OFFICE OF
RIVER PROTECTION
United States Department of Energy

Status of Waste Treatment & Immobilization Plant Pretreatment Technical Issues

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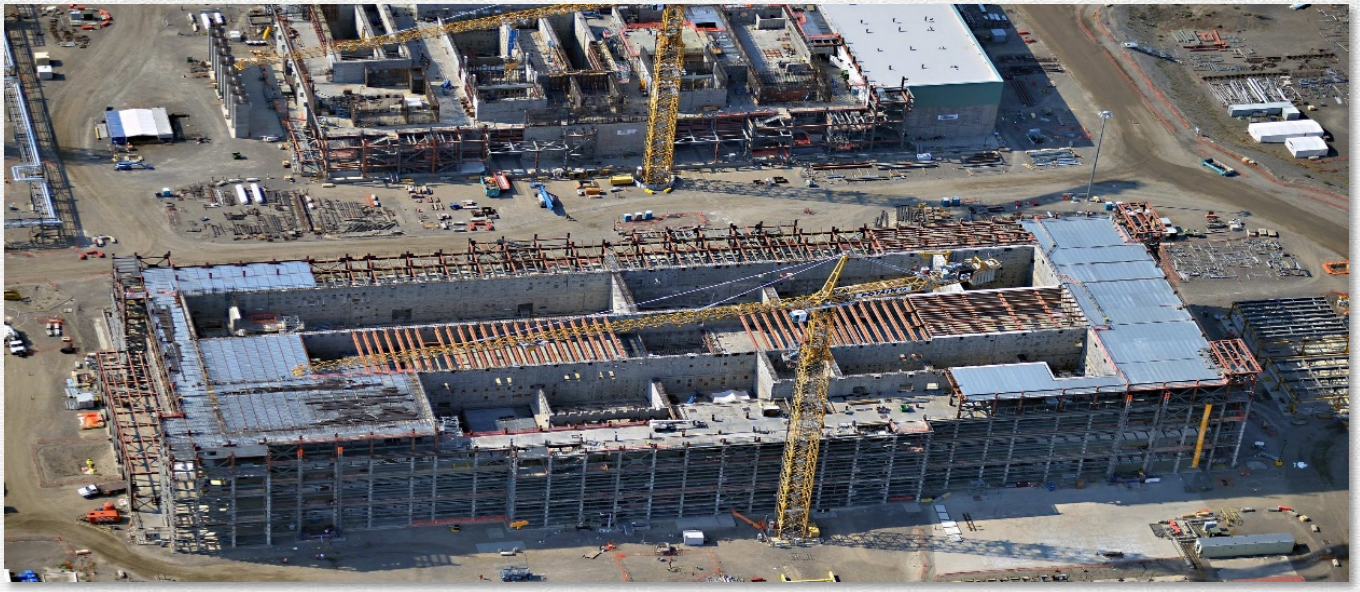
Summary



- **In late 2012, the U.S. Department of Energy (DOE), Office of River Protection limited project activities at the High-Level Waste (HLW) and Pretreatment (PT) facilities**
- **Restrictions were imposed on the remaining engineering, procurement, and construction (EPC) work due to:**
  - Unresolved technical, management, and quality issues
  - Need for design and nuclear safety basis alignment
- **Return to production engineering authorized in August 2014 for HLW**
- **Recent technical issue resolution efforts have focused on the PT Facility**

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Current Status – Pretreatment Facility Technical Issue Resolution Anticipated Completion of Work Spring 2018

T1 Hydrogen Gas Events in Vessels*	➢ Risk of combustion in the headspace of high-solids vessels due to hydrogen accumulation ➢ Resolved with approval of revised hydrogen safety control strategy consisting of both preventive and mitigative safety and process controls – *Resolved December 2016*
T2 Criticality in Pulse-Jet Mixer (PJM) Vessels*	➢ Dense fissile particles could settle on the bottom of Waste Treatment and Immobilization Plant (WTP) vessels with sufficient mass and geometry such that a criticality event is credible ➢ Issue resolved via calculations, engineering, and chemistry studies; criticality safety evaluations; and integrated process controls – *Resolved December 2016*
T3 Hydrogen in Piping and Ancillary Vessels*	➢ Flammable gases generated by waste treated in WTP could accumulate in process piping and cause deflagration event ➢ Resolved by updating WTP safety basis, basis of design, and process piping design criteria to prevent or control potential hydrogen explosions – *Resolved December 2016*
T4 PJM Vessel Mixing and Control	➢ Concern with adequacy of PJM mixing and control system ➢ *Standard high-solids vessel (SHSV) control and mixing testing completed September 2017; method to confirm vessel designs – Spring 2018*
T5 Erosion/Corrosion in Piping and Vessels	➢ Uncertainties exist in waste feed characteristics and ability to meet 40-year service life ➢ Confirm erosion/corrosion design basis for pipe and vessels, including margin, through testing and analysis – *Technical reports for erosion and corrosion to be completed spring 2018*
T6 Design Redundancy/ In Service Inspection	➢ Perform failure modes, effects, and criticality analysis, ventilation system studies ➢ Complete conceptual design of Planning Areas 2, 3, and 4 – *Design report issued November 2017*
T7 Black Cell Vessel/ Equipment Structural Integrity	➢ Seismic ground motion criteria for WTP changed in 2005 ➢ Complete structural analysis of standard vessel and strategy for structural upgrades for installed vessels – *Design strategy for installed vessels spring 2018*
T8 Facility Ventilation/Process Offgas Treatment	➢ Multiple technical challenges associated with ventilation system, including HEPA filters ➢ Complete engineering/nuclear safety assessments to ensure ventilation meets requirements – *Design report for HVAC issued November 2016, process ventilation system report September 2017*

Resolved Ongoing

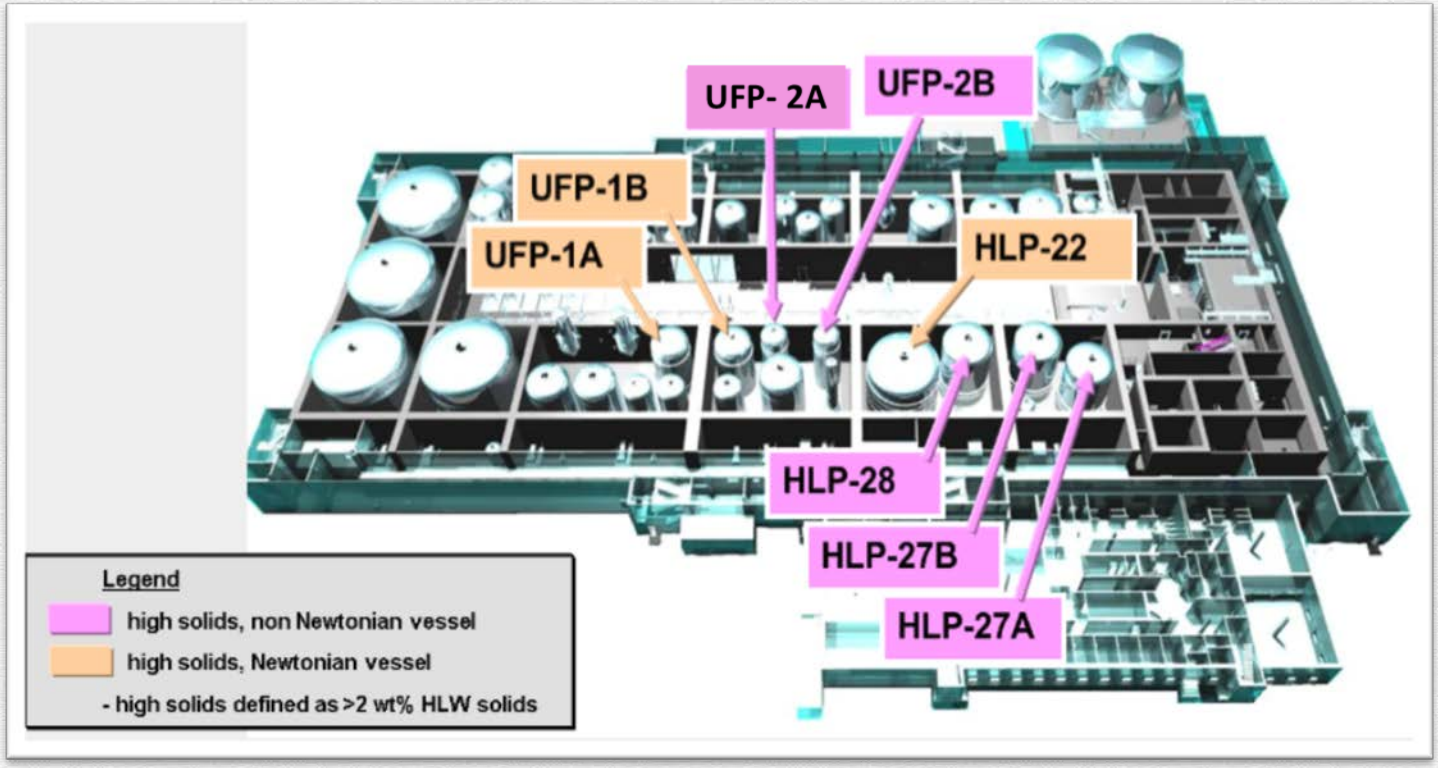
*This technical issue has been sufficiently resolved to allow engineering to proceed in support of design and safety basis development.

Technical Issue Resolution Strategic Elements

- **Design changes –** *Preliminary Engineering Complete*
  - SHSV PJM vessel designs
  - Planning Areas 2, 3, and 4 conceptual design study
- **Pretreatment flowsheet changes –** *Preliminary Engineering Complete*
  - Removal of oxidative leaching process
  - Reduced aluminum leaching temperature
  - Removal of cesium concentration evaporator
- **Test SHSV at full scale –** *Testing Completed*
- **Updated nuclear safety analysis –** *Issues Resolved to Support Engineering*
  - Hydrogen in vessels
  - Criticality
  - Hydrogen in piping and ancillary vessels

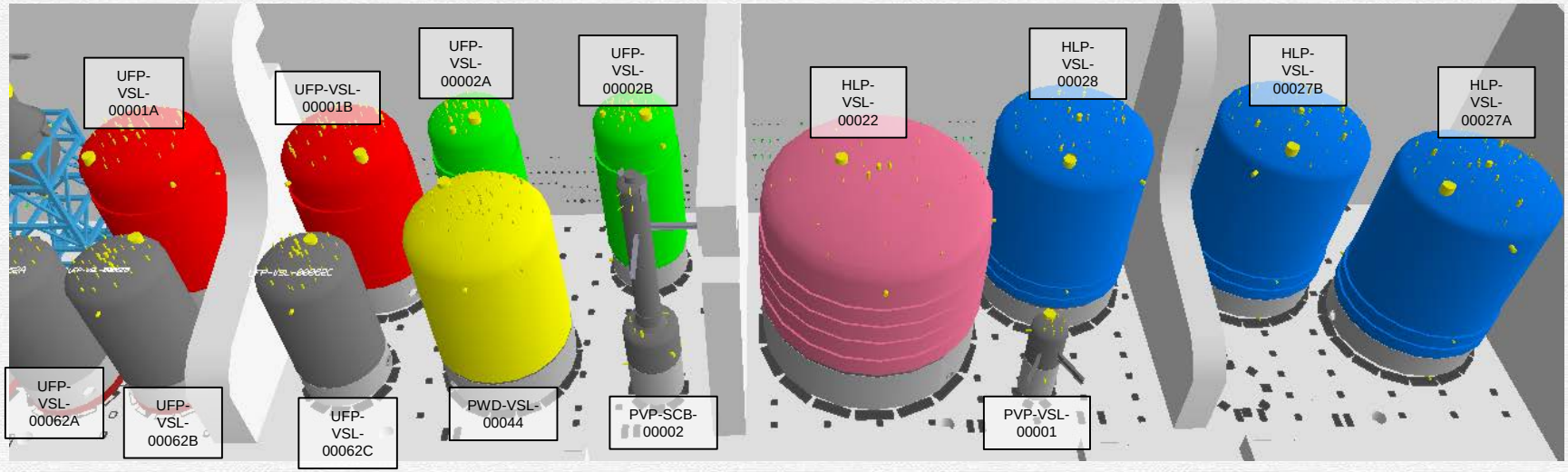
Focus of Technical Issues

- DOE has evaluated replacing up to 8 vessels with 16 smaller vessels; approximately 22,000 gallons, 16-feet diameter, 6 PJMs
- Candidate vessels to replace in design represent 5 designs: 30,000–160,000 gallons

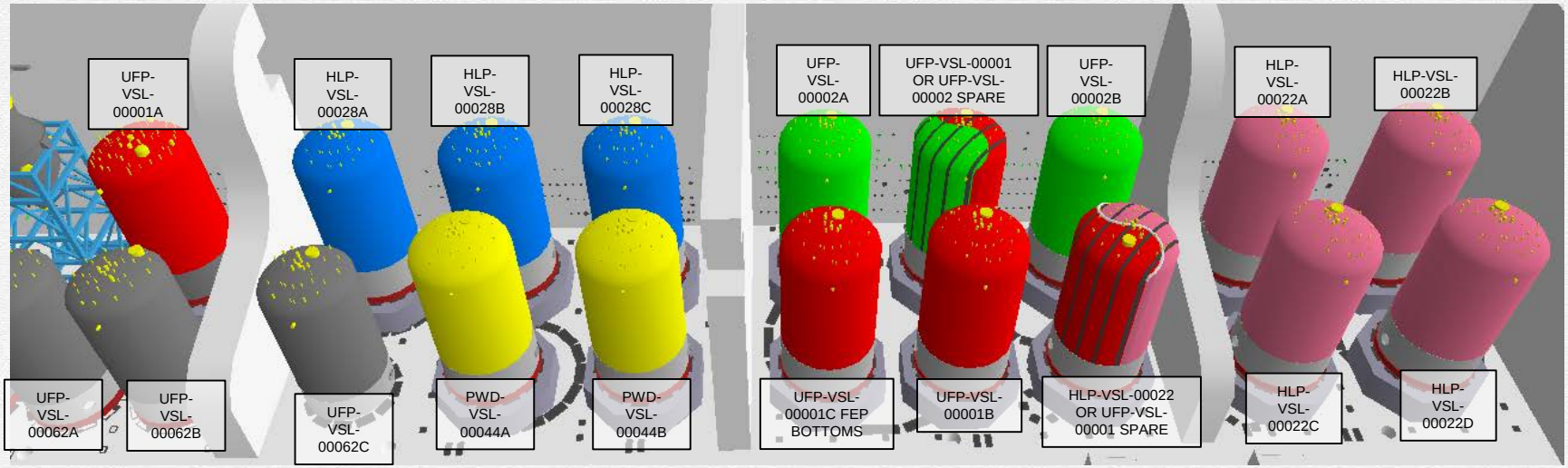


Revised Pretreatment Facility Conceptual Layout

CURRENT BLACK CELL LAYOUT FOR HIGH SOLIDS VESSELS



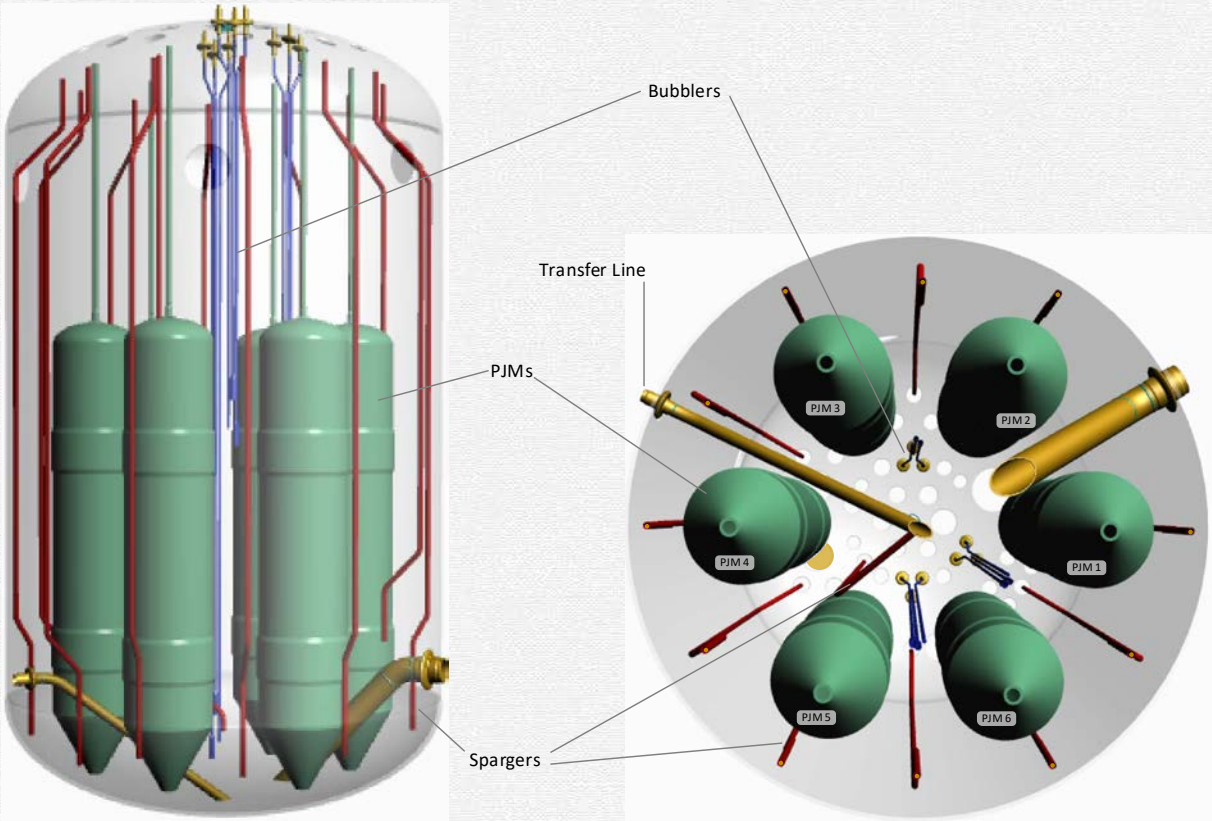
DESIGN CONCEPT LAYOUT FOR BLACK CELL SHSV DESIGN



Vessel color coding depicts common functionality between current design configuration (top) and proposed design configuration with SHSV (bottom).

Standard High-Solids Vessel Design Concept

- **Design derived from previous testing and evaluation**
- **Proposed to replace eight WTP vessels**



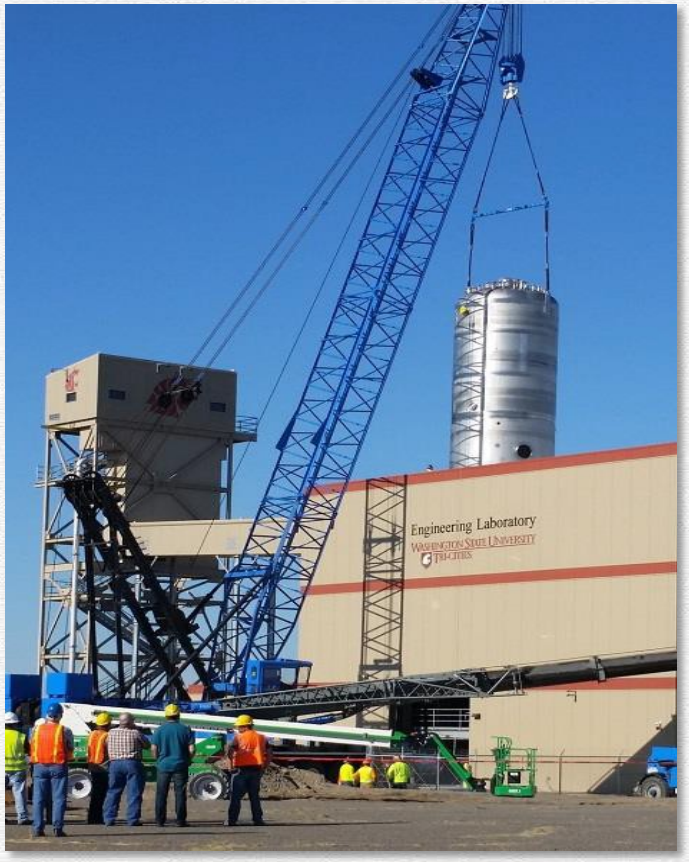
Vessel Internals and Key Parameters, Side and Bottom Views

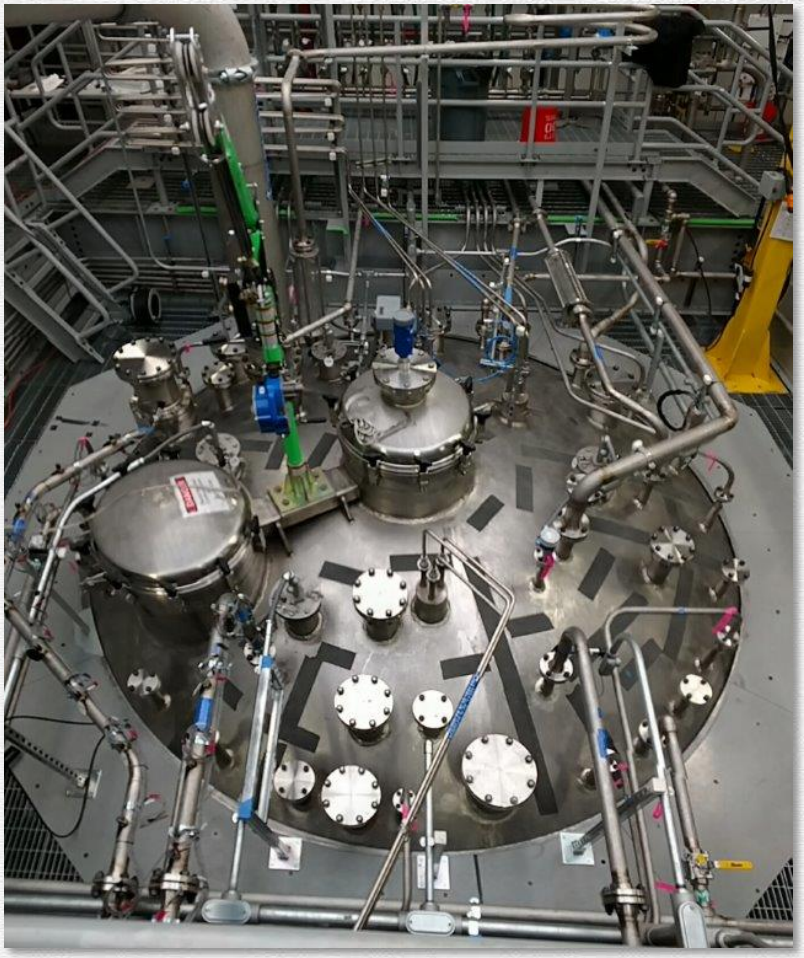
Design Parameters	
Vessel diameter	16 ft
Vessel batch volume	17,000 gal
Vessel mixing volume	22,000 gal
Number of PJMs	6
PJM nozzle ID	4 inches
Number of spargers	13
PJM drive velocity	12 m/s

Internal Instrumentation and Sampling
Level & Density Bubblers – Three elevations
Grab Sample Nozzles – Two elevations (testing only)

Standard High-Solids Vessel Testing

- Pulse jet mixer control testing in SHSV began in December 2016
- Mixing testing – Completed September 2017





An overhead view of the 16-foot diameter by 35-foot tall vessel shows the platform and all test equipment installed.

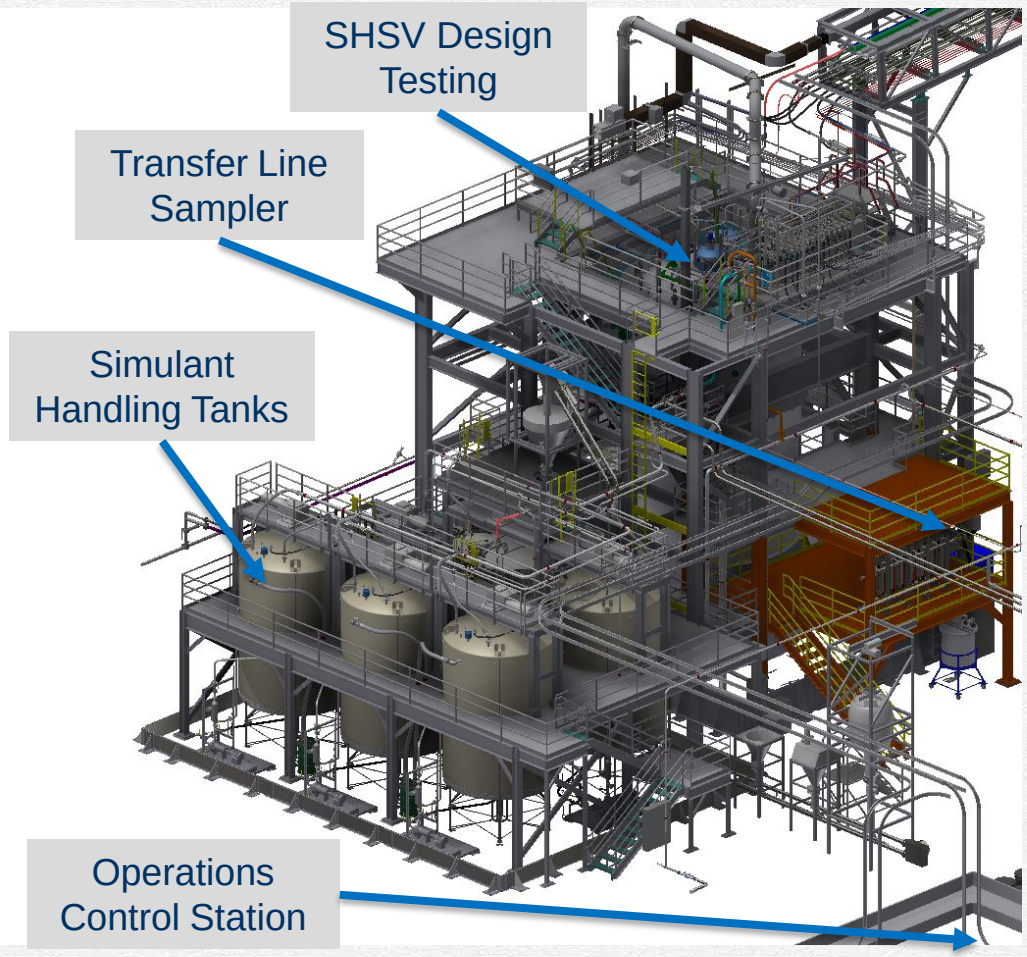
Standard High-Solids Vessel Testing (cont.)

- Standardized design for application of PJM vessel baseline technology for application at WTP
- Full-scale testing program designed to qualify PJM vessel design against functional mixing requirements
- Test results show mixing success criteria were met to qualify vessel
- Additional testing completed to evaluate PJM vessel performance at conditions outside of current design basis

Full-Scale SHSV Prototype Prior to Top Head Installation

Standard High-Solids Vessel Qualification Testing

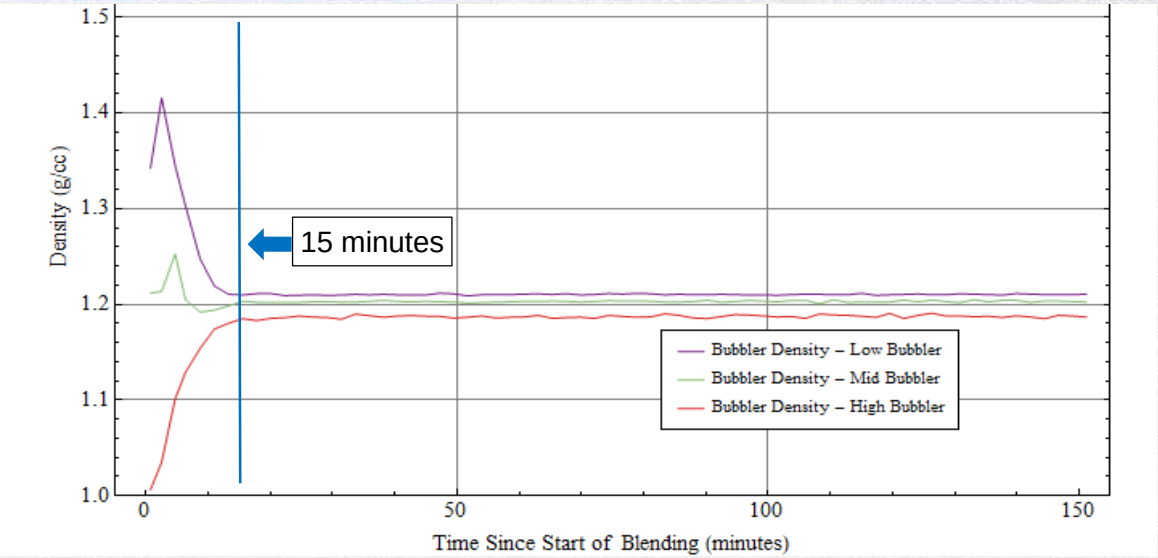
- **Purpose**
  - Provides technical basis to confirm design for mixing and process control functions
- **Strategy**
  - Identify test objectives and test matrix based on functional mixing requirements
    - Design Condition simulants
  - Commission test platform including tuning of PJM control parameters
  - Qualify prototype SHSV in full-scale test
  - Document qualification test results to show requirements are met by the design

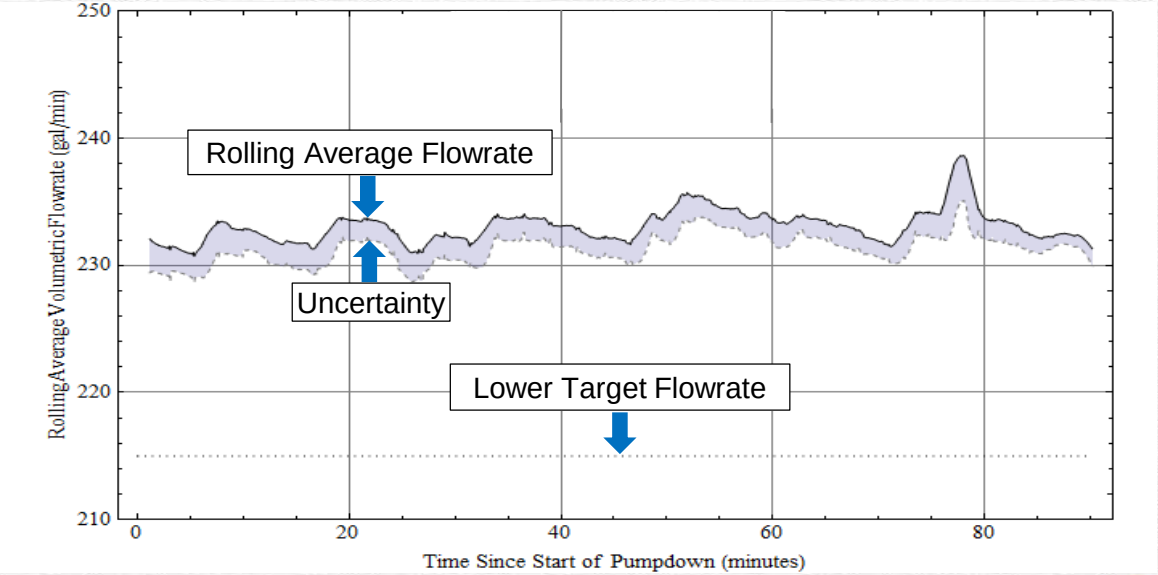


Full-Scale PJM Vessel Prototype Interior from Top

SHSV Blending and Transfer Test Success Criteria

- **Miscible Fluid Blend Test –** Requirements Successfully Met
  - Demonstrate blending of low density into high density fluid
  - Achieve a blended state within allotted time (140 min Newt., 660 minutes NN)
- **Transfer Test –** Requirements Successfully Met
  - Maintain average volumetric flowrate above minimum established target flowrate (215 gpm Newt., 150 gpm NN)
  - Maintain average volumetric flowrate below maximum flowrate established to limit erosion (430 gpm)

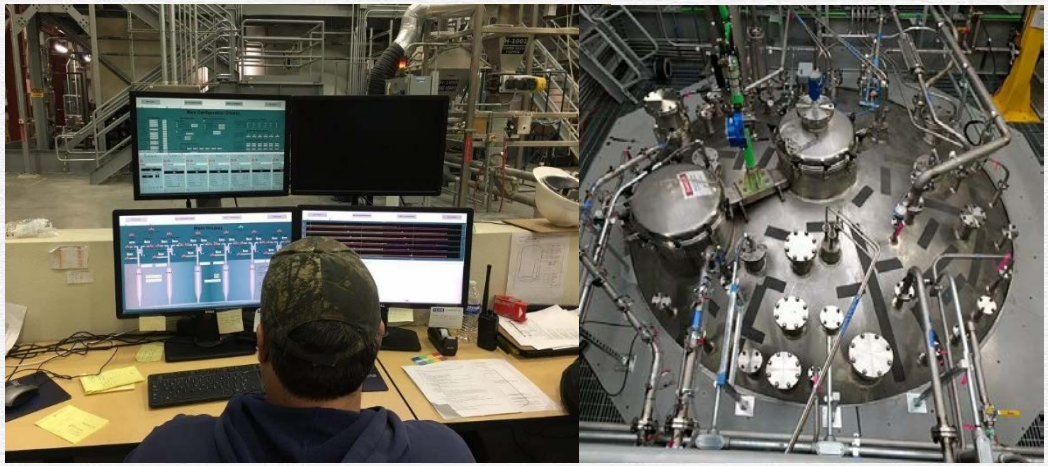




Verification of Pulse-Jet Mixer Controls and Additional Tests

- **PJM Control System – Control system monitoring during all operating modes and conditions**
  - Success criteria was based on:
    - Drive pressure
    - PJM synchronization
    - Overblow avoidance
- **Mixing Testing Surpassing Requirements**
  - Additional tests conducted at conditions outside of the current design basis
  - Demonstrated ability to de-inventory large, dense simulant particles (representative of 100 µm plutonium oxide)
  - Demonstrated ability to transfer Newtonian fluids at higher solids loading

Newtonian Simulant Testing in 16-ft Prototype SHSV Test Vessel



PJM Operations Monitoring and Top Head of Full-Scale Prototype Vessel

Summary

- **Significant progress has been made in resolution of PT Facility technical issues**
  - Resolution of Defense Nuclear Facilities Safety Board issues on hydrogen control in vessels and piping, and criticality in vessels
  - Qualification of SHSV by testing
  - Planning Areas 2, 3, and 4 conceptual design studies
- **Work Remains on:**
  - Design verification methodology for installed PJM mixed vessels
  - Vessel structural re-analysis for installed vessels
  - Resolution of vessel and piping, erosion, and corrosion issues

Safety Always Comes First!