U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Start-up of Salt Waste Processing Facility – Impacts on Glass Formulation and Sludge/Salt Processing

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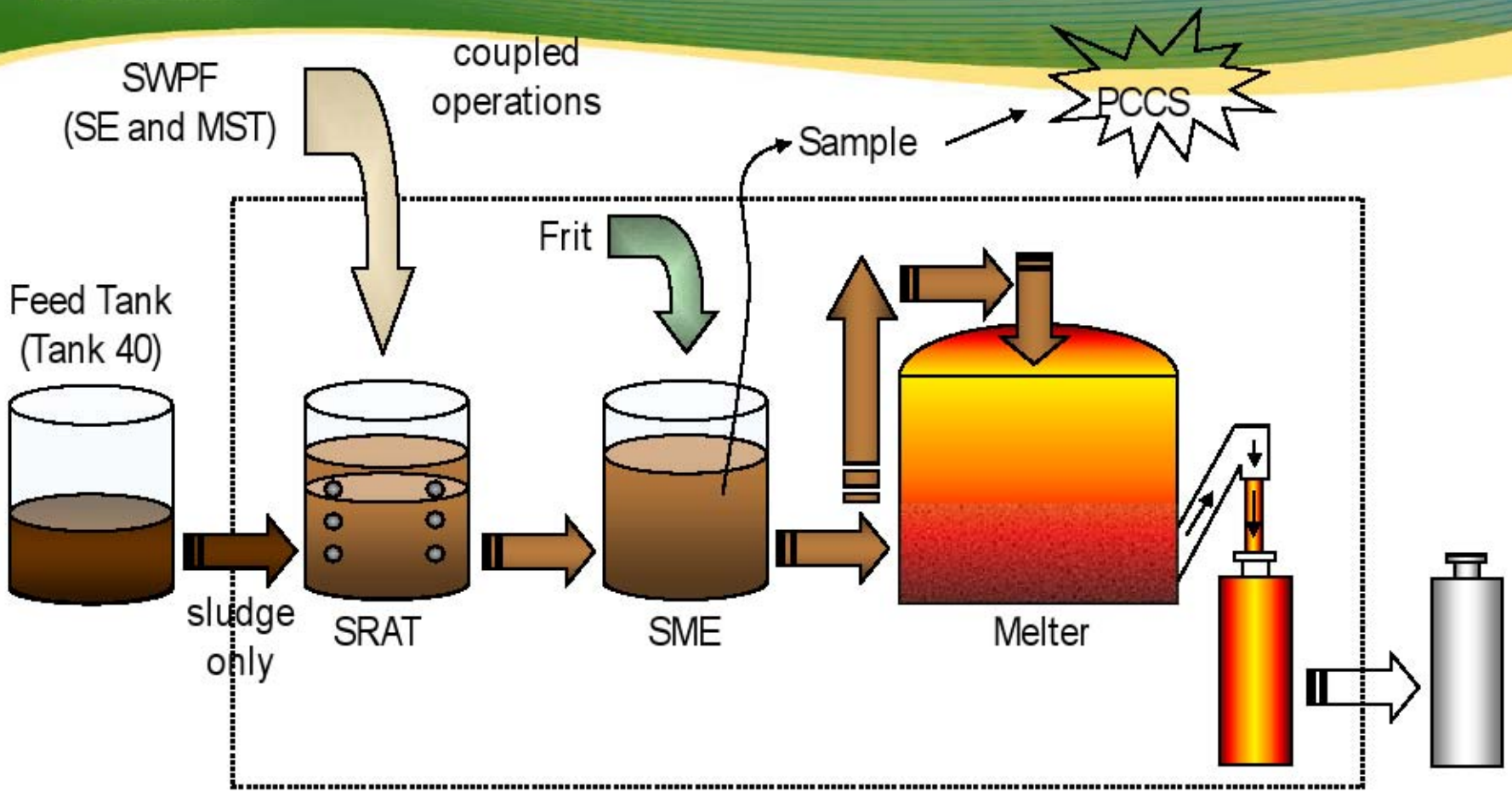
DWPF Coupled Operations Schematic



SRAT – Sludge Receipt Adjustment Tank

SME – Slurry Mix Evaporator

PCCS – Product Composition Control System

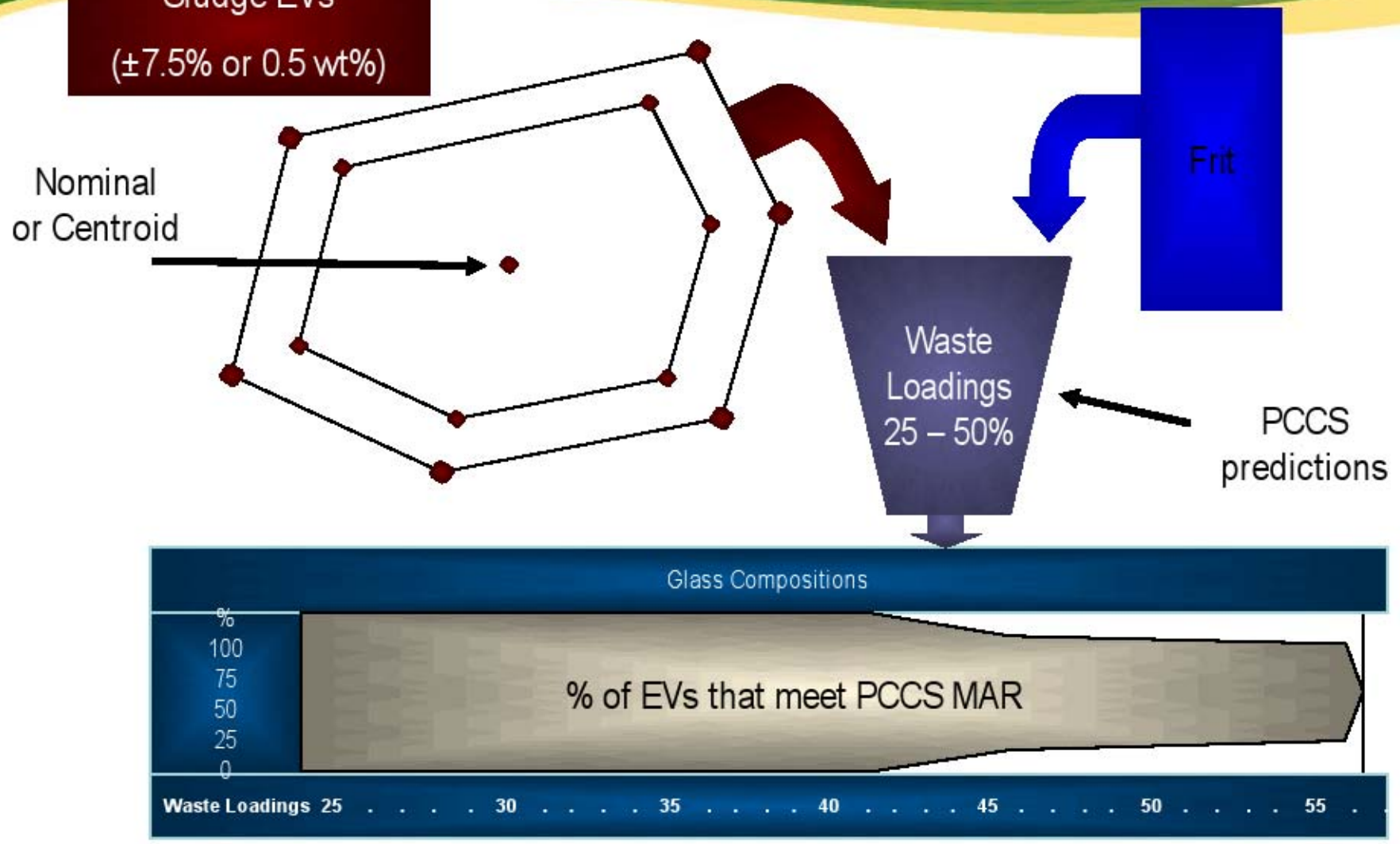
Integration of SWPF Flowsheet into DWPF

- **Key questions from a glass science or formulation perspective:**
  - What are the changes to key oxide components as DWPF transitions from current operations to a SWPF-coupled flowsheet?
  - Are the current process control models applicable to the future SWPF glass processing region?
  - Can frits be designed or tailored for each sludge batch to accommodate SWPF operations while still
    - *Providing access to waste loadings of interest to DWPF (nominal 40% WL)*
      - 36 – 44% WL interval acceptable based on PCCS predictions
    - *Meeting both process (e.g., viscosity (η), liquidus temperature (T_L), SO_4 solubility, etc.) and product performance (durability) constraints*
    - *Being robust to anticipated compositional variation in the SRAT-to-SRAT transfers*

Integration of SWPF Flowsheet into DWPF

- Technical program to support the integration of SWPF into the DWPF flowsheet is currently in progress
  - Based on Revision 19 of HLW Systems Plan (in particular Sludge Batches 11 through 18)
- Performed paper study assessments using existing models to identify candidate frits to support DWPF processing expectations once SWPF is integrated
  - Identify compositional gaps
  - If gaps are found, define testing program to fill gaps (supplement existing data)
  - Assess applicability of current models to future SWPF glass processing regions
- Primary assumptions being made:
  - Current models can be relied upon to assess future glass compositional regions
  - SWPF meet DWPF Waste Acceptance Criteria (WAC) limit of 0.7 M Na^+ (total solids)
  - Assessment based on addition of sludge and SWPF (MST and SE); where SWPF processing rate was 7M gallons per year

Variation Stage Measurement Acceptability Region (MAR) Assessment



EV – Extreme Vertices

PCCS – Product Composition Control System

Sludge Oxides with SWPF Additions (not glass; no frit)

	SB11	SB12	SB13	SB14	SB15	SB16	SB17	SB18
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
Al_2O_3	12.32	10.53	9.07	12.23	17.69	19.23	21.12	20.86
CaO	1.88	1.87	1.82	1.46	1.22	1.60	1.50	1.38
Cr_2O_3	0.21	0.25	0.27	0.23	0.20	0.20	0.17	0.16
Cs_2O	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82
Fe_2O_3	20.07	19.01	19.56	17.59	20.41	22.05	25.34	25.27
K_2O	0.25	0.28	0.25	0.21	0.20	0.25	0.21	0.20
MgO	1.98	1.17	0.76	0.40	1.00	0.76	0.65	0.73
MnO	1.66	1.81	1.84	1.94	1.07	2.05	2.03	1.81
Na_2O	29.16	31.99	32.57	33.38	32.66	31.64	27.62	27.23
NiO	0.71	0.79	1.33	1.64	0.86	0.36	0.21	0.22
SO_4	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
SiO_2	5.15	5.46	5.01	3.21	3.86	3.48	3.33	4.13
ThO_2	1.57	0.86	0.48	0.17	0.07	0.02	0.01	0.03
TiO_2	12.47	12.47	12.47	12.47	12.47	12.47	12.47	12.47
U_3O_8	8.77	9.89	10.99	11.67	5.20	2.64	2.07	2.20
ZrO_2	0.39	0.40	0.40	0.33	0.28	0.33	0.31	0.29

Summary of Measurement Acceptability Region (MAR) Assessments

- SB11 – SB18
  - Frits were identified for all sludge batches that yield projected operating windows of at least 36 – 44% WL while accounting for the ±7.5% variation for SWPF operations while meeting all process and product performance constraints
    - Assuming current models are still applicable

- Technical Challenges:
  - Low Al_2O_3 concentrations (contributed also by 40% WL) in some sludge batches require addition of Al_2O_3 in frit
    - SWPF dilution effect → lower Al_2O_3 constraint in glass of 3.0 wt% (without uncertainties)
  - *High Na_2O concentration in SRAT → leads to Na_2O management among three sources (sludge, frit, and salt waste stream)*
    - SWPF adds Na_2O to the SRAT; dilutes Al_2O_3 and most other sludge components
    - Lower Na_2O concentration in frit targeted to meet process and product performance constraints
  - *Balance Tank 51 washing strategy, volume of SWPF, and Na_2O concentration in frit, waste loading and fissile loading*

Experimental Program – Current Status

- Defined compositional gaps between models and future SWPF processing regions
  - Primary gap: 2 – 6 wt% TiO_2 (in glass)
    - *Example: T_L model validated up to 2 wt% TiO_2*
- Developed test matrix to fill compositional gaps
- Currently fabricating the test matrix glasses
- Planned activities:
  - Measure various glass properties
  - Assess measured properties versus model predictions
  - If warranted, refine models and implement into PCCS to support SWPF processing
    - *Measurement Acceptability Region (MAR) assessment would be revisited for SWPF based processing*

Oxide	Minimum	Maximum
Al_2O_3	3.5	13
B_2O_3	4.5	10
BaO	0	0.45
CaO	0.2	2
Ce_2O_3	0	0.4
CoO	0	0.25
Cr_2O_3	0	0.35
Cs_2O	0.3	1
CuO	0	0.3
Fe_2O_3	5	16
K_2O	0	0.4
La_2O_3	0	0.3
Li_2O	0.5	7
MgO	0	2
MnO	0.2	4
Na_2O	8	18
NiO	0	2
PbO	0	0.4
SO_4	0	0.4
SiO_2	35	55
ThO_2	0	1
TiO_2	2	6
U_3O_8	0	6
ZnO	0	0.3
ZrO_2	0	0.4

Salt-Sludge Heel Processing

- **Key aspects to consider from a glass formulation perspective:**
  - Minimum Al_2O_3 requirements in glass
    - *SWPF → TiO_2, Na_2O, Cs_2O, and SO_4*
  - Impact on waste loadings
    - Fissile limits
    - Heat loading limits
  - Addition of simulated sludge vs tailoring the frit to match qualified iron containing borosilicate glass
    - *Impact on waste loadings/canister count?*
  - Model ranges or applicability
  - Solubility limits (e.g., TiO_2, SO_4)
  - Others… CPC processing (rheology, suspension, acid addition strategy, …)

Summary

- Based on current process control models and their associated constraints, frits have been identified that are robust enough to handle SWPF feeds into DWPF (SB11 – SB18) while:
  - Allowing DWPF to target nominal WLs of 40%
  - Meeting all process and product performance constraints
    - *Notes:*
      - Each sludge batch will likely require a different (uniquely tailored) frit which is consistent with previous frit development efforts to support DWPF operations
      - Assumes current process control models are valid in expanded compositional region – which will be verified prior to implementation and through qualification program for each sludge batch
- Experimental program is in place to assess applicability of current PCCS models to accommodate expanded compositional region with SWPF integration
- Detailed assessment of salt-sludge heel processing flowsheet (SB19 – SB20) has not been performed at this time and will be addressed in future systems plan studies