Tank Side Cesium Removal Demonstration Project

External Independent Review Team recommended two-phased pretreatment strategy
- Tank Side Cesium Removal (TSCR) system as a “first feed” solution
- Optimized Low-Activity Waste Pretreatment System (LAWPS) for long-term Low-Activity Waste (LAW) Vitrification feed

Subsequent U.S. Department of Energy (DOE) direction to suspend LAWPS facility design; perform future alternative analysis to determine long-term feed solution

DOE issued a request for proposal (RFP) for Technology Demonstration of TSCR capability
- Provide system to meet LAW Vitrification waste acceptance criteria
- Enable LAW Vitrification to complete hot commissioning by 12/21
- Enable initial LAW Vitrification operations until LAWPS becomes operational
- Use relevant information from Savannah River’s tank closure cesium removal (TCCR) demonstration
- Leverage experience from commercial nuclear waste cleanup projects
TSCR Demonstration Objectives

Tank side cesium removal system will remove suspended solids and cesium from double-shell tank (DST) liquids to provide LAW feed to the Waste Treatment and Immobilization Plant (WTP)

- The initial phase is a “proof of concept” demonstration that has a target of loading the first set of columns with approximately 100,000 curies (Ci) of cesium
  - Evaluate the selected ion exchange (IX) resin removal efficiency performance
  - Achieve a decontamination factor (DF) of greater than 1000
  - First campaign will produce about 170K gallons of feed

- The second phase would target up to an additional 5 million gallons of waste in order to validate overall operability of the system including reliability and unit efficiencies
  - Increase column loading while maintaining >1000 DF
  - Increase Total Operating Efficiency
  - Prove Crystalline Silicotitanate kinetics
  - Proving filter operation and cleaning (simulant vs. real waste)
  - Prove the ability for continued operations using replaceable columns
  - Demonstrate column transportability, and
  - Use process knowledge to sustain operations
TSCR Conceptual System Diagram
Conceptual TSCR Layout

On track for Producing Feed for DFLAW Operations as soon as 2022
Key Metrics:

- 5-gpm
- 5.6M Na+ Waste
- 160 ppm UDS
- 20 to 35°C
- 0.163 Ci/L $^{137}$Cs (process)
- 0.30 Ci/L $^{137}$Cs (safety)

Performance

- $^{137}$Cs DF of $\approx 1000$
- $H_2 < 0.25$ LFL
- No boiling at Atm
- Phase 1 – 170,000 gal
- Sys Availability > 70%
IXC-150 Design Features

1. Center Cooling Core Creates Annular IX Bed
   - Eliminates high temperature center-line region of ion exchange column (IXC)
   - Creates convective air flow in the core increasing decay heat dissipation
   - Annulus created by core limits horizontal bubble migration and bubble agglomeration
   - Significantly lowers overall operating temperature increasing gas solubility in liquid while reducing G-Value
   - Rated for 669 W of decay heat
   - IXC base and top designed to allow full natural convection flow while maintaining shielding

2. Resin Port and Shield Plug
   - 4-in. port to facilitate resin fill and future removal

3. Vent Design
   - The vessel vent incorporates a “high-point” cavity ensuring gas migration to the vent
   - Wedgewire screen provides large surface area for gas migration while precluding the release of resin

4. IX Column Internal Design
   - Ensures even distribution of flow
   - Mitigates channeling and other flow maldistributions
   - Plug flow ensures full media utilization and minimizes Cs leakage
   - Sized to retain 300 to 800 μm resin beads
   - Bottom (effluent) screens take effluent from within 1/2” of the flat vessel bottom maximizing CST and dewatering efficiency

5. Proven Experience
   - Treating liquid waste with Cs concentration up to 0.5 Ci/gal
   - 400+ Mgal treated
   - 5+ megaraduries Cs removed
   - 175 IX columns provided in 6 years
   - Creates 15 times less waste than competing technologies at Fukushima
   - Nozzle screens are structurally strong and mounted to minimize the moment arm - no failures in 18 years of operations

6. Simplified - Safe Handling/Exchange
   - Integral lifting trunions for safe handling
   - Maximum lift height limited to <6 in. minimizing drop scenarios
   - ChemJoint connections minimize worker time to make fast leak-free connections during exchange

7. CST Resin Design Compatibility
   - Small amount of freeboard above packed media bed limits radiolytic gas accumulation and potential for episodic gas release
   - Loading capacity of over 140,000 Ci $^{137}$Cs

8. Integral Shielding Design
   - Limits contact dose to <5 mrem/hr allowing personnel access to the IX columns
   - Minimizes space for the IX column
   - ≈5 in. lead equivalent
• **Flow Path**
  - Bottom feed / Self-Venting

• **Polypropylene Filter Media**

• **Filter Metrics**
  - Extremely low flux
    - 9 GFD (0.00625 gpm/ft²)
  - 4 µm pore size
  - 24 filter – 2 5/8 inch diameter X 30 inch length

• **Air Receiver (20 gal.)** supplies motive force for backwash
  - Empties filter housing and related piping into AP-108
• Retains CST media in event of lateral failure

• Design Metrics
  • 0.003 inch (75 µm) Screen Slot
  • < 0.2 psid at 5 gpm
  • All Welded Construction
  • Self Venting

• Bottom Nozzle
  • Allows maintenance backwashing without sending media to DST

• Replaceable
Key Components:

- Air Compressors
- Air Dryer
- Receiver Tanks
- Potable Water Tank & Pump
- Potable Water Demineralizer
- Sodium Hydroxide (Reagent)
- Caustic Metering Pump

Features:

- Insulated/ Heated
- Side Personnel Door
- Rear Cargo Door
AP Farm Integration

- Design, fabrication and field work for waste transfer from tanks to TSCR (transfer line, shielding, pump, jumpers, valves, and cover plate)
- Design, fabrication and field work for waste return, TSCR IXC vent, plant wash, and treated waste from TSCR to tanks (transfer line, shielding, adapter/drop leg)
- Fieldwork and construction of TSCR concrete pad
- Design, fabrication, and fieldwork for waste transfer system from WTP feed tank to the W-211 transfer lines
AP Farm Integration
Technology Maturation

Tank Side Cesium Removal (TSCR) Demonstration Project
Technology Testing/ Maturation Timeline

<table>
<thead>
<tr>
<th>FY 2018</th>
<th>FY 2019</th>
<th>FY 2020</th>
<th>FY 2021</th>
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<tbody>
<tr>
<td>CD-3A Authorized Procurement</td>
<td>Complete 30% design</td>
<td>Complete 60% design</td>
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<td>Tall Column Test</td>
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<td>Batch Contact Test</td>
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• Completed 30% designs in CY2018
• Completed TSCR system 60%
• Completed WFD 60% design
• On track to initiate TFU 60% design review on March 4, 2019
• On track to initiate TSCR system 90% design review on April 5, 2019
**Project Timeline Expectation**

**Tank Side Cesium Removal (TSCR) Demonstration Project and Tank Farm Upgrade (TFU) / Waste Feed Delivery (WFD)**

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<th>FY 2019</th>
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<th>FY 2021</th>
<th>FY 2022</th>
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<td><strong>Tank Side Cesium Removal System Demonstration (TSCR)</strong> <em>(Filtration &amp; Non-Elastisable Exchange)</em> &amp; *<em>Tank Farm Upgrade (TFU) / Waste Feed Delivery (WFD)</em></td>
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<td>CD-43 * 1-26-2021</td>
<td>TSCR RCRA Permit Application 9-30-2019</td>
<td>TSCR Commissioning Complete 11-2-2020</td>
<td>CD-44b Ready to Feed LAW 5-12-2021</td>
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*Includes Waste Transfer Lines & TSCR Infrastructure (Site prep, TSCR pad, utilities, canister storage facility/pad)

**Legend:**
- **Critical Decision Approval**
- **Project Milestones**
- **PEMP FY2019 Complete**

**Abbreviations:**
- FAT = Factory Acceptance Test
- CAT = Construction Acceptance Test
- SAA = Startup Authorization Authority
- TIPR = Technical Independent Project Review