EM U.S. Department of Energy
Office Of Environmental Management

EM Engineering & Technology Roadmap and Major Technology Demonstrations

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Introduction

- Progress made in EM cleanup mission with completion at Fernald and Rocky Flats; more expected over next few years.

- Nevertheless, challenges for continuing completions across the complex requires technical risks and uncertainties to be addressed; some large and unique efforts need untested technologies.

- Roadmap developed to guide Applied Research and Technology Development and Deployment

Roadmap Development

- Roadmap identifies technical risks and uncertainties in EM program over next ten years
- Input provided by EM Federal Project Directors, Stakeholders, Contractors, National Laboratories, and the National Academy of Science
- Identified technology risks in Waste Processing, Groundwater and Soil Remediation, and Deactivation & Decommissioning/Facility Engineering, Spent Nuclear Fuel, Challenging Materials, and Integration
- Establishes strategic initiatives to address technical risks and identifies expected outcomes when implemented
- Issued to Congress in March 2008
- National Research Council Interim Report issued in February 2008 agrees with major program areas for strategic R&D presented in Roadmap

Roadmap Implementation

- Federal Strategic Initiative Managers will lead implementation
  - Work with Federal Project Directors
  - Establish effective communications
  - Develop technical projects for each initiative

- Multiyear Program Plans (MYPP) being developed to implement Roadmap

- Staff from National Laboratories across the DOE complex has been involved in formulating the Engineering and Technology MYPP

- MYPP will address:
  - prioritized work activities, required budget, schedule, major products/deliverables, performance metrics, and performer selection
  - Final MYPP will be completed in FY2008

- Roadmap will be updated as new information becomes available

Waste Processing
Risks & Strategic Initiatives

Technical Risk and Uncertainty

Waste Storage

- Existing tanks provide limited storage and processing capacity, have exceeded their original design life, and will likely be in service for extended periods of time.
- Conservative assumptions regarding behavior of waste during storage, such as flammable gas generation, restrict operations and increase costs.

Waste Retrieval

- Current waste removal and retrieval operations and monitoring technologies are costly, sometimes inefficient, and are limited by complicated internal tank design (e.g., obstructions) and conditions (e.g., past leak sites).

Tank Closure

- Achieving lower levels of residual radioactivity and improving immobilization of residual materials might be possible if there were more cost-effective and efficient closure methods for some tanks.
- Final closure of some waste management areas, including closure of ancillary equipment such as underground transfer lines and valve boxes, would be facilitated by improved closure methods that would make the process more cost-effective and efficient.

Waste Pretreatment

- Achieving effective separation of low- and high-level wastes (HLW) prior to stabilization requires improved, engineered waste processes and a more thorough understanding of chemical behavior.

Stabilization

- Waste loading (i.e., the amount of waste concentrated in waste containers) constraints limit the rate that HLW can be vitrified and the tanks can be closed.
- Current vitrification techniques may require supplemental pretreatment to meet facility constraints.

Strategic Initiatives

Improved Waste Storage Technology

- Develop cost-effective, real-time monitoring of tank integrity and waste volumes to ensure safe storage and maximum storage capacity.
- Improve understanding of corrosion and changing waste chemistry, including flammable gas generation, retention, release, and behavior to establish appropriate assumptions in safety analyses.

Reliable & Efficient Waste Retrieval Technologies

- Develop optimization strategies and technologies for waste retrieval that lead to successful processing and tank closure.
- Develop a suite of demonstrated cleaning technologies that can be readily deployed throughout the complex to achieve required levels of removal.

Enhanced Tank Closure Processes

- Improve methods for characterization and stabilization of residual materials.
- Develop cost-effective and improved materials (i.e., grouts) and technologies to efficiently close complicated ancillary systems.
- Perform integrated cleaning, closure, and capping demonstrations.

Next-Generation Pretreatment Solutions

- Develop in- or at-tank separations solutions for varying tank compositions and configurations.
- Improve methods for separation to minimize the amount of waste processed as HLW.

Enhanced Stabilization Technologies

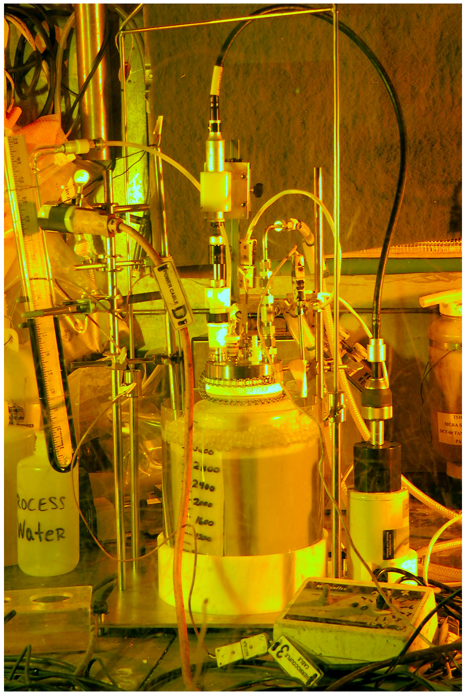
- Develop next-generation stabilization technologies to facilitate improved operations and cost.
- Develop advanced glass formulations that simultaneously maximize loading and throughput.
- Develop supplemental treatment technologies.

Technology Demonstrations

The following slides illustrate some the major technology demonstrations of FY ’08. Each slide presents the need, the solution, the results, and the impacts.

Sludge Mass Reduction

- Need
  - **The current understanding of the actual mass of sludge contained in the SRS HLW tanks indicates that about 7,900 canisters will be produced**
  - **This is higher than projected in prior years**
  - **There is a risk that the Site Treatment Plan commitment to vitrify all existing and future HLW by 2028 may be missed**
- Solution
  - **One method to reduce the mass of sludge to be vitrified is to remove aluminum present in the sludge**
  - **SRS developed a simple low temperature caustic leaching process that can be deployed in an existing waste tank with minimal modifications**
  - **The process was recently demonstrated at full scale in Tank 51**
- Results
  - **No new equipment was required for the demonstration**
  - **120,000 gallons of caustic was added to Tank 51**
  - **Tank temperature was elevated to 60-65oC by operating mixer pumps**
  - **Dissolution was complete after 80 days**
  - **65% of the insoluble aluminum was removed**
  - **the aluminum-rich decant stream is staged for feed to the Salt Waste Processing Facility**
- Impact
  - **The aluminum removed reduced the sludge volume by the equivalent of 100 canisters**
  - **The life cycle cost of the SRS HLW mission was therefore reduced by $100 million**
  - **This process will be used on future sludge batches and is expected to reduce sludge mass by the equivalent of 900 canisters with a corresponding life cycle cost reduction**



SRNL test rig

Small Column Ion Exchange

- Need
  - **SRS and Hanford are developing methods to increase the rate at which radioactive liquid waste is treated and waste tanks are closed. The largest fraction of the waste to be processed is salt waste (90% of the SRS volume). Processes that remove Cs and allow the waste to be disposed of as low level waste are required.**

  Solution
  - **SRNL and ORNL are developing the Small Column Ion Exchange (SCIX) process for two resins: non-elutable crystalline silicotitanate (CST) and elutable resorcinol formaldehyde (RF).**
- Results
  - **CST**
    - **Tested with SRS simulant at Oak Ridge**
    - **Tested with SRS real waste at SRNL in small scale column (1.5 cm x 160 cm)**
    - **30,000 gallons real waste processed at ORNL in 10 gallon column**
  - **RF**
    - **53 bed volumes tested with Hanford simulant at SRNL and PNNL**
    - **Tested with Hanford real waste at PNNL**
    - **Being adopted as the Baseline for Hanford WTP**
  - **Decontaminated salt solution processed through either resin easily met Class A limits**
  - **In-riser column design is available**
  - **Current investment stands at $6 million**
- Impact
  - **This additional waste treatment would accelerate tank closure by decreasing the life cycle associated with salt waste processing. The SCIX equipment can be mounted in existing waste tank risers thus reducing the shielding and infrastructure needed for the process (and the construction and installation cost).**

SRNL test rig

Fluidized Bed Steam Reforming at Savannah River Site (SRS)

Need

- SRS Tank 48 contains 240,000 gallons of highly radioactive liquid waste including 22,000 kgs of organic compounds that pose a flammability hazard. A radiochemical process is needed to treat the waste to destroy the organic constituents so that Tank 48 can be converted to service as a Salt Waste Processing facility feed preparation tank.

Solution

- Several evaluations have been conducted to identify technology alternatives.
- Numerous radiochemical processes for treating the Tank 48 waste have been tested dating back to 2003
- Fluidized Bed Steam Reforming (FBSR) selected as the most mature technology in meeting test requirements for organic destruction

Results

- 500 hours of testing performed on a 75% scale FBSR pilot plant
- 3,300 gallons of waste simulant treated
- 6,900 pounds of granular solid product produced
- >99.9% of organics destroyed
- All test conditions met
- Offgas samples obtained for future testing

Impact/Benefit

- The investment made by the Department has resulted in Fluidized Bed Steam Reforming being selected as the baseline technology for the Tank 48 Treatment Process project.

Cold Crucible Induction Melter

- Need
  - **Current waste volume projections at SRS indicate more sludge than previously estimated. The existing joule-heated melter technology used at DWPF may not be capable of vitrifying waste at a rate to meet the Site Treatment Plan date of 2028.**
- Solution
  - **Replace the existing joule-heated melter with the Areva Cold Crucible Induction Melter (CCIM) technology. The CCIM provides increased waste loading and increased waste throughput capability over the existing joule-heated melter.**
- Results
  - **Collaborated with SIA Radon in Russia to demonstrate maximized waste loading on DWPF type feeds**
  - **Completed DOE EM-21 Advanced Remediation Technology (ART) CCIM Phase 1 to perform lab and pilot scale testing to assess the feasibility of using CCIM to process SRS liquid waste**
  - **Completed two 72-hour CCIM pilot-scale demonstrations using SRS simulated waste at the Marcoule Demonstration Facility near Avignon, France**
  - **Commenced DOE EM-21 ART Phase II-A to extend the CCIM testing under representative conditions and to conduct the first set engineering tasks**
- Impact
  - **The CCIM technology offers several advantages over the ceramic lined, joule heated melter at DWPF. These advantages include 1) increased waste loading of 50+ wt% versus 34 to 38 wt%, 2) higher waste throughput and melt rate, 3) possible extended melter service life, and 4) higher tolerance for noble metals. Because of these advantages, the CCIM will result in substantial life cycle cost and schedule reduction and provide assurance that regulatory agreements and closure dates can be met.**

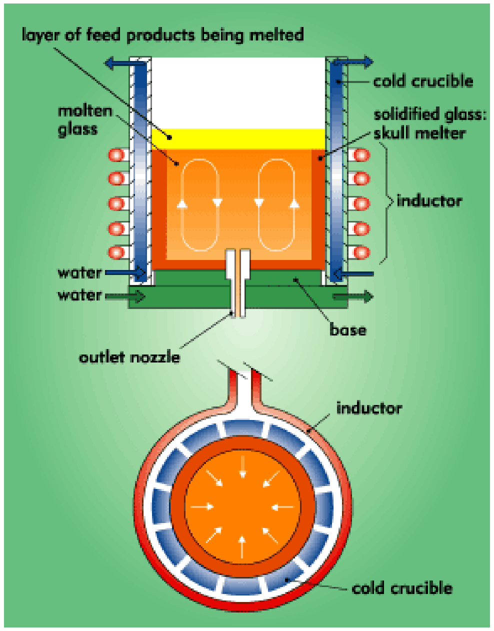


Figure 1: General view of the CCIM demonstration platform – CEA Marcoule

Conclusions

- Roadmap presents integrated approach to reduce technical risks and uncertainties in EM program; a "living" document, therefore, expect changes

- Risks include challenges in:
  - Waste Processing
  - Groundwater and Soil Remediation
  - Deactivation and Decommissioning
  - Spent Nuclear Fuel
  - Challenging Materials
  - Integration

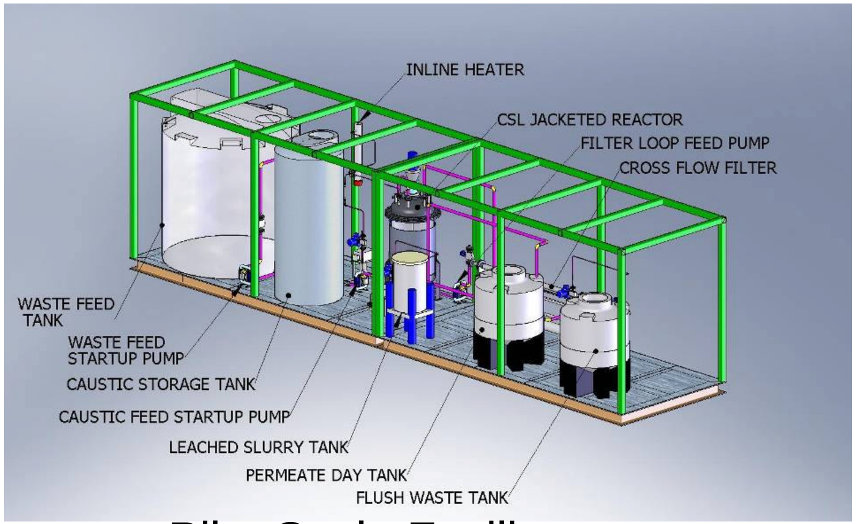
- EM will used applied research and engineering to improve technologies and processes at sites across the country

Backup Information

Continuous Sludge Leaching CSL)

? **Need**

The CSL process is designed to leach the boehmite form of aluminum present in significant quantities in the High Level Waste (HLW) sludges at both the SRS and Hanford sites. Boehmite is not effectively leached by current baseline technologies at either site. At SRS, the large tank aluminum leaching process is currently limited to ~60ºC, which is not effective in leaching boehmite. At Hanford, the WTP ultrafiltration process does not have sufficient reaction time to effectively leach the boehmite. Leaching the inert boehmite allows it to be separated from the HLW sludge by cross-flow filtration.



Pilot Scale Facility

•**Solution**

–Deploy the CSL process at SRS and/or Hanford to leach the boehmite from the HLW sludge such that it can be treated as low-level/low activity waste.

•**Results**

–Completed DOE EM-21 Advanced Remediation Technology (ART) CSL Phase 1 to perform literature reviews demonstrating the feasibility of using CSL to greatly reduce the SRS and Hanford sludge waste mass to reduce the number of HLW canisters produced.

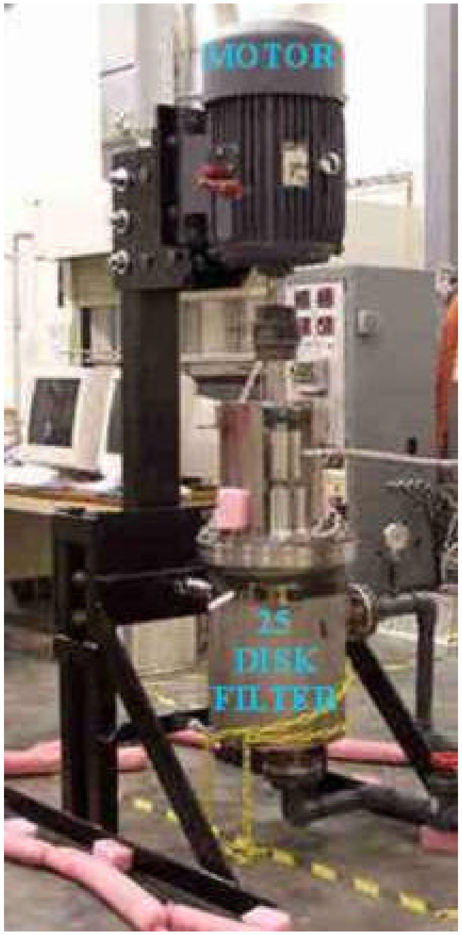
–Phase 2 contract awarded in September, 2007 to perform lab and pilot scale testing. Lab scale testing to begin in the Spring of 2008.

•**Impact**

–CSL will dramatically reduce the quantity of HLW canisters produced at both the Savannah River Site (35%) and at the Hanford Site (55%) in comparison to the current technology baselines. This would result in billions of dollars in savings. CSL produces a feed stream suitable for processing in the ART Near Tank Cesium Removal project.

Rotary Microfilter

- Need
  - **SRS and Hanford are developing methods to increase the rate at which radioactive liquid waste is treated and waste tanks are closed. The processes that they are developing require a solid-liquid separation that is rate limiting and requires a big footprint.**
- Solution
  - **SRNL has been developing the rotary microfilter to perform the solid-liquid separation step needed for these processes.**
- Results
  - **Full scale 25-disk prototype tested with SRS simulated waste**
  - **Design drawings for deployment in SRS waste tank risers completed.**
  - **Testing currently underway for Hanford and planned for SRS as a pre-treatment for ion exchange and sludge washing to complete in FY08**
  - **Current investment stands at 3 million**
- Impact
  - **By deploying the rotary microfilter as the solid-liquid separation process, the SRS and Hanford sites can treat additional radioactive liquid waste for processes such as Small Column Ion Exchange, Supplemental Pretreatment, and Bulk Vitrification, and Sludge Washing. This additional waste treatment would accelerate tank closure. The rotary filter can be placed in a waste tank riser, which reduces the shielding and infrastructure needed for the process (and the construction and installation cost). Because of its smaller size, the rotary filter will have a lower disposal cost at the conclusion of its life.**



Near Tank Cesium Removal

- Need

  Current retrieval activities at Hanford are slow due to need for additional Double Shell Tank (DST) space. Current TPA milestones require that all waste be removed from the Single Shell Tanks by 2018.

- Solution

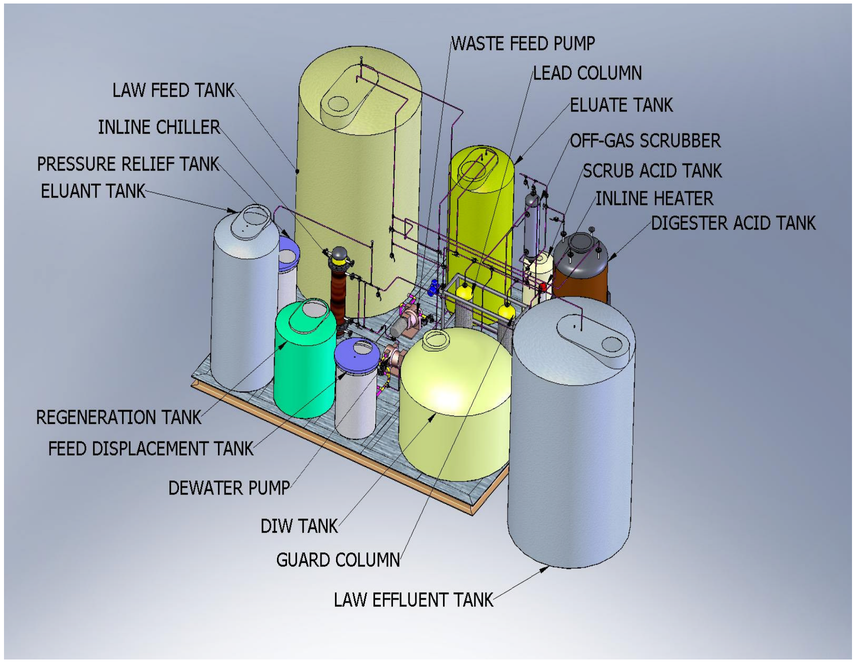
  Deployment of the Near Tank Cesium Removal (NTCR) will allow the low activity waste (LAW) stream to go to supplemental treatment (e.g., bulk vitrification). This accelerates both retrieval and tank closures activities.

- Results

  Completed the system description for the Phase II demonstration unit including risk review to identify testing needs.

  Completed PFD, P&ID, GA and cost and schedule estimates for Phase II demonstration unit

  Completed Proof of Principle experiments to test resin destruction and dissolution in nitric acid



•Impact

- **Deployment of the NTCR process could accelerate the start of WTP LAW Vitrification Facility up to 6 years**
- **Deployment of the NTCR process will supply feed to supplemental treatment (bulk vitrification)**
- **Processing of this tank waste early will: free up DST space, allow SST retrieval to proceed, demonstrate progress on waste treatment, be independent of the schedule for the WTP Pretreatment Facility completion date, and accelerate Tank Farm Closure**

Fluidized Bed Steam Reforming at the Idaho Cleanup Project (ICP)

- **Need**
  - The ICP has approximately one million gallons of liquid sodium bearing waste that must be solidified and packaged for shipment to the Waste Isolation Pilot Project or the High Level Waste Repository depending on results of waste determination.
  - If waste is determined to be high level waste then disposal in high level waste repository would require a waste that would satisfy repository requirements.
- **Solution**
  - A mineralized waste form produced by fluidized bed steam reforming (FBSR) may be able to satisfy high level waste disposal performance requirements.
  - Principal of FBSR mineralizing chemistry demonstrated by bench scale test at Savannah River National Laboratory and system objectives proven by FBSR pilot scale testing at SAIC's Star Center in Idaho Falls.
- **Results**
  - Testing demonstrated that mineralized waste form can be produced from sodium bearing waste simulants.
  - Waste form contained target surrogate materials of interest, was resistant to leaching and produced in a continuous operation lasting up to 100 hours.
  - Tests show that FBSR can be operated in an environmentally safe manner.
- **Impact/Benefit**
  - With some modifications to the Integrated Waste Treatment Unit (IWTU), a mineralized flowsheet can be implemented for this planned facility.
  - Testing performed confirmed applicability of FBSR to treatment of Hanford low activity waste.

FBSR test facility at Hazen, CO

Fluidized Bed Steam Reforming (FBSR) of Hanford Waste

Pilot Scale Facility

? **Need**

In 1996, DOE-ORP initiated a project to design, build, and commission the Hanford Tank Waste Treatment and Immobilization Plant (WTP) to treat 53 million gallons of waste, constituting 190 million curies in 177 tanks. The WTP will separate wastes into a small-volume, high-level waste (HLW) and a large-volume, low-activity waste (LAW) fraction.

- **Solution**
  - Deploy the THOR Treatment Technologies, LLC proprietary FBSR technology (currently under construction for treatment of sodium bearing waste in Idaho) to process early LAW and future WTP recycle streams and to supplement LAW processing with a FBSR to accelerate LAW processing.
- **Results**
  - Completed DOE EM-21 Advanced Remediation Technology (ART) FBSR Phase 1 to perform literature reviews demonstrating the feasibility of using FBSR for Hanford waste processing.
  - Phase 2 contract awarded in September, 2007 to perform pilot scale and lab scale real waste testing. All pilot modifications are complete. Simulants are being procured. Pilot scale testing scheduled to start early April..
- **Impact**
  - FBSR would eliminate all issues with ETF WTP recycle testing removing a major flowsheet issue from the early LAW deployment. An FBSR to process LAW would reduce the overall WTP mission length by 30% at a lower cost than other options currently available.