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Measurement Acceptance Region (MAR) Assessment Results Based on Confirmation Sample Sludge Batch 10 Projections

F.C. Johnson

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EXECUTIVE SUMMARY

The Defense Waste Processing Facility (DWPF) is currently preparing to initiate processing of Sludge Batch 10 (SB10), which is comprised of material from Tanks 11H, 13H, 15H, 26F, 40H (heel only), and Alternate Feed Stock-2 and Sodium Reactor Experiment material from H-Canyon. Frit 473 was recommended for sludge-only (SO) and coupled processing with the Salt Waste Processing Facility (SWPF) based on previous assessments of SB10 projections with the DWPF Product Composition Control System (PCCS) glass property models and their associated Measurement Acceptance Region (MAR) constraints. Savannah River Mission Completion (SRMC) subsequently pursued Wash Cycle Y to further reduce the total sulfur in the sludge batch and increase processing flexibility at DWPF. In October 2022, SRMC System Planning provided an updated SB10 Tank 40H blend baseline projection based on the Tank 51 confirmation sample results. Due to the reduced Na concentration relative to previous SB10 projections, two additional projections based on the addition of 7,000 gallons of caustic were provided in November 2022.

The objectives of this task were to:

- Determine the impact on the operating windows for SO and coupled processing
- Determine whether any composition gaps exist between the already completed SB10 variability study and the reprojected SB10 glass composition region
- Compare the SB10 glass composition region to the DWPF PCCS model development and validation ranges to ensure that compositional gaps do not exist between the data sets

This report documents the results of these evaluations.

Calculation-based frit assessments were performed using the DWPF PCCS glass property models and their associated MAR constraints. Evaluated parameters for coupled processing included the following transfer volumes per SRAT batch: 5700 gallons of Tank 40H sludge, 2400-4500 gallons of the SWPF monosodium titanate (MST) and sludge solids stream, and 15,000 gallons of strip effluent. Due to the reduced Na concentration of the baseline Tank 40H projection, the SO operating windows are significantly reduced as compared to the previous August 2022 projection; 0-4 versus 8-12 percentage points, respectively. An addition of 7,000 gallons of caustic improves the SO operating windows; however, Frit 625 is still more limited than Frit 473. Frit 473 remains viable for SB10 processing with the caustic addition of 7,000 gallons. A target waste loading (WL) of 36% is possible for SO operation and single strike (0.4 g/L MST) coupled processing up to 600 mg/L of Sludge Batch 9 (SB9) insoluble sludge solids at a nominal transfer volume of ~2800 gallons. Increasing the nominal single strike transfer volume to 4500 gallons may reduce the maximum WL below 40%. The use of Frit 625 during the SB9 to SB10 transition is feasible for coupled operation, but more risk will be involved during SO processing due to the reduced operating window. Predictive PCCS evaluations performed at DWPF will provide insight into batch-specific acceptability at desired WLs for compositions having expected oxide ratios during processing versus the extreme vertices (corner points) evaluated in this study.

The reprojected SB10 glass composition region generally overlaps the previously evaluated SB10 variability study composition region. Thus, the minor composition shift of these updated SB10 projections indicates that no additional glasses are necessary to demonstrate acceptability relative to the chemical durability of the Environmental Assessment benchmark glass and predictability using the current PCCS models for durability. Based on a comparison of the PCCS model development and validation data to the reprojected SB10 glass composition region, the viscosity and liquidus temperature models will reliably predict SB10 compositions. No additional glasses are necessary to demonstrate predictability of these models.

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LIST OF ABBREVIATIONS

DWPF	Defense Waste Processing Facility
EA	Environmental Assessment
EVs	extreme vertices
ISS	insoluble sludge solids
MAR	Measurement Acceptance Region
MST	monosodium titanate
NGS	Next Generation Solvent
PCCS	Product Composition Control System
SB9	Sludge Batch 9
SB10	Sludge Batch 10
SE	strip effluent
SME	Slurry Mix Evaporator
SO	sludge-only
SRAT	Sludge Receipt and Adjustment Tank
SRMC	Savannah River Mission Completion
SRNL	Savannah River National Laboratory
SS	sludge solids
SSRT	Sludge Solids Receipt Tank
SWPF	Salt Waste Processing Facility
WL	waste loading
wt.%	weight percent

1.0 Introduction

The Defense Waste Processing Facility (DWPF) is currently preparing to initiate processing of Sludge Batch 10 (SB10), which is comprised of material from Tanks 11H, 13H, 15H, 26F, 40H (heel only), and Alternate Feed Stock-2 and Sodium Reactor Experiment material from H-Canyon. Frit 473[a] was recommended for sludge-only (SO) and coupled processing with the Salt Waste Processing Facility (SWPF) based on previous assessments of SB10 projections with the DWPF Product Composition Control System (PCCS) glass property models and their associated Measurement Acceptance Region (MAR) constraints.[1,2] Savannah River Mission Completion (SRMC) subsequently pursued Wash Cycle Y to further reduce the total sulfur in the sludge batch and increase processing flexibility at DWPF.[3] In October 2022, SRMC System Planning provided an updated SB10 Tank 40H blend baseline projection based on the Tank 51 confirmation sample results.[4,5] Due to the reduced Na concentration relative to previous SB10 projections, two additional projections based on the addition of 7,000 gallons of caustic were provided in November 2022.[6]

The objectives of this task were to:

- Determine the impact on the operating windows for SO and coupled processing
- Determine whether any composition gaps exist between the already completed SB10 variability study and the reprojected SB10 glass composition region[7,8]
- Compare the SB10 glass composition region to the DWPF PCCS model development and validation ranges to ensure that compositional gaps do not exist between the data sets[9-11]

This report documents the results of these evaluations.

2.0 Quality Assurance

This work was requested via a Technical Task Request and directed by a Task Technical and Quality Assurance Plan.[12,13] The functional classification of this task is Production Support. The variability study is waste form affecting and needs to follow the quality assurance requirements of RW-0333P.[14] Microsoft Excel and JMP Version 16.0.0 were used to support this work.[15,16] Requirements for performing reviews of technical reports and the extent of review are established in Manual E7, Procedure 2.60.[17] This document, including calculations, was reviewed by a Design Verification. The Savannah River National Laboratory (SRNL) documents the Design Verification using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.[18] The Design Checklists for this report are stored in electronic laboratory notebook experiment C7592-00311-49.

3.0 MAR Assessments

Calculation-based frit assessments were performed using the DWPF PCCS glass property models and their associated MAR constraints.[1]

3.1 Inputs and Assumptions

The elemental concentrations of each SO Tank 40H blend projection provided by SRMC System Planning (on a calcine basis) were converted to oxides and normalized to 100 weight percent (wt.%) as shown in Appendix A Table A-1.[5,6] These projections represent the baseline confirmation sample Tank 40H blend projection and two Tank 40H blend projections with 7,000 gallons of added caustic[b]; one with a Tank 51 heel of 10 inches and the other with a heel of 30 inches.

[a] $8B_2O_3$-$8Li_2O$-$5Na_2O$-$79SiO_2$ in weight percent.
[b] 50 weight percent NaOH.

3.1.1 SRNL-Developed Inputs for Coupled Processing with SWPF

SRNL performed subsequent calculations with the SO projections in Appendix A Table A-1 to estimate the composition in the Sludge Receipt and Adjustment Tank (SRAT) during coupled operation with SWPF. These calculations were based on projected compositions for strip effluent (SE) as well as the following four cases for compositions of monosodium titanate and sludge solids (MST/SS) in the Sludge Solids Receipt Tank (SSRT) effluent that were originally developed for Sludge Batch 9 (SB9):[19-22]

- Case 1: Single strike operation with no entrained insoluble sludge solids (ISS). This case represents the baseline.
- Case 3A: Single strike operation, with 600 mg/L of entrained ISS, which were assumed to be SB9 sludge solids.[23]
- Case 3B: Single strike operation, with 1200 mg/L of entrained ISS, which were assumed to be SB9 sludge solids.
- Case 4: Double strike operation with no entrained ISS.

Case 2 (single strike with no aluminum) and Case 5 (double strike with no aluminum) were eliminated as these cases are not applicable to SB10.[c,20]

Other pertinent inputs include:

- DWPF receives 5700 gallons of sludge slurry from Tank 40H per SRAT batch[24]
- Nominal single strike operation results in 2800 gallons of the SSRT effluent stream (MST/SS) and 4200 gallons for double strike operation per SRAT batch[20]
    - Incremental variations in these transfer volumes were initially requested for SB9,[20] which SRNL assumed to be ±400 gallons for these assessments; however, DWPF also requested that 4500 gallons be evaluated for single strike operation.[25]
- 0.4 g/L of MST for a single strike[20]
- DWPF receives 15,000 gallons of SE per SRAT batch (Next Generation Solvent (NGS)[d])[20,24]
- Cs-137 concentration in SE is 66 Ci/gallon[26]

SE based on BOBCalixC6 solvent[e] was not evaluated. Previous SB10 MAR assessments have demonstrated that there are minimal or no differences between the operating windows of either solvent.[2,3]

3.2 Method for the Variation Stage MAR Assessments

The approach taken for the Variation Stage MAR assessment[27] was to evaluate how robust candidate frit compositions were relative to expected variation in the composition of the SB10 SRAT material and the uncertainty in targeting the desired waste loading (WL). These uncertainties take effect as DWPF (i) conducts the blending process[f] to target the desired WL for the next Slurry Mix Evaporator (SME) batch, and (ii) subsequently evaluates the new SME batch for acceptability with PCCS, which is driven by the analysis of samples of the new SME batch.

Compositional variation (±) was applied to SRAT compositions to account for likely, but not necessarily bounding, differences that may be seen in the material that is transferred from Tank 40H and SWPF into the SRAT during the processing of SB10. The compositional variation for the individually tracked oxides was represented by the larger of 0.5 wt.% or 7.5% of the nominal concentration.[28] Those oxides not tracked

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[c] Per SRR-WSE-2018-00025, more conservative cases were developed for SB9 where the aluminum concentration in the SSRT effluent stream was set to 0 mg/L. SB10 has a higher Al_2O_3 concentration than SB9, thus there is no concern with the Al_2O_3 concentration being too low in glass for SB10 and Cases 2 and 5 were eliminated.

[d] NGS contains the extractant MaxCalix (1,3-alt-25,27-bis(3,7- dimethyloctyl-1-oxy) calix[4]arene-benzocrown-6), which uses a boric acid strip solution.

[e] BOBCalixC6 is calix[4]arene-bis(tert-octylbenzo-crown-6), which uses a nitric acid strip solution.

[f] Combining SRAT material with frit and the heel of the SME.

individually were grouped into an "Others" component.[g] Note that Gd_2O_3 is present in the Tank 40H blend projections at ~0.1 wt.%; however, it is not an included component in PCCS.[1] Per the DWPF Glass Product Control Program, Gd_2O_3 is currently considered a trace component (elemental concentration <0.5 wt.%) and can be ignored for SB10 process control.[29] Extreme vertices (EVs) were generated using the oxide intervals for each SB10 scenario and were combined with Frit 473 over the interval of 24-42% WL. These SRAT EVs represent the corner points of a multidimensional SB10 composition space. Frit 625[h] was also evaluated against these projections to determine its viability for the SB9 to SB10 transition. Each of the resulting glass compositions was evaluated against the PCCS MAR criteria to determine whether the composition would pass the SME acceptability process.[1] A target WL of 36% ± 4 percentage points is desired for SB10 processing.

3.3 Result and Discussion

Table 3-1 presents a summary of the operating windows for the sludge-only and the nominal single strike MST/SS transfer volume of 2800 gallons. Complete summaries of the operating windows at varied transfer volumes and other cases are shown in Appendix A Table A-2. More detailed MAR assessment results are shown in Appendix A Table A-4 through Table A-9. Results for Cases 3B and 4 are shown, but these cases are unlikely and are not included in the discussion.

Table 3-1. Operating Windows for SB10 with Frit 473 and Frit 625

Case	Case 1 Single Strike	Case 3A Single Strike 600 mg/L ISS	SO
Frit 473			
Baseline (no caustic added)	28-41	32-42	37-40
7000 gal Caustic-10" Heel	26-40	29-42	32-40
7000 gal Caustic-30" Heel	25-40	29-42	31-40
Frit 625			
Baseline (no caustic added)	31-40	35-41	none
7000 gal Caustic-10" Heel	28-39	32-41	36-38
7000 gal Caustic-30" Heel	28-39	32-41	35-38

Due to the decreased Na concentration of the baseline Tank 40H projection, the SO operating windows are significantly reduced as compared to the previous August 2022 projection; 0-4 versus 8-12 percentage points, respectively.[3] The addition of 7,000 gallons of caustic improves the SO operating windows; however, Frit 625 is still more limited than Frit 473. Overall there are minimal differences in the operating windows between the two heel heights of 10 and 30 inches. Other high level trends for the caustic addition projections are described below.

- Cases 1 (nominal single strike) and 3A (single strike with 600 mg/L SB9 ISS) – A target WL of ~36% ± 4 percentage points is possible for nominal single strike operation (MST/SS transfer volume of ~2800 gallons). The maximum WL for Case 1 is reduced below 40% by either using Frit 625 or increasing the MST/SS transfer volume to 4500 gallons.
- SO – Frit 473 has a sufficient operating window of at least 9 percentage points whereas Frit 625 has an operating window of 3-4 percentage points.

These results demonstrate that Frit 473 remains viable for SB10 processing with the caustic addition of 7,000 gallons. A target WL of 36% is possible for SO operation and single strike (0.4 g/L MST) coupled processing up to 600 mg/L of SB9 ISS at a nominal transfer volume of ~2800 gallons. Increasing the single

[g] The "Others" component typically includes BaO, Ce_2O_3, Cr_2O_3, CuO, K_2O, La_2O_3, Li_2O, MgO, PbO, SO_4^{2-}, ZnO, and ZrO_2.
[h] $1Al_2O_3$-$8B_2O_3$-$7Li_2O$-$6Na_2O$-$78SiO_2$ in weight percent.

Case 1 transfer volume to 4500 gallons may reduce the maximum WL below 40%. The use of Frit 625 during the SB9 to SB10 transition is feasible for coupled operation, but more risk will be involved during SO processing due to the reduced operating window. Predictive PCCS evaluations performed at DWPF will provide insight into batch-specific acceptability at desired WLs for compositions having expected oxide ratios during processing versus the EVs (corner points) evaluated in this study.

4.0 Variability Study Evaluation

An evaluation of the reprojected SB10 glass composition region and previously developed SB10 variability study glass composition region is necessary to determine whether additional glasses would be needed to demonstrate that the reprojected SB10 glass composition region is acceptable and predictable.

Prior to developing the SB10 variability study test matrix, the ComPro™ database[30-32] was used to determine whether glasses from previous studies were already within the SB10 glass composition region of interest. As documented previously, eighty-five "model" entries were found to have compositions that simultaneously satisfied the oxide intervals of the search criteria.[i,7] These entries included glass compositions from the Sludge Batch 6,[33] Sludge Batch 7a,[34-36] and Sludge Batch 7b[37] variability studies. Thus, eight glasses were fabricated and tested for the SB10 variability study to supplement the existing durability data.[7,8]

Table 4-1 presents a comparison of the minimum and maximum nominal oxide concentrations of the most recent reprojected SB10 glass composition region, and the composition region defined by the eighty-five ComPro™ entries and eight SB10 variability study test glasses. The reprojected SB10 composition region is based on the Tank 40H blend projections with and without caustic addition (Appendix A Table A-1) and both Frit 473 and Frit 625 over a WL interval of 32-40%. Projections representing both Tank 51 heel heights of 10 and 30 inches were included. SO, sludge and SE, and the following coupled operation scenarios from Section 3.1.1 were evaluated:

- DWPF receives 5700 gallons of sludge slurry from Tank 40H per SRAT batch
- Case 1 (nominal single strike) and Case 3A (single strike with 600 mg/L of SB9 ISS) with MST/SS transfer volumes of 2400, 2800 and 4500 gallons per SRAT batch
- 15,000 gallons of SE transferred per SRAT batch (NGS)

A numerical difference is shown in Table 4-1 only when the reprojected SB10 oxide concentration falls outside of the oxide interval defined by the SB10 variability study glasses and ComPro™ entries. The oxide intervals for the reprojected SB10 glass composition region are generally within the oxide intervals evaluated in the variability studies. TiO_2 has the highest difference (1.09 wt.%) followed by Cs_2O (0.89 wt.%). Otherwise, minor compositional differences less than 0.4 wt.% exist for Al_2O_3, Gd_2O_3, Li_2O, Na_2O, SO_4^{2-}, U_3O_8, and ZrO_2. The Cs_2O concentration in glass is highly dependent on the operating parameters and the maximum concentration is reduced if the actual Cs-137 concentration is less than the assumed 66 Ci/gal. DWPF durability models have been validated to 5.85 wt.% TiO_2 and 1.62 wt.% Cs_2O,[10] so the anticipated concentrations for SB10 are still within the validated ranges although being outside of the SB10 variability study. As mentioned in Section 3.2, Gd_2O_3 is not an included component in PCCS.[1] Per the DWPF Glass Product Control Program, Gd_2O_3 is currently considered a trace component (elemental concentration <0.5 wt.%) and can be ignored for SB10 process control.[29]

Despite minor compositional differences, the PCCS durability models[1] will reliably predict the durability of compositions within the reprojected SB10 glass region. Based on the slight compositional shifts of the reprojected SB10 glass region, no additional glasses are necessary to demonstrate acceptability relative to

[i] "Model" entries are results from studies that were conducted under quality assurance criteria that were RW-0333P compliant or criteria determined to be RW-0333P equivalent.

the chemical durability of the Environmental Assessment (EA) benchmark glass and predictability using the PCCS models for durability.[1,29,38,39]

Table 4-1. Comparison of Reprojected SB10 Glass Oxide Intervals and Previous SB10 Variability Study Oxide Intervals (wt.%)

	SB10 Variability Study and ComPro^{TM} Entries		Reprojected SB10 Glass Composition Region		Difference*	
	minimum	maximum	minimum	maximum	minimum	maximum
Al_2O_3	7.01	12.69	6.91	12.29	-0.10	----
B_2O_3	4.37	7.45	4.82	5.75	----	----
BaO	0.00	0.07	0.02	0.04	----	----
CaO	0.27	0.84	0.32	0.55	----	----
Ce_2O_3	0.01	0.17	0.06	0.10	----	----
Cr_2O_3	0.01	0.22	0.04	0.10	----	----
Cs_2O	0.00	0.00	0.00	0.89	----	0.89
CuO	0.01	0.10	0.01	0.03	----	----
Fe_2O_3	5.08	10.09	5.28	9.17	----	----
Gd_2O_3	0.00	0.00	0.02	0.04	----	0.04
K_2O	0.03	0.47	0.05	0.14	----	----
La_2O_3	0.00	0.04	0.01	0.03	----	----
Li_2O	4.59	6.40	4.24	5.47	-0.35	----
MgO	0.03	0.46	0.12	0.20	----	----
MnO	1.07	2.67	1.49	2.66	----	----
Na_2O	11.36	17.07	11.54	17.12	----	0.05
NiO	0.20	1.50	0.22	0.37	----	----
P_2O_5	0.00	0.17	0.00	0.06	----	----
PbO	0.00	0.05	0.01	0.02	----	----
SO_4^{2-}	0.32	1.23	0.23	0.42	-0.09	----
SiO_2	45.22	54.49	47.74	54.47	----	----
ThO_2	0.14	1.26	0.51	0.94	----	----
TiO_2	0.01	3.28	0.01	4.37	----	1.09
U_3O_8	1.06	2.88	0.98	1.70	-0.09	----
ZnO	0.00	0.04	0.01	0.02	----	----
ZrO_2	0.03	0.21	0.02	0.04	-0.01	----

* Differences were calculated using more decimal places than shown in this table, which may result in slight variation due to rounding.

5.0 PCCS Models Evaluation

The DWPF PCCS is comprised of three composition-based glass property models, which include durability, viscosity and liquidus temperature.[1] Each of the DWPF PCCS glass property models have been developed and validated over specific oxide ranges.[9-11] While the variability study focuses on the waste-form affecting durability model and is performed for each sludge batch, the viscosity and liquidus temperature models are processing constraints and are not included.[29,39] The objective of this evaluation is to compare the reprojected SB10 composition region shown in Table 4-1 to the PCCS model development ranges to ensure that compositional gaps do not exist between the data sets.

Table 5-1 shows a comparison of the reprojected SB10 glass composition region (Tank 40H blend projections with and without caustic addition) to the PCCS model development oxides ranges. As noted below the table, the durability model ranges include both the model development data and SWPF validation data for ease of comparison since the model development ranges are more limited for some of the oxides.[10]

A numerical difference is only shown in Table 5-1 when the reprojected SB10 concentrations fall outside of the ranges defined by the PCCS model data. The SB10 data generally fall within the PCCS model ranges and minor differences exist for Gd_2O_3, P_2O_5, and SO_4^{2-}. Na_2O has the highest difference of 1.32 wt.% for the liquidus temperature model only; however, the liquidus temperature model has been validated to 17.39 wt.% Na_2O versus a maximum 17.12 wt.% projected for SB10. Based on a comparison of the PCCS model development and validation data to the SB10 glass composition region, the viscosity and liquidus temperature models will reliably predict SB10 compositions. No additional glasses are necessary to demonstrate predictability of these models.

Table 5-1. Comparison of PCCS Model Data and Reprojected SB10 Glass Composition Region (wt.%)

Oxide	Model Development Ranges						Reproj. SB10 Glass Region		Durability Difference**		Viscosity Difference**		Liquidus Temp Difference**	
	Durability*		Viscosity		Liquidus Temp									
	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Al_2O_3	2.99	13.90	0	13.90	0.99	14.16	6.91	12.29	----	----	----	----	----	----
B_2O_3	4.57	13.30	4.57	12.20	4.57	12.65	4.82	5.75	----	----	----	----	----	----
BaO	0	0.66	0	0.31	0	0.29	0.02	0.04	----	----	----	----	----	----
CaO	0.22	2.23	0	2.05	0.23	2.01	0.32	0.55	----	----	----	----	----	----
Ce_2O_3	0	1.44	0	0.42	0	0.24	0.06	0.10	----	----	----	----	----	----
Cr_2O_3	0	0.55	0	0.19	0	0.30	0.04	0.10	----	----	----	----	----	----
Cs_2O	0	1.62	0	1.62	0	1.26	0.00	0.89	----	----	----	----	----	----
CuO	0	0.33	0	0.66	0	0.06	0.01	0.03	----	----	----	----	----	----
Fe_2O_3	0	15.51	0	15.51	3.43	16.98	5.28	9.17	----	----	----	----	----	----
Gd_2O_3	0	0	0	0	0	0	0.02	0.04	----	0.04	----	0.04	----	0.04
K_2O	0	5.73	0	5.73	0	3.89	0.05	0.14	----	----	----	----	----	----
La_2O_3	0	0.42	0	0.36	0	0.36	0.01	0.03	----	----	----	----	----	----
Li_2O	1.05	6.81	1.05	6.96	2.26	6.81	4.24	5.47	----	----	----	----	----	----
MgO	0	3.24	0	2.92	0	2.65	0.12	0.20	----	----	----	----	----	----
MnO	0	4.08	0	4.08	0.74	4.08	1.49	2.66	----	----	----	----	----	----
Na_2O	6.42	18.14	5.80	18.14	5.99	15.81	11.54	17.12	----	----	----	----	----	1.32
NiO	0	1.99	0	2.97	0	3.05	0.22	0.37	----	----	----	----	----	----
P_2O_5	0	0.65	0	0	0	0	0.00	0.06	----	----	----	0.06	----	0.06
PbO	0	0.25	0	0.23	0	0.23	0.01	0.02	----	----	----	----	----	----
SO_4^{2-}	0	0.37	0	0.37	0	0.34	0.23	0.42	----	0.05	----	0.05	----	0.08
SiO_2	39.80	57.00	40.00	77.04	40.10	58.23	47.74	54.47	----	----	----	----	----	----
ThO_2	0	0.95	0	0.95	0	0.95	0.51	0.94	----	----	----	----	----	----
TiO_2	0	5.85	0	5.85	0	5.85	0.01	4.37	----	----	----	----	----	----
U_3O_8	0	6.24	0	6.24	0	6.24	0.98	1.70	----	----	----	----	----	----
ZnO	0	1.46	0	0.20	0	0.20	0.01	0.02	----	----	----	----	----	----
ZrO_2	0	1.80	0	0.99	0	0.97	0.02	0.04	----	----	----	----	----	----

*The durability model ranges include both the model development data and the SWPF validation data.[10]

**Differences were calculated using more decimal places than shown in this table, which may result in slight variation due to rounding.

6.0 Conclusions

Calculation-based frit assessments were performed using the DWPF PCCS glass property models and their associated MAR constraints. Evaluated parameters for coupled processing included the following transfer volumes per SRAT batch: 5700 gallons of Tank 40H sludge, 2400-4500 gallons of the SWPF MST/SS stream, and 15,000 gallons of SE. Due to the decreased Na concentration of the baseline Tank 40H projection, the SO operating windows are significantly reduced as compared to the previous August 2022 projection; 0-4 versus 8-12 percentage points, respectively. An addition of 7,000 gallons of caustic improves the SO operating windows; however, Frit 625 is still more limited than Frit 473. Frit 473 remains viable for SB10 processing with the caustic addition of 7,000 gallons. A target WL of 36% is possible for SO operation and single strike (0.4 g/L MST) coupled processing up to 600 mg/L of SB9 ISS at a nominal transfer volume of ~2800 gallons. Increasing the Case 1 transfer volume to 4500 gallons may reduce the maximum WL below 40%. The use of Frit 625 during the SB9 to SB10 transition is feasible for coupled operation, but more risk will be involved during SO processing due to the reduced operating window. Predictive PCCS evaluations performed at DWPF will provide insight into batch-specific acceptability at desired WLs for compositions having expected oxide ratios during processing versus the EVs (corner points) evaluated in this study.

The reprojected SB10 glass composition region generally overlaps the previously evaluated SB10 variability study composition region. Thus, the minor composition shift of these updated SB10 projections indicates that no additional glasses are necessary to demonstrate acceptability relative to the chemical durability of the EA benchmark glass and predictability using the current PCCS models for durability. Based on a comparison of the PCCS model development and validation data to the reprojected SB10 glass composition region, the viscosity and liquidus temperature models will reliably predict SB10 compositions. No additional glasses are necessary to demonstrate predictability of these models.

7.0 References

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Appendix A. Supplementary Information and MAR Assessment Results

Table A-1. Normalized SB10 Confirmation Sample Tank 40H Blend Projections (wt.%)

Projection	Baseline October 2022	7000 gal Caustic 10” Heel November 2022	7000 gal Caustic 30” Heel November 2022
Al_2O_3	29.21	28.10	27.42
B_2O_3	0.05	0.05	0.05
BaO	0.09	0.09	0.09
CaO	1.39	1.33	1.35
Ce_2O_3	0.25	0.24	0.24
Cr_2O_3	0.24	0.23	0.23
CuO	0.08	0.07	0.07
Fe_2O_3	22.93	22.03	22.27
Gd_2O_3	0.10	0.09	0.09
K_2O	0.17	0.17	0.17
La_2O_3	0.07	0.06	0.06
Li_2O	0.09	0.09	0.09
MgO	0.51	0.49	0.48
MnO	6.46	6.20	6.29
Na_2O	27.62	30.43	30.74
NiO	0.94	0.90	0.93
PbO	0.05	0.05	0.05
SO_4^{2-}	0.91	0.88	0.88
SiO_2	2.08	2.00	2.06
ThO_2	2.35	2.26	2.21
TiO_2	0.04	0.04	0.04
U_3O_8	4.25	4.08	4.08
ZnO	0.04	0.04	0.04
ZrO_2	0.09	0.09	0.09

Table A-2. Summary of Operating Windows of SB10 Confirmation Sample Projections (NGS)

Case	Case 1 Single Strike			Case 3A Single Strike 600 mg/L ISS			Case 3B Single Strike 1200 mg/L ISS			Case 4 Double Strike			SO
SRAT Transfer Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
MST/SS Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Volume (gal)	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	0
Frit 473 Operating Windows (%WL)													
Baseline (no caustic added)	28-41	28-41	25-40	32-42	32-42	30-41	35-39	35-39	35-37	26-40	25-40	24-37	37-40
7000 gal Caustic-10” Heel	26-41	26-40	24-38	29-42	29-42	28-42	33-41	33-41	33-38	24-39	24-38	24-38	32-40
7000 gal Caustic-30” Heel	26-40	25-40	24-38	29-42	29-42	28-42	32-42	32-41	33-38	24-38	24-38	24-38	31-40
Frit 625 Operating Windows (%WL)													
Baseline (no caustic added)	31-40	31-40	28-40	35-41	35-41	33-40	39	none	none	28-40	28-40	27-37	none
7000 gal Caustic-10” Heel	29-39	28-39	26-39	33-41	32-41	32-42	36-41	36-40	37-38	27-40	26-39	26-38	36-38
7000 gal Caustic-30” Heel	29-39	28-39	26-39	32-41	32-41	31-42	35-41	35-40	36-38	26-39	26-39	25-38	35-38

Guidance for Interpretation of Detailed MAR Assessment Results

Consider the Case 1 column (SSRT [MST/SS] transfer volume of 2800 gallons) in Table A-4 as an example for the interpretation of the information provided. The number of EVs are provided for reference. The projected operating window is 28-41% WL (shaded green). At each WL shaded green, all 9,744 EVs pass the SME acceptability process. At 27% WL, 0.08% of the EVs fail the high viscosity constraint (shaded yellow). At 42% WL, 5.4% of the EVs fail the nepheline constraint (shaded red). Entries shaded in yellow have EVs failing processing constraints (low/high viscosity and liquidus temperature) whereas entries shaded in red have EVs failing waste form affecting constraints (nepheline) or exceeding a concentration limit (maximum TiO_2).

A list of the DWPF PCCS constraints is shown in Table A-3 for reference. Reference 1 provides details of the constraints themselves and additional uncertainties that are not accounted for in the nominal values shown in this table.

Table A-3. DWPF PCCS Constraints

Name	**Constraint**[1]
Conservation (Sum of Oxides)	95-105 wt.%
Durability*	B release ≤ 14.251 g/L Li release ≤ 8.095 g/L Na release ≤ 11.542 g/L
Homogeneity	If $TiO_2 \leq 2$ wt.% $Al_2O_3 \geq 3$ wt.% AND sum of alkali ≤ 19.3 wt.% OR $Al_2O_3 \geq 4$ wt.% If $TiO_2 > 2$ wt.% $Al_2O_3 \geq 4$ wt.%
Liquidus Temperature	≤ 1050°C
TiO_2	≤ 6 wt.%
Viscosity	20-110 poise
NaCl	≤ 1 wt.%
NaF	≤ 1 wt.%
Cr_2O_3	≤ 0.3 wt.%
Cu	≤ 0.5 wt.%
Nepheline	$\frac{SiO_2}{SiO_2+Na_2O+Al_2O_3} > 0.62$

* Note that the durability constraints represent Product Consistency Test releases that are two standard deviations below the reported mean releases from the EA benchmark glass, as required per the Waste Acceptance Product Specifications acceptance criterion for product consistency.[38]

Table A-4. SB10 MAR Assessment Results (Baseline Projection, Frit 473 – October 2022)

Case: Baseline (no caustic added)	Case 1 Single Strike			Case 3A Single Strike - 600 mg/L ISS			Case 3B Single Strike - 1200 mg/L ISS			Case 4 Double Strike			SO
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9618	9744	9445	9408	9408	9559	9408	9660	9751	9368	9368	9242	2091
%WL, 24	highv(50%)	highv(43%)	highv(1.7%)	highv(90%)	highv(85%)	highv(69%)	highv(100%)	highv(100%)	highv(100%)	highv(13%)	highv(1.4%)		highv(100%)
25	highv(41%)	highv(34%)		highv(67%)	highv(65%)	highv(60%)	highv(100%)	highv(100%)	highv(100%)	highv(0.01%)			highv(100%)
26	highv(28%)	highv(12%)		highv(59%)	highv(56%)	highv(42%)	highv(94%)	highv(95%)	highv(98%)				highv(93%)
27	highv(6.5%)	highv(0.08%)		highv(45%)	highv(43%)	highv(33%)	highv(77%)	highv(79%)	highv(82%)				highv(79%)
28				highv(38%)	highv(35%)	highv(18%)	highv(68%)	highv(69%)	highv(71%)				highv(64%)
29				highv(28%)	highv(22%)	highv(3.1%)	highv(60%)	highv(60%)	highv(62%)				highv(56%)
30				highv(11%)	highv(6.7%)		highv(43%)	highv(42%)	highv(43%)				highv(49%)
31				highv(0.74%)	highv(0.01%)		highv(35%)	highv(34%)	highv(33%)				highv(43%)
32							highv(26%)	highv(25%)	highv(23%)				highv(37%)
33							highv(13%)	highv(13%)	highv(12%)				highv(30%)
34							highv(3.1%)	highv(2.8%)	highv(2.4%)				highv(22%)
35													highv(13%)
36													highv(1.9%)
37													
38									TL(0.77%)			maxTi(48%)	
39									TL(6.2%)			maxTi(48%)	
40							TL(0.07%)	TL(1.0%)	TL(17%)			lowv(0.01%) lowv maxTi(0.35%) maxTi(49%)	
41			lowv(9.6%)				TL(2.0%)	TL(6.6%)	TL(29%)	lowv(0.36%)	lowv(2.9%) lowv maxTi(3.2%) maxTi(44%)	lowv(8.9%) lowv maxTi(10%) maxTi(42%)	Neph(2.7%)
42	Neph(6.1%)	Neph(5.4%)	lowv(34%) Neph(4.4%)			TL(0.60%)	TL(8.3%)	TL(16%)	TL(40%)	lowv(18%)	lowv(16%) lowv maxTi(15%) maxTi(33%)	lowv(18%) lowv maxTi(19%) maxTi(34%)	Neph(13%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline

Table A-5. SB10 MAR Assessment Results (Baseline Projection, Frit 625 – October 2022)

Case: Baseline (no caustic added)	**Case 1 Single Strike**			**Case 3A Single Strike - 600 mg/L ISS**			**Case 3B Single Strike - 1200 mg/L ISS**			**Case 4 Double Strike**			**SO**
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9618	9744	9445	9408	9408	9559	9408	9660	9751	9368	9368	9242	2091
%WL, 24	highv(96%)	highv(82%)	highv(50%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(57%)	highv(51%)	highv(44%)	highv(100%)
25	highv(69%)	highv(61%)	highv(40%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(44%)	highv(39%)	highv(33%)	highv(100%)
26	highv(59%)	highv(52%)	highv(23%)	highv(100%)	highv(100%)	highv(89%)	highv(100%)	highv(100%)	highv(100%)	highv(34%)	highv(22%)	highv(6.4%)	highv(100%)
27	highv(48%)	highv(42%)	highv(0.43%)	highv(86%)	highv(81%)	highv(67%)	highv(100%)	highv(100%)	highv(100%)	highv(9.1%)	highv(0.50%)		highv(100%)
28	highv(40%)	highv(33%)		highv(66%)	highv(64%)	highv(59%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
29	highv(28%)	highv(11%)		highv(58%)	highv(56%)	highv(42%)	highv(94%)	highv(95%)	highv(98%)				highv(93%)
30	highv(7.3%)	highv(0.16%)		highv(46%)	highv(43%)	highv(34%)	highv(78%)	highv(79%)	highv(83%)				highv(80%)
31				highv(39%)	highv(36%)	highv(21%)	highv(68%)	highv(70%)	highv(72%)				highv(65%)
32				highv(31%)	highv(25%)	highv(4.8%)	highv(62%)	highv(63%)	highv(64%)				highv(56%)
33				highv(15%)	highv(9.8%)		highv(46%)	highv(46%)	highv(47%)				highv(52%)
34				highv(2.5%)	highv(0.57%)		highv(37%)	highv(36%)	highv(35%)				highv(44%)
35							highv(31%)	highv(29%)	highv(28%)				highv(38%)
36							highv(18%)	highv(17%)	highv(16%)				highv(33%)
37							highv(7.1%)	highv(6.9%)	highv(5.8%) TL(0.28%)				highv(24%)
38							highv(0.52%)	highv(0.30%)	highv(0.27%) TL(5.1%)			maxTi(48%)	highv(17%)
39								TL(0.28%)	TL(16%)			maxTi(48%)	highv(7.7%)
40							TL(0.95%)	TL(5.1%)	TL(27%)			maxTi(49%)	Neph(7.2%)
41	Neph(9.6%)	Neph(9.5%)	Neph(8.3%)			TL(0.37%)	TL(6.6%)	TL(15%)	TL(38%)	Neph(2.8%)	maxTi(47%)	lowv maxTi(0.14%) maxTi(52%)	Neph(23%)
42	Neph(38%)	Neph(36%)	lowv(0.07%) lowv Neph(7.1%) Neph(30%)	Neph(5.0%)	TL(0.01%)	TL(4.0%)	TL(16%)	TL(23%)	TL(53%)	lowv(0.10%) Neph(13%)	lowv(1.7%) lowv maxTi(2.6%) maxTi(45%) maxTi Neph(1.2%) Neph(8.9%)	lowv(6.5%) lowv maxTi(10%) lowv maxTi Neph(0.01%) maxTi(42%) maxTi Neph(1.6%) Neph(8.7%)	Neph(85%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline

Table A-6. SB10 Confirmation Sample MAR Assessment Results (10" Heel-7000 gal Caustic Projection, Frit 473 – November 2022)

Case: 10" Heel 7000 gal Caustic	Case 1 Single Strike			Case 3A Single Strike - 600 mg/L ISS			Case 3B Single Strike - 1200 mg/L ISS			Case 4 Double Strike			SO
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9468	9468	9522	9048	9048	9685	9660	9660	9811	9536	9410	9284	2056
%WL, 24	highv(29%)	highv(13%)		highv(58%)	highv(57%)	highv(53%)	highv(99%)	highv(100%)	highv(100%)				highv(88%)
25	highv(4.1%)	highv(0.08%)		highv(45%)	highv(43%)	highv(39%)	highv(79%)	highv(82%)	highv(92%)				highv(66%)
26				highv(36%)	highv(34%)	highv(27%)	highv(65%)	highv(66%)	highv(74%)				highv(56%)
27				highv(23%)	highv(19%)	highv(6.1%)	highv(55%)	highv(57%)	highv(65%)				highv(52%)
28				highv(5.4%)	highv(3.3%)		highv(39%)	highv(40%)	highv(47%)				highv(45%)
29							highv(32%)	highv(33%)	highv(34%)				highv(36%)
30							highv(19%)	highv(20%)	highv(24%)				highv(23%)
31							highv(6.2%)	highv(6.9%)	highv(11%)				highv(10%)
32							highv(0.16%)	highv(0.17%)	highv(1.7%)				
33													
34													
35													
36													
37													
38													
39			lowv(0.75%)						TL(0.11%)		lowv(0.15%)	lowv(1.7%) lowv maxTi(2.7%) maxTi(44%)	
40			lowv(24%)						TL(2.2%)	lowv(7.9%)	lowv(21%)	lowv(18%) lowv maxTi(13%) maxTi(35%)	
41		lowv(2.1%)	lowv(40%)						TL(9.6%)	lowv(33%)	lowv(39%)	lowv(25%) lowv maxTi(17%) maxTi(33%)	Neph(7.6%)
42	lowv(9.7%) Neph(9.8%)	lowv(24%) Neph(9.8%)	lowv(43%) lowv Neph(6.5%) Neph(1.6%)				TL(0.01%)	TL(0.89%)	TL(21%)	lowv(42%) lowv Neph(1.4%) Neph(1.5%)	lowv(29%) lowv maxTi(20%) maxTi(28%)	lowv(30%) lowv maxTi(23%) maxTi(29%)	Neph(47%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline

Table A-7. SB10 Confirmation Sample MAR Assessment Results (10" Heel-7000 gal Caustic Projection, Frit 625 – November 2022)

Case: 10" Heel 7000 gal Caustic	Case 1 Single Strike			Case 3A Single Strike - 600 mg/L ISS			Case 3B Single Strike - 1200 mg/L ISS			Case 4 Double Strike			SO
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9468	9468	9522	9048	9048	9685	9660	9660	9811	9536	9410	9284	2056
%WL, 24	highv(58%)	highv(53%)	highv(36%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(100%)	highv(41%)	highv(35%)	highv(28%)	highv(100%)
25	highv(48%)	highv(43%)	highv(9.5%)	highv(93%)	highv(90%)	highv(80%)	highv(100%)	highv(100%)	highv(100%)	highv(24%)	highv(9.6%)	highv(0.81%)	highv(100%)
26	highv(38%)	highv(33%)		highv(67%)	highv(65%)	highv(63%)	highv(100%)	highv(100%)	highv(100%)	highv(0.43%)			highv(100%)
27	highv(25%)	highv(9.2%)		highv(57%)	highv(56%)	highv(50%)	highv(97%)	highv(99%)	highv(100%)				highv(85%)
28	highv(3.3%)			highv(44%)	highv(42%)	highv(38%)	highv(78%)	highv(81%)	highv(91%)				highv(66%)
29				highv(36%)	highv(34%)	highv(26%)	highv(65%)	highv(66%)	highv(73%)				highv(56%)
30				highv(23%)	highv(19%)	highv(6.8%)	highv(56%)	highv(58%)	highv(66%)				highv(52%)
31				highv(6.3%)	highv(3.7%)	highv(0.01%)	highv(40%)	highv(41%)	highv(49%)				highv(46%)
32				highv(0.11%)			highv(33%)	highv(34%)	highv(35%)				highv(39%)
33							highv(22%)	highv(24%)	highv(28%)				highv(26%)
34							highv(9.3%)	highv(10%)	highv(15%)				highv(13%)
35							highv(0.72%)	highv(1.4%)	highv(4.3%)				highv(0.49%)
36									highv(0.08%)				
37													
38													
39									TL(1.4%)			maxTi(47%)	Neph(2.0%)
40	Neph(6.2%)	Neph(6.2%)	lowv(0.38%) Neph(5.1%)						TL(8.2%)		lowv(0.13%)	lowv(0.98%) lowv maxTi(1.9%) maxTi(46%)	Neph(15%)
41	Neph(33%)	Neph(20%)	lowv(21%) lowv Neph(1.9%) Neph(14%)					TL(0.30%)	TL(19%)	lowv(6.0%) Neph(8.0%)	lowv(18%) Neph(8.1%)	lowv(16%) lowv maxTi(13%) maxTi(37%) maxTi Neph(0.40%) Neph(5.7%)	Neph(80%)
42	Neph(85%)	lowv Neph(0.77%) Neph(84%)	lowv(1.8%) lowv Neph(38%) Neph(31%)	Neph(10%)	Neph(7.3%)		TL(0.53%)	TL(3.2%)	TL(28%)	lowv(14%) lowv Neph(18%) Neph(16%)	lowv(11%) lowv maxTi(8.3%) lowv maxTi Neph(8.1%) lowv Neph(11%) maxTi(29%) maxTi Neph(2.6%) Neph(11%)	lowv(12%) lowv maxTi(10%) lowv maxTi Neph(8.6%) lowv Neph(11%) maxTi(31%) maxTi Neph(2.3%) Neph(10%)	Neph(95%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline

Table A-8. SB10 Confirmation Sample MAR Assessment Results (30" Heel-7000 gal Caustic Projection, Frit 473 – November 2022)

Case: 30" Heel 7000 gal Caustic	Case 1 Single Strike			Case 3A Single Strike - 600 mg/L ISS			Case 3B Single Strike - 1200 mg/L ISS			Case 4 Double Strike			SO
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9468	9360	9396	9048	9048	9685	9408	9408	9727	9410	9284	9284	1993
%WL, 24	highv(15%)	highv(3.2%)		highv(54%)	highv(52%)	highv(46%)	highv(92%)	highv(95%)	highv(100%)				highv(73%)
25	highv(0.10%)			highv(39%)	highv(38%)	highv(35%)	highv(70%)	highv(74%)	highv(86%)				highv(58%)
26				highv(30%)	highv(28%)	highv(17%)	highv(60%)	highv(62%)	highv(70%)				highv(51%)
27				highv(11%)	highv(8.2%)	highv(0.96%)	highv(44%)	highv(47%)	highv(60%)				highv(45%)
28				highv(0.50%)	highv(0.10%)		highv(33%)	highv(34%)	highv(38%)				highv(36%)
29							highv(23%)	highv(25%)	highv(30%)				highv(20%)
30							highv(7.8%)	highv(9.7%)	highv(17%)				highv(8.2%)
31							highv(0.49%)	highv(1.3%)	highv(4.7%)				
32									highv(0.09%)				
33													
34													
35													
36													
37													
38													
39			lowv(7.8%)						TL(0.05%)	lowv(0.14%)	lowv(3.2%)	lowv(7.6%) lowv maxTi(6.0%) maxTi(39%)	
40			lowv(34%)						TL(1.4%)	lowv(19%)	lowv(30%)	lowv(22%) lowv maxTi(15%) maxTi(33%)	
41	lowv(1.1%)	lowv(9.8%)	lowv(45%)						TL(7.9%)	lowv(39%)	lowv(43%)	lowv(29%) lowv maxTi(19%) maxTi(31%)	Neph(5.8%)
42	lowv(22%) Neph(9.8%)	lowv(34%) lowv Neph(0.43%) Neph(9.5%)	lowv(46%) lowv Neph(7.5%) Neph(0.48%) Del Gp lowv(0.01%)					TL(0.36%)	TL(18%)	lowv(49%)	lowv(32%) lowv maxTi(21%) maxTi(26%)	lowv(32%) lowv maxTi(26%) maxTi(25%)	Neph(31%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline

Table A-9. SB10 Confirmation Sample MAR Assessment Results (30" Heel-7000 gal Caustic Projection, Frit 625 – November 2022)

Case: 30" Heel 7000 gal Caustic	Case 1 Single Strike			Case 3A Single Strike - 600 mg/L ISS			Case 3B Single Strike - 1200 mg/L ISS			Case 4 Double Strike			SO
Tank 40 Volume (gal)	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700	5700
SSRT Volume (gal)	2400	2800	4500	2400	2800	4500	2400	2800	4500	3800	4200	4600	0
SE Extractant	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	NGS	----
SE Volume (gal)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0
Number of EVs	9468	9360	9396	9048	9048	9685	9408	9408	9727	9410	9284	9284	1993
%WL, 24	highv(53%)	highv(49%)	highv(28%)	highv(100%)	highv(100%)	highv(97%)	highv(100%)	highv(100%)	highv(100%)	highv(35%)	highv(29%)	highv(16%)	highv(100%)
25	highv(44%)	highv(39%)	highv(0.69%)	highv(83%)	highv(80%)	highv(72%)	highv(100%)	highv(100%)	highv(100%)	highv(11%)	highv(1.0%)		highv(100%)
26	highv(34%)	highv(23%)		highv(62%)	highv(61%)	highv(60%)	highv(100%)	highv(100%)	highv(100%)				highv(92%)
27	highv(10%)	highv(1.5%)		highv(51%)	highv(49%)	highv(43%)	highv(89%)	highv(93%)	highv(100%)				highv(69%)
28	highv(0.05%)			highv(39%)	highv(38%)	highv(34%)	highv(69%)	highv(72%)	highv(84%)				highv(57%)
29				highv(30%)	highv(28%)	highv(17%)	highv(60%)	highv(62%)	highv(70%)				highv(51%)
30				highv(12%)	highv(8.7%)	highv(1.7%)	highv(45%)	highv(48%)	highv(61%)				highv(46%)
31				highv(0.90%)	highv(0.17%)		highv(34%)	highv(35%)	highv(40%)				highv(37%)
32							highv(26%)	highv(27%)	highv(31%)				highv(25%)
33							highv(11%)	highv(13%)	highv(20%)				highv(11%)
34							highv(1.7%)	highv(3.2%)	highv(7.9%)				highv(0.50%)
35									highv(0.49%)				
36													
37													
38													
39									TL(0.96%)			maxTi(45%)	Neph(1.4%)
40	Neph(6.2%)	Neph(5.7%)	lowv(5.6%) Neph(3.2%)						TL(7.4%)	lowv(0.04%)	lowv(2.5%)	lowv(5.9%) lowv maxTi(6.1%) maxTi(42%)	Neph(14%)
41	Neph(15%)	Neph(15%)	lowv(31%) lowv Neph(1.7%) Neph(12%)					TL(0.21%)	TL(17%)	lowv(17%) Neph(6.6%)	lowv(28%) Neph(6.1%)	lowv(21%) lowv maxTi(15%) lowv maxTi Neph(0.01%) lowv Neph(0.03%) maxTi(35%) maxTi Neph(0.4%) Neph(5.0%)	Neph(78%)
42	lowv Neph(0.69%) Neph(84%)	lowv Neph(7.0%) Neph(64%)	lowv(3.9%) lowv Neph(40%) Neph(27%)	Neph(10%)	Neph(7.3%)		TL(0.30%)	TL(2.2%)	TL(26%)	lowv(19%) lowv Neph(19%) Neph(14%)	lowv(13%) lowv maxTi(9.0%) lowv maxTi Neph(7.7%) lowv Neph(12%) maxTi(28%) maxTi Neph(2.3%) Neph(10%)	lowv(20%) lowv maxTi(18%) lowv maxTi Neph(1.8%) lowv Neph(7.6%) maxTi(30%) maxTi Neph(1.4%) Neph(5.5%)	Neph(92%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: TiO_2 concentration > 6 wt.%
Neph: nepheline