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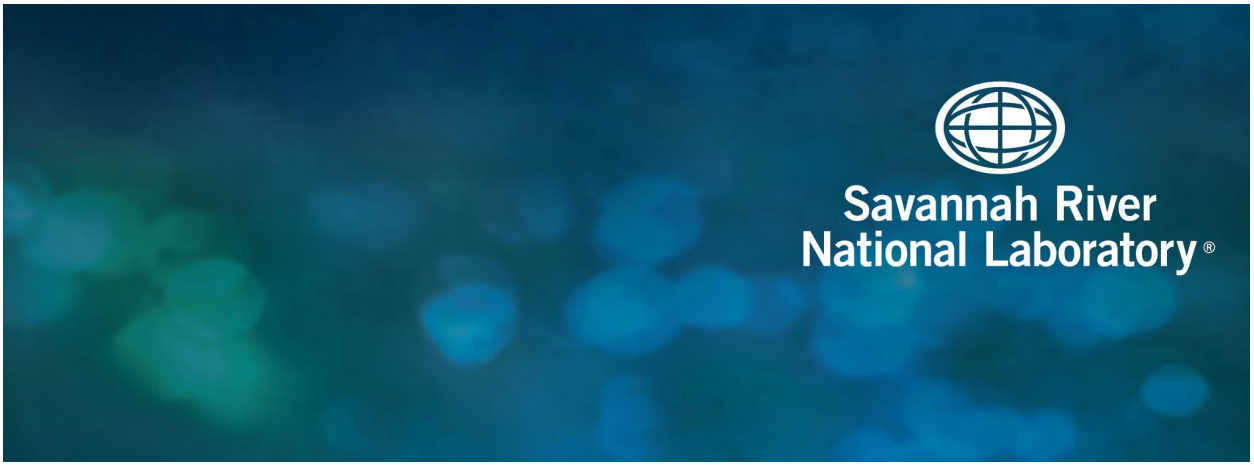

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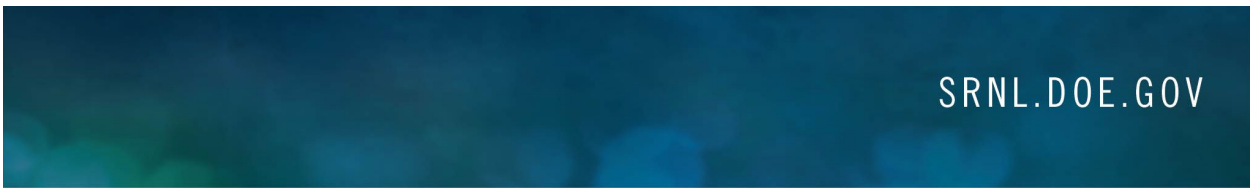
Composition Measurements of the HLW HAIG Glasses

M. C. Hsieh

July 2022

SRNL-STI-2022-00297, Revision 0



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APPROVAL:

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PREFACE OR ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

This report provides the results from the chemical analyses of the glass compositions of the High-Level Waste High-Aluminum Glass 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 Cr_2O_3, P_2O_5, and ZrO_2 for several of the glasses were greater than 10%. The relative difference between the targeted and measured concentrations of CaO was greater than 10% for one glass. The relative difference between the targeted and measured concentrations of Li_2O 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.

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LIST OF ABBREVIATIONS

ARG-1	Analytical Reference Glass-1
BDL	below detection limit
DOE	U. S. Department of Energy
IC	ion chromatography
ICP-OES	inductively coupled plasma – optical emission spectroscopy
ID	identifier
HLW HAlG	High-Level Waste High-Aluminum Glass
KH	potassium hydroxide fusion
LM	lithium metaborate fusion
LRM	low-activity test reference material
ORP	Office of River Protection
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
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.[3,4] The glasses were designated the High-Level Waste High-Aluminum Glass (HLW HAlG) 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.[5] SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011.[6] Laboratory data for this study were recorded in the SRNL Electronic Laboratory Notebook system, experiment L6390-00441-06. 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 HLW HAlG Study Glasses

PNNL ID	Lab ID
HAlG-01-Q-COMP	S-13688
HAlG-02-Q-COMP	S-13689
HAlG-03-Q-COMP	S-13690
HAlG-04-Q-COMP	S-13691
HAlG-05-Q-COMP	S-13692
HAlG-06-Q-COMP	S-13693
HAlG-07-1-Q-COMP	S-13694
HAlG-08-Q-COMP	S-13695
HAlG-09-Q-COMP	S-13696
HAlG-10-Q-COMP	S-13697
HAlG-11-Q-COMP	S-13698
HAlG-12-Q-COMP	S-13699
HAlG-13-Q-COMP	S-13700
HAlG-14-Q-COMP	S-13701
HAlG-15-Q-COMP	S-13702
HAlG-16-Q-COMP	S-13703
HAlG-17-Q-COMP	S-13704
HAlG-18-Q-COMP	S-13705
HAlG-19-Q-COMP	S-13706
HAlG-20-Q-COMP	S-13707
HAlG-21-Q-COMP	S-13708
HAlG-22-Q-COMP	S-13709
HAlG-23-Q-COMP	S-13710
HAlG-24-Q-COMP	S-13711
HAlG-25-Q-COMP	S-13712

2.3 Glass Composition Analysis

Chemical analyses were performed under the direction of an analytical plan[7] 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)).[8-10] 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)[11] or ion chromatography (IC),[12] 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 Analytical Reference Glass-1 (ARG-1) and low-level reference material (LRM) were included as part of the analytical plan.[7] The ARG-1 composition reported as the "Corning, Inc., Glass Composition"[13] and the LRM composition reported as the "Consensus Average"[14] are used as the reference compositions of these glasses. 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
Bi	ICP-OES	LM
Ca	ICP-OES	LM
Cd	ICP-PES	LM
Cr	ICP-OES	LM
F^-	IC	KH
Fe	ICP-OES	LM
K	ICP-OES	LM
Li	ICP-OES	PF
Mg	ICP-OES	LM
Mn	ICP-OES	LM
Na	ICP-OES	LM
Ni	ICP-OES	LM
P	ICP-OES	PF
S	ICP-OES	LM
Si	ICP-OES	PF
Sr	ICP-OES	LM
Ti	ICP-OES	LM
Zn	ICP-OES	LM
Zr	ICP-OES	PF

3.0 Results and Discussion

JMP® Version 16.0.0 (SAS Institute, Inc.)[15] 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 of 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 and ARG-1 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.[11,12] 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 calculations for 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. All ARG-1 standard glass measurements were within 10% of reference values. The ARG-1 composition reported as the "Corning, Inc., Glass Composition" was used as the reference composition.[13]

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 96.2 wt.% and 100 wt.%, indicating acceptable recovery of the glass components.[16] 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.

- CaO relative difference was 10% for HAlG-22-Q-COMP.
- Cr_2O_3 relative differences were 10% or greater for HAlG-02-Q-COMP, HAlG-09-Q-COMP, HAlG-10-Q-COMP, HAlG-12-Q-COMP, and HAlG-16-Q-COMP.
- Li_2O relative difference was 12% for HAlG-02-Q-COMP.
- P_2O_5 relative differences were 10% or greater for HAlG-02-Q-COMP, HAlG-03-Q-COMP, HAlG-06-Q-COMP, HAlG-07-1-Q-COMP, HAlG-08-Q-COMP, HAlG-10-Q-COMP, HAlG-18-Q-COMP, HAlG-20-Q-COMP, HAlG-21-Q-COMP, HAlG-22-Q-COMP, HAlG-23-Q-COMP, HAlG-24-Q-COMP, and HAlG-25-Q-COMP.
- ZrO_2 relative differences were 10% or greater for HAlG-20-Q-COMP and HAlG-21-Q-COMP.

4.0 Summary

Chemical analyses were performed on a representative sample of each of the HLW HAlG quenched glasses to allow for comparisons with targeted compositions. The relative differences between the targeted and measured concentrations of Cr_2O_3, P_2O_5, and ZrO_2 for several of the glasses were greater than 10%. The relative difference between the targeted and measured concentrations of CaO was greater than 10% for one glass. The relative difference between the targeted and measured concentrations of Li_2O 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 HLW HAlG Glass Composition Measurements

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	F^-
LRM	LRMKH111	1	1	1	0.914
ARG	ARGKH111	1	1	2	<0.0500
HAlG-25-Q-COMP	S-13712KH11	1	1	3	0.0839
HAlG-14-Q-COMP	S-13701KH11	1	1	4	0.0797
HAlG-02-Q-COMP	S-13689KH21	1	1	5	0.116
HAlG-14-Q-COMP	S-13701KH21	1	1	6	0.0783
HAlG-25-Q-COMP	S-13712KH21	1	1	7	0.0830
HAlG-03-Q-COMP	S-13690KH11	1	1	8	0.178
HAlG-09-Q-COMP	S-13696KH21	1	1	9	0.129
HAlG-09-Q-COMP	S-13696KH11	1	1	10	0.129
LRM	LRMKH112	1	1	11	0.926
ARG	ARGKH112	1	1	12	<0.0500
HAlG-11-Q-COMP	S-13698KH21	1	1	13	0.285
HAlG-02-Q-COMP	S-13689KH11	1	1	14	0.115
HAlG-01-Q-COMP	S-13688KH11	1	1	15	0.723
HAlG-22-Q-COMP	S-13709KH21	1	1	16	0.708
HAlG-11-Q-COMP	S-13698KH11	1	1	17	0.279
HAlG-22-Q-COMP	S-13709KH11	1	1	18	0.709
HAlG-01-Q-COMP	S-13688KH21	1	1	19	0.729
HAlG-03-Q-COMP	S-13690KH21	1	1	20	0.179
LRM	LRMKH113	1	1	21	0.913
ARG	ARGKH113	1	1	22	<0.0500
LRM	LRMKH121	1	2	1	0.922
ARG	ARGKH121	1	2	2	<0.0500
HAlG-09-Q-COMP	S-13696KH12	1	2	3	0.135
HAlG-11-Q-COMP	S-13698KH12	1	2	4	0.292
HAlG-11-Q-COMP	S-13698KH22	1	2	5	0.297
HAlG-01-Q-COMP	S-13688KH12	1	2	6	0.752
HAlG-09-Q-COMP	S-13696KH22	1	2	7	0.136
HAlG-02-Q-COMP	S-13689KH22	1	2	8	0.123
HAlG-25-Q-COMP	S-13712KH22	1	2	9	0.0876
HAlG-22-Q-COMP	S-13709KH22	1	2	10	0.729
LRM	LRMKH122	1	2	11	0.906
ARG	ARGKH122	1	2	12	<0.0500
HAlG-01-Q-COMP	S-13688KH22	1	2	13	0.743
HAlG-14-Q-COMP	S-13701KH22	1	2	14	0.0833
HAlG-03-Q-COMP	S-13690KH12	1	2	15	0.189
HAlG-25-Q-COMP	S-13712KH12	1	2	16	0.0900
HAlG-14-Q-COMP	S-13701KH12	1	2	17	0.0859
HAlG-03-Q-COMP	S-13690KH22	1	2	18	0.189
HAlG-02-Q-COMP	S-13689KH12	1	2	19	0.124
HAlG-22-Q-COMP	S-13709KH12	1	2	20	0.743
LRM	LRMKH123	1	2	21	0.936
ARG	ARGKH123	1	2	22	<0.0500
LRM	LRMKH211	2	1	1	0.908
ARG	ARGKH211	2	1	2	<0.0500
HAlG-07-1-Q-COMP	S-13694KH21	2	1	3	0.561

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	F^-
HAlG-12-Q-COMP	S-13699KH21	2	1	4	0.405
HAlG-18-Q-COMP	S-13705KH11	2	1	5	0.347
HAlG-18-Q-COMP	S-13705KH21	2	1	6	0.351
HAlG-21-Q-COMP	S-13708KH21	2	1	7	0.445
HAlG-10-Q-COMP	S-13697KH21	2	1	8	0.0967
HAlG-19-Q-COMP	S-13706KH11	2	1	9	0.126
HAlG-19-Q-COMP	S-13706KH21	2	1	10	0.126
HAlG-12-Q-COMP	S-13699KH11	2	1	11	0.404
LRM	LRMKH212	2	1	12	0.918
ARG	ARGKH212	2	1	13	<0.0500
HAlG-20-Q-COMP	S-13707KH21	2	1	14	0.199
HAlG-10-Q-COMP	S-13697KH11	2	1	15	0.0972
HAlG-13-Q-COMP	S-13700KH11	2	1	16	0.578
HAlG-20-Q-COMP	S-13707KH11	2	1	17	0.202
HAlG-21-Q-COMP	S-13708KH11	2	1	18	0.448
HAlG-07-1-Q-COMP	S-13694KH11	2	1	19	0.561
HAlG-17-Q-COMP	S-13704KH11	2	1	20	0.302
HAlG-13-Q-COMP	S-13700KH21	2	1	21	0.564
HAlG-17-Q-COMP	S-13704KH21	2	1	22	0.299
LRM	LRMKH213	2	1	23	0.927
ARG	ARGKH213	2	1	24	<0.0500
LRM	LRMKH221	2	2	1	0.951
ARG	ARGKH221	2	2	2	<0.0500
HAlG-07-1-Q-COMP	S-13694KH12	2	2	3	0.574
HAlG-18-Q-COMP	S-13705KH22	2	2	4	0.360
HAlG-13-Q-COMP	S-13700KH12	2	2	5	0.594
HAlG-20-Q-COMP	S-13707KH12	2	2	6	0.207
HAlG-19-Q-COMP	S-13706KH12	2	2	7	0.132
HAlG-17-Q-COMP	S-13704KH12	2	2	8	0.302
HAlG-07-1-Q-COMP	S-13694KH22	2	2	9	0.572
HAlG-13-Q-COMP	S-13700KH22	2	2	10	0.583
HAlG-20-Q-COMP	S-13707KH22	2	2	11	0.206
LRM	LRMKH222	2	2	12	0.927
ARG	ARGKH222	2	2	13	<0.0500
HAlG-19-Q-COMP	S-13706KH22	2	2	14	0.131
HAlG-21-Q-COMP	S-13708KH22	2	2	15	0.485
HAlG-21-Q-COMP	S-13708KH12	2	2	16	0.468
HAlG-17-Q-COMP	S-13704KH22	2	2	17	0.304
HAlG-12-Q-COMP	S-13699KH12	2	2	18	0.432
HAlG-12-Q-COMP	S-13699KH22	2	2	19	0.423
HAlG-18-Q-COMP	S-13705KH12	2	2	20	0.355
HAlG-10-Q-COMP	S-13697KH22	2	2	21	0.100
HAlG-10-Q-COMP	S-13697KH12	2	2	22	0.0992
LRM	LRMKH223	2	2	23	0.927
ARG	ARGKH223	2	2	24	<0.0500
LRM	LRMKH311	3	1	1	0.924
ARG	ARGKH311	3	1	2	<0.0500

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	F^-
HAlG-05-Q-COMP	S-13692KH21	3	1	3	0.389
HAlG-05-Q-COMP	S-13692KH11	3	1	4	0.384
HAlG-16-Q-COMP	S-13703KH11	3	1	5	0.192
HAlG-16-Q-COMP	S-13703KH21	3	1	6	0.195
HAlG-04-Q-COMP	S-13691KH11	3	1	7	0.685
HAlG-06-Q-COMP	S-13693KH21	3	1	8	0.157
HAlG-08-Q-COMP	S-13695KH21	3	1	9	0.0849
HAlG-23-Q-COMP	S-13710KH21	3	1	10	0.405
LRM	LRMKH312	3	1	11	0.926
ARG	ARGKH312	3	1	12	<0.0500
HAlG-24-Q-COMP	S-13711KH21	3	1	13	0.248
HAlG-04-Q-COMP	S-13691KH21	3	1	14	0.686
HAlG-23-Q-COMP	S-13710KH11	3	1	15	0.401
HAlG-08-Q-COMP	S-13695KH11	3	1	16	0.0845
HAlG-15-Q-COMP	S-13702KH21	3	1	17	0.306
HAlG-15-Q-COMP	S-13702KH11	3	1	18	0.306
HAlG-06-Q-COMP	S-13693KH11	3	1	19	0.160
HAlG-24-Q-COMP	S-13711KH11	3	1	20	0.242
LRM	LRMKH313	3	1	21	0.925
ARG	ARGKH313	3	1	22	<0.0500
LRM	LRMKH321	3	2	1	0.929
ARG	ARGKH321	3	2	2	<0.0500
HAlG-15-Q-COMP	S-13702KH12	3	2	3	0.323
HAlG-04-Q-COMP	S-13691KH12	3	2	4	0.726
HAlG-05-Q-COMP	S-13692KH22	3	2	5	0.408
HAlG-16-Q-COMP	S-13703KH12	3	2	6	0.202
HAlG-04-Q-COMP	S-13691KH22	3	2	7	0.729
HAlG-08-Q-COMP	S-13695KH22	3	2	8	0.0891
HAlG-23-Q-COMP	S-13710KH12	3	2	9	0.426
HAlG-15-Q-COMP	S-13702KH22	3	2	10	0.325
LRM	LRMKH322	3	2	11	0.906
ARG	ARGKH322	3	2	12	<0.0500
HAlG-16-Q-COMP	S-13703KH22	3	2	13	0.206
HAlG-08-Q-COMP	S-13695KH12	3	2	14	0.0890
HAlG-06-Q-COMP	S-13693KH12	3	2	15	0.169
HAlG-05-Q-COMP	S-13692KH12	3	2	16	0.407
HAlG-24-Q-COMP	S-13711KH22	3	2	17	0.264
HAlG-24-Q-COMP	S-13711KH12	3	2	18	0.257
HAlG-06-Q-COMP	S-13693KH22	3	2	19	0.167
HAlG-23-Q-COMP	S-13710KH22	3	2	20	0.428
LRM	LRMKH323	3	2	21	0.924
ARG	ARGKH323	3	2	22	<0.0500

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Bi	Ca	Cd	Cr	Fe	K	Mg	Mn	Na	Ni	S	Sr	Ti	Zn
LRM	LRMLM111	1	1	1	<0.100	0.361	0.145	0.130	1.01	1.15	0.0669	0.0607	15.3	0.140	0.0729	<0.0500	0.0618	<0.0500
ARG	ARGLM111	1	1	2	<0.100	1.09	<0.0250	0.0629	9.85	2.25	0.506	1.48	8.89	0.759	<0.0500	<0.0500	0.665	<0.0500
HAlG-20-Q-COMP	S-13707LM21	1	1	3	0.184	0.308	0.0344	1.00	0.490	0.535	0.130	0.0211	11.1	0.334	<0.0500	<0.0500	0.0560	0.0666
HAlG-09-Q-COMP	S-13696LM11	1	1	4	0.136	0.234	<0.0250	0.643	3.34	0.375	0.104	0.0206	10.4	0.184	<0.0500	<0.0500	0.0654	<0.0500
HAlG-11-Q-COMP	S-13698LM11	1	1	5	0.267	0.441	0.0467	1.22	1.21	0.742	0.190	0.0309	14.9	0.372	0.0576	<0.0500	0.0969	0.0895
HAlG-07-1-Q-COMP	S-13694LM21	1	1	6	0.519	0.791	0.0962	0.0539	6.24	1.46	0.356	0.0662	14.8	0.670	0.144	0.0805	0.159	0.169
HAlG-04-Q-COMP	S-13691LM21	1	1	7	0.541	0.831	0.101	0.737	4.78	1.54	0.371	0.0648	14.6	0.725	0.153	0.0877	0.170	0.175
HAlG-24-Q-COMP	S-13711LM11	1	1	8	0.891	2.43	0.0775	0.481	3.69	0.577	0.304	0.715	8.50	0.288	0.107	0.0852	<0.0500	<0.0500
HAlG-06-Q-COMP	S-13693LM21	1	1	9	0.157	0.281	0.0289	0.786	1.05	0.456	0.112	0.0185	15.0	0.223	<0.0500	<0.0500	0.0736	0.0903
HAlG-04-Q-COMP	S-13691LM11	1	1	10	0.537	0.829	0.100	0.739	4.81	1.55	0.371	0.0646	14.7	0.723	0.155	0.086	0.169	0.181
LRM	LRMLM112	1	1	11	<0.100	0.361	0.144	0.131	1.03	1.19	0.0666	0.0594	15.9	0.139	0.0780	<0.0500	0.0617	<0.0500
ARG	ARGLM112	1	1	12	<0.100	1.09	<0.0250	0.0632	10.0	2.25	0.507	1.47	8.61	0.760	<0.0500	<0.0500	0.670	<0.0500
HAlG-09-Q-COMP	S-13696LM21	1	1	13	0.136	0.283	<0.0250	0.654	3.39	0.377	0.107	0.0213	10.1	0.190	<0.0500	<0.0500	0.0824	0.0624
HAlG-20-Q-COMP	S-13707LM11	1	1	14	0.189	0.314	0.0351	0.885	0.495	0.540	0.131	0.0207	10.5	0.286	0.0536	<0.0500	0.0571	0.0662
HAlG-15-Q-COMP	S-13702LM21	1	1	15	0.266	0.442	0.0482	1.28	0.887	0.742	0.185	0.0289	11.0	0.350	0.0650	<0.0500	0.0997	0.0849
HAlG-07-1-Q-COMP	S-13694LM11	1	1	16	0.524	0.804	0.0970	0.0538	6.29	1.48	0.362	0.0667	14.7	0.672	0.144	0.0855	0.158	0.168
HAlG-06-Q-COMP	S-13693LM11	1	1	17	0.161	0.273	0.0292	0.792	1.03	0.452	0.112	0.0186	14.5	0.219	<0.0500	<0.0500	0.0751	0.0600
HAlG-24-Q-COMP	S-13711LM21	1	1	18	0.890	2.43	0.0768	0.481	3.69	0.571	0.304	0.716	8.54	0.286	0.108	0.0849	<0.0500	<0.0500
HAlG-15-Q-COMP	S-13702LM11	1	1	19	0.260	0.421	0.0469	1.28	0.868	0.721	0.178	0.0284	10.8	0.373	0.0687	<0.0500	0.0977	0.0917
HAlG-11-Q-COMP	S-13698LM21	1	1	20	0.272	0.522	0.0477	1.23	1.22	0.734	0.194	0.0321	14.7	0.401	0.0645	<0.0500	0.107	0.104
LRM	LRMLM113	1	1	21	<0.100	0.363	0.145	0.131	1.03	1.21	0.0668	0.0602	15.7	0.140	0.0726	<0.0500	0.0619	<0.0500
ARG	ARGLM113	1	1	22	<0.100	1.07	<0.0250	0.0633	9.89	2.23	0.499	1.46	8.30	0.759	<0.0500	<0.0500	0.660	<0.0500
LRM	LRMLM121	1	2	1	<0.100	0.387	0.1438	0.130	1.01	1.24	0.0666	0.0607	15.3	0.140	0.0758	<0.0500	0.0622	<0.0500
ARG	ARGLM121	1	2	2	<0.100	1.01	<0.0250	0.0630	9.77	2.40	0.505	1.50	8.47	0.774	<0.0500	<0.0500	0.674	<0.0500
HAlG-24-Q-COMP	S-13711LM12	1	2	3	0.869	2.54	0.0778	0.478	3.72	0.560	0.296	0.726	8.54	0.290	0.106	0.0821	<0.0500	<0.0500
HAlG-04-Q-COMP	S-13691LM12	1	2	4	0.544	0.896	0.100	0.740	4.65	1.48	0.373	0.0663	14.1	0.740	0.156	0.0835	0.172	0.179
HAlG-06-Q-COMP	S-13693LM22	1	2	5	0.161	0.304	0.0288	0.785	1.00	0.478	0.114	0.0188	14.3	0.227	<0.0500	<0.0500	0.0753	0.0891
HAlG-09-Q-COMP	S-13696LM22	1	2	6	0.133	0.297	<0.0250	0.648	3.28	0.399	0.104	0.0209	9.88	0.192	<0.0500	<0.0500	0.0820	0.0609
HAlG-06-Q-COMP	S-13693LM12	1	2	7	0.161	0.292	0.0289	0.787	0.998	0.475	0.113	0.0187	14.5	0.221	<0.0500	<0.0500	0.0755	0.0592
HAlG-07-1-Q-COMP	S-13694LM22	1	2	8	0.530	0.856	0.0967	0.0538	6.11	1.44	0.362	0.0680	14.7	0.685	0.157	0.0825	0.163	0.169
HAlG-24-Q-COMP	S-13711LM22	1	2	9	0.871	2.521	0.0779	0.479	3.71	0.561	0.297	0.727	8.49	0.292	0.120	0.0822	<0.0500	<0.0500
HAlG-09-Q-COMP	S-13696LM12	1	2	10	0.140	0.259	<0.0250	0.650	3.26	0.407	0.108	0.0215	9.88	0.189	<0.0500	<0.0500	0.0685	<0.0500
LRM	LRMLM122	1	2	11	<0.100	0.400	0.1447	0.131	1.01	1.30	0.0679	0.0618	15.3	0.143	0.0863	<0.0500	0.0638	<0.0500
ARG	ARGLM122	1	2	12	<0.100	1.04	<0.0250	0.0637	9.74	2.47	0.518	1.53	8.57	0.784	<0.0500	<0.0500	0.696	<0.0500
HAlG-20-Q-COMP	S-13707LM12	1	2	13	0.189	0.342	0.0351	0.886	0.501	0.559	0.132	0.0212	10.3	0.293	0.0531	<0.0500	0.0579	0.0654
HAlG-15-Q-COMP	S-13702LM12	1	2	14	0.260	0.455	0.0466	1.24	0.874	0.752	0.179	0.0290	10.7	0.379	0.0709	<0.0500	0.0993	0.0903
HAlG-11-Q-COMP	S-13698LM12	1	2	15	0.276	0.481	0.0470	1.20	1.19	0.786	0.194	0.0318	14.5	0.380	0.0662	<0.0500	0.100	0.0892
HAlG-20-Q-COMP	S-13707LM22	1	2	16	0.190	0.340	0.0347	0.957	0.503	0.570	0.133	0.0222	10.5	0.344	0.0500	<0.0500	0.0572	0.0665
HAlG-15-Q-COMP	S-13702LM22	1	2	17	0.270	0.480	0.0479	1.25	0.899	0.775	0.187	0.0296	10.9	0.358	0.0739	<0.0500	0.102	0.0839
HAlG-04-Q-COMP	S-13691LM22	1	2	18	0.553	0.914	0.102	0.747	4.65	1.47	0.380	0.0676	14.2	0.749	0.160	0.0875	0.177	0.175
HAlG-11-Q-COMP	S-13698LM22	1	2	19	0.280	0.570	0.0475	1.20	1.18	0.780	0.197	0.0327	14.3	0.411	0.0755	<0.0500	0.110	0.103
HAlG-07-1-Q-COMP	S-13694LM12	1	2	20	0.531	0.871	0.0971	0.0545	6.08	1.39	0.366	0.0683	14.4	0.692	0.160	0.0828	0.162	0.167
LRM	LRMLM123	1	2	21	<0.100	0.397	0.1462	0.132	0.997	1.26	0.0680	0.0622	15.3	0.143	0.0719	<0.0500	0.0639	<0.0500
ARG	ARGLM123	1	2	22	<0.100	1.03	<0.0250	0.0642	9.64	2.39	0.516	1.54	8.42	0.784	<0.0500	<0.0500	0.694	<0.0500
LRM	LRMLM211	2	1	1	<0.100	0.367	0.142	0.131	1.01	1.15	0.0645	0.0606	15.3	0.158	0.0763	<0.0500	0.0614	<0.0500

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Bi	Ca	Cd	Cr	Fe	K	Mg	Mn	Na	Ni	S	Sr	Ti	Zn
ARG	ARGLM211	2	1	2	<0.100	1.08	<0.0250	0.0627	9.88	2.19	0.495	1.43	8.71	0.751	<0.0500	<0.0500	0.647	<0.0500
HAlG-23-Q-COMP	S-13710LM11	2	1	3	0.336	0.559	0.0622	0.558	0.141	1.02	0.237	0.0364	8.43	0.463	0.0937	0.0535	0.103	0.108
HAlG-22-Q-COMP	S-13709LM21	2	1	4	0.566	1.08	0.105	1.20	0.773	1.66	0.403	0.0622	10.0	0.787	0.159	0.0896	0.168	0.181
HAlG-12-Q-COMP	S-13699LM21	2	1	5	0.385	0.633	0.0695	0.896	0.134	1.14	0.278	0.0411	14.5	0.517	0.103	0.0616	0.132	0.119
HAlG-02-Q-COMP	S-13689LM21	2	1	6	0.122	0.224	<0.0250	0.760	3.28	0.360	0.0870	0.0195	14.4	0.167	<0.0500	<0.0500	0.0507	<0.0500
HAlG-08-Q-COMP	S-13695LM21	2	1	7	<0.100	0.161	<0.0250	0.465	7.41	0.249	0.0688	0.0229	13.2	0.135	<0.0500	<0.0500	0.0510	<0.0500
HAlG-17-Q-COMP	S-13704LM11	2	1	8	0.254	0.439	0.0469	0.0834	0.519	0.762	0.189	0.0301	13.0	0.361	0.0849	<0.0500	0.103	0.0832
HAlG-25-Q-COMP	S-13712LM21	2	1	9	<0.100	0.153	<0.0250	0.421	7.45	0.254	0.0608	0.0238	13.3	0.114	<0.0500	<0.0500	0.0502	<0.0500
HAlG-02-Q-COMP	S-13689LM11	2	1	10	0.119	0.222	<0.0250	0.758	3.29	0.356	0.0862	0.0185	14.4	0.165	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-25-Q-COMP	S-13712LM11	2	1	11	<0.100	0.151	<0.0250	0.415	7.44	0.250	0.0599	0.0240	13.2	0.111	<0.0500	<0.0500	0.0502	<0.0500
LRM	LRMLM212	2	1	12	<0.100	0.378	0.142	0.132	1.02	1.18	0.066	0.0609	15.4	0.158	0.0720	<0.0500	0.0629	<0.0500
ARG	ARGLM212	2	1	13	<0.100	1.10	<0.0250	0.0622	9.81	2.23	0.499	1.43	8.66	0.745	<0.0500	<0.0500	0.652	<0.0500
HAlG-19-Q-COMP	S-13706LM11	2	1	14	0.118	0.197	0.0208	0.545	4.15	0.334	0.0851	0.0205	14.7	0.159	<0.0500	0.0199	0.0639	<0.0500
HAlG-22-Q-COMP	S-13709LM11	2	1	15	0.564	1.09	0.105	1.20	0.772	1.63	0.403	0.0623	9.90	0.788	0.165	0.0907	0.170	0.181
HAlG-12-Q-COMP	S-13699LM11	2	1	16	0.379	0.630	0.0683	0.885	0.135	1.09	0.277	0.0407	14.5	0.513	0.0998	0.0627	0.132	0.118
HAlG-16-Q-COMP	S-13703LM21	2	1	17	0.181	0.327	0.0297	1.10	2.91	0.526	0.136	0.0248	14.1	0.252	<0.0500	<0.0500	0.0780	0.0604
HAlG-23-Q-COMP	S-13710LM21	2	1	18	0.336	0.565	0.0618	0.557	0.139	1.01	0.239	0.0362	8.38	0.460	0.109	0.0542	0.101	0.108
HAlG-19-Q-COMP	S-13706LM21	2	1	19	0.117	0.201	0.0208	0.547	4.15	0.332	0.0849	0.0204	14.8	0.159	<0.0500	0.0199	0.0637	<0.0500
HAlG-17-Q-COMP	S-13704LM21	2	1	20	0.262	0.454	0.0485	0.0814	0.528	0.751	0.193	0.0290	13.1	0.352	0.0806	<0.0500	0.101	0.0837
HAlG-08-Q-COMP	S-13695LM11	2	1	21	<0.100	0.154	<0.0250	0.590	7.42	0.250	0.0615	0.0241	13.4	0.195	<0.0500	<0.0500	0.0547	<0.0500
HAlG-16-Q-COMP	S-13703LM11	2	1	22	0.182	0.331	0.0281	1.09	2.91	0.572	0.140	0.0238	14.3	0.229	<0.0500	<0.0500	0.0768	0.0601
LRM	LRMLM213	2	1	23	<0.100	0.392	0.144	0.134	1.03	1.22	0.0679	0.0624	15.7	0.161	0.0782	<0.0500	0.0650	<0.0500
ARG	ARGLM213	2	1	24	<0.100	0.989	<0.0250	0.0635	9.82	2.30	0.514	1.47	8.76	0.759	<0.0500	<0.0500	0.677	<0.0500
LRM	LRMLM221	2	2	1	<0.100	0.368	0.142	0.133	1.00	1.15	0.0657	0.0615	15.4	0.161	0.0877	<0.0500	0.0627	<0.0500
ARG	ARGLM221	2	2	2	<0.100	1.09	<0.0250	0.0634	9.70	2.20	0.509	1.45	8.66	0.761	<0.0500	<0.0500	0.664	<0.0500
HAlG-17-Q-COMP	S-13704LM12	2	2	3	0.255	0.430	0.0471	0.0863	0.522	0.751	0.191	0.0305	12.7	0.377	0.0878	<0.0500	0.103	0.0838
HAlG-08-Q-COMP	S-13695LM22	2	2	4	<0.100	0.160	<0.0250	0.468	7.19	0.245	0.0698	0.0230	12.9	0.136	<0.0500	<0.0500	0.0513	<0.0500
HAlG-16-Q-COMP	S-13703LM12	2	2	5	0.178	0.315	0.0279	1.06	2.81	0.561	0.138	0.0234	13.9	0.229	<0.0500	<0.0500	0.0745	0.0597
HAlG-22-Q-COMP	S-13709LM22	2	2	6	0.577	1.02	0.106	1.17	0.782	1.65	0.415	0.0632	9.74	0.801	0.161	0.0919	0.173	0.184
HAlG-19-Q-COMP	S-13706LM22	2	2	7	0.118	0.207	0.0209	0.544	4.18	0.321	0.0826	0.0206	14.5	0.161	<0.0500	0.019	0.0625	<0.0500
HAlG-23-Q-COMP	S-13710LM22	2	2	8	0.343	0.566	0.0622	0.568	0.141	1.02	0.246	0.0367	8.30	0.470	0.103	0.0546	0.103	0.111
HAlG-12-Q-COMP	S-13699LM12	2	2	9	0.393	0.637	0.0693	0.904	0.137	1.11	0.289	0.0415	14.3	0.522	0.104	0.0638	0.135	0.121
HAlG-16-Q-COMP	S-13703LM22	2	2	10	0.189	0.332	0.0302	1.10	2.87	0.548	0.142	0.0253	13.9	0.257	<0.0500	<0.0500	0.0801	0.0622
HAlG-19-Q-COMP	S-13706LM12	2	2	11	0.116	0.203	0.0210	0.544	4.22	0.320	0.0825	0.0206	14.5	0.161	<0.0500	0.019	0.0630	<0.0500
LRM	LRMLM222	2	2	12	<0.100	0.380	0.141	0.134	0.980	1.23	0.0677	0.0617	15.1	0.161	0.0791	<0.0500	0.0641	<0.0500
ARG	ARGLM222	2	2	13	<0.100	1.11	<0.0250	0.0638	9.61	2.30	0.520	1.46	8.58	0.761	<0.0500	<0.0500	0.678	<0.0500
HAlG-25-Q-COMP	S-13712LM22	2	2	14	<0.100	0.154	<0.0250	0.426	7.16	0.258	0.0622	0.0242	12.9	0.116	<0.0500	<0.0500	0.0515	<0.0500
HAlG-12-Q-COMP	S-13699LM22	2	2	15	0.396	0.648	0.0695	0.911	0.143	1.12	0.293	0.0421	14.1	0.526	0.109	0.0641	0.138	0.122
HAlG-02-Q-COMP	S-13689LM22	2	2	16	0.126	0.231	<0.0250	0.771	3.18	0.376	0.0910	0.0198	14.3	0.169	<0.0500	<0.0500	0.0518	<0.0500
HAlG-08-Q-COMP	S-13695LM12	2	2	17	<0.100	0.152	<0.0250	0.594	7.20	0.259	0.0628	0.0240	12.9	0.195	<0.0500	<0.0500	0.0545	<0.0500
HAlG-02-Q-COMP	S-13689LM12	2	2	18	0.126	0.229	<0.0250	0.770	3.17	0.372	0.0900	0.0189	14.2	0.168	<0.0500	<0.0500	0.0509	<0.0500
HAlG-23-Q-COMP	S-13710LM12	2	2	19	0.348	0.577	0.0621	0.567	0.149	1.03	0.252	0.0377	8.29	0.469	0.103	0.0563	0.108	0.110
HAlG-22-Q-COMP	S-13709LM12	2	2	20	0.588	1.04	0.106	1.18	0.785	1.65	0.426	0.0639	9.87	0.807	0.166	0.0937	0.176	0.186
HAlG-17-Q-COMP	S-13704LM22	2	2	21	0.264	0.450	0.0481	0.0833	0.525	0.778	0.198	0.0288	13.1	0.362	0.0841	<0.0500	0.102	0.0843
HAlG-25-Q-COMP	S-13712LM12	2	2	22	<0.100	0.156	<0.0250	0.424	7.22	0.260	0.0630	0.0244	13.2	0.113	<0.0500	<0.0500	0.0519	<0.0500
LRM	LRMLM223	2	2	23	<0.100	0.388	0.142	0.135	1.00	1.26	0.0693	0.0624	15.7	0.162	0.0726	<0.0500	0.0651	<0.0500

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

Glass ID	Lab ID	Block	Sub-Blk	Seq	Bi	Ca	Cd	Cr	Fe	K	Mg	Mn	Na	Ni	S	Sr	Ti	Zn
ARG	ARGLM223	2	2	24	<0.100	0.983	<0.0250	0.0640	9.59	2.33	0.527	1.47	8.80	0.762	<0.0500	<0.0500	0.684	<0.0500
LRM	LRMLM311	3	1	1	<0.100	0.376	0.139	0.134	0.983	1.17	0.0626	0.0611	14.6	0.184	0.0817	<0.0500	0.0628	<0.0500
ARG	ARGLM311	3	1	2	<0.100	1.11	<0.0250	0.0650	9.44	2.18	0.492	1.43	8.26	0.757	<0.0500	<0.0500	0.652	<0.0500
HAlG-01-Q-COMP	S-13688LM21	3	1	3	0.609	1.08	0.112	<0.0250	0.897	1.67	0.419	0.0666	14.3	0.841	0.154	0.0986	0.172	0.194
HAlG-18-Q-COMP	S-13705LM21	3	1	4	0.309	0.523	0.0549	0.472	0.343	0.886	0.213	0.0333	13.1	0.425	0.0962	<0.0500	0.105	0.0973
HAlG-05-Q-COMP	S-13692LM21	3	1	5	0.365	0.608	0.0679	0.441	7.29	1.02	0.253	0.0520	10.9	0.501	0.100	0.0580	0.123	0.116
HAlG-10-Q-COMP	S-13697LM11	3	1	6	0.105	0.185	<0.0250	1.81	5.27	0.292	0.0800	0.0226	10.6	0.183	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-21-Q-COMP	S-13708LM21	3	1	7	0.394	0.654	0.0714	0.289	5.42	1.08	0.271	0.0517	11.2	0.539	0.121	0.0627	0.120	0.125
HAlG-21-Q-COMP	S-13708LM11	3	1	8	0.390	0.647	0.0711	0.287	5.41	1.11	0.268	0.0514	11.3	0.535	0.122	0.0620	0.120	0.124
HAlG-14-Q-COMP	S-13701LM11	3	1	9	<0.100	0.134	<0.0250	1.15	6.60	0.210	0.0532	0.0203	12.7	0.105	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-18-Q-COMP	S-13705LM11	3	1	10	0.311	0.526	0.0548	0.472	0.344	0.882	0.215	0.0332	13.0	0.423	0.0970	<0.0500	0.102	0.0974
LRM	LRMLM312	3	1	11	<0.100	0.382	0.138	0.134	0.966	1.17	0.0639	0.0610	14.3	0.182	0.0900	<0.0500	0.0636	<0.0500
ARG	ARGLM312	3	1	12	<0.100	1.12	<0.0250	0.0638	9.38	2.26	0.489	1.42	8.04	0.734	<0.0500	<0.0500	0.647	<0.0500
HAlG-05-Q-COMP	S-13692LM11	3	1	13	0.364	0.603	0.0670	0.418	7.23	1.02	0.251	0.0514	10.6	0.480	0.0926	0.0575	0.122	0.114
HAlG-03-Q-COMP	S-13690LM21	3	1	14	0.184	0.330	0.0333	0.118	3.73	0.526	0.127	0.0269	11.5	0.252	0.0503	<0.0500	0.0650	0.0587
HAlG-03-Q-COMP	S-13690LM11	3	1	15	0.186	0.328	0.0333	0.117	3.74	0.531	0.127	0.0270	11.6	0.252	0.0563	<0.0500	0.0634	0.0590
HAlG-13-Q-COMP	S-13700LM11	3	1	16	0.482	0.807	0.0846	0.217	5.79	1.30	0.350	0.0620	12.0	0.697	0.130	0.0795	0.159	0.153
HAlG-10-Q-COMP	S-13697LM21	3	1	17	0.103	0.182	<0.0250	1.80	5.23	0.283	0.0791	0.0223	10.7	0.179	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-14-Q-COMP	S-13701LM21	3	1	18	<0.100	0.136	<0.0250	1.37	6.52	0.214	0.0542	0.0217	12.7	0.213	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-13-Q-COMP	S-13700LM21	3	1	19	0.482	0.797	0.0853	0.238	5.75	1.24	0.346	0.0624	11.5	0.693	0.136	0.0791	0.159	0.154
HAlG-01-Q-COMP	S-13688LM11	3	1	20	0.601	1.06	0.109	<0.0250	0.877	1.60	0.415	0.0651	13.7	0.826	0.169	0.0968	0.169	0.191
LRM	LRMLM313	3	1	21	<0.100	0.382	0.140	0.135	0.979	1.18	0.0645	0.0615	14.4	0.185	0.0727	<0.0500	0.0638	<0.0500
ARG	ARGLM313	3	1	22	<0.100	0.977	<0.0250	0.0652	9.46	2.25	0.497	1.43	8.19	0.753	<0.0500	<0.0500	0.656	<0.0500
LRM	LRMLM321	3	2	1	<0.100	0.365	0.142	0.136	1.00	1.19	0.0633	0.0620	15.1	0.187	0.0745	<0.0500	0.0629	<0.0500
ARG	ARGLM321	3	2	2	<0.100	1.08	<0.0250	0.0659	9.45	2.23	0.499	1.46	8.33	0.769	<0.0500	<0.0500	0.657	<0.0500
HAlG-14-Q-COMP	S-13701LM12	3	2	3	<0.100	0.132	<0.0250	1.17	6.70	0.212	0.0548	0.0208	13.4	0.108	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-01-Q-COMP	S-13688LM12	3	2	4	0.607	1.03	0.113	<0.0250	0.908	1.66	0.422	0.0669	14.4	0.855	0.156	0.0922	0.172	0.194
HAlG-03-Q-COMP	S-13690LM12	3	2	5	0.186	0.320	0.0341	0.120	3.82	0.516	0.129	0.0277	12.2	0.260	<0.0500	<0.0500	0.0638	0.0597
HAlG-18-Q-COMP	S-13705LM22	3	2	6	0.312	0.512	0.0565	0.486	0.354	0.878	0.219	0.0340	13.4	0.438	0.0863	<0.0500	0.107	0.0988
HAlG-01-Q-COMP	S-13688LM22	3	2	7	0.619	1.04	0.115	<0.0250	0.917	1.68	0.432	0.0683	14.3	0.865	0.161	0.0980	0.174	0.197
HAlG-05-Q-COMP	S-13692LM22	3	2	8	0.365	0.593	0.0690	0.451	7.20	1.00	0.258	0.0529	11.2	0.510	0.0986	0.0568	0.125	0.116
HAlG-18-Q-COMP	S-13705LM12	3	2	9	0.311	0.511	0.0563	0.486	0.355	0.868	0.217	0.0339	13.3	0.437	0.0947	<0.0500	0.102	0.0985
HAlG-13-Q-COMP	S-13700LM12	3	2	10	0.484	0.783	0.0881	0.226	5.76	1.30	0.353	0.0639	11.8	0.728	0.125	0.0762	0.160	0.156
LRM	LRMLM322	3	2	11	<0.100	0.375	0.141	0.137	0.988	1.20	0.0648	0.0622	14.7	0.186	0.0812	<0.0500	0.0642	<0.0500
ARG	ARGLM322	3	2	12	<0.100	1.10	<0.0250	0.0672	9.46	2.24	0.507	1.44	8.39	0.778	<0.0500	<0.0500	0.668	<0.0500
HAlG-10-Q-COMP	S-13697LM22	3	2	13	0.104	0.182	<0.0250	1.79	5.23	0.283	0.0815	0.0230	10.6	0.187	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-14-Q-COMP	S-13701LM22	3	2	14	<0.100	0.122	<0.0250	1.40	6.66	0.202	0.0500	0.0207	13.2	0.216	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-05-Q-COMP	S-13692LM12	3	2	15	0.339	0.546	0.0684	0.427	7.27	0.975	0.236	0.0496	11.3	0.489	0.0930	0.0528	0.113	0.111
HAlG-10-Q-COMP	S-13697LM12	3	2	16	0.102	0.169	<0.0250	1.83	5.35	0.277	0.0758	0.0217	11.0	0.186	<0.0500	<0.0500	<0.0500	<0.0500
HAlG-21-Q-COMP	S-13708LM12	3	2	17	0.379	0.595	0.0734	0.296	5.45	1.10	0.258	0.0499	11.5	0.549	0.112	0.0596	0.112	0.124
HAlG-03-Q-COMP	S-13690LM22	3	2	18	0.175	0.298	0.0338	0.120	3.84	0.496	0.119	0.0257	12.2	0.255	<0.0500	<0.0500	0.0597	0.0575
HAlG-13-Q-COMP	S-13700LM22	3	2	19	0.466	0.728	0.0877	0.243	5.80	1.30	0.329	0.0601	12.0	0.707	0.120	0.0756	0.150	0.152
HAlG-21-Q-COMP	S-13708LM22	3	2	20	0.381	0.599	0.0732	0.296	5.37	1.13	0.260	0.0497	11.4	0.546	0.118	0.0588	0.112	0.124
LRM	LRMLM323	3	2	21	<0.100	0.341	0.140	0.136	0.992	1.17	0.0590	0.0577	14.9	0.183	0.0738	<0.0500	0.0582	<0.0500
ARG	ARGLM323	3	2	22	<0.100	1.01	<0.0250	0.0657	9.45	2.14	0.4669	1.35	8.33	0.754	<0.0500	<0.0500	0.612	<0.0500

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	Li	P	Si	Zr
LRM	LRMPF111	1	1	1	5.33	2.29	<0.100	0.170	25.0	0.713
ARG	ARGPF111	1	1	2	2.53	2.50	1.58	0.133	21.7	0.121
HAlG-22-Q-COMP	S-13709PF11	1	1	3	10.9	2.76	2.17	1.00	17.5	1.51
HAlG-22-Q-COMP	S-13709PF21	1	1	4	10.6	2.73	2.16	1.08	17.3	1.52
HAlG-14-Q-COMP	S-13701PF21	1	1	5	11.8	4.82	2.60	0.344	10.2	0.468
HAlG-01-Q-COMP	S-13688PF11	1	1	6	10.6	2.80	0.265	1.71	14.7	3.16
HAlG-25-Q-COMP	S-13712PF11	1	1	7	12.6	4.34	0.896	1.78	11.4	<0.100
HAlG-13-Q-COMP	S-13700PF21	1	1	8	10.9	2.43	2.35	0.390	13.1	3.93
HAlG-12-Q-COMP	S-13699PF11	1	1	9	11.4	4.82	0.373	0.473	13.6	4.30
HAlG-10-Q-COMP	S-13697PF21	1	1	10	10.4	4.96	2.39	1.53	10.1	3.01
LRM	LRMPF112	1	1	11	5.42	2.27	<0.100	0.256	25.0	0.751
ARG	ARGPF112	1	1	12	2.56	2.50	1.60	0.142	21.8	0.133
HAlG-07-1-Q-COMP	S-13694PF21	1	1	13	12.6	3.35	0.107	0.823	11.6	1.36
HAlG-12-Q-COMP	S-13699PF21	1	1	14	11.1	4.69	0.368	0.521	13.3	4.16
HAlG-25-Q-COMP	S-13712PF21	1	1	15	12.9	4.31	0.914	1.69	11.4	<0.100
HAlG-07-1-Q-COMP	S-13694PF11	1	1	16	12.5	3.33	0.100	0.939	11.5	1.33
HAlG-14-Q-COMP	S-13701PF11	1	1	17	12.1	4.95	2.68	0.378	10.4	0.506
HAlG-13-Q-COMP	S-13700PF11	1	1	18	10.8	2.39	2.41	0.328	13.0	3.92
HAlG-01-Q-COMP	S-13688PF21	1	1	19	10.8	2.78	0.270	1.65	14.8	3.21
HAlG-10-Q-COMP	S-13697PF11	1	1	20	10.4	5.03	2.32	1.66	10.4	3.04
LRM	LRMPF113	1	1	21	5.38	2.24	<0.100	0.272	24.8	0.730
ARG	ARGPF113	1	1	22	2.54	2.44	1.61	0.140	21.5	0.131
LRM	LRMPF121	1	2	1	5.23	2.30	<0.100	0.124	25.1	0.670
ARG	ARGPF121	1	2	2	2.50	2.53	1.51	<0.100	22.0	<0.100
HAlG-13-Q-COMP	S-13700PF22	1	2	3	10.6	2.47	2.05	0.244	13.2	3.88
HAlG-22-Q-COMP	S-13709PF22	1	2	4	10.6	2.81	1.83	0.873	17.5	1.51
HAlG-10-Q-COMP	S-13697PF12	1	2	5	10.4	5.24	2.02	1.57	10.5	3.01
HAlG-13-Q-COMP	S-13700PF12	1	2	6	10.9	2.49	2.26	0.309	13.4	3.94
HAlG-25-Q-COMP	S-13712PF12	1	2	7	12.8	4.50	0.841	1.57	11.7	<0.100
HAlG-10-Q-COMP	S-13697PF22	1	2	8	10.2	5.14	2.24	1.61	10.3	2.91
HAlG-07-1-Q-COMP	S-13694PF12	1	2	9	12.4	3.50	<0.100	0.808	11.8	1.31
HAlG-14-Q-COMP	S-13701PF22	1	2	10	11.7	5.08	2.45	0.322	10.4	0.437
LRM	LRMPF122	1	2	11	5.39	2.38	<0.100	0.213	25.6	0.706
ARG	ARGPF122	1	2	12	2.55	2.58	1.52	<0.100	22.4	0.101
HAlG-12-Q-COMP	S-13699PF22	1	2	13	11.0	4.92	0.333	0.431	13.5	4.21
HAlG-07-1-Q-COMP	S-13694PF22	1	2	14	12.5	3.50	<0.100	0.685	11.8	1.38
HAlG-25-Q-COMP	S-13712PF22	1	2	15	12.8	4.60	0.848	1.70	11.8	<0.100
HAlG-01-Q-COMP	S-13688PF22	1	2	16	10.7	2.91	0.242	1.73	15.1	3.13
HAlG-14-Q-COMP	S-13701PF12	1	2	17	11.9	5.09	2.49	0.299	10.6	0.469
HAlG-01-Q-COMP	S-13688PF12	1	2	18	10.6	2.91	0.235	1.66	15.1	3.14
HAlG-12-Q-COMP	S-13699PF12	1	2	19	11.2	4.93	0.328	0.506	13.7	4.21
HAlG-22-Q-COMP	S-13709PF12	1	2	20	10.6	2.83	2.01	0.877	17.5	1.51
LRM	LRMPF123	1	2	21	5.42	2.35	<0.100	0.234	25.4	0.735
ARG	ARGPF123	1	2	22	2.54	2.54	1.50	0.105	22.1	0.104
LRM	LRMPF211	2	1	1	5.32	2.35	0.145	<0.100	25.3	0.690
ARG	ARGPF211	2	1	2	2.54	2.53	1.60	<0.100	21.9	0.113
HAlG-21-Q-COMP	S-13708PF21	2	1	3	11.6	3.52	2.23	1.48	11.9	0.694

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	Li	P	Si	Zr
HAlG-19-Q-COMP	S-13706PF11	2	1	4	14.1	2.38	2.59	0.695	12.0	1.83
HAlG-19-Q-COMP	S-13706PF21	2	1	5	14.6	2.42	2.65	0.622	12.2	1.89
HAlG-02-Q-COMP	S-13689PF21	2	1	6	12.3	5.86	0.617	1.38	10.4	1.44
HAlG-08-Q-COMP	S-13695PF11	2	1	7	12.7	4.40	0.927	1.71	12.1	<0.100
HAlG-15-Q-COMP	S-13702PF21	2	1	8	11.5	2.57	2.80	0.206	18.6	0.732
HAlG-09-Q-COMP	S-13696PF11	2	1	9	10.7	6.47	2.51	0.472	10.8	3.91
HAlG-24-Q-COMP	S-13711PF11	2	1	10	11.1	4.60	1.47	0.301	14.4	0.706
HAlG-04-Q-COMP	S-13691PF21	2	1	11	10.7	3.05	0.306	0.166	15.3	0.452
LRM	LRMPF212	2	1	12	5.38	2.31	0.150	0.178	25.1	0.703
ARG	ARGPF212	2	1	13	2.54	2.54	1.59	<0.100	21.8	0.117
HAlG-21-Q-COMP	S-13708PF11	2	1	14	11.4	3.46	2.21	1.44	11.6	0.804
HAlG-09-Q-COMP	S-13696PF21	2	1	15	11.0	6.49	2.68	0.606	10.8	3.92
HAlG-02-Q-COMP	S-13689PF11	2	1	16	12.4	5.87	0.620	1.32	10.4	1.45
HAlG-17-Q-COMP	S-13704PF21	2	1	17	10.8	3.93	1.32	0.477	16.9	2.90
HAlG-17-Q-COMP	S-13704PF11	2	1	18	10.7	3.91	1.32	0.419	17.1	2.91
HAlG-15-Q-COMP	S-13702PF11	2	1	19	11.8	2.62	2.85	<0.100	18.8	0.796
HAlG-04-Q-COMP	S-13691PF11	2	1	20	10.8	3.08	0.310	0.110	15.6	0.450
HAlG-24-Q-COMP	S-13711PF21	2	1	21	11.8	4.70	1.52	0.299	14.9	0.711
HAlG-08-Q-COMP	S-13695PF21	2	1	22	12.7	4.40	0.911	1.64	11.8	<0.100
LRM	LRMPF213	2	1	23	5.36	2.32	0.155	0.280	24.9	0.672
ARG	ARGPF213	2	1	24	2.52	2.53	1.58	0.113	21.7	0.121
LRM	LRMPF221	2	2	1	5.24	2.35	<0.100	<0.100	25.0	0.672
ARG	ARGPF221	2	2	2	2.52	2.59	1.49	<0.100	22.0	<0.100
HAlG-21-Q-COMP	S-13708PF22	2	2	3	11.7	3.61	2.17	1.50	11.9	0.683
HAlG-02-Q-COMP	S-13689PF12	2	2	4	12.2	5.99	0.493	1.50	10.4	1.41
HAlG-04-Q-COMP	S-13691PF12	2	2	5	10.5	3.08	0.177	0.214	15.4	0.404
HAlG-24-Q-COMP	S-13711PF12	2	2	6	11.2	4.67	1.38	0.327	14.6	0.679
HAlG-21-Q-COMP	S-13708PF12	2	2	7	11.6	3.57	2.14	1.63	11.8	0.780
HAlG-08-Q-COMP	S-13695PF22	2	2	8	12.4	4.50	0.801	1.75	12.2	<0.100
HAlG-09-Q-COMP	S-13696PF12	2	2	9	11.0	6.68	2.62	0.670	10.9	3.95
HAlG-15-Q-COMP	S-13702PF22	2	2	10	11.6	2.65	2.75	<0.100	19.1	0.770
HAlG-04-Q-COMP	S-13691PF22	2	2	11	10.9	3.18	0.181	0.132	15.6	0.443
LRM	LRMPF222	2	2	12	5.33	2.39	<0.100	0.134	25.4	0.696
ARG	ARGPF222	2	2	13	2.52	2.63	1.50	0.109	22.1	0.101
HAlG-15-Q-COMP	S-13702PF12	2	2	14	11.8	2.68	2.76	<0.100	18.9	0.775
HAlG-17-Q-COMP	S-13704PF22	2	2	15	10.8	4.05	1.23	0.362	17.2	2.96
HAlG-24-Q-COMP	S-13711PF22	2	2	16	11.5	4.81	1.40	0.327	15.0	0.703
HAlG-08-Q-COMP	S-13695PF12	2	2	17	12.8	4.62	0.813	1.64	12.4	<0.100
HAlG-02-Q-COMP	S-13689PF22	2	2	18	12.4	6.14	0.501	1.52	10.6	1.43
HAlG-19-Q-COMP	S-13706PF12	2	2	19	14.5	2.50	2.57	0.720	12.3	1.88
HAlG-19-Q-COMP	S-13706PF22	2	2	20	14.8	2.54	2.60	0.684	12.7	1.94
HAlG-17-Q-COMP	S-13704PF12	2	2	21	10.8	4.02	1.23	0.448	17.4	2.96
HAlG-09-Q-COMP	S-13696PF22	2	2	22	11.1	6.70	2.62	0.569	11.0	4.03
LRM	LRMPF223	2	2	23	5.37	2.41	<0.100	0.151	25.5	0.707
ARG	ARGPF223	2	2	24	2.51	2.60	1.48	0.114	22.1	0.106
LRM	LRMPF311	3	1	1	5.44	2.41	<0.100	<0.100	25.5	0.704
ARG	ARGPF311	3	1	2	2.53	2.57	1.42	0.166	22.0	0.111
HAlG-18-Q-COMP	S-13705PF11	3	1	3	15.3	3.49	2.64	1.44	11.0	2.29
HAlG-23-Q-COMP	S-13710PF21	3	1	4	11.0	5.40	2.57	1.34	15.9	1.48

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

Glass ID	Lab ID	Block	Sub-Blk	Seq.	Al	B	Li	P	Si	Zr
HAlG-23-Q-COMP	S-13710PF11	3	1	5	11.3	5.42	2.60	1.20	16.0	1.43
HAlG-06-Q-COMP	S-13693PF21	3	1	6	14.8	6.01	0.167	0.920	11.8	0.182
HAlG-05-Q-COMP	S-13692PF21	3	1	7	10.9	6.50	0.219	0.381	10.5	2.18
HAlG-18-Q-COMP	S-13705PF21	3	1	8	15.3	3.42	2.60	1.47	10.9	2.27
HAlG-16-Q-COMP	S-13703PF21	3	1	9	11.6	3.08	1.11	0.945	14.4	3.50
HAlG-20-Q-COMP	S-13707PF21	3	1	10	11.5	5.97	1.56	1.62	13.6	2.09
LRM	LRMPF312	3	1	11	5.48	2.34	<0.100	0.279	25.5	0.699
ARG	ARGPF312	3	1	12	2.60	2.54	1.41	0.129	22.0	0.127
HAlG-03-Q-COMP	S-13690PF21	3	1	13	10.7	4.75	0.403	1.09	15.4	1.41
HAlG-11-Q-COMP	S-13698PF21	3	1	14	13.1	2.68	2.08	1.51	12.3	3.73
HAlG-03-Q-COMP	S-13690PF11	3	1	15	10.4	4.73	0.402	1.27	16.1	1.37
HAlG-20-Q-COMP	S-13707PF11	3	1	16	10.7	6.15	1.61	1.86	14.0	2.10
HAlG-11-Q-COMP	S-13698PF11	3	1	17	12.9	2.65	2.08	1.54	12.2	3.70
HAlG-05-Q-COMP	S-13692PF11	3	1	18	10.4	6.34	0.223	0.313	10.3	2.12
HAlG-06-Q-COMP	S-13693PF11	3	1	19	14.5	5.91	0.168	0.832	11.9	0.191
HAlG-16-Q-COMP	S-13703PF11	3	1	20	11.1	3.05	1.12	0.977	14.5	3.43
LRM	LRMPF313	3	1	21	5.43	2.33	<0.100	0.196	25.4	0.716
ARG	ARGPF313	3	1	22	2.53	2.49	1.42	0.125	21.6	0.120
LRM	LRMPF321	3	2	1	5.27	2.32	<0.100	0.100	24.9	0.670
ARG	ARGPF321	3	2	2	2.47	2.49	1.43	<0.100	21.6	<0.100
HAlG-06-Q-COMP	S-13693PF12	3	2	3	14.6	5.84	0.156	0.804	11.7	0.150
HAlG-11-Q-COMP	S-13698PF22	3	2	4	12.8	2.58	2.05	1.51	12.0	3.60
HAlG-20-Q-COMP	S-13707PF22	3	2	5	11.4	5.85	1.55	1.65	13.3	2.02
HAlG-16-Q-COMP	S-13703PF22	3	2	6	11.3	3.01	1.13	0.946	14.1	3.40
HAlG-20-Q-COMP	S-13707PF12	3	2	7	11.2	6.11	1.62	1.69	13.9	2.15
HAlG-05-Q-COMP	S-13692PF22	3	2	8	10.5	6.35	0.178	0.407	10.2	2.10
HAlG-03-Q-COMP	S-13690PF12	3	2	9	10.3	4.69	0.389	1.24	15.2	1.37
HAlG-05-Q-COMP	S-13692PF12	3	2	10	10.3	6.27	0.215	0.349	10.1	2.09
LRM	LRMPF322	3	2	11	5.29	2.31	<0.100	0.163	24.8	0.697
ARG	ARGPF322	3	2	12	2.47	2.49	1.40	<0.100	21.4	0.109
HAlG-18-Q-COMP	S-13705PF12	3	2	13	14.9	3.37	2.64	1.36	10.7	2.22
HAlG-16-Q-COMP	S-13703PF12	3	2	14	11.2	3.00	1.14	0.895	14.2	3.42
HAlG-11-Q-COMP	S-13698PF12	3	2	15	12.5	2.54	2.04	1.38	11.9	3.58
HAlG-18-Q-COMP	S-13705PF22	3	2	16	14.8	3.26	2.63	1.46	10.5	2.16
HAlG-23-Q-COMP	S-13710PF12	3	2	17	10.8	5.07	2.53	1.33	15.4	1.34
HAlG-06-Q-COMP	S-13693PF22	3	2	18	13.8	5.62	0.152	0.882	11.5	0.153
HAlG-23-Q-COMP	S-13710PF22	3	2	19	10.5	5.07	2.56	1.35	15.3	1.38
HAlG-03-Q-COMP	S-13690PF22	3	2	20	10.1	4.57	0.399	1.30	15.0	1.33
LRM	LRMPF323	3	2	21	5.29	2.25	<0.100	0.280	24.7	0.671
ARG	ARGPF323	3	2	22	2.47	2.43	1.41	0.116	21.4	0.101

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
ARG	Al_2O_3	4.77	4.73	0.040	1%
ARG	B_2O_3	8.14	8.67	-0.527	-6%
ARG	Bi_2O_3	<0.111	0	0.111	
ARG	CaO	1.48	1.43	0.053	4%
ARG	CdO	<0.0286	0	0.029	
ARG	Cr_2O_3	0.0936	0.0930	0.001	
ARG	F^-	<0.05	0	0.050	
ARG	Fe_2O_3	13.8	14.0	-0.184	-1%
ARG	K_2O	2.73	2.71	0.023	1%
ARG	Li_2O	3.24	3.21	0.025	1%
ARG	MgO	0.835	0.860	-0.025	
ARG	MnO	1.88	1.88	0.001	0%
ARG	Na_2O	11.5	11.5	-0.044	0%
ARG	NiO	0.969	1.05	-0.081	-8%
ARG	P_2O_5	<0.266	0.220	0.046	
ARG	SiO_2	46.7	47.9	-1.180	-2%
ARG	SO_3	<0.125	0	0.125	
ARG	SrO	<0.0591	0.00370	0.055	
ARG	TiO_2	1.11	1.15	-0.042	-4%
ARG	ZnO	<0.0622	0.0200	0.042	
ARG	ZrO_2	<0.151	0.130	0.021	
ARG	**Sum of Oxides**	**98.1**	**99.6**	**-1.461**	**-1%**
LRM	Al_2O_3	10.1	9.51	0.606	6%
LRM	B_2O_3	7.50	7.85	-0.351	-4%
LRM	Bi_2O_3	<0.111	0	0.111	
LRM	CaO	0.526	0.540	-0.014	
LRM	CdO	0.163	0.160	0.003	
LRM	Cr_2O_3	0.195	0.190	0.005	
LRM	F^-	0.923	0.860	0.063	
LRM	Fe_2O_3	1.43	1.38	0.052	4%
LRM	K_2O	1.45	1.48	-0.033	-2%
LRM	Li_2O	<0.233	0.110	0.123	
LRM	MgO	0.109	0.100	0.009	
LRM	MnO	0.0789	0.0800	-0.001	
LRM	Na_2O	20.5	20.0	0.445	2%
LRM	NiO	0.206	0.190	0.016	
LRM	P_2O_5	<0.424	0.540	-0.116	
LRM	SiO_2	53.8	54.2	-0.373	-1%
LRM	SO_3	0.194	0.300	-0.106	
LRM	SrO	<0.0591	0	0.059	
LRM	TiO_2	0.105	0.100	0.005	
LRM	ZnO	<0.0622	0	0.062	
LRM	ZrO_2	0.946	0.930	0.016	
LRM	**Sum of Oxides**	**99.1**	**98.6**	**0.580**	**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
HAlG-01-Q-COMP	Al_2O_3	20.2	20.2	-0.030	0%
HAlG-01-Q-COMP	B_2O_3	9.18	9.50	-0.323	-3%
HAlG-01-Q-COMP	Bi_2O_3	0.679	0.714	-0.035	
HAlG-01-Q-COMP	CaO	1.47	1.43	0.043	3%
HAlG-01-Q-COMP	CdO	0.128	0.143	-0.015	
HAlG-01-Q-COMP	Cr_2O_3	<0.0365	0.0190	0.018	
HAlG-01-Q-COMP	F^-	0.737	0.820	-0.083	
HAlG-01-Q-COMP	Fe_2O_3	1.29	1.36	-0.074	-5%
HAlG-01-Q-COMP	K_2O	1.99	2.10	-0.109	-5%
HAlG-01-Q-COMP	Li_2O	0.545	0.495	0.050	
HAlG-01-Q-COMP	MgO	0.700	0.714	-0.014	
HAlG-01-Q-COMP	MnO	0.0862	0.0870	-0.001	
HAlG-01-Q-COMP	Na_2O	19.1	20.0	-0.892	-4%
HAlG-01-Q-COMP	NiO	1.08	1.14	-0.063	-5%
HAlG-01-Q-COMP	P_2O_5	3.87	4.21	-0.343	-8%
HAlG-01-Q-COMP	SiO_2	31.9	31.5	0.429	1%
HAlG-01-Q-COMP	SO_3	0.400	0.486	-0.086	
HAlG-01-Q-COMP	SrO	0.114	0.147	-0.033	
HAlG-01-Q-COMP	TiO_2	0.286	0.286	0.000	
HAlG-01-Q-COMP	ZnO	0.241	0.241	0.000	
HAlG-01-Q-COMP	ZrO_2	4.27	4.41	-0.141	-3%
HAlG-01-Q-COMP	**Sum of Oxides**	**98.3**	**100**	**-1.703**	**-2%**
HAlG-02-Q-COMP	Al_2O_3	23.3	23.9	-0.612	-3%
HAlG-02-Q-COMP	B_2O_3	19.2	19.7	-0.493	-3%
HAlG-02-Q-COMP	Bi_2O_3	0.137	0.143	-0.006	
HAlG-02-Q-COMP	CaO	0.317	0.286	0.031	
HAlG-02-Q-COMP	CdO	<0.0286	0.0290	0.000	
HAlG-02-Q-COMP	Cr_2O_3	1.12	1.60	-0.482	-30%
HAlG-02-Q-COMP	F^-	0.120	0.164	-0.045	
HAlG-02-Q-COMP	Fe_2O_3	4.62	4.78	-0.162	-3%
HAlG-02-Q-COMP	K_2O	0.441	0.420	0.021	
HAlG-02-Q-COMP	Li_2O	1.20	1.07	0.131	12%
HAlG-02-Q-COMP	MgO	0.147	0.143	0.004	
HAlG-02-Q-COMP	MnO	0.0248	0.0170	0.008	
HAlG-02-Q-COMP	Na_2O	19.3	19.2	0.110	1%
HAlG-02-Q-COMP	NiO	0.213	0.229	-0.016	
HAlG-02-Q-COMP	P_2O_5	3.28	3.71	-0.433	-12%
HAlG-02-Q-COMP	SiO_2	22.4	22.3	0.056	0%
HAlG-02-Q-COMP	SO_3	<0.125	0.0970	0.028	
HAlG-02-Q-COMP	SrO	<0.0591	0.0290	0.030	
HAlG-02-Q-COMP	TiO_2	<0.0848	0.0570	0.028	
HAlG-02-Q-COMP	ZnO	<0.0622	0.0480	0.014	
HAlG-02-Q-COMP	ZrO_2	1.94	2.07	-0.135	-7%
HAlG-02-Q-COMP	**Sum of Oxides**	**98.1**	**100**	**-1.925**	**-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
HAlG-03-Q-COMP	Al_2O_3	19.6	20.1	-0.496	-2%
HAlG-03-Q-COMP	B_2O_3	15.1	15.7	-0.615	-4%
HAlG-03-Q-COMP	Bi_2O_3	0.204	0.213	-0.009	
HAlG-03-Q-COMP	CaO	0.446	0.426	0.020	
HAlG-03-Q-COMP	CdO	0.0384	0.043	-0.005	
HAlG-03-Q-COMP	Cr_2O_3	0.174	0.172	0.002	
HAlG-03-Q-COMP	F^-	0.184	0.244	-0.060	
HAlG-03-Q-COMP	Fe_2O_3	5.41	5.69	-0.282	-5%
HAlG-03-Q-COMP	K_2O	0.623	0.625	-0.002	
HAlG-03-Q-COMP	Li_2O	0.857	0.930	-0.073	
HAlG-03-Q-COMP	MgO	0.208	0.213	-0.005	
HAlG-03-Q-COMP	MnO	0.0346	0.0260	0.009	
HAlG-03-Q-COMP	Na_2O	16.0	16.7	-0.692	-4%
HAlG-03-Q-COMP	NiO	0.324	0.341	-0.017	
HAlG-03-Q-COMP	P_2O_5	2.81	3.37	-0.563	-17%
HAlG-03-Q-COMP	SiO_2	33.0	32.8	0.199	1%
HAlG-03-Q-COMP	SO_3	<0.129	0.145	-0.016	
HAlG-03-Q-COMP	SrO	<0.0591	0.0440	0.015	
HAlG-03-Q-COMP	TiO_2	0.105	0.0850	0.020	
HAlG-03-Q-COMP	ZnO	0.0731	0.0720	0.001	
HAlG-03-Q-COMP	ZrO_2	1.85	2.02	-0.169	-8%
HAlG-03-Q-COMP	**Sum of Oxides**	**97.2**	**100**	**-2.739**	**-3%**
HAlG-04-Q-COMP	Al_2O_3	20.3	20.7	-0.435	-2%
HAlG-04-Q-COMP	B_2O_3	9.97	10.2	-0.226	-2%
HAlG-04-Q-COMP	Bi_2O_3	0.606	0.621	-0.015	
HAlG-04-Q-COMP	CaO	1.21	1.24	-0.026	-2%
HAlG-04-Q-COMP	CdO	0.115	0.124	-0.009	
HAlG-04-Q-COMP	Cr_2O_3	1.08	1.13	-0.047	-4%
HAlG-04-Q-COMP	F^-	0.707	0.713	-0.006	
HAlG-04-Q-COMP	Fe_2O_3	6.75	6.89	-0.138	-2%
HAlG-04-Q-COMP	K_2O	1.82	1.82	-0.001	0%
HAlG-04-Q-COMP	Li_2O	0.524	0.382	0.142	
HAlG-04-Q-COMP	MgO	0.620	0.621	-0.001	
HAlG-04-Q-COMP	MnO	0.0850	0.0760	0.009	
HAlG-04-Q-COMP	Na_2O	19.4	19.5	-0.089	0%
HAlG-04-Q-COMP	NiO	0.934	0.993	-0.059	
HAlG-04-Q-COMP	P_2O_5	0.356	0.371	-0.015	
HAlG-04-Q-COMP	SiO_2	33.1	33.0	0.106	0%
HAlG-04-Q-COMP	SO_3	0.390	0.422	-0.0320	
HAlG-04-Q-COMP	SrO	0.102	0.128	-0.026	
HAlG-04-Q-COMP	TiO_2	0.287	0.248	0.039	
HAlG-04-Q-COMP	ZnO	0.221	0.210	0.011	
HAlG-04-Q-COMP	ZrO_2	0.591	0.604	-0.013	
HAlG-04-Q-COMP	**Sum of Oxides**	**99.2**	**100**	**-0.833**	**-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
HAlG-05-Q-COMP	Al_2O_3	19.9	20.0	-0.113	-1%
HAlG-05-Q-COMP	B_2O_3	20.5	21.2	-0.705	-3%
HAlG-05-Q-COMP	Bi_2O_3	0.399	0.428	-0.029	
HAlG-05-Q-COMP	CaO	0.822	0.856	-0.034	
HAlG-05-Q-COMP	CdO	0.0778	0.0860	-0.008	
HAlG-05-Q-COMP	Cr_2O_3	0.635	0.662	-0.027	
HAlG-05-Q-COMP	F^-	0.397	0.491	-0.094	
HAlG-05-Q-COMP	Fe_2O_3	10.4	11.1	-0.738	-7%
HAlG-05-Q-COMP	K_2O	1.21	1.26	-0.051	-4%
HAlG-05-Q-COMP	Li_2O	0.449	0.452	-0.003	
HAlG-05-Q-COMP	MgO	0.414	0.428	-0.014	
HAlG-05-Q-COMP	MnO	0.0665	0.0520	0.014	
HAlG-05-Q-COMP	Na_2O	14.8	15.7	-0.872	-6%
HAlG-05-Q-COMP	NiO	0.630	0.685	-0.055	
HAlG-05-Q-COMP	P_2O_5	0.831	0.780	0.051	
HAlG-05-Q-COMP	SiO_2	22.0	22.0	-0.019	0%
HAlG-05-Q-COMP	SO_3	0.240	0.291	-0.051	
HAlG-05-Q-COMP	SrO	0.0666	0.0880	-0.021	
HAlG-05-Q-COMP	TiO_2	0.201	0.171	0.030	
HAlG-05-Q-COMP	ZnO	0.142	0.145	-0.003	
HAlG-05-Q-COMP	ZrO_2	2.87	3.06	-0.193	-6%
HAlG-05-Q-COMP	**Sum of Oxides**	**97.0**	**99.9**	**-2.935**	**-3%**
HAlG-06-Q-COMP	Al_2O_3	27.3	27.9	-0.644	-2%
HAlG-06-Q-COMP	B_2O_3	18.8	19.6	-0.780	-4%
HAlG-06-Q-COMP	Bi_2O_3	0.178	0.182	-0.004	
HAlG-06-Q-COMP	CaO	0.402	0.365	0.037	
HAlG-06-Q-COMP	CdO	0.0331	0.0360	-0.003	
HAlG-06-Q-COMP	Cr_2O_3	1.15	1.19	-0.039	-3%
HAlG-06-Q-COMP	F^-	0.163	0.209	-0.046	
HAlG-06-Q-COMP	Fe_2O_3	1.46	1.47	-0.012	-1%
HAlG-06-Q-COMP	K_2O	0.560	0.536	0.024	
HAlG-06-Q-COMP	Li_2O	0.346	0.322	0.024	
HAlG-06-Q-COMP	MgO	0.187	0.182	0.005	
HAlG-06-Q-COMP	MnO	0.0241	0.0220	0.002	
HAlG-06-Q-COMP	Na_2O	19.6	19.7	-0.053	0%
HAlG-06-Q-COMP	NiO	0.283	0.292	-0.009	
HAlG-06-Q-COMP	P_2O_5	1.97	2.32	-0.351	-15%
HAlG-06-Q-COMP	SiO_2	25.1	25.2	-0.117	0%
HAlG-06-Q-COMP	SO_3	<0.125	0.124	0.001	
HAlG-06-Q-COMP	SrO	<0.0591	0.0380	0.021	
HAlG-06-Q-COMP	TiO_2	0.125	0.0730	0.052	
HAlG-06-Q-COMP	ZnO	0.0929	0.0620	0.031	
HAlG-06-Q-COMP	ZrO_2	0.228	0.247	-0.019	
HAlG-06-Q-COMP	**Sum of Oxides**	**98.2**	**100**	**-1.877**	**-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
HAlG-07-1-Q-COMP	Al_2O_3	23.6	23.7	-0.081	0%
HAlG-07-1-Q-COMP	B_2O_3	11.0	11.3	-0.288	-3%
HAlG-07-1-Q-COMP	Bi_2O_3	0.586	0.597	-0.011	
HAlG-07-1-Q-COMP	CaO	1.16	1.19	-0.028	-2%
HAlG-07-1-Q-COMP	CdO	0.111	0.119	-0.008	
HAlG-07-1-Q-COMP	Cr_2O_3	0.0789	0.0740	0.005	
HAlG-07-1-Q-COMP	F^-	0.567	0.685	-0.118	
HAlG-07-1-Q-COMP	Fe_2O_3	8.84	9.08	-0.244	-3%
HAlG-07-1-Q-COMP	K_2O	1.74	1.75	-0.012	-1%
HAlG-07-1-Q-COMP	Li_2O	<0.219	0.175	0.044	
HAlG-07-1-Q-COMP	MgO	0.599	0.597	0.002	
HAlG-07-1-Q-COMP	MnO	0.0869	0.0730	0.014	
HAlG-07-1-Q-COMP	Na_2O	19.7	19.8	-0.052	0%
HAlG-07-1-Q-COMP	NiO	0.865	0.954	-0.089	
HAlG-07-1-Q-COMP	P_2O_5	1.86	2.10	-0.235	-11%
HAlG-07-1-Q-COMP	SiO_2	25.0	24.8	0.176	1%
HAlG-07-1-Q-COMP	SO_3	0.378	0.406	-0.028	
HAlG-07-1-Q-COMP	SrO	0.0979	0.123	-0.025	
HAlG-07-1-Q-COMP	TiO_2	0.268	0.239	0.029	
HAlG-07-1-Q-COMP	ZnO	0.209	0.202	0.007	
HAlG-07-1-Q-COMP	ZrO_2	1.82	1.90	-0.083	-4%
HAlG-07-1-Q-COMP	**Sum of Oxides**	**98.8**	**99.9**	**-1.026**	**-1%**
HAlG-08-Q-COMP	Al_2O_3	23.9	24.3	-0.398	-2%
HAlG-08-Q-COMP	B_2O_3	14.4	14.8	-0.375	-3%
HAlG-08-Q-COMP	Bi_2O_3	<0.111	0.0960	0.015	
HAlG-08-Q-COMP	CaO	0.219	0.192	0.027	
HAlG-08-Q-COMP	CdO	<0.0286	0.0190	0.010	
HAlG-08-Q-COMP	Cr_2O_3	0.774	0.649	0.125	
HAlG-08-Q-COMP	F^-	0.0869	0.110	-0.023	
HAlG-08-Q-COMP	Fe_2O_3	10.4	10.7	-0.256	-2%
HAlG-08-Q-COMP	K_2O	0.302	0.283	0.019	
HAlG-08-Q-COMP	Li_2O	1.86	1.80	0.058	3%
HAlG-08-Q-COMP	MgO	0.109	0.0960	0.013	
HAlG-08-Q-COMP	MnO	0.0303	0.0120	0.018	
HAlG-08-Q-COMP	Na_2O	17.7	17.5	0.159	1%
HAlG-08-Q-COMP	NiO	0.21	0.154	0.056	
HAlG-08-Q-COMP	P_2O_5	3.86	4.36	-0.499	-11%
HAlG-08-Q-COMP	SiO_2	25.9	24.8	1.139	5%
HAlG-08-Q-COMP	SO_3	<0.125	0.0650	0.060	
HAlG-08-Q-COMP	SrO	<0.0591	0.0200	0.039	
HAlG-08-Q-COMP	TiO_2	0.0882	0.0380	0.050	
HAlG-08-Q-COMP	ZnO	<0.0622	0.0330	0.029	
HAlG-08-Q-COMP	ZrO_2	<0.135	0.0410	0.094	
HAlG-08-Q-COMP	**Sum of Oxides**	**100**	**100**	**0.361**	**0%**

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
HAlG-09-Q-COMP	Al_2O_3	20.7	21.1	-0.410	-2%
HAlG-09-Q-COMP	B_2O_3	21.2	21.8	-0.597	-3%
HAlG-09-Q-COMP	Bi_2O_3	0.152	0.156	-0.004	
HAlG-09-Q-COMP	CaO	0.375	0.312	0.063	
HAlG-09-Q-COMP	CdO	<0.0286	0.0310	-0.002	
HAlG-09-Q-COMP	Cr_2O_3	0.948	1.06	-0.112	-11%
HAlG-09-Q-COMP	F^-	0.132	0.179	-0.047	
HAlG-09-Q-COMP	Fe_2O_3	4.74	4.81	-0.067	-1%
HAlG-09-Q-COMP	K_2O	0.469	0.459	0.010	
HAlG-09-Q-COMP	Li_2O	5.61	5.62	-0.006	0%
HAlG-09-Q-COMP	MgO	0.175	0.156	0.019	
HAlG-09-Q-COMP	MnO	0.0272	0.0190	0.008	
HAlG-09-Q-COMP	Na_2O	13.6	13.6	-0.032	0%
HAlG-09-Q-COMP	NiO	0.240	0.250	-0.010	
HAlG-09-Q-COMP	P_2O_5	1.33	1.36	-0.033	-2%
HAlG-09-Q-COMP	SiO_2	23.3	23.2	0.065	0%
HAlG-09-Q-COMP	SO_3	<0.125	0.106	0.019	
HAlG-09-Q-COMP	SrO	<0.0591	0.0320	0.027	
HAlG-09-Q-COMP	TiO_2	0.124	0.0620	0.062	
HAlG-09-Q-COMP	ZnO	<0.0695	0.0530	0.016	
HAlG-09-Q-COMP	ZrO_2	5.34	5.60	-0.261	-5%
HAlG-09-Q-COMP	**Sum of Oxides**	**98.7**	**100**	**-1.290**	**-1%**
HAlG-10-Q-COMP	Al_2O_3	19.6	20.2	-0.644	-3%
HAlG-10-Q-COMP	B_2O_3	16.4	17.7	-1.303	-7%
HAlG-10-Q-COMP	Bi_2O_3	0.115	0.120	-0.005	
HAlG-10-Q-COMP	CaO	0.251	0.240	0.011	
HAlG-10-Q-COMP	CdO	<0.0286	0.0240	0.005	
HAlG-10-Q-COMP	Cr_2O_3	2.64	1.88	0.762	41%
HAlG-10-Q-COMP	F^-	0.0983	0.138	-0.040	
HAlG-10-Q-COMP	Fe_2O_3	7.53	7.49	0.045	1%
HAlG-10-Q-COMP	K_2O	0.342	0.352	-0.010	
HAlG-10-Q-COMP	Li_2O	4.83	4.94	-0.112	-2%
HAlG-10-Q-COMP	MgO	0.131	0.120	0.011	
HAlG-10-Q-COMP	MnO	0.0289	0.0150	0.014	
HAlG-10-Q-COMP	Na_2O	14.5	15.4	-0.943	-6%
HAlG-10-Q-COMP	NiO	0.234	0.192	0.042	
HAlG-10-Q-COMP	P_2O_5	3.65	4.08	-0.431	-11%
HAlG-10-Q-COMP	SiO_2	22.1	22.6	-0.512	-2%
HAlG-10-Q-COMP	SO_3	<0.125	0.0820	0.043	
HAlG-10-Q-COMP	SrO	<0.0591	0.0250	0.034	
HAlG-10-Q-COMP	TiO_2	<0.0834	0.0480	0.035	
HAlG-10-Q-COMP	ZnO	<0.0622	0.0410	0.021	
HAlG-10-Q-COMP	ZrO_2	4.04	4.31	-0.268	-6%
HAlG-10-Q-COMP	**Sum of Oxides**	**96.8**	**100**	**-3.243**	**-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
HAlG-11-Q-COMP	Al_2O_3	24.2	24.5	-0.267	-1%
HAlG-11-Q-COMP	B_2O_3	8.41	8.84	-0.428	-5%
HAlG-11-Q-COMP	Bi_2O_3	0.305	0.316	-0.011	
HAlG-11-Q-COMP	CaO	0.704	0.631	0.073	
HAlG-11-Q-COMP	CdO	0.0539	0.0630	-0.009	
HAlG-11-Q-COMP	Cr_2O_3	1.77	1.81	-0.038	-2%
HAlG-11-Q-COMP	F^-	0.288	0.362	-0.074	
HAlG-11-Q-COMP	Fe_2O_3	1.72	1.73	-0.014	-1%
HAlG-11-Q-COMP	K_2O	0.916	0.927	-0.011	
HAlG-11-Q-COMP	Li_2O	4.44	4.59	-0.150	-3%
HAlG-11-Q-COMP	MgO	0.321	0.316	0.005	
HAlG-11-Q-COMP	MnO	0.0412	0.0390	0.002	
HAlG-11-Q-COMP	Na_2O	19.7	19.9	-0.219	-1%
HAlG-11-Q-COMP	NiO	0.498	0.505	-0.007	
HAlG-11-Q-COMP	P_2O_5	3.40	3.70	-0.297	-8%
HAlG-11-Q-COMP	SiO_2	25.9	25.8	0.086	0%
HAlG-11-Q-COMP	SO_3	0.165	0.215	-0.050	
HAlG-11-Q-COMP	SrO	<0.0591	0.0650	-0.006	
HAlG-11-Q-COMP	TiO_2	0.173	0.126	0.047	
HAlG-11-Q-COMP	ZnO	0.120	0.107	0.013	
HAlG-11-Q-COMP	ZrO_2	4.93	5.43	-0.496	-9%
HAlG-11-Q-COMP	**Sum of Oxides**	**98.1**	**100**	**-1.852**	**-2%**
HAlG-12-Q-COMP	Al_2O_3	21.1	21.1	0.015	0%
HAlG-12-Q-COMP	B_2O_3	15.6	16.1	-0.516	-3%
HAlG-12-Q-COMP	Bi_2O_3	0.433	0.455	-0.022	
HAlG-12-Q-COMP	CaO	0.891	0.910	-0.019	
HAlG-12-Q-COMP	CdO	0.0790	0.0910	-0.012	
HAlG-12-Q-COMP	Cr_2O_3	1.31	1.65	-0.336	-20%
HAlG-12-Q-COMP	F^-	0.416	0.522	-0.106	
HAlG-12-Q-COMP	Fe_2O_3	0.196	0.170	0.026	
HAlG-12-Q-COMP	K_2O	1.34	1.34	0.003	0%
HAlG-12-Q-COMP	Li_2O	0.755	0.713	0.042	
HAlG-12-Q-COMP	MgO	0.471	0.455	0.016	
HAlG-12-Q-COMP	MnO	0.0534	0.0560	-0.003	
HAlG-12-Q-COMP	Na_2O	19.3	19.4	-0.056	0%
HAlG-12-Q-COMP	NiO	0.661	0.728	-0.067	
HAlG-12-Q-COMP	P_2O_5	1.11	1.06	0.046	4%
HAlG-12-Q-COMP	SiO_2	28.9	28.6	0.334	1%
HAlG-12-Q-COMP	SO_3	0.260	0.309	-0.049	
HAlG-12-Q-COMP	SrO	0.0746	0.0940	-0.019	
HAlG-12-Q-COMP	TiO_2	0.224	0.182	0.042	
HAlG-12-Q-COMP	ZnO	0.149	0.154	-0.005	
HAlG-12-Q-COMP	ZrO_2	5.70	5.96	-0.260	-4%
HAlG-12-Q-COMP	**Sum of Oxides**	**99.1**	**100**	**-0.945**	**-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
HAlG-13-Q-COMP	Al_2O_3	20.4	20.4	0.007	0%
HAlG-13-Q-COMP	B_2O_3	7.87	8.24	-0.367	-4%
HAlG-13-Q-COMP	Bi_2O_3	0.533	0.574	-0.041	
HAlG-13-Q-COMP	CaO	1.09	1.15	-0.060	-5%
HAlG-13-Q-COMP	CdO	0.0987	0.115	-0.016	
HAlG-13-Q-COMP	Cr_2O_3	0.338	0.254	0.084	
HAlG-13-Q-COMP	F^-	0.580	0.659	-0.079	
HAlG-13-Q-COMP	Fe_2O_3	8.26	8.61	-0.353	-4%
HAlG-13-Q-COMP	K_2O	1.55	1.69	-0.142	-8%
HAlG-13-Q-COMP	Li_2O	4.88	4.81	0.072	1%
HAlG-13-Q-COMP	MgO	0.571	0.574	-0.003	
HAlG-13-Q-COMP	MnO	0.0802	0.0700	0.010	
HAlG-13-Q-COMP	Na_2O	15.9	16.8	-0.860	-5%
HAlG-13-Q-COMP	NiO	0.899	0.919	-0.020	
HAlG-13-Q-COMP	P_2O_5	0.728	0.644	0.084	
HAlG-13-Q-COMP	SiO_2	28.2	28.1	0.085	0%
HAlG-13-Q-COMP	SO_3	0.319	0.390	-0.071	
HAlG-13-Q-COMP	SrO	0.0918	0.118	-0.026	
HAlG-13-Q-COMP	TiO_2	0.262	0.230	0.032	
HAlG-13-Q-COMP	ZnO	0.191	0.194	-0.003	
HAlG-13-Q-COMP	ZrO_2	5.29	5.37	-0.078	-1%
HAlG-13-Q-COMP	**Sum of Oxides**	**98.2**	**99.9**	**-1.747**	**-2%**
HAlG-14-Q-COMP	Al_2O_3	22.4	22.9	-0.462	-2%
HAlG-14-Q-COMP	B_2O_3	16.1	16.8	-0.749	-4%
HAlG-14-Q-COMP	Bi_2O_3	<0.111	0.0870	0.024	
HAlG-14-Q-COMP	CaO	0.183	0.173	0.010	
HAlG-14-Q-COMP	CdO	<0.0286	0.0170	0.012	
HAlG-14-Q-COMP	Cr_2O_3	1.86	1.76	0.100	6%
HAlG-14-Q-COMP	F^-	0.0818	0.100	-0.018	
HAlG-14-Q-COMP	Fe_2O_3	9.46	9.98	-0.515	-5%
HAlG-14-Q-COMP	K_2O	0.252	0.255	-0.003	
HAlG-14-Q-COMP	Li_2O	5.50	5.34	0.161	3%
HAlG-14-Q-COMP	MgO	0.0880	0.0870	0.001	
HAlG-14-Q-COMP	MnO	0.0270	0.0110	0.016	
HAlG-14-Q-COMP	Na_2O	17.5	18.6	-1.076	-6%
HAlG-14-Q-COMP	NiO	0.204	0.139	0.065	
HAlG-14-Q-COMP	P_2O_5	0.769	0.795	-0.026	
HAlG-14-Q-COMP	SiO_2	22.2	22.2	0.049	0%
HAlG-14-Q-COMP	SO_3	<0.125	0.0590	0.066	
HAlG-14-Q-COMP	SrO	<0.0591	0.0180	0.041	
HAlG-14-Q-COMP	TiO_2	<0.0834	0.0350	0.048	
HAlG-14-Q-COMP	ZnO	<0.0622	0.0290	0.033	
HAlG-14-Q-COMP	ZrO_2	0.635	0.614	0.021	
HAlG-14-Q-COMP	**Sum of Oxides**	**97.8**	**100**	**-2.202**	**-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
HAlG-15-Q-COMP	Al_2O_3	22.1	22.4	-0.340	-2%
HAlG-15-Q-COMP	B_2O_3	8.47	8.65	-0.182	-2%
HAlG-15-Q-COMP	Bi_2O_3	0.294	0.297	-0.003	
HAlG-15-Q-COMP	CaO	0.629	0.595	0.034	
HAlG-15-Q-COMP	CdO	0.0541	0.0590	-0.005	
HAlG-15-Q-COMP	Cr_2O_3	1.85	1.95	-0.105	-5%
HAlG-15-Q-COMP	F^-	0.315	0.341	-0.026	
HAlG-15-Q-COMP	Fe_2O_3	1.26	1.29	-0.029	-2%
HAlG-15-Q-COMP	K_2O	0.900	0.874	0.026	
HAlG-15-Q-COMP	Li_2O	6.01	5.93	0.077	1%
HAlG-15-Q-COMP	MgO	0.302	0.297	0.005	
HAlG-15-Q-COMP	MnO	0.0374	0.0360	0.001	
HAlG-15-Q-COMP	Na_2O	14.6	14.9	-0.274	-2%
HAlG-15-Q-COMP	NiO	0.464	0.476	-0.012	
HAlG-15-Q-COMP	P_2O_5	<0.290	0.176	0.114	
HAlG-15-Q-COMP	SiO_2	40.3	40.1	0.226	1%
HAlG-15-Q-COMP	SO_3	0.174	0.202	-0.028	
HAlG-15-Q-COMP	SrO	<0.0591	0.0610	-0.002	
HAlG-15-Q-COMP	TiO_2	0.166	0.119	0.047	
HAlG-15-Q-COMP	ZnO	0.109	0.101	0.008	
HAlG-15-Q-COMP	ZrO_2	1.04	1.10	-0.062	-6%
HAlG-15-Q-COMP	**Sum of Oxides**	**99.4**	**100**	**-0.528**	**-1%**
HAlG-16-Q-COMP	Al_2O_3	21.4	21.6	-0.249	-1%
HAlG-16-Q-COMP	B_2O_3	9.77	10.4	-0.628	-6%
HAlG-16-Q-COMP	Bi_2O_3	0.203	0.223	-0.020	
HAlG-16-Q-COMP	CaO	0.456	0.445	0.011	
HAlG-16-Q-COMP	CdO	0.0331	0.0450	-0.012	
HAlG-16-Q-COMP	Cr_2O_3	1.59	2.00	-0.411	-21%
HAlG-16-Q-COMP	F^-	0.199	0.256	-0.057	
HAlG-16-Q-COMP	Fe_2O_3	4.11	4.21	-0.100	-2%
HAlG-16-Q-COMP	K_2O	0.665	0.654	0.011	
HAlG-16-Q-COMP	Li_2O	2.42	2.54	-0.118	-5%
HAlG-16-Q-COMP	MgO	0.231	0.223	0.008	
HAlG-16-Q-COMP	MnO	0.0314	0.027	0.004	
HAlG-16-Q-COMP	Na_2O	18.9	19.0	-0.061	0%
HAlG-16-Q-COMP	NiO	0.308	0.356	-0.048	
HAlG-16-Q-COMP	P_2O_5	2.16	2.21	-0.054	-2%
HAlG-16-Q-COMP	SiO_2	30.6	30.5	0.092	0%
HAlG-16-Q-COMP	SO_3	<0.125	0.151	-0.026	
HAlG-16-Q-COMP	SrO	<0.0591	0.0460	0.013	
HAlG-16-Q-COMP	TiO_2	0.129	0.0890	0.040	
HAlG-16-Q-COMP	ZnO	0.0754	0.0750	0.000	
HAlG-16-Q-COMP	ZrO_2	4.64	4.93	-0.287	-6%
HAlG-16-Q-COMP	**Sum of Oxides**	**98.1**	**100**	**-1.890**	**-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
HAlG-17-Q-COMP	Al_2O_3	20.4	20.6	-0.241	-1%
HAlG-17-Q-COMP	B_2O_3	12.8	13.1	-0.293	-2%
HAlG-17-Q-COMP	Bi_2O_3	0.288	0.305	-0.017	
HAlG-17-Q-COMP	CaO	0.620	0.610	0.010	
HAlG-17-Q-COMP	CdO	0.0544	0.0610	-0.007	
HAlG-17-Q-COMP	Cr_2O_3	0.122	0.132	-0.010	
HAlG-17-Q-COMP	F^-	0.302	0.350	-0.048	
HAlG-17-Q-COMP	Fe_2O_3	0.748	0.763	-0.015	
HAlG-17-Q-COMP	K_2O	0.916	0.896	0.020	
HAlG-17-Q-COMP	Li_2O	2.74	2.63	0.115	4%
HAlG-17-Q-COMP	MgO	0.320	0.305	0.015	
HAlG-17-Q-COMP	MnO	0.0382	0.0370	0.001	
HAlG-17-Q-COMP	Na_2O	17.5	17.5	-0.010	0%
HAlG-17-Q-COMP	NiO	0.462	0.488	-0.026	
HAlG-17-Q-COMP	P_2O_5	0.977	1.05	-0.073	-7%
HAlG-17-Q-COMP	SiO_2	36.7	36.5	0.189	1%
HAlG-17-Q-COMP	SO_3	0.211	0.207	0.004	
HAlG-17-Q-COMP	SrO	<0.0591	0.0630	-0.004	
HAlG-17-Q-COMP	TiO_2	0.171	0.122	0.049	
HAlG-17-Q-COMP	ZnO	0.104	0.103	0.001	
HAlG-17-Q-COMP	ZrO_2	3.96	4.13	-0.169	-4%
HAlG-17-Q-COMP	**Sum of Oxides**	**99.4**	**100**	**-0.507**	**-1%**
HAlG-18-Q-COMP	Al_2O_3	28.5	28.6	-0.116	0%
HAlG-18-Q-COMP	B_2O_3	10.9	11.2	-0.301	-3%
HAlG-18-Q-COMP	Bi_2O_3	0.346	0.366	-0.020	
HAlG-18-Q-COMP	CaO	0.725	0.732	-0.007	
HAlG-18-Q-COMP	CdO	0.0635	0.0730	-0.009	
HAlG-18-Q-COMP	Cr_2O_3	0.700	0.745	-0.045	
HAlG-18-Q-COMP	F^-	0.353	0.420	-0.067	
HAlG-18-Q-COMP	Fe_2O_3	0.499	0.518	-0.019	
HAlG-18-Q-COMP	K_2O	1.06	1.08	-0.022	-2%
HAlG-18-Q-COMP	Li_2O	5.66	5.87	-0.213	-4%
HAlG-18-Q-COMP	MgO	0.358	0.366	-0.008	
HAlG-18-Q-COMP	MnO	0.0434	0.0450	-0.002	
HAlG-18-Q-COMP	Na_2O	17.8	18.7	-0.906	-5%
HAlG-18-Q-COMP	NiO	0.548	0.586	-0.038	
HAlG-18-Q-COMP	P_2O_5	3.28	3.97	-0.688	-17%
HAlG-18-Q-COMP	SiO_2	23.1	22.9	0.151	1%
HAlG-18-Q-COMP	SO_3	0.234	0.249	-0.015	
HAlG-18-Q-COMP	SrO	<0.0591	0.0750	-0.016	
HAlG-18-Q-COMP	TiO_2	0.173	0.146	0.027	
HAlG-18-Q-COMP	ZnO	0.122	0.124	-0.002	
HAlG-18-Q-COMP	ZrO_2	3.02	3.31	-0.291	-9%
HAlG-18-Q-COMP	**Sum of Oxides**	**97.5**	**100**	**-2.605**	**-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
HAlG-19-Q-COMP	Al_2O_3	27.4	27.6	-0.202	-1%
HAlG-19-Q-COMP	B_2O_3	7.92	8.02	-0.099	-1%
HAlG-19-Q-COMP	Bi_2O_3	0.131	0.136	-0.005	
HAlG-19-Q-COMP	CaO	0.283	0.271	0.012	
HAlG-19-Q-COMP	CdO	0.0238	0.0270	-0.003	
HAlG-19-Q-COMP	Cr_2O_3	0.797	0.846	-0.049	
HAlG-19-Q-COMP	F^-	0.129	0.156	-0.027	
HAlG-19-Q-COMP	Fe_2O_3	5.97	6.14	-0.171	-3%
HAlG-19-Q-COMP	K_2O	0.394	0.398	-0.004	
HAlG-19-Q-COMP	Li_2O	5.60	5.50	0.103	2%
HAlG-19-Q-COMP	MgO	0.139	0.136	0.003	
HAlG-19-Q-COMP	MnO	0.0265	0.0170	0.010	
HAlG-19-Q-COMP	Na_2O	19.7	19.8	-0.085	0%
HAlG-19-Q-COMP	NiO	0.204	0.217	-0.013	
HAlG-19-Q-COMP	P_2O_5	1.56	1.69	-0.131	-8%
HAlG-19-Q-COMP	SiO_2	26.3	26.1	0.213	1%
HAlG-19-Q-COMP	SO_3	<0.125	0.0920	0.033	
HAlG-19-Q-COMP	SrO	0.0230	0.0280	-0.005	
HAlG-19-Q-COMP	TiO_2	0.106	0.0540	0.052	
HAlG-19-Q-COMP	ZnO	<0.0622	0.0460	0.016	
HAlG-19-Q-COMP	ZrO_2	2.55	2.69	-0.144	-5%
HAlG-19-Q-COMP	**Sum of Oxides**	**99.5**	**100**	**-0.500**	**0%**
HAlG-20-Q-COMP	Al_2O_3	21.2	20.9	0.262	1%
HAlG-20-Q-COMP	B_2O_3	19.4	20.0	-0.616	-3%
HAlG-20-Q-COMP	Bi_2O_3	0.210	0.217	-0.007	
HAlG-20-Q-COMP	CaO	0.456	0.434	0.022	
HAlG-20-Q-COMP	CdO	0.0398	0.0430	-0.003	
HAlG-20-Q-COMP	Cr_2O_3	1.36	1.27	0.092	7%
HAlG-20-Q-COMP	F^-	0.204	0.249	-0.045	
HAlG-20-Q-COMP	Fe_2O_3	0.711	0.735	-0.024	
HAlG-20-Q-COMP	K_2O	0.664	0.638	0.026	
HAlG-20-Q-COMP	Li_2O	3.41	3.53	-0.118	-3%
HAlG-20-Q-COMP	MgO	0.218	0.217	0.001	
HAlG-20-Q-COMP	MnO	0.0275	0.0260	0.002	
HAlG-20-Q-COMP	Na_2O	14.3	14.1	0.189	1%
HAlG-20-Q-COMP	NiO	0.400	0.347	0.053	
HAlG-20-Q-COMP	P_2O_5	3.91	4.48	-0.573	-13%
HAlG-20-Q-COMP	SiO_2	29.3	29.3	0.008	0%
HAlG-20-Q-COMP	SO_3	<0.129	0.148	-0.019	
HAlG-20-Q-COMP	SrO	<0.0591	0.0450	0.014	
HAlG-20-Q-COMP	TiO_2	0.0952	0.0870	0.008	
HAlG-20-Q-COMP	ZnO	0.0824	0.0730	0.009	
HAlG-20-Q-COMP	ZrO_2	2.82	3.13	-0.307	-10%
HAlG-20-Q-COMP	**Sum of Oxides**	**98.9**	**100**	**-1.026**	**-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
HAlG-21-Q-COMP	Al_2O_3	21.9	22.7	-0.829	-4%
HAlG-21-Q-COMP	B_2O_3	11.4	11.8	-0.402	-3%
HAlG-21-Q-COMP	Bi_2O_3	0.43	0.466	-0.036	
HAlG-21-Q-COMP	CaO	0.873	0.932	-0.059	
HAlG-21-Q-COMP	CdO	0.0826	0.0930	-0.010	
HAlG-21-Q-COMP	Cr_2O_3	0.427	0.445	-0.018	
HAlG-21-Q-COMP	F^-	0.462	0.535	-0.074	
HAlG-21-Q-COMP	Fe_2O_3	7.74	8.15	-0.412	-5%
HAlG-21-Q-COMP	K_2O	1.33	1.37	-0.039	-3%
HAlG-21-Q-COMP	Li_2O	4.71	4.64	0.069	1%
HAlG-21-Q-COMP	MgO	0.438	0.466	-0.028	
HAlG-21-Q-COMP	MnO	0.0654	0.0570	0.008	
HAlG-21-Q-COMP	Na_2O	15.3	15.9	-0.600	-4%
HAlG-21-Q-COMP	NiO	0.690	0.746	-0.056	
HAlG-21-Q-COMP	P_2O_5	3.47	4.30	-0.834	-19%
HAlG-21-Q-COMP	SiO_2	25.2	25.5	-0.256	-1%
HAlG-21-Q-COMP	SO_3	0.295	0.317	-0.022	
HAlG-21-Q-COMP	SrO	0.0719	0.0960	-0.024	
HAlG-21-Q-COMP	TiO_2	0.193	0.186	0.007	
HAlG-21-Q-COMP	ZnO	0.155	0.158	-0.003	
HAlG-21-Q-COMP	ZrO_2	1.00	1.18	-0.180	-15%
HAlG-21-Q-COMP	**Sum of Oxides**	**96.2**	**100**	**-3.797**	**-4%**
HAlG-22-Q-COMP	Al_2O_3	20.2	20.7	-0.530	-3%
HAlG-22-Q-COMP	B_2O_3	8.96	9.29	-0.331	-4%
HAlG-22-Q-COMP	Bi_2O_3	0.640	0.675	-0.035	
HAlG-22-Q-COMP	CaO	1.48	1.35	0.130	10%
HAlG-22-Q-COMP	CdO	0.121	0.135	-0.014	
HAlG-22-Q-COMP	Cr_2O_3	1.74	1.72	0.016	1%
HAlG-22-Q-COMP	F^-	0.722	0.775	-0.053	
HAlG-22-Q-COMP	Fe_2O_3	1.11	1.18	-0.068	-6%
HAlG-22-Q-COMP	K_2O	1.98	1.98	0.005	0%
HAlG-22-Q-COMP	Li_2O	4.40	4.32	0.077	2%
HAlG-22-Q-COMP	MgO	0.683	0.675	0.008	
HAlG-22-Q-COMP	MnO	0.0812	0.0820	-0.001	
HAlG-22-Q-COMP	Na_2O	13.3	13.2	0.115	1%
HAlG-22-Q-COMP	NiO	1.01	1.08	-0.067	-6%
HAlG-22-Q-COMP	P_2O_5	2.19	2.58	-0.386	-15%
HAlG-22-Q-COMP	SiO_2	37.3	37.1	0.231	1%
HAlG-22-Q-COMP	SO_3	0.406	0.459	-0.053	
HAlG-22-Q-COMP	SrO	0.108	0.139	-0.031	
HAlG-22-Q-COMP	TiO_2	0.286	0.270	0.016	
HAlG-22-Q-COMP	ZnO	0.228	0.228	0.000	
HAlG-22-Q-COMP	ZrO_2	2.04	2.13	-0.087	-4%
HAlG-22-Q-COMP	**Sum of Oxides**	**99.0**	**100**	**-1.058**	**-1%**

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

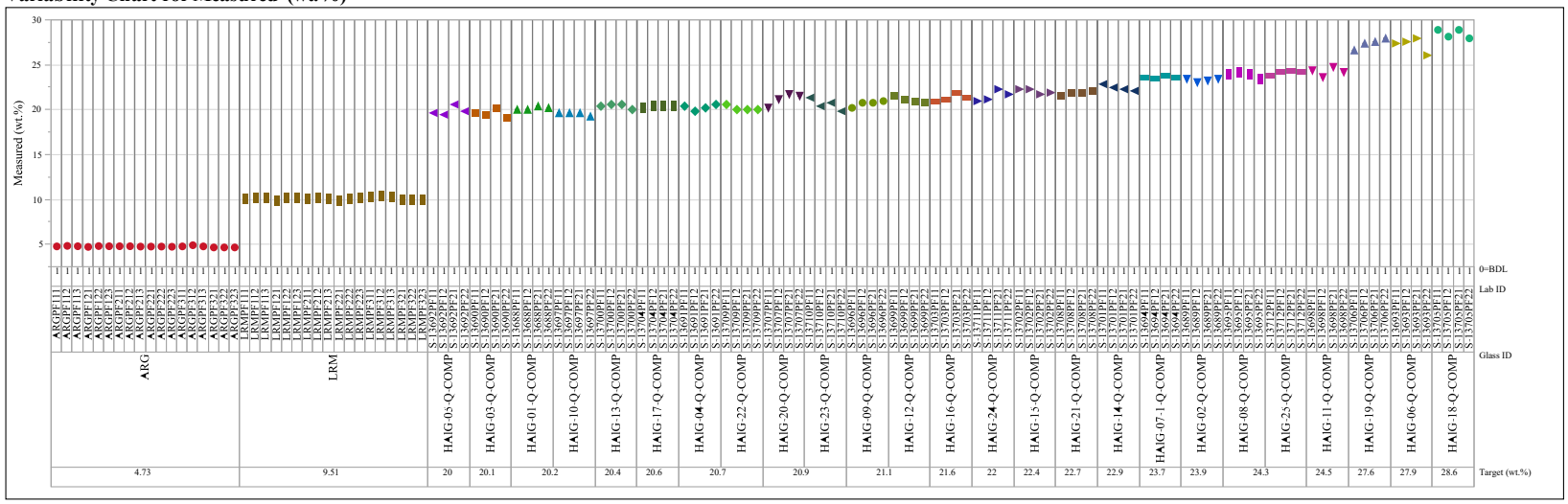
PNNL ID	Oxide	Measured (wt.%)	Target (wt.%)	Difference of Measured vs Target	% Difference Measured vs Target
HAlG-23-Q-COMP	Al_2O_3	20.6	20.9	-0.304	-1%
HAlG-23-Q-COMP	B_2O_3	16.9	17.5	-0.628	-4%
HAlG-23-Q-COMP	Bi_2O_3	0.380	0.401	-0.021	
HAlG-23-Q-COMP	CaO	0.793	0.803	-0.010	
HAlG-23-Q-COMP	CdO	0.0709	0.0800	-0.009	
HAlG-23-Q-COMP	Cr_2O_3	0.822	0.881	-0.059	
HAlG-23-Q-COMP	F^-	0.415	0.461	-0.046	
HAlG-23-Q-COMP	Fe_2O_3	0.204	0.192	0.012	
HAlG-23-Q-COMP	K_2O	1.23	1.18	0.049	4%
HAlG-23-Q-COMP	Li_2O	5.52	5.73	-0.208	-4%
HAlG-23-Q-COMP	MgO	0.404	0.401	0.003	
HAlG-23-Q-COMP	MnO	0.0475	0.0490	-0.002	
HAlG-23-Q-COMP	Na_2O	11.3	11.1	0.156	1%
HAlG-23-Q-COMP	NiO	0.592	0.642	-0.050	
HAlG-23-Q-COMP	P_2O_5	2.99	3.42	-0.430	-13%
HAlG-23-Q-COMP	SiO_2	33.5	33.5	-0.020	0%
HAlG-23-Q-COMP	SO_3	0.255	0.273	-0.018	
HAlG-23-Q-COMP	SrO	0.0646	0.0830	-0.018	
HAlG-23-Q-COMP	TiO_2	0.173	0.161	0.012	
HAlG-23-Q-COMP	ZnO	0.136	0.136	0.000	
HAlG-23-Q-COMP	ZrO_2	1.90	2.10	-0.199	-9%
HAlG-23-Q-COMP	**Sum of Oxides**	**98.2**	**100**	**-1.790**	**-2%**
HAlG-24-Q-COMP	Al_2O_3	21.5	22.0	-0.460	-2%
HAlG-24-Q-COMP	B_2O_3	15.1	15.5	-0.383	-2%
HAlG-24-Q-COMP	Bi_2O_3	0.981	1.00	-0.019	-2%
HAlG-24-Q-COMP	CaO	3.47	3.50	-0.030	-1%
HAlG-24-Q-COMP	CdO	0.0885	0.100	-0.011	
HAlG-24-Q-COMP	Cr_2O_3	0.701	0.750	-0.049	
HAlG-24-Q-COMP	F^-	0.253	0.300	-0.047	
HAlG-24-Q-COMP	Fe_2O_3	5.29	5.50	-0.207	-4%
HAlG-24-Q-COMP	K_2O	0.683	0.700	-0.017	
HAlG-24-Q-COMP	Li_2O	3.11	3.00	0.106	4%
HAlG-24-Q-COMP	MgO	0.498	0.500	-0.002	
HAlG-24-Q-COMP	MnO	0.931	1.00	-0.069	-7%
HAlG-24-Q-COMP	Na_2O	11.5	11.5	-0.018	0%
HAlG-24-Q-COMP	NiO	0.368	0.400	-0.032	
HAlG-24-Q-COMP	P_2O_5	0.718	1.00	-0.282	-28%
HAlG-24-Q-COMP	SiO_2	31.5	31.5	0.001	0%
HAlG-24-Q-COMP	SO_3	0.275	0.300	-0.025	
HAlG-24-Q-COMP	SrO	0.0989	0.120	-0.021	
HAlG-24-Q-COMP	TiO_2	<0.0834	0	0.083	
HAlG-24-Q-COMP	ZnO	<0.0622	0	0.062	
HAlG-24-Q-COMP	ZrO_2	0.945	1.00	-0.055	-5%
HAlG-24-Q-COMP	**Sum of Oxides**	**98.2**	**99.7**	**-1.473**	**-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
HAlG-25-Q-COMP	Al_2O_3	24.1	24.3	-0.162	-1%
HAlG-25-Q-COMP	B_2O_3	14.3	14.8	-0.512	-3%
HAlG-25-Q-COMP	Bi_2O_3	<0.111	0.0960	0.015	
HAlG-25-Q-COMP	CaO	0.215	0.192	0.023	
HAlG-25-Q-COMP	CdO	<0.0286	0.0190	0.010	
HAlG-25-Q-COMP	Cr_2O_3	0.616	0.649	-0.033	
HAlG-25-Q-COMP	F^-	0.0861	0.110	-0.024	
HAlG-25-Q-COMP	Fe_2O_3	10.5	10.7	-0.238	-2%
HAlG-25-Q-COMP	K_2O	0.308	0.283	0.025	
HAlG-25-Q-COMP	Li_2O	1.88	1.80	0.083	5%
HAlG-25-Q-COMP	MgO	0.102	0.0960	0.006	
HAlG-25-Q-COMP	MnO	0.0311	0.0120	0.019	
HAlG-25-Q-COMP	Na_2O	17.7	17.5	0.226	1%
HAlG-25-Q-COMP	NiO	0.144	0.154	-0.010	
HAlG-25-Q-COMP	P_2O_5	3.86	4.36	-0.499	-11%
HAlG-25-Q-COMP	SiO_2	24.8	24.8	-0.038	0%
HAlG-25-Q-COMP	SO_3	<0.125	0.0650	0.060	
HAlG-25-Q-COMP	SrO	<0.0591	0.0200	0.039	
HAlG-25-Q-COMP	TiO_2	0.0850	0.0380	0.047	
HAlG-25-Q-COMP	ZnO	<0.0622	0.0330	0.029	
HAlG-25-Q-COMP	ZrO_2	<0.135	0.0410	0.094	
HAlG-25-Q-COMP	**Sum of Oxides**	**99.2**	**100**	**-0.838**	**-1%**

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.%)

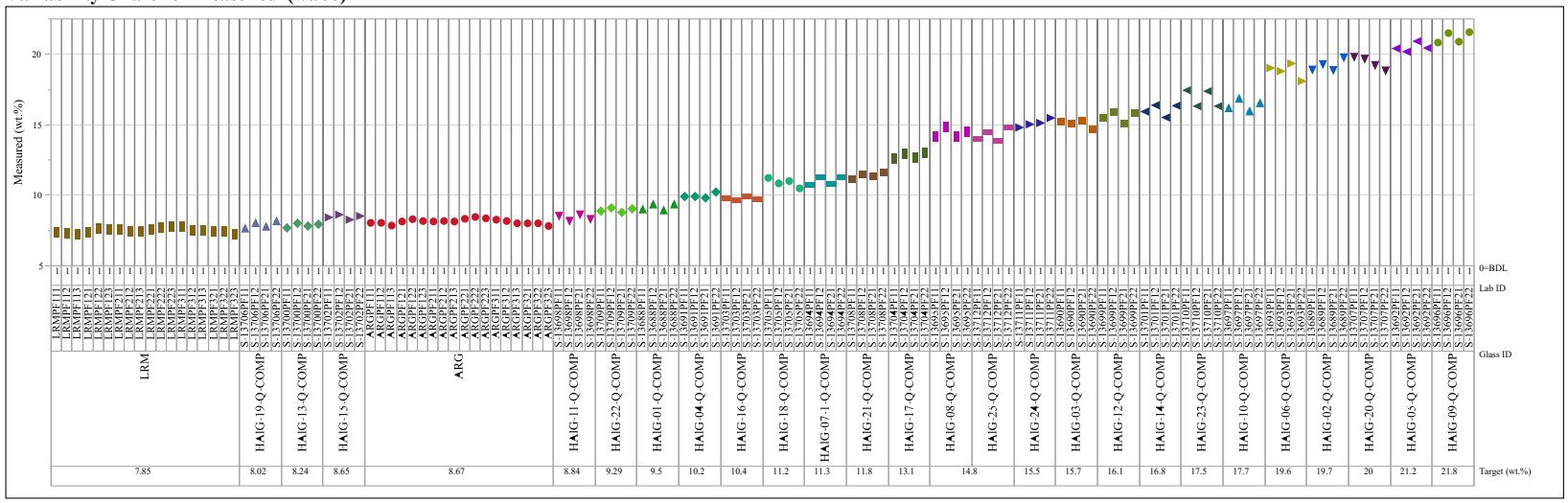
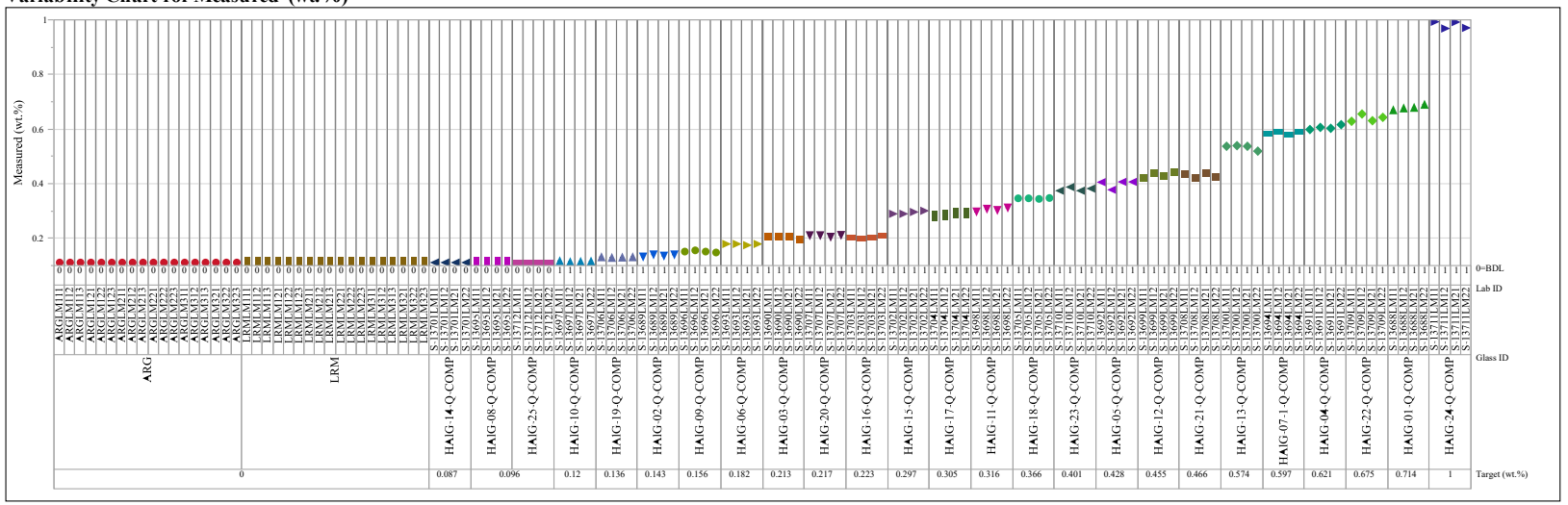


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

Oxide=Bi_2O_3, Prep Method=LM
Variability Chart for Measured (wt.%)



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

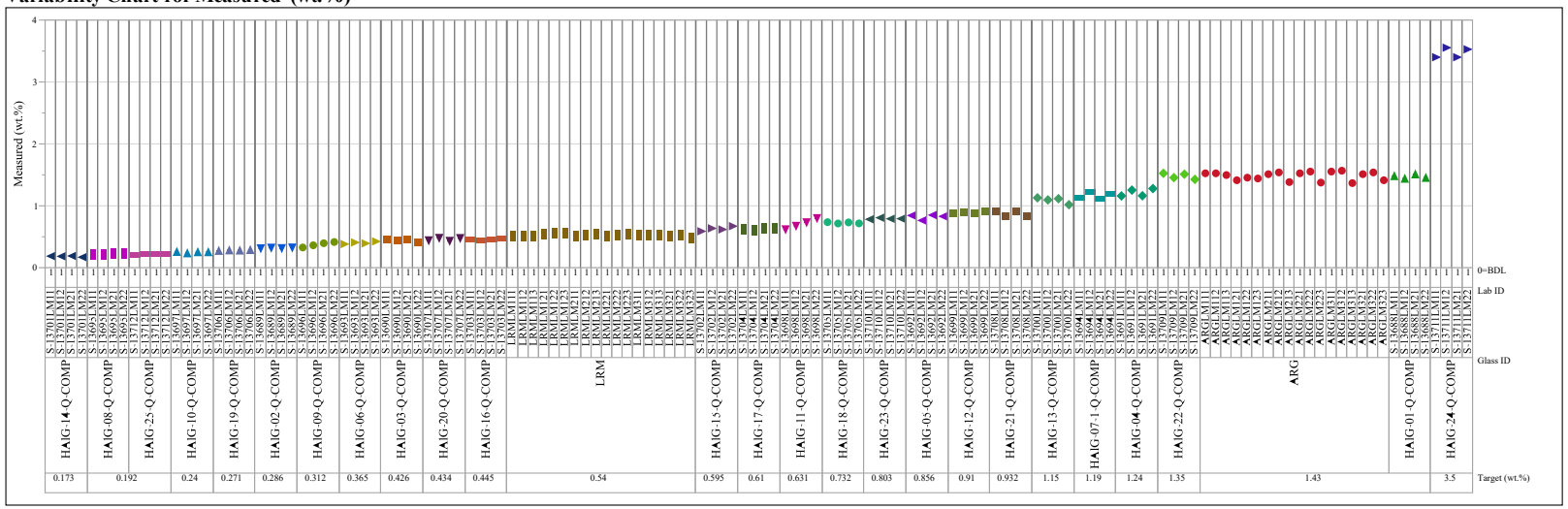
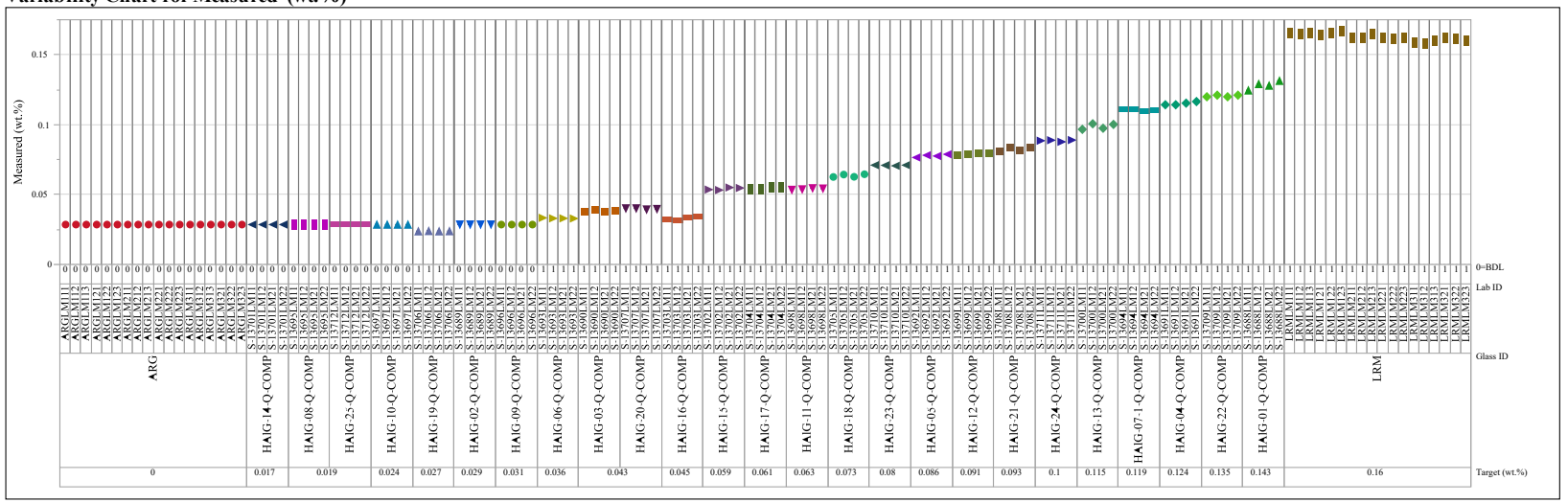


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

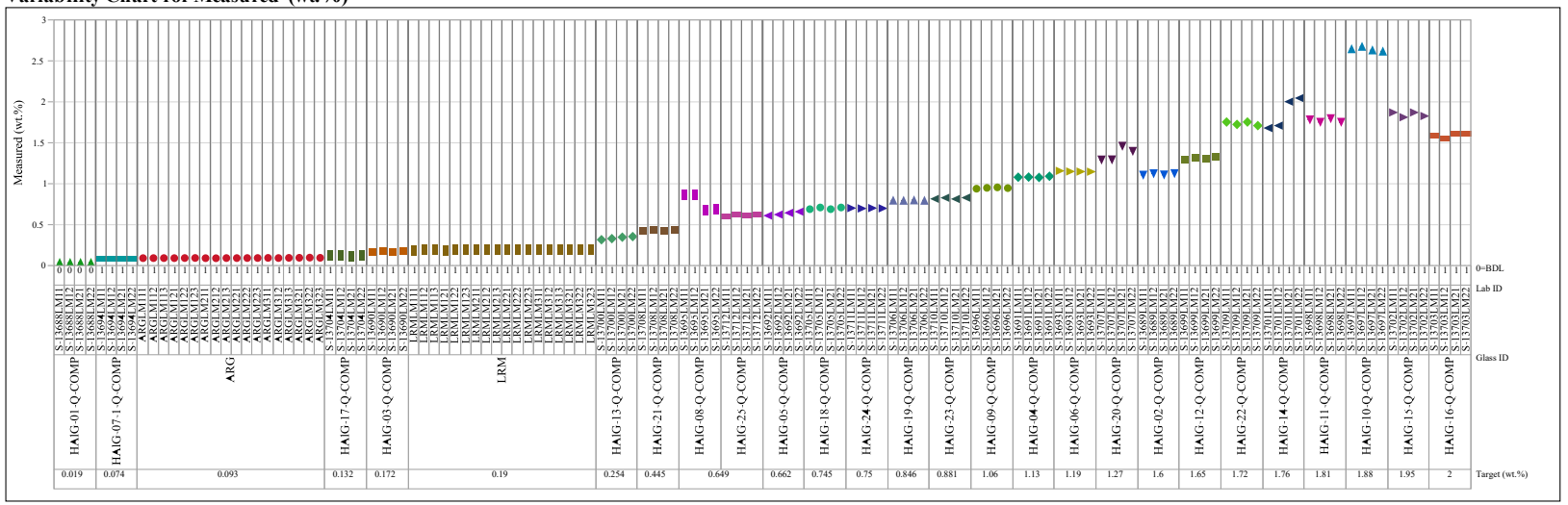
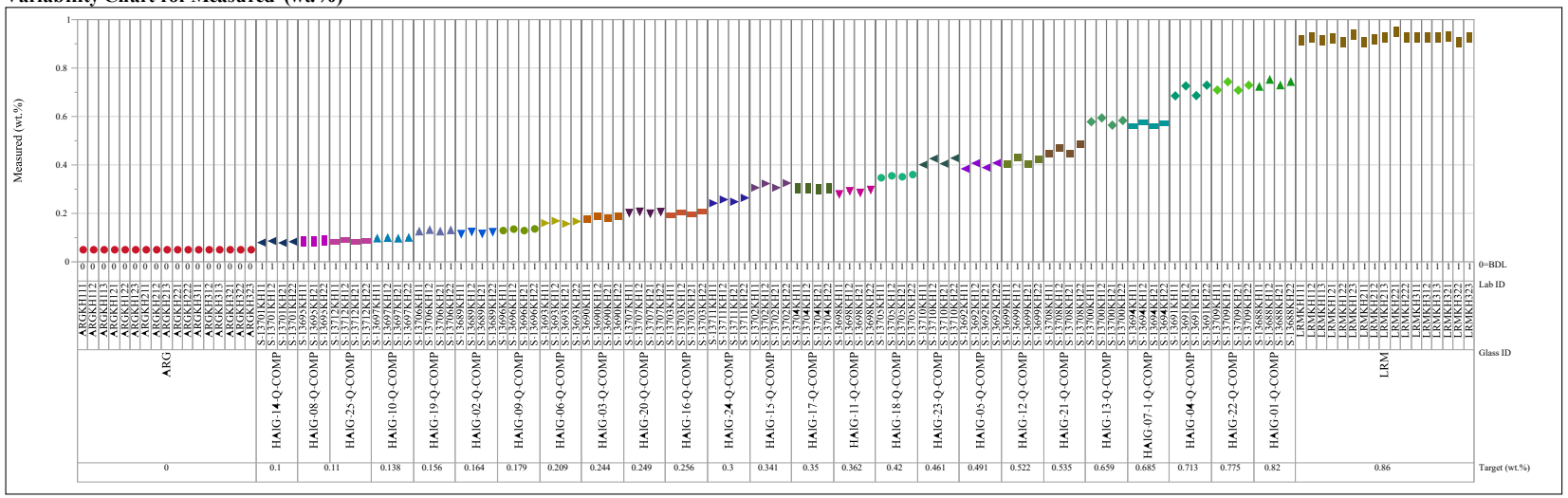


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

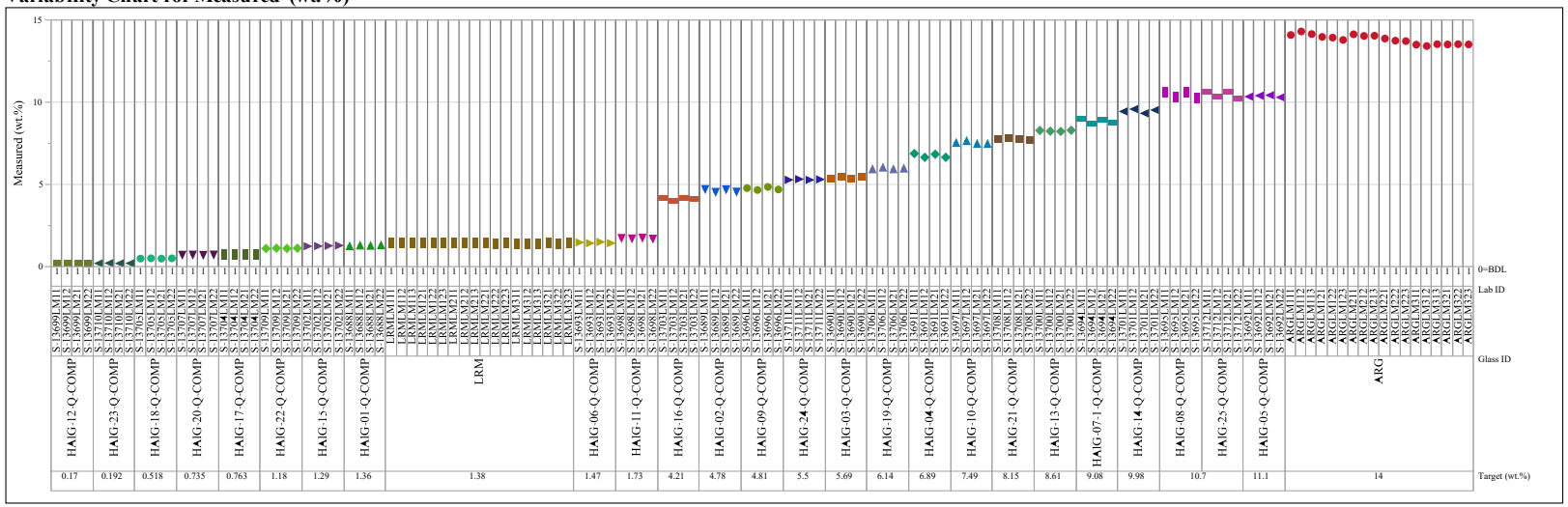
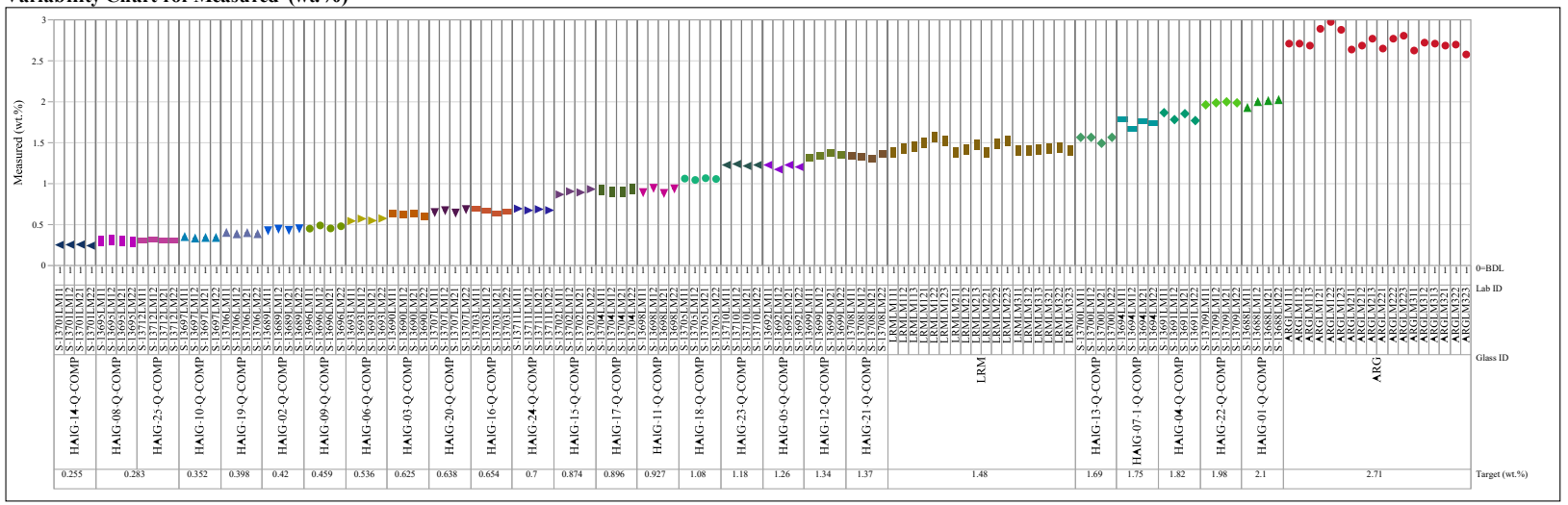


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

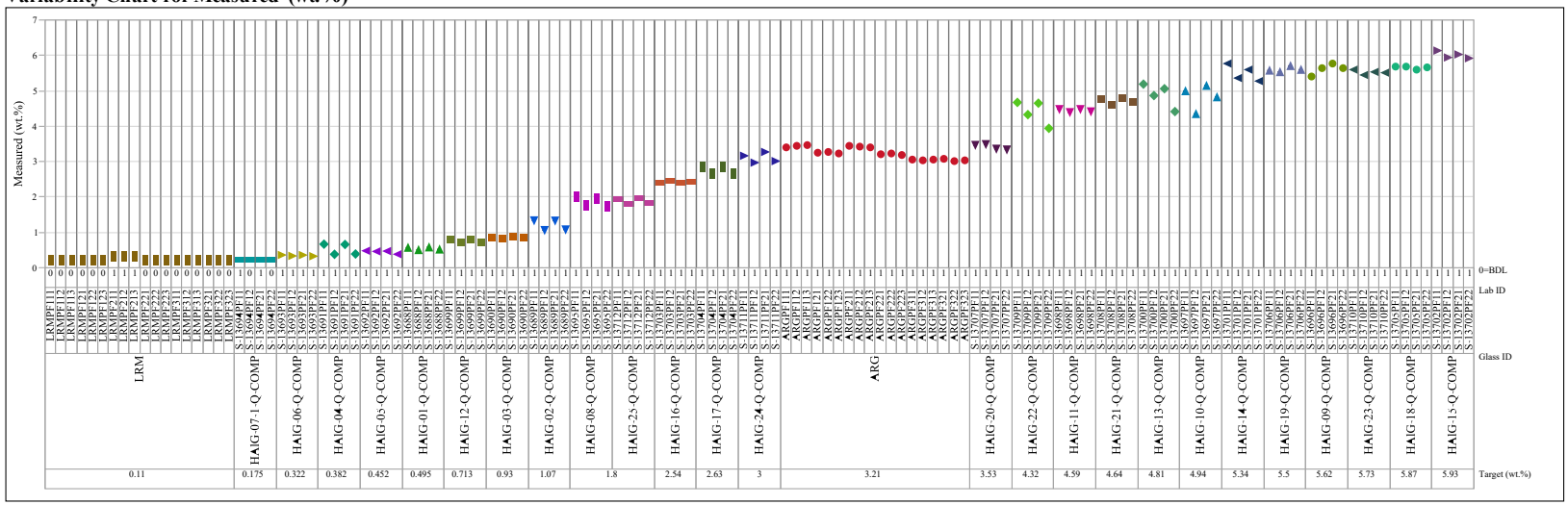
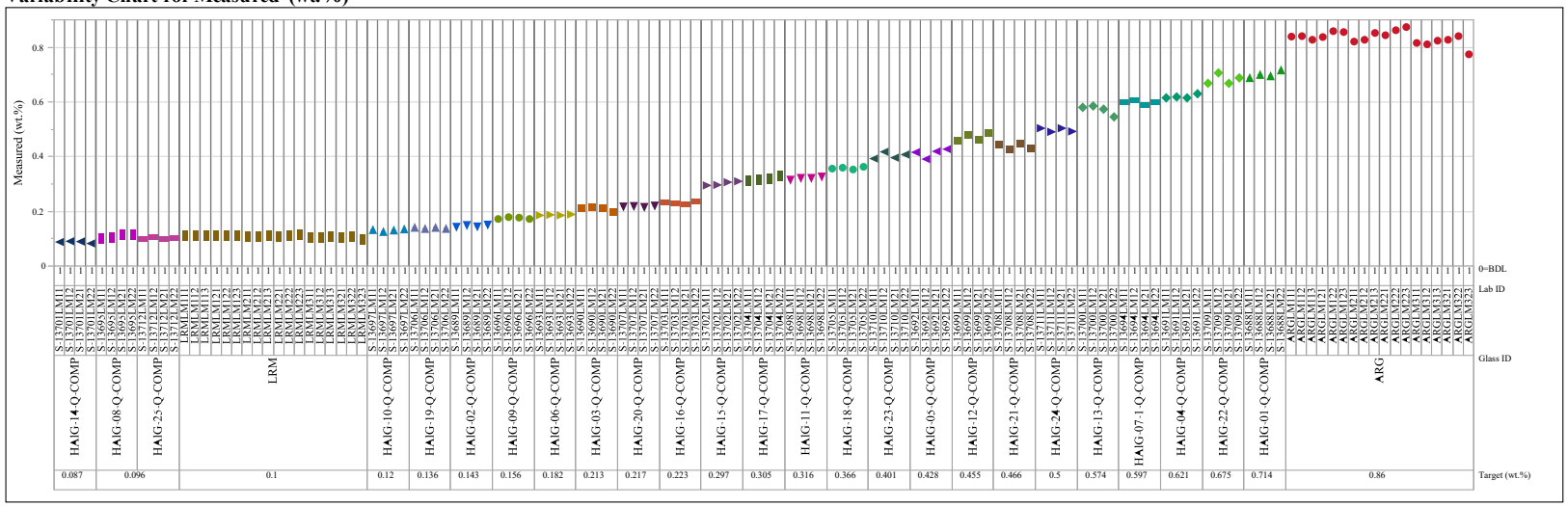


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

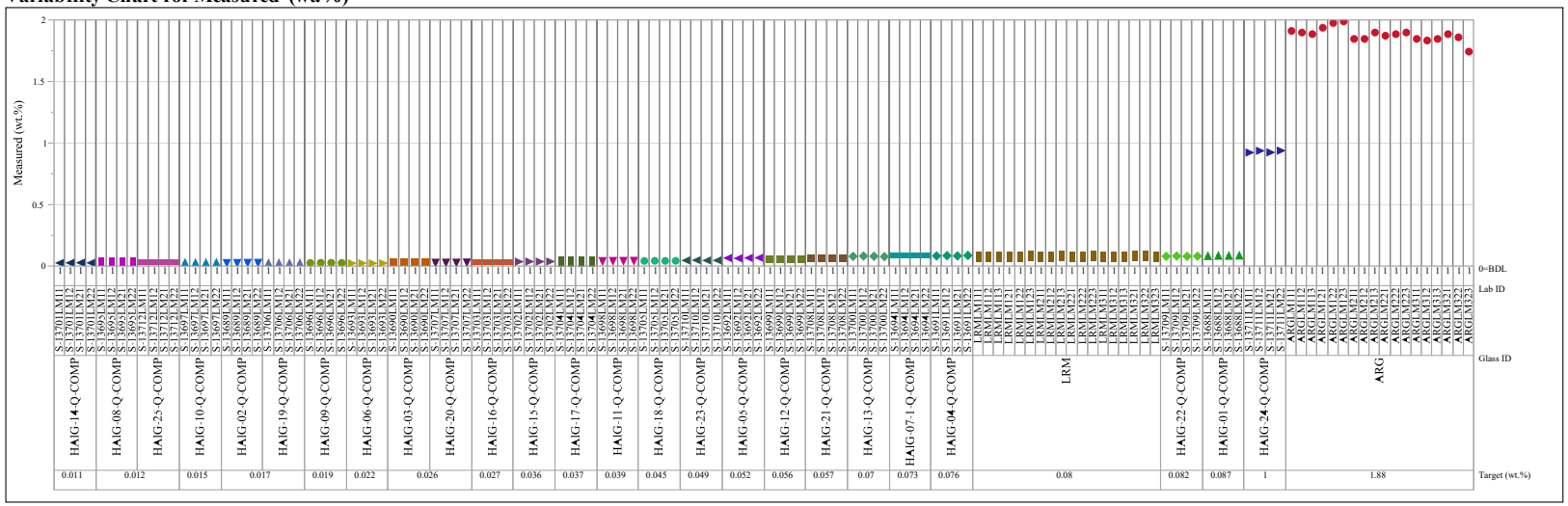
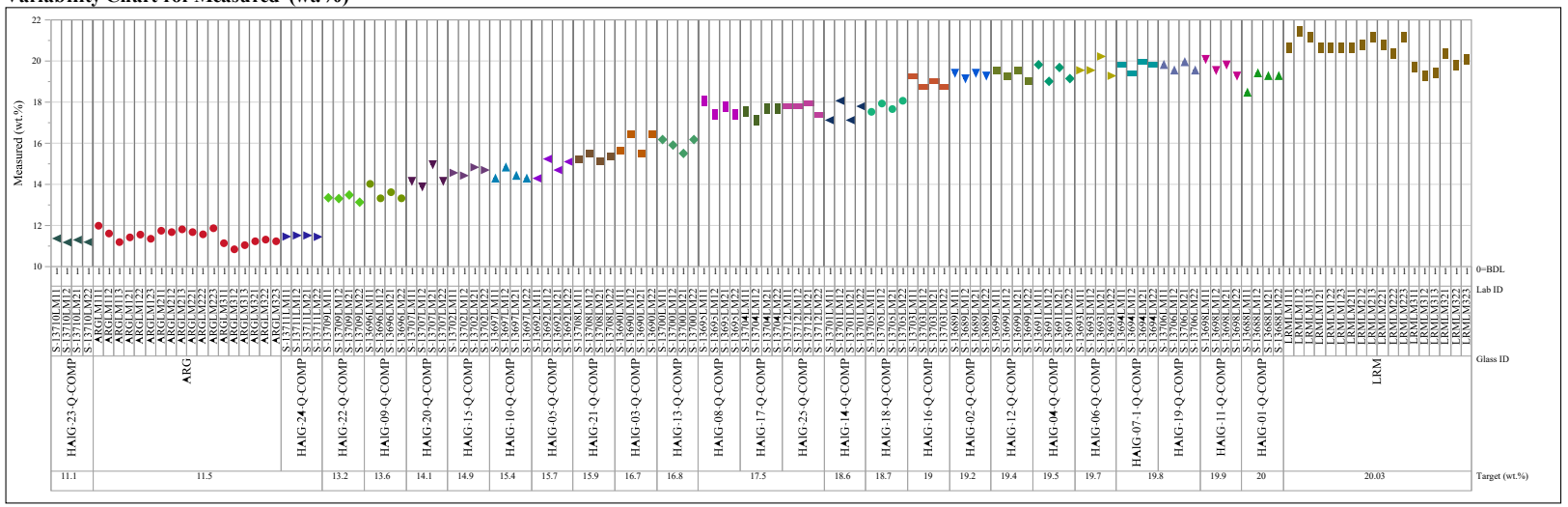


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

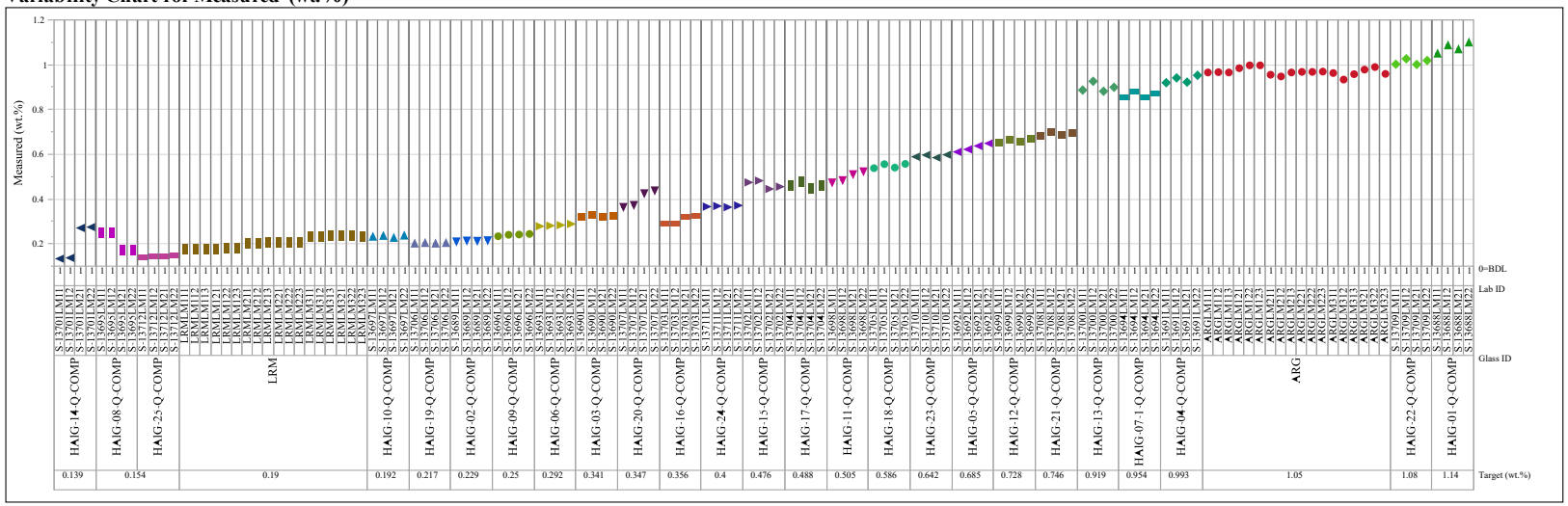
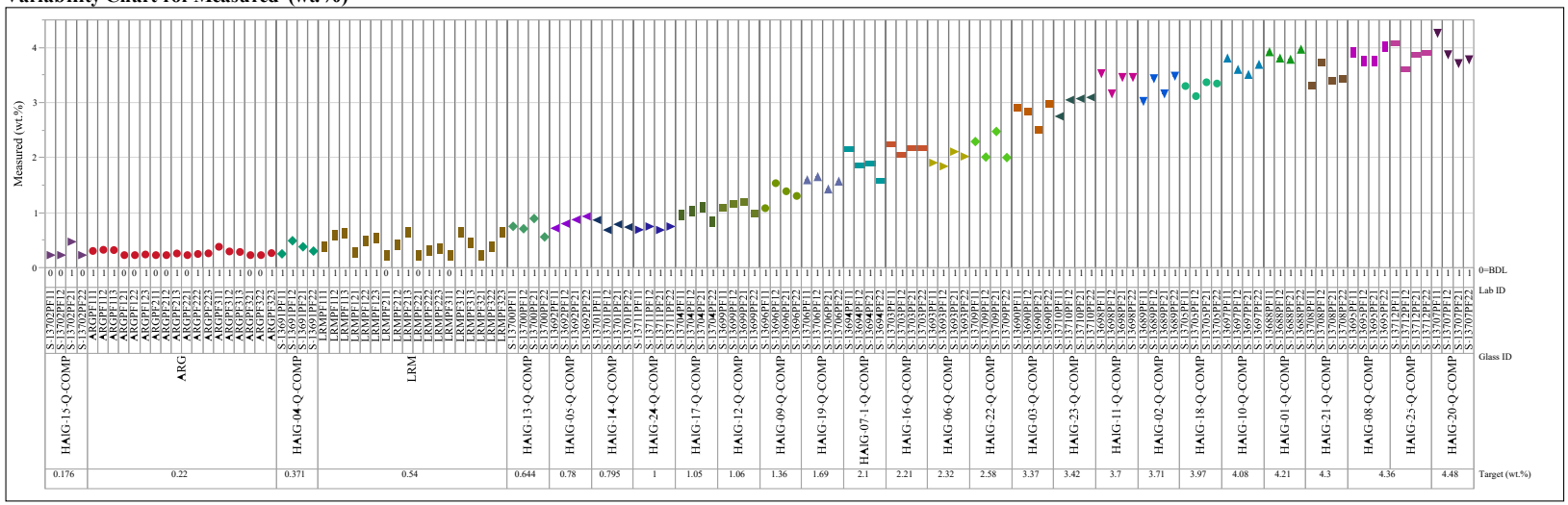


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

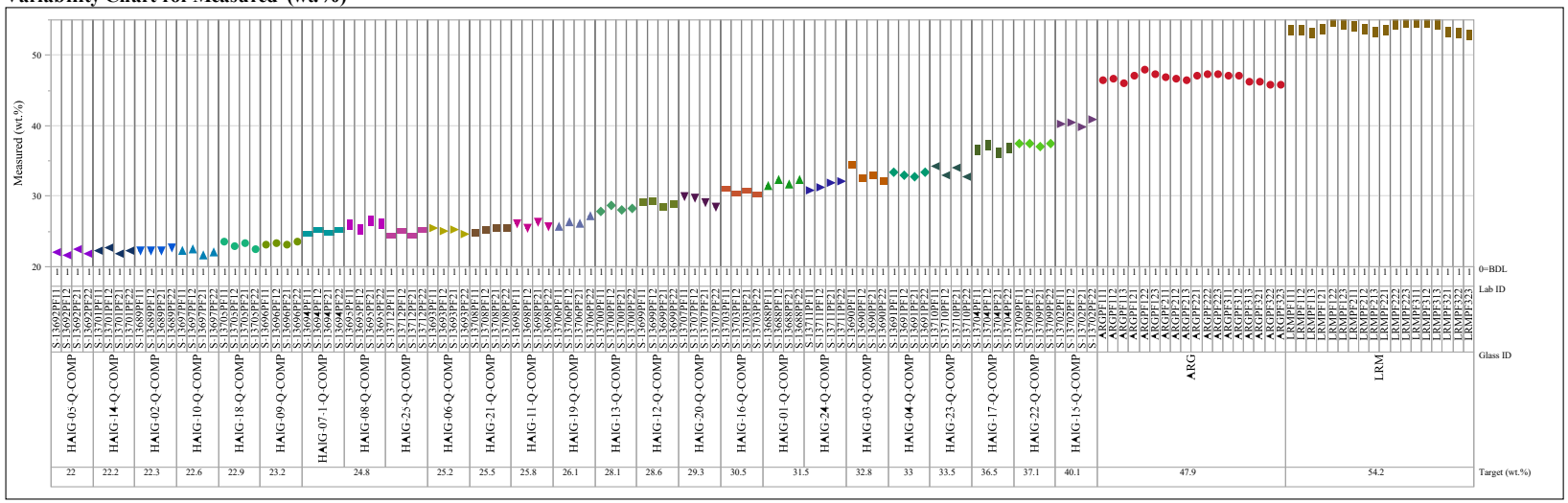
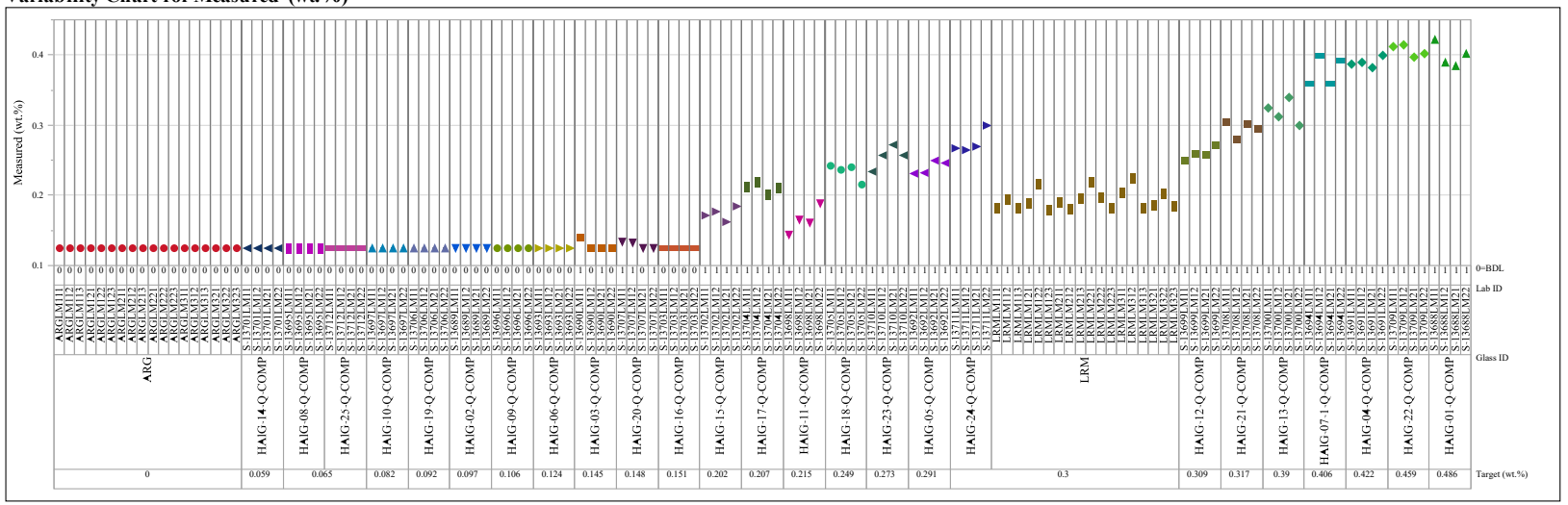


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

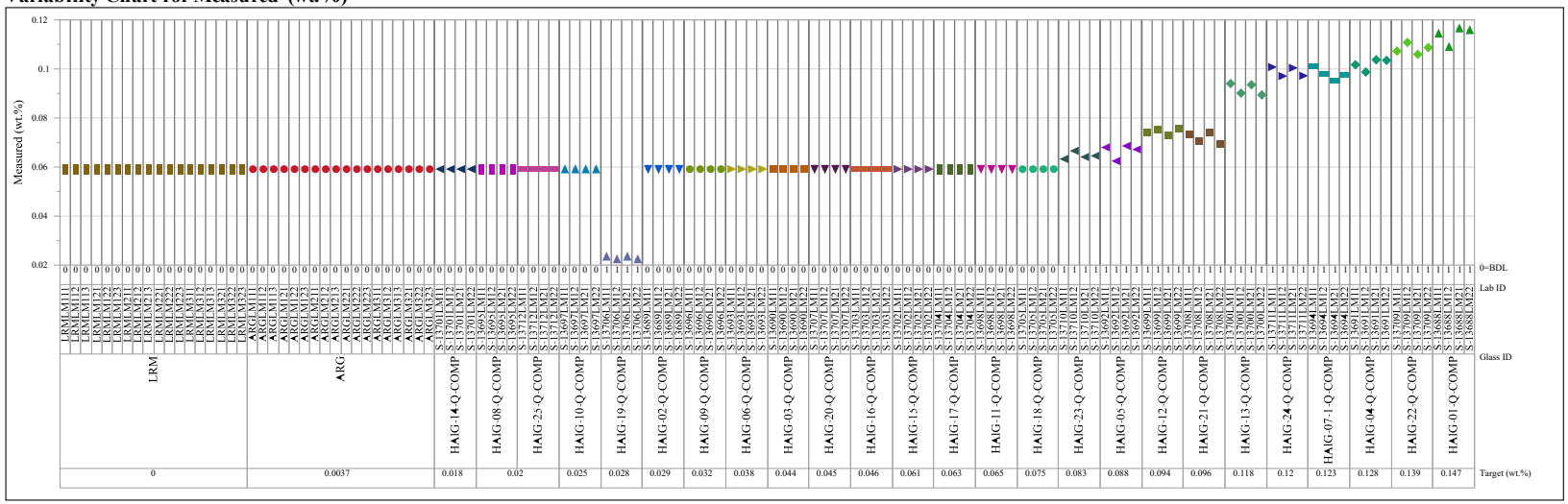
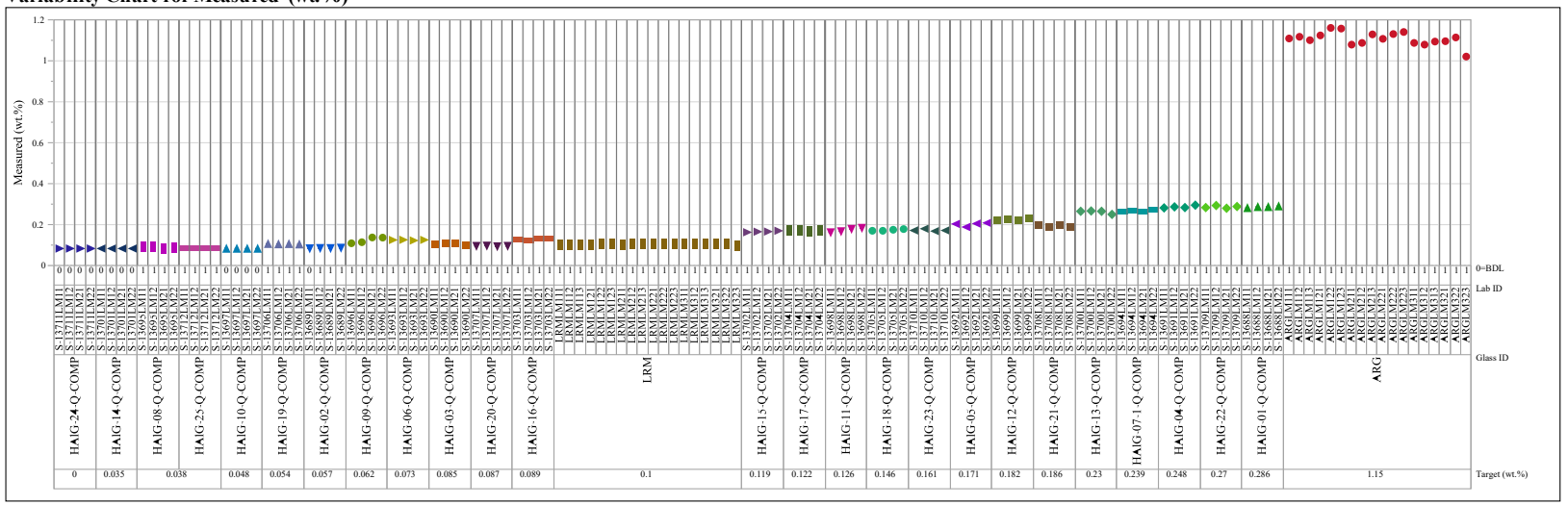


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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



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

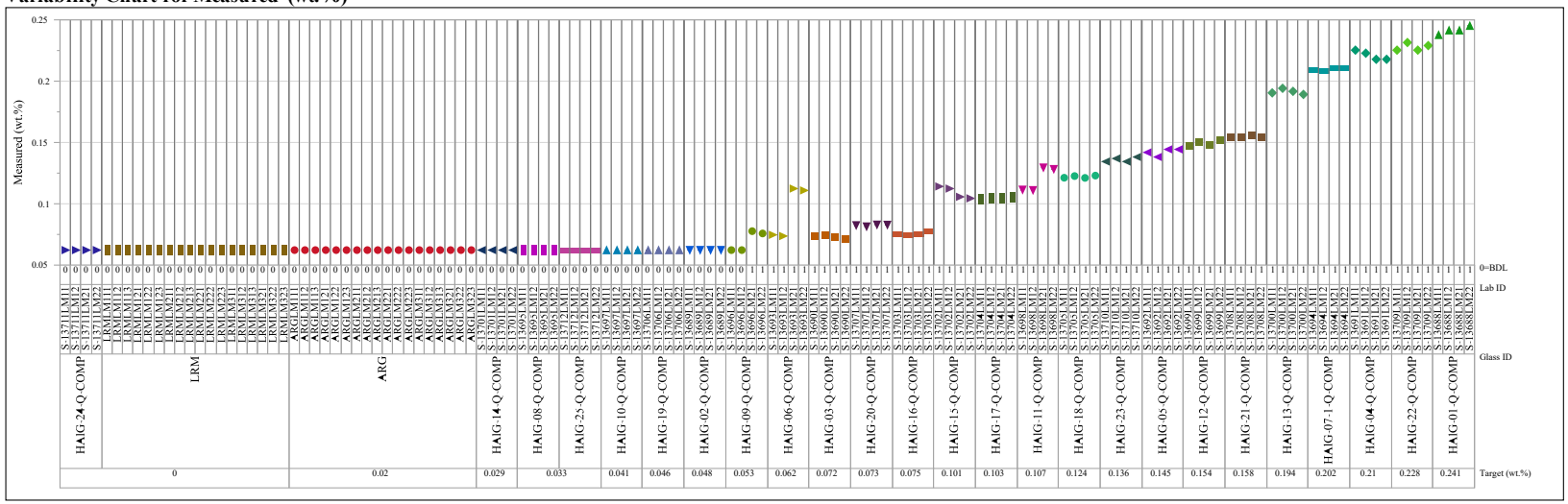


Exhibit A-1. Plots of Oxide Measurements by Glass Identifier by Target Concentrations (continued)

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

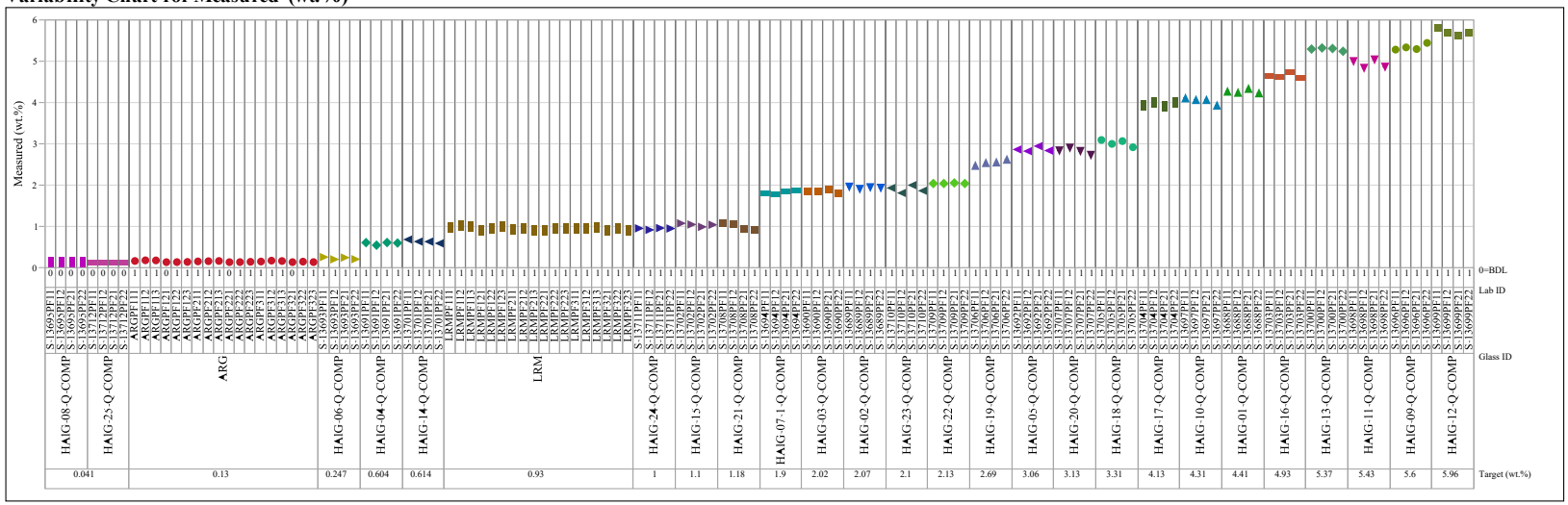
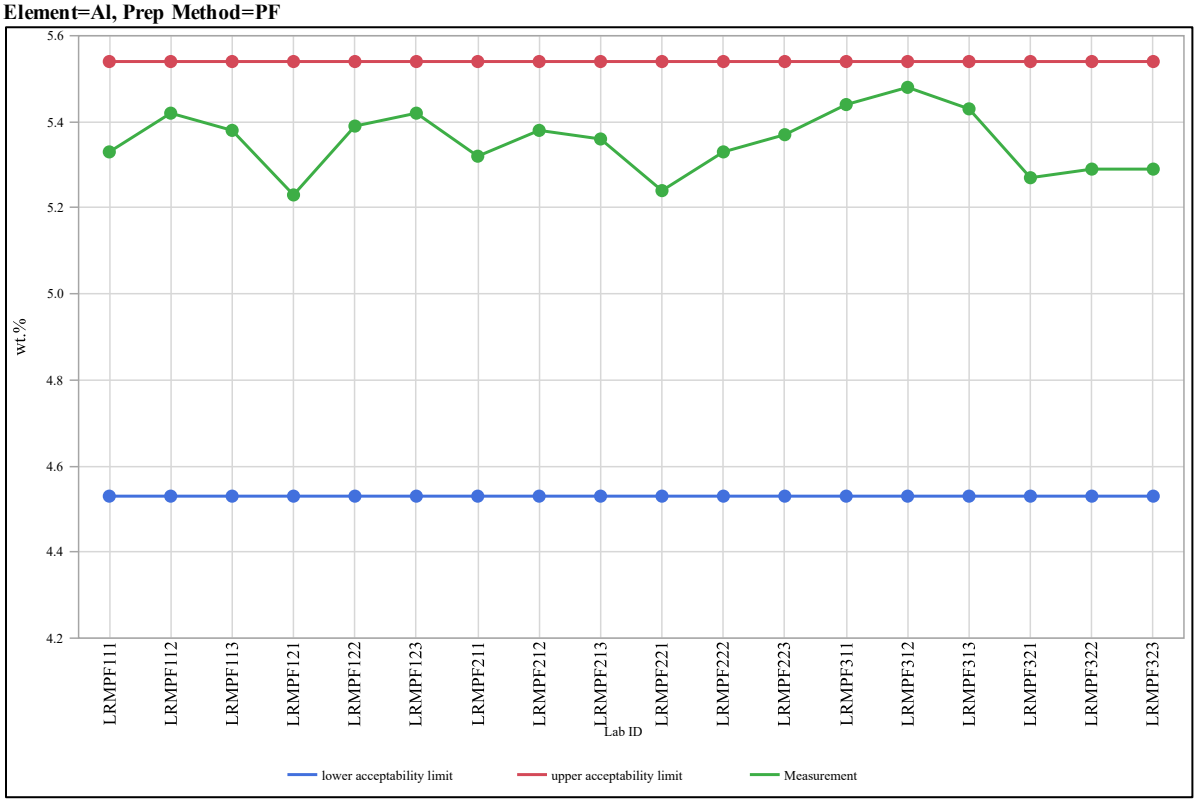


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass

Element=Al, Prep Method=PF



Element=B, Prep Method=PF

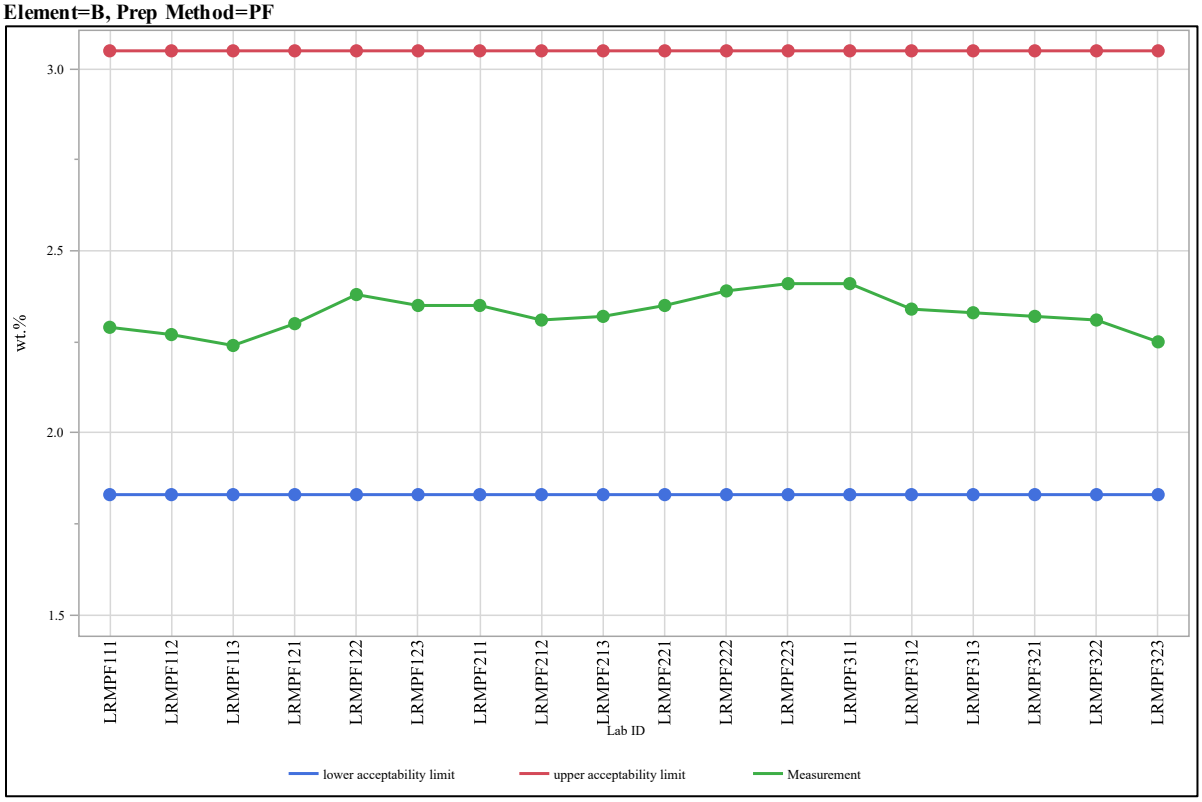
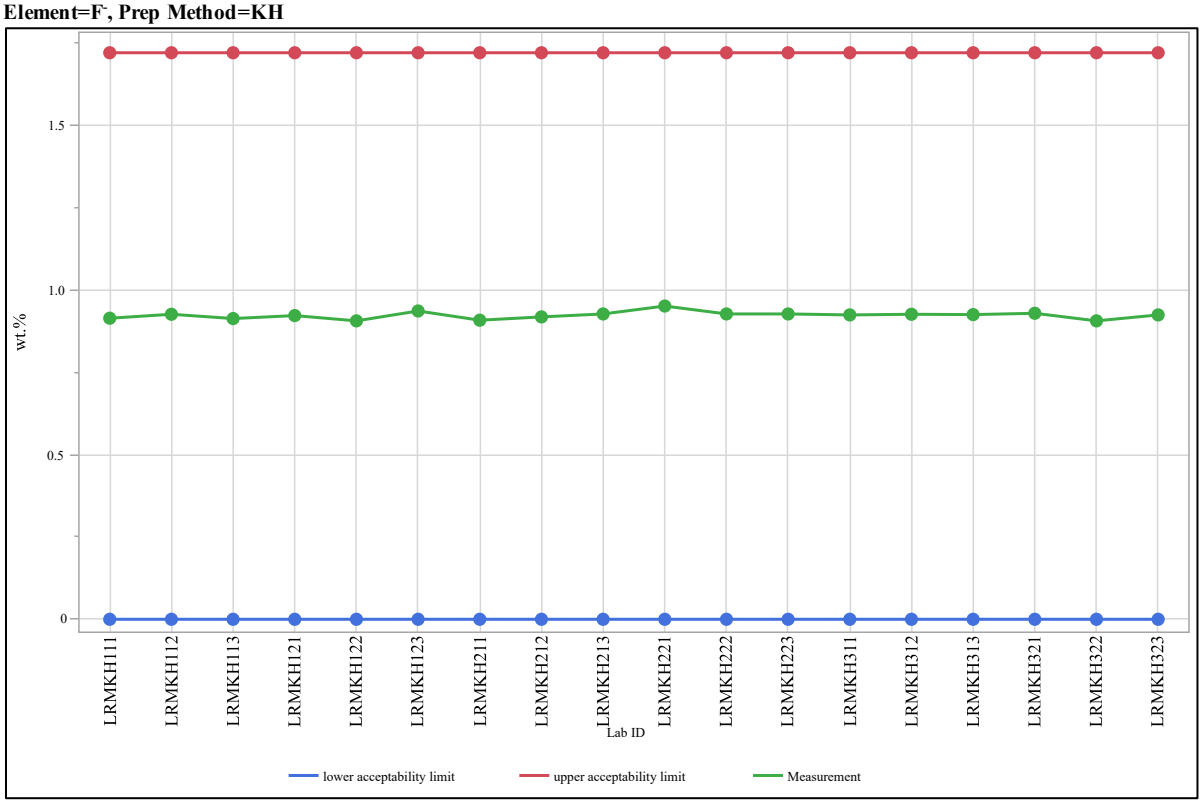


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=F⁻, Prep Method=KH



Element=Fe, Prep Method=LM

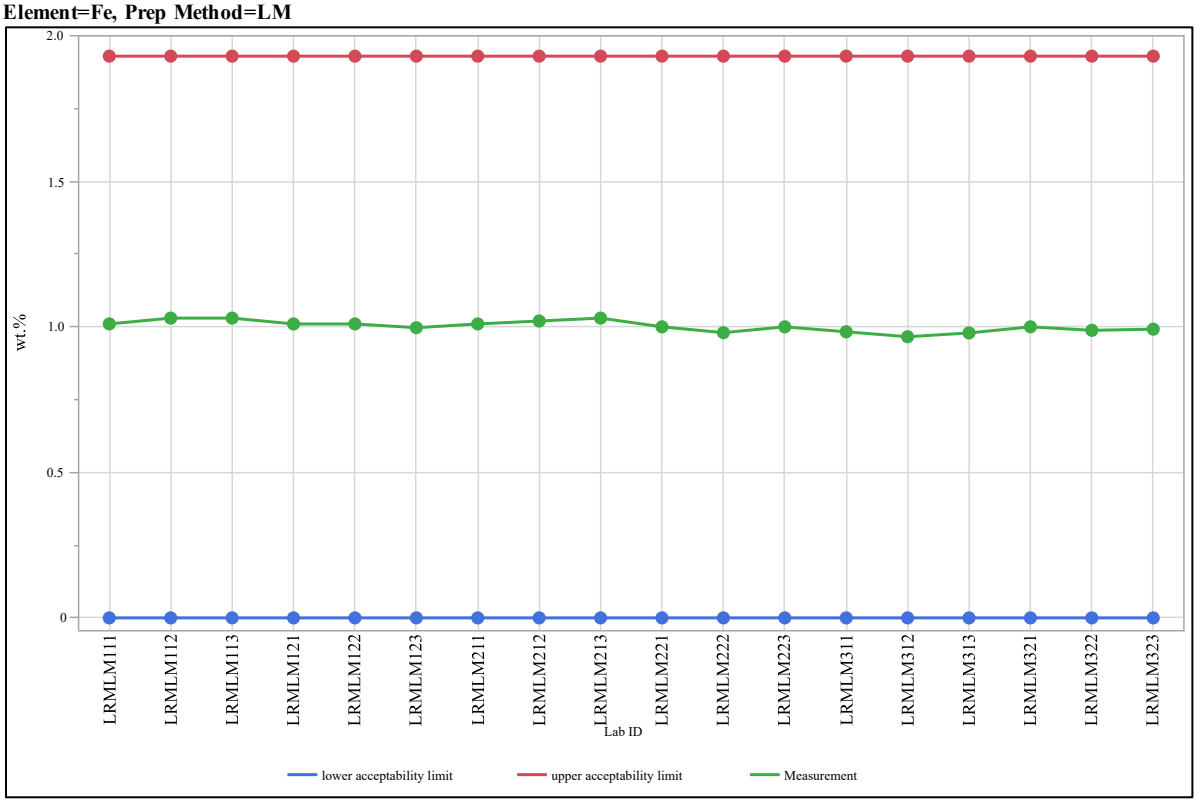
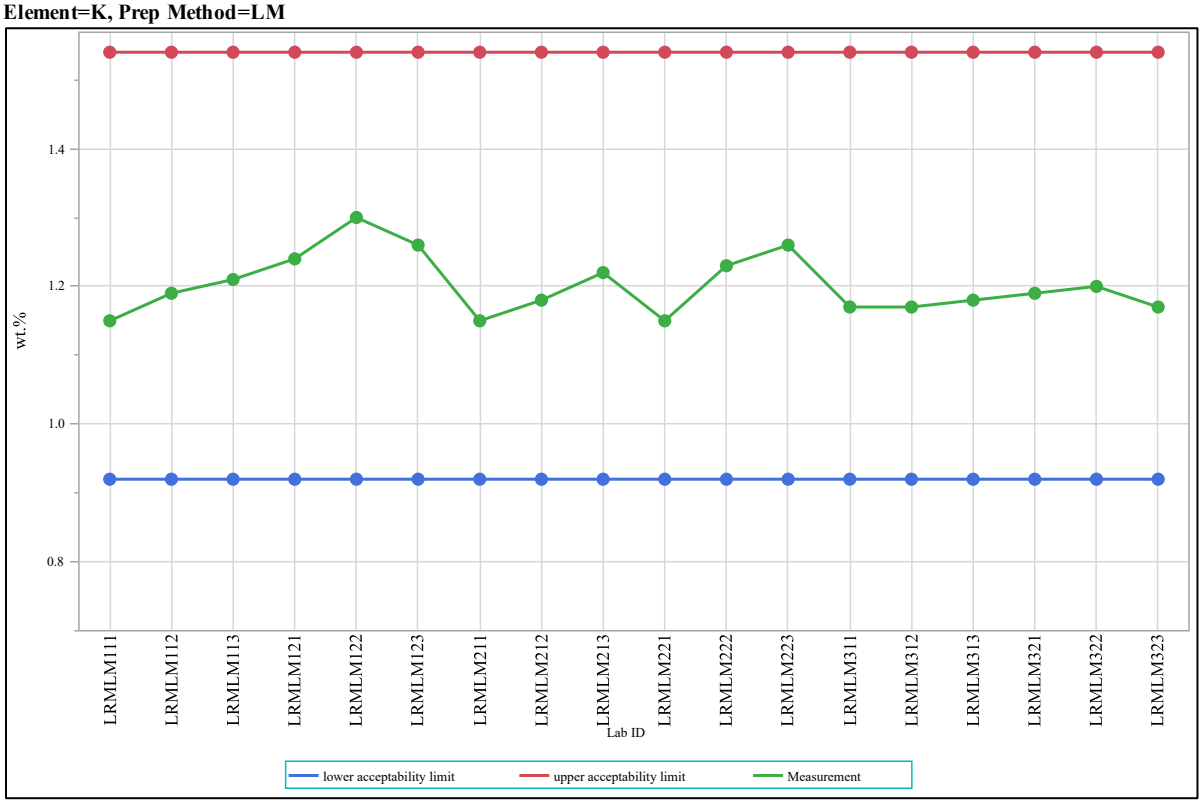


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=K, Prep Method=LM



Element=Na, Prep Method=LM

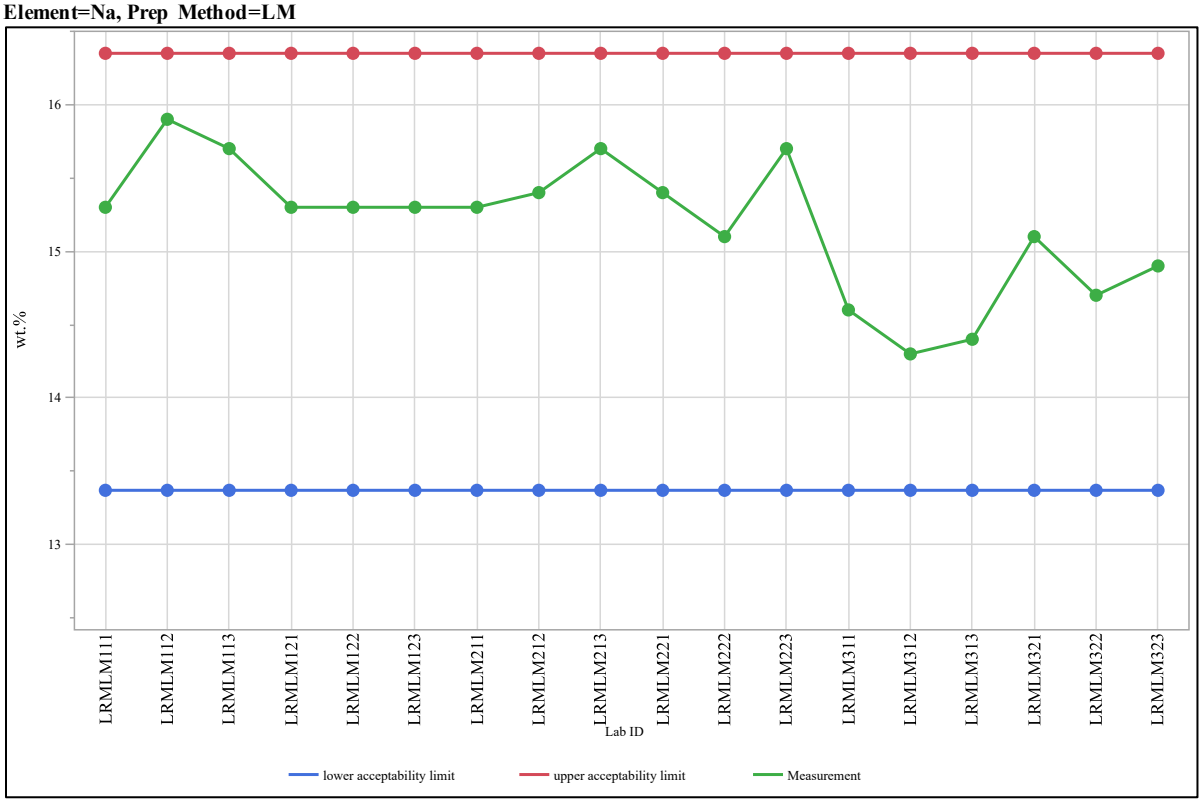
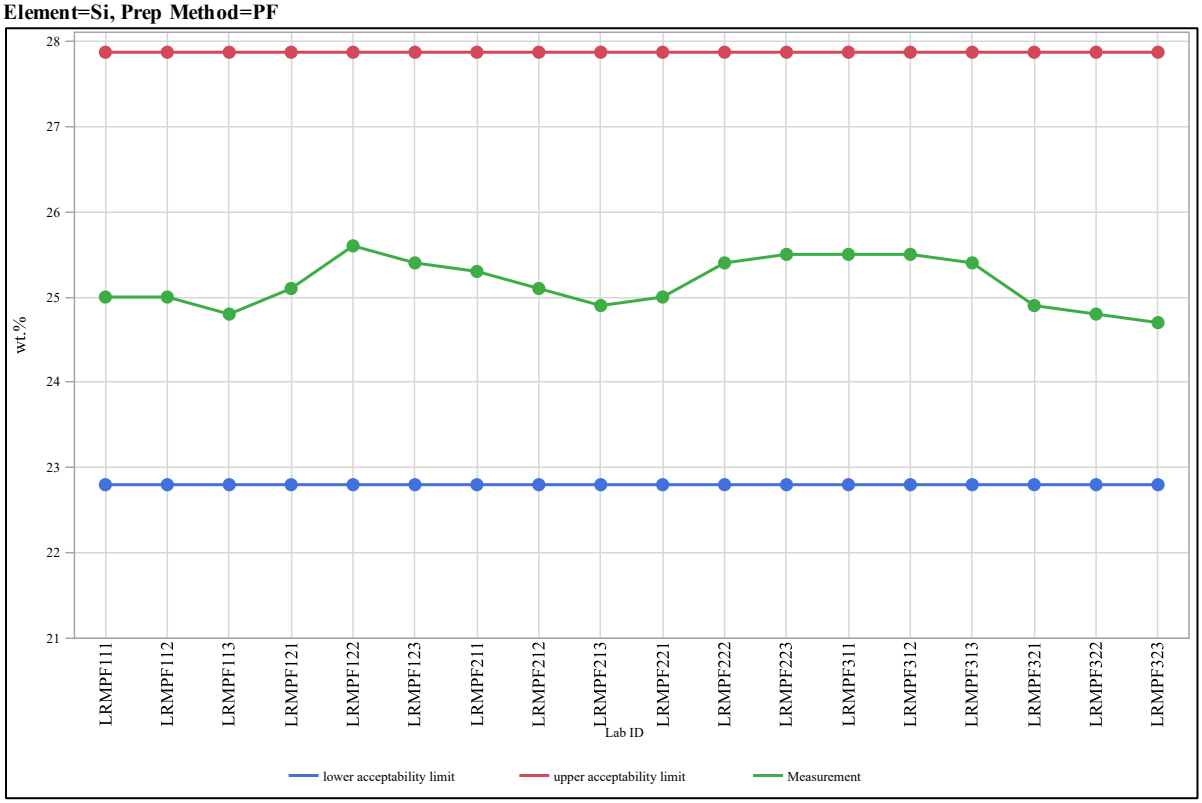


Exhibit A-2. Acceptability Evaluation for Measurements of the LRM Glass (continued)

Element=Si, Prep Method=PF



Element=Zr, Prep Method=PF

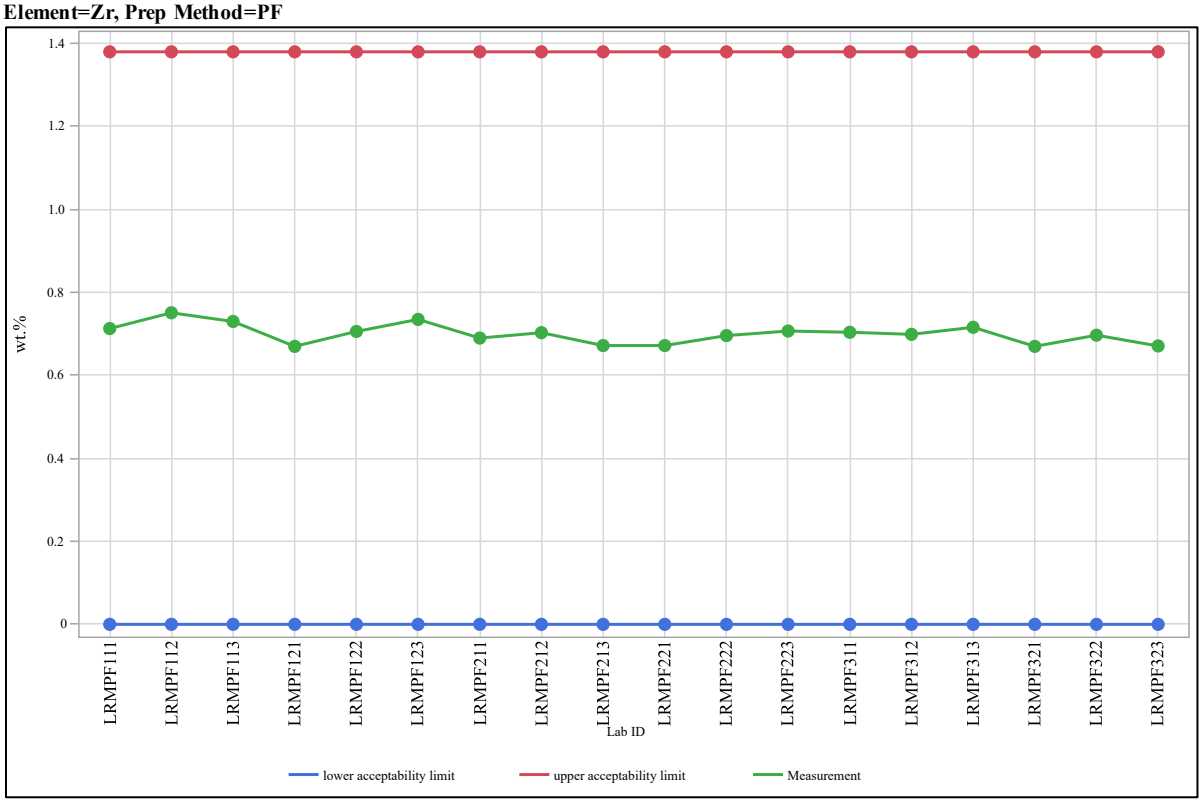
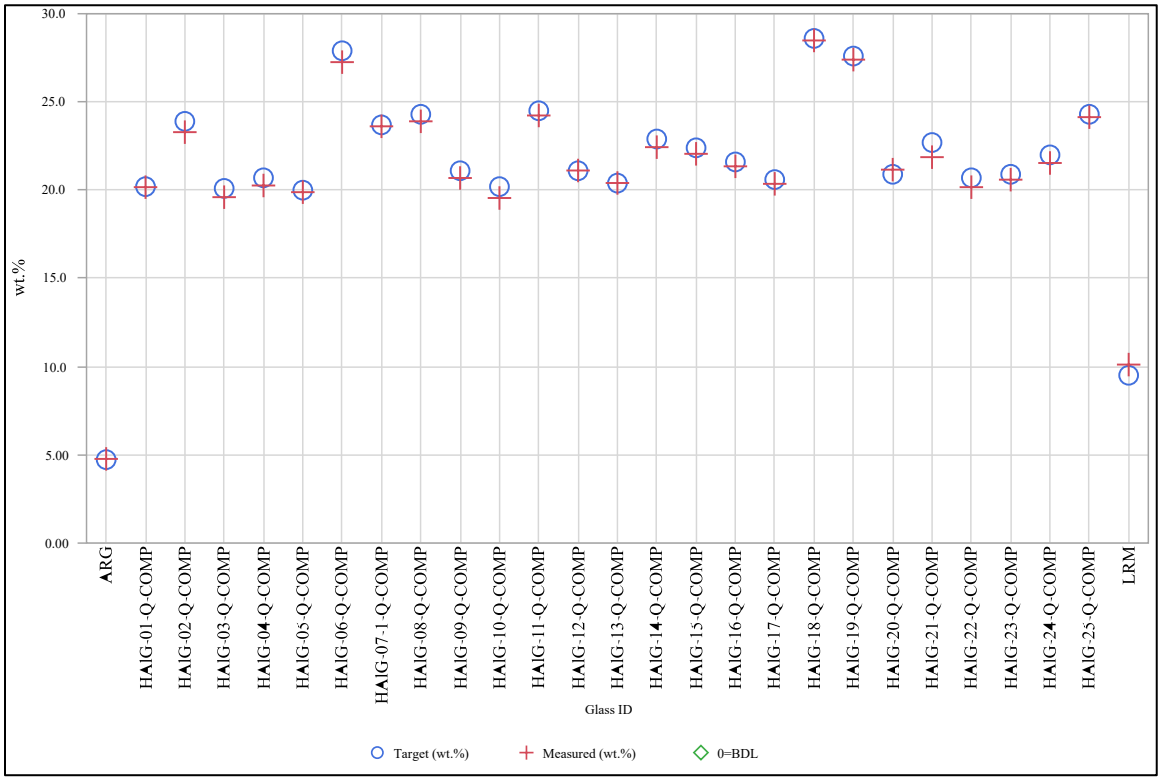


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide

Oxide=Al_2O_3



Oxide=B_2O_3

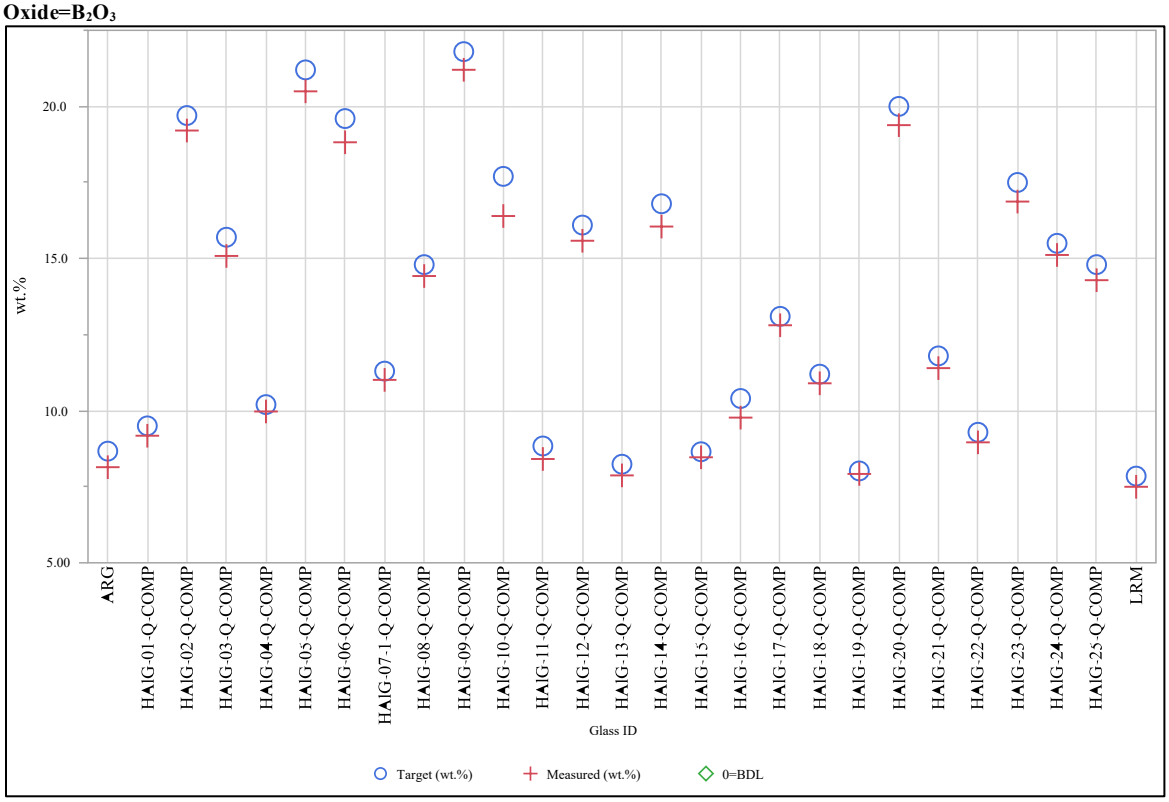
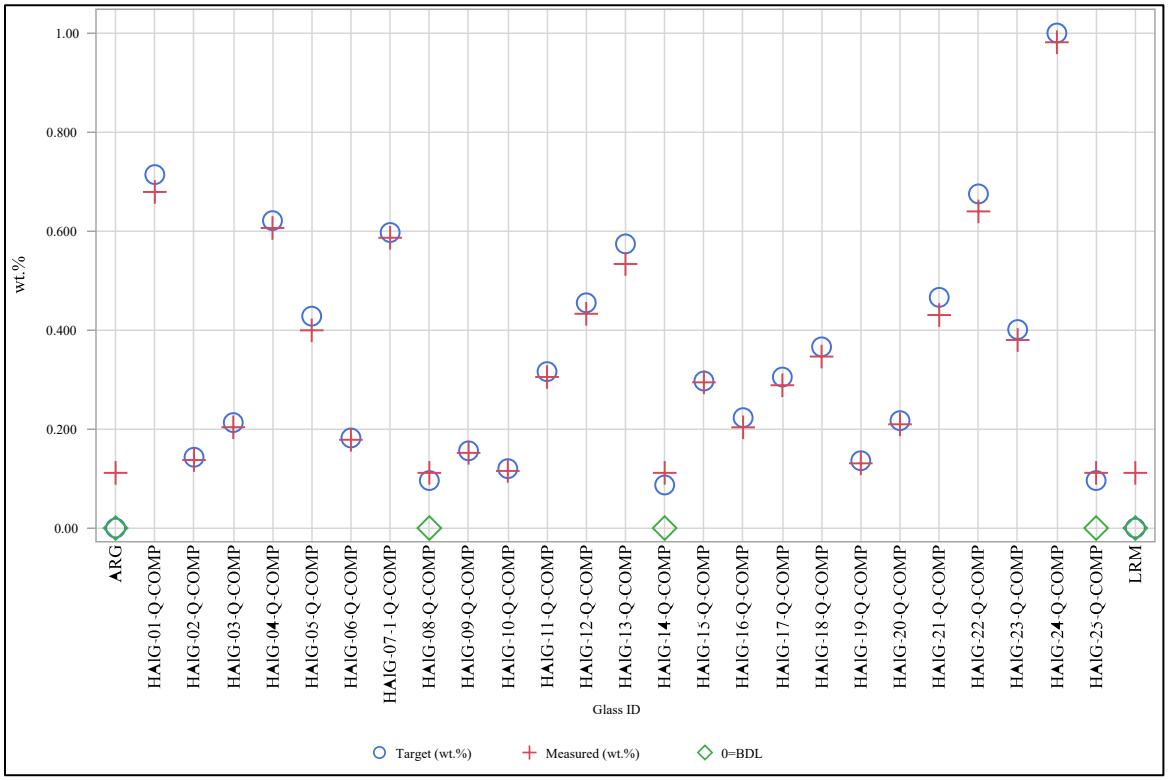


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Bi_2O_3



Oxide=CaO

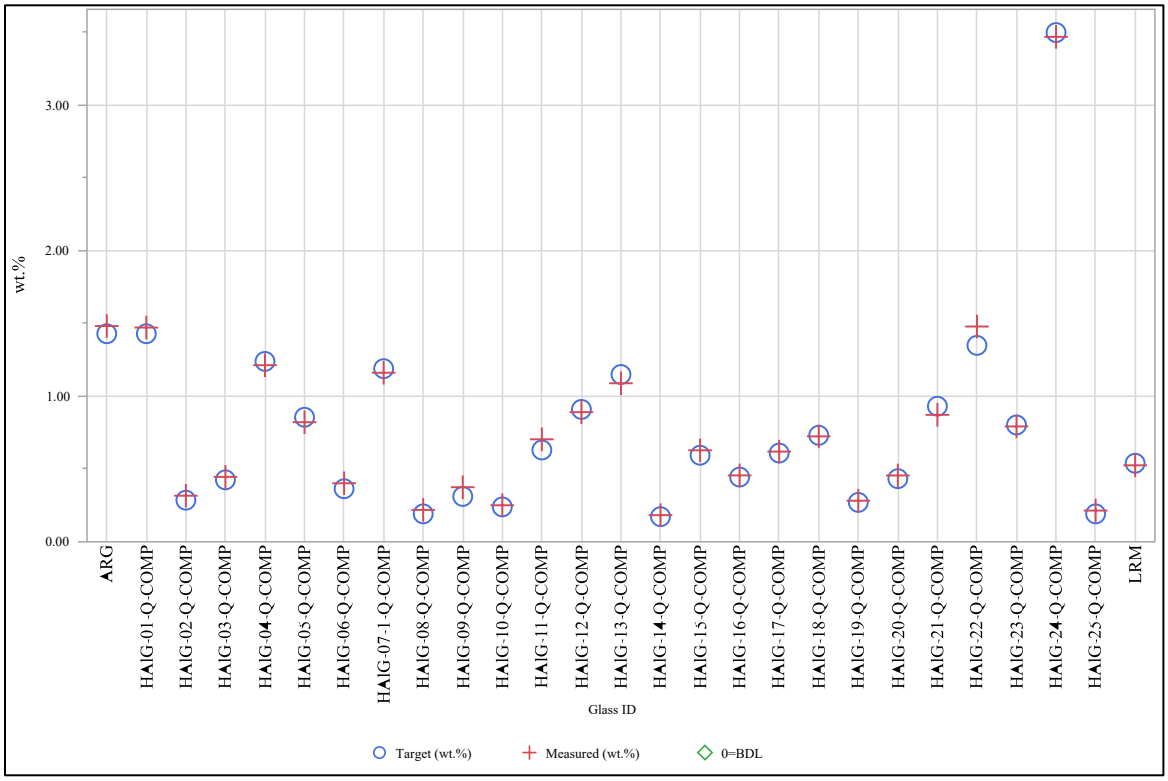
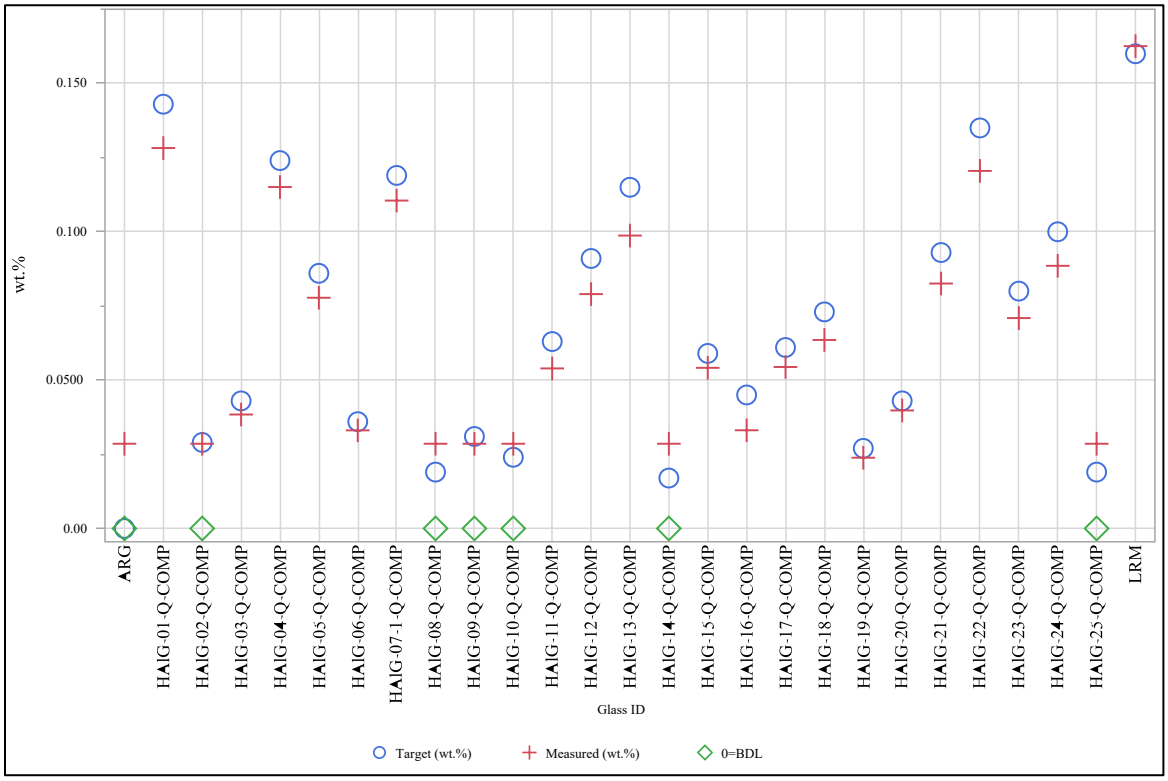


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=CdO



Oxide=Cr_2O_3

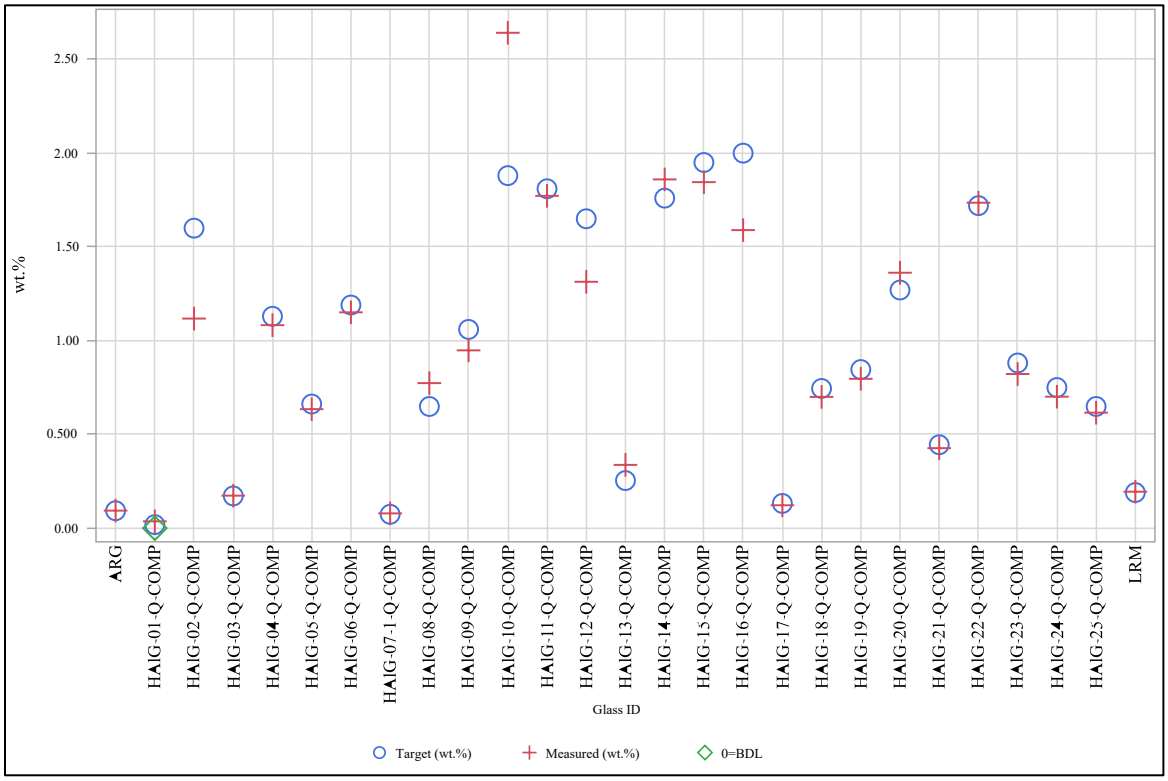
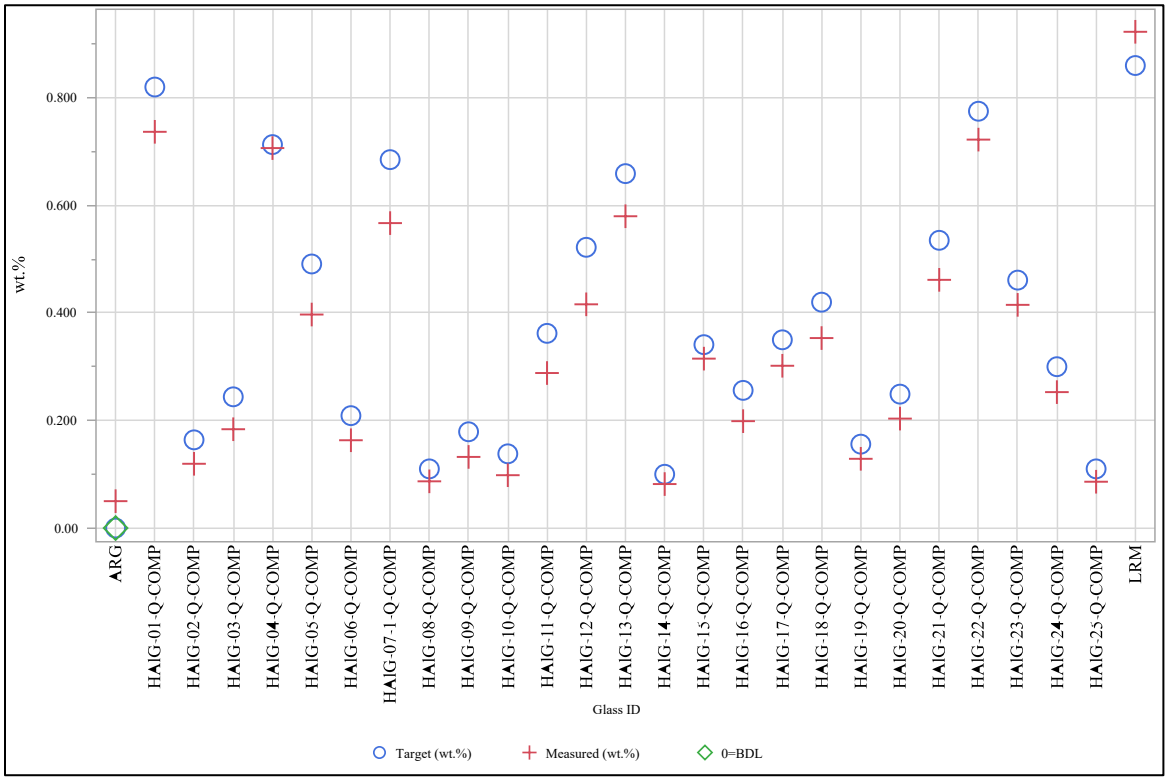


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=F^-



Oxide=Fe_2O_3

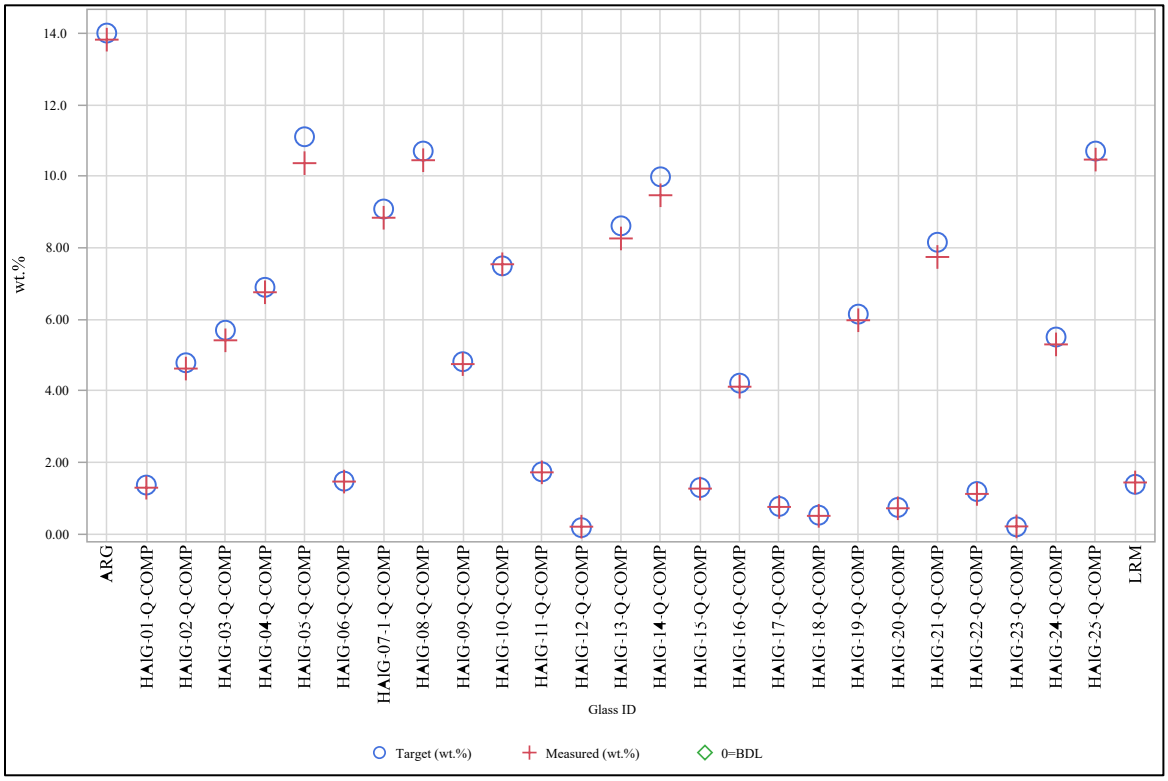
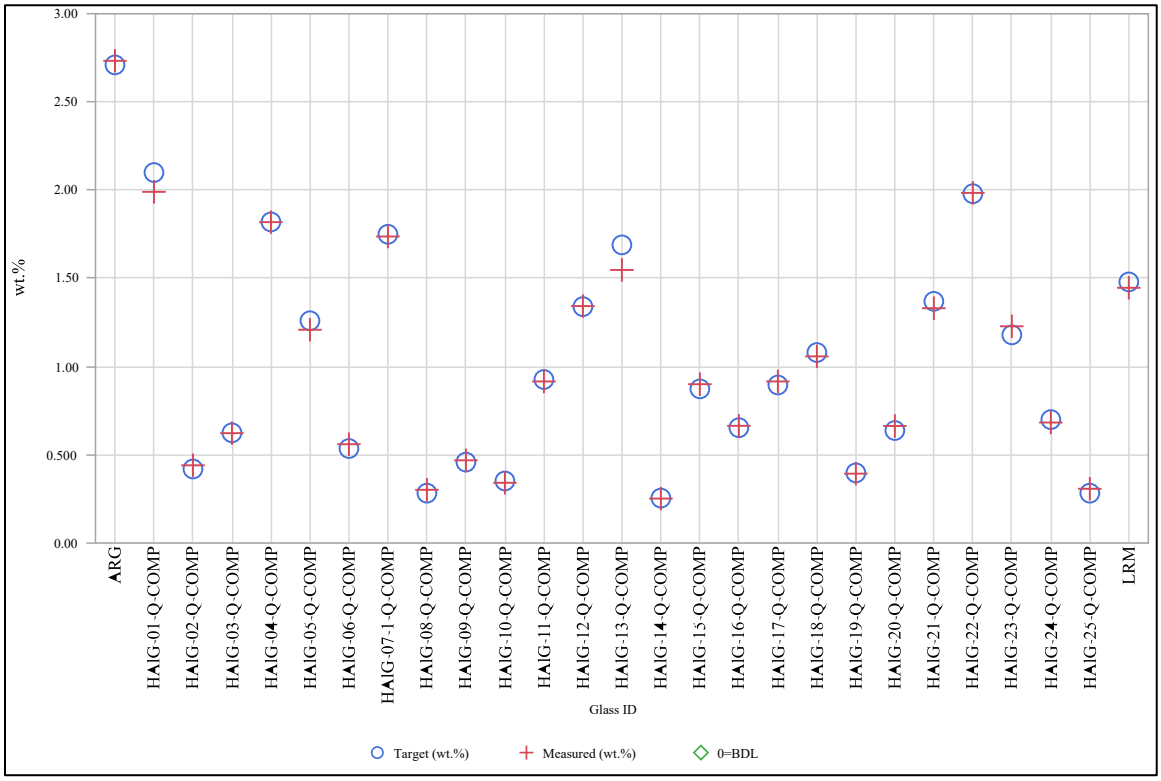


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=K_2O



Oxide=Li_2O

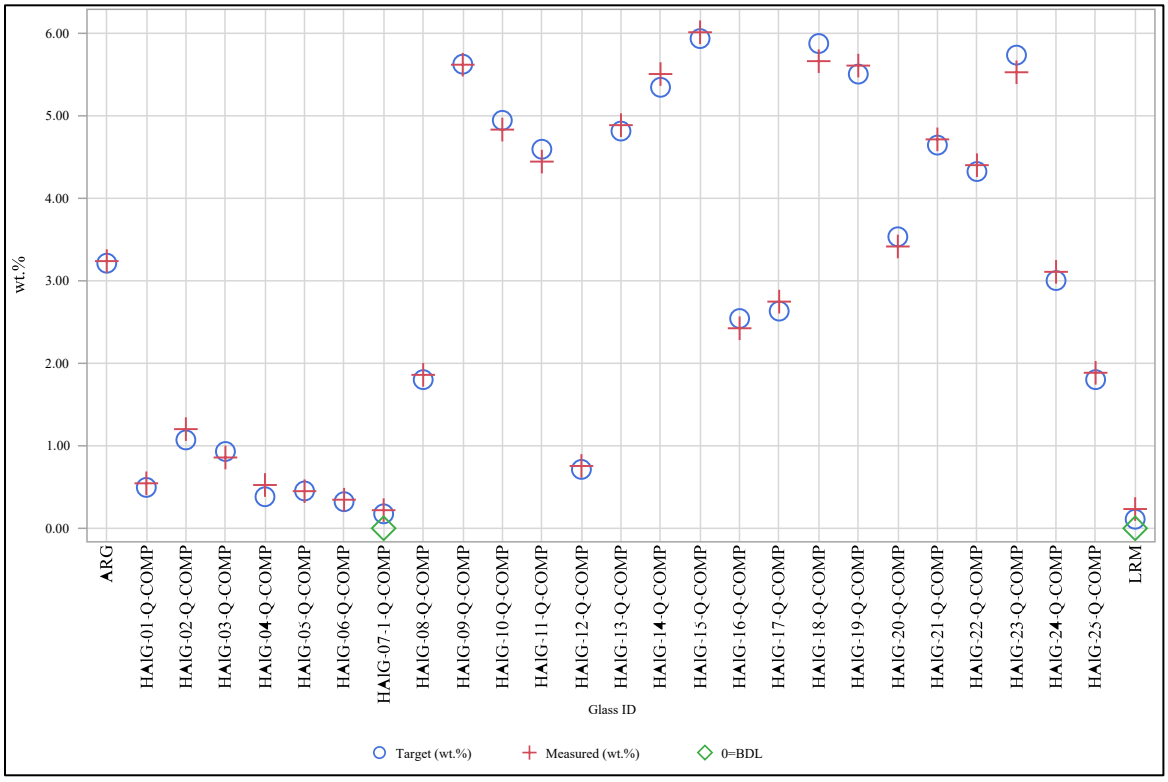
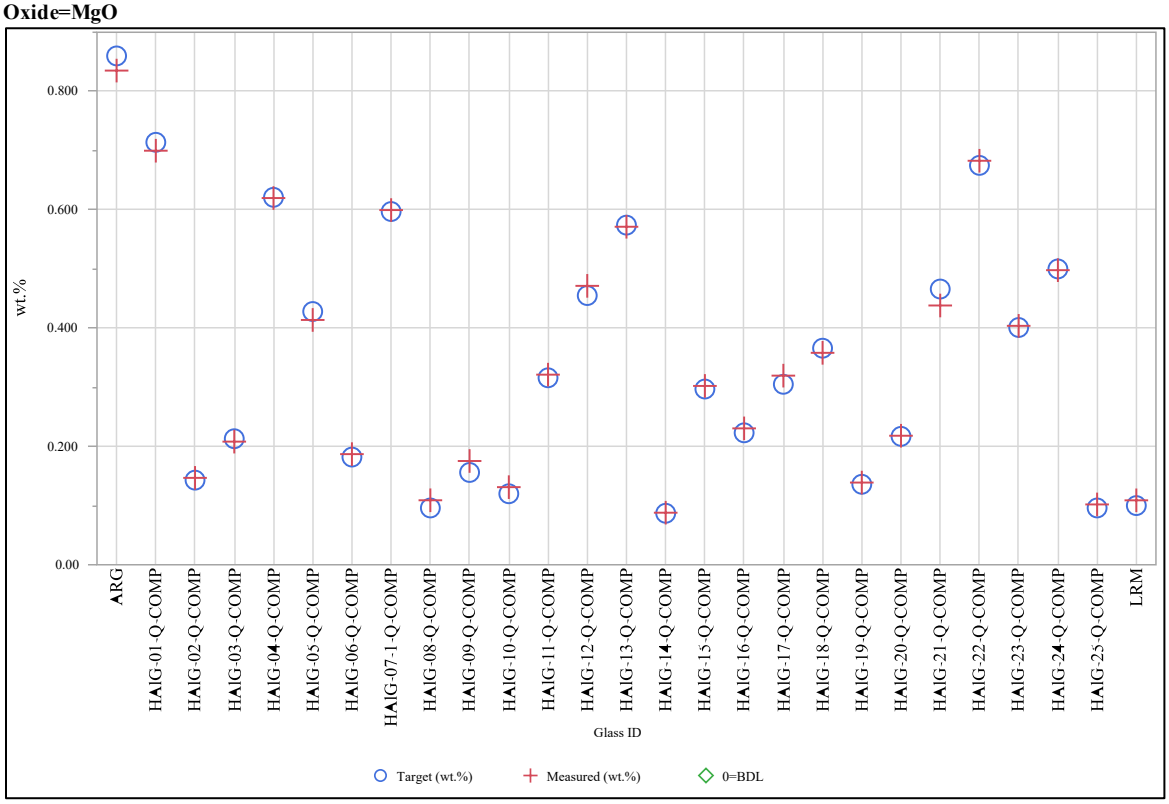


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=MgO



Oxide=MnO

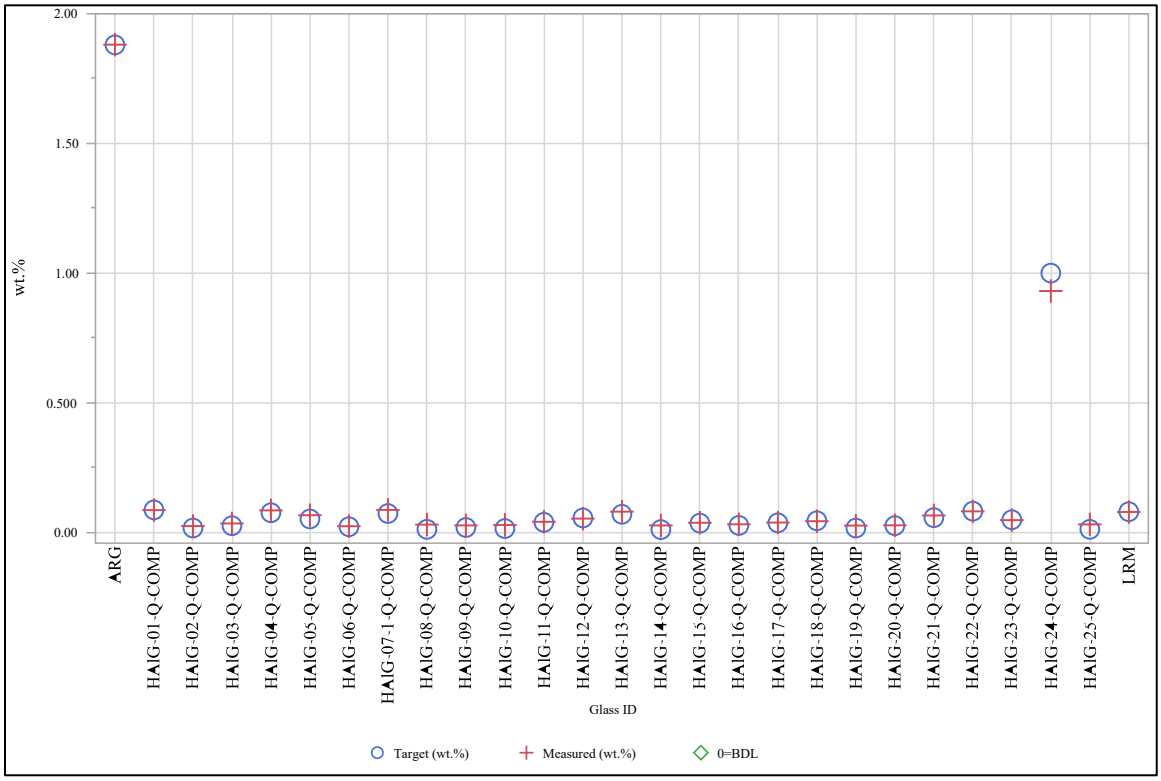
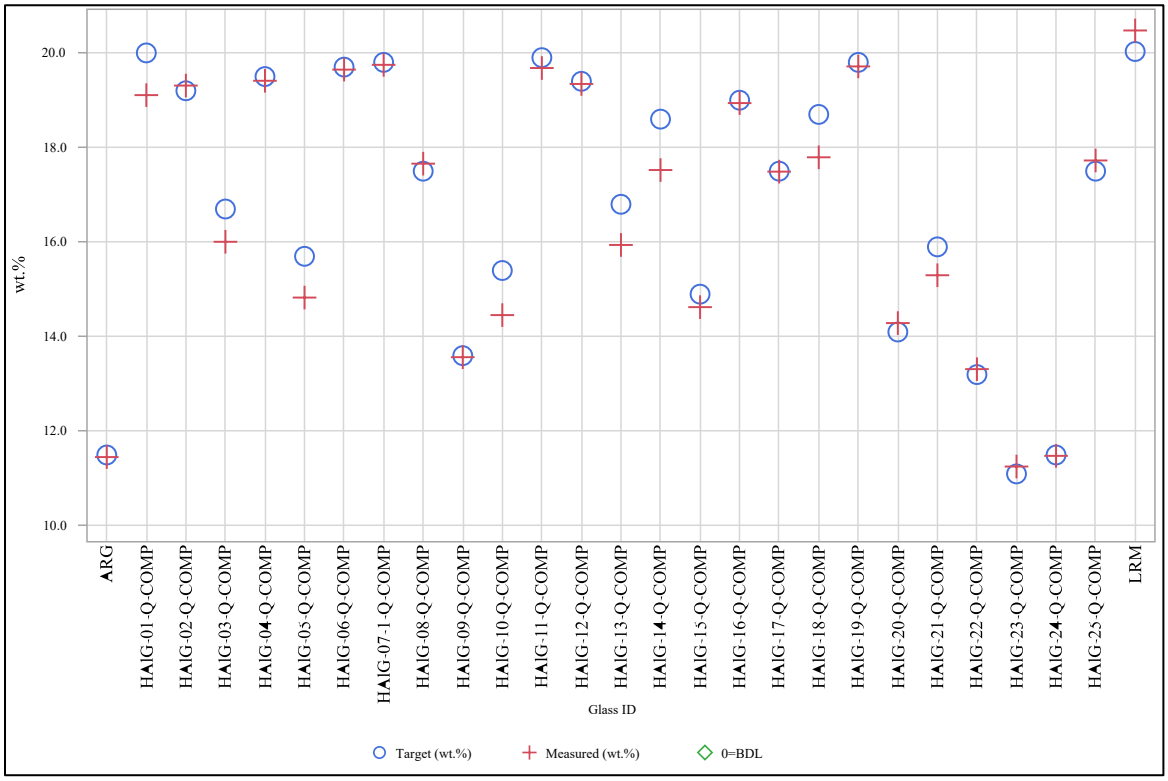


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=Na_2O



Oxide-NiO

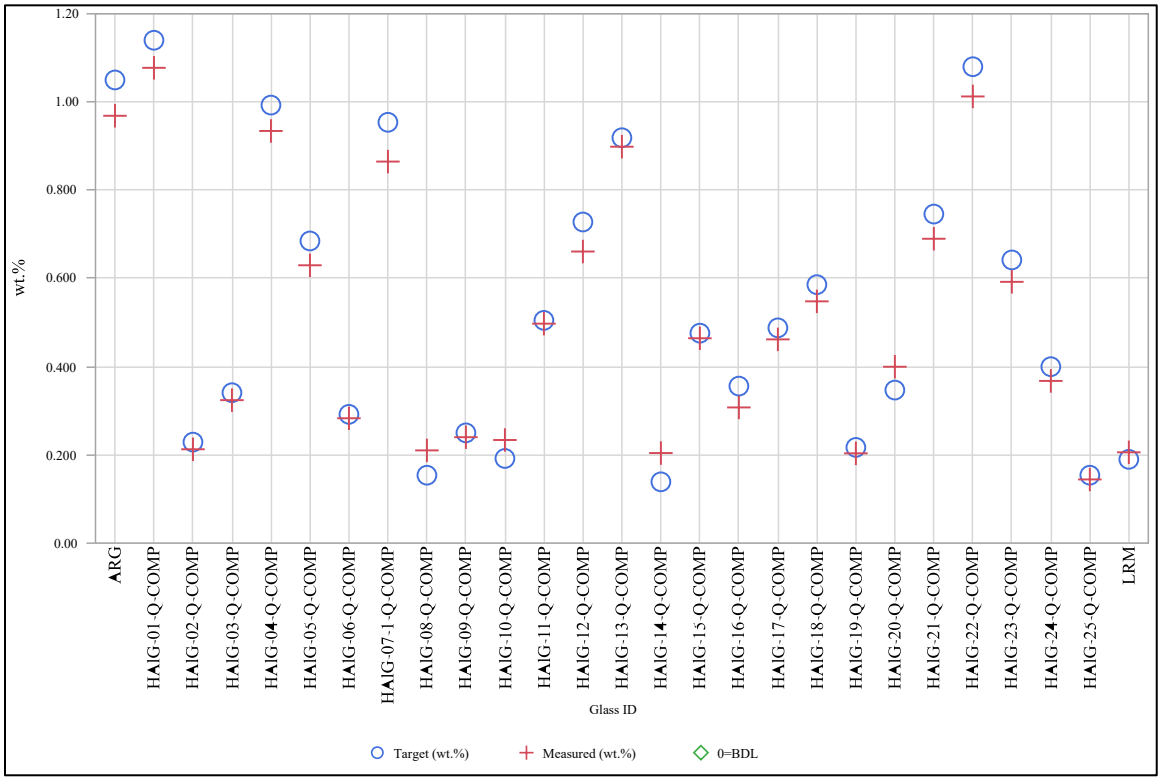
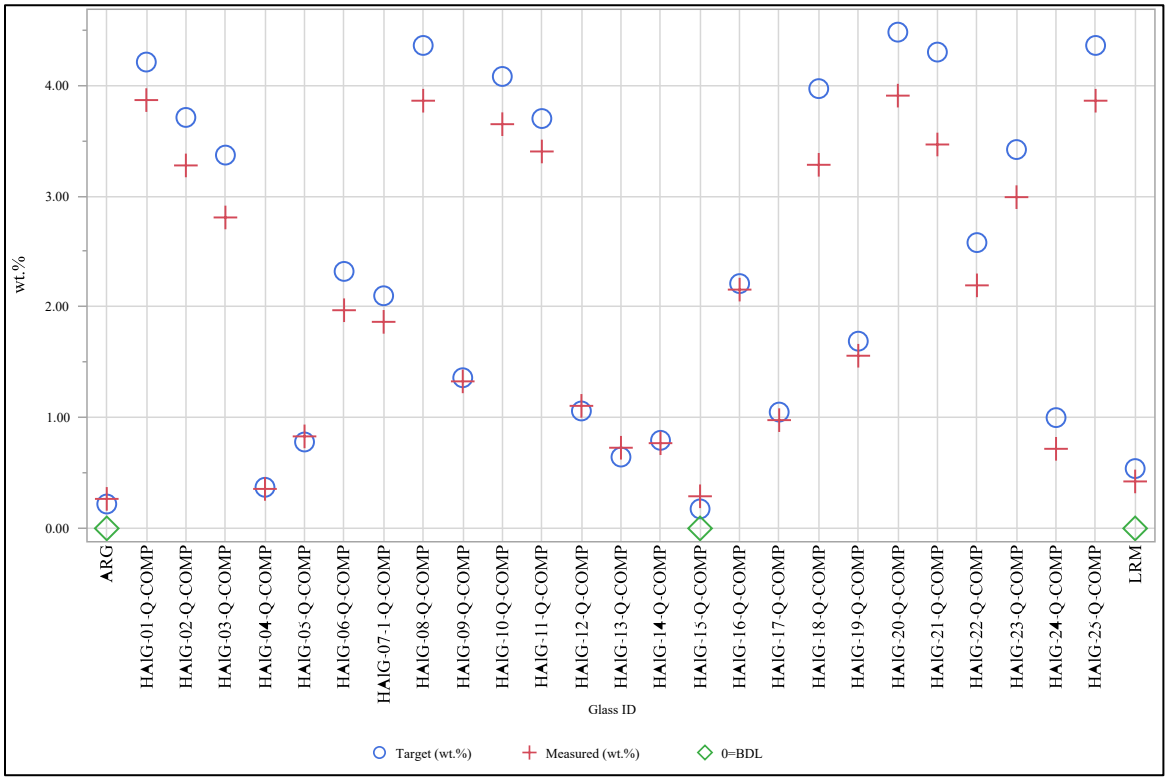


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=P_2O_5



Oxide=SiO_2

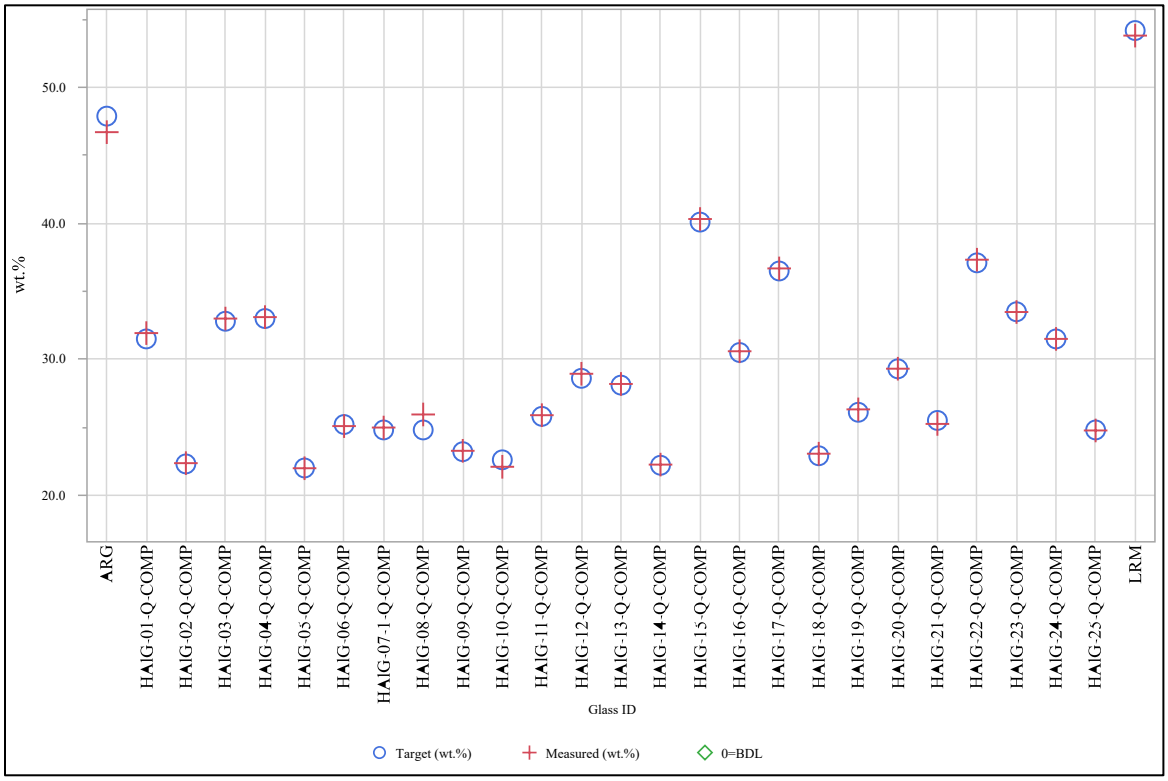
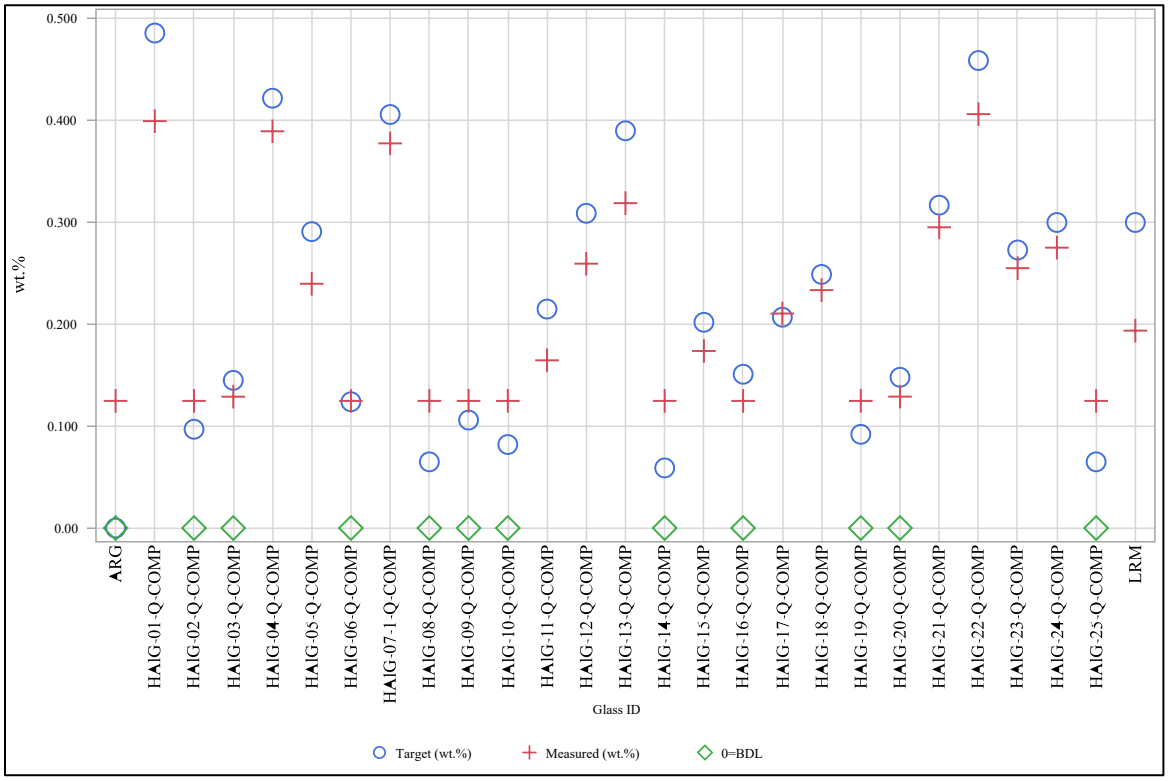


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=SO_3



Oxide=SrO

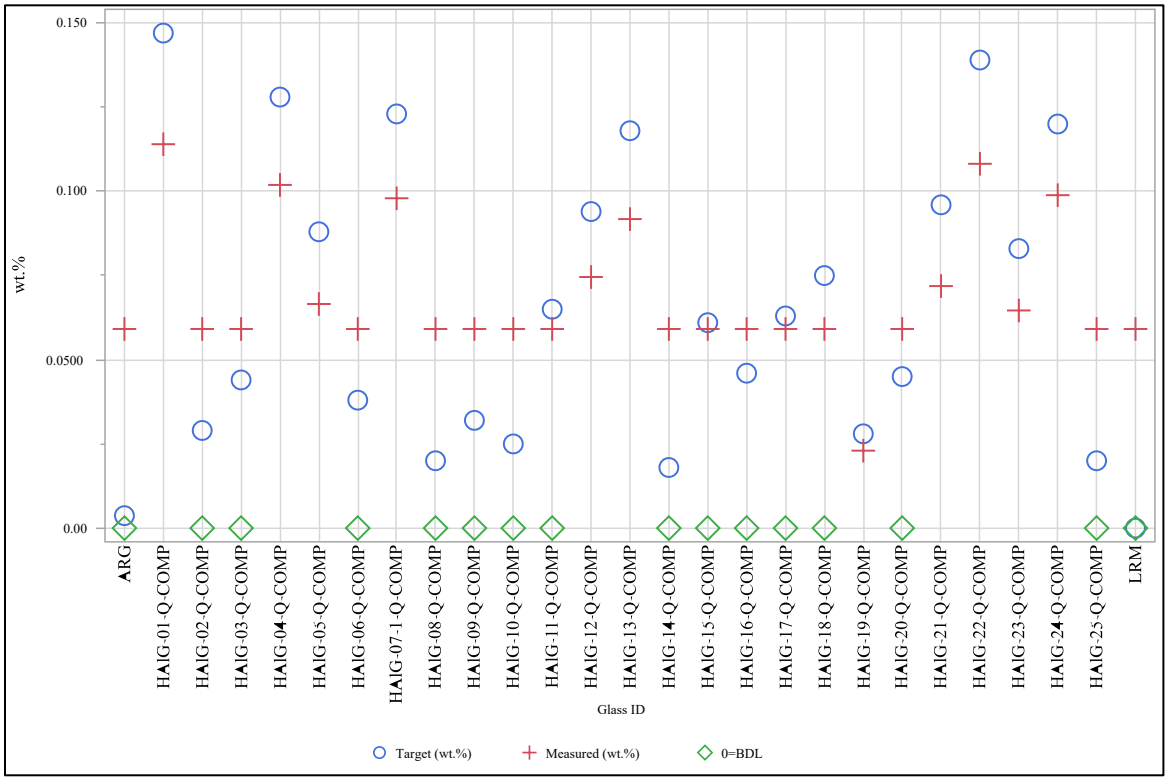
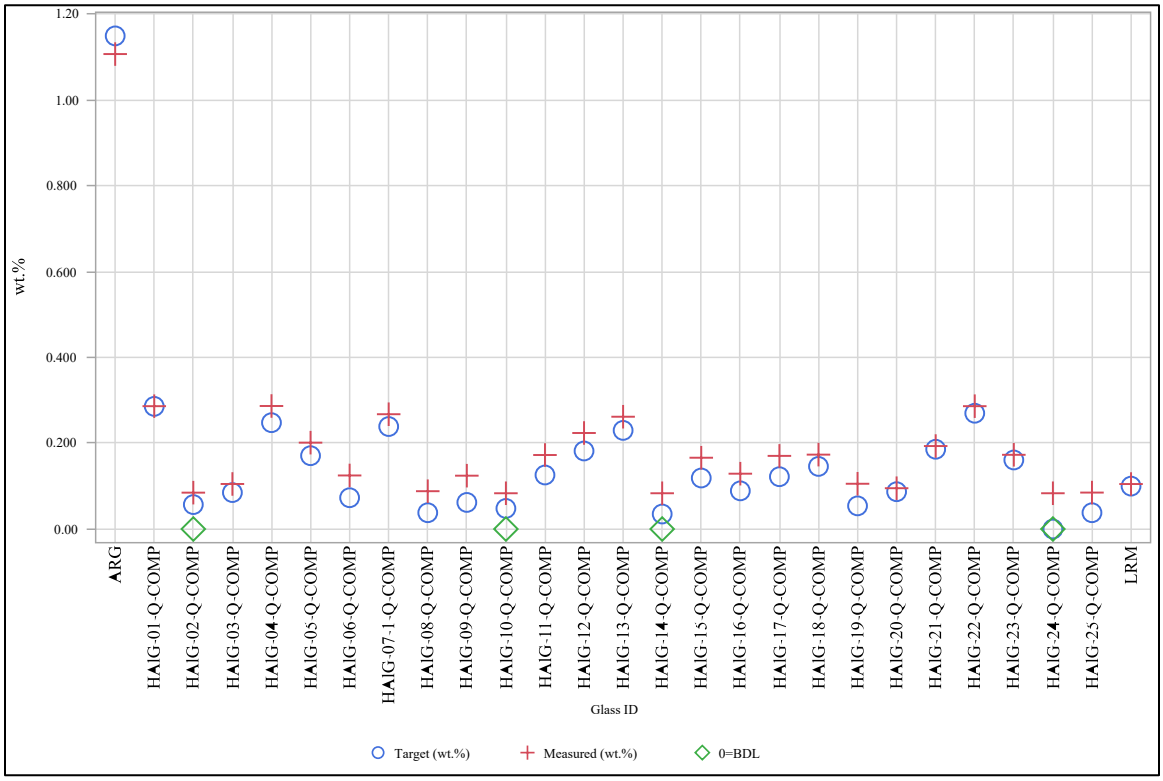


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=TiO_2



Oxide=ZnO

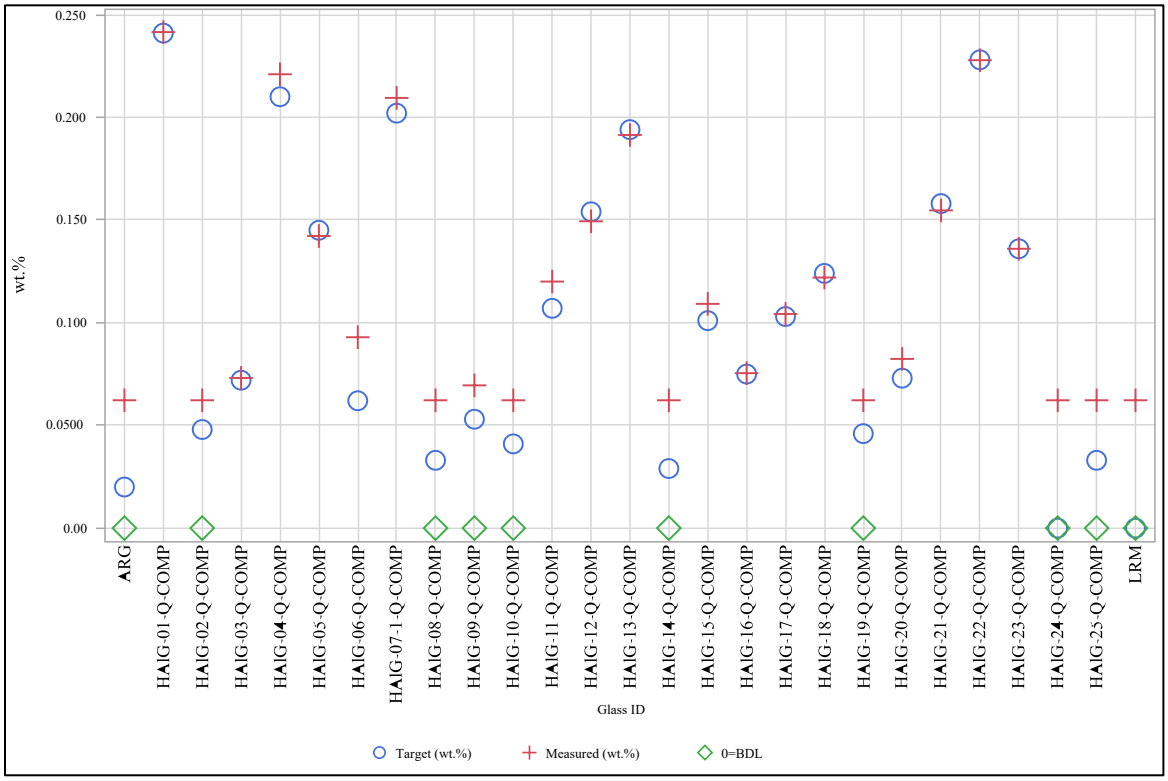
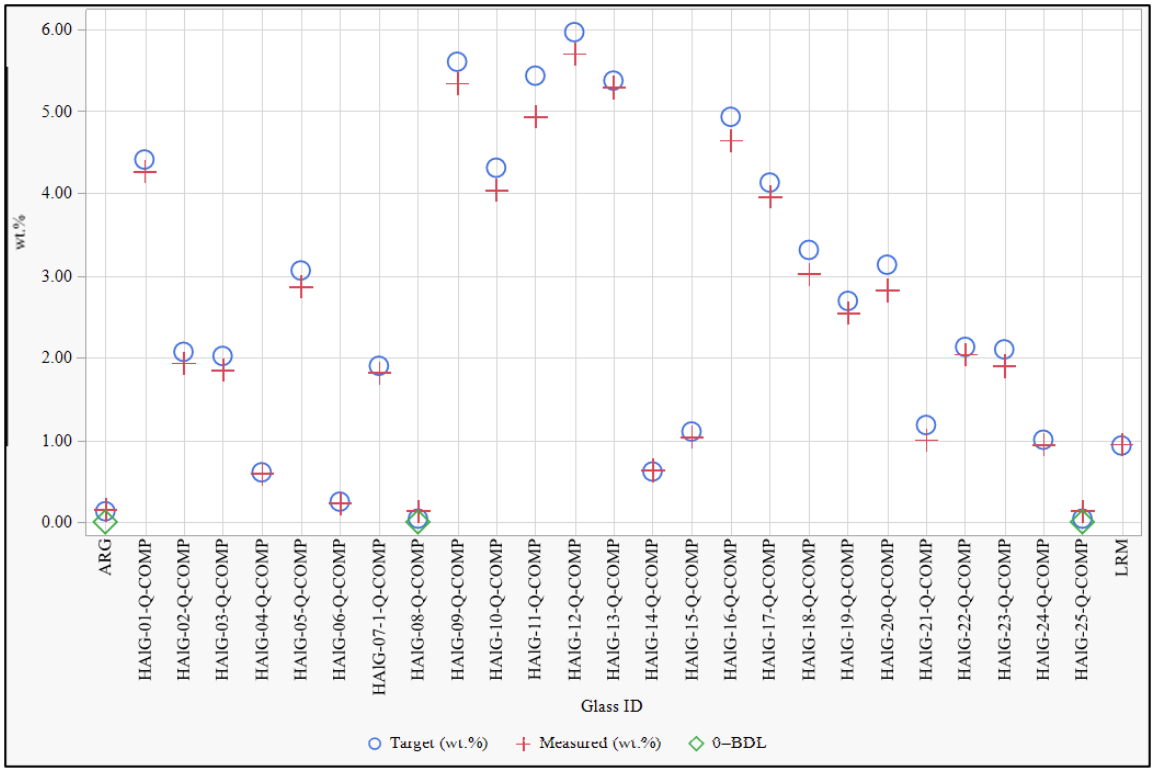
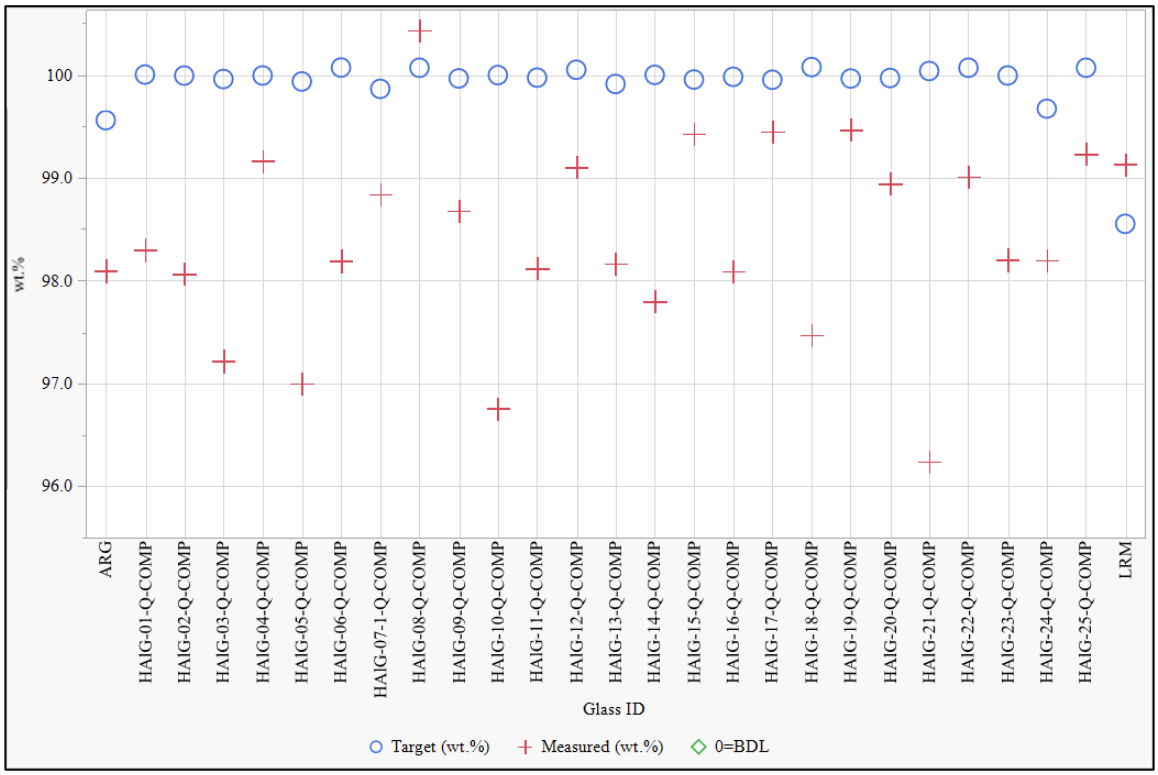


Exhibit A-3. Average Measured versus Target Concentrations by Glass ID by Oxide (continued)

Oxide=ZrO_2



Oxide=Sum of Oxides



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