Chemical Process Alternatives for Radioactive Waste

DE-FG01-05EW07033_1

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Outline

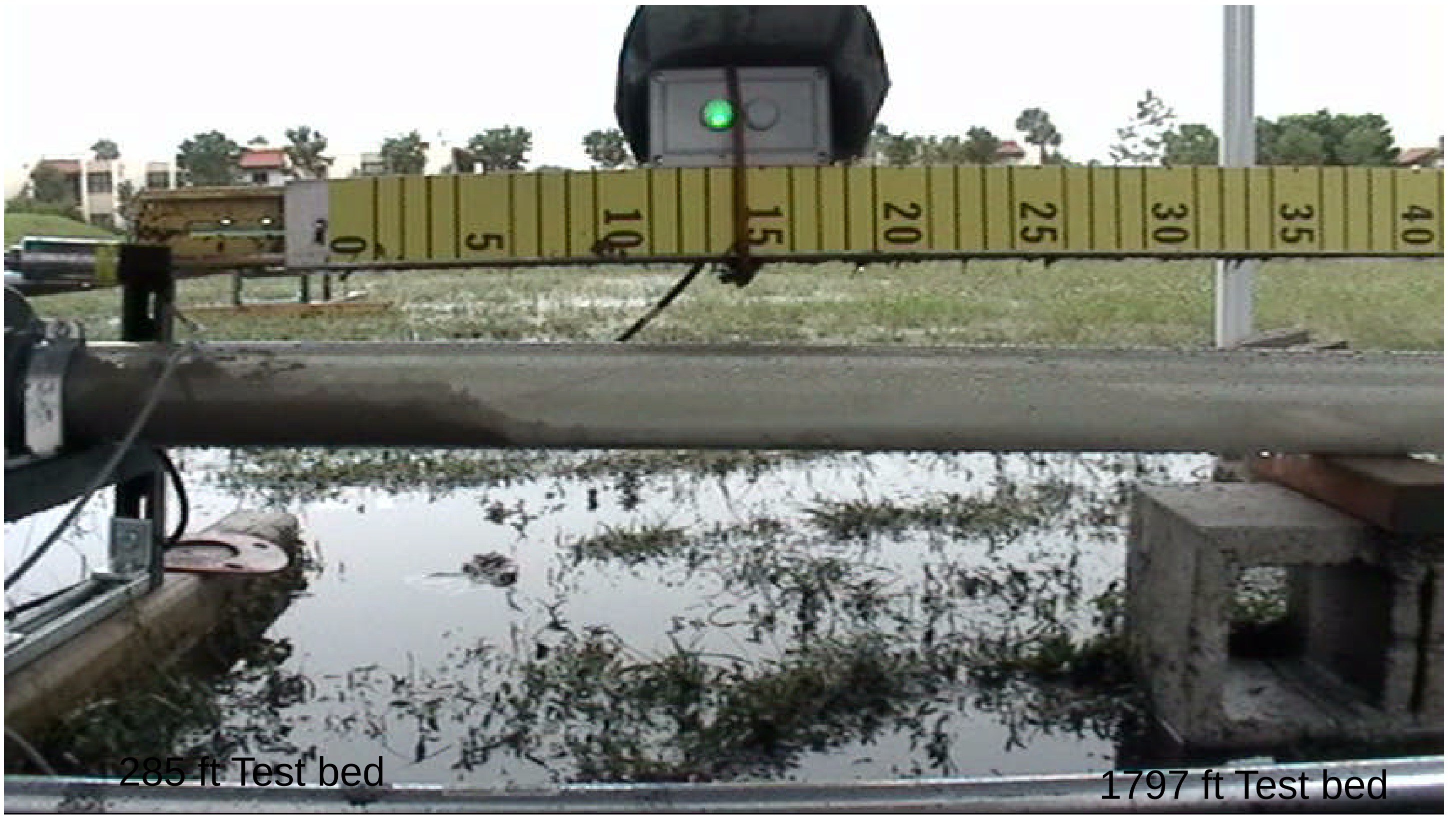
- Task 2: Waste Slurry Transport Characterization (Pipeline Unplugging)
- Task 6: Remote, Automated Monitoring Systems for High-Level Radioactive Waste (SLIM)
- Task 8: Engineering Studies of Innovative Technologies to Increase Tank Space
- Task 11: In-Line Solids Monitor (ILSM)
- Project Impact

Task 2 – Project Description

- Qualify pipeline unplugging technologies for the DOE sites
  - NuVision's Fluidic Wave-Action Technology
  - AIMM Technologies Hydrokinetic Cleaning Process
- Use of 285 ft, 621 ft, and 1797 ft pipeline lengths to extrapolate technology performance for longer lengths
  - Understand technology mechanics and limitations
- Use of 3 test plugs of varying composition to determine unplugging effectiveness
- Management decisions can be made whether a technology has a reasonable chance to unplug a pipeline (e.g. the cross-site transfer line ~ 5 miles).
- Tank Closure Pipeline Unplugging, High Priority*

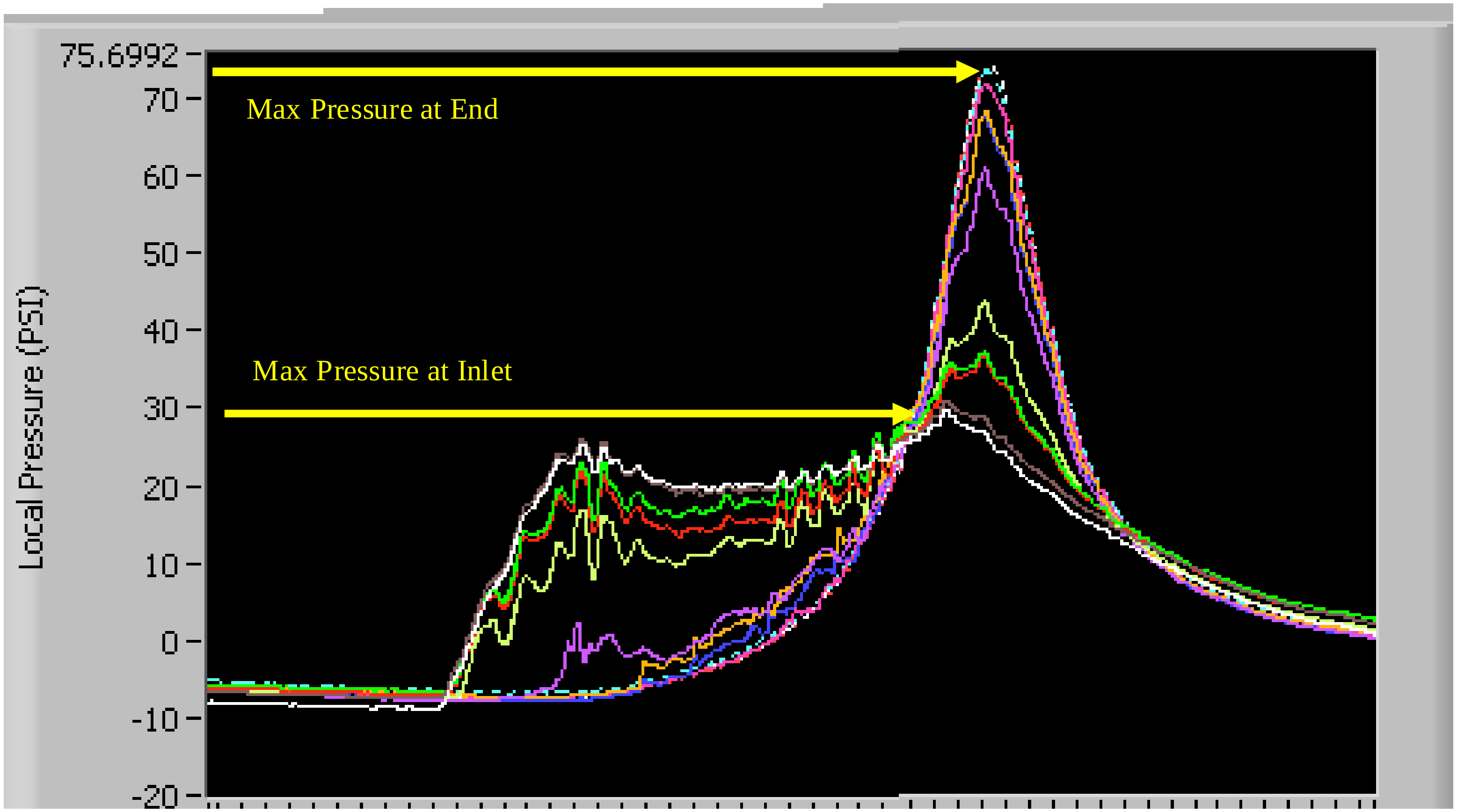
Task 2 – Status and Results

NuVision's Fluidic Wave-Action Technology Assessment



Task 2 – Status and Results

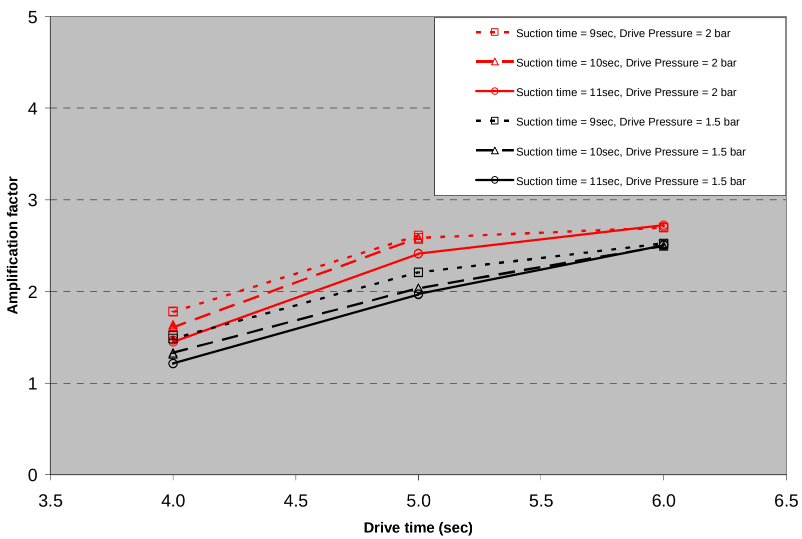
Pressure Data – 285 ft Test bed



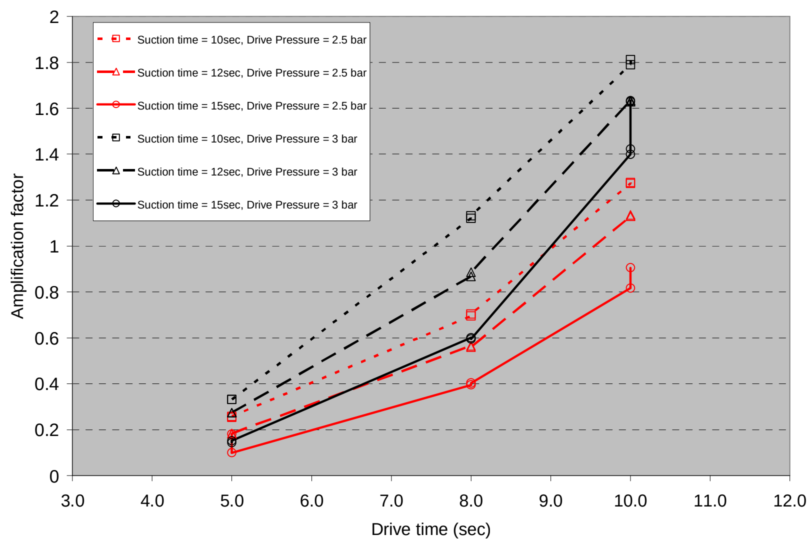
Task 2 – Status and Results

Effect of Drive Time on Amplification Factor

Blind Flange Testing



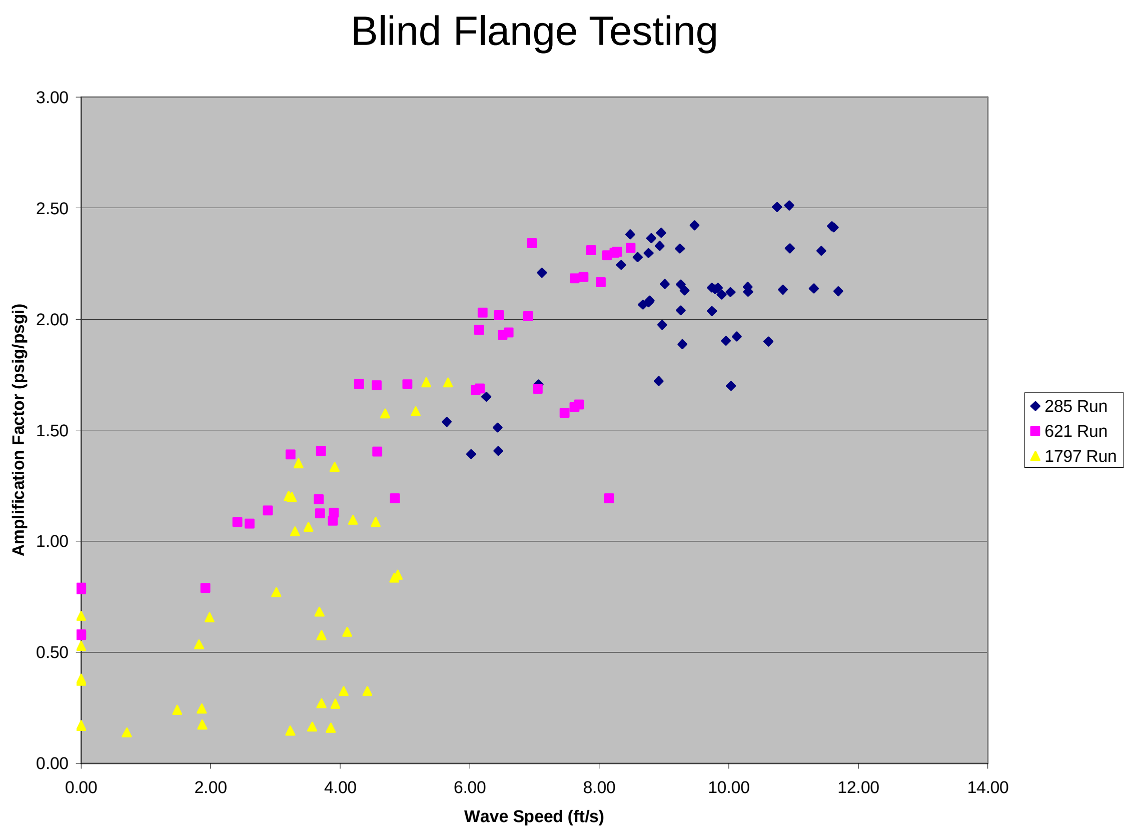
285 ft Test bed



1797 ft Test bed

Task 2 – Status and Results

Correlation of Wave Speed with Amplification Factor



EM Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

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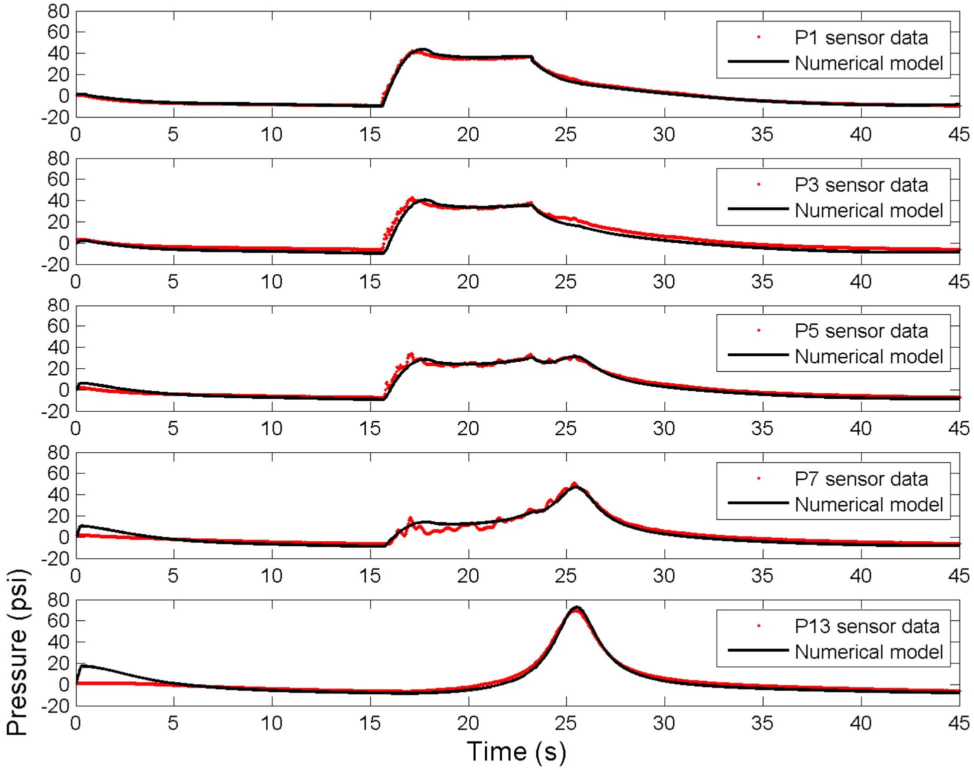
Task 2 – Status and Results

- 1D Waterhammer code modified to simulate flow in pipeline with air entrained at end section
- Pressure variation in time matched with experimental data at several locations

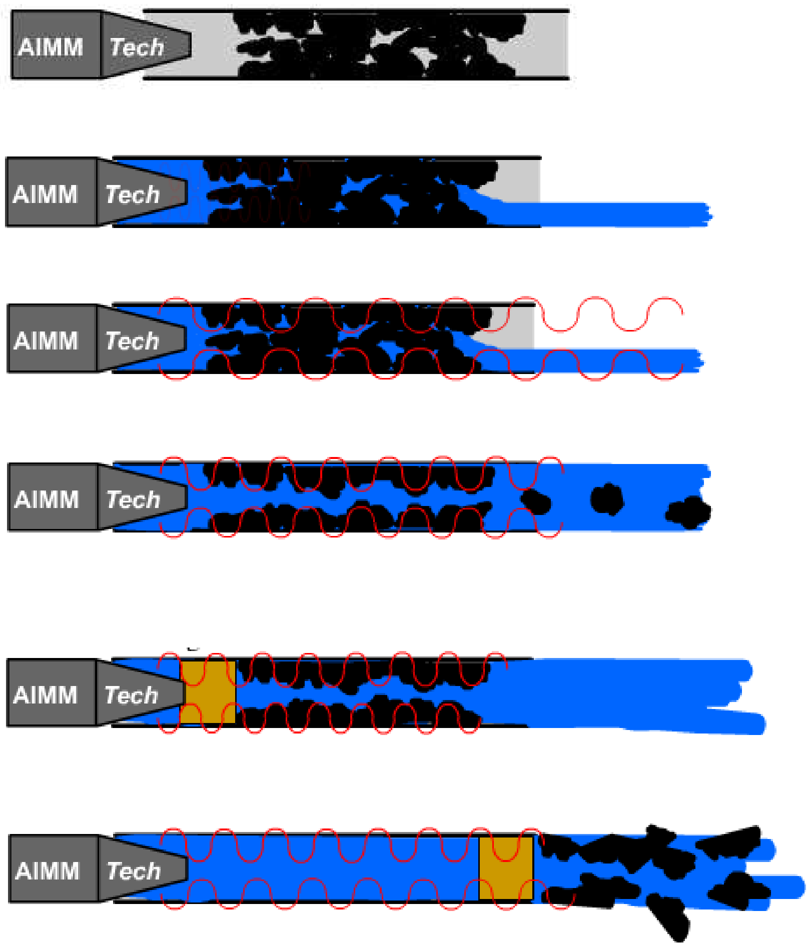
Simulation – 621 ft Test bed



Task 2 – Status & Results

- Topical draft report submitted for review to Hanford POCs
- Erosion rate decreases with length
- Amplification factor influenced by cavity size
- Wave speed linearly correlated to amplification factor.
- Aluminum gel plug was most difficult to erode
- Temperature affected air cavity size and erosion rates

Hydrokinetic Cleaning Process



Low pressure fluid fills the pipe up to the blockage.

Using the pressure source, pulsations are generated to form a standing wave in the liquid in the pipe.

Cavitation occurs in the liquid during pressure fluctuations within the standing wave.

Cavitation creates vibrations of differing frequencies transmitted through the liquid to the fouling material and the pipe, wherein the fouling material and the pipe vibrate at different frequencies to break the fouling material free of the pipe.

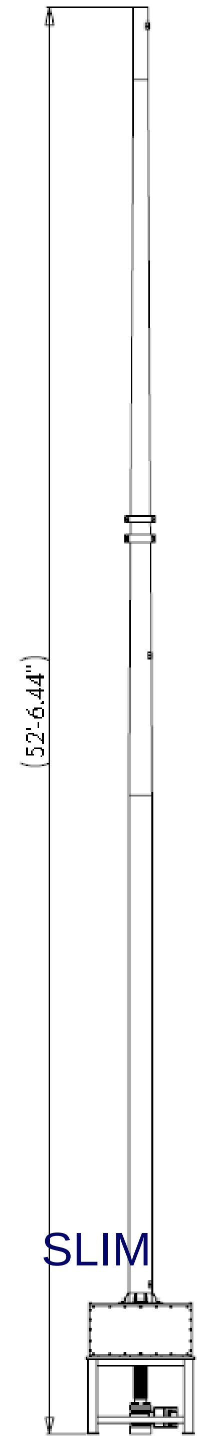
Task 6 – Project Description

- Develop a Solid-Liquid Interface Monitor (SLIM) for determining tank waste volume that meets the following requirements:
  - Capable of being operated remotely
  - Be non-sparking due to the possible presence of hydrogen gas
  - Be capable of deployment through a 4” pipe riser
  - Radiation- & Caustic- Hardened
- Technology will aid in the remote monitoring of retrieval progress (residual tank waste measurement, high priority*).

* *Mauss, B., Raymond, R. “Office of River Protection Clean-Up”, Savannah River/Hanford/Idaho Technical Exchange, October 2007*

Task 6 – Status & Results

- Optimized enclosure support system design
- Completed structural analysis on containment system
- SLIM enclosure fabrication completed
- Finalize the SLIM operational control logic and data acquisition including interface with the Hanford's tank farm telemetry system
- Draft FIU SLIM verification test plan document in progress



Environmental Management
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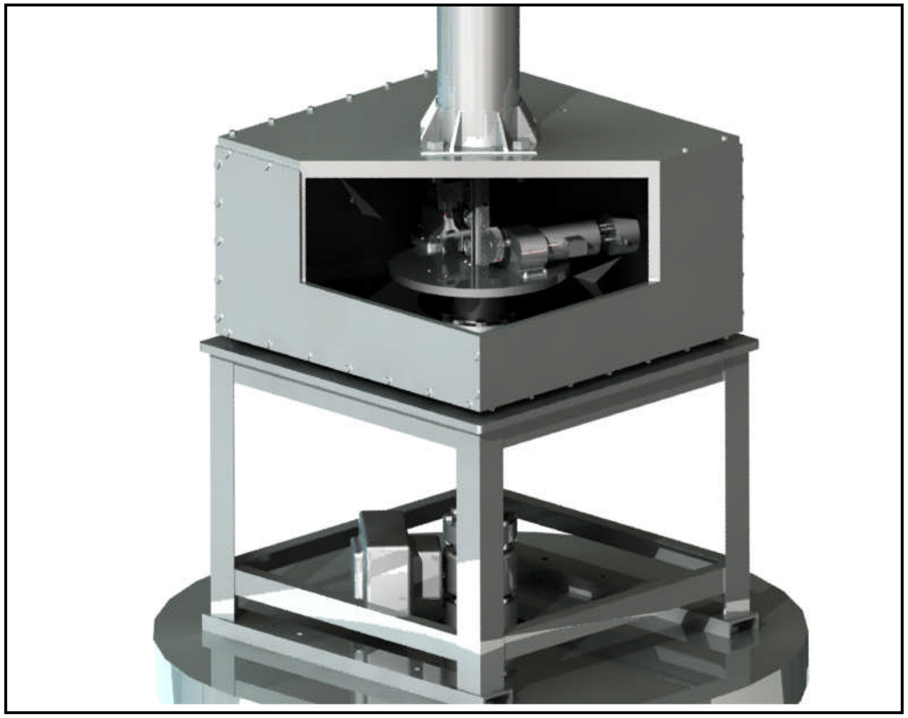
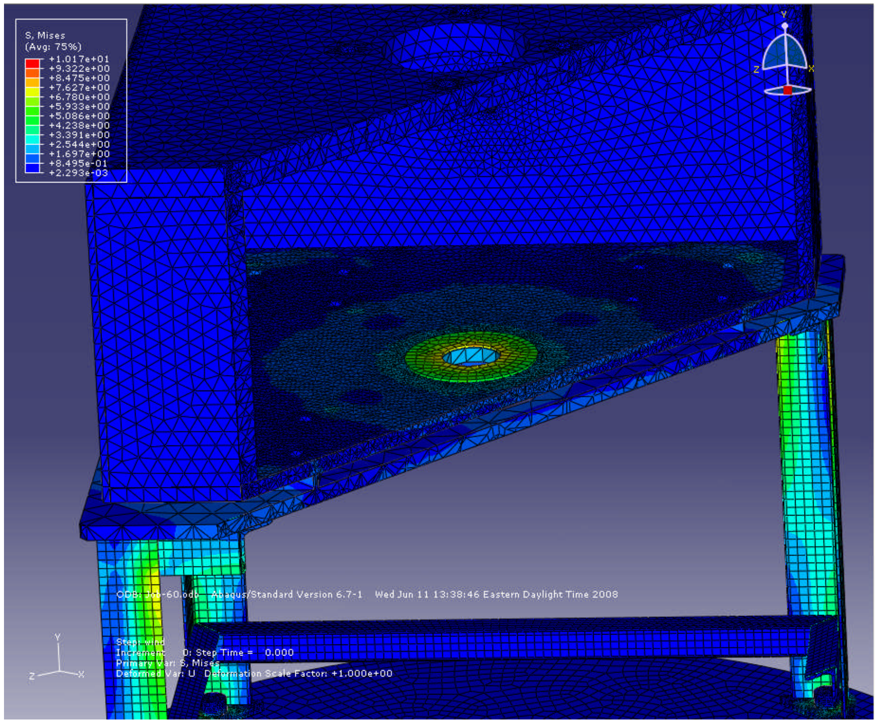
Task 6 – Status & Results



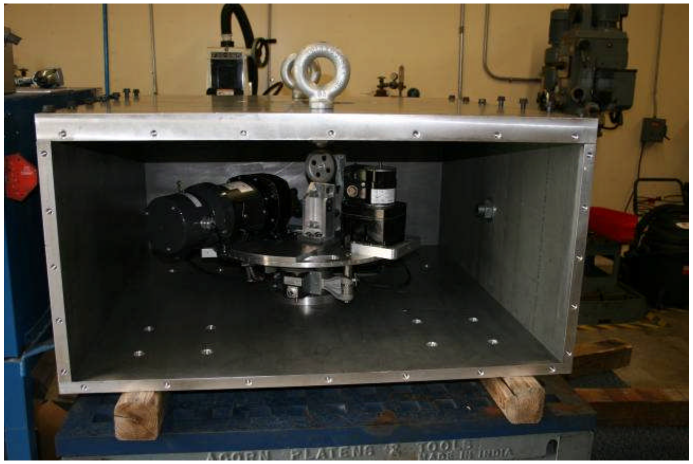
Cutaway of SLIM assembly; Solidworks rendering of enclosure cutaway exposing turntable assembly



SLIM Structural analysis; stress contours due to wind loading.

Task 6 – Status & Results

SLIM fabrication of turntable and enclosure



Task 8 – Project Description

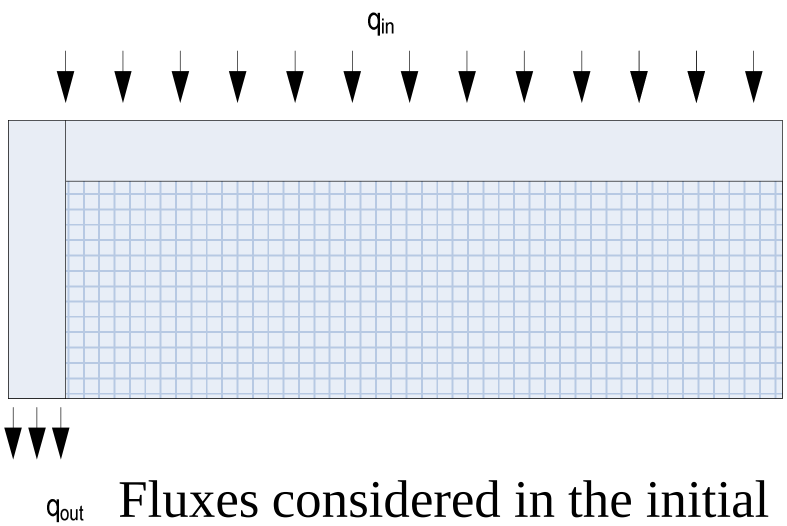
- S-109 Partial Waste Retrieval Project (PWVS) will provide waste feed (0.32 Ci/L) to DBVS system
- PWVS will be used to segregate low curie salt from high curie salt by draining the interstitial fluid while washing fluid is continuously being added at the top
- Depending on the concentration of Cs in the drained fluid, PWRS will be capable of pumping brine solution either to a Double Shell Tank (241-SY-101) or to the DBVS facility (< 0.006 Ci/L)
- Alternative retrieval technologies and minimization of the use of double shell tank space is an important operating factor for decreasing the retrieval costs

Task 8 - Project Approach

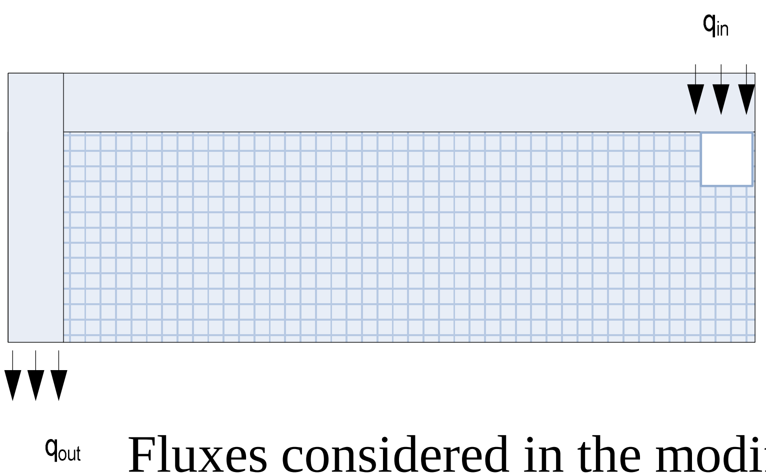
- A 2-D axisymmetric finite element model has been developed to couple the flow in variably saturated regime with transport of non-reacting cesium in single layer (same conductivity throughout) system. The numerical model was modified to simulate water addition through a periphery channel.
- A layer with lower permeability is normally observed in HLW tanks. The homogeneous media was modified to include 2 layers with low permeability. Two layers, the bottom one (3 ft thickness, the top one is 1 ft at 10 ft) have one order of magnitude lower hydraulic conductivity.
- The objective was to determine the retrieval performance for the multi-layer system. The model was used to analyze for two cases:
- 1) Continuous water addition and drainage
- 2) Incremental drainage and water addition.

Task 8 - Technical Strategy

- The model couples flow in variably saturated regime with transport of non-reacting cesium. The numerical model was used to compare water addition through the top of the tank and through a periphery channel.



Fluxes considered in the initial model-Uniformly distributed water addition



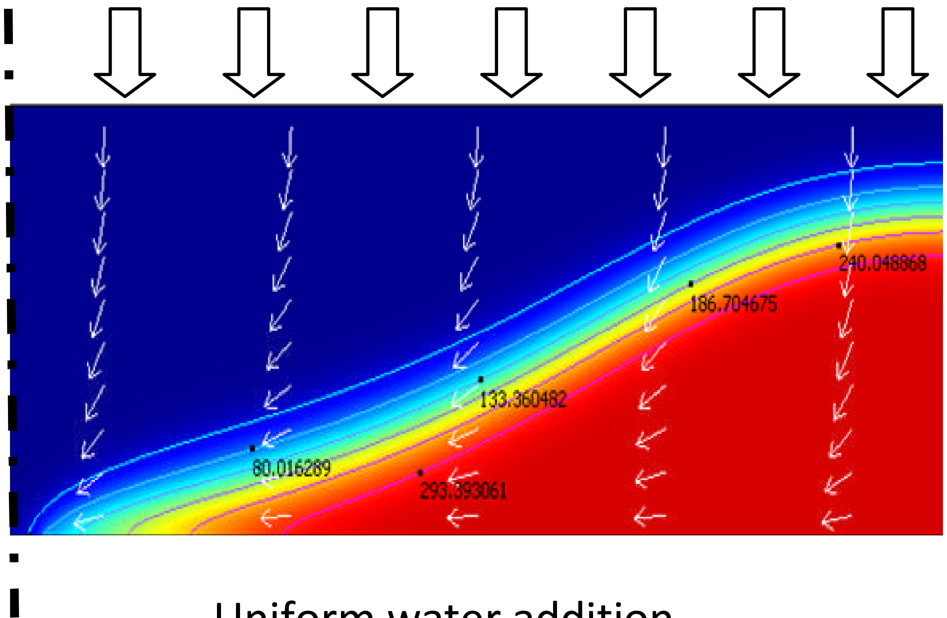
Fluxes considered in the modified system-Side Channel water addition

Task 8 - Status and Results

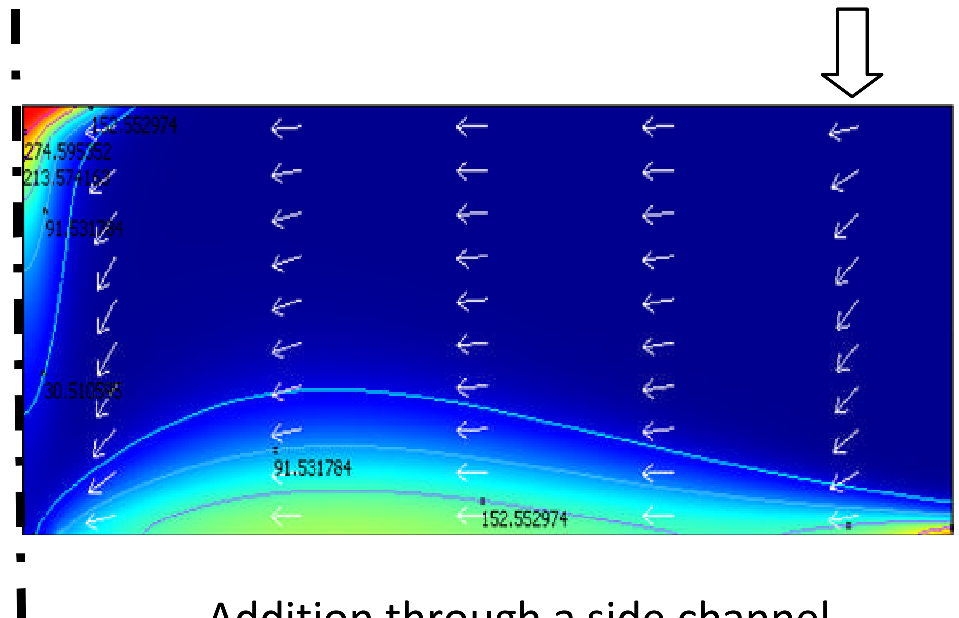
- Determined the effect of washing fluid addition through the periphery channel, combined with drainage, and the displacement of the interstitial fluid and the resulting retrieval of Cs
- Calculated the volumes drained and the concentrations of Cs within the tank.
- Determined the concentration distribution as a function of time and location within the tank. The modeling of Cs displacement simulated two cases (for addition of washing fluid at the top and through a perypheral side channel):
  - Case 1 simulates continuous side water addition to the top of the tank through a periphery channel and concurrent drainage through the central well.
  - Case 2 simulates initial drainage of the tank, followed by water addition until resaturation, and several cycles of consisting of a drainage and a resaturation.

Task 8 - Status and Results

Top and Side-Channel addition of washing fluid

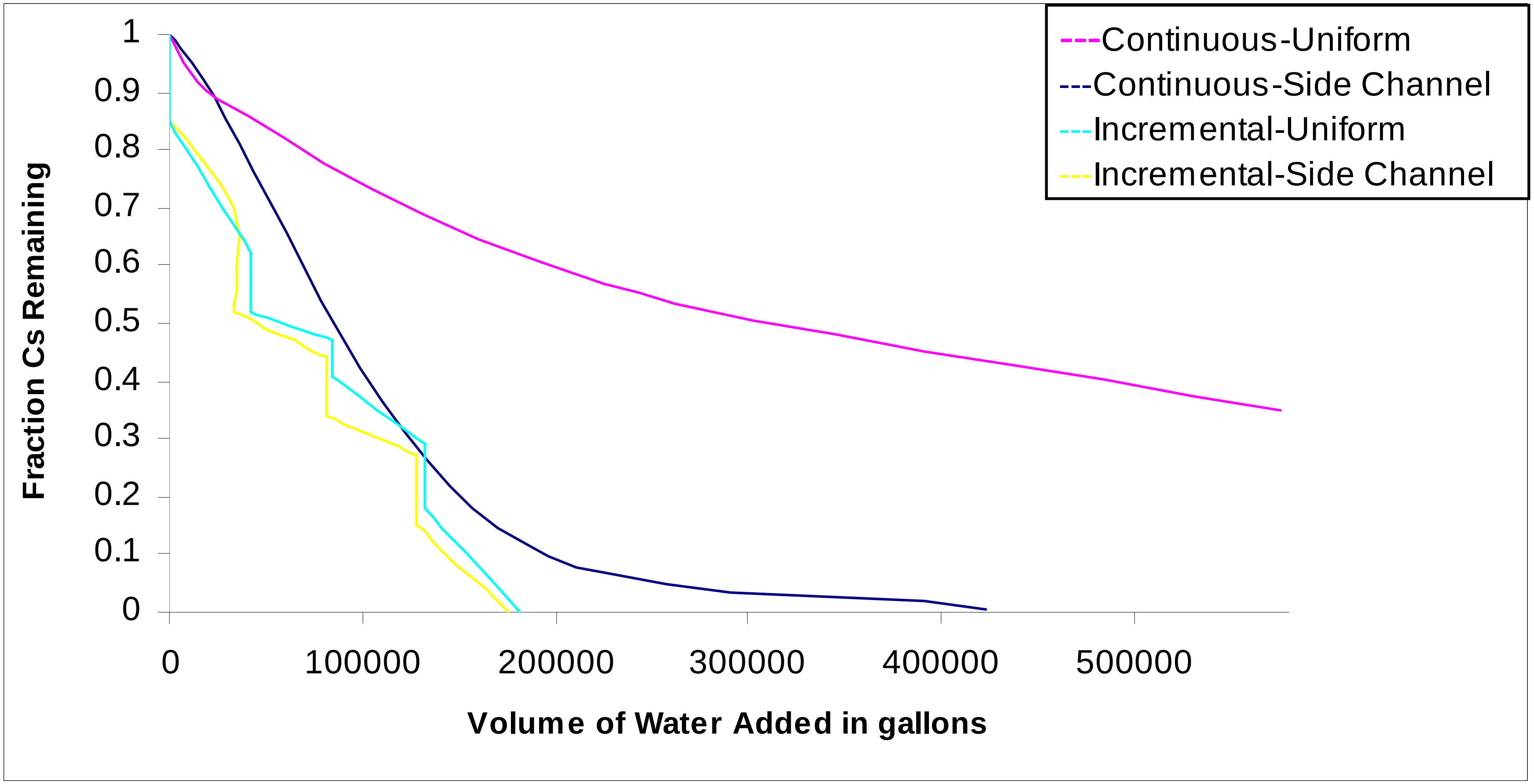


Uniform water addition
Added Water 225,000 gallons
Cs remaining 57%



Addition through a side channel
Added Water 169,000 gallons
Cs remaining 14%

Task 8 - Status and Results



Remaining fraction of Cs as function of Volume of Water Added

Task 8 - Status and Results

- Incremental retrieval has a better performance with respect to waste minimization
- If there are no layers with lower conductivity, side channel addition is equivalent to incremental addition from the top
- For multi-layer system, side channel addition has limitations with respect to preferential flow path (horizontal flow is preferred) and lower overall conductivity
- For multi-layer system, incremental is the best alternative
- In terms of time, incremental addition at the top has lowest processing time

Task 8 – Conclusions and Impact

- The comparison between the two shows a considerable reduction of total volume of waste retrieved when water is added through the side channel This method reduces the influence of dead zones in the tank.
- Simulations comparing incremental with continuous water addition showed that incremental addition and drainage of the tank is considerably more efficient compared to continuous addition of water and removal via a central well pump of the salt solution.
- Any strategy that would greatly reduce the amount of water needed to remove Cs-137 to acceptable levels would significantly reduce the retrieval costs

Task 11 - Project Description

- Develop particulate concentration monitor for in-line measurement during waste transport operation.
- Provide operators with real-time % solids concentration information during waste delivery operations (Waste Feed Delivery)
  - ➢ (On-Line Monitoring of Solids Concentration, Medium Priority*)

* *Mauss, B., Raymond, R. "Office of River Protection Clean-Up", Savannah River/Hanford/Idaho Technical Exchange, October 2007*

Task 11 – Status & Results

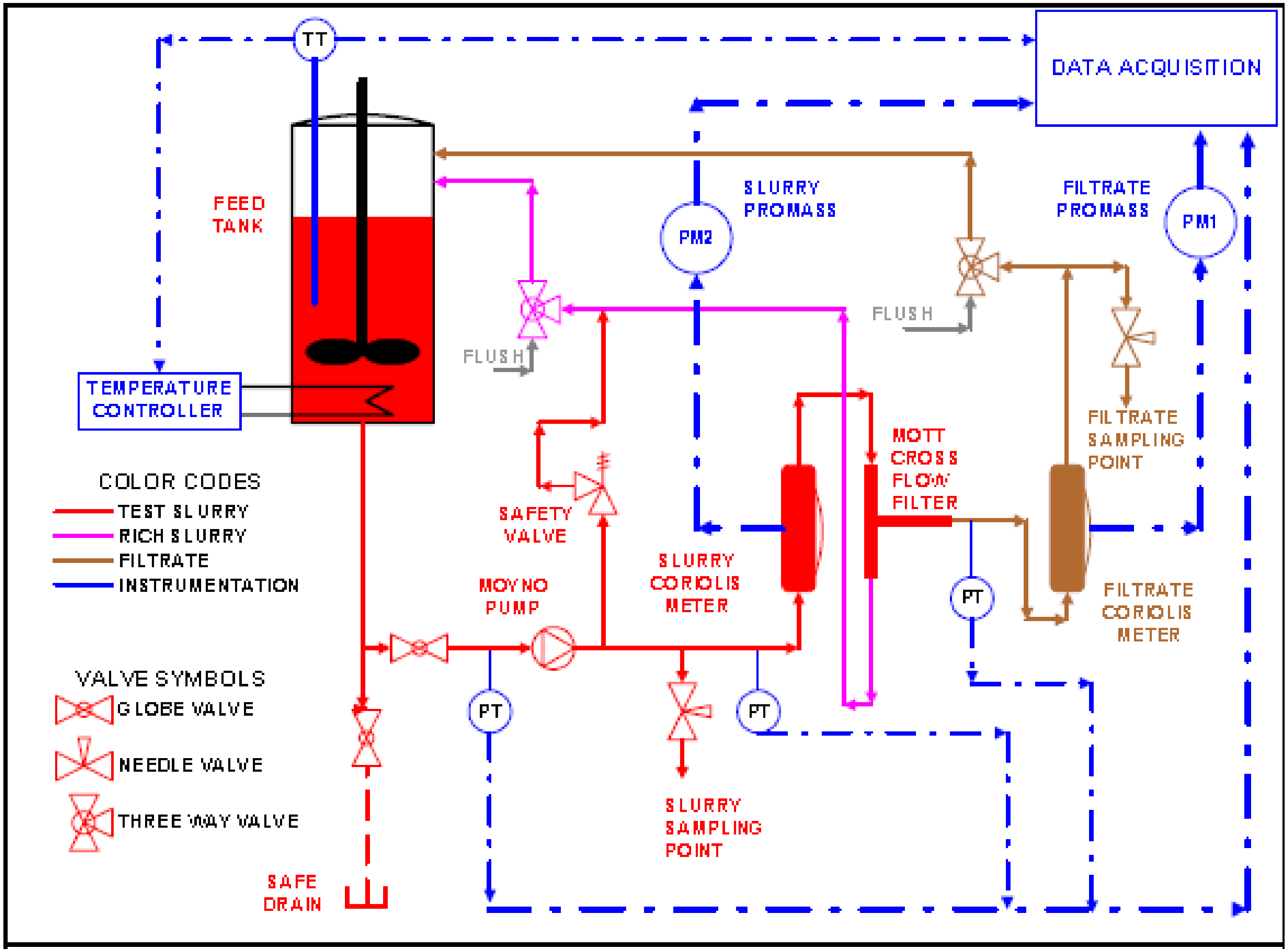
- FY01 & FY02: ARC designed, fabricated, and tested a real-time and online particulate concentration monitor.
  - Two coriolis meters, and a cross-flow filter
  - Capable of providing online, real-time measurement of particulate concentrations in liquid-solid slurries, despite dynamic disturbances.
- System performance was validated experimentally for a matrix of liquid-solid slurry conditions.
  - Matrix of slurry conditions; varying temperatures, carrier fluid densities, and undissolved particulate concentrations.
- Statistical analysis of the experimental results showed the DCSM produced measurements with high accuracy and precision.
- First prototype DCSM was designed as a probe for easy introduction into DOE tanks at the Savannah River Site (SRS).

Task 11 – Status & Results

FY08/FY09 Proposed Scope

- Evaluate Mott & Scepter cross-flow filters for varying flow/velocity/%-solids for filtrate plugging potential
- Develop filter test bed
- Develop prototype in-line monitor
- Verification testing at FIU

Task 11 - ILSM Conceptual Design



Project Impact

- Support the retrieval, processing and disposal of high-level radioactive waste (HLW) at the DOE sites Hanford and Savannah River sites.
- Provide DOE end-users with sufficient test data to make technology decisions
- Task 2: multi-million dollar cost/risk reduction for certified toolbox for unplugging lines
- Task 6: ONLY monitor to know solids layer, allows better filling and emptying of HLW Tanks
- Task 8: huge cost saving for optimizing retrieval/ separation process using data from 5 tanks at Hanford
- Task 11: ONLY monitor to meet requirement for measuring solids transported across site.