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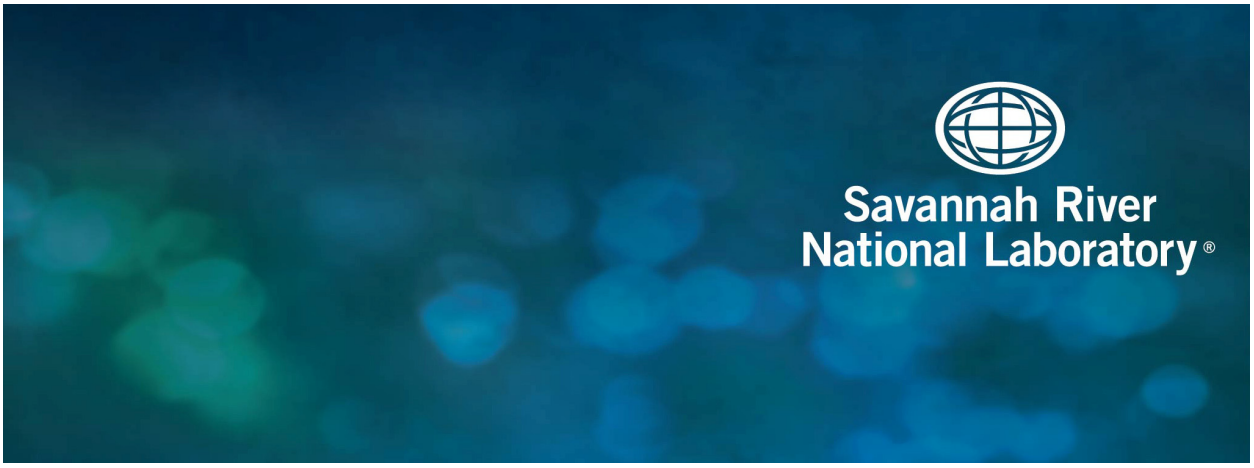

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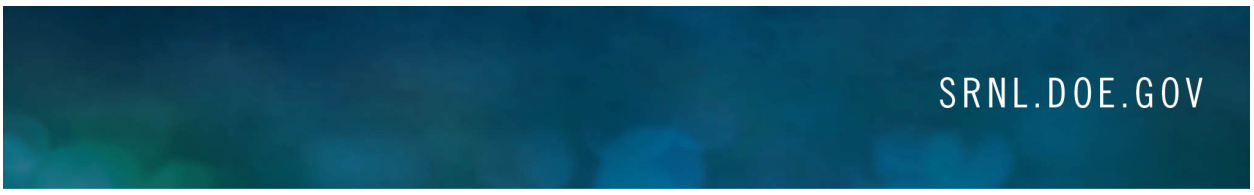
Measurement Acceptance Region (MAR) Assessment Results Based on Sludge Batch 10 Projections from December 2021, February 2022 and August 2022

F.C. Johnson

October 2022

SRNL-STI-2022-00022, Revision 0



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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, and 26F, Alternate Feed Stock-2 and Sodium Reactor Experiment material from H-Canyon. Frit 473 ($8B_2O_3$-$8Li_2O$-$5Na_2O$-$79SiO_2$, in weight percent) 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. Due to the lower processing rate of Sludge Batch 9 (SB9), the heel in Tank 40 is anticipated to be greater than 40 inches at the projected start of SB10 processing to meet the upcoming Accelerated Basin Deinventory addition dates in Tank 51 for Sludge Batch 11. In December 2021 and February 2022, Savannah River Remediation System Planning provided updated SB10 Tank 40 blend projections based on heels of 74 inches, 84 inches, 94 inches and 103.4 inches. 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 August 2022, SRMC System Planning provided an updated SB10 Tank 40 blend projection with a 76 inch-heel representing Decant Y2 and 60 kilogallons of bearing water inleakage that is anticipated during the Tank 51 to Tank 40 transfer.

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 reprojected 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 Sludge Receipt and Adjustment Tank batch: 5700 gallons of Tank 40 sludge, 2400-4500 gallons of the SWPF monosodium titanate (MST) and sludge solids stream, and 15,000 gallons of strip effluent. Based on these MAR assessment results, Frit 473 remains viable for SB10 processing. 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 SB9 insoluble sludge solids at a nominal transfer volume of ~2800 gallons. Increasing the single strike transfer volume to 4500 gallons may reduce the maximum WL below 40%. Operating windows are 12 percentage points for SO processing and 14-16 percentage points for coupled processing. Frit 625 allows for a target WL of 36% and is acceptable for use during the SB9 to SB10 transition to deplete remaining inventory as needed. Operating windows are 8 percentage points for SO processing and 12-14 percentage points for coupled processing. 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
kgal	kilogallon
MAR	Measurement Acceptance Region
MST	monosodium titanate
NGS	Next Generation Solvent
PCCS	Product Composition Control System
SB10	Sludge Batch 10
SB9	Sludge Batch 9
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
SRR	Savannah River Remediation
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, and 26F, 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] Due to the lower processing rate of Sludge Batch 9 (SB9), the heel in Tank 40 is anticipated to be greater than 40 inches at the projected start of SB10 processing to meet the upcoming Accelerated Basin Deinventory addition dates in Tank 51 for Sludge Batch 11. In December 2021 and February 2022, Savannah River Remediation (SRR) System Planning provided updated SB10 Tank 40 blend projections based on heels of 74 inches, 84 inches, 94 inches and 103.4 inches.[3,4] Savannah River Mission Completion (SRMC)[b] subsequently pursued Wash Cycle Y to further reduce the total sulfur in the sludge batch and increase processing flexibility at DWPF. In August 2022, SRMC System Planning provided an updated SB10 Tank 40 blend projection with a 76 inch-heel representing Decant Y2 and 60 kilogallons (kgal) of bearing water inleakage that is anticipated during the Tank 51 to Tank 40 transfer.[5]

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[6,7]
- 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[8-10]

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.[11-13] 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 Versions 14.3.0[15] and 16.0.0[16,17] were used to support this work. Requirements for performing reviews of technical reports and the extent of review are established in Manual E7, Procedure 2.60.[18] 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.[19] The Design Checklists for this report are stored in electronic laboratory notebook experiment C7592-00311-41.

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

3.1.1 SB10 SO December 2021 and February 2022 Projections

The elemental concentrations of each SO Tank 40 blend projection provided by SRR System Planning (on a calcine basis) were converted to oxides and normalized to 100 weight percent (wt.%) as shown in

[a] $8B_2O_3$-$8Li_2O$-$5Na_2O$-$79SiO_2$ in weight percent.
[b] The SRMC contract started on February 27, 2022. SRR was the contractor prior to this date.

Appendix A Table A-1.[3,4] These projections represent SB9 heels of 74 inches, 84 inches, 94 inches and 103.4 inches. The projections for 74-94 inches were received in December 2021 and the projection for 103.4 inches was received in February 2022. Note that 103.4 inches was a conservative case that represented the Tank 40 level after the Tank 40 to DWPF transfer on January 3, 2022.

3.1.2 SB10 SO August 2022 Projections

The elemental concentrations of the 76 inch-heel Decant Y2 Tank 40 blend projection (on a calcine basis) were converted to oxides and normalized to 100 wt.% as shown in Appendix Table A-2.

3.1.3 SRNL-Developed Inputs for Coupled Processing with SWPF

SRNL performed subsequent calculations with the SO projections in Appendix A Table A-1 and Table A-2 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 SB9:[20-23]

- 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.[24]
- 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,21]

Other pertinent inputs include:

- DWPF receives 5700 gallons of sludge slurry from Tank 40 per SRAT batch[25]
- 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[21]
    - Incremental variations in these transfer volumes were initially requested for SB9,[21] which SRNL assumed to be ±400 gallons for these assessments; however, DWPF also requested that 4500 gallons be evaluated for single strike operation.[26]
- 0.4 g/L of MST for a single strike[21]
- DWPF receives 15,000 gallons of SE per SRAT batch (BOBCalixC6 solvent[d] or Next Generation Solvent (NGS)[e])[21,25]
- Cs-137 concentration in SE is 66 Ci/gallon[27]

3.2 Method for the Variation Stage MAR Assessments

The approach taken for the Variation Stage MAR assessment[28] 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,

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

[e] 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.

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

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 40 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.[29] Those oxides not tracked individually were grouped into an "Others" component.[g] 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 the August 2022 projection 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 projected operating window[i] of at least 9 percentage points (target of 36% WL ± 4 percentage points) was the primary success metric used to determine the viability of frits for SB10 processing. Frit 473 was previously selected as the candidate frit for SB10 based on its operating windows for nominal single strike operation up to 600 mg/L of SB9 ISS (Cases 1 and 3A).[2]

3.3 Results and Discussion

3.3.1 December 2021 and February 2022 Projections (74", 84", 94" and 103.4" Heels)

Table 3-1 presents a summary of the operating windows for the nominal single strike and double strike MST/SS transfer volumes (2800 and 4200 gallons, respectively). Complete summaries of the operating windows at varied transfer volumes are shown in Appendix A Table A-3 and Table A-4 and more detailed MAR assessment results are shown in Appendix A Table A-8 through Table A-15. Note that the SO results are repeated in each Appendix A table for reference. Previous May 2021 1M Na wash endpoint results are shown for comparison in Appendix A Table A-3 and Table A-4.

Table 3-1. Operating Windows for SB10 with 74-103.4" Heels and Frit 473

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
SE Extractant: NGS					
Heel: 74 inches	26-41	30-42	34-39	24-38	34-40
Heel: 84 inches	26-40	30-42	34-39	24-38	33-40
Heel: 94 inches	26-40	29-42	33-39	24-38	33-40
Heel: 103.4 inches	25-40	29-42	33-39	24-38	33-41
SE Extractant: BOBCalixC6					
Heel: 74 inches	26-41	30-42	34-39	24-38	34-40
Heel: 84 inches	26-41	30-42	34-39	24-38	33-40
Heel: 94 inches	26-40	29-42	33-39	24-38	33-40
Heel: 103.4 inches	25-40	29-42	33-39	24-38	33-41

The operating windows are generally the same for all four heel cases (74-103.4 inches) and are consistent between SE based on NGS or BOBCalixC6. Other high level trends 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

[g] The "Others" component typically includes B_2O_3, BaO, Ce_2O_3, Cr_2O_3, CuO, K_2O, La_2O_3, Li_2O, MgO, PbO, SO_4^{2-}, ZnO, and ZrO_2; however, B_2O_3 is an individually tracked oxide when SE with NGS is evaluated.
[h] $1Al_2O_3$-$8B_2O_3$-$7Li_2O$-$6Na_2O$-$78SiO_2$ in weight percent.
[i] WL interval over which all EVs pass the SME acceptability process.

volume of ~2800 gallons). Increasing the MST/SS transfer volume to 4500 gallons incrementally reduces the maximum WL below 40% for Case 1 only. The operating windows are similar to those for the May 2021 1M Na wash endpoint projections.

- Case 3B (single strike with 1200 mg/L SB9 ISS) - The operating windows are less than 9 percentage points. Both the operating window and maximum WL decreased as compared to the May 2021 1M Na wash endpoint projections.
- Case 4 (nominal double strike) - The operating windows are at least 9 percentage points; however, the maximum WLs are generally below 40% due to the maximum TiO_2 constraint. The operating windows are improved as compared to the May 2021 1M Na wash endpoint projections.
- SO - The operating window is slightly less than 9 percentage points; however, both the operating window and maximum WL improved as compared to the May 2021 1M Na wash endpoint projections.

These results demonstrate that Frit 473 remains viable for SB10 processing regardless of the increase in the Tank 40 heel to 74-103.4 inches. Due to the similar operating windows between the May 2021 projections and these updated projections, other Tank 40 and SE transfer volumes were not evaluated. See Reference 2 for the results of these additional transfer volumes for the May 2021 projections.[2]

3.3.2 August 2022 Projection (Decant Y2 with 60 kgal Inleakage)

Table 3-2 presents a summary of the operating windows for the nominal single strike and double strike MST/SS transfer volumes (2800 and 4200 gallons, respectively). Complete summaries of the operating windows at varied transfer volumes are shown in Appendix A Table A-5 and Table A-6 and more detailed MAR assessment results are shown in Appendix A Table A-16 through Table A-19. Note that the SO results are repeated in each Appendix A table for reference.

Generally, the trends are similar to those observed for the projections in Section 3.3.1. For SO processing and coupled operation Cases 1 and 3A, a target WL of 36% is possible for nominal single strike operation (MST/SS transfer volume of ~2800 gallons). Increasing the single strike transfer volume to 4500 gallons may reduce the maximum WL below 40%. Operating windows are 12 percentage points for SO processing and 14-16 percentage points for coupled processing. Frit 625 allows for a target WL of 36% and is acceptable for use during the SB9 to SB10 transition to deplete remaining inventory as needed. Operating windows are 8 percentage points for SO processing and 12-14 percentage points for coupled processing. 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.

Table 3-2. Operating Windows for SB10 with Decant Y2 and 60 kgal Inleakage

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
SE Extractant: NGS					
Frit 473	24-39	28-42	31-40	24-37	30-41
Frit 625	27-40	31-42	35-39	25-37	33-40
SE Extractant: BOBCalixC6					
Frit 473	24-39	28-42	31-39	24-37	30-41
Frit 625	27-40	31-42	35-39	25-37	33-40

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.[j,6] 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.[6,7]

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 August 2022 Tank 40 blend projection (Decant Y2 with 60 kgal inleakage - Appendix A Table A-2) and both Frit 473 and Frit 625 over a WL interval of 32-40%. SO operation and the following coupled operation scenarios from Section 3.1.3 were evaluated:

- DWPF receives 5700 gallons of sludge slurry from Tank 40 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 (both BOBCalixC6 and NGS)

A rounded 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 (1.5 wt.%) followed by Cs_2O (1 wt.%) and Al_2O_3 (0.8 wt.%). Otherwise, minor compositional differences exist for Li_2O, MnO and SO_4^{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 developed to 2.99 wt.% Al_2O_3 and validated to 5.85 wt.% TiO_2 and 1.62 wt.% Cs_2O,[9] so the anticipated concentrations for SB10 are still within the validated ranges although being outside of the SB10 variability study.

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

[j] "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.

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

	SB10 Variability Study and ComPro™ Entries		Reprojected SB10 Glass Composition Region		Difference	
	minimum	maximum	minimum	maximum	minimum	maximum
Al_2O_3	7.01	12.69	6.24	10.76	-0.8	----
B_2O_3	4.37	7.45	4.84	5.81	----	----
BaO	0.00	0.07	0.02	0.04	----	----
CaO	0.27	0.84	0.33	0.58	----	----
Ce_2O_3	0.01	0.17	0.06	0.10	----	----
Cr_2O_3	0.01	0.22	0.05	0.10	----	----
Cs_2O	0.00	0.00	0.00	0.99	----	1.0
CuO	0.01	0.10	0.01	0.03	----	----
Fe_2O_3	5.08	10.09	5.44	9.41	----	----
K_2O	0.03	0.47	0.03	0.13	----	----
La_2O_3	0.00	0.04	0.01	0.02	----	----
Li_2O	4.59	6.40	4.23	5.46	-0.4	----
MgO	0.03	0.46	0.12	0.21	----	----
MnO	1.07	2.67	1.58	2.77	----	0.1
Na_2O	11.36	17.07	11.91	17.10	----	----
NiO	0.20	1.50	0.22	0.39	----	----
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	0.22	0.41	-0.1	----
SiO_2	45.22	54.49	47.74	54.47	----	----
ThO_2	0.14	1.26	0.58	1.06	----	----
TiO_2	0.01	3.28	0.01	4.74	----	1.5
U_3O_8	1.06	2.88	1.04	1.80	----	----
ZnO	0.00	0.04	0.01	0.02	----	----
ZrO_2	0.03	0.21	0.03	0.07	----	----

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.[8-10] 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.[39,40] 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 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.[9]

A rounded 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 P_2O_5, SO_4^{2-} and ThO_2. Na_2O has the highest difference of 1.3 wt.% for the liquidus temperature model only; however, the liquidus temperature model has been validated to 17.39 wt.% Na_2O. 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.%)

	Model Development Ranges							Reprojected SB10 Glass Region		Durability Difference		Viscosity Difference		Liquidus Temp Difference	
	Durability*		Viscosity		Liquidus Temp										
	minimum	maximum	minimum	maximum	minimum	maximum		minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
Al_2O_3	2.99	13.90	0	13.90	0.99	14.16		6.24	10.76	----	----	----	----	----	----
B_2O_3	4.57	13.30	4.57	12.20	4.57	12.65		4.84	5.81	----	----	----	----	----	----
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		0.33	0.58	----	----	----	----	----	----
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		0.05	0.10	----	----	----	----	----	----
Cs_2O	0	1.62	0	1.62	0	1.26		0.00	0.99	----	----	----	----	----	----
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		5.44	9.41	----	----	----	----	----	----
K_2O	0	5.73	0	5.73	0	3.89		0.03	0.13	----	----	----	----	----	----
La_2O_3	0	0.42	0	0.36	0	0.36		0.01	0.02	----	----	----	----	----	----
Li_2O	1.05	6.81	1.05	6.96	2.26	6.81		4.23	5.46	----	----	----	----	----	----
MgO	0	3.24	0	2.92	0	2.65		0.12	0.21	----	----	----	----	----	----
MnO	0	4.08	0	4.08	0.74	4.08		1.58	2.77	----	----	----	----	----	----
Na_2O	6.42	18.14	5.80	18.14	5.99	15.81		11.91	17.10	----	----	----	----	----	1.3
NiO	0	1.99	0	2.97	0	3.05		0.22	0.39	----	----	----	----	----	----
P_2O_5	0	0.65	0	0	0	0		0.00	0.06	----	----	----	0.1	----	0.1
PbO	0	0.25	0	0.23	0	0.23		0.01	0.02	----	----	----	----	----	----
SO_4	0	0.37	0	0.37	0	0.34		0.22	0.41	----	----	----	----	----	0.1
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		0.58	1.06	----	0.1	----	0.1	----	0.1
TiO_2	0	5.85	0	5.85	0	5.85		0.01	4.74	----	----	----	----	----	----
U_3O_8	0	6.24	0	6.24	0	6.24		1.04	1.80	----	----	----	----	----	----
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		0.03	0.07	----	----	----	----	----	----

*The durability model ranges include both the model development data and the SWPF validation data.[9]

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 40 sludge, 2400-4500 gallons of the SWPF MST and SS stream, and 15,000 gallons of SE. Based on these MAR assessment results, Frit 473 remains viable for SB10 processing. 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 strike transfer volume to 4500 gallons may reduce the maximum WL below 40%. Operating windows are 12 percentage points for SO processing and 14-16 percentage points for coupled processing. Frit 625 allows for a target WL of 36% and is acceptable for use during the SB9 to SB10 transition to deplete remaining inventory as needed. Operating windows are 8 percentage points for SO processing and 12-14 percentage points for coupled processing. 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.

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Appendix A. Supplementary Information and MAR Assessment Results

Table A-1. Normalized SB10 Tank 40 Blend Projections - December 2021 and February 2022 (wt.%)

Heel	74 inches	84 inches	94 inches	103.4 inches
Al_2O_3	28.40	27.89	27.43	27.11
B_2O_3	0.31	0.30	0.29	0.29
BaO	0.08	0.09	0.09	0.09
CaO	1.36	1.39	1.41	1.44
Ce_2O_3	0.22	0.23	0.23	0.24
Cr_2O_3	0.29	0.28	0.28	0.27
CuO	0.06	0.06	0.06	0.06
Fe_2O_3	21.86	22.22	22.56	23.02
K_2O	0.14	0.15	0.15	0.14
La_2O_3	0.05	0.05	0.05	0.05
Li_2O	0.05	0.05	0.06	0.06
MgO	0.50	0.50	0.49	0.50
MnO	6.28	6.39	6.50	6.64
Na_2O	29.33	29.28	29.23	28.82
NiO	0.92	0.96	0.99	1.03
PbO	0.03	0.03	0.03	0.03
SO_4^{2-}	1.38	1.36	1.35	1.31
SiO_2	2.05	2.12	2.17	2.24
ThO_2	2.36	2.31	2.27	2.24
TiO_2	0.04	0.04	0.04	0.04
U_3O_8	4.09	4.11	4.13	4.18
ZnO	0.04	0.04	0.04	0.04
ZrO_2	0.17	0.16	0.16	0.16

Table A-2. Normalized SB10 Tank 40 Blend Projection - August 2022 (wt.%)

	Decant Y2 60 kgal Inleakage
Al_2O_3	25.40
B_2O_3	0.18
BaO	0.10
CaO	1.44
Ce_2O_3	0.25
Cr_2O_3	0.26
CuO	0.07
Fe_2O_3	23.53
K_2O	0.11
La_2O_3	0.06
Li_2O	0.07
MgO	0.53
MnO	6.84
Na_2O	29.86
NiO	0.97
PbO	0.04
SO_4^{2-}	0.86
SiO_2	2.02
ThO_2	2.64
TiO_2	0.04
U_3O_8	4.50
ZnO	0.04
ZrO_2	0.19

Table A-3. Summary of Operating Windows of SB10 Projections with Frit 473 (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
May 2021 1M Na Wash Endpoint													
Operating Window (%WL)	26-40	25-40	24-38	30-42	29-42	29-42	33-42	33-41	34-38	24-38	24-37	24-34	33-38
December 2021 74" Heel													
Operating Window (%WL)	27-41	26-41	24-38	30-42	30-42	29-41	34-40	34-39	34-37	24-39	24-38	24-36	34-40
December 2021 84" Heel													
Operating Window (%WL)	26-41	26-40	24-38	30-42	30-42	29-41	33-40	34-39	34-37	24-39	24-38	24-36	33-40
December 2021 94" Heel													
Operating Window (%WL)	26-41	26-40	24-38	30-42	29-42	29-41	33-40	33-39	34-37	24-39	24-38	24-36	33-40
February 2022 103.4" Heel													
Operating Window (%WL)	26-41	25-40	24-38	30-42	29-42	29-41	33-40	33-39	34-37	24-39	24-38	24-35	33-41

Table A-4. Summary of Operating Windows of SB10 Projections with Frit 473 (BOBCalixC6)

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
May 2021 1M Na Wash Endpoint													
Operating Window (%WL)	26-39	25-39	24-38	30-41	29-42	29-42	33-42	33-41	34-38	24-38	24-36	24-34	33-38
December 2021 74" Heel													
Operating Window (%WL)	27-41	26-41	24-39	30-42	30-42	29-41	34-40	34-39	34-37	24-39	24-38	24-35	34-40
December 2021 84" Heel													
Operating Window (%WL)	26-41	26-41	24-38	30-42	30-42	29-41	33-40	34-39	34-37	24-39	24-38	24-35	33-40
December 2021 94" Heel													
Operating Window (%WL)	26-41	26-40	24-38	30-42	29-42	29-41	33-40	33-39	34-37	24-39	24-38	24-35	33-40
February 2022 103.4" Heel													
Operating Window (%WL)	26-41	25-40	24-38	30-42	29-42	29-41	33-40	33-39	34-37	24-39	24-38	24-35	33-41

Table A-5. Summary of Operating Windows of August 2022 SB10 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 Window (%WL)	24-39	24-39	24-37	28-42	28-42	27-42	31-40	31-40	32-37	24-37	24-37	25-35	30-41
Frit 625													
Operating Window (%WL)	27-40	27-40	25-38	31-42	31-42	30-41	35-39	35-39	35-36	25-39	25-37	24-35	33-40

Table A-6 . Summary of Operating Windows of August 2022 SB10 Projections (BOBCalixC6)

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 Window (%WL)	24-39	24-39	24-37	28-42	28-42	27-42	31-40	31-39	32-37	24-38	24-37	25-34	30-41
Frit 625													
Operating Window (%WL)	27-40	27-40	25-38	31-42	31-42	30-41	35-39	35-39	35-36	25-39	25-37	24-34	33-40

Guidance for Interpretation of Detailed MAR Assessment Results

Consider the Case 1 column (SSRT [MST/SS] transfer volume of 2800 gallons) in Table A-8 as an example for the interpretation of the information provided. The number of EVs are provided for reference. The projected operating window is 26-41% WL (shaded green). At each WL shaded green, all 9,612 EVs pass the SME acceptability process. At 25% WL, 1.9% of the EVs fail the high viscosity constraint (shaded yellow). At 42% WL, 11% of the EVs fail the low viscosity constraint and 6.1% 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-7 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. Note that the durability constraints represent Product Consistency Test releases that are two standard deviations below the reported mean releases from the Environmental Assessment benchmark glass, as required per the Waste Acceptance Product Specifications acceptance criterion for product consistency.[38]

Table A-7. 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	$\frac{SiO_2}{SiO_2+Na_2O+Al_2O_3} > 0.62$

Table A-8. SB10 MAR Assessment Results (74" Heel, Frit 473, NGS - December 2021)

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
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	9828	9612	9536	9408	9408	9685	9768	9912	9919	9536	9284	9284	1993
%WL, 24	highv(37%)	highv(27%)		highv(66%)	highv(64%)	highv(60%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
25	highv(16%)	highv(1.9%)		highv(57%)	highv(54%)	highv(43%)	highv(95%)	highv(97%)	highv(100%)				highv(89%)
26	highv(0.16%)			highv(43%)	highv(41%)	highv(34%)	highv(76%)	highv(79%)	highv(86%)				highv(67%)
27				highv(35%)	highv(33%)	highv(16%)	highv(64%)	highv(67%)	highv(71%)				highv(57%)
28				highv(21%)	highv(15%)	highv(1.1%)	highv(54%)	highv(57%)	highv(63%)				highv(51%)
29				highv(4.5%)	highv(1.2%)		highv(39%)	highv(39%)	highv(43%)				highv(45%)
30							highv(32%)	highv(32%)	highv(33%)				highv(39%)
31							highv(20%)	highv(20%)	highv(22%)				highv(31%)
32							highv(7.3%)	highv(7.9%)	highv(10%)				highv(18%)
33							highv(0.19%)	highv(0.48%)	highv(1.4%)				highv(7.1%)
34													
35													
36													
37												maxTi(47%)	
38									TL(0.14%)			maxTi(49%)	
39			lowv(0.13%)						TL(2.5%)		maxTi(47%)	lowv(0.17%) lowv maxTi(1.1%) maxTi(49%)	
40			lowv(18%)					TL(0.07%)	TL(13%)	lowv(2.5%)	lowv(6.3%) lowv maxTi(7.1%) maxTi(40%)	lowv(12%) lowv maxTi(14%) maxTi(39%)	
41			lowv(38%)				TL(0.29%)	TL(1.9%)	TL(23%)	lowv(28%)	lowv(21%) lowv maxTi(15%) maxTi(34%)	lowv(22%) lowv maxTi(19%) maxTi(36%)	Neph(3.6%)
42	lowv(1.1%) Neph(6.5%)	lowv(11%) Neph(6.1%)	lowv(44%) lowv Neph(4.2%) Neph(1.1%)			TL(0.06%)	TL(2.8%)	TL(8.4%)	TL(33%)	lowv(24%) lowv maxTi(17%) maxTi(30%)	lowv(27%) lowv maxTi(20%) maxTi(32%)	lowv maxTi(52%) maxTi(48%)	Neph(17%)

highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-9. SB10 MAR Assessment Results (74" Heel, Frit 473, BOBCalixC6 - December 2021)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4356	4356	4644	4644	4588	4420	4420	4686	4804	4740	4740	1993
%WL, 24	highv(39%)	highv(30%)		highv(68%)	highv(67%)	highv(61%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
25	highv(19%)	highv(4.0%)		highv(58%)	highv(56%)	highv(44%)	highv(96%)	highv(97%)	highv(100%)				highv(89%)
26	highv(0.44%)			highv(44%)	highv(41%)	highv(35%)	highv(78%)	highv(80%)	highv(86%)				highv(67%)
27				highv(35%)	highv(33%)	highv(17%)	highv(64%)	highv(65%)	highv(70%)				highv(57%)
28				highv(20%)	highv(15%)	highv(1.8%)	highv(55%)	highv(57%)	highv(63%)				highv(51%)
29				highv(6.0%)	highv(1.8%)		highv(38%)	highv(39%)	highv(43%)				highv(45%)
30							highv(31%)	highv(31%)	highv(32%)				highv(39%)
31							highv(20%)	highv(20%)	highv(23%)				highv(31%)
32							highv(8.8%)	highv(9.2%)	highv(10%)				highv(18%)
33							highv(0.43%)	highv(0.72%)	highv(1.5%)				highv(7.1%)
34													
35													
36												maxTi(45%)	
37												maxTi(48%)	
38									TL(0.09%)			maxTi(49%)	
39									TL(2.3%)		maxTi(47%)	lowv maxTi(0.84%) maxTi(50%)	
40			lowv(17%)					TL(0.11%)	TL(11%)	lowv(1.6%)	lowv(6.2%) lowv maxTi(6.9%) maxTi(42%)	lowv(13%) lowv maxTi(13%) maxTi(39%)	
41			lowv(38%)				TL(0.20%)	TL(1.5%)	TL(21%)	lowv(26%)	lowv(20%) lowv maxTi(15%) maxTi(34%)	lowv(21%) lowv maxTi(19%) maxTi(35%)	Neph(3.6%)
42	lowv(0.32%) Neph(6.2%)	lowv(9.1%) Neph(6.2%)	lowv(44%) lowv Neph(3.7%) Neph(1.5%)			TL(0.02%)	TL(3.2%)	TL(9.2%)	TL(30%)	lowv(24%) lowv maxTi(16%) maxTi(31%)	lowv(27%) lowv maxTi(19%) maxTi(32%)	lowv maxTi(51%) maxTi(49%)	Neph(17%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-10. SB10 MAR Assessment Results (84" Heel, Frit 473, NGS - December 2021)

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
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	9828	9612	9536	9408	9408	9685	10020	9912	9919	9536	9284	9284	1993
%WL, 24	highv(35%)	highv(20%)		highv(64%)	highv(63%)	highv(59%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
25	highv(11%)	highv(0.38%)		highv(54%)	highv(51%)	highv(41%)	highv(92%)	highv(95%)	highv(99%)				highv(85%)
26				highv(41%)	highv(40%)	highv(32%)	highv(73%)	highv(76%)	highv(84%)				highv(64%)
27				highv(33%)	highv(29%)	highv(12%)	highv(64%)	highv(66%)	highv(70%)				highv(55%)
28				highv(15%)	highv(11%)	highv(0.31%)	highv(49%)	highv(52%)	highv(60%)				highv(50%)
29				highv(1.2%)	highv(0.17%)		highv(36%)	highv(37%)	highv(40%)				highv(43%)
30							highv(29%)	highv(30%)	highv(31%)				highv(34%)
31							highv(15%)	highv(16%)	highv(19%)				highv(24%)
32							highv(4.2%)	highv(4.9%)	highv(7.3%)				highv(12%)
33								highv(0.06%)	highv(0.53%)				
34													
35													
36													
37												maxTi(47%)	
38									TL(0.14%)			maxTi(48%)	
39			lowv(0.40%)						TL(2.5%)		lowv(0.01%) lowv maxTi(0.10%) maxTi(47%)	lowv(1.1%) lowv maxTi(2.3%) maxTi(48%)	
40			lowv(23%)					TL(0.07%)	TL(13%)	lowv(5.8%)	lowv(9.4%) lowv maxTi(8.4%) maxTi(39%)	lowv(15%) lowv maxTi(14%) maxTi(38%)	
41		lowv(0.10%)	lowv(40%)				TL(0.29%)	TL(1.9%)	TL(23%)	lowv(31%)	lowv(22%) lowv maxTi(15%) maxTi(33%)	lowv(23%) lowv maxTi(20%) maxTi(34%)	Neph(2.0%)
42	lowv(4.4%) Neph(6.0%)	lowv(16%) Neph(5.5%)	lowv(45%) lowv Neph(4.3%) Neph(0.10%)			TL(0.06%)	TL(2.9%)	TL(8.7%)	TL(33%)	lowv(25%) lowv maxTi(18%) maxTi(29%)	lowv(28%) lowv maxTi(20%) maxTi(31%)	lowv maxTi(53%) maxTi(47%)	Neph(14%)

highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-11. SB10 MAR Assessment Results (84" Heel, Frit 473, BOBCalixC6 - December 2021)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4356	4356	4644	4644	4588	4308	4420	4644	4580	4740	4740	1993
%WL, 24	highv(36%)	highv(24%)		highv(66%)	highv(65%)	highv(60%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
25	highv(11%)	highv(1.3%)		highv(56%)	highv(53%)	highv(43%)	highv(94%)	highv(95%)	highv(100%)				highv(85%)
26				highv(41%)	highv(40%)	highv(33%)	highv(76%)	highv(76%)	highv(84%)				highv(64%)
27				highv(33%)	highv(30%)	highv(13%)	highv(64%)	highv(64%)	highv(69%)				highv(55%)
28				highv(15%)	highv(11%)	highv(0.57%)	highv(51%)	highv(53%)	highv(61%)				highv(50%)
29				highv(1.8%)	highv(0.30%)		highv(37%)	highv(37%)	highv(40%)				highv(43%)
30							highv(30%)	highv(29%)	highv(30%)				highv(34%)
31							highv(16%)	highv(17%)	highv(19%)				highv(24%)
32							highv(5.5%)	highv(6.6%)	highv(8.3%)				highv(12%)
33								highv(0.02%)	highv(0.39%)				
34													
35													
36												maxTi(45%)	
37												maxTi(48%)	
38									TL(0.09%)			maxTi(49%)	
39			lowv(0.37%)						TL(2.5%)		maxTi(46%)	lowv(0.11%) lowv maxTi(1.6%) maxTi(49%)	
40			lowv(22%)					TL(0.11%)	TL(11%)	lowv(2.8%)	lowv(8.7%) lowv maxTi(7.3%) maxTi(40%)	lowv(14%) lowv maxTi(14%) maxTi(39%)	
41			lowv(40%)				TL(0.21%)	TL(1.6%)	TL(21%)	lowv(28%)	lowv(21%) lowv maxTi(15%) maxTi(34%)	lowv(22%) lowv maxTi(19%) maxTi(35%)	Neph(2.0%)
42	lowv(1.8%) Neph(6.2%)	lowv(14%) Neph(5.2%)	lowv(45%) lowv Neph(3.1%) Neph(0.46%)			TL(0.13%)	TL(3.3%)	TL(9.5%)	TL(31%)	lowv(24%) lowv maxTi(17%) maxTi(29%)	lowv(28%) lowv maxTi(20%) maxTi(31%)	lowv maxTi(52%) maxTi(48%)	Neph(14%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-12. SB10 MAR Assessment Results (94" Heel, Frit 473, NGS - December 2021)

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
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	9612	9612	9536	9408	9408	9685	10,020	9804	9835	9536	9284	9284	1993
%WL, 24	highv(30%)	highv(13%)		highv(63%)	highv(61%)	highv(56%)	highv(100%)	highv(100%)	highv(100%)				highv(96%)
25	highv(4.3%)	highv(0.01%)		highv(51%)	highv(48%)	highv(39%)	highv(89%)	highv(91%)	highv(99%)				highv(79%)
26				highv(39%)	highv(38%)	highv(29%)	highv(70%)	highv(73%)	highv(82%)				highv(61%)
27				highv(29%)	highv(25%)	highv(8.1%)	highv(63%)	highv(64%)	highv(69%)				highv(53%)
28				highv(11%)	highv(6.6%)	highv(0.04%)	highv(44%)	highv(47%)	highv(56%)				highv(47%)
29				highv(0.17%)			highv(34%)	highv(34%)	highv(37%)				highv(40%)
30							highv(25%)	highv(26%)	highv(29%)				highv(31%)
31							highv(11%)	highv(12%)	highv(16%)				highv(18%)
32							highv(1.5%)	highv(2.2%)	highv(4.8%)				highv(6.8%)
33									highv(0.08%)				
34													
35													
36													
37												maxTi(47%)	
38									TL(0.14%)			maxTi(48%)	
39			lowv(1.5%)						TL(2.6%)		lowv(0.09%) lowv maxTi(0.33%) maxTi(45%)	lowv(2.5%) lowv maxTi(3.8%) maxTi(46%)	
40			lowv(27%)					TL(0.12%)	TL(12%)	lowv(8.7%)	lowv(12%) lowv maxTi(9.6%) maxTi(38%)	lowv(17%) lowv maxTi(15%) maxTi(37%)	
41		lowv(0.61%)	lowv(41%)				TL(0.29%)	TL(1.9%)	TL(23%)	lowv(34%)	lowv(23%) lowv maxTi(16%) maxTi(33%)	lowv(24%) lowv maxTi(20%) maxTi(33%)	Neph(1.3%)
42	lowv(6.1%) Neph(3.5%)	lowv(21%) Neph(3.5%)	lowv(48%) lowv Neph(2.7%)			TL(0.06%)	TL(3.0%)	TL(8.7%)	TL(33%)	lowv(26%) lowv maxTi(18%) maxTi(29%)	lowv(29%) lowv maxTi(21%) maxTi(30%)	lowv maxTi(55%) maxTi(45%)	Neph(8.5%)

highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-13. SB10 MAR Assessment Results (94" Heel, Frit 473, BOBCalixC6 - December 2021)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4356	4580	4644	4644	4588	4308	4308	4658	4516	4516	4740	1993
%WL, 24	highv(33%)	highv(17%)		highv(65%)	highv(63%)	highv(58%)	highv(100%)	highv(100%)	highv(100%)				highv(96%)
25	highv(6.7%)	highv(0.02%)		highv(53%)	highv(50%)	highv(41%)	highv(91%)	highv(93%)	highv(99%)				highv(79%)
26				highv(40%)	highv(38%)	highv(30%)	highv(73%)	highv(75%)	highv(82%)				highv(61%)
27				highv(30%)	highv(26%)	highv(9.0%)	highv(63%)	highv(65%)	highv(69%)				highv(53%)
28				highv(11%)	highv(7.2%)	highv(0.02%)	highv(46%)	highv(49%)	highv(58%)				highv(47%)
29				highv(0.30%)			highv(35%)	highv(36%)	highv(37%)				highv(40%)
30							highv(26%)	highv(28%)	highv(29%)				highv(31%)
31							highv(12%)	highv(14%)	highv(17%)				highv(18%)
32							highv(2.2%)	highv(3.2%)	highv(6.0%)				highv(6.8%)
33									highv(0.04%)				
34													
35													
36												maxTi(46%)	
37												maxTi(48%)	
38									TL(0.09%)			maxTi(49%)	
39			lowv(1.5%)						TL(2.5%)		lowv maxTi(0.18%) maxTi(46%)	lowv(1.8%) lowv maxTi(2.5%) maxTi(48%)	
40			lowv(25%)					TL(0.12%)	TL(11%)	lowv(5.9%)	lowv(11%) lowv maxTi(9.6%) maxTi(38%)	lowv(16%) lowv maxTi(14%) maxTi(38%)	
41		lowv(0.32%)	lowv(40%)				TL(0.23%)	TL(1.9%)	TL(21%)	lowv(31%)	lowv(20%) lowv maxTi(17%) maxTi(33%)	lowv(24%) lowv maxTi(20%) maxTi(34%)	Neph(1.3%)
42	lowv(4.8%) Neph(3.5%)	lowv(17%) Neph(3.5%)	lowv(46%) lowv Neph(4.2%)			TL(0.13%)	TL(3.4%)	TL(9.7%)	TL(30%)	lowv(26%) lowv maxTi(17%) maxTi(29%)	lowv(28%) lowv maxTi(21%) maxTi(30%)	lowv maxTi(54%) maxTi(46%)	Neph(8.5%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-14. SB10 MAR Assessment Results (103.4" Heel, Frit 473, NGS - February 2022)

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
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	9108	9612	9536	9408	9408	9937	9,912	9912	9835	9536	9284	9284	2028
%WL, 24	highv(28%)	highv(12%)		highv(63%)	highv(62%)	highv(58%)	highv(100%)	highv(100%)	highv(100%)				highv(97%)
25	highv(3.4%)			highv(52%)	highv(48%)	highv(38%)	highv(90%)	highv(93%)	highv(99%)				highv(82%)
26				highv(39%)	highv(38%)	highv(28%)	highv(71%)	highv(74%)	highv(82%)				highv(64%)
27				highv(29%)	highv(25%)	highv(7.8%)	highv(63%)	highv(65%)	highv(69%)				highv(55%)
28				highv(11%)	highv(6.6%)	highv(0.03%)	highv(44%)	highv(47%)	highv(57%)				highv(47%)
29				highv(0.17%)			highv(34%)	highv(34%)	highv(37%)				highv(39%)
30							highv(24%)	highv(25%)	highv(29%)				highv(30%)
31							highv(11%)	highv(12%)	highv(16%)				highv(18%)
32							highv(1.5%)	highv(2.2%)	highv(4.8%)				highv(7.5%)
33									highv(0.14%)				
34													
35													
36												maxTi(45%)	
37												maxTi(47%)	
38									TL(0.27%)			maxTi(48%)	
39			lowv(1.5%)						TL(4.3%)		lowv(0.09%) lowv maxTi(0.3%) maxTi(47%)	lowv(2.1%) lowv maxTi(3.7%) maxTi(48%)	
40			lowv(26%)					TL(0.29%)	TL(15%)	lowv(8.7%)	lowv(11%) lowv maxTi(10%) maxTi(38%)	lowv(17%) lowv maxTi(15%) maxTi(37%)	
41		lowv(0.50%)	lowv(41%)				TL(0.99%)	TL(3.0%)	TL(25%)	lowv(33%)	lowv(23%) lowv maxTi(16%) maxTi(34%)	lowv(24%) lowv maxTi(20%) maxTi(34%)	
42	lowv(4.5%)	lowv(20%)	lowv(51%)			TL(0.28%)	TL(6.3%)	TL(14%)	TL(36%)	lowv(26%) lowv maxTi(18%) maxTi(29%)	lowv(28%) lowv maxTi(22%) maxTi(30%)	lowv maxTi(55%) maxTi(45%)	Neph(7.4%)

highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-15. SB10 MAR Assessment Results (103.4" Heel, Frit 473, BOBCalixC6 - February 2022)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4356	4516	4644	4644	4588	4308	4420	4658	4516	4516	4752	2028
%WL, 24	highv(33%)	highv(15%)		highv(65%)	highv(64%)	highv(59%)	highv(100%)	highv(100%)	highv(100%)				highv(97%)
25	highv(6.7%)			highv(54%)	highv(50%)	highv(40%)	highv(91%)	highv(94%)	highv(99%)				highv(82%)
26				highv(40%)	highv(38%)	highv(29%)	highv(74%)	highv(78%)	highv(83%)				highv(64%)
27				highv(30%)	highv(25%)	highv(8.9%)	highv(64%)	highv(66%)	highv(69%)				highv(55%)
28				highv(11%)	highv(7.1%)	highv(0.02%)	highv(47%)	highv(50%)	highv(60%)				highv(47%)
29				highv(0.30%)			highv(35%)	highv(35%)	highv(37%)				highv(39%)
30							highv(26%)	highv(27%)	highv(29%)				highv(30%)
31							highv(13%)	highv(14%)	highv(17%)				highv(18%)
32							highv(2.7%)	highv(3.6%)	highv(6.0%)				highv(7.5%)
33									highv(0.04%)				
34													
35													
36												maxTi(46%)	
37												maxTi(48%)	
38									TL(0.19%)			maxTi(49%)	
39			lowv(0.89%)						TL(3.6%)		lowv maxTi(0.18%) maxTi(46%)	lowv(1.8%) lowv maxTi(2.3%) maxTi(48%)	
40			lowv(24%)					TL(0.23%)	TL(14%)	lowv(5.9%)	lowv(9.4%) lowv maxTi(10%) maxTi(39%)	lowv(16%) lowv maxTi(14%) maxTi(38%)	
41		lowv(0.28%)	lowv(40%)				TL(1.2%)	TL(3.2%)	TL(23%)	lowv(31%)	lowv(20%) lowv maxTi(17%) maxTi(33%)	lowv(24%) lowv maxTi(20%) maxTi(34%)	
42	lowv(4.4%) Neph(2.8%)	lowv(17%) Neph(2.5%)	lowv(50%)			TL(0.24%)	TL(6.1%)	TL(13%)	TL(34%)	lowv(26%) lowv maxTi(17%) maxTi(29%)	lowv(28%) lowv maxTi(21%) maxTi(30%)	lowv maxTi(54%) maxTi(46%)	Neph(7.4%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
Neph: nepheline
TL: liquidus temperature
maxTi: maximum TiO_2

Table A-16. SB10 MAR Assessment Results (Decant Y2 with 60 kgal Inleakage, Frit 473, NGS - August 2022)

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
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	9108	9108	9284	9408	9408	9829	9768	9775	9821	9284	9284	9788	2049
%WL, 24				highv(43%)	highv(41%)	highv(36%)	highv(88%)	highv(92%)	highv(100%)			Al2O3/TiO2(45%)	highv(66%)
25				highv(31%)	highv(30%)	highv(23%)	highv(68%)	highv(71%)	highv(84%)				highv(55%)
26				highv(14%)	highv(10%)	highv(3.1%)	highv(58%)	highv(61%)	highv(69%)				highv(45%)
27				highv(0.58%)	highv(0.16%)		highv(35%)	highv(38%)	highv(55%)				highv(35%)
28							highv(27%)	highv(29%)	highv(34%)				highv(19%)
29							highv(12%)	highv(15%)	highv(24%)				highv(6.1%)
30							highv(2.0%)	highv(3.3%)	highv(10%)				
31									highv(1.1%)				
32													
33													
34													
35													
36												maxTi(47%)	
37												maxTi(49%)	
38			lowv(6.6%)						TL(0.07%)	lowv(0.08%)	lowv(1.0%) lowv maxTi(1.4%) maxTi(44%)	lowv(5.3%) lowv maxTi(6.4%) maxTi(44%)	
39			lowv(33%)						TL(1.7%)	lowv(17%)	lowv(16%) lowv maxTi(12%) maxTi(36%)	lowv(19%) lowv maxTi(15%) maxTi(37%)	
40	lowv(0.29%)	lowv(6.3%)	lowv(46%)						TL(9.1%)	lowv(38%)	lowv(26%) lowv maxTi(17%) maxTi(33%)	lowv(28%) lowv maxTi(20%) maxTi(34%)	
41	lowv(17%)	lowv(32%)	lowv(55%)				TL(0.12%)	TL(1.3%)	TL(20%)	lowv(31%) lowv maxTi(19%) maxTi(28%)	lowv(31%) lowv maxTi(24%) maxTi(28%)	lowv maxTi(63%) maxTi(37%)	
42	lowv(37%)	lowv(44%)	lowv(66%) Del Gp lowv(0.83%)				TL(1.9%)	TL(6.4%)	TL(29%)	lowv(35%) lowv maxTi(26%) maxTi(22%)	lowv(34%) lowv maxTi(32%) maxTi(20%)	lowv maxTi(78%) maxTi(22%)	Neph(5.3%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
Del Gp: durability
TL: liquidus temperature
Al2O3/TiO2: Al_2O_3 is less than 4 wt.% when TiO_2 is greater than 2 wt.%
maxTi: maximum TiO_2
Neph: nepheline

Table A-17. SB10 MAR Assessment Results (Decant Y2 with 60 kgal Inleakage, Frit 625, NGS - August 2022)

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
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	9108	9108	9284	9408	9408	9829	9768	9775	9821	9284	9284	9788	2049
%WL, 24	highv(46%)	highv(39%)	highv(0.17%)	highv(97%)	highv(95%)	highv(91%)	highv(100%)	highv(100%)	highv(100%)	highv(6.8%)	highv(0.42%)		highv(100%)
25	highv(33%)	highv(19%)		highv(72%)	highv(69%)	highv(68%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
26	highv(6.6%)	highv(0.14%)		highv(58%)	highv(57%)	highv(52%)	highv(100%)	highv(100%)	highv(100%)				highv(86%)
27				highv(40%)	highv(39%)	highv(35%)	highv(85%)	highv(89%)	highv(99%)				highv(63%)
28				highv(31%)	highv(29%)	highv(21%)	highv(68%)	highv(70%)	highv(82%)				highv(53%)
29				highv(13%)	highv(10%)	highv(3.1%)	highv(58%)	highv(61%)	highv(69%)				highv(44%)
30				highv(0.97%)	highv(0.36%)		highv(36%)	highv(38%)	highv(57%)				highv(36%)
31							highv(28%)	highv(30%)	highv(36%)				highv(20%)
32							highv(15%)	highv(17%)	highv(27%)				highv(10%)
33							highv(3.8%)	highv(5.1%)	highv(13%)				
34							highv(0.04%)	highv(0.10%)	highv(3.2%)				
35													
36												maxTi(47%)	
37									TL(0.07%)			maxTi(49%)	
38									TL(1.6%)		maxTi(46%)	maxTi(50%)	
39			lowv(4.7%)						TL(8.4%)		lowv(0.37%) lowv maxTi(1.0%) maxTi(47%)	lowv(4.2%) lowv maxTi(5.3%) maxTi(47%)	
40			lowv(31%)				TL(0.06%)	TL(0.93%)	TL(20%)	lowv(15%)	lowv(15%) lowv maxTi(12%) maxTi(38%)	lowv(18%) lowv maxTi(15%) maxTi(39%)	
41	lowv(0.08%) Neph(3.7%)	lowv(4.8%) Neph(3.7%)	lowv(42%) lowv Neph(3.5%) Neph(0.70%)				TL(1.6%)	TL(6.2%)	TL(29%)	lowv(22%) lowv maxTi(15%) maxTi(32%)	lowv(24%) lowv maxTi(18%) maxTi(34%)	lowv maxTi(47%) maxTi(53%)	Neph(12%)
42	lowv(14%) lowv Neph(0.7%) Neph(15%)	lowv(27%) lowv Neph(2.0%) Neph(14%)	lowv(42%) lowv Neph(12%) Neph(1.3%)			TL(0.36%)	TL(7.5%)	TL(15%)	TL(40%)	lowv(25%) lowv maxTi(18%) lowv maxTi Neph(0.4%) lowv Neph(4.6%) maxTi(30%) Neph(1.1%)	lowv(26%) lowv maxTi(22%) lowv maxTi Neph(0.8%) lowv Neph(4.7%) maxTi(29%)	lowv maxTi(55%) lowv maxTi Neph(5.8%) maxTi(39%)	Neph(61%)

NGS: Next Generation Solvent
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: maximum TiO_2
Neph: nepheline

Table A-18. SB10 MAR Assessment Results (Decant Y2 with 60 kgal Inleakage, Frit 473, BOBCalixC6 - August 2022)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4580	4516	4644	4644	4588	4532	4532	4686	4516	4516	4528	2049
%WL, 24				highv(48%)	highv(46%)	highv(39%)	highv(91%)	highv(93%)	highv(100%)			Al2O3/TiO2(44%)	highv(66%)
25				highv(35%)	highv(34%)	highv(25%)	highv(73%)	highv(76%)	highv(85%)				highv(55%)
26				highv(16%)	highv(14%)	highv(4.2%)	highv(63%)	highv(65%)	highv(70%)				highv(45%)
27				highv(1.8%)	highv(0.54%)		highv(40%)	highv(43%)	highv(58%)				highv(35%)
28							highv(32%)	highv(33%)	highv(34%)				highv(19%)
29							highv(16%)	highv(18%)	highv(26%)				highv(6.1%)
30							highv(4.2%)	highv(6.2%)	highv(11%)				
31									highv(1.9%)				
32													
33													
34													
35												maxTi(46%)	
36												maxTi(48%)	
37												maxTi(50%)	
38			lowv(4.4%)						TL(0.11%)		lowv(0.24%) lowv maxTi(0.9%) maxTi(45%)	lowv(4.6%) lowv maxTi(6.9%) maxTi(45%)	
39			lowv(32%)						TL(2.0%)	lowv(15%)	lowv(15%) lowv maxTi(12%) maxTi(36%)	lowv(19%) lowv maxTi(16%) maxTi(37%)	
40	lowv(0.02%)	lowv(6.0%)	lowv(46%)					TL(0.11%)	TL(9.9%)	lowv(36%)	lowv(24%) lowv maxTi(18%) maxTi(32%)	lowv(26%) lowv maxTi(22%) maxTi(32%)	
41	lowv(17%)	lowv(31%)	lowv(54%)				TL(0.15%)	TL(1.5%)	TL(20%)	lowv(31%) lowv maxTi(18%) maxTi(27%)	lowv(30%) lowv maxTi(24%) maxTi(28%)	lowv maxTi(61%) maxTi(39%)	
42	lowv(37%)	lowv(42%)	lowv(65%) Del Gp lowv(1.5%)				TL(2.1%)	TL(6.7%)	TL(29%)	lowv(32%) lowv maxTi(29%) maxTi(21%)	lowv(33%) lowv maxTi(33%) maxTi(20%)	lowv maxTi(75%) maxTi(25%)	Neph(5.3%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
Del Gp: durability
TL: liquidus temperature
Al2O3/TiO2: Al_2O_3 is less than 4 wt.% when TiO_2 is greater than 2 wt.%
maxTi: maximum TiO_2
Neph: nepheline

Table A-19. SB10 MAR Assessment Results (Decant Y2 with 60 kgal Inleakage, Frit 625, BOBCalixC6 - August 2022)

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
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	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	BC	----
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	4356	4580	4516	4644	4644	4588	4532	4532	4686	4516	4516	4528	2049
%WL, 24	highv(48%)	highv(40%)	highv(0.51%)	highv(98%)	highv(97%)	highv(92%)	highv(100%)	highv(100%)	highv(100%)	highv(8.7%)	highv(0.55%)		highv(100%)
25	highv(36%)	highv(23%)		highv(75%)	highv(73%)	highv(68%)	highv(100%)	highv(100%)	highv(100%)				highv(100%)
26	highv(10%)	highv(1.0%)		highv(61%)	highv(59%)	highv(54%)	highv(100%)	highv(100%)	highv(100%)				highv(86%)
27				highv(45%)	highv(43%)	highv(37%)	highv(88%)	highv(91%)	highv(99%)				highv(63%)
28				highv(35%)	highv(33%)	highv(23%)	highv(71%)	highv(75%)	highv(84%)				highv(53%)
29				highv(16%)	highv(14%)	highv(4.2%)	highv(63%)	highv(65%)	highv(70%)				highv(44%)
30				highv(2.5%)	highv(1.0%)		highv(42%)	highv(45%)	highv(60%)				highv(36%)
31							highv(32%)	highv(33%)	highv(36%)				highv(20%)
32							highv(18%)	highv(21%)	highv(28%)				highv(10%)
33							highv(6.8%)	highv(8.6%)	highv(15%)				
34							highv(0.02%)	highv(0.31%)	highv(4.4%)				
35												maxTi(46%)	
36												maxTi(48%)	
37									TL(0.06%)			maxTi(50%)	
38									TL(1.4%)		maxTi(46%)	maxTi(52%)	
39			lowv(3.0%)						TL(9.4%)		lowv(0.13%) lowv maxTi(0.6%) maxTi(47%)	lowv(3.9%) lowv maxTi(6.9%) maxTi(46%)	
40			lowv(29%)				TL(0.15%)	TL(1.4%)	TL(20%)	lowv(13%)	lowv(12%) lowv maxTi(13%) maxTi(37%)	lowv(16%) lowv maxTi(17%) maxTi(37%)	
41	Neph(3.6%)	lowv(4.0%) Neph(5.9%)	lowv(40%) lowv Neph(4.4%) Neph(1.5%)				TL(1.6%)	TL(6.0%)	TL(29%)	lowv(20%) lowv maxTi(14%) maxTi(32%)	lowv(22%) lowv maxTi(19%) maxTi(34%)	lowv maxTi(47%) maxTi(53%)	Neph(12%)
42	lowv(3.7%) lowv Neph(11%) Neph(19%)	lowv(13%) lowv Neph(15%) Neph(16%)	lowv(28%) lowv Neph(26%) Neph(2.8%)			TL(0.48%)	TL(7.5%)	TL(16%)	TL(39%)	lowv(22%) lowv maxTi(19%) lowv maxTi Neph(0.7%) lowv Neph(6.3%) maxTi(30%) Neph(1.7%)	lowv(24%) lowv maxTi(22%) lowv maxTi Neph(1.3%) lowv Neph(6.1%) maxTi(30%)	lowv maxTi(52%) lowv maxTi Neph(7.6%) maxTi(41%)	Neph(61%)

BC: BOBCalixC6
highv: high viscosity
lowv: low viscosity
TL: liquidus temperature
maxTi: maximum TiO_2
Neph: nepheline