

Steam Reforming Process to Treat Hanford LAW and LAW Recycle

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DE-AC09-06SR22521

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Presentation Outline

- Summary
- Project Description
- Technical Strategy/Approach
- Technical Results and Status
- Impact on High Risk/Cost Reduction or Avoidance



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Summary

- Project Scope
 - Engineering-scale (ES) demonstration of fluidized bed steam reforming on simulated Hanford LAW and LAW recycle (LAW melter off-gas secondary liquid wastes)
 - Develop and test monolithic waste forms from granular product
 - Conduct Bench-Scale Reformer (BSR) test with actual LAW
- Programmatic Impacts
 - Supports Early LAW by treating LAW recycle which can't be handled by ETF and produces better product than ETF for improved Hanford Performance Assessment
 - Alternative supplemental treatment for LAW reduces programmatic risks, handles problematic LAW feeds and provides opportunity for accelerated treatment
- Project Status
 - ES demos completed 2.5 weeks ahead of schedule
 - No unplanned shutdowns, no safety incidents
 - ES data evaluation / report preparation in progress, BSR test planning started
 - Project Cost Performance Index of 1.12, Schedule Performance Index of 0.98



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Project Description

Technology Need / Requirements

- Demonstrate viable treatment solution to Hanford Early LAW melter secondary wastes (LAW recycle)
 - Hanford's Effluent Treatment Facility (ETF) can't accommodate anticipated waste volumes and waste characteristics
- Demonstrate ability to process LAW simulant and produce a compliant product for on-site disposal
 - Provides alternative supplemental LAW treatment to reduce DOE's programmatic risks, handle problematic feeds and provide opportunity for accelerated treatment



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Mission Needs - Hanford's Effluent Treatment Facility (ETF)

- Low ETF throughput can't meet mission requirements
- Forecast of WTP LAW recycle composition is outside of the ETF WAC (some by 2+ orders of magnitude)
- Solid and liquid discharge from ETF may challenge the Hanford Performance Assessment (99-Tc and 129-I)
- Steam reforming resolves ETF issues and produces a waste form as good as glass that can be disposed of on-site as a monolithic waste form



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Project Description

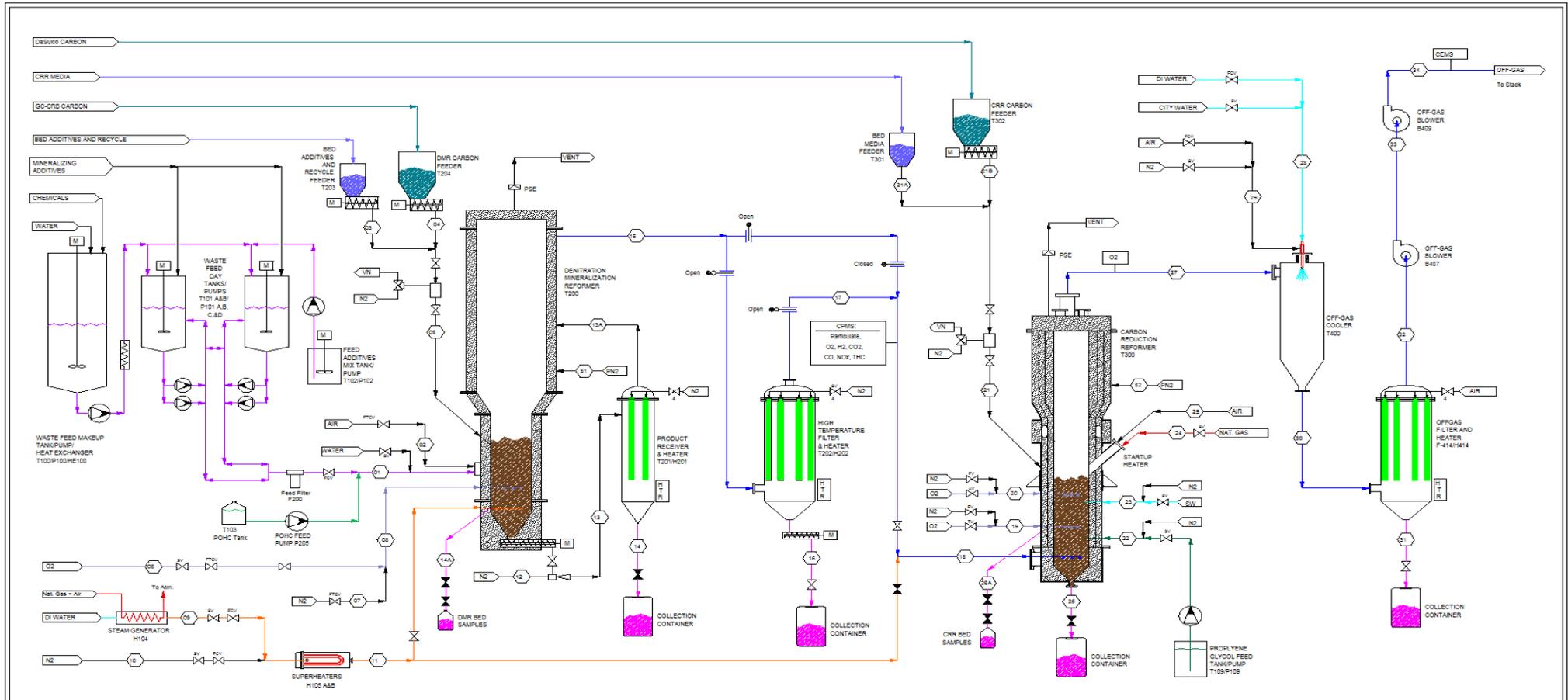
Technical Strategy / Approach

- Engineering-scale fluidized bed steam reforming (FBSR) process demonstrations using simulated Hanford LAW and LAW Recycle
 - Produce mineralized products in engineering-scale sized system
 - Produce monolithic product and confirm durability performance
 - Collect data to enable life-cycle cost analysis and scale-up
- Bench-Scale Reformer (BSR) testing
 - Produce mineralized monolithic product with actual Hanford LAW
 - Confirm properties are as good as or better than WTP glass
 - Validate that Tc is non-volatile



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Engineering-Scale System PFD



FLOW DIAGRAM - THOR STEAM REFORMING PROCESS
ENGINEERING SCALE TEST DEMONSTRATION - LAW WASTE

Rev. 6, June 2, 2008

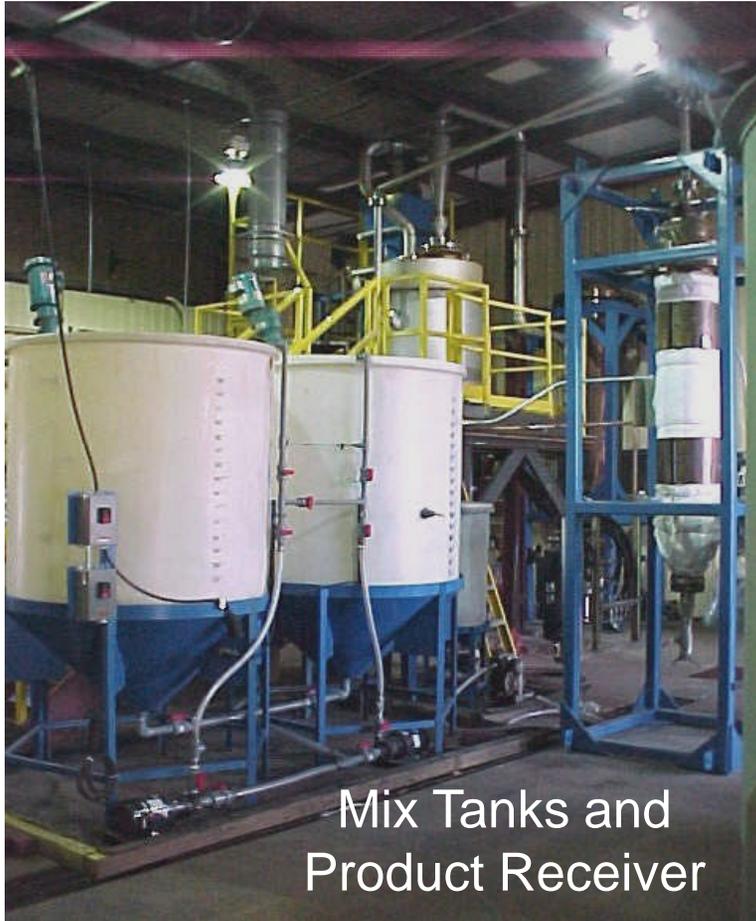


EM Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

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Engineering-Scale System Components



Mix Tanks and
Product Receiver



DMR Reformer
and Filter



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Technical Status and Results

LAW Recycle Simulant Demonstration

- LAW Recycle testing complete; report being drafted
- Performance Summary for Production Run
 - 1222 gal of simulant processed into 7636 lbs of product
 - Concentrated LAW Recycle simulant used (20x concentration)
 - 102.5 hours of continuous operation – no unplanned shutdowns
 - 100% availability - tests completed 2.5 weeks ahead of schedule
- Process Performance
 - Early indications of excellent leach resistance results
 - Off-gas met MACT requirements for constituents monitored on-line



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Technical Status and Results

LAW Simulant Demonstration

- LAW testing complete; report being drafted
- Performance Summary for Production Run
 - 1191 gal of simulant processed into 7503 lbs of product
 - 101.5 hours of continuous operation – no unplanned shutdowns
 - 100% availability - tests completed 2.5 weeks ahead of schedule
 - Successfully incorporated lessons learned from past demonstrations
- Process Performance
 - Boron and Silica content processed with no issues
 - Early indications of excellent leach resistance results
 - Off-gas met MACT requirements for constituents monitored on-line



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Technical Status and Results

Safety

- Zero safety incidents
- No environmental releases
- Zero process shutdowns
- Continued good safety performance by testing subcontractor (Hazen Research, Inc.) since TTT carried out a safety evaluation and increased its emphasis on the subcontractor's safety performance
 - Since initiatives announced in February, Hazen staff worked without a recordable injury for the ES tests



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Technical Status and Results

Monolithic Waste Form Testing

- Testing being performed at SRNL
- Granular product satisfies leach resistance requirements without solidification
- Solidification provides structural support to address disposal facility WAC with respect to:
 - Human intrusion barrier
 - Compressive strength to prevent long-term subsidence



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Technical Status and Results

Monolithic Waste Form Testing

- Granular product from ESTD production runs with simulated wastes used for monolithic tests
- Formed 2-in square monoliths using 8 different binders (e.g., silicon, geopolymers, cements, and ceramicrete) and two waste loadings each (~75% and ~85%)
- Will select 3 best performing monoliths for scale-up, first to 3-in x 6-in cylinders, then 6-in x 12-in cylinders
- Conduct compressive strength, PCT, bulk density, skeletal density, and TCLP on the monoliths; if compressive strength is not $\geq 3.45E6$ Pa, the monolith fails and other tests will not be done
- Will provide 2-in x 4-in cylinders of the LAWR monolith for PNNL analysis



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Technical Status and Results

Bench-Scale Reformer (BSR) Test

- Test with actual LAW
- Planning started
- Need definition of LAW to move planning forward
 - Waste composition input is critical to schedule
- Pursuing test at SRNL
 - Tank 48 BSR unit is in place
 - Procedures, hazards analysis, and training completed



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Bench-Scale Reformer Test Objectives

- Confirm radionuclide partitioning during treatment of 1-5 liters of actual radioactive Hanford LAW
- Produce actual waste product for analysis to evaluate performance to Hanford WAC
- Demonstrate correlation of surrogate waste formulations and previous demonstration results to actual waste at Hanford to further validate the data base

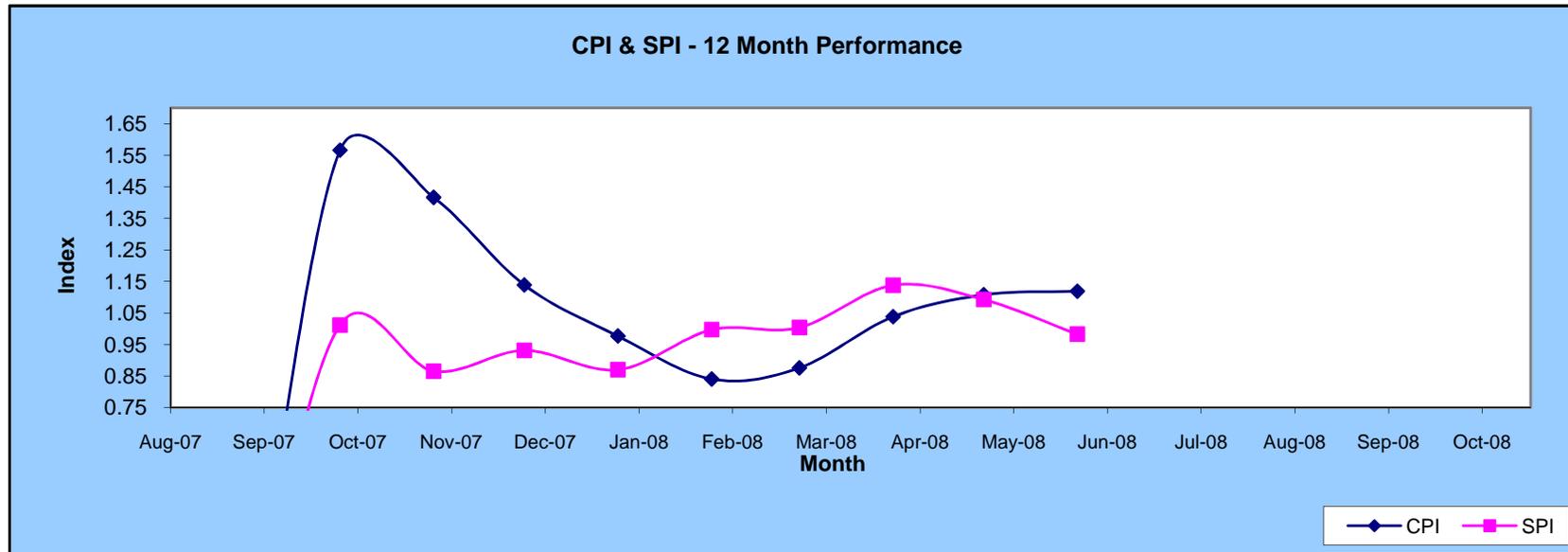


Bench-Scale Reformer at SRNL

Project Performance Data

Project CPI: 1.12

Project SPI: 0.98



CPI: ESTD runs completed 2.5 weeks early resulting in positive cost variance of >\$350k. Other contributions include higher than baseline efficiency in preparing the preliminary demonstration report and reduced analysis costs.

SPI: Early completion of ESTD runs allowed work to begin early on demobilization and the preliminary report. Receipt and reduction of analytical results and monolith testing is driving the report. The recent decline in the SPI value is primarily due to monolith preparation and analysis being behind schedule.



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Project Impact

Successful demonstration of FBSR process will:

- Facilitate Early LAW treatment at WTP by processing the LAW melter off-gas scrubber liquid waste stream that ETF cannot handle
- Support long-term WTP mission program by treating on-going secondary liquid wastes
- Improve the Hanford Site Performance Assessment since the FBSR product is expected to perform much better than the ETF product
- Provide an alternative supplemental LAW treatment method to reduce DOE's programmatic risks, better handle problematic feed envelopes and provide opportunity for accelerated treatment



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Supplemental / Background Slides



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THOR[®] Fluidized Bed Steam Reforming (FBSR) Process

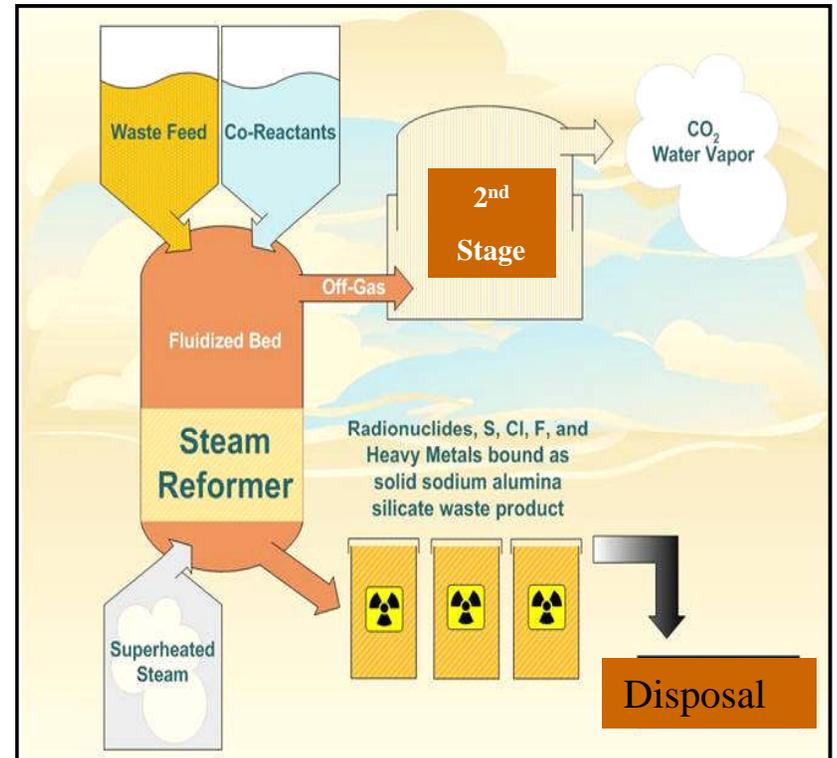
- Fluid beds used extensively in the US and abroad
 - Biomass gasification
 - Syngas production
 - Metal reduction
 - Petroleum refinery applications
 - Pulp and paper industry
- Successfully deployed on commercial scale for radioactive wastes
 - Studsvik Processing Facility in Erwin, TN



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THOR[®] FBSR Process

- Accommodates widely varying inputs
 - Solid, liquid, sludges or gases
 - High or low pH (no adjustment required)
 - Organic or inorganic materials
 - High Cl, F, P, SO₄
 - Reactive and corrosive chemicals
 - High iron and metal content
 - Reactive metals
- Moderate temperature (600-750 °C)
 - Does not volatilize Cs, Tc (Re)
 - Less complex offgas system
 - No wet scrubber so no liquid effluents



- Fluid bed agitated by low pressure steam
- Energy produced by carbon reductant and oxygen (autothermal steam reforming)

Studsvik Processing Facility

Full-scale FBSR facility treats commercial power plant waste

- Radionuclide retention in solid product >99.99%
- >200,000 cu ft of LLW processed
- >1,600 shipments
- LLW dose rates up to 500 R/hr (Cs, Co)
- Over 9 years LLRW operations
- Waste feed: ion exchange resins, plastics, cellulose, carbon, oils, high salt content waste



Studsvik Processing Facility, Erwin TN



Hanford Effluent Treatment Facility (ETF) WAC for Inorganics Compared with Average WTP Recycle

| Inorganic | WTP Recycle Average (ppm) | ETF Table F-1 Limit (ppm) | Multiples Over Limit |
|-------------------------------|---------------------------|---------------------------|----------------------|
| Cl | 810 | 59 ¹ | 13.7 |
| F | 1240 | 4 ¹ | 310 |
| K | 28 | 6.5 | 4.3 |
| Na | 596 | 59 | 10.1 |
| NH ₄ | 1133 | 736.9 | 1.5 |
| NO ₂ ⁻ | 328 | 39 | 8.4 |
| PO ₄ ³⁺ | 22.5 | 1.3 | 17.3 |
| SO ₄ | 349 | 84 | 4.2 |

¹ The absolute limit for Cl and F is 200 ppm



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Hanford Effluent Treatment Facility (ETF) WAC for Radionuclides Compared with Average WTP Recycle

| Radionuclide | WTP Recycle Average (Ci/L) | ETF Table F-1 Limit (Ci/L) | Multiples Over Limit |
|-------------------|----------------------------|----------------------------|----------------------|
| Am ²⁴¹ | 7.69E-08 | 1.40E-09 | 54.9 |
| Cs ¹³⁷ | 1.66E-04 | 9.90E-06 | 16.8 |
| Se ⁷⁹ | 3.36E-07 | 1.50E-07 | 2.2 |
| Tc ⁹⁹ | 596 | 59 | 10.1 |
| Sr ⁹⁰ | 1.11E-05 ^a | 4.20E-05 | 0.26 |

^a Strontium-90 was under the limit, but was close to the limit. These are the average composition, so it is likely that strontium-90 exceeds the concentration for some feeds.

