Application of a Thin Film Evaporator System for Management of Liquid High-Level Wastes at Hanford - 10170

Allan R "Rick" Tedeschi
Washington River Protection Solutions
P.O. Box 850
Richland, Washington 99352

Robert A. Wilson
Columbia Energy & Environmental Services, Inc.
1806 Terminal Drive
Richland, Washington 99354

ABSTRACT

A modular, transportable evaporator system, using thin film evaporative technology, is planned for deployment at the Hanford radioactive waste storage tank complex. This technology, herein referred to as a wiped film evaporator (WFE), will be located at grade level above an underground storage tank to receive pumped liquids, concentrate the liquid stream from 1.1 specific gravity to approximately 1.4 and then return the concentrated solution back into the tank. Water is removed by evaporation at an internal heated drum surface exposed to high vacuum. The condensed water stream will be shipped to the site effluent treatment facility for final disposal. This operation provides significant risk mitigation to failure of the aging 242-A Evaporator facility; the only operating evaporative system at Hanford maximizing waste storage.

This technology is being implemented through a development and deployment project by the tank farm operating contractor, Washington River Protection Solutions (WRPS), for the Office of River Protection/Department of Energy (ORP/DOE), through Columbia Energy & Environmental Services, Inc. (Columbia Energy). The project will finalize technology maturity and install a system at one of the double-shell tank farms.

This paper discusses results of pre-project pilot-scale testing by Columbia Energy and ongoing technology maturation development scope through fiscal year 2012, including planned additional pilot-scale and full-scale simulant testing and operation with actual radioactive tank waste.

INTRODUCTION

Tank Farm Need

Concentration of liquid wastes is essential at the Hanford tank farm complex to ensure continued protection of the environment from stored material and support final waste disposition planning. Liquid volume is increasing in the tank farm complex from retrieval of waste in single-shell tanks (SSTs) and from minor system drainages and flushes. This liquid must be concentrated to maintain sufficient space for planned retrievals.

The Hanford Site has 149 aging, leak-prone SSTs, built during the 1940's through 1966, containing approximately 1.14 x 10^5 m^3 (30 million gallons) of mixed waste. This waste is primarily in the form of saltcake and sludges. Sixty-seven of these tanks are known leakers or assumed to have leaked into the environment. Pumpable liquids were removed from these tanks several years ago. The tank farm also contains 28 newer, double-shell tanks (DSTs) containing approximately 9.8 x 10^4 m^3 (26 million gallons) of mixed waste. The SSTs and DSTs are contained in eighteen tank farms spread over a general area of 5.2 x 10^6 m^2 – 7.8 x 10^6 m^2 (2-3 square miles), with some farms being connected over a 6.4 x 10^3 m (4 mile) distance by transfer pipelines. Tank sizes range from 208 m3 (55,000 gallons) to 3785 m^3 (1 million gallons). [1]

Current plans are to retrieve the waste from the SSTs and store it in the DSTs. Eventually DST waste will be retrieved and vitrified at the Hanford Waste Treatment Plant (WTP) currently under construction at Hanford. Retrieval of SSTs relies upon DST space management and integration of WTP construction and operation to ensure adequate DST space. Free DST space is gradually being consumed through this process.

Current Evaporator Facility Risk

Maintenance of adequate DST space through the next decade relies upon the usage of boiling liquid evaporator facility, the 242-A Evaporator. This facility concentrates tank supernate (dilute alkaline liquid waste). This facility is hard-piped to a specific tank farm for receiving dilute liquid waste and transferring concentrated solutions.

The 242-A Evaporator was constructed in 1977 with a design life of ten years. Since then several projects have been completed to extend the life of the facility. A major program has just been implemented to manage facility equipment failure risk, and upgrade/replace components to allow facility operation through planned WTP waste supply until 2052 [2].

Regardless of life-extension activities a single point or large system failure at the 242-A Evaporator is still considered a significant risk [3]. The impacts of such a failure could lead to extended facility downtime, with the ensuing reduction of SST retrievals to maintain adequate DST freeboard, and ultimately delay Waste Treatment Plant transfers.

Mission Summary

The four mission objectives for the WFE are noted in Table I.

Table I. Wiped Film Evaporator Mission Value.

WFE Mission	Value Added
1. Mitigate 242-A critical failure	Concentrate DST supernate waste, maximizing DST freeboard, and minimizing impacts to SST retrievals
2. Supplement 242-A capacity	Accelerate DST supernate concentration, and minimizing secondary waste
3. Concentrate staged SST waste	Mitigate risks associated with SST staging
4. Concentrate secondary waste	Minimize impacts from potential secondary wastes not treated directly at the Effluent Treatment Facility

An additional evaporator system would mitigate the risk of a 242-A Evaporator critical failure, and disruption of SST retrievals. Besides maintaining an adequate freeboard for the addition of new wastes into DSTs, lower water content wastes require less storage capacity significantly reducing the storage footprint and associated storage costs. More concentrated wastes generally reduce the risk of system leakage.

The proposed WFE would be modular and transportable, allowing it to be potentially located at any DST. This provides a degree of freedom for evaporation planning that the existing 242-A facility does not have, being hard-piped to specific tanks. The WFE would thus supplement existing evaporative capacity anywhere within the DST system. This supplemental usage also reduces the production of secondary waste. The 242-A Evaporator requires waste transferred from the DST complex to its specific DST feed tank. This transfer involves water flushing of the pipeline, and could be significant depending upon the transfer rout. The flush volumes are greatly reduced by evaporating directly at a DST. A general concept diagram is noted below in Figure 1, showing a primary evaporation unit within the tank farm boundary, directly connected to a tank riser, with supporting systems located outside the tank farm.

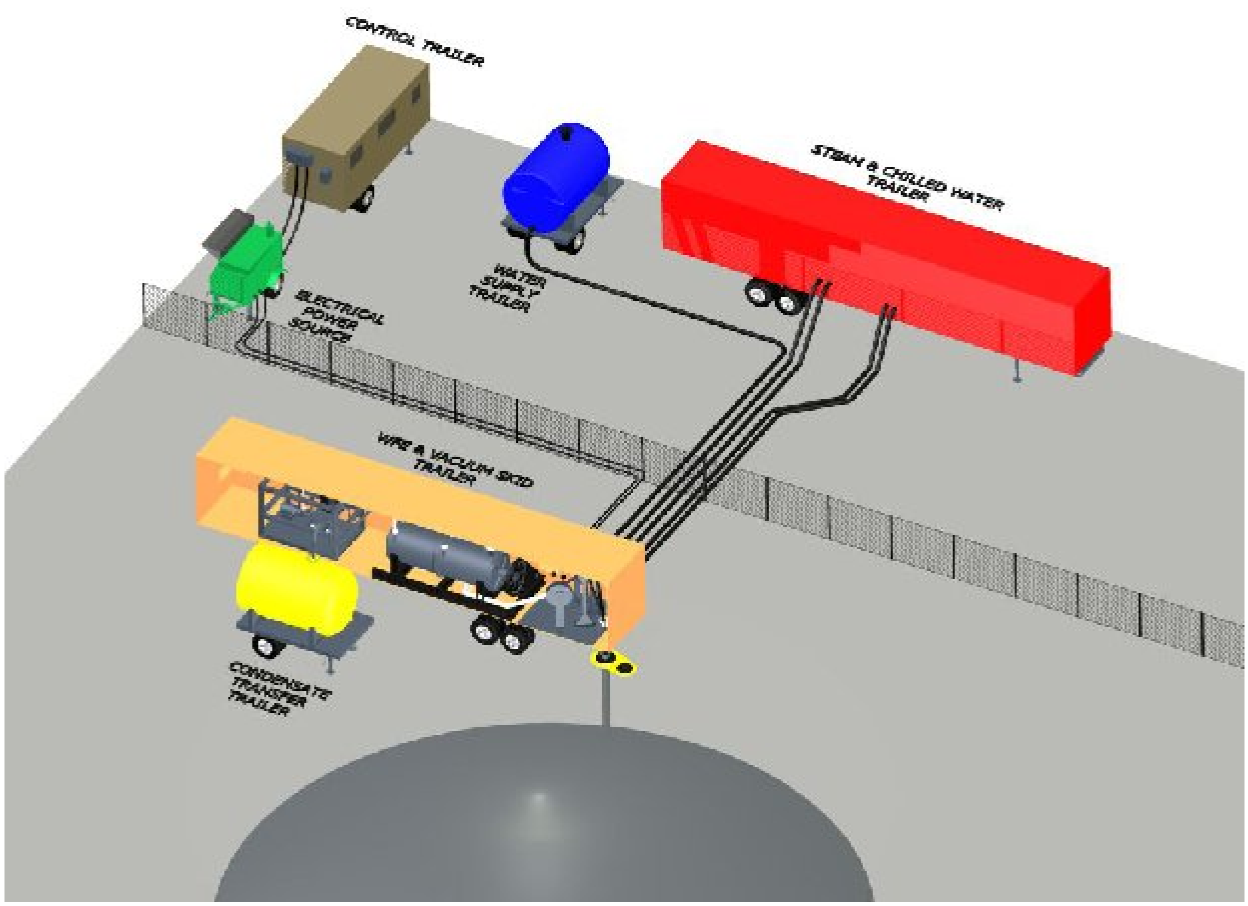

Fig.1. Modular WFE concept.

A WFE also could provide concentration of retrieved SST wastes consolidated/staged in other non-leaking SSTs. There is currently no capability of concentrating staged SST waste. The WFE would be located adjacent to an SST and reduce the risk of leakage from this staged vessel by minimizing overall liquid volume. SST staging is being evaluated as a new strategy to accelerate SST retrievals by decoupling the need for available DST space. While there are significant hurdles to overcome for this strategy to be enacted, it has the potential to greatly minimize DST space issues.

Lastly, the WFE is proposed for reduction of liquid secondary waste volume obtained from WTP operation. Supplemental evaporative capacity at the tanks interfacing with WTP would have the advantage of minimizing space issues from unplanned WTP waste returns or secondary waste transfers from WTP that are not handled by the Hanford Effluent Treatment facility.

Technology Application

Columbia Energy has demonstrated a WFE system to concentrate Hanford stored liquid wastes using commercially-available thin film evaporative technology. They have applied for patents on the technology and modular approach for nuclear applications. Columbia Energy has demonstrated effective concentration during initial non-radioactive simulant testing with pilot-scale equipment, in conjunction with Energy*Solutions*, Inc.; and more details on this prior testing are detailed in this report.

Thin film evaporative technology has been used commercially for many years within a variety of industries. The general process is depicted below in Figure 2.

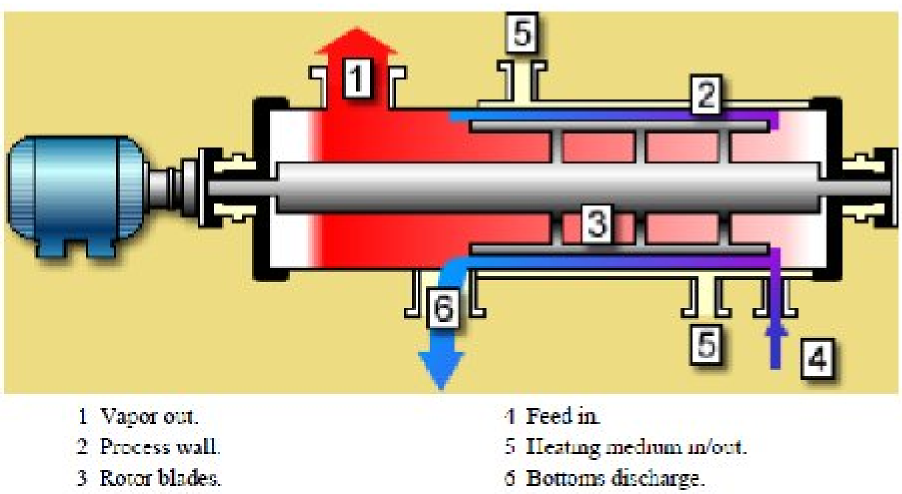

Fig. 2. Typical thin film evaporator process (Courtesy of Artisan Industries).

Thin film evaporation augments traditional water removal through the usage of high vacuum. It uses this high vacuum within a fixed, heated drum, through which dilute material is flung upon the interior drum surface by a high rpm rotating shaft and paddles. This rotation creates a thin film of approximately 1.59×10^{-3} m (1/16 in) to 3.18×10^{-3} m (1/8 in) on the drum interior allowing heat transfer and evaporation across a large surface volume.

WFE Technology Advantages

The WFE process provides the following additional value for nuclear applications by nature of its technology.

- Vacuum operation reduces the boiling point of water to approximately 322-333 ^oK (120–140 ^oF); low temperature operation limits component carryover (e.g., organics, salts, etc.) into the vapor.
- Low temperature evaporation allows processing of the waste below typical regulatory thresholds for thermal processes, approximately 344 ^oK (160 ^oF), reducing the complexity of the regulatory process.
- Centrifugal force holds a thin film of material, approximately 3.18 10^{-3} m (1/8 inch) thick, against the heated wall; increasing heat transfer and keeping the material holdup and residence time very low. Low material holdup within the unit reduces the quantity of shielding necessary to meet dose exposure constraints.
- Direct connection to a DST may allow use of the existing DST ventilation system, thus eliminating the need for separate air emission control systems.

PRIOR TESTING

Summary

Columbia Energy successfully concentrated DST simulants representing two major constituent feed streams/tanks: 241-AN-105 (Envelope A) and 241-AN-107 (Envelope C) in 2007 [4]. They used a pilot-scale system, including evaporator, vacuum pump and condensate system, heat transfer fluid heating and pumping system, and simulant supply system. Also tested was a simulant representing SST dissolved saltcake (typical liquid radioactive waste constituents include nitrates, halides, organics, and sodalite precursors). Testing resulted in the WFE system producing concentrated slurry having a specific gravity of 1.47, while the single-shell simulant was easily concentrated to 1.46 without system fouling or the need for excessive flushing; continuing concentration capacity potential and issues were documented. Evaporator condensate was equal to or less than U.S. Environmental Protection Agency drinking water standards.

Scope

Testing of thin film evaporative technology was performed in 2007 by Columbia Energy under a contract with Energy*Solutions*, Inc. to validate the concept for Hanford application. The test sought to produce data useful for quantifying system performance and the constituents of the process streams (i.e., feed, bottoms, and condensate). The data collected during the test was intended to help predict full-scale system performance.

The test setup involved a 1/150th-scale system, i.e., a 9.29 x 10^{-2} m (1 ft^2) heated area. Major components included:

- Rototherm® evaporator assembly with condenser; 9.29 x 10^{-2} m (1 ft^2)
- Portable diesel generator; 175-kW
- Delta-Therm™ Ice T™ water chiller assembly; 8.86 x 10^7 joule/hr (7 ton)
- Tuthill Vacuum and Blower Systems liquid ring vacuum pumping system; 34 m3/sec (20 cfm)
- Delta-Therm oil heater assembly; 24 kW

- Three Seepex, Inc. progressive cavity pumps (one each for the feed, bottoms, and condensate streams)
- Feed solution pre-heater
- Programmable logic control cabinet
- Pump and motor control panel
- Various flow transmitters, thermocouples, pressure transmitters, and level indicators
- Various manually operated valves.

® Rototherm is a registered trademark of Artisan Industries, Inc.
™ Delta-Therm and Ice T are trademarks of Delta T Systems, Inc.

The pilot-scale process is depicted below in Figure 3.

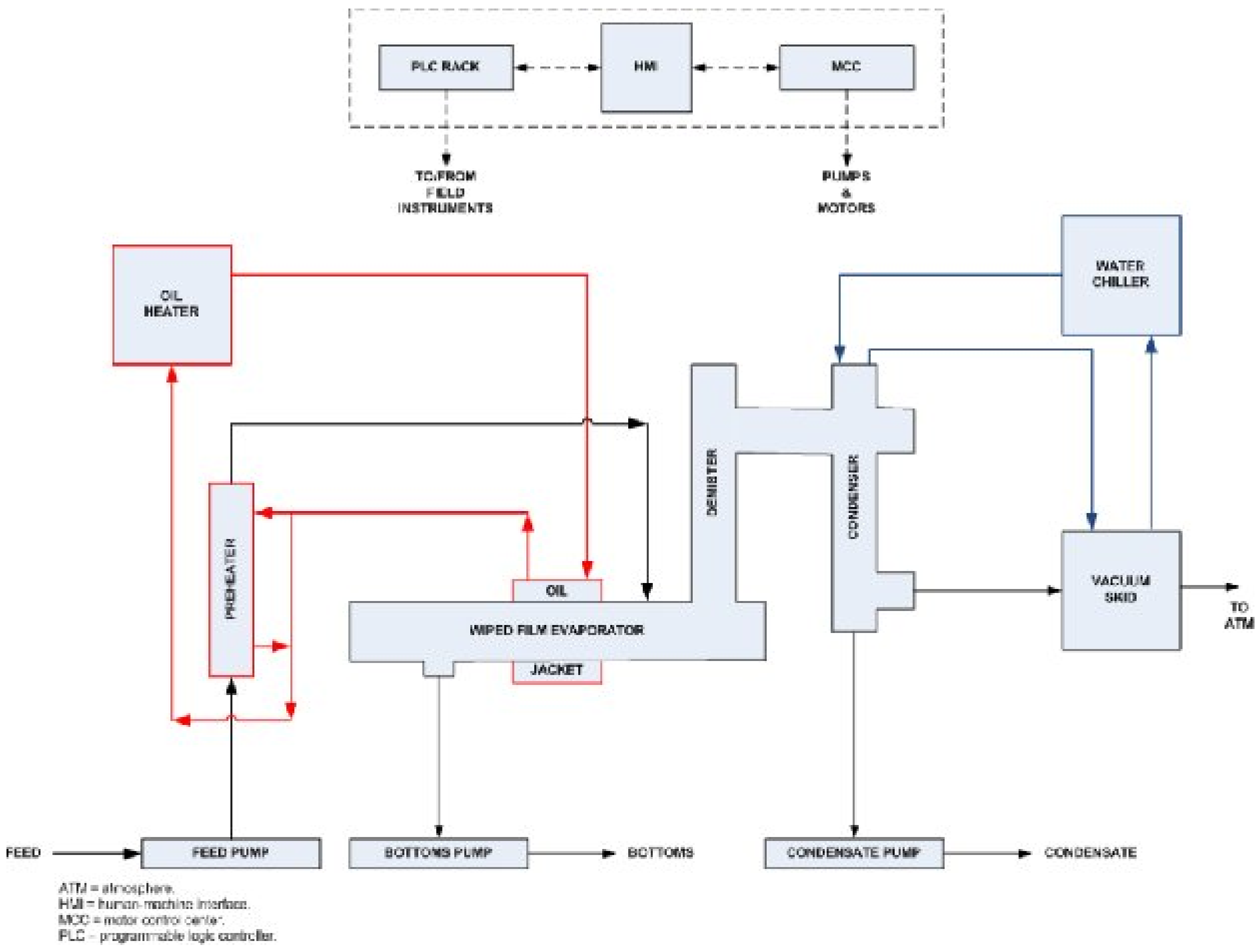

Fig. 3. Columbia Energy pilot-scale testing flow diagram.

Simulants

Pilot-scale testing used three waste simulants to represent typical Hanford tank waste. Simulant 1 represented mixed waste from DST 241-AN-105. Simulant 2 represented mixed waste from DST 241-AN-107. Simulant 3 represented a composite of dissolved saltcake waste from S and U tank farm SSTs. Actual simulants were prepared by NOAH Technologies Corp. of San Antonio, Texas, who has had extensive experience in preparing Hanford's and other DOE facilities' simulants.

Analytes for each simulant are listed below in Table II.

Table II. Simulant analytes.

Analyte	Simulant 1 (AN-105)	Simulant 2 (AN-107)	Simulant #3 (SST Dissolved Saltcake)
Acetate	X		X
Aluminum	X	X	X
Ammonium	X	X	
Barium		X	X
Boron	X	X	X
Cadmium	X	X	
Calcium	X	X	
Carbonate (Reported as $CaCO_3$)	X	X	X
Cerium		X	
Cesium	X	X	X
Chloride	X	X	
Chlorine			X
Chromium	X	X	X
Copper		X	X
Fluoride	X	X	X
Fluorine			X
Formate	X		X
Iodide	X	X	X
Iron		X	
Lanthanum		X	
Lead	X	X	
Magnesium	X	X	
Manganese		X	
Molybdenum	X	X	
Neodymium		X	
Nickel		X	
Nitrate	X	X	X
Nitrite	X	X	X
Phosphate	X	X	X
Potassium	X	X	X
Selenium	X	X	
Silicon	X		
Silver	X	X	

The tank 241-AN-105 waste simulant was prepared in accordance with *Hanford Waste Simulants Created to Support the Research and Development on the River Protection Project – Waste Treatment Plant* [5] and spiked with additional cesium nitrate (non-radioactive) to 0.16 kg/m^3, i.e., 0.24 gm total cesium nitrate). Even at this elevated level, the cesium concentration in the condensate stream was not expected to meet the minimum detection limit (MDL) capabilities of the laboratory. The elevated cesium concentration bounds the maximum concentrations for this type of Hanford waste. Iodine concentration, as sodium iodate, was also increased to 0.05 kg/m^3. The iodine concentration in the condensate stream was expected to be 100 times greater than the MDL capabilities of the laboratory, assuming that 50 percent of the iodine volatized during evaporation.

The tank 241-AN-107 simulant was prepared also per the same simulant report [5] with increased cesium concentration at 0.186 kg/m^3, i.e., 0.27 gm total cesium nitrate), and iodine to 0.05 kg/m^3.

The SST dissolved saltcake waste simulant was prepared in accordance with *Cold Dissolved Saltcake Waste Simulant Development, Preparation, and Analysis* [6]. It was spiked with additional cesium to 0.1 kg/m^3 (i.e., four times the initial concentration), and iodine from 0 to 0.05 kg/m^3.

Testing

Equipment qualification testing was performed with de-ionized water instead of waste simulant. Qualification testing verified the operability and workmanship of the pilot-scale system, established the approximate process parameters for subsequent pilot-scale testing (e.g., pumping rates, temperature settings, vacuum settings), and qualified five Columbia Energy employees and one Energy*Solutions* employee, as test operators for the pilot-scale WFE system.

Pilot-scale testing with the three simulants was then performed to accomplish the following test objectives: document the performance of the system (i.e., process parameters), assess system wear at regular intervals, and collect samples and other data to characterize the properties of each of the three waste streams (i.e., feed, bottoms, and condensate).

Pilot-scale testing proceeded according to the following sequence:

- Concentrated 3.78 x 10^{-2} m^3 (10 gal) of Simulant 1 (tank 241-AN-105 envelope A) to a specific gravity of 1.48 to determine optimized system settings for this simulant
- Concentrated 3.78 x 10^{-2} m^3 (10 gal) of Simulant 2 (tank 241-AN-107 envelope C) to a specific gravity of 1.48 to determine optimized system settings for this simulant
- Concentrated 3.78 x 10^{-2} m^3 (10 gal) of Simulant 3 (SST dissolved saltcake) to a specific gravity of 1.46 to determine optimized system settings for this simulant
- Concentrated 1.14 x 10^{-1} m^3 (30 gal) of Simulant 1 to a specific gravity of 1.47
- "Dried" the remainder of Simulant 1 to a specific gravity of 1.52
- Reconstituted the "dried" bottoms from Simulant 1 using the collected condensate to measure the ability of the solids in the bottoms to re-dissolve
- Inspected the pilot-scale system for wear after concentrating and drying Simulant 1
- Concentrated 1.14 x 10^{-1} m^3 (30 gal) of Simulant 2 to a specific gravity of 1.47
- "Dried" the remainder of Simulant 2 to a specific gravity of 1.49

• Reconstituted the “dried” bottoms from Simulant 2 using the collected condensate to measure the ability of the solids in the bottoms to re-dissolve

• Inspected the pilot-scale system for wear after concentrating and drying Simulant 2

• Concentrated 1.14 x 10^{-1} m^3 (30 gal) of Simulant 3 to a specific gravity of approximately 1.465, at which point the concentrated solution rapidly transitioned to a solid phase

• Reconstituted the “dried” bottoms from Simulant 3 using the collected condensate to measure the ability of the solids in the bottoms to re-dissolve

• Inspected the pilot-scale system for wear after concentrating and drying Simulant 3.

Pictures of the pilot-scale system are shown below in Figure 4.

Pilot-scale WFE (from drive end)

Pilot-scale WFE (from discharge end)

Fig. 4. Photographs of the pilot-scale WFE at the Columbia Energy test facility in Pasco, Wa.

Pilot-scale Test Results

The pilot-scale WFE system successfully concentrated each of the three simulants [4]. For the DST simulants (Simulants 1 and 2), the pilot-scale WFE system achieved a bottoms concentration in excess of the specific gravity goal of 1.47. The resulting concentrated simulant remained in solution (i.e., no solids precipitated in the bottoms process stream). Based on observation of the concentrated simulant, further concentration of the DST simulants was possible.

The SST simulant (Simulant 3) behaved similarly to Simulants 1 and 2 until the specific gravity exceeded a value of 1.46. At a specific gravity of 1.465, the concentrated simulant quickly began to transition to a wet sludge as constituents precipitated out of solution. Further processing was discontinued at this point.

Specific gravity results are listed below in Table III.

Table III. Pilot-scale testing specific gravity results.

Simulant	Specific Gravity		Specific Gravity a Test Goal	Specific Gravity Versus Time	
	Start	End		Equation Fit	R^2
DST #1	1.36	1.52	1.47	Linear	0.9954
DST #2	1.404	1.489	1.47	2nd Order Polynomial	0.9816
SST #3	1.24	1.465 b	1.47	Linear	0.9971

a The specific gravity goal of 1.47 was established prior to testing.
b Crystallization proceeded rapidly at this point and further processing was discontinued.

Concentration was essentially linear with time despite the variation of primary process parameters (e.g., feed rate and vacuum pressure). Regression analysis was used to determine the best fit for describing the concentration behavior, expressed in terms of specific gravity versus time. Simulants 1 and 3 demonstrated an approximately linear relationship with respect to time. Simulant 2 was best described by a second-order polynomial.

Evaporation was conducted under a relatively narrow range of vacuum and thin film temperature and, with the exception of increased vacuum excursions, remained essentially constant. Condensate production was varied primarily by adjusting the feed rate and the amount of vacuum applied to the WFE within the ranges presented in Table IV. Overall, condensate production varied from 4.28×10^{-3} to 8.44×10^{-3} kg/sec (34 to 67 lbs/hr) based on operator-measured volumetric flow rates. Operator-measured volumetric flow rates were used in lieu of the condensate flow meter which failed during the testing.

For the pilot-scale WFE system, i.e., a 9.29×10^{-2} m (1 ft^2) heating area with a 316 SS evaporation chamber, operating in a continuous concentration mode, the maximum condensate production rate for dilute aqueous solutions ranges from 6.30×10^{-3} to 1.26×10^{-2} kg/sec (50 to 100 lbs/hr). For salt solutions, such as the DST and SST simulants, the condensate production rate was expected to be less than the maximum condensate production rate due to boiling point elevation effects that increase with solution concentration. The boiling point elevation effect causes the temperature of the thin film within the evaporator chamber to gradually increase as the specific gravity of the solution increases.

Table IV. Pilot-scale testing process results.

Simulant	WFE Vacuum a	WFE Film Temperature	Feed Rate	Condensate Production
1	-96.5 to -91.0 kPa (–14.0 to –13.2 psi)	317 to 334 °K (111 to 142 °F)	0.09 to 0.12 kg/sec (678 to 992 lb/hr)	4.28×10^{-3} to 8.44×10^{-3} kg/sec (34 to 67 lb/hr)
2	-92.4 to -90.3 kPa (–13.4 to –13.1 psi)	321 to 335 °K (118 to 144 °F)	0.07 to 0.10 kg/sec (536 to 813 lb/hr)	4.79×10^{-3} to 4.91×10^{-3} kg/sec (38 to 39 lb/hr)
3	-97.2 to -92.4 kPa (–14.1 to –13.4 psi)	316 to 328 °K (109 to 131 °F)	0.09 to 0.10 kg/sec (716 to 805 lb/hr)	4.28×10^{-3} to 6.30×10^{-3} kg/sec (34 to 50 lb/hr)

a WFE vacuum pressure measured just outside the Rototherm b chamber and before the demister.
b Rototherm is a registered trademark of Artisan Industries, Inc.

Primary process parameters of feed rate and vacuum were varied during testing to assess the impact on the WFE performance. During testing on Simulants 1 and 3, the vacuum was varied to determine the impact on condensate production. When the WFE was operated at vacuums of approximately -94.8 kPa (–13.75 psi) or greater, constituent carryover into the condensate was identifiable by a distinct color change of the condensate, which coincided with the peak conductivity readings for the test. Constituent carryover was verified through analysis of the condensate samples. For example, anion concentrations in the condensate quickly decreased after the vacuum was reduced from -96.5 to -91.7 kPa (–14.0 to –13.3 psi). This response suggests that the optimal vacuum is near the carryover point in order to maximize the condensate production rate, but sufficiently beneath the carryover point to ensure the highest purity condensate.

With the exception of the condensate samples taken near the high vacuum conditions, analytes were reported at or near the MDL and most were reported as less-than values. The results reflected the ability of the WFE to produce "clean" condensate when operated in the optimum processing envelope.

The key contaminants of concern, cesium and iodide, were consistently reported at or near the MDL. Interestingly, iodide in Simulant 3 exceeded the MDL for all four condensate samples. Because all four condensate samples are above the MDL, it is unlikely that the iodide results are the result of the vacuum excursions, especially in light of the fact that the cesium concentrations for Simulant 3 were in line with the concentrations from Simulants 1 and 2. Nevertheless, the WFE system effectively produced a condensate low in cesium and iodide from the as-formulated simulant recipes.

Test Conclusions

The pilot-scale WFE system effectively concentrated the DST and SST simulants while producing a "clean" condensate, as measured against 40 CFR 141[7], when operated below the carryover vacuum threshold. Simulants 1 and 2 were concentrated beyond the specific gravity test goal of 1.47. Both simulants remained in solution with specific gravities in excess of 1.47. While Simulant 3 neared the 1.47 specific gravity goal, it exhibited a tendency to rapidly transition to the solid phase at a specific gravity of 1.465.

The pilot-scale WFE system is capable of producing between 4.47 x 10^{-6} and 8.83 x 10^{-6} m^3/sec (4.25 and 8.4 gal/hr) of condensate. As expected, the system performance, as measured by the quality of the condensate produced, is sensitive to vacuum. Condensate conductivity and contaminant concentration are low when the WFE system is operated beneath the carryover vacuum threshold. Results of the pilot-scale testing suggest that the optimal vacuum for steady-state processing, including a prudent buffer, is -91.4 kPa (-13.25 psi).

The rapidly agitated, thin film processing configuration concentrated each simulant without fouling or equipment failure. Studies with longer testing durations would likely provide additional longevity data, but, based on the results, the WFE system is capable of processing the DST and SST simulants without fouling or need for excessive flushing. Furthermore, the results of this initial demonstration suggest that the WFE is a viable option for concentrating the SST and DST wastes present in the Hanford Tank Farms.

Key Pilot-scale Testing Lessons Learned

A number of lessons learned were identified during the pilot-scale WFE testing. Key lessons-learned included:

1. Process controls should be implemented to ensure that the preheat fluid can be isolated from the preheater when the feed pump is shut off. This ensures that the preheater does not boil when the main flow is stopped.
2. Ensure seal water is constantly provided to the evaporator rotor during operation. During testing, a kinked seal water supply line resulted in a distinct, off-normal noise that was quickly eliminated once the supply line was restored to normal operation.
3. Upgrade the carbon steel components (i.e., piping and valves for feed, bottoms, and condensate) to stainless steel. In addition to visual inspection of the condensate, solution conductivity was the primary real-time feedback mechanism for WFE performance during testing. The presence of rust from the carbon steel piping may have influenced the conductivity measurements.
4. Fluids and containers that may come in contact with simulants and/or samples during processing should be sampled and analyzed for potential trace contaminants. The presence of unexpected selenium (Simulant 2) and copper (Simulant 3) may have been due to chemical impurities introduced during simulant manufacture, but confirmatory analysis of other items that came in contact with the system (e.g., de-ionized water and pipe thread sealant) would aid in identifying the source of these elements.

WFE FURTHER DEVELOPMENT AND DEPLOYMENT

The ORP/DOE has authorized a project to finalize development activities and deploy a WFE unit within tank farms [8]. The project began in the summer of FY09 and will extend through FY17. It is managed through two distinct phases, both as a logical application of DOE technology maturity planning, and to properly manage the Recovery Act development funding source. The major activities per the two phases are noted below in Table V.

Table V. WFE Project phased approach.

<table>
<tr><th>Phase</th><th colspan="5">DEVELOPMENT</th><th colspan="5">DEPLOYMENT</th></tr>
<tr><td>Fiscal Year</td><td>FY09</td><td colspan="2">FY10</td><td>FY11</td><td>FY12</td><td>FY13</td><td>FY14</td><td>FY15</td><td>FY16</td><td>FY17</td></tr>
<tr><td>Major Scope</td><td>Tech Eval</td><td colspan="2">Pilot Scale Simulant Testing (DST/SST)</td><td>Full Scale Simulant Testing (DST)</td><td>Other Pilot Scale Simulant Testing (OPTIONAL)</td><td>Final Design & Procure</td><td>Final Fabr. Const. & Testing</td><td colspan="3">Field Testing and Operation with Actual Waste</td></tr>
<tr><td>Technology Readiness Level</td><td>3</td><td>4</td><td>5</td><td colspan="2">6</td><td colspan="2">7</td><td>8</td><td colspan="2">9</td></tr>
<tr><td>DOE 413.3 Stage</td><td colspan="4">Preconceptual Planning</td><td>Conceptual</td><td>Concept & Final</td><td>Const. & Turnover</td><td colspan="3">Operation</td></tr>
<tr><td>Quality Assurance Level</td><td colspan="3">Commercial Grade</td><td colspan="2">Enhanced & Commercial</td><td colspan="5">Enhanced</td></tr>
<tr><td>Funding Base</td><td colspan="4">Recovery Act</td><td colspan="6">Baseline</td></tr>
</table>

Development Phase

This phase of the project completes additional pilot-scale and new full-scale simulant testing. Key design, safety evaluation, and regulatory analysis are being performed during this phase to ensure the procured full-scale demonstration test system maximizes fidelity for field implementation. The plan is to deploy as much equipment as possible used for full-scale demonstration testing to the field.

Deployment Phase

This phase implements the majority of DOE 413.3 project planning to install field modifications, complete all safety and regulatory permits, and deploy the full-scale demonstration system to the field. Key to the successful effort is ensuring maximum fidelity of the test system, and use of the proper quality assurance procurement protocols to allow adequate commercial grade item dedication of potential safety systems.

Project Status

The project entails a Development phase baseline of approximately $17 million. The project is on track to complete all development work with recovery Act funding by the end of FY11. This will result in pilot-scale and full-scale test reports and a full-scale demonstration test system suitable for further field deployment and radioactive waste processing. Key project objectives are listed below in Table VI.

Table VI. Continued WFE testing objectives.

Phase	Objectives
General	1. Deploy full-scale testing demonstration system to field for actual waste processing
Development	2. Demonstrate effective concentration in a pilot-scale system of simulant(s) representing DST and SST wastes
	3. Demonstrate effective concentration of DST supernate simulant(s) in a full-scale system (e.g., validating scale-up performance, and minimal scale impacts, such as from aluminosilicates)
	4. Complete all pilot and full-scale development effort to achieve DOE Technology Readiness Level 6
	5. Qualify strategic application of technology, including other feed applications (e.g., secondary liquid effluent)
Deployment	6. Complete all remaining project effort to achieve DOE Technology Readiness Level 6
	7. Demonstrate system mobility for tank farm set up
	8. Demonstrate safe and effective concentration of actual tank waste, in normal operating conditions (while connected to a Hanford waste storage tank)
	9. Validate decontamination and other field activities for transportability of contaminated system

CONCLUSIONS

Initial pilot-scale testing performed by Columbia Energy and Energy*Solutions* Inc. has demonstrated a viable evaporative technology for mitigating a significant risk to Hanford tank farm retrievals and space management. Completion of full-scale development testing in FY11 should demonstrate scale-up performance and allow field deployment for radioactive waste processing.

REFERENCES

1. M.J. RODGERS, "Waste tank Summary for Month Ending August 31, 2009", HNF-EP-0182, Rev. 257, Washington River Protections Solutions (2009).

2. D.A. THOMPSON, "Engineering Study for the 242-A Life Extension Upgrades for Fiscal Years 2010 through 2052", HNF-3327, Rev. 2, Washington River Protections Solutions (2009).

3. "Risk Management Plan", RPP-27195, TFC-PLN-39, Rev. D, Washington River Protections Solutions (2009).

4. "Pilot-Scale Thin Film Evaporator Test Report", CEES-0393 Rev. 0, Columbia Energy and Environmental Services, Inc., (2008).

5. "Hanford Waste Simulants Created to Support the Research and Development on the River Protection Project – Waste Treatment Plant, Rev. 0, WSRC-TR-2000-00338, Westinghouse Savannah River Company (2001).

6. "Cold Dissolved Saltcake Waste Simulant Development, Preparation, and Analysis", PNNL-14194, Rev. 1, Pacific Northwest National Laboratory (2003).

7. 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

8. A.R. TEDESCHI, Wiped Film Evaporator Project Execution Plan, RPP-PLAN-4153, Rev. 0, Washington River Protections Solutions (2009).