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DEPARTMENT OF ENERGY

Office of River Protection

HANFORD SITE

Advances in Glass Formulations for Hanford High-Aluminum, High-Iron and Enhanced Sulphate Management in HLW – 13000

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Session 58

Presentation Outline

- Background
- Office of River Protection Advanced Glass Formulations Development
- Challenges and Approaches for Hanford HLW Vitrification
- Consequences of HLW Improvements on Hanford LAW Vitrification

Key Messages

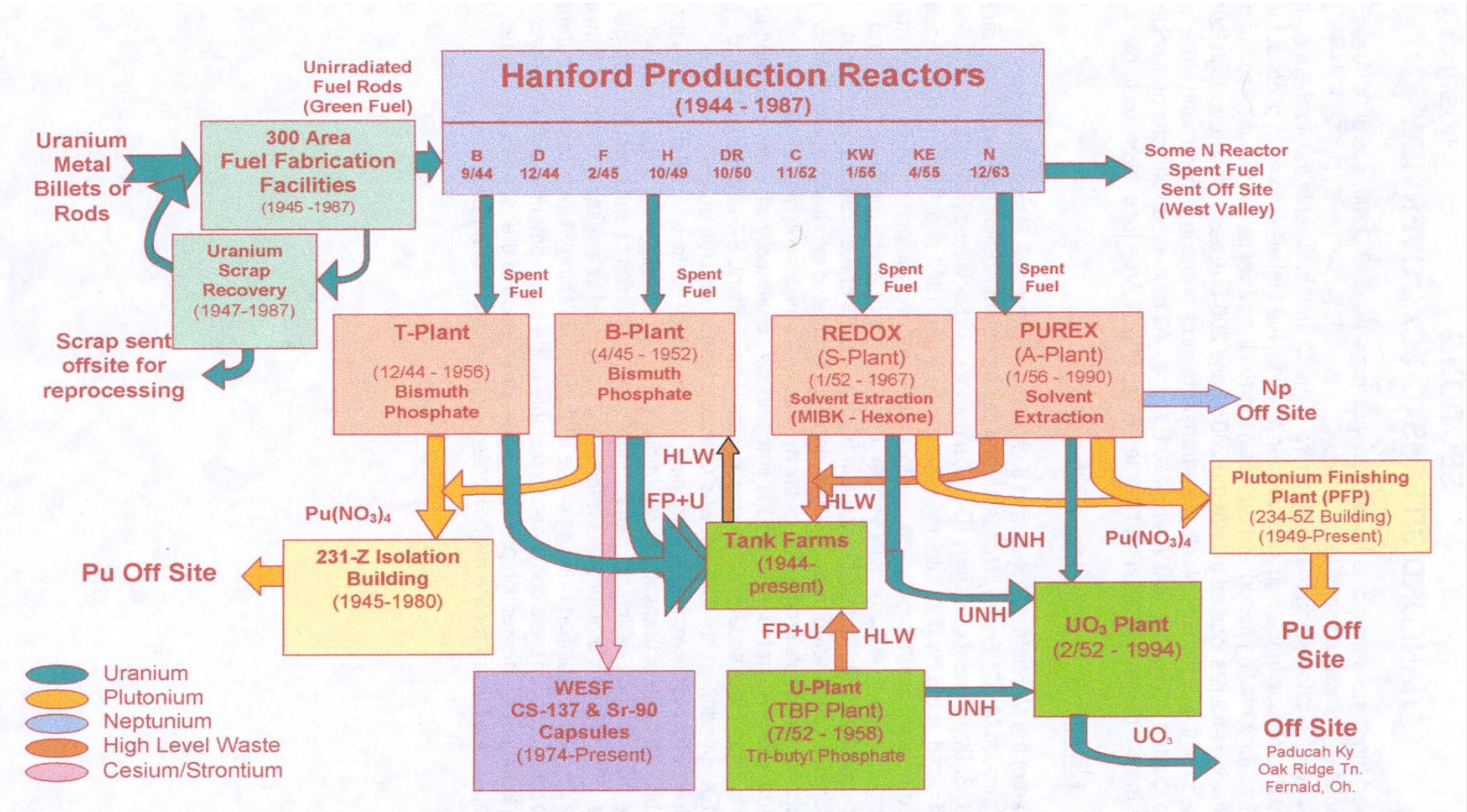
- Advanced glass formulations have the potential of reducing HLW canister counts by one-third and LAW container counts by greater than 50%. The HLW mission life will become limited by the ability to deliver feed. The WTP LAW might require a modest supplemental LAW facility to address the remaining inventory within the regulatory framework.

Key Messages
Continued

- Advanced HLW glass formulations for increased Aluminum loading offers the advantage of reducing the soda added in PT (19 MT of soda are added to the 51 MT of sodium in the tank waste inventory).
  - This addresses concerns for corrosion in PT vessels (UFP-1 & UFP-2) from challenging thermal cycling.
- Performance enhancements through improved glass formulations are essentially transparent to the engineered facility.

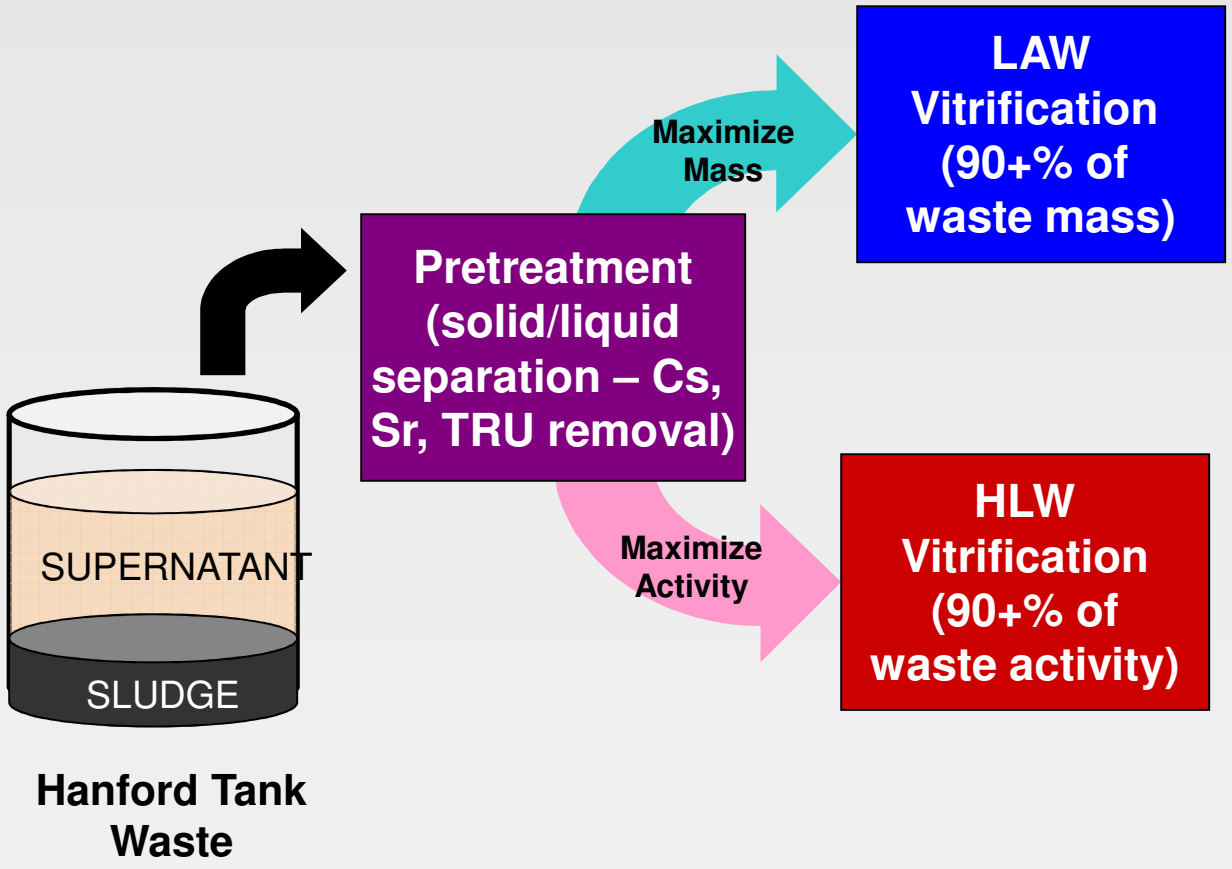
Background

Generation of Tank Wastes

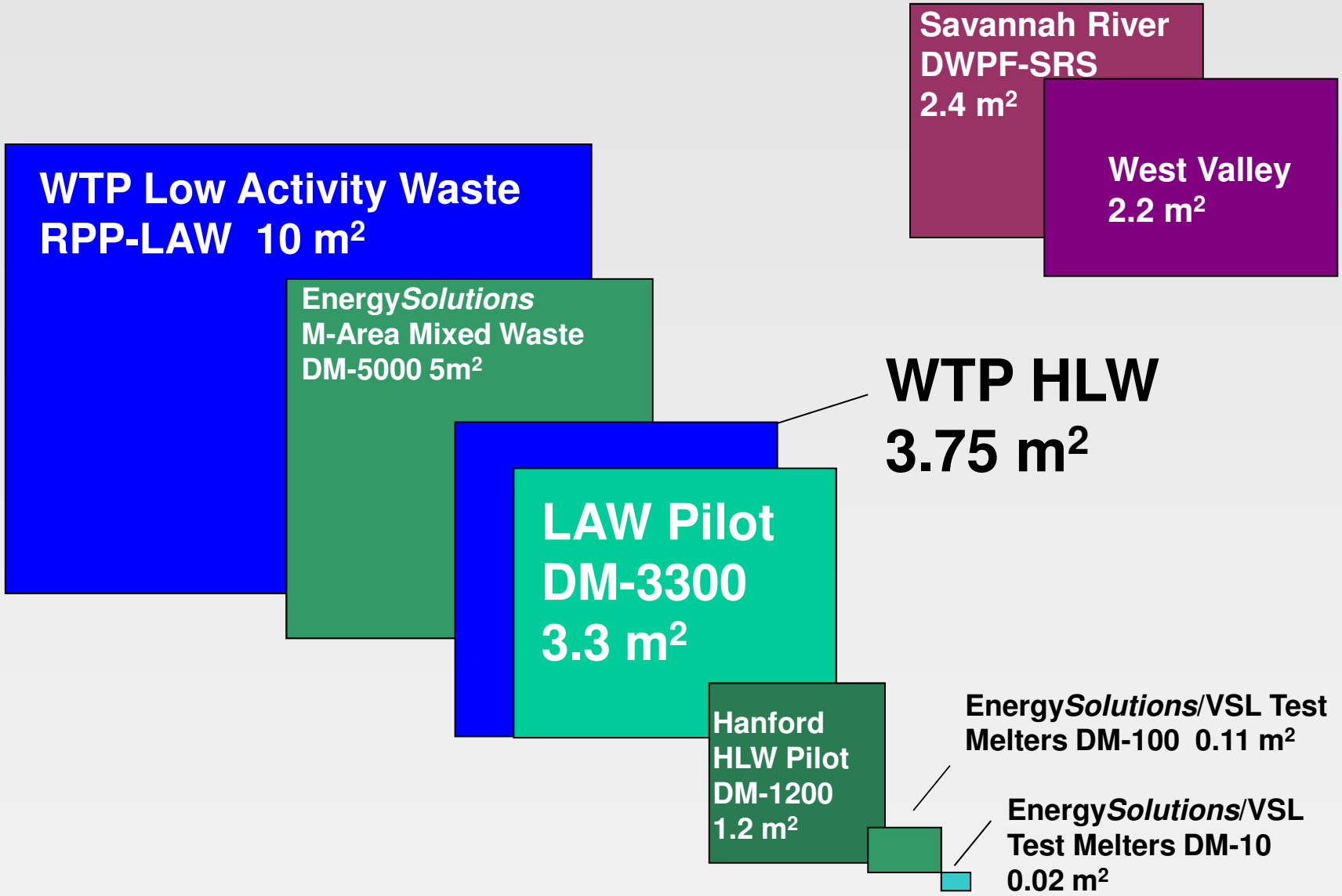


9 Reactors; 4 Fuel Reprocessing Flow sheets;
100,000 MT Fuel Processed

WTP Flow Sheet
Key Process Flows



Melter Scale Comparison



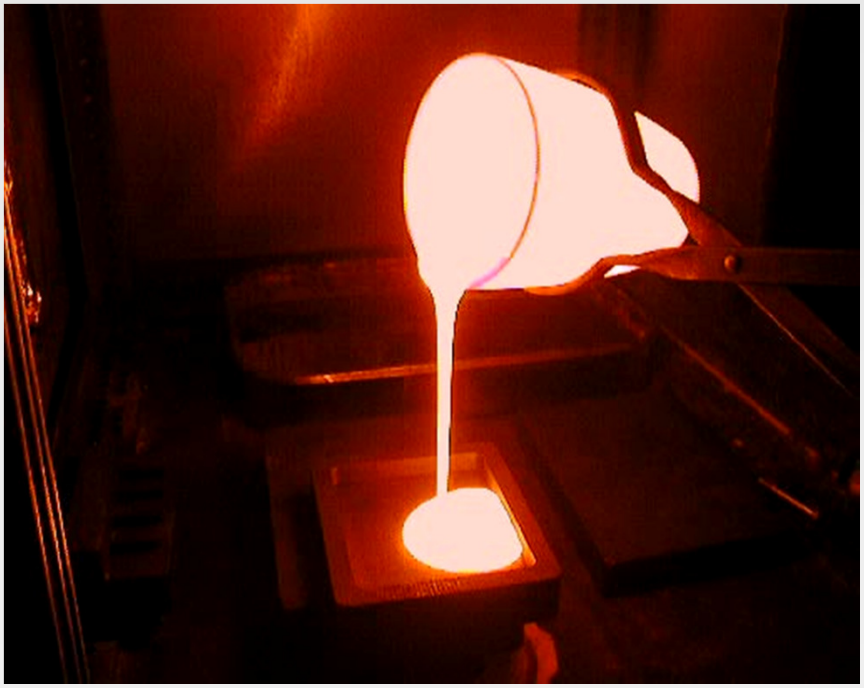
Contract Glass Formulation for HLW Treatment

- Current estimates (SP6: ORP-11242) project that ORP will produce 10,586 HLW canisters (31,968 MT glass).
- The current glass formulation efforts have been conservative in terms of achievable waste loadings (WTP baseline).
- These formulations have been specified to ensure the glasses are homogenous, preclude secondary phases (sulfate-based salts or crystalline phases), are processable in joule-heated, ceramic-lined melters and meet WTP Contract terms.

Office of River Protection Advanced Glass Formulations Development:

Aluminum, Iron and Sulphur

Reducing the Cost and Schedule for Mission Completion



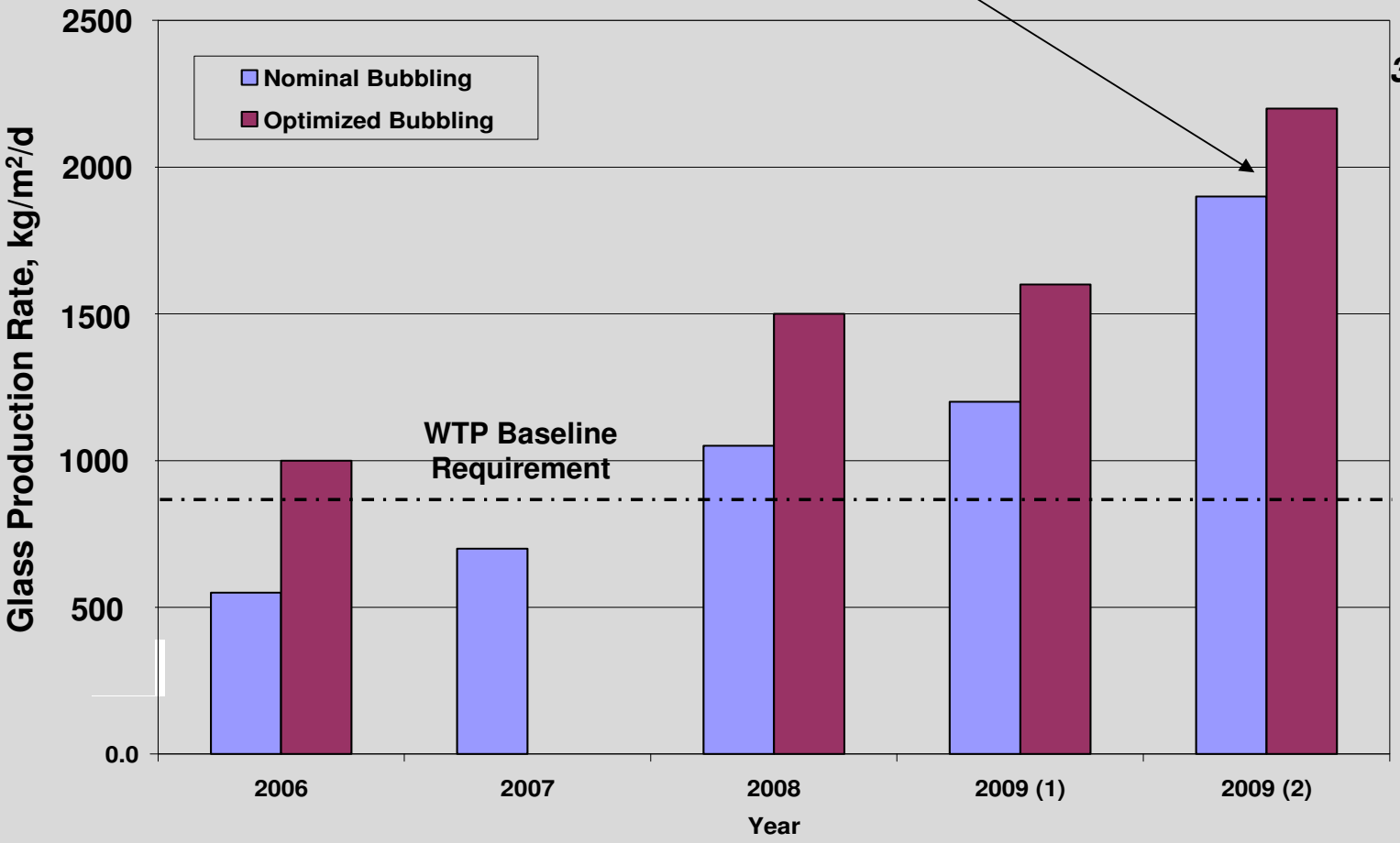
- Improve LAW and HLW glass waste loadings
- Increase HLW glass production rate
- Optimize HLW and LAW melter performance
- Enhance HLW and LAW glass property-composition models

The WTP Mission can be significantly improved without costly mechanical changes or new capital projects!

High-Al HLW Glass Formulations

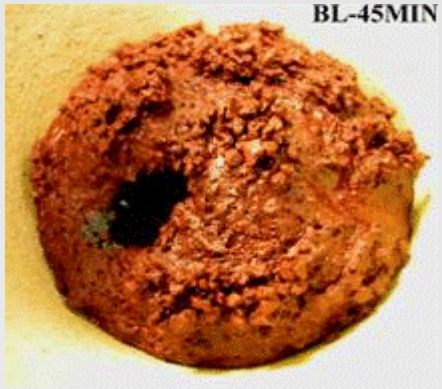
Waste loading increased to 50 wt% **(26.6 wt% Al_2O_3)**
Glass production rate further increased:

Most recent tests have reached 3000 kg/m²/d

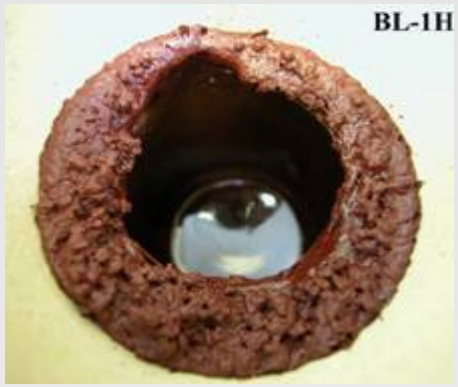


Small-Scale Melt Rate Screening Results: ORP HLW Glasses with 24 wt% Al_2O_3

30 min



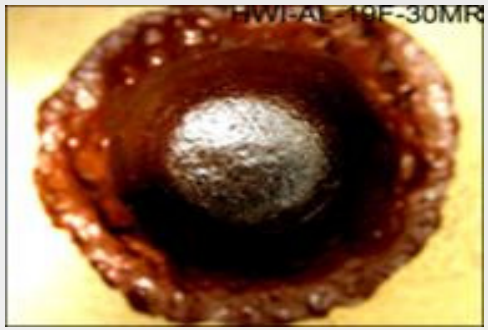
45 min



60 min

Initial Formulation

Reaction Time



30 min

60 min

Improved Formulation

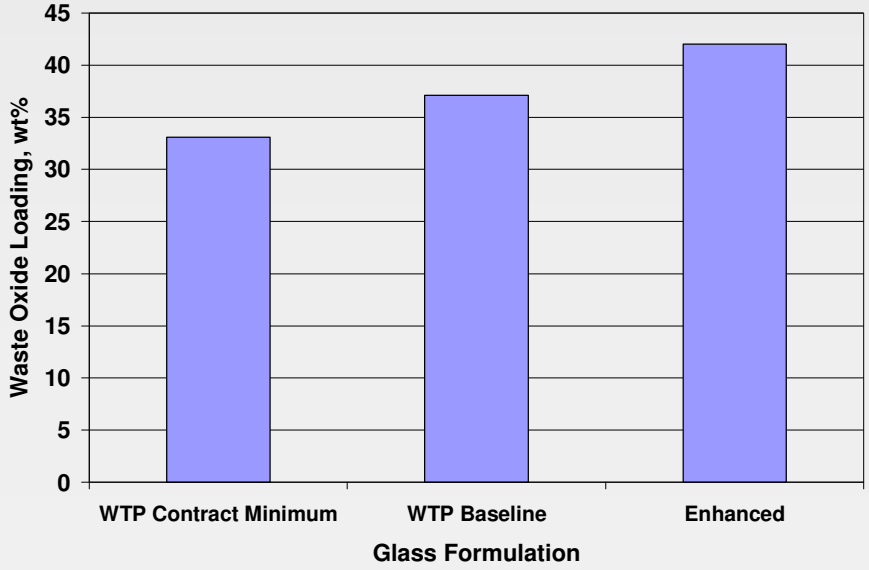
Improvements confirmed in one-third scale pilot melter tests

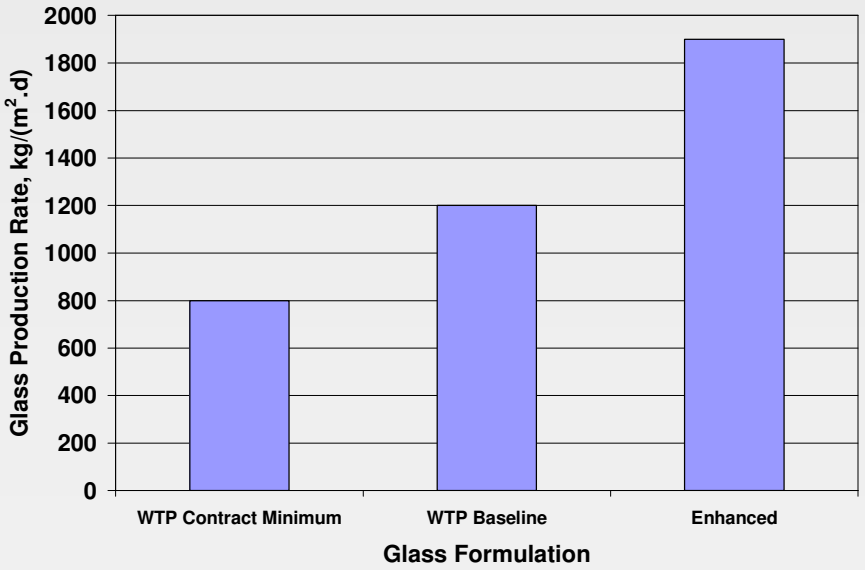
Melt Rate and Waste Loading in High Fe HLW Glasses

Waste loading in typical high-Fe HLW stream is limited by spinel crystallization

Higher waste loadings often result in lower processing rates

Improved formulations have been developed with both high melt rates and high waste loadings





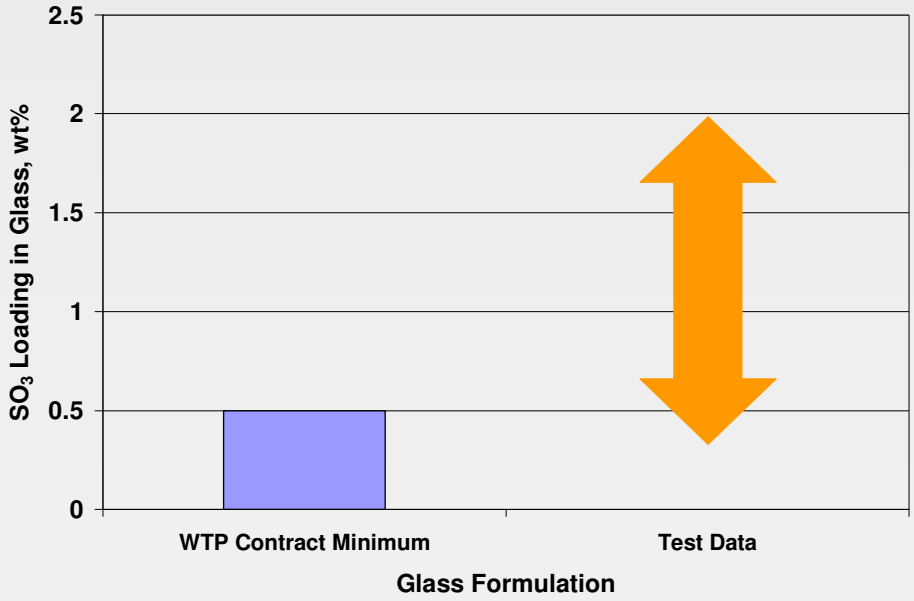
Waste Loading in High Sulfur HLW Glasses

About 22% of the projected HLW feed batches to the WTP are expected to be limited by sulfate

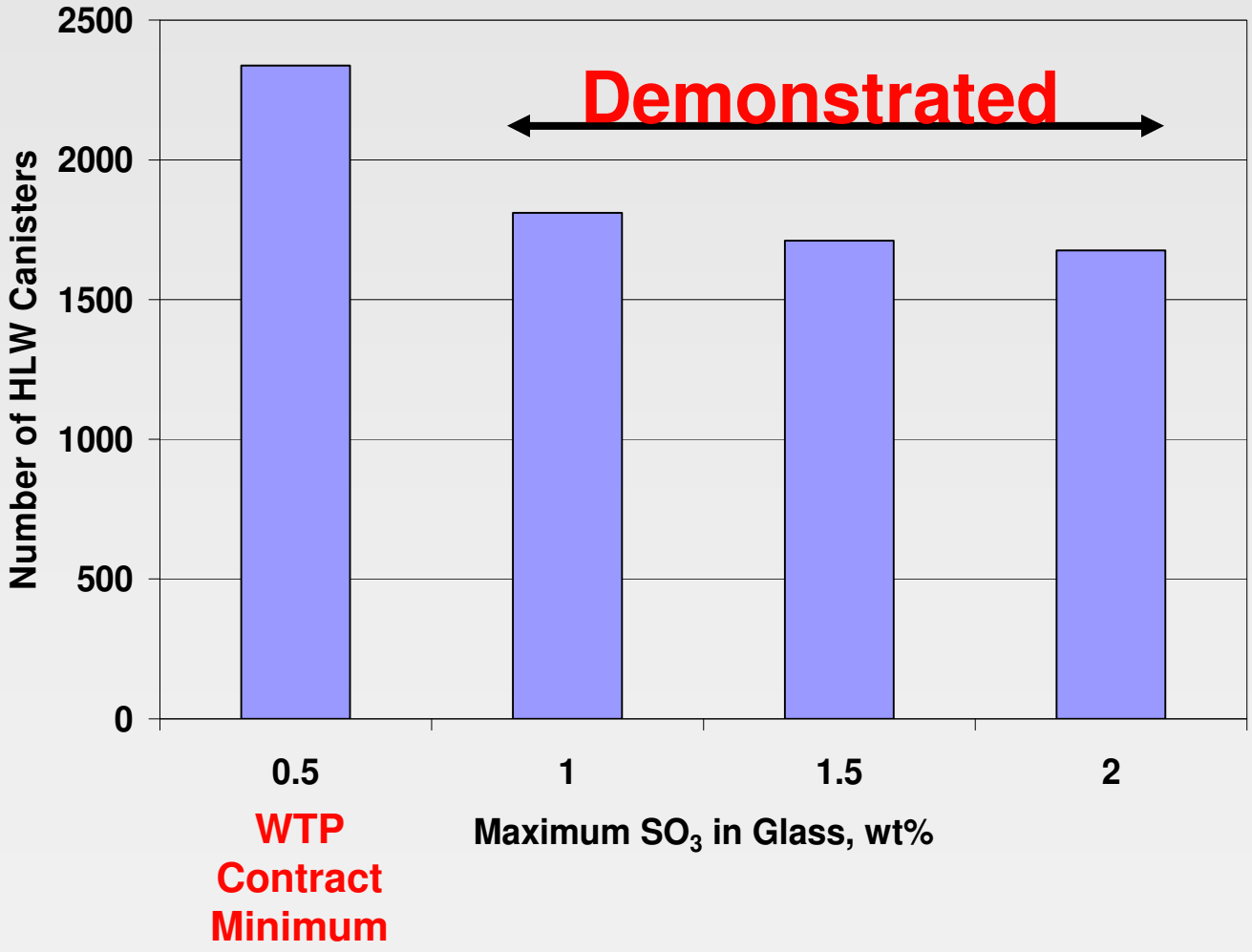
The sulfate content in the HLW fraction is dependent on the washing performance in pretreatment

High sulfate feeds pose the risk of molten salt formation in the melter

HLW glass formulations with high sulfate solubility have been developed to address this risk



Effect of Glass Sulfate Capacity on Amount of Sulfate-Limited HLW Glass



Challenges and Approaches for Hanford HLW Vitrification

Key Challenges for HLW Vitrification

- Robustness of the Glass Formulation: The present work was aimed at exploring the limits of waste loading for a high-aluminum, high-chromium, high-iron, high-bismuth and phosphate Hanford HLW streams. To implement these new glass formulations for HLW processing at the WTP and realize the associated cost and schedule benefits, it is necessary to determine the robustness of these compositions with respect to process and feed variations expected at the WTP. This can be accomplished by completing the data set for composition space and incorporating the resulting model into the glass algorithm.

Key Challenges for HLW Vitrification

continued

- Property-Composition Model Enhancement:
  - Only a small fraction of the ORP HLW glasses fall within the validity regions of the various baseline WTP composition-property models. The glass components that have large increases in their respective compositional ranges include Al_2O_3, B_2O_3, Bi_2O_3, CaO, Cr_2O_3, Fe_2O_3, P_2O_5, and SiO_2.
  - While the nepheline discriminator is effective in screening out glasses that form nepheline, it also screens out many compositions that do not.
- Processing & Formulating Glasses with higher crystal contents:
  - Previous tests with HLW iron-limited wastes showed that allowing a higher crystal content product can allow significantly increased waste loadings. Evaluation of this enhanced “operational liquidus temperature” approach for other waste streams would result in further waste loading increases.

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