DOE Lecture Series

Tank Waste 101 – Hanford’s Greatest Challenge

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Hanford Site History – World War II to Cleanup

1940s-1980s: Construction & Plutonium Production
1940s-1980s: Creation of Tank Waste
Present: Waste Treatment Plant Construction
Present: Stabilization & Safe Storage
Hanford’s Greatest Challenge

- **1943-1964:** 149 single-shell tanks constructed
  - Up to 67 presumed to have leaked
- **1968-1986:** 28 double-shell tanks constructed
  - 1 leaking, waste contained within annulus
- **170 million curies** of radioactivity
- **240,000 tons** of complex chemicals

Disposition of **56 million gallons** of radioactive and chemical waste
What’s in the Tanks

Saltcake
23M gallons

Mostly water-soluble salts; small amount of interstitial liquid

Supernate
21M gallons

Any non-interstitial liquid in the tanks – similar to saltcake in composition

Sludge
12M gallons

Water-insoluble metal oxides, significant amount of interstitial liquid – texture similar to peanut butter
Vast majority of tank waste consists of sodium salts

- Sodium nitrate makes up about 50% of the weight by dry mass
- Other sodium salts comprise about 40% of waste by dry mass
No Two Tanks are the Same

- Waste temperatures range from 60°F to 160°F
- Highly caustic
- Moderate-to-high radioactivity
- No two tanks have the same waste contents
- Most waste produces some hydrogen
Origin of Tank Waste

The 56 million gallons of waste are a byproduct of national defense plutonium-production efforts during World War II and the Cold War.

Separation Processes:

- Bismuth Phosphate Process
- Redox
- PUREX
Bismuth Phosphate Process

- T Plant Activated December 1944; B Plant April 1945
- Batch process using precipitation & dissolution
- Al Cladding dissolved with sodium nitrate & sodium hydroxide; fuel dissolved with nitric acid
- Pu (IV) co-precipitated from solution with bismuth nitrate & sodium phosphate
- Uranium kept in solution by presence of sufficient sulfate ion
- Sludge dissolved with nitric acid
- Sodium bismuthate (NaBiO₃) oxidized Pu(IV) to Pu(VI)
- Pu concentration process in 224-T Building - used lanthanum fluoride
- Capacity 1-1.5 metric tons of uranium MTU/day
221B/221T Buildings: Spent Fuel Processing, (Bismuth Phosphate era)

SPENT FUEL

COATING DISSOLUTION

URANIUM DISSOLUTION

URANIUM SEPARATION

1ST DECON CYCLE FOR PU

2ND DECON CYCLE FOR PU

COATING REMOVAL WASTE; COMBINED WITH 1ST DECON CYCLE WASTE

Metal Waste
Uranium & 90% of FP
TO B/T 101-103

1ST DECON CYCLE WASTE ~ 10% of FP
To B/T 104-109

2ND DECON CYCLE WASTE ≤ 0.1% FP
To B/T 110-112

B Plant: 1945 - 1952
T Plant: 1945 – 1956

T Plant: 1952 - 1956

B & T Plants: 1946 - 1952

1945-1946

Pu PRODUCT TO 231-Z

224-B/T Buildings: Plutonium Concentration Cycle

To Crib

To Crib

To Reverse Well

EM Environmental Management

Environmental Management

safety ◇ performance ◇ cleanup ◇ closure

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Redox (reduction-oxidation) Plant constructed 1949-51

- Hot operations January 1952 to 1967
- Al-clad dissolved like the Bismuth Phosphate plant
- Continuous process using solvent extraction
  - Methyl isobutyl ketone (hexone) chemistry
  - Aluminum nitrate as “salting agent”
  - Drove Pu & U into organic phase
  - Separate cycles purified Pu & U
- High-heat self-concentrating waste
  - Challenged 241-S off-gas system
  - Lead to re-design of 241-SX system
- Significant production increase
  - Capacity 2-12 MTU/day (after 3 capacity increase projects)
PUREX Plant constructed 1953-55

- Hot operations January 1956 to 1972, & 1983 to 1988
- Received both Al-clad & Zircaloy-2 clad fuel
- Continuous Solvent Extraction operations
  - Tri-Butyl Phosphate (TBP), normal paraffin hydrocarbon (NPH) (refined kerosene) chemistry
  - Nitric acid as dissolving & salting agent
  - Ferrous sulfamate, sulfamic acid, hydroxylamine nitrate & hydrazine as reducing agents
- Capacity from 6 to 30 MTU/day
149 single-shell tanks were built 1944 - 1965

Various capacities
- Type I 55 kgal
- Type II 530 kgal
- Type III 760 kgal
- Type IV 1 million gal

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<th>Tank Series</th>
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<th>IVA</th>
<th>IVB</th>
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<td>Farms</td>
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<td>Total Tanks</td>
<td>16 Tanks</td>
<td>60 Tanks</td>
<td>48 Tanks</td>
<td>15 Tanks</td>
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Original Tank Farms
- 500,000 gallon capacity
- Designed to store waste from Bismuth Phosphate process
  - Waterproof design based on American Waterworks Association
  - Tank vented to the atmosphere
  - Dished, knuckled bottoms

Tank 241-AX
- Million gallon capacity
- Designed to handle self-concentrating wastes in PUREX process
  - 22 airlift circulators
  - Tank ventilation collected and condensed vapors
- Tanks designed with leak-detection system
- Many other construction differences
AY and AZ Farms

Four 1,018 kgal aging-waste tanks

- AY constructed 1968-70, AZ 1970-74
- Nearly identical design; 40 (AY) vs. 20 (AZ) year design life
- Built with sidefill lines, 22 ALCs
- Built with A-515 steel

AY-101 collected AZ-301 condensate, condensate pooled on surface

AY-102 is the WTP LAW commissioning tank –

- Retrieved as of Feb. 28 in accordance with Settlement Agreement due to leak from main tank into annulus.

Only DST to receive a unique B-Plant low level waste.
Three 1,160 kgal tanks saltcake storage tanks
- Constructed 1974-76 to support 242-S operations and 200-West needs
- Built from A-516 steel
- 40 year design life

SY-101 famous “burping” tank, since resolved but restricted from adding solids
- Receiver for 219-S 222-S Analytical Laboratory waste

SY-101 is main transfer hub between 200-E & 200-W via cross-site transfer line
Six 1,160 kgal tanks for additional HLW storage

- Constructed 1976-80
- 50 year design life
- Upper side wall thickness increased to 1/2” from 3/8”

**AW-102 serves as 242-A feed tank**
Seven 1,160 kgal tanks for additional HLW storage

- Constructed 1977-80
- Originally six tanks planned, AN-107 built in separate project as spare aging waste tank with 22 ALCs
- Built using A-537 steel
- 50 year design life

**AN-101 and AN-106 used for C Farm retrieval**
Eight 1,160 kgal tanks for additional HLW storage
- Constructed 1982-86
- Four tanks increased level to 1,257 kgal storage capacity
- Built with A-537 steel
- 50 year design life

**AP-101 former LAW commissioning tank; supernatant transferred to AY-102 in 2006**
Single-Shell Tank Waste Retrieval in C Farm

RETRIEVAL TECHNOLOGIES

- Mobile Arm Retrieval System Sluicing (MARS-S)
- Chemical Dissolution
- Enhanced Reach Sluicing System (ERSS)
- Modified Sluicing
- In-Tank Vehicle (Foldtrack)
- Mobile Arm Retrieval System Vacuum (MARS-V)

Aerial photograph of C-Farm with graphical overlay that depicts current status of each single-shell tank.
Modified Sluicing with Extended Reach Sluicing System
Mobile Arm Retrieval System (MARS) - Sluice
MARS-S Mast/Arm and Carriage
MARS-S Wrist and End Effector
MARS-Vacuum
MARS-V Carriage and Arm
Saltcake Dissolution / Chemical Dissolution

Chemical Water Supply
From SY Farm

Water Distribution Skid

Riser Extension

Distribution Pit

Recirculation Drop Leg

Raw Water Dilution Line

Raw Water Distribution Devices

Supernate Solids

ASSD

241-S-A Valve Pit

241-S-Farm

241-SY-102

Sludge Saltcake Working Solution

Environmental Management

Safety ◆ Performance ◆ Cleanup ◆ Closure
Chemical Retrieval Process
Caustic Addition System
High Pressure Water – Extended Reach Sluicer
High pressure water delivery systems
Tank Farms – Complex and accessible only from the surface
Original treatment approach sent all tank waste through the WTP Pretreatment Facility first, producing feed for high-level and low activity waste facilities.
Tank Waste Treatment Approach

- SST – Single-Shell Tanks
- DST – Double-Shell Tanks
- CH-TRU – Contact Handled TRU
- ETF – Effluent Treatment Facility
- HLW – High-Level Waste
- LAW – Low-Activity Waste
- IHSF – Interim Hanford Storage Facility
- IDF – Integrated Disposal Facility

Color Key
- Salmon – Existing
- Gold – Proposed new tank farm project
- Green – WTP in construction
- Blue – New facility needed to support HLW operations
DFLAW sends pretreated tank liquids to the Low-Activity Waste Facility, enabling treatment operations as soon as practicable.
The DFLAW approach sends pretreated tank liquids directly to the Low-Activity Waste (LAW) Facility, enabling treatment operations as early as 2022. The LAWPS facility is needed to support this approach.
LAWPS Scope

- Provide cesium and solids removal capability to support direct feed Low Activity Waste (LAW) to WTP

Benefits of LAWPS and DFLAW

- Begin tank waste treatment prior to completion of the entire WTP
- Enable DOE to meet Consent Decree requirement to complete WTP LAW facility hot commissioning by December 2023
- Develop operational experience with WTP LAW, LAB, and Balance of Facilities prior to startup of the more complex HLW and PT Facilities
- Create Tank Farm double-shell tank space to support other Tank Farm cleanup activities such as retrieval of waste from older tanks
Ion Exchange

Waste from filtration

Dilution caustic

Loading Cycle Operation

Rinse, elution, and regeneration solutions

Cesium eluate and other solutions to DSTs

Periodic Regeneration Cycle Operation

Treated LAW to immobilization

Lead Column

Polish Column

sRF Resin

Crossflow Filtration Element
DFLAW Program
Expected Results

20 Proposed waste feed delivery campaigns

1,000,000 Gallons per campaign

6.3 Million gallons of tank space generated*

9,600 Metric tons of sodium processed

15% of Tank Farm sodium inventory

12,000 Immobilized LAW containers produced
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