Hanford Waste Vitrification Plant Project
Waste Form Qualification Program and Approach

Presented to:

Nuclear Waste Technical Review Board
Richland, Washington

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Hanford Waste Vitrification Plant

Waste Form Qualification

- Waste form qualification (WFQ) documentation per U.S. Department of Energy Waste Acceptance Process
- Process overview
- Approach for WFQ compliance
- Technology and WFQ schedule
- WFQ summary
### Hanford Waste Vitrification Plant

**WFQ Document Flowchart**

**Inputs**

1. Repository Program
2. HWVP
3. Inputs

**Repository Program**

- Generic Waste Acceptance Specifications
- 1991 Draft WAPS

**HWVP**

- Waste Form Description
- Waste Compliance Plan
- Waste Qualification Report
- Production Records

**WFQ Strategy**

- Models and Tests

**Inputs**

- HWVP Glass and DWPF Canister
- WFQ Program Plan

**Drafted**

- Issued for Four Waste Types

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**Acronyms**

- DWPF = Defense Waste Processing Facility
- HWVP = Hanford Waste Vitrification Plant
- WAPS = Waste Acceptance Preliminary Specifications
- WFQ = Waste form qualification

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Waste Acceptance Preliminary Specifications

Technical requirements

1.0 Waste Form
- Chemical composition
- Radionuclide inventory
- Product consistency
- Phase stability

2.0 Canister
- Material
- Fabrication and closure
- Identification and labeling

3.0 Canistered Waste Form
- Free Liquids
- Gases
- Explosives, pyrophorics, combustibles
- Organic materials
- Fill height
- Surface contamination
- Heat generation
- Maximum dose rate
- Chemical compatibility
- Subcriticality
- Weight, length, diameter, overall dimensions
- Drop test
- Handling features

4.0 Quality Assurance
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Process Overview

- Receive pretreated high-level and transuranic waste slurries
- Incorporate radioactive waste components into a vitrified borosilicate glass
- Seal vitrified waste in stainless steel canisters
- Provide interim storage of filled canisters until shipment for disposal at a federal repository
- Size the plant for 100-kg/h glass production
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HWVP Glass Production--
Process Flow Schematic Diagram

Canister Decontamination Frit

Waste

Diatomaceous Earth

Fresh Frit

Condensate Recycle

Zeolite

Offgas

Scrubbing and Waste Treatment System

SRAT

RWCT

SME

MFT

Melter

Glass

Canister

Formic Acid

Filter

Low-Level Waste to Tank Farms

Boll-off Solution to Waste Treatment

MFT = Melter Feed Tank
RWCT = Recycle Waste Collection Tank
SME = Slurry Mix Evaporator
SRAT = Slurry Receipt and Adjustment Tank
Hanford Waste Vitrification Plant

Contribution of Major Process Stream Components to HWVP Glass Composition

<table>
<thead>
<tr>
<th>Fresh Frit</th>
<th>HWVP Pretreated Feed</th>
<th>Recycle Stream</th>
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<tr>
<td>SiO₂, B₂O₃, Na₂O, CaO, Li₂O, MgO</td>
<td>SiO₂, Na₂O, CaO, MgO, Fe₂O₃, Al₂O₃, ZrO₂, U₃O₈, Other oxides</td>
<td>SiO₂, Al₂O₃, Fe₂O₃, B₂O₃, Na₂O/K₂O, CaO, MgO, Li₂O</td>
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<tr>
<td>~69%</td>
<td>~28%</td>
<td>~3.4% (0 - 7%)</td>
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</table>

GLASS 100%

HWVP = Hanford Waste Vitrification Plant
Hanford Waste Vitrification Plant

HWVP Filled Canister Processing

Inner Canister Closure/Temperature Survey Station

Preliminary Canister Decontamination

Final Canister Decontamination Chamber

Decontamination Frit Slurry

Vent

Water

To Welder, Inspection, and Storage

Smear Test Station

Canister Systems
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Approach for WFQ Compliance

- Adapt technology and design applications from the West Valley Demonstration Project (WVDP) and especially the Defense Waste Processing Facility (DWPF)

- Control glass properties by controlling glass composition
  - Composition variability study (CVS) property correlations
  - Qualified composition region
  - Feed processibility assessment
  - Process/product composition control models
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Approach for WFQ Compliance (cont)

- Perform confirmation testing
  - Scaled testing
  - DWPF Project experience
  - HWVP testing
  - HWVP hot production
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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ

Direct application to support WFQ compliance

2.1 Canister Material
2.2 Canister and Fabrication Closure
2.3 Canister Identification and Labeling
3.6 Removable Radioactive Contamination on External Surfaces
3.11 Dimensions
3.12 Drop Test
3.13 Handling Features
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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ (cont)

Adaptations of methodology to support WFQ compliance

1.1 Chemical Composition
1.2 Radionuclide Inventory
1.3 Product Consistency
1.4 Phase Stability
3.1 Free Liquid
3.2 Gases
3.3 Explosives, Pyrophoricity, and Combustibility
3.4 Organic Material
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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ (cont)

Adaptations of methodology to support WFQ compliance (cont)

3.5 Fill Height
3.7 Heat Generation
3.8 Maximum Dose Rates
3.10 Subcriticality
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Control Glass Properties by Controlling Glass Composition

Product composition control is a significant contributor to compliance strategy of the following Waste Acceptance Preliminary Specifications:

1.1 - "Glass Composition and Phases"
1.2 - "Radionuclide Inventory"
3.7 Heat Generation
3.8 Maximum Dose Rate
3.10 Subcriticality
1.3 - "Product Consistency"
1.4 - "Chemical and Phase Stability"
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Control Glass Properties by Controlling Glass Composition (cont)

**HWVP CVS**

- Correlates glass properties to glass composition using:
  - Ten major oxide components
  - Multi-component constraints

- Determines qualified composition region per property constraints for:
  - Liquidus  - Electrical conductivity
  - Viscosity  - Product Consistency Specification (1.3)
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Control Glass Properties by Controlling Glass Composition (cont)

HWVP CVS (cont)
- Determines overall envelope of acceptable glass compositions
- Provides basis for optimizing frit compositions
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Schematic of Qualified Composition Region

Acceptable Glass per Waps 1.3

Qualified Region

Processable Glass

Plant Operating Limit

Target Composition

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Feed Processibility Assessment

- Structured to:
  - Systematically assess most current feed characterization data
  - Evaluate relationship of projected feed characteristics to HWVP design basis
  - Project glass formulations and waste loadings based on CVS models
  - Assess specific plant process streams for compatibility with design
  - Integrate vitrification feed constraints with pretreatment capability
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Waste Processibility Assessment

Waste Characterization

Best Estimate Tank Waste Compositions

DST Wastes
NCAW, NCRW,
PFP, CC
SST Waste (TBD)

Pretreatment Process Development Studies

Pretreatment Flowsheets Definition

Best Estimate of Pretreated Waste Compositions

Glass Formulations for Each Waste Feed Composition

Assessments of Waste Composition Effects on HWVP Process and Systems

HWVP Processing Capability
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Feed Processibility Assessment (cont)

• Double-shell tank wastes
  – Initial assessments have been completed for four defined high-level waste types:
    • Neutralized current acid waste
    • Neutralized cladding removal waste
    • Plutonium Finishing Plant waste
    • Complexant concentrate waste

• Single-shell tank wastes
  – Assessment work has recently started for initial candidates
### Hanford Waste Vitrification Plant

#### Projected HWVP Feed and Frit Compositions for Double-Shell Tank Waste Types

<table>
<thead>
<tr>
<th>Nonvolatile oxides</th>
<th>Wt% of total nonvolatile oxides</th>
<th>NCAW</th>
<th>CC</th>
<th>PFP</th>
<th>NCRW</th>
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<td></td>
<td>Waste</td>
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<td>SiO₂</td>
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<td>MgO</td>
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</table>

CC = Complexant concentrate  
NCAW = Neutralized current acid waste  
NCRW = Neutralized cladding removal waste  
PFP = Plutonium Finishing Plant
Hanford Waste Vitrification Plant

Projected HWVP Glass Compositions and Attributes for Double-Shell Tank Waste Types

<table>
<thead>
<tr>
<th>Attribute</th>
<th>NCAW</th>
<th>CC¹</th>
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<td>Waste loading (%)²</td>
<td>26</td>
<td>64</td>
<td>22</td>
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<td>E 1150 (S/cm)</td>
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<td>0.34</td>
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<td>B release (g/m²)/7 days³</td>
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<td>Glass T (6 Pa·s) (°C)</td>
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<td>1,100</td>
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Nonvolatile oxides, wt%

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<tr>
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<th>NCRW</th>
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<td>17.5</td>
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<td>8.3</td>
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<td>Li₂O</td>
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<td>0.3</td>
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<td>MgO</td>
<td>0.1</td>
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<td>Fe₂O₃</td>
<td>8.8</td>
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<td>Al₂O₃</td>
<td>3.0</td>
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<td>Others</td>
<td>8.0</td>
<td>6.2</td>
<td>3.4</td>
<td>1.9</td>
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</tbody>
</table>

¹Compositions listed are for CC contained in 200 East Area tanks.
²Waste loading reduced 5% below maximum to allow flexibility for processing.
³Product consistency test results.

CC = Complexant concentrate  NCRW = Neutralized cladding removal waste
NCAW = Neutralized current acid waste  PFP = Plutonium Finishing Plant
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Product Composition Control Modeling

- Glass properties modeling
  - Predictive modeling of glass properties versus glass composition (CVS work)

- Process mass balance modeling
  - Predictive modeling of glass composition based on process stream samples and mass balance model
  - Modeling will rationalize analytical errors and uncertainties of process measurements
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Process Data Sources for Mass Balance Modeling to Support Product Composition Control

RLST/SRAT (Pretreated Feed)
- Composition
- Concentration
- Tank Level
- Glass Envelope Overcheck

RWCT (Recycle Stream)
- Composition
- Concentration
- Tank Level and Transfers
- Glass Envelope Overcheck

Fresh Frit Tank Feed
- Composition
- Mass

SME (Hold Point)
- Tank Heel Composition
- Concentration
- Tank Level
- Adjusted Composition after Transfers
- Glass Envelope Acceptance Verification

MFT
- Tank Heel Composition
- Adjusted Composition after Transfer from SME

Melter
- Feed Rate
- Glass Pouring Rate
- Glass Sample Composition
- Mass

MFT = Melter feed tank
RLST = Receipt and lag storage tank
RWCT = Recycle waste collection tank
SME = Slurry mix evaporator
SRAT = Slurry receipt and adjustment tank
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Confirmation Testing

Nonradioactive Feed

**Scaled systems**
- Bench (1/50)
- Pilot (1/10)
- Demonstration (~1/2)

**Full-scale system**
- Simulated process tank(s)
- HWVP (operations testing and qualification runs)
- DWPF experience
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Confirmation Testing (cont)

Radioactive Feed

Scaled systems

- Laboratory crucible work
- Bench-scale
- DWPF Project experience

Full-scale system

- HWVP hot production experience (confirmation of compliance with certain acceptance specifications)
- DWPF hot production
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Technology and Waste Form Qualification
Overview Schedule

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</tbody>
</table>

CC = Complexant Concentrate   NCRW = Neutralized Cladding Removal Waste
HWVP = Hanford Waste Vitrification Plant   PFP = Plutonium Finishing Plant
LFCM = Liquid-Fed Ceramic Melter   WFCD = Waste Form Qualification Description
NCAW = Neutralized Current Acid Waste   B-S = Bench-Scale
Hanford Waste Vitrification Plant

WFQ Summary

- HWVP gains technical benefits from DWPF and WVDP
- Hanford Site wastes will require unique process and WFQ approaches
- Control of glass properties will be achieved by:
  - Correlating glass properties to glass composition
  - Establishing a qualified composition (glass) region
  - Glass composition control via mass balance modeling
- Perform scaled and full-sized (HWVP) testing to establish and confirm bases for acceptance specifications compliance