-18	**Sum of Oxides**	**95.1**	**100**	**-4.963**	**-5%**
LAW-HPVR-19	Al_2O_3	5.07	5.19	-0.121	-2%
LAW-HPVR-19	B_2O_3	9.47	9.61	-0.143	-1%
LAW-HPVR-19	CaO	8.43	8.7	-0.27	-3%
LAW-HPVR-19	Cl^-	0.662	0.04	0.622	1554%
LAW-HPVR-19	Cr_2O_3	0.0623	0.068	-0.006	
LAW-HPVR-19	F^-	0.0573	0.079	-0.022	
LAW-HPVR-19	Fe_2O_3	0.100	0.091	0.009	
LAW-HPVR-19	K_2O	0.557	0.382	0.175	
LAW-HPVR-19	Li_2O	1.93	1.95	-0.02	-1%
LAW-HPVR-19	MgO	0.0762	0.011	0.065	
LAW-HPVR-19	Na_2O	21.2	21.4	-0.236	-1%
LAW-HPVR-19	P_2O_5	0.269	0.295	-0.026	
LAW-HPVR-19	SiO_2	43.2	44.1	-0.94	-2%
LAW-HPVR-19	SnO_2	0.417	0.392	0.025	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-19	SO_3	0.351	0.391	-0.04	
LAW-HPVR-19	TiO_2	0.823	0.888	-0.065	
LAW-HPVR-19	V_2O_5	3.90	4	-0.099	-2%
LAW-HPVR-19	ZnO	0.268	0.283	-0.015	
LAW-HPVR-19	ZrO_2	1.82	2.06	-0.243	-12%
LAW-HPVR-19	**Sum of Oxides**	**98.6**	**99.9**	**-1.352**	**-1%**
LAW-HPVR-20	Al_2O_3	3.43	3.51	-0.076	-2%
LAW-HPVR-20	B_2O_3	11.8	11.9	-0.107	-1%
LAW-HPVR-20	CaO	6.12	6.25	-0.125	-2%
LAW-HPVR-20	Cl^-	1.02	0.087	0.93	1069%
LAW-HPVR-20	Cr_2O_3	0.140	0.15	-0.01	
LAW-HPVR-20	F^-	0.136	0.175	-0.039	
LAW-HPVR-20	Fe_2O_3	0.202	0.2	0.002	
LAW-HPVR-20	K_2O	<0.151	0.006	0.145	
LAW-HPVR-20	Li_2O	0.249	0.245	0.004	
LAW-HPVR-20	MgO	0.0750	0.025	0.05	
LAW-HPVR-20	Na_2O	24.3	25.4	-1.102	-4%
LAW-HPVR-20	P_2O_5	0.606	0.649	-0.043	
LAW-HPVR-20	SiO_2	43.1	43.4	-0.347	-1%
LAW-HPVR-20	SnO_2	0.325	0.307	0.018	
LAW-HPVR-20	SO_3	0.797	0.861	-0.064	
LAW-HPVR-20	TiO_2	1.54	1.63	-0.091	-6%
LAW-HPVR-20	V_2O_5	1.45	1.53	-0.077	-5%
LAW-HPVR-20	ZnO	0.590	0.624	-0.034	
LAW-HPVR-20	ZrO_2	2.81	3.1	-0.287	-9%
LAW-HPVR-20	**Sum of Oxides**	**98.8**	**100**	**-1.252**	**-1%**
LAW-HPVR-21	Al_2O_3	8.40	9.06	-0.661	-7%
LAW-HPVR-21	B_2O_3	12.1	12.9	-0.777	-6%
LAW-HPVR-21	CaO	5.99	6.03	-0.038	-1%
LAW-HPVR-21	Cl^-	0.815	0.084	0.731	871%
LAW-HPVR-21	Cr_2O_3	0.143	0.143	0	
LAW-HPVR-21	F^-	0.140	0.167	-0.027	
LAW-HPVR-21	Fe_2O_3	0.211	0.191	0.02	
LAW-HPVR-21	K_2O	5.27	5.83	-0.563	-10%
LAW-HPVR-21	Li_2O	<0.108	0.086	0.022	
LAW-HPVR-21	MgO	0.0721	0.024	0.048	
LAW-HPVR-21	Na_2O	19.3	19.8	-0.456	-2%
LAW-HPVR-21	P_2O_5	0.537	0.622	-0.085	
LAW-HPVR-21	SiO_2	32.9	34.7	-1.755	-5%
LAW-HPVR-21	SnO_2	0.189	0.166	0.023	
LAW-HPVR-21	SO_3	0.753	0.825	-0.072	
LAW-HPVR-21	TiO_2	2.67	2.74	-0.067	-2%
LAW-HPVR-21	V_2O_5	3.33	3.42	-0.091	-3%
LAW-HPVR-21	ZnO	0.565	0.598	-0.033	
LAW-HPVR-21	ZrO_2	2.27	2.64	-0.367	-14%
LAW-HPVR-21	**Sum of Oxides**	**95.9**	**100**	**-4.147**	**-4%**
LAW-HPVR-22	Al_2O_3	5.65	5.81	-0.156	-3%

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-22	B_2O_3	7.49	7.74	-0.254	-3%
LAW-HPVR-22	CaO	7.32	6.95	0.368	5%
LAW-HPVR-22	Cl^-	0.801	0.085	0.716	842%
LAW-HPVR-22	Cr_2O_3	0.148	0.146	0.002	
LAW-HPVR-22	F^-	0.134	0.17	-0.036	
LAW-HPVR-22	Fe_2O_3	0.199	0.195	0.004	
LAW-HPVR-22	K_2O	3.20	3.58	-0.376	-10%
LAW-HPVR-22	Li_2O	1.61	1.6	0.014	1%
LAW-HPVR-22	MgO	0.0783	0.024	0.054	
LAW-HPVR-22	Na_2O	20.1	20.3	-0.215	-1%
LAW-HPVR-22	P_2O_5	0.596	0.632	-0.036	
LAW-HPVR-22	SiO_2	35.1	35.6	-0.462	-1%
LAW-HPVR-22	SnO_2	4.83	4.45	0.381	9%
LAW-HPVR-22	SO_3	0.695	0.839	-0.144	
LAW-HPVR-22	TiO_2	3.10	2.99	0.108	4%
LAW-HPVR-22	V_2O_5	3.99	3.83	0.155	4%
LAW-HPVR-22	ZnO	0.572	0.608	-0.036	
LAW-HPVR-22	ZrO_2	4.08	4.45	-0.374	-8%
LAW-HPVR-22	**Sum of Oxides**	**99.7**	**100**	**-0.286**	**0%**
LAW-HPVR-23	Al_2O_3	5.13	5.39	-0.255	-5%
LAW-HPVR-23	B_2O_3	6.85	7.14	-0.29	-4%
LAW-HPVR-23	CaO	7.35	7.14	0.209	3%
LAW-HPVR-23	Cl^-	1.26	0.065	1.195	1838%
LAW-HPVR-23	Cr_2O_3	0.104	0.111	-0.007	
LAW-HPVR-23	F^-	0.107	0.13	-0.024	
LAW-HPVR-23	Fe_2O_3	0.154	0.148	0.006	
LAW-HPVR-23	K_2O	1.36	1.48	-0.122	-8%
LAW-HPVR-23	Li_2O	0.908	0.959	-0.051	
LAW-HPVR-23	MgO	0.0763	0.019	0.057	
LAW-HPVR-23	Na_2O	22.1	23.3	-1.159	-5%
LAW-HPVR-23	P_2O_5	0.442	0.482	-0.04	
LAW-HPVR-23	SiO_2	39.7	41	-1.263	-3%
LAW-HPVR-23	SnO_2	3.48	3.25	0.232	7%
LAW-HPVR-23	SO_3	0.571	0.64	-0.069	
LAW-HPVR-23	TiO_2	1.36	1.45	-0.093	-6%
LAW-HPVR-23	V_2O_5	1.29	1.37	-0.076	-6%
LAW-HPVR-23	ZnO	0.441	0.463	-0.022	
LAW-HPVR-23	ZrO_2	4.71	5.37	-0.659	-12%
LAW-HPVR-23	**Sum of Oxides**	**97.5**	**99.9**	**-2.43**	**-2%**
LAW-HPVR-24	Al_2O_3	3.78	3.83	-0.046	-1%
LAW-HPVR-24	B_2O_3	6.78	7.04	-0.262	-4%
LAW-HPVR-24	CaO	7.77	8.08	-0.311	-4%
LAW-HPVR-24	Cl^-	0.788	0.085	0.703	826%
LAW-HPVR-24	Cr_2O_3	0.136	0.145	-0.009	
LAW-HPVR-24	F^-	0.131	0.17	-0.039	
LAW-HPVR-24	Fe_2O_3	0.199	0.194	0.005	
LAW-HPVR-24	K_2O	5.59	5.77	-0.178	-3%

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

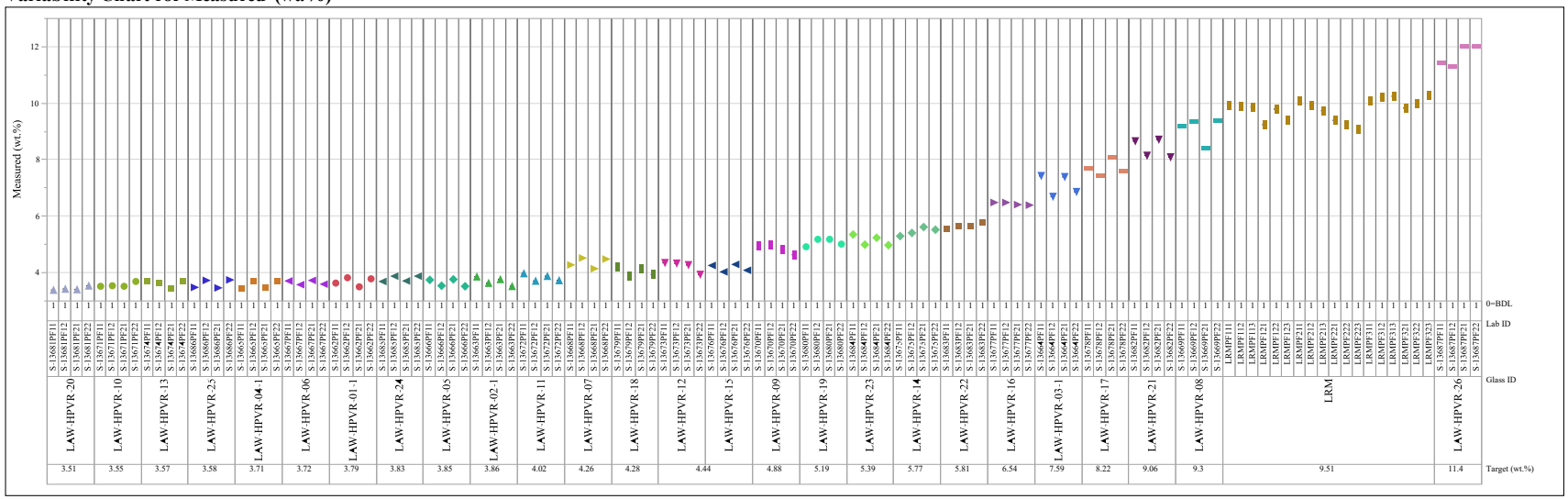
PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-24	Li_2O	2.87	2.92	-0.046	-2%
LAW-HPVR-24	MgO	0.0849	0.024	0.061	
LAW-HPVR-24	Na_2O	15.4	15.9	-0.465	-3%
LAW-HPVR-24	P_2O_5	0.608	0.63	-0.022	
LAW-HPVR-24	SiO_2	41.9	42.6	-0.723	-2%
LAW-HPVR-24	SnO_2	2.48	2.4	0.079	3%
LAW-HPVR-24	SO_3	0.748	0.837	-0.089	
LAW-HPVR-24	TiO_2	2.84	2.96	-0.12	-4%
LAW-HPVR-24	V_2O_5	2.95	3.06	-0.105	-3%
LAW-HPVR-24	ZnO	0.571	0.606	-0.035	
LAW-HPVR-24	ZrO_2	2.46	2.68	-0.218	-8%
LAW-HPVR-24	**Sum of Oxides**	**98.1**	**99.9**	**-1.821**	**-2%**
LAW-HPVR-25	Al_2O_3	3.60	3.58	0.019	1%
LAW-HPVR-25	B_2O_3	6.47	6.68	-0.208	-3%
LAW-HPVR-25	CaO	10.7	11.4	-0.654	-6%
LAW-HPVR-25	Cl^-	0.708	0.105	0.603	574%
LAW-HPVR-25	Cr_2O_3	0.175	0.18	-0.005	
LAW-HPVR-25	F^-	0.168	0.21	-0.042	
LAW-HPVR-25	Fe_2O_3	0.262	0.24	0.022	
LAW-HPVR-25	K_2O	1.76	2.01	-0.248	-12%
LAW-HPVR-25	Li_2O	0.458	0.437	0.021	
LAW-HPVR-25	MgO	0.119	0.03	0.089	
LAW-HPVR-25	Na_2O	21.9	24.7	-2.761	-11%
LAW-HPVR-25	P_2O_5	0.764	0.779	-0.015	
LAW-HPVR-25	SiO_2	39.6	39.3	0.331	1%
LAW-HPVR-25	SnO_2	1.78	1.73	0.051	3%
LAW-HPVR-25	SO_3	0.947	1.03	-0.083	-8%
LAW-HPVR-25	TiO_2	1.86	1.9	-0.036	-2%
LAW-HPVR-25	V_2O_5	0.229	0.224	0.005	
LAW-HPVR-25	ZnO	0.764	0.749	0.015	
LAW-HPVR-25	ZrO_2	4.42	4.69	-0.273	-6%
LAW-HPVR-25	**Sum of Oxides**	**96.8**	**100**	**-3.171**	**-3%**
LAW-HPVR-26	Al_2O_3	11.7	11.4	0.277	2%
LAW-HPVR-26	B_2O_3	13.5	13.7	-0.16	-1%
LAW-HPVR-26	CaO	6.06	6.25	-0.188	-3%
LAW-HPVR-26	Cl^-	0.983	0.077	0.906	1177%
LAW-HPVR-26	Cr_2O_3	0.129	0.132	-0.003	
LAW-HPVR-26	F^-	0.118	0.155	-0.038	
LAW-HPVR-26	Fe_2O_3	0.195	0.177	0.018	
LAW-HPVR-26	K_2O	3.09	3.1	-0.013	0%
LAW-HPVR-26	Li_2O	3.59	3.55	0.04	1%
LAW-HPVR-26	MgO	0.0747	0.022	0.053	
LAW-HPVR-26	Na_2O	15.9	17.6	-1.727	-10%
LAW-HPVR-26	P_2O_5	0.591	0.574	0.017	
LAW-HPVR-26	SiO_2	35.9	35.5	0.387	1%
LAW-HPVR-26	SnO_2	1.70	1.7	0.001	0%
LAW-HPVR-26	SO_3	0.725	0.762	-0.037	

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

PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
LAW-HPVR-26	TiO_2	0.867	0.884	-0.017	
LAW-HPVR-26	V_2O_5	0.291	0.29	0.001	
LAW-HPVR-26	ZnO	0.558	0.552	0.006	
LAW-HPVR-26	ZrO_2	3.29	3.57	-0.284	-8%
LAW-HPVR-26	**Sum of Oxides**	**99.2**	**100**	**-0.763**	**-1%**
LRM	Al_2O_3	9.78	9.51	0.273	3%
LRM	B_2O_3	7.66	7.85	-0.194	-2%
LRM	CaO	0.516	0.54	-0.024	
LRM	Cl^-	<0.0250	0	0.025	
LRM	Cr_2O_3	0.189	0.19	-0.001	
LRM	F^-	0.885	0.86	0.025	
LRM	Fe_2O_3	1.38	1.38	-0.004	0%
LRM	K_2O	1.53	1.48	0.045	3%
LRM	Li_2O	<0.110	0.11	0	
LRM	MgO	0.108	0.1	0.008	
LRM	Na_2O	20.5	20.03	0.46	2%
LRM	P_2O_5	0.472	0.54	-0.068	
LRM	SiO_2	53.9	54.2	-0.349	-1%
LRM	SnO_2	<0.127	0	0.127	
LRM	SO_3	0.214	0.3	-0.086	
LRM	TiO_2	0.100	0.1	0	
LRM	V_2O_5	<0.0893	0	0.089	
LRM	ZnO	<0.124	0	0.124	
LRM	ZrO_2	0.953	0.93	0.023	
LRM	**Sum of Oxides**	**98.6**	**98.1**	**0.474**	**0%**

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

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



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

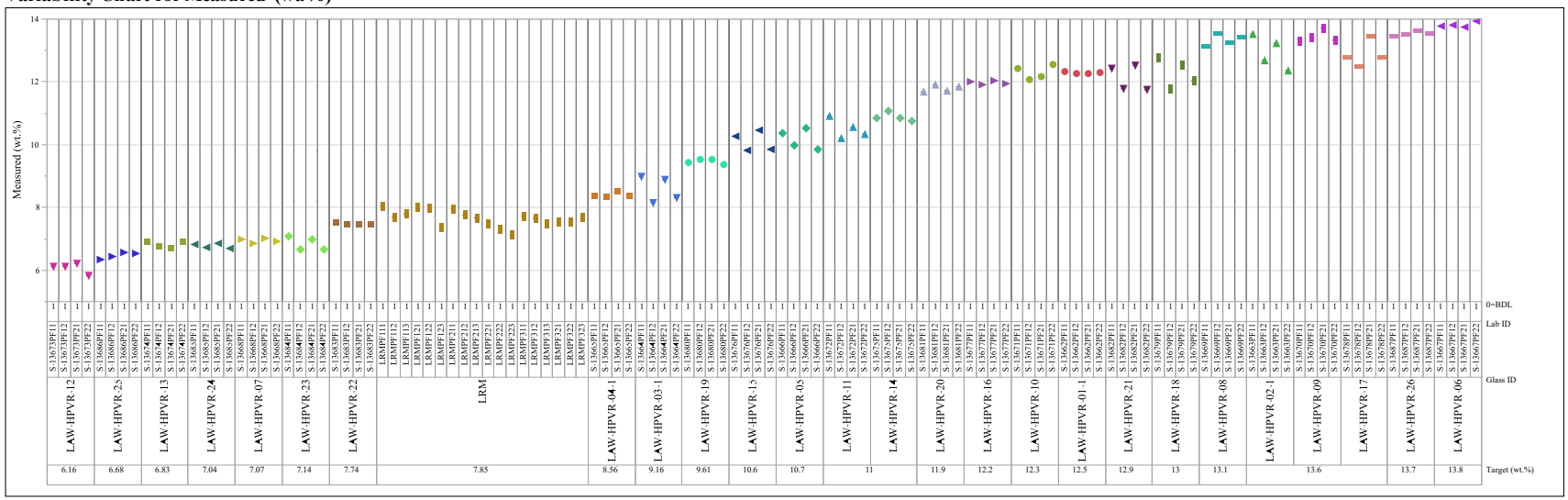
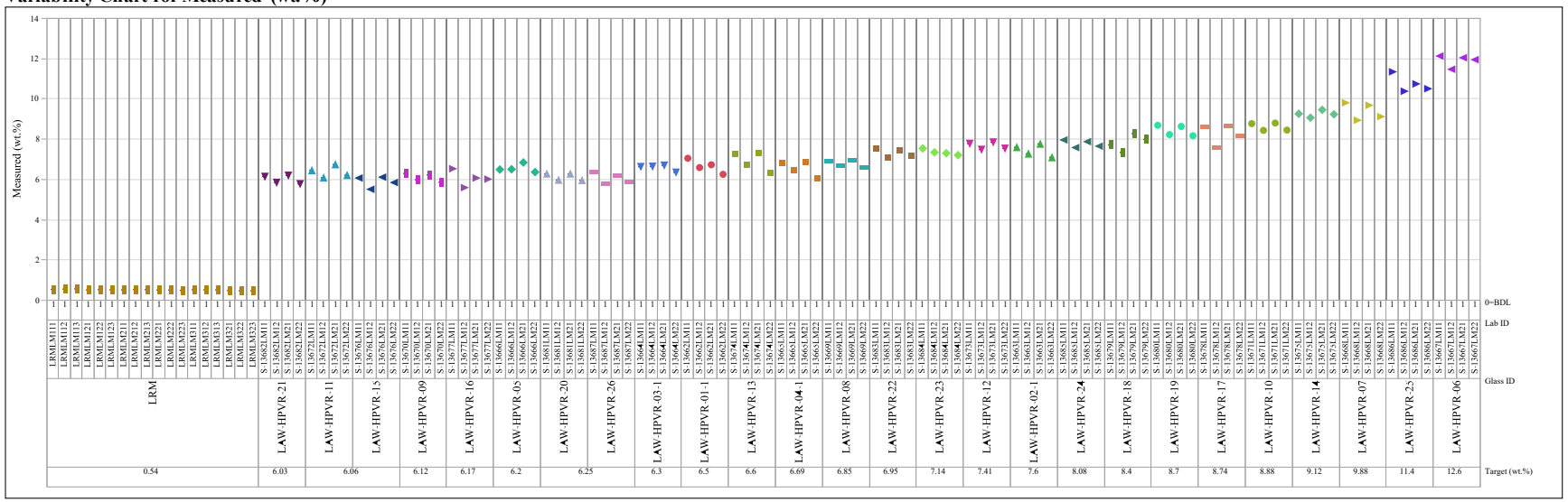


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

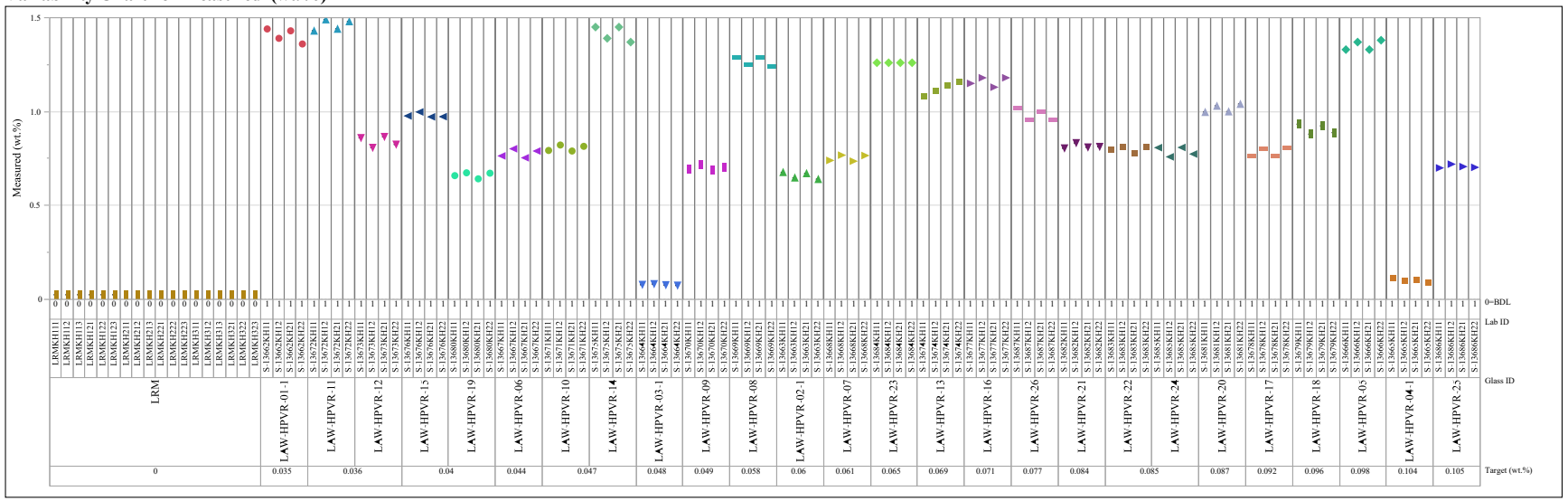
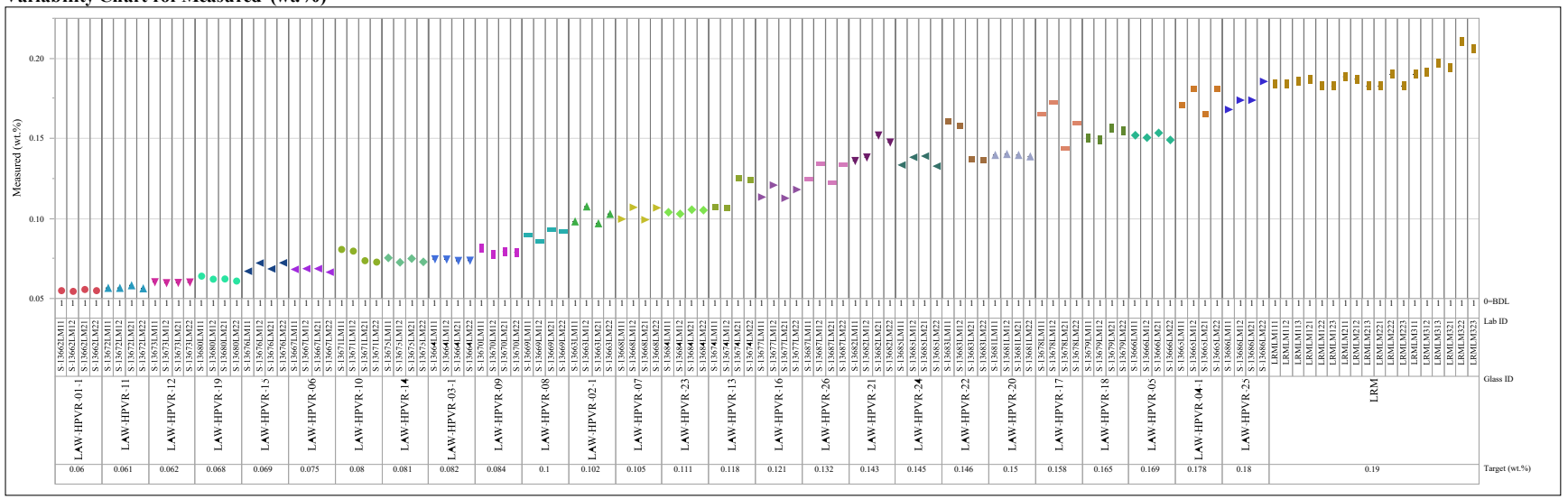


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

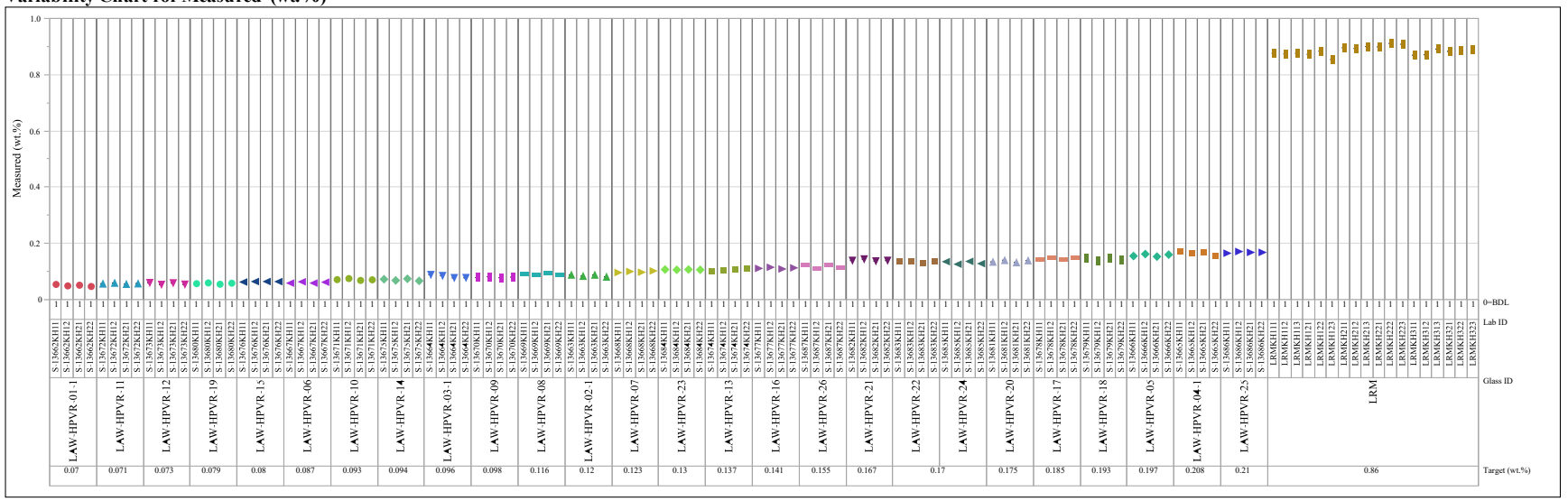
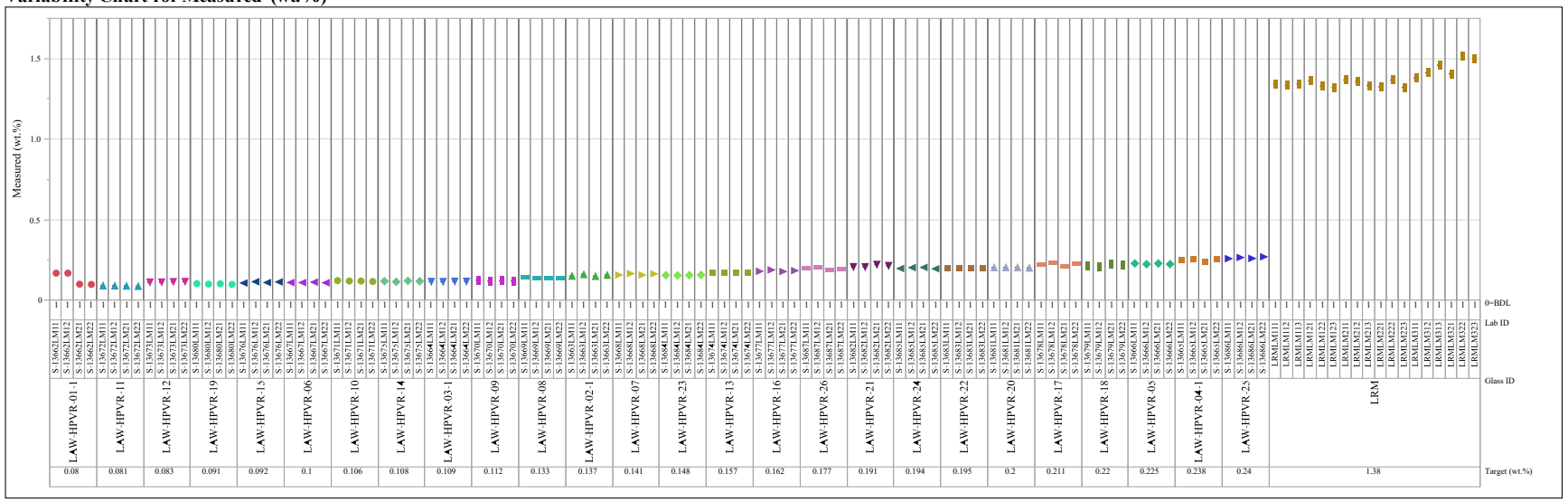


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

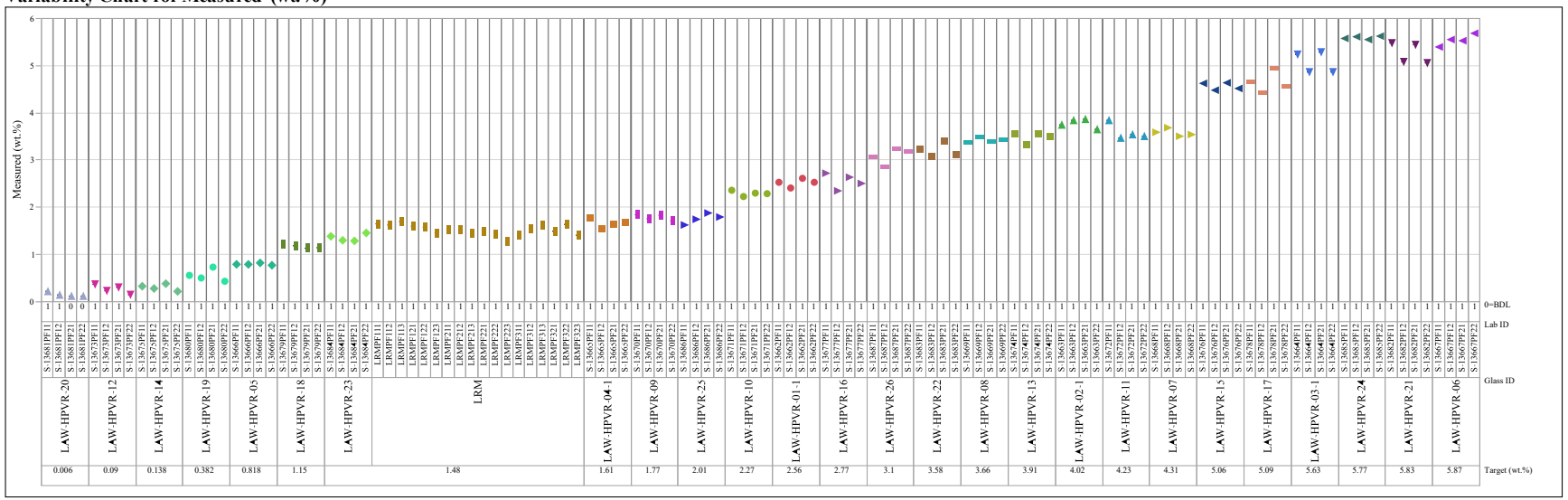
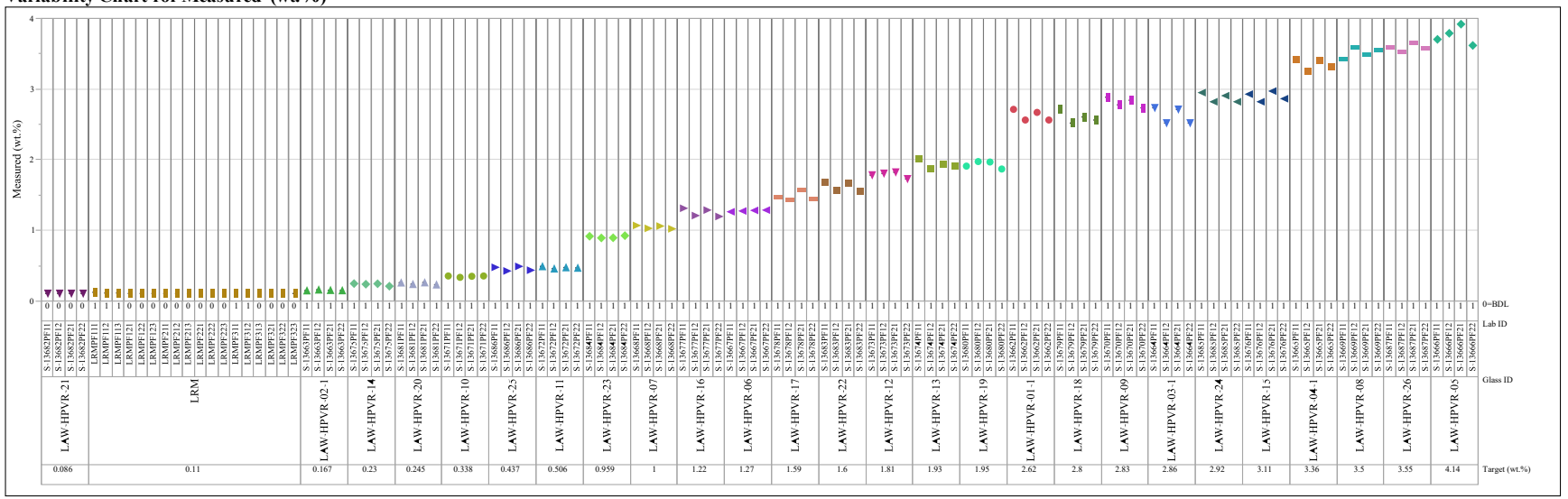


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

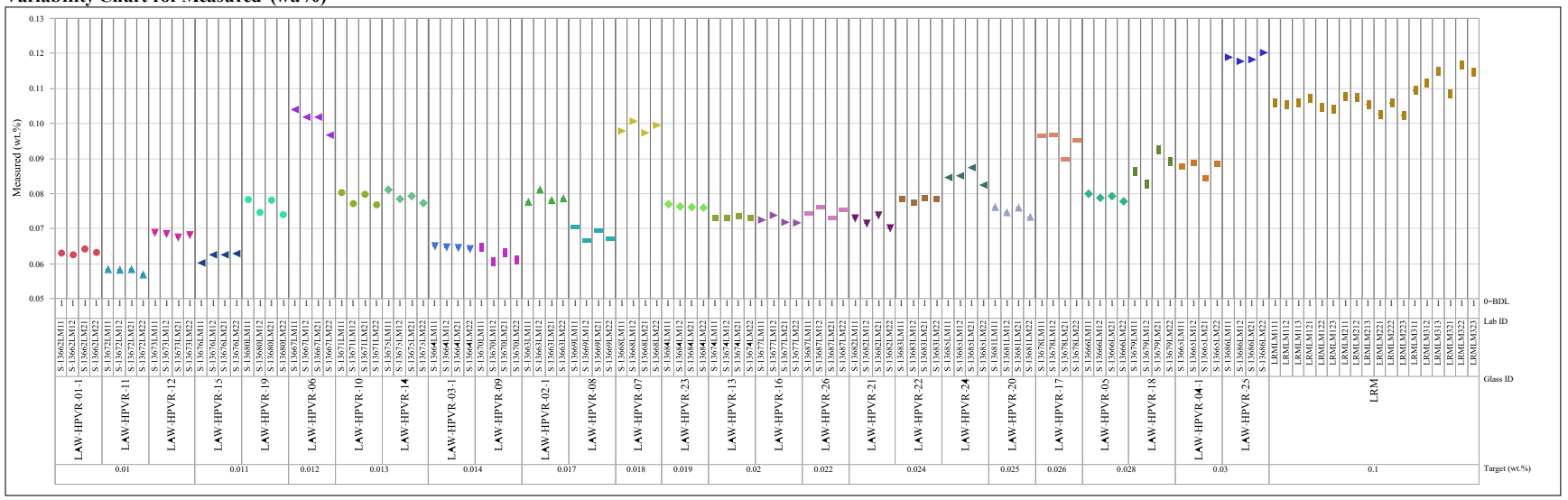
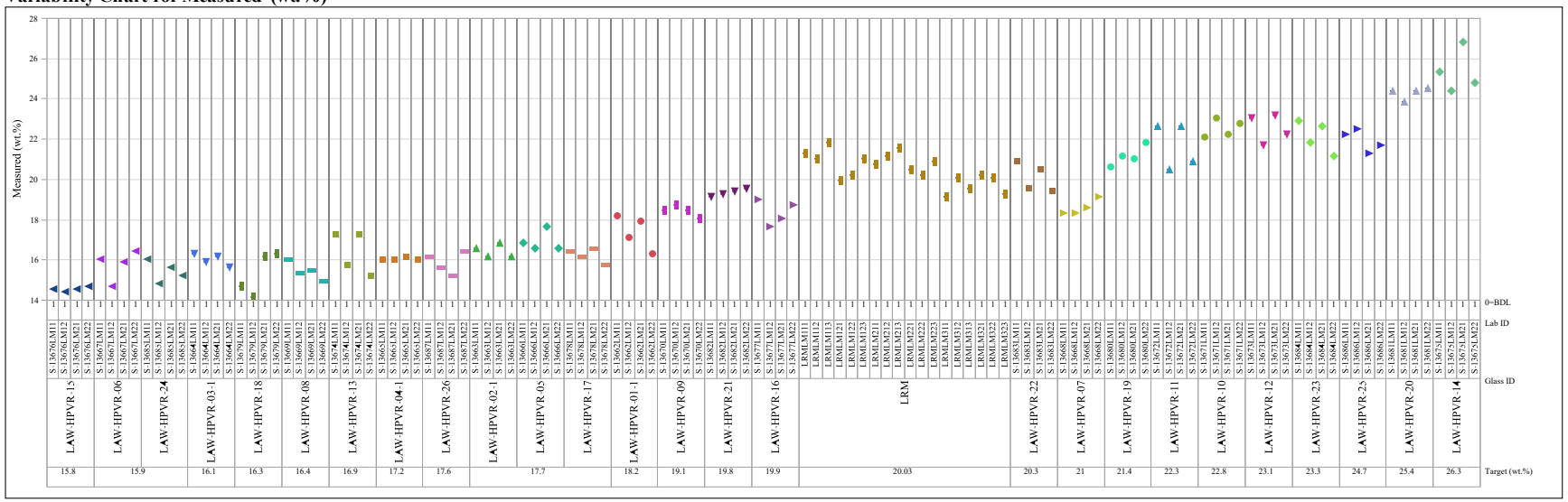


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

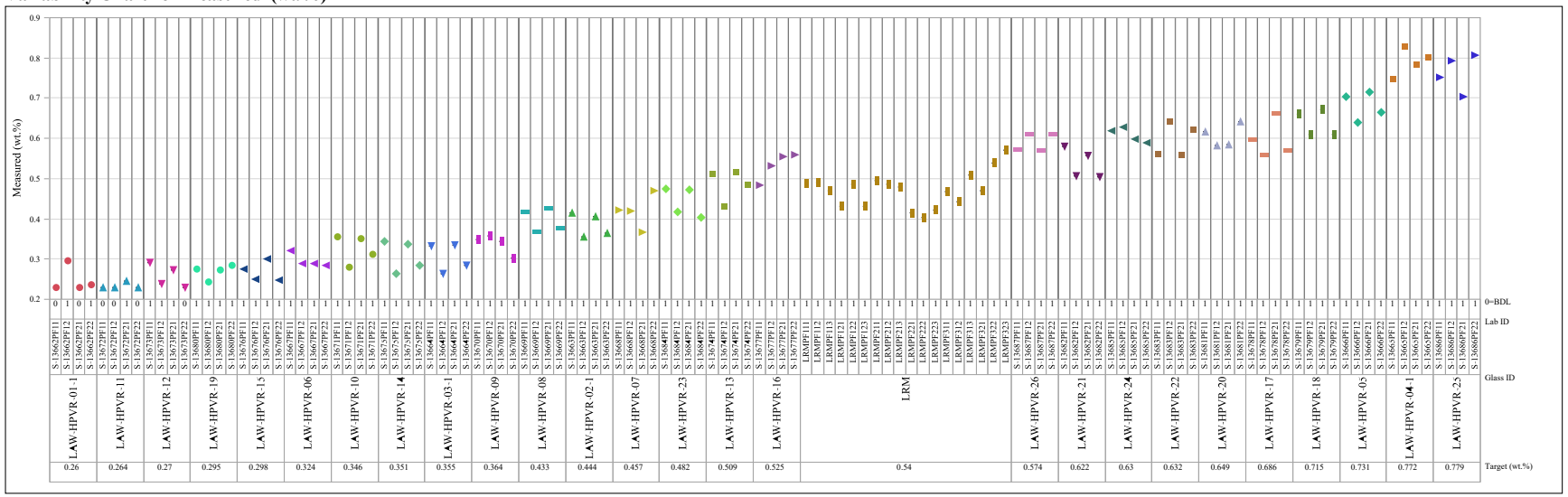
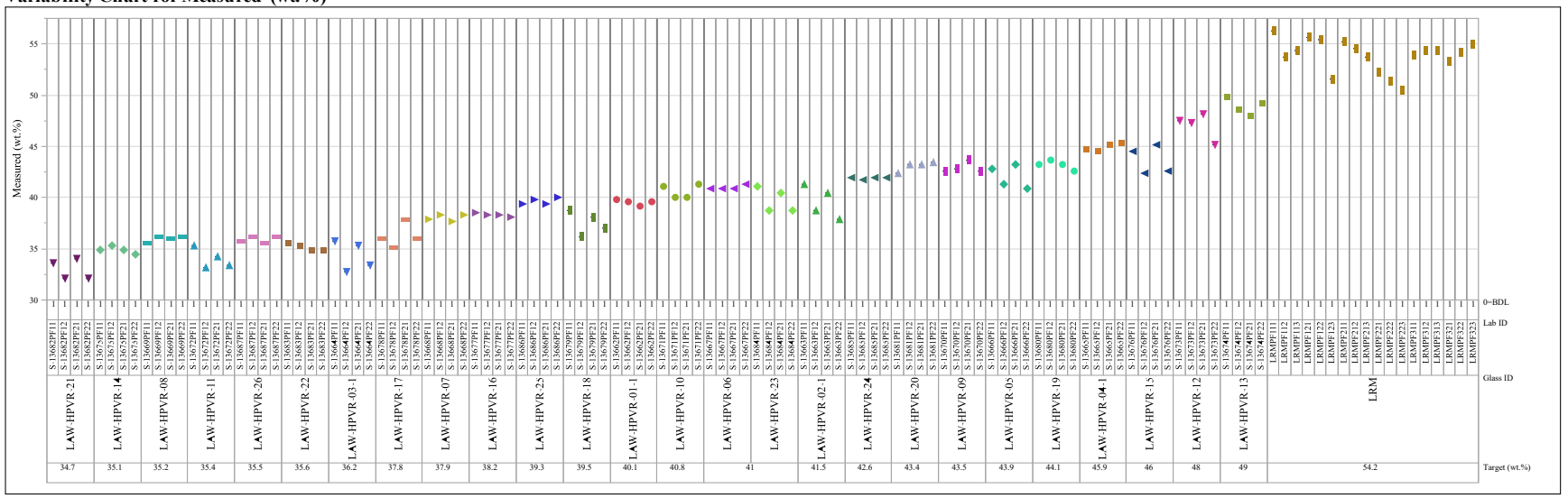


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

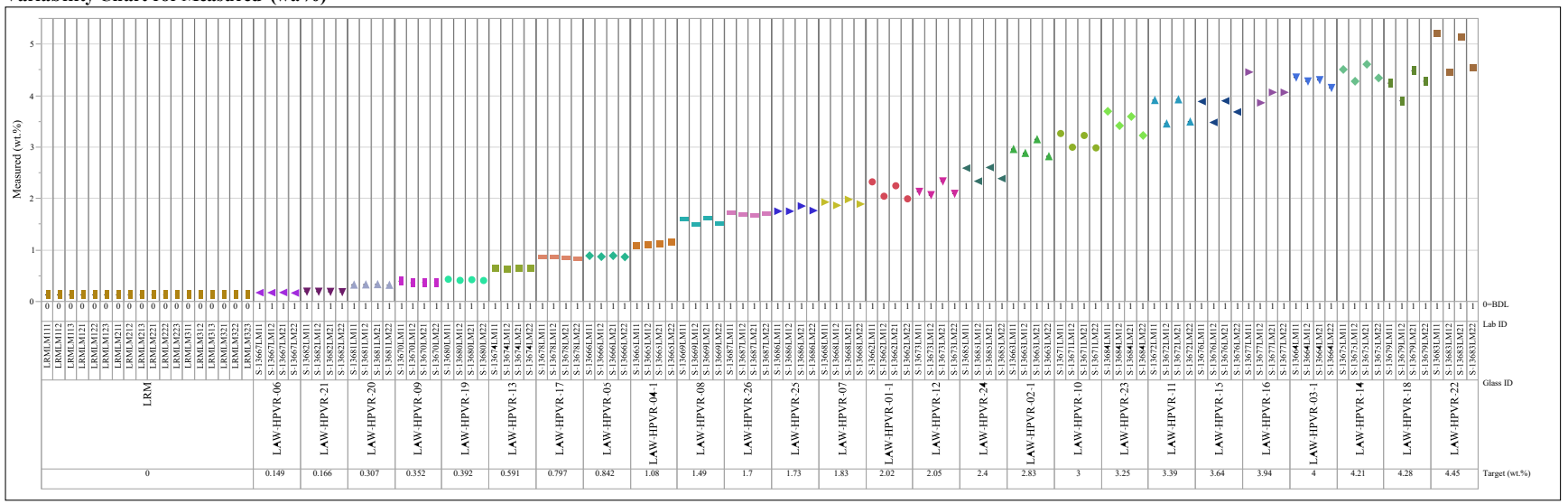
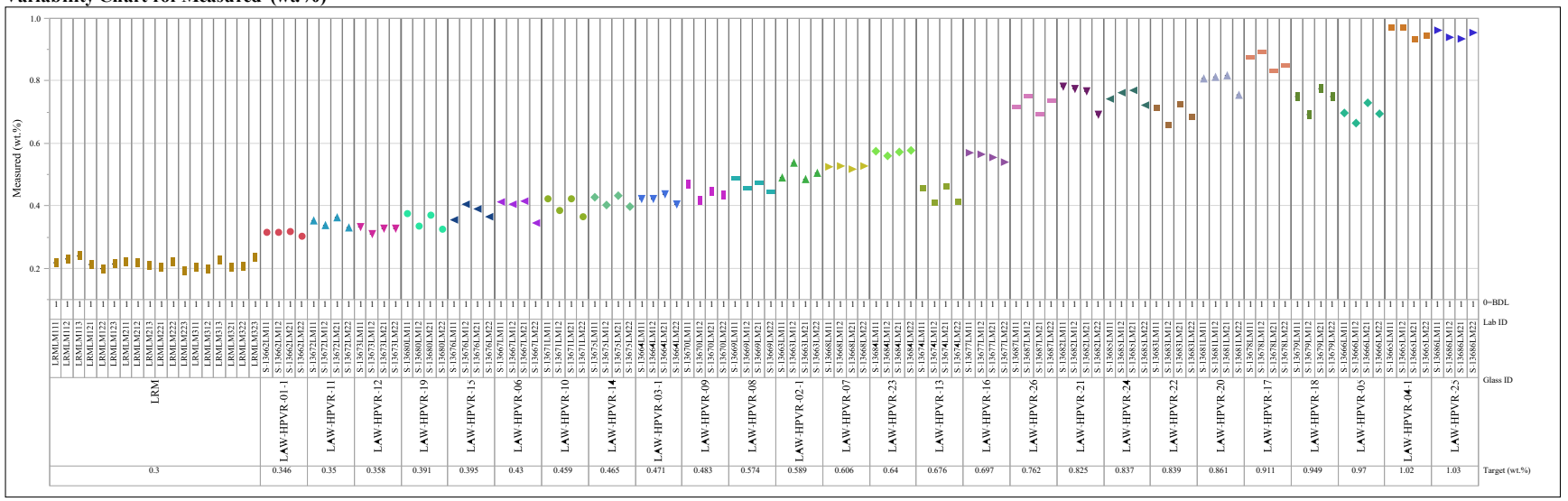


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

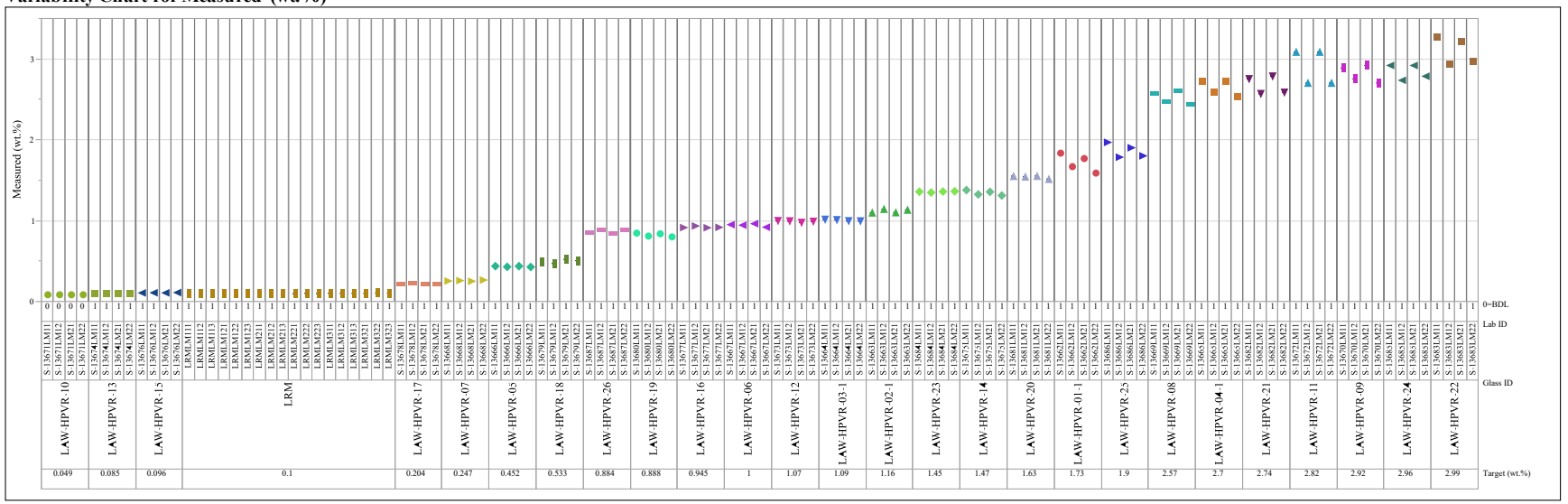
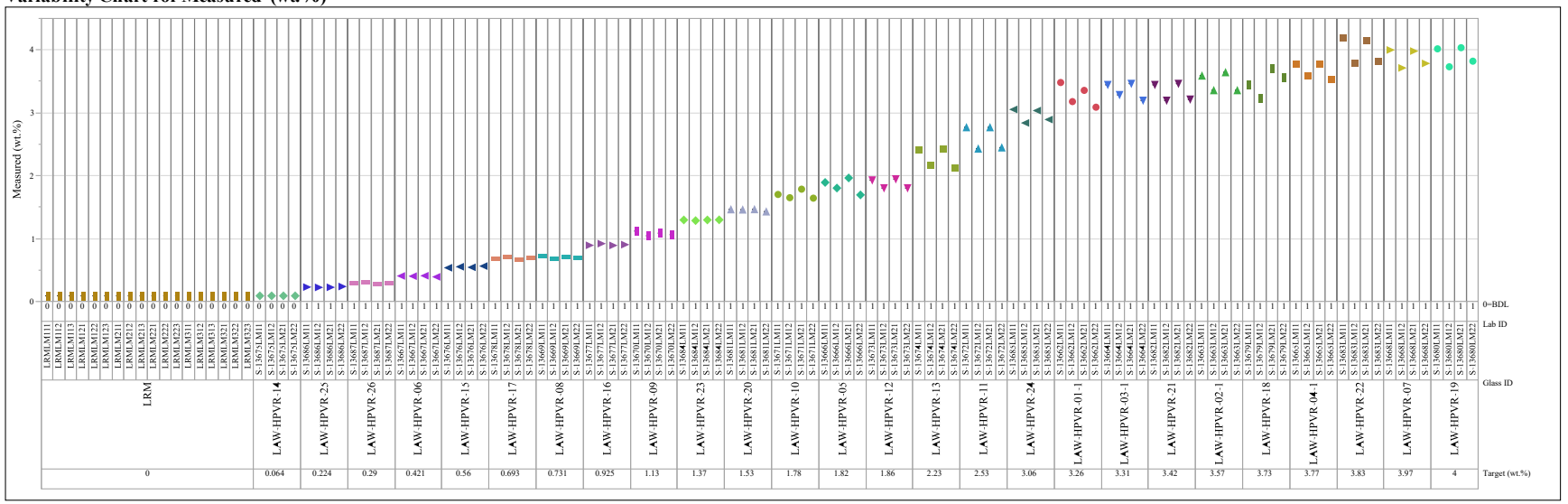


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

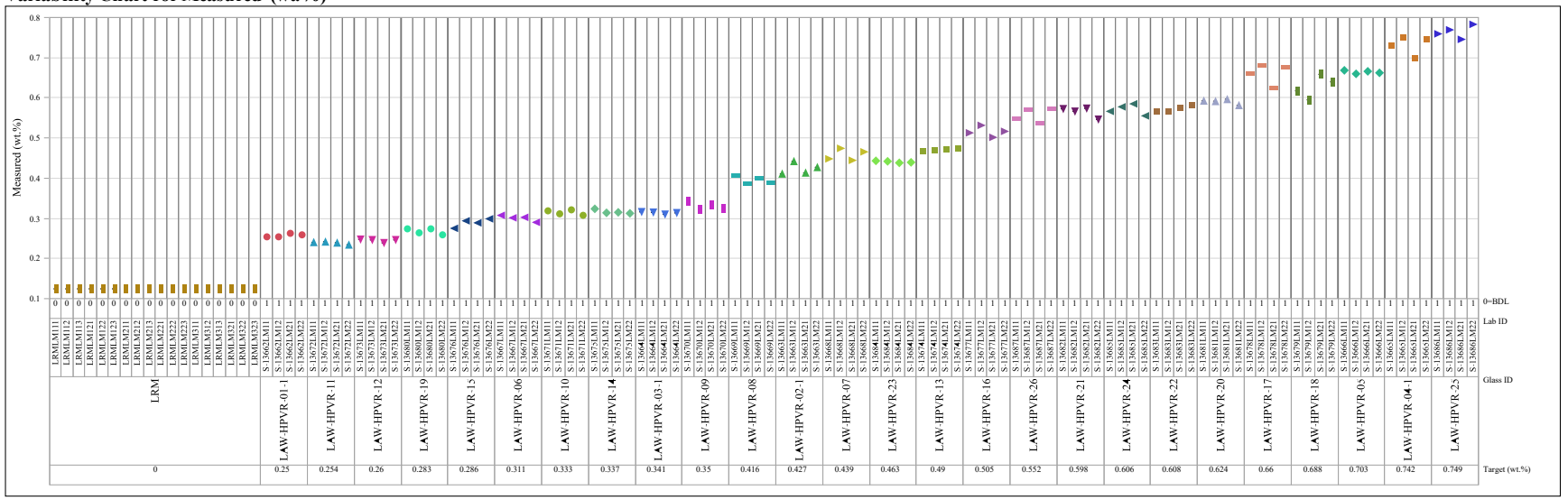


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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

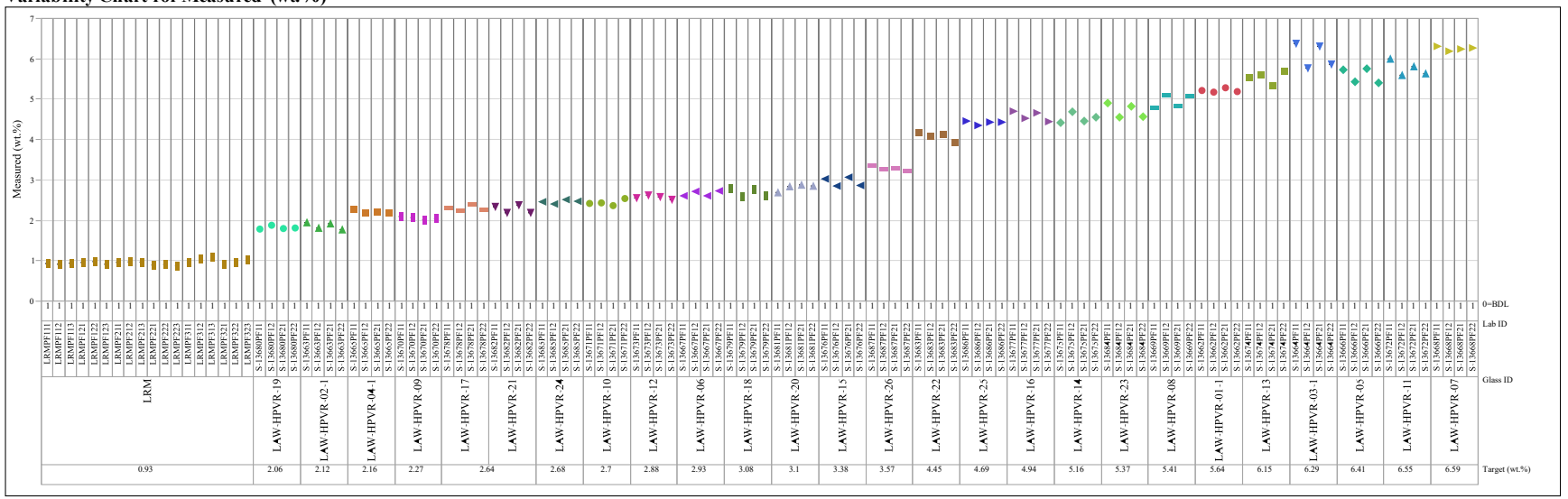
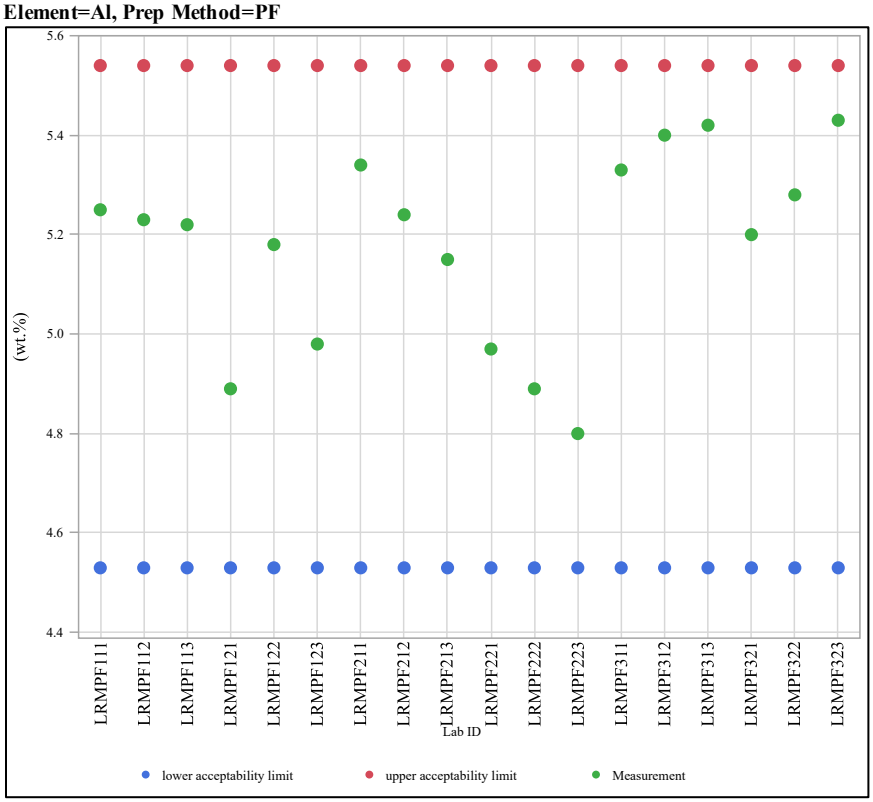


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass

Element=Al, Prep Method=PF



Element=B, Prep Method=PF

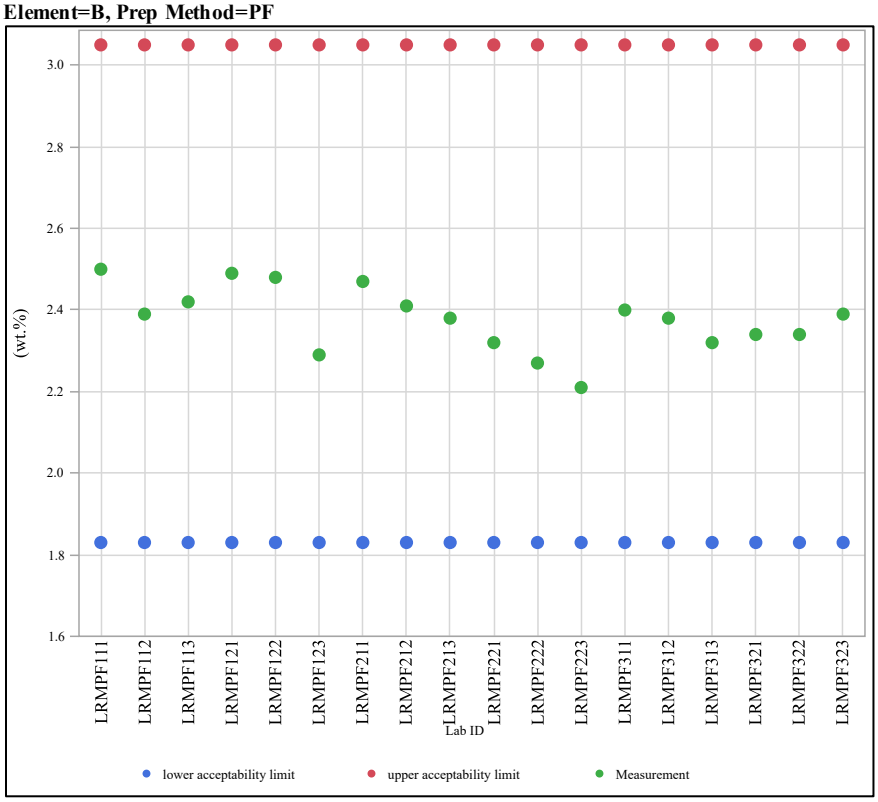
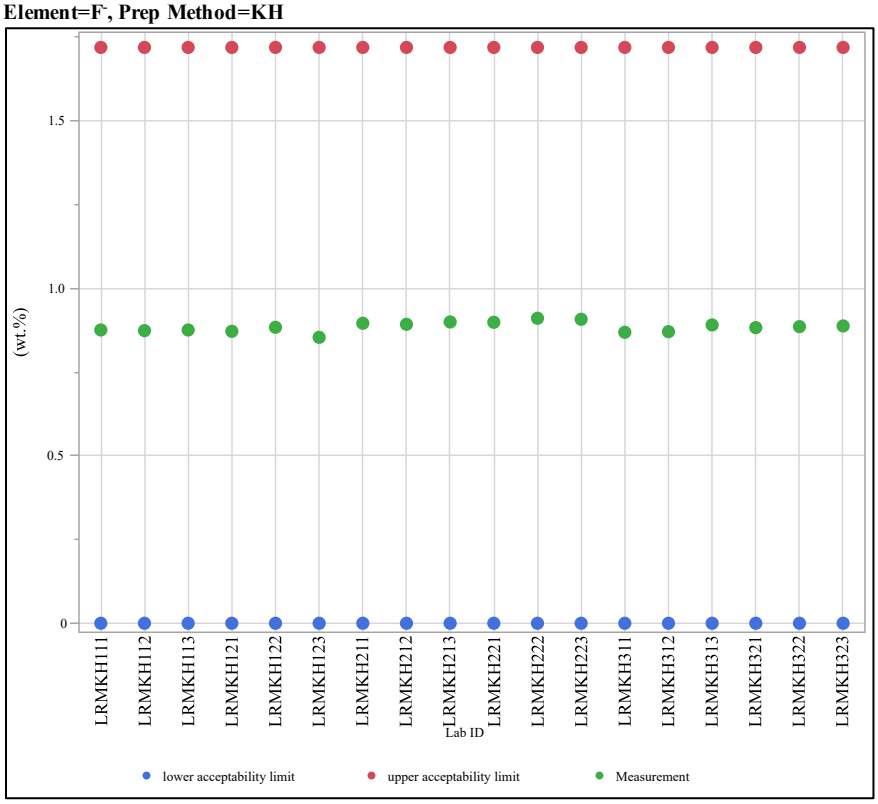


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=F⁻, Prep Method=KH



Element=Fe, Prep Method=LM

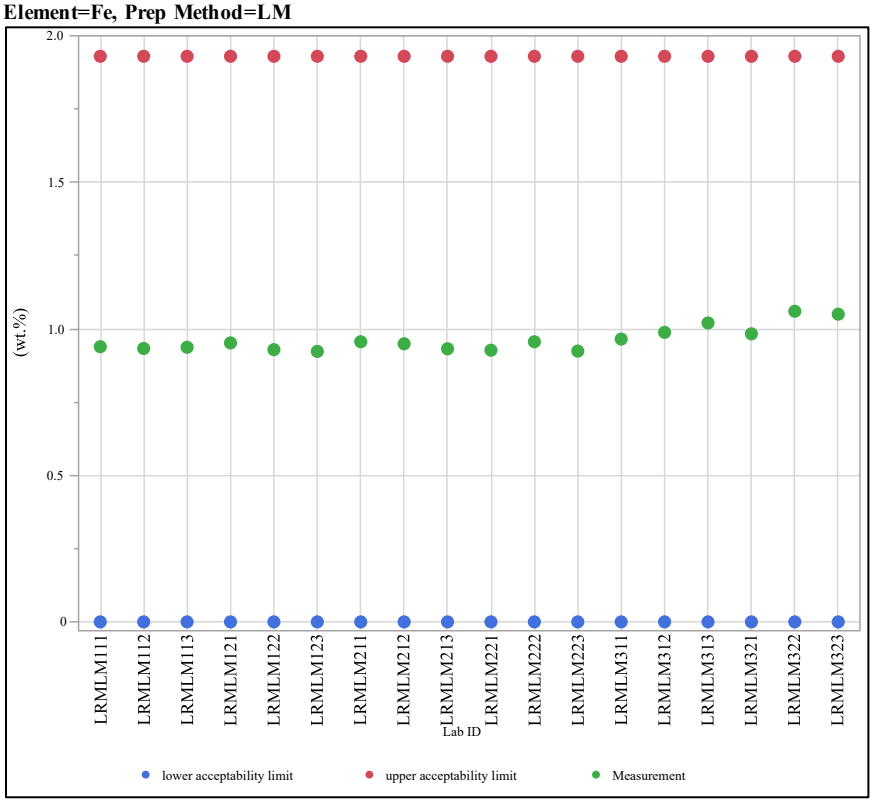
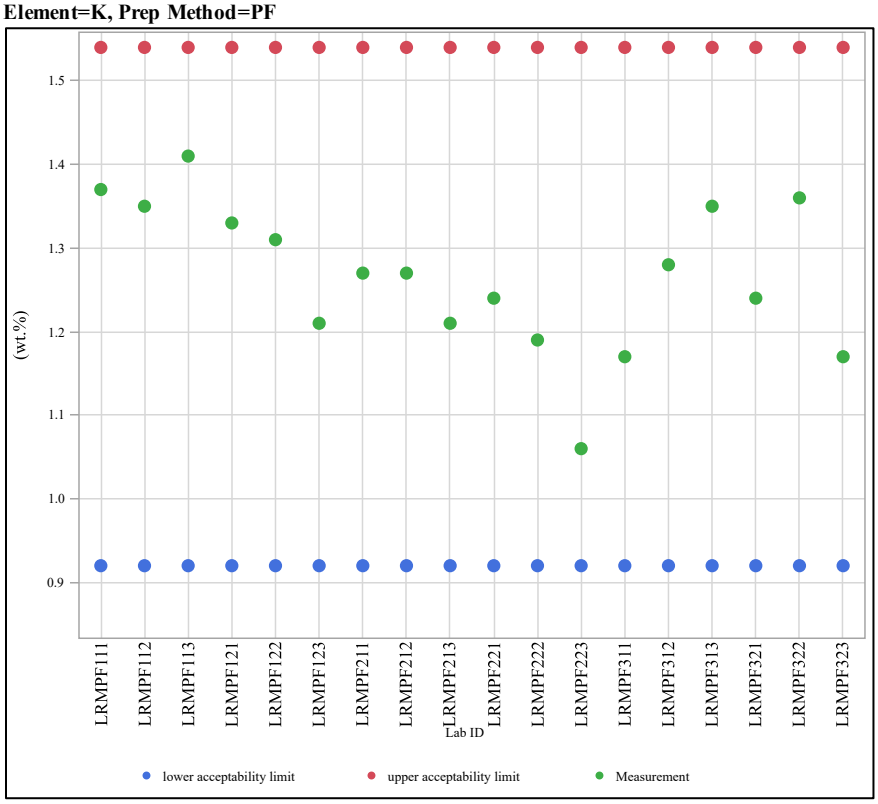


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=K, Prep Method=PF



Element=Na, Prep Method=LM

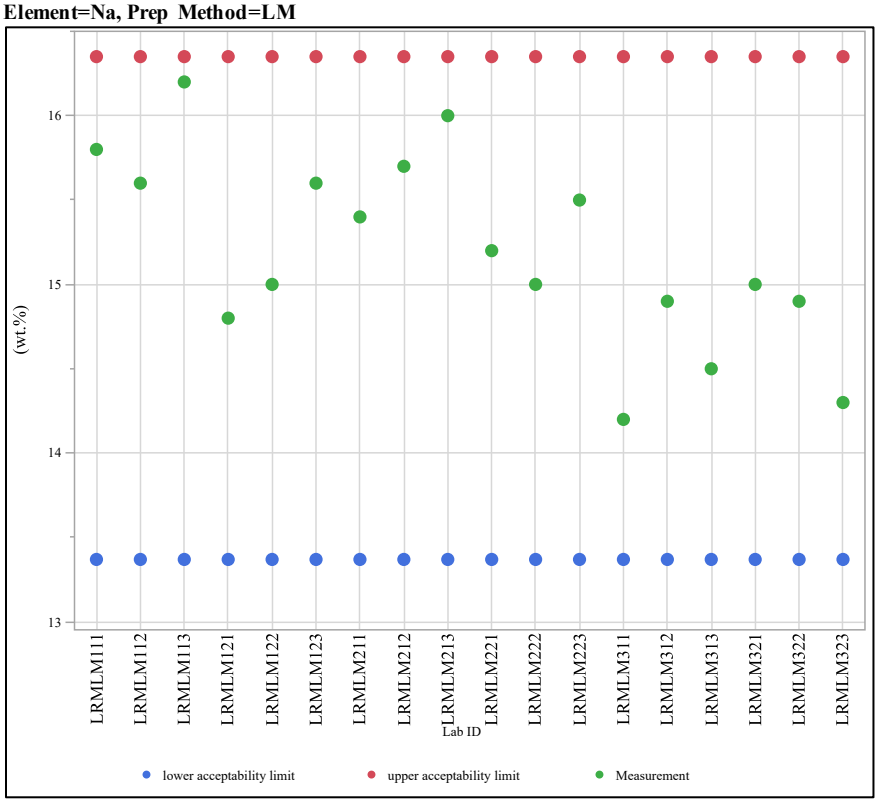
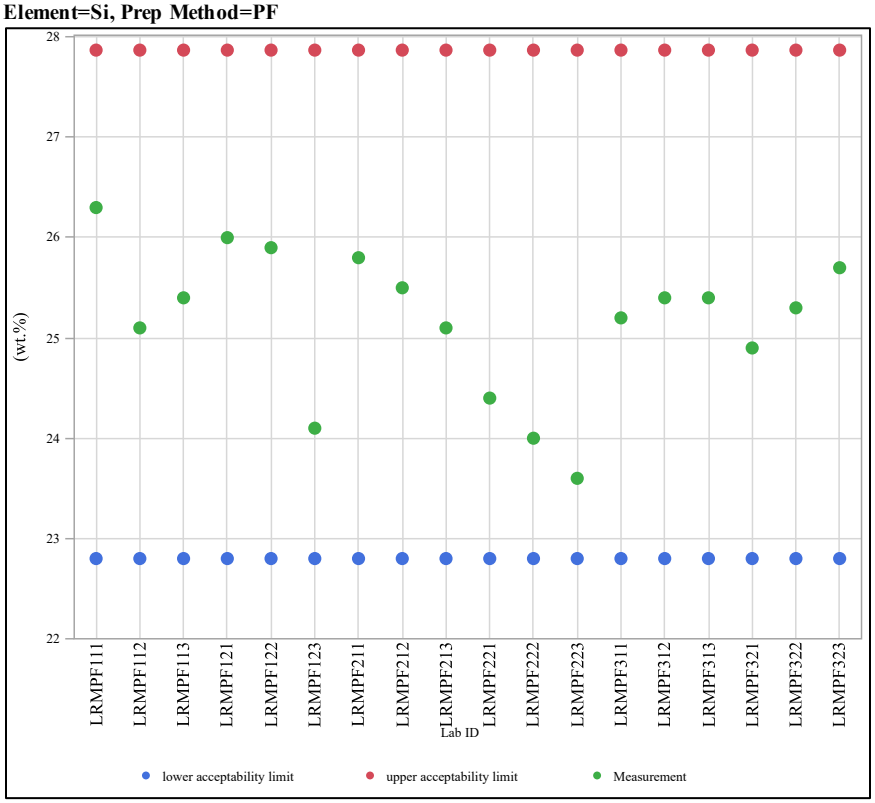


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=Si, Prep Method=PF



Element=Zr, Prep Method=PF

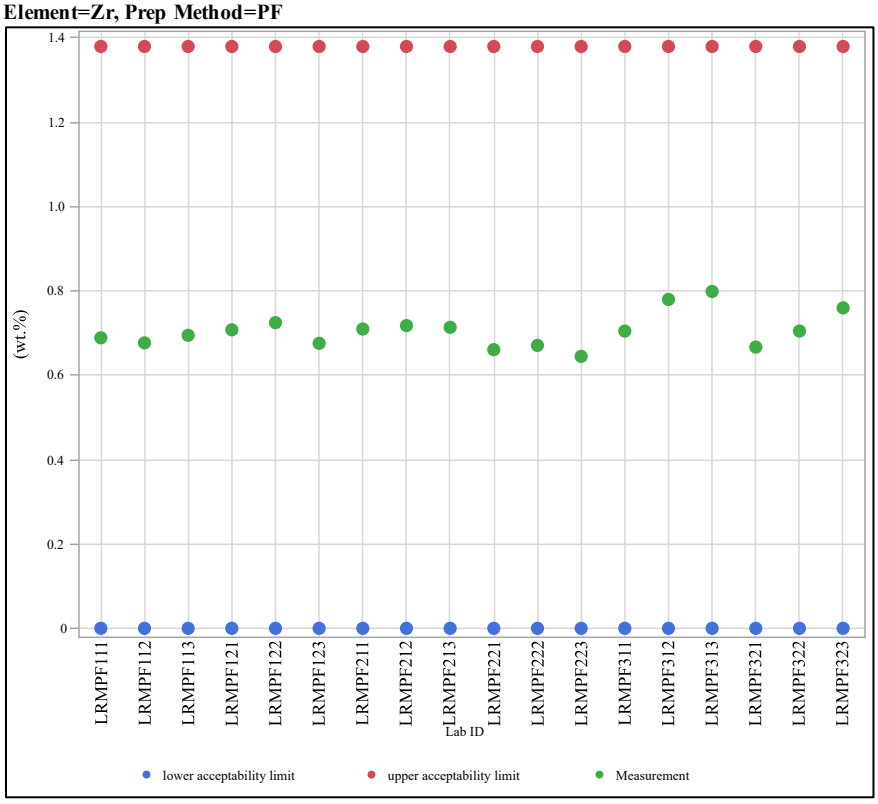
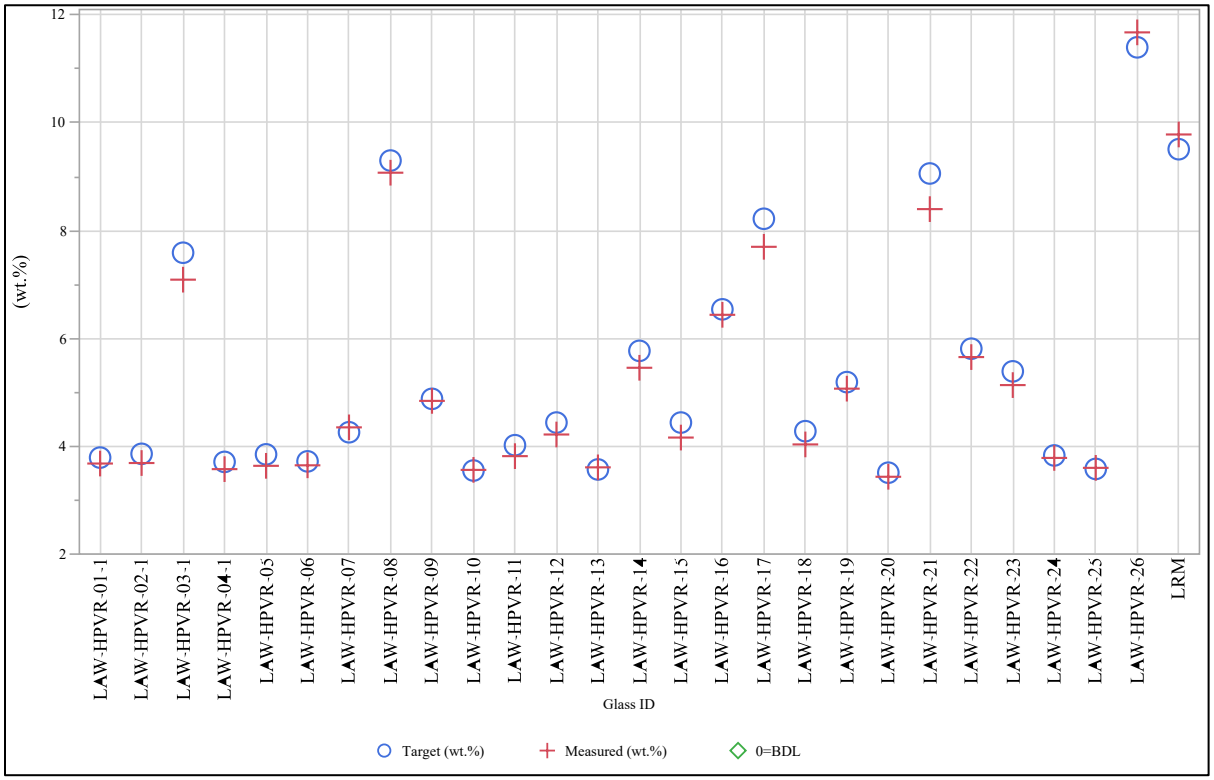


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide

Oxide=Al_2O_3



Oxide=B_2O_3

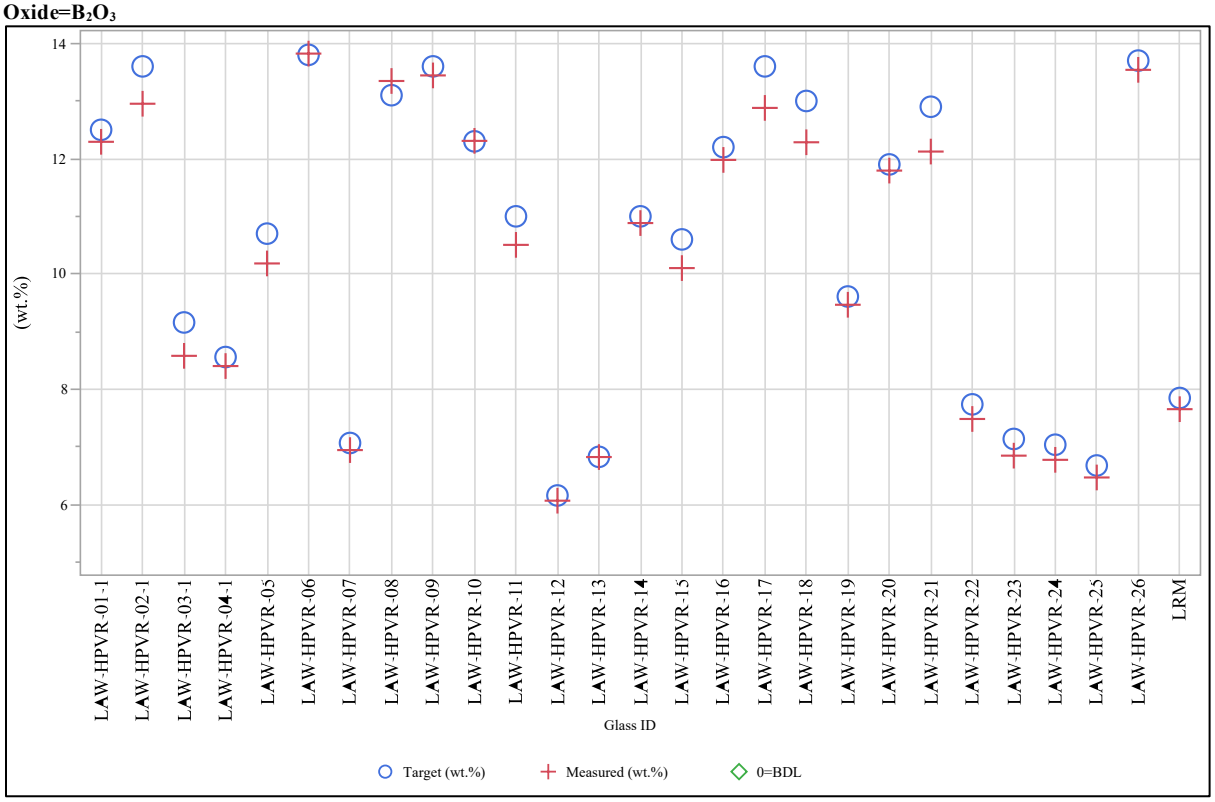
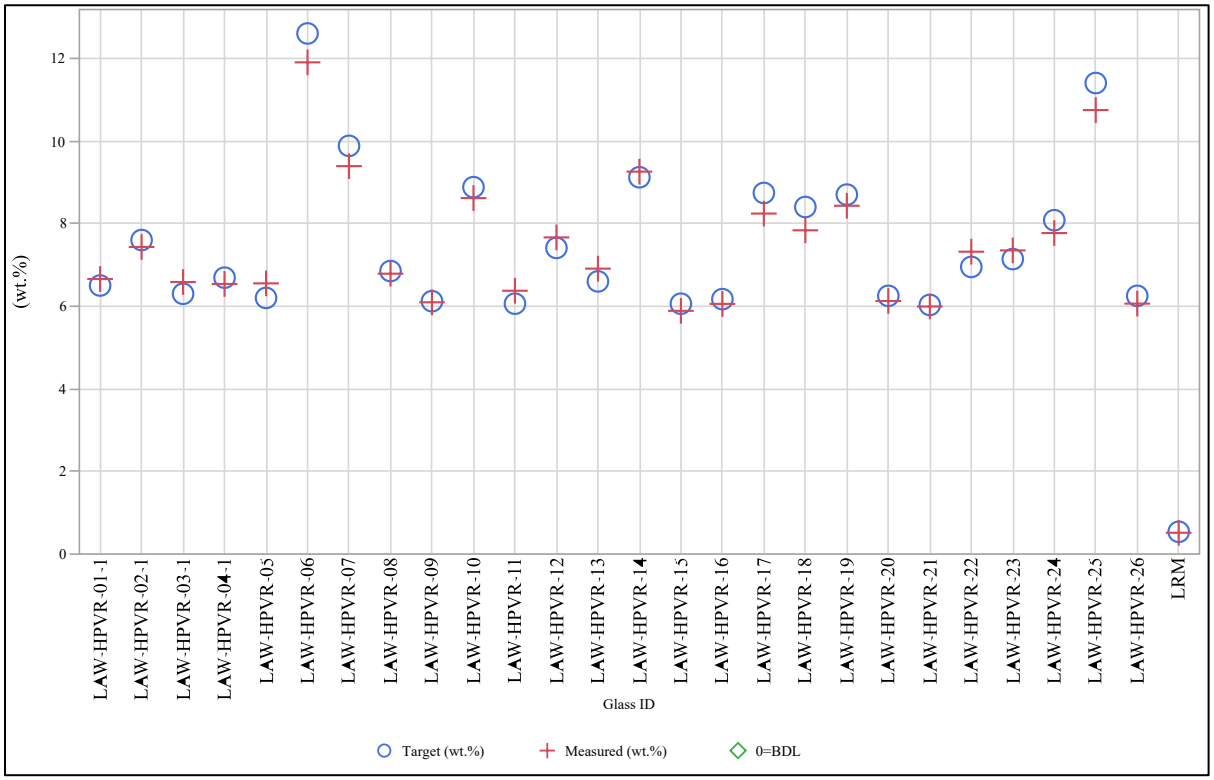


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=CaO



Oxide=Cl^-

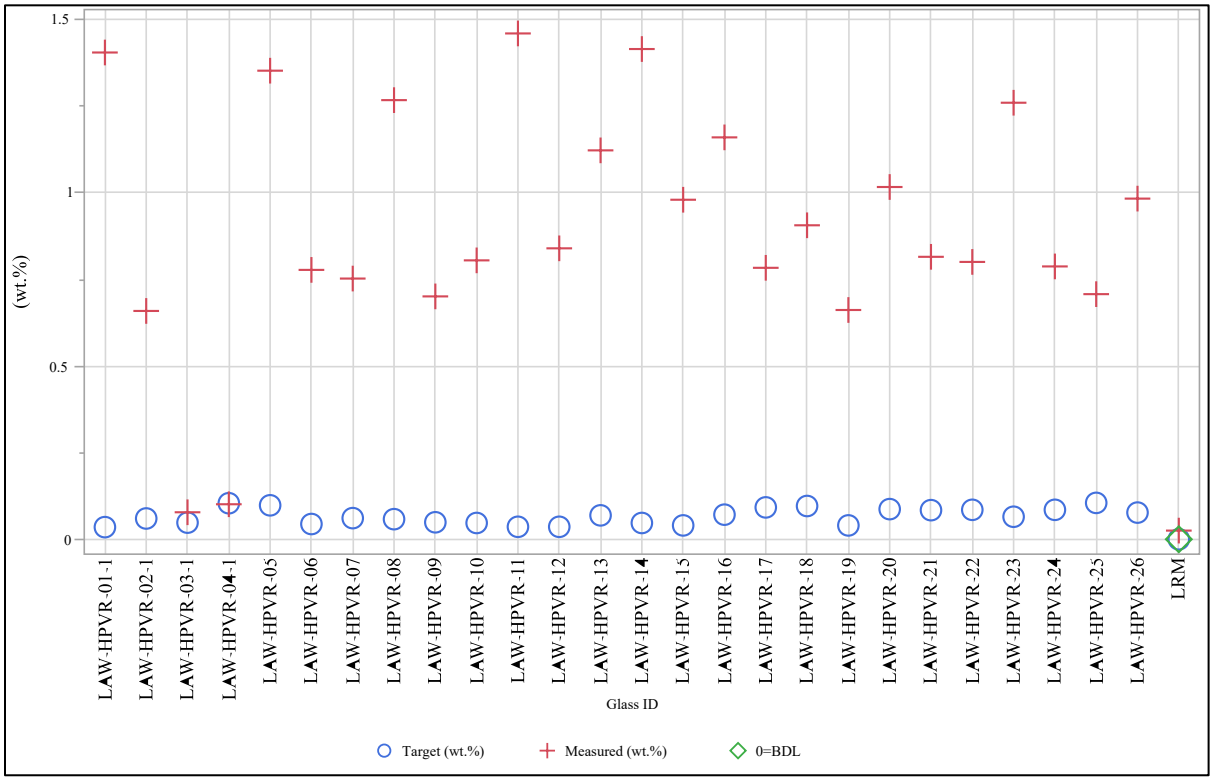
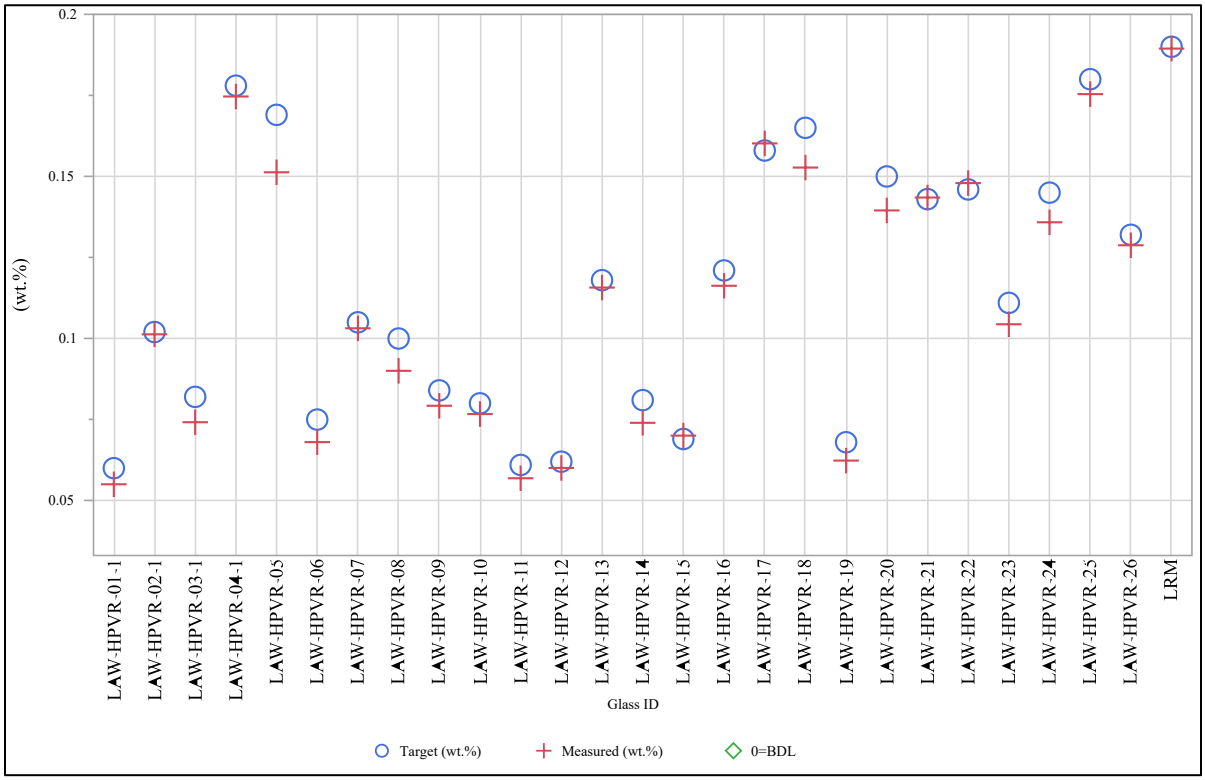


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Cr_2O_3



Oxide=F^-

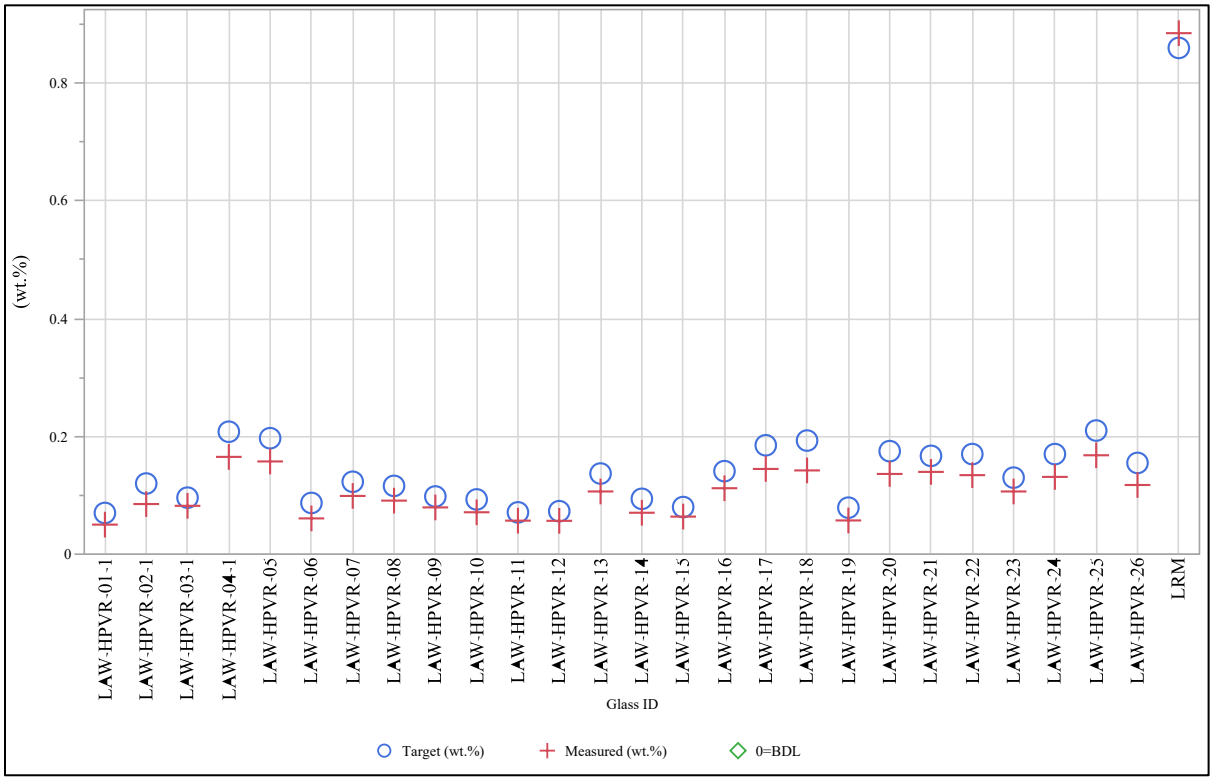
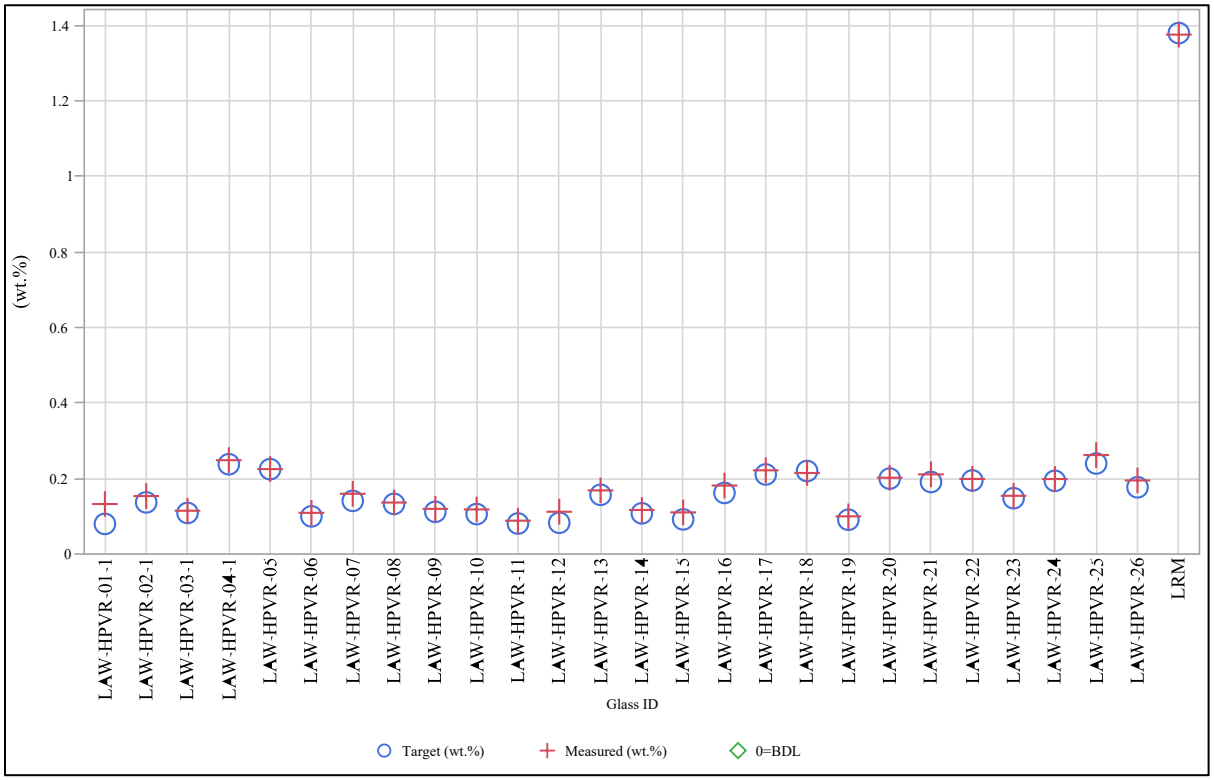


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Fe_2O_3



Oxide=K_2O

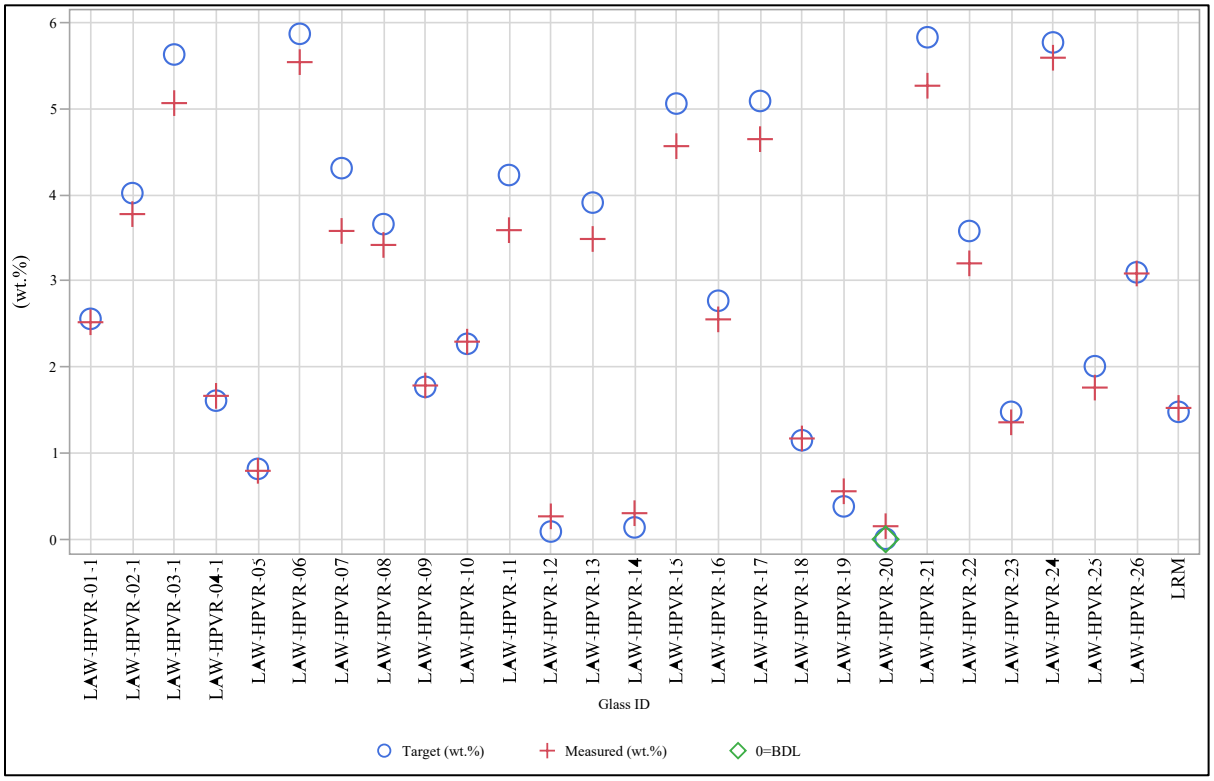
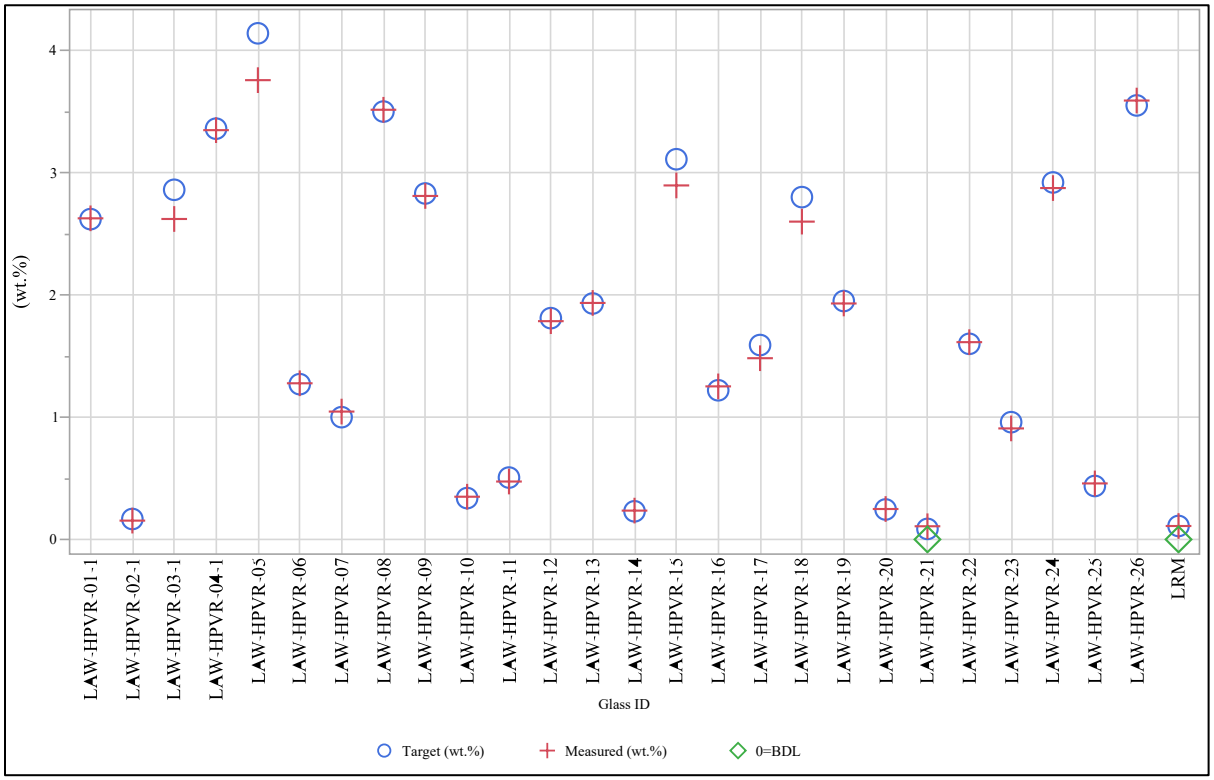


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Li_2O



Oxide=MgO

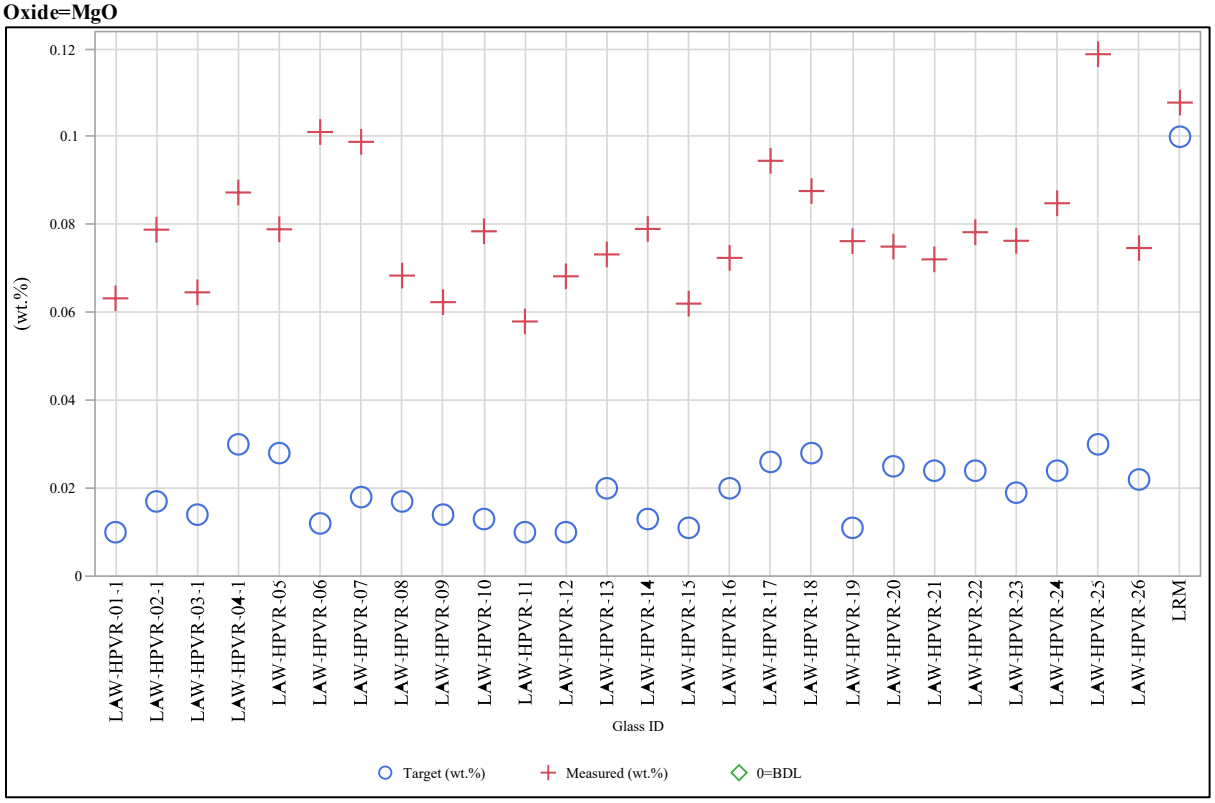
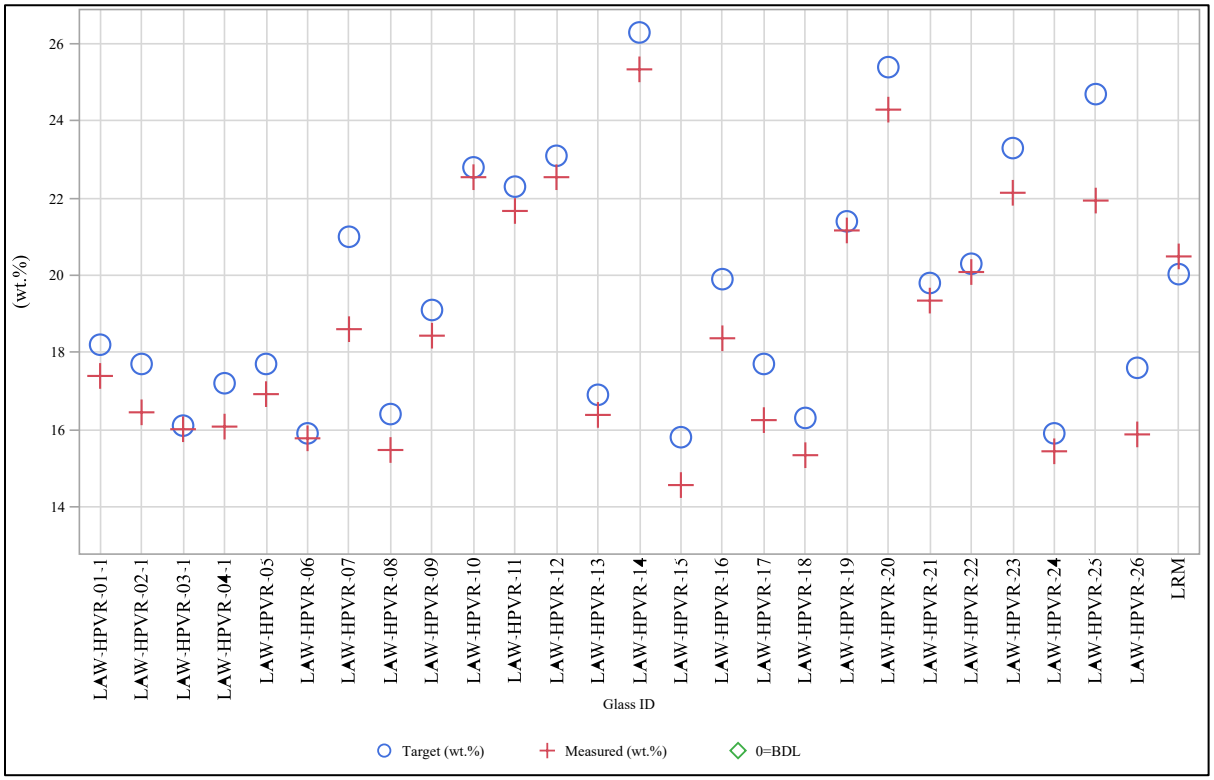


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Na_2O



Oxide=P_2O_5

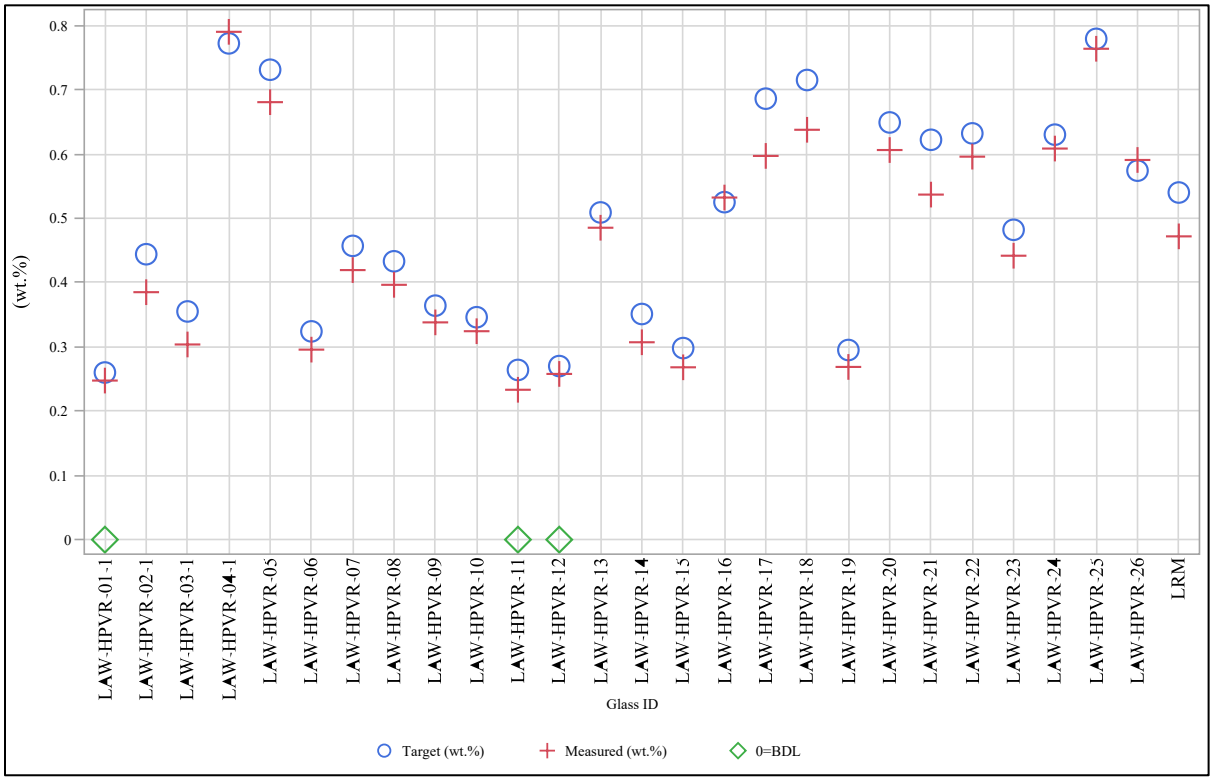
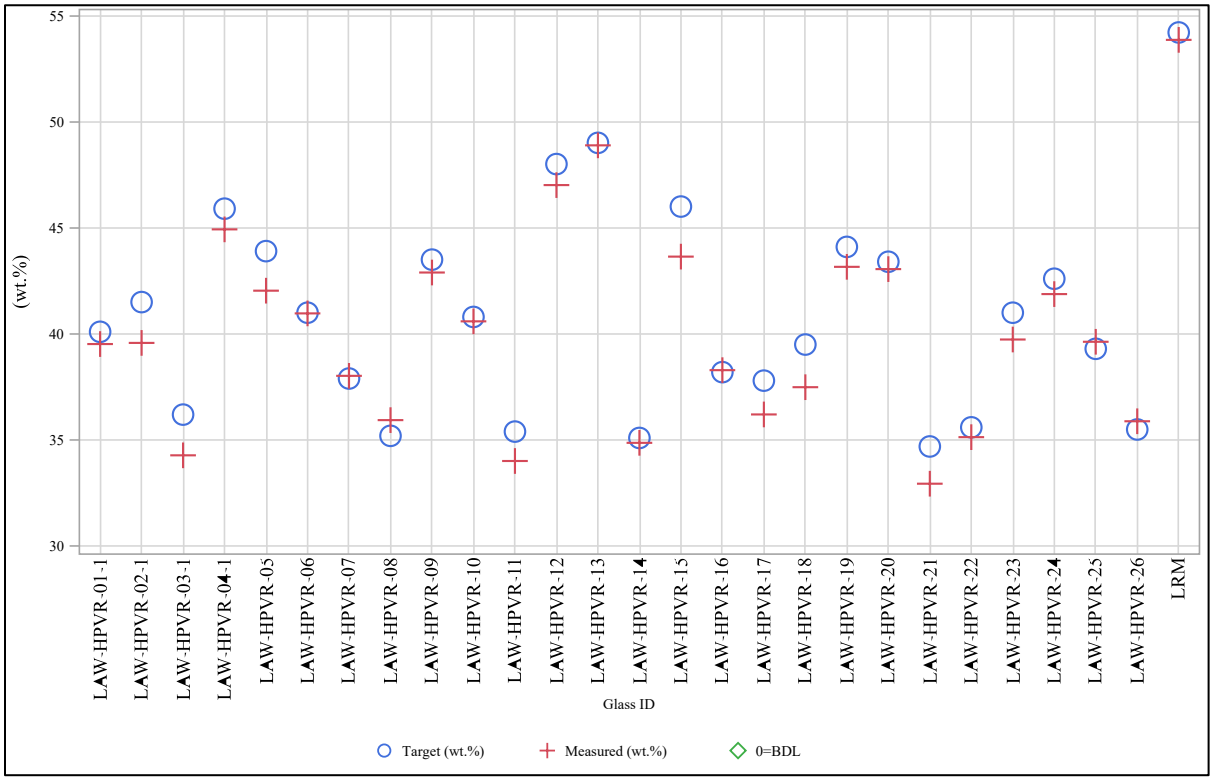


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=SiO_2



Oxide=SnO_2

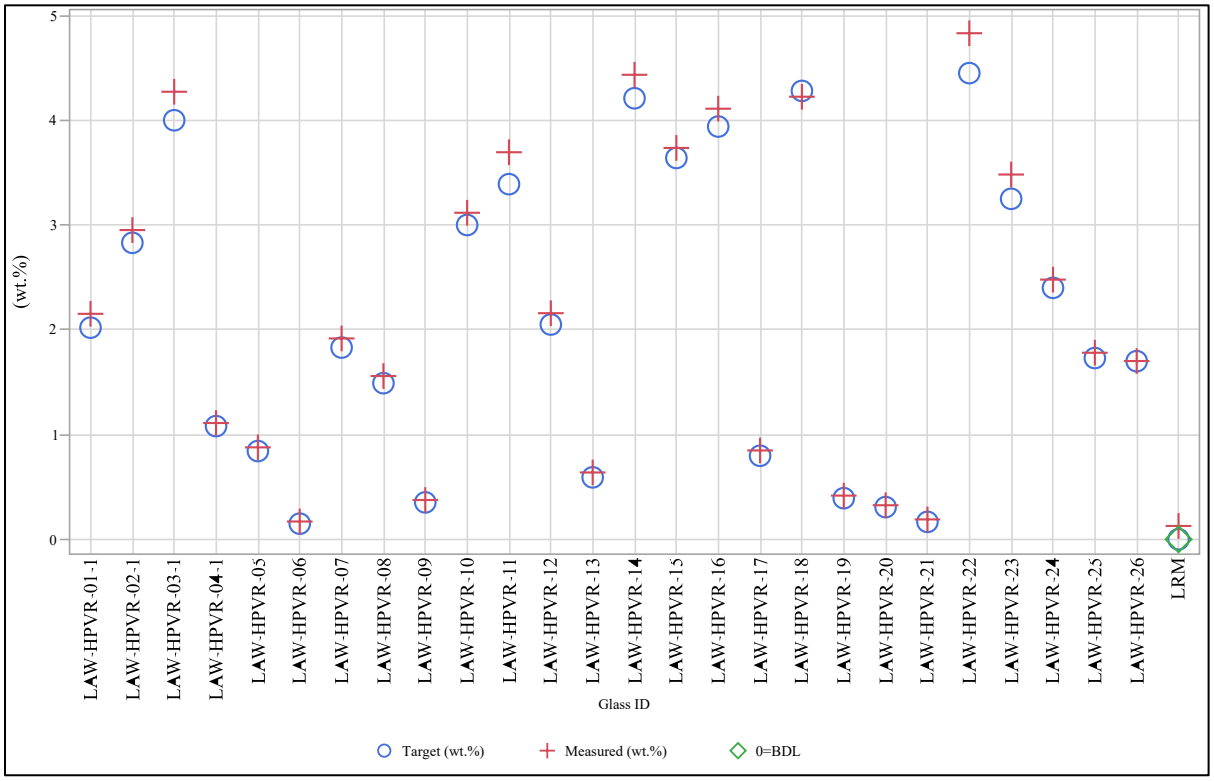
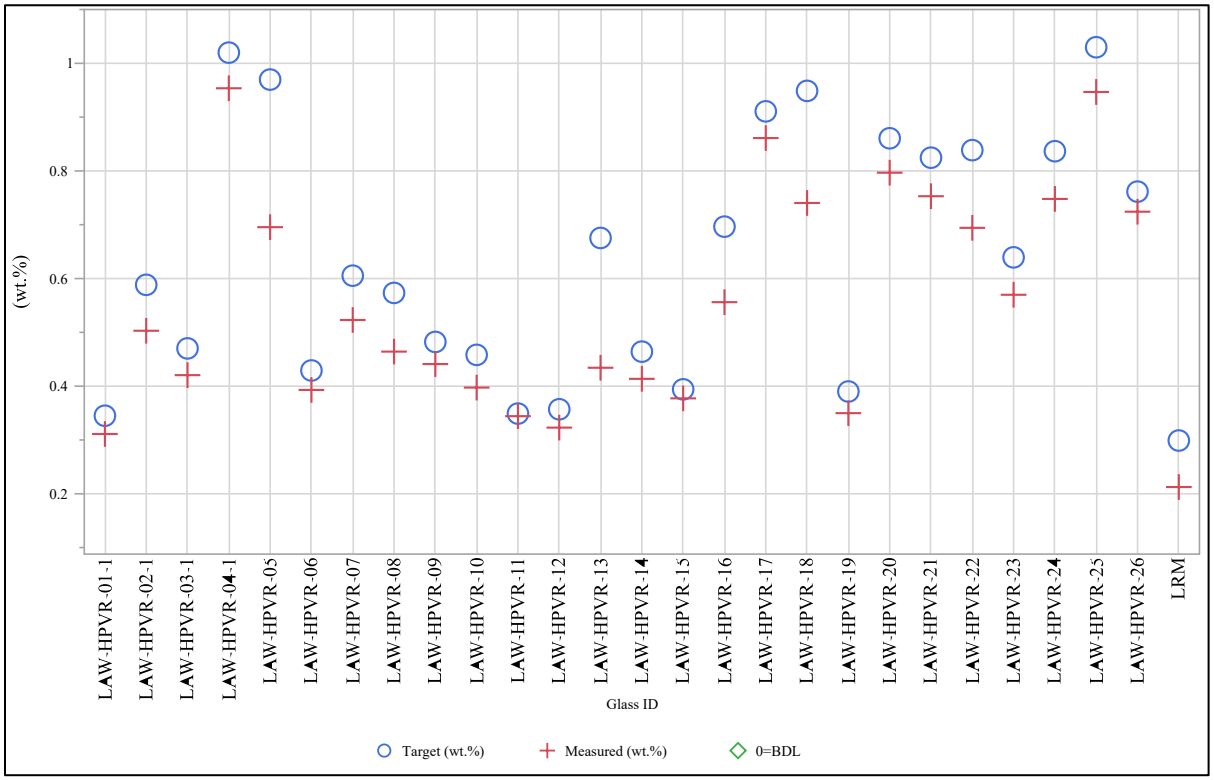


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=SO_3



Oxide=TiO_2

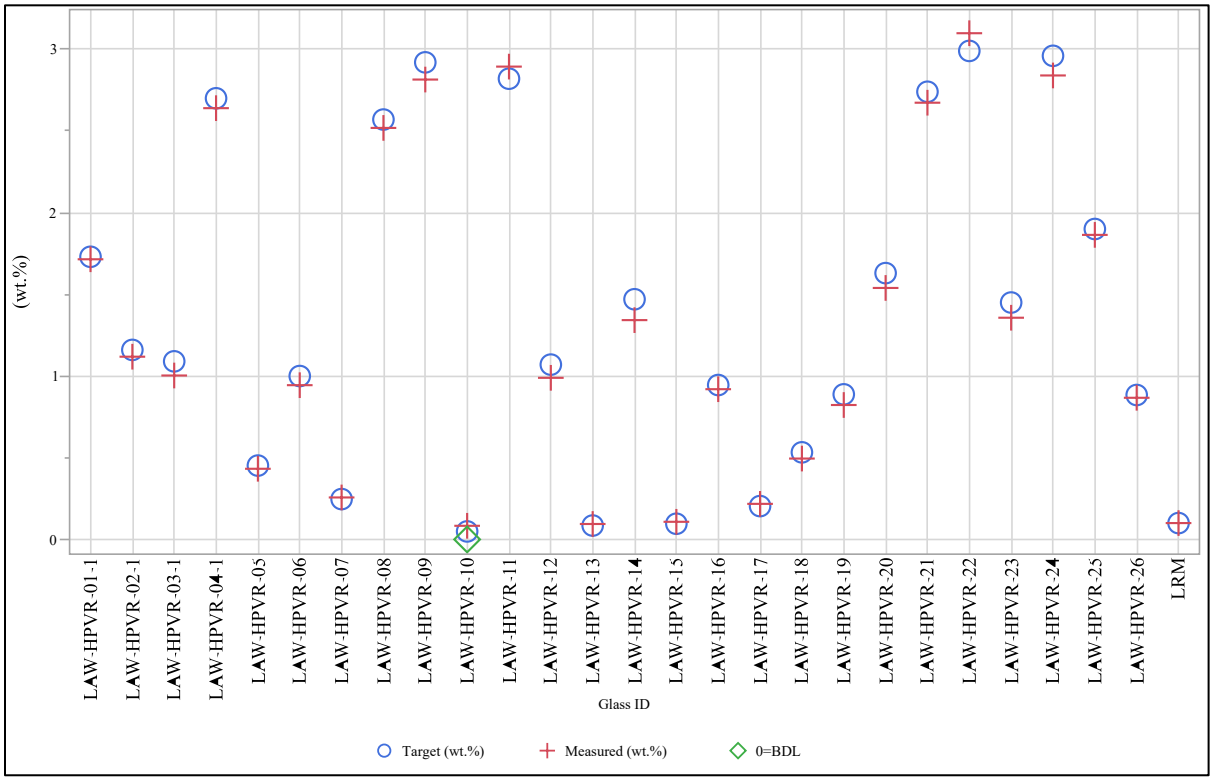
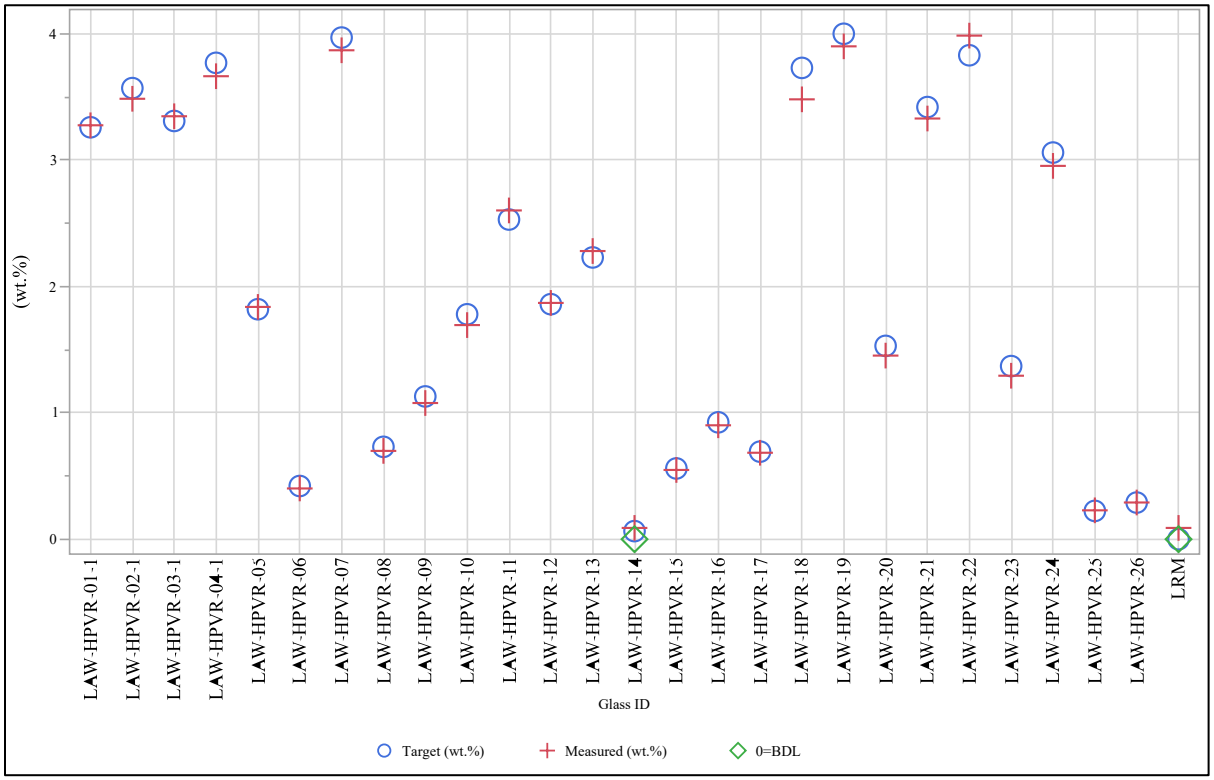


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=V_2O_5



Oxide=ZnO

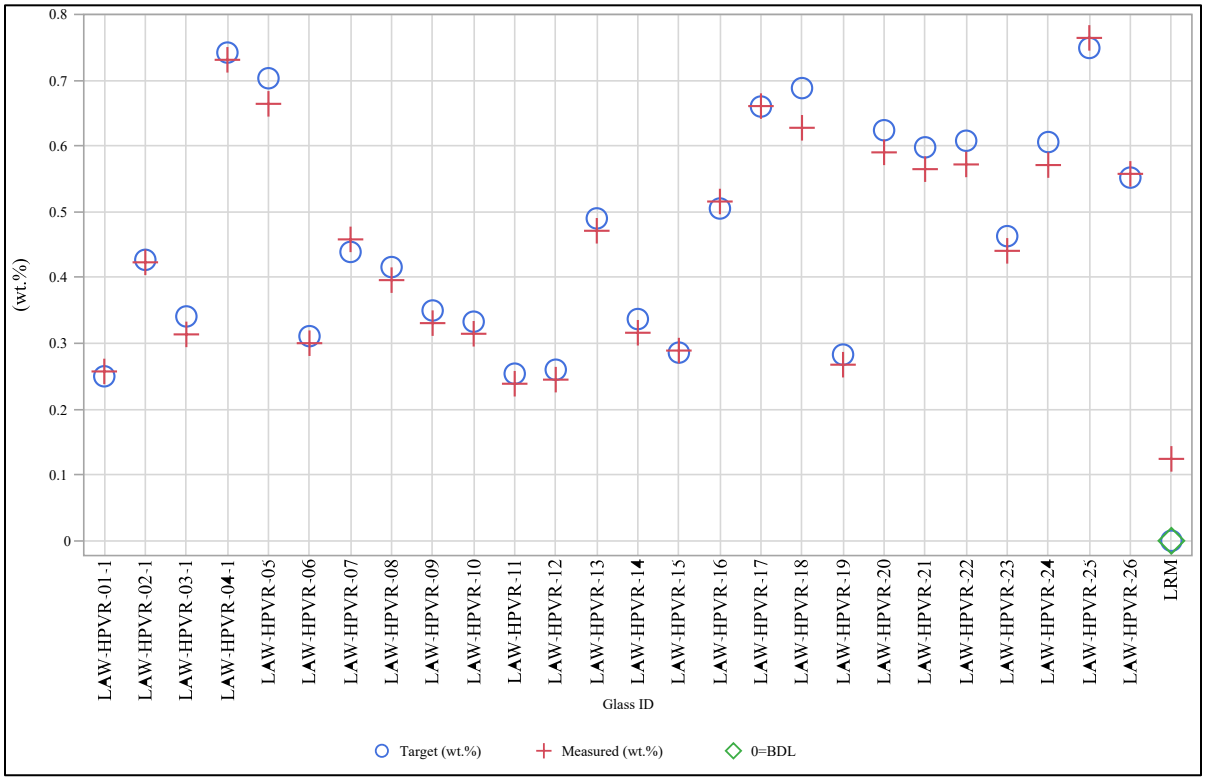
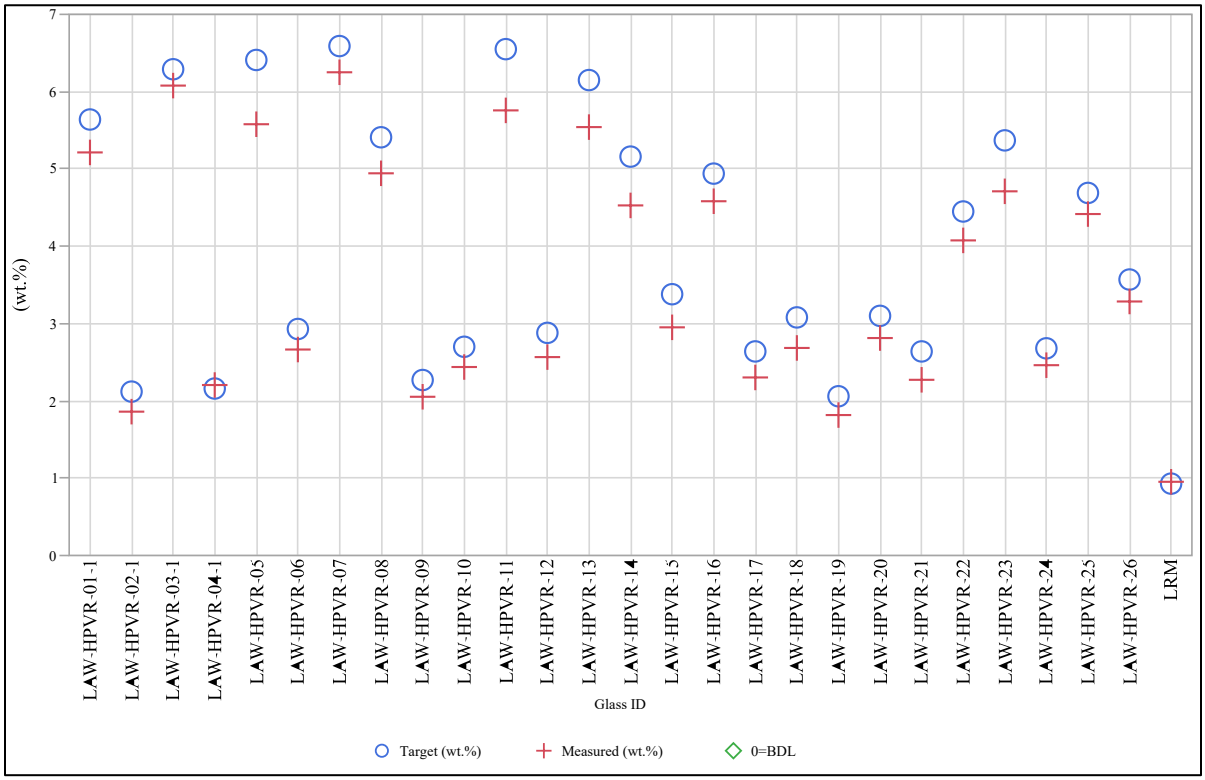
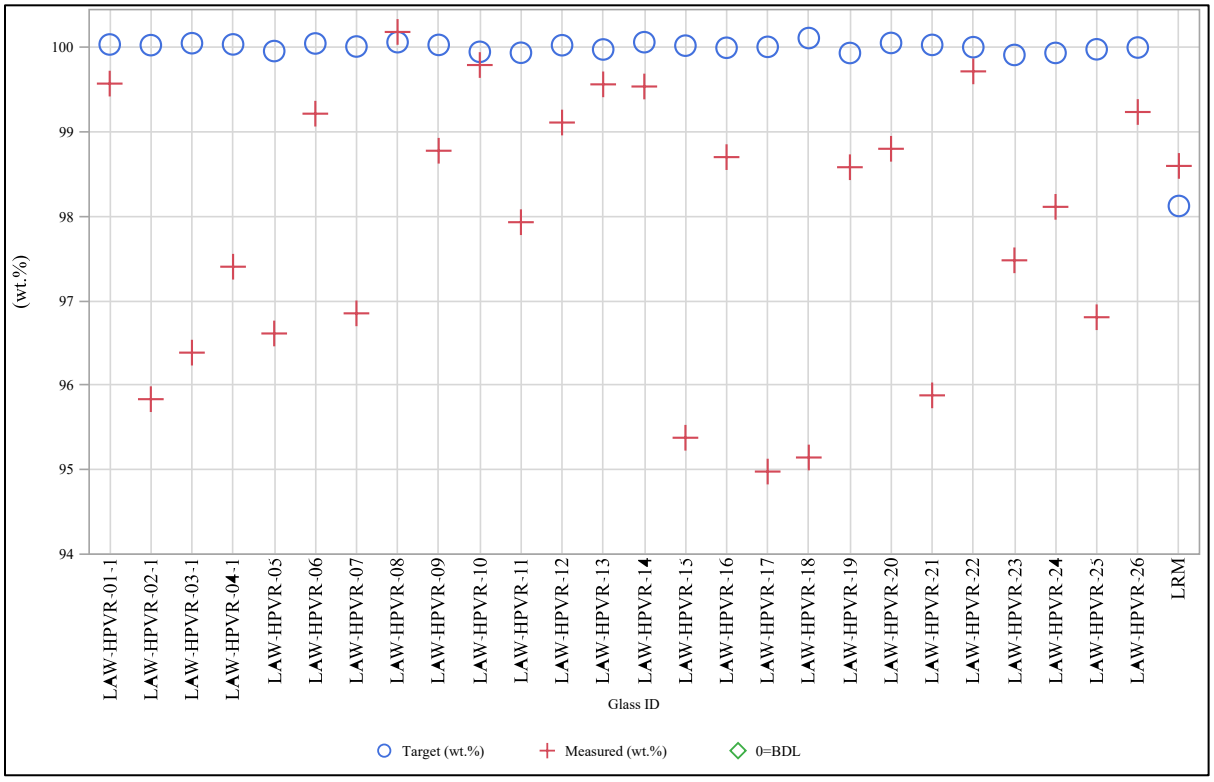


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=ZrO_2



Oxide=Sum of Oxides



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