

Reducing WTP Mission Life Through Advanced Glass Formulations

The U.S. Department of Energy Office of River Protection (ORP) has implemented an integrated program to increase the loading of Hanford tank wastes in glass while meeting melter lifetime expectancies and process, regulatory, and product quality requirements. The program will provide a technical, science-based foundation for making key decisions about facility operations at Hanford Tank Waste Treatment and Immobilization Plant (WTP). The program will provide data to support development of advanced glass formulations, key process control models, and tactical processing strategies to ensure safe, successful operations at the low-activity waste (LAW) and high-level waste (HLW) vitrification facilities, with an appreciation toward reducing overall mission life.

Research and development plans for both LAW (see Figure 1) and HLW (see Figure 2) vitrification have been established to identify the near-, mid-, and longer-term activities required to develop and validate advanced LAW and HLW glasses and their associated models, including both direct feed and full pretreatment flowsheets. The program spans key technical areas including (but not limited to) advanced waste glass formulations for HLW and LAW; glass property-composition model development and implementation to support mission planning and facility operations; SO_3 , Tc, and halogen retention in glass; nepheline formation in glass; crystal-tolerant glass formulations; and melting rate enhancements. The plans also integrate technical support for facility operations and waste qualification activities to show how these activities are interdependent with the advanced waste glass program.

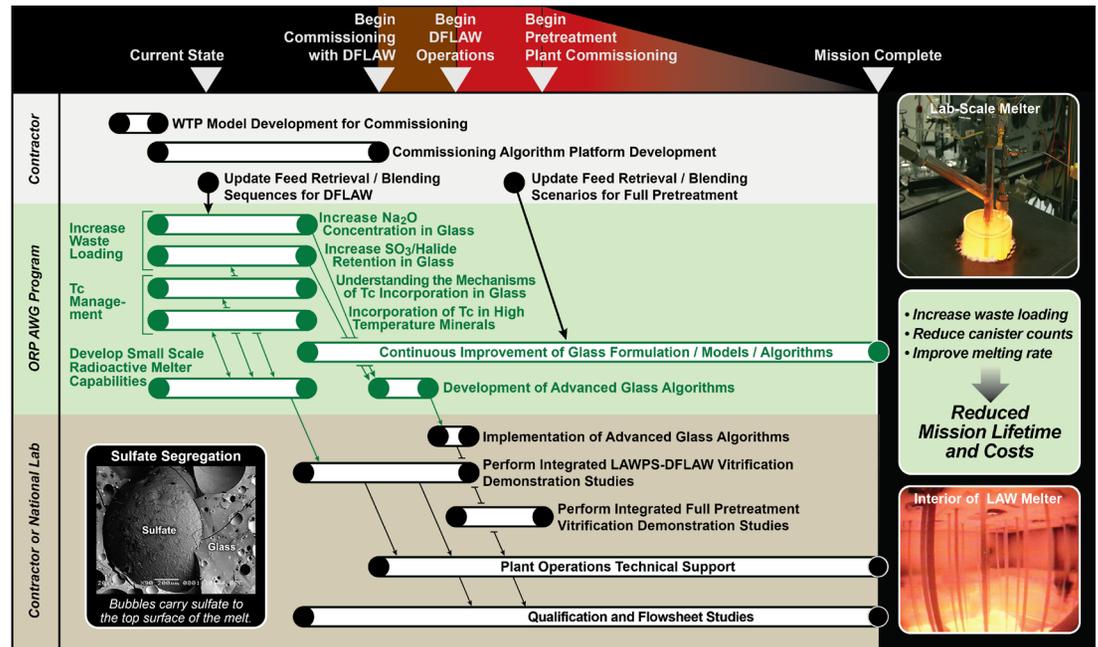


Figure 1. Advanced Low-Activity Waste Glass Research and Development Plan to Support the WTP Mission

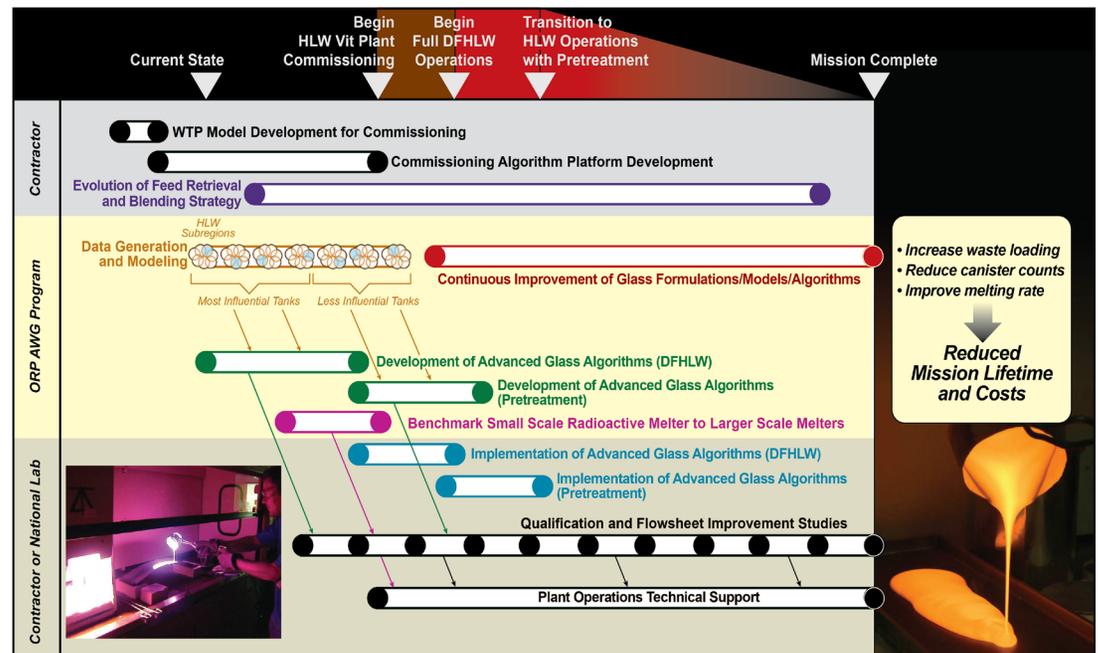


Figure 2. Advanced High-Level Waste Glass Research and Development Plan to Support the WTP Mission

The research outlined in these plans is motivated by the potential for substantial economic benefits from continued advancements in glass formulation and models supporting facility operations, including significant increases in waste loading and waste throughput. Advanced glass formulations will make Hanford tank waste management more cost effective by reducing both the tank waste treatment schedule and the amount of LAW and HLW glass for storage, transportation, and disposal.

For example, PNNL used a preliminary set of advanced models and constraints developed on limited data and compared the HLW glass volumes expected under the current WTP models and constraints (commissioning based) for a series of feed vectors or clusters. Figure 3 compares the different model and constraint sets on estimated glass volumes that may be produced. Implementing the advanced glass models (recognizing they are preliminary and currently do not address uncertainties) would reduce the volume of HLW glass produced by ~2.5 times compared to the current WTP baseline constraints by targeting higher waste loading for a broad range of waste streams.

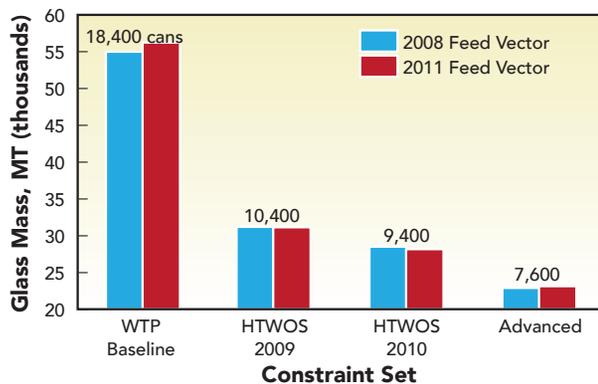


Figure 3. Comparison of Estimated Glass Masses Based on Various Model and Constraint Sets (from Vienna et al. 2013)

PNNL also demonstrated how LAW glass mass could be reduced through waste loading enhancements indicated by more recent studies. The results suggest that average sodium loading in glass would increase from ~12 to 20 wt% Na₂O and the number of LAW glass containers would decrease by ~38% (from ~135,000 to ~82,000 containers). Figure 4 compares the projected number of containers under current WTP baseline constraints to the number projected under the advanced formulation rules (with the optimistic halide constraints). Recent advanced HLW glass formulations have shown significant improvements in Cr₂O₃ and Al₂O₃ loadings and could be the basis for eliminating solids leaching in pretreatment. Eliminating solids leaching from pretreatment would decrease the waste Na mass (estimated to be 50,580 tons) substantially, significantly reducing LAW glass volume. Figure 4 also compares the number of LAW containers expected without solids leaching using the current WTP and advanced glass formulation rules.

There are additional benefits to developing advanced glasses that are more tolerant to key components in the waste (e.g., Al₂O₃, Cr₂O₃, SO₃, and Na₂O) than current WTP constraints. It may reduce (or even eliminate) the need for leaching to remove Cr and Al and washing to remove excess S and Na from the HLW fraction. It may also make direct vitrification of the HLW fraction without significant pretreatment more cost effective. Increased waste loading, reduced leaching/washing requirements, and improved melting rates provide a system-wide approach to improve the effectiveness of the WTP process.

To support this effort, ORP has assembled an international team of experts from PNNL, The Catholic University of America, Savannah River National Laboratory, Idaho National Laboratory,

Washington State University, Rutgers University, Tokyo Institute of Technology, the University of Sheffield, the University of Ottawa, and the University of Chemistry and Technology Prague, with independent technical oversight from Alfred University and Vanderbilt University

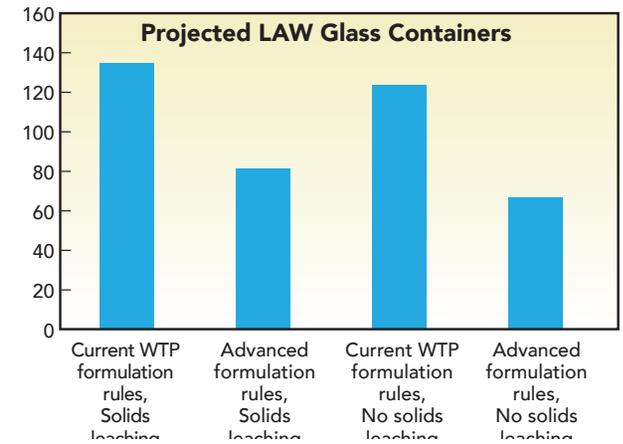


Figure 4. Comparison of Predicted LAW Glass Containers Using Current WTP Formulation Rules and Advanced Glass Formulation Rules for Solids Leaching and No Leaching Cases

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