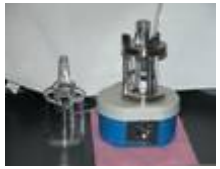
Development of the Rotary Microfilter for Treating Radioactive Liquid Waste



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Savannah River/Hanford/Idaho Technical Exchange
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Introduction

- An alternative process to treat radioactive liquid waste at SRS is ion exchange
- First step is MST addition to sorb strontium and select actinides
  - Followed by filtration to remove MST and entrained sludge
- Filtrate processed through ion exchange (or solvent extraction) process to remove cesium
- Crossflow filter testing showed filtration rates less than desired
- Baseline design had 3000 ft^2 crossflow filter and 5000 gpm filter feed pump
  - large filter and pump needed will significantly increase footprint
- Investigated methods to improve separation of sludge and MST solids from high level waste salt solution

Alternative Technologies Investigated

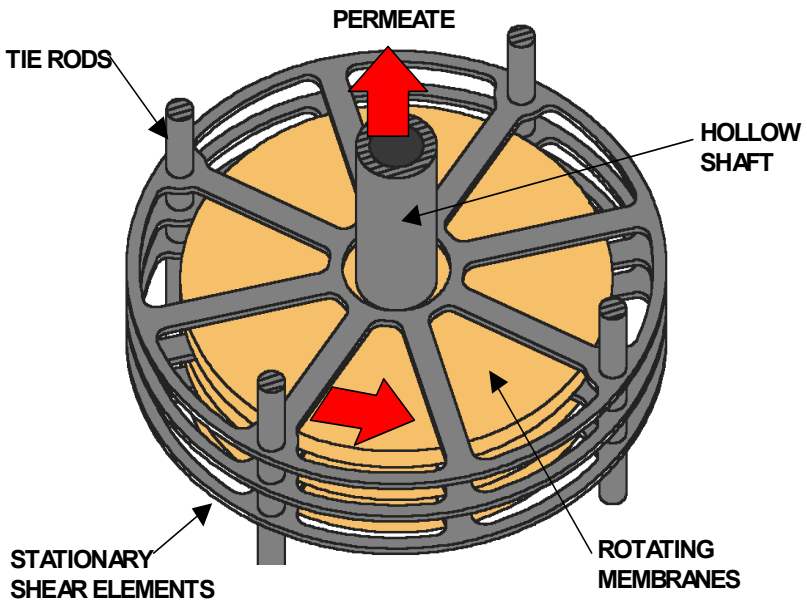
- Alternate crossflow filters
  - Smaller pore size Mott filters
  - Graver filter
  - *Rotary Microfilter*
  - Vibratory Shear Enhanced Processing (VSEP) Filter
  - Vacco filter
- Dead-end filtration
- Settling and decanting
  - No polishing step
  - Dead-end filtration polishing step
  - Crossflow filtration polishing step
- Centrifuge
- Magnetic filter

Scoping Rotary Filter Test

- Objective
  - Perform test with SRS HLW simulant to evaluate rotary microfilter
- Test performed with SpinTek Rotary Microfilter
- 5.6 M Na average salt solution simulant
- 0.06 - 6.0 wt % insoluble solids (Tank 40H simulated sludge and MST)
- Measured filter flux as a function of operating parameters
- Measured filtrate turbidity

SpinTek Rotary Microfilter

- 1 - 25 filter disks
- 11 inch diameter
- 1170 rpm
- 60 ft/s tip speed
- 40 psi TMP
- Filter disks
  - 0.1 μ ceramic membrane/SS backing
  - Polyethylene mesh
  - Ryton™ support structure
- Turbulence promoters/baffles above and below disks increase shear and reduce cake buildup



SpinTek versus Mott

Solids (g/L)	Speed (rpm)	Flux (gpm/ft^2) Rotary (measured)	Flux (gpm/ft^2) Cross-Flow (predicted)
0.6	1170	0.21	0.08
2.8	1170	0.19	0.07
12.9	1170	0.15	0.04
60.0	1170	0.13	0.02
60.0	148	0.04	0.02

Rotary filter operating at 40 psi.
Rotary filter used 0.1 μ ceramic filter
Crossflow filter used 0.5 μ SS
Cross-flow operating at 40 psi and 10 ft/s - predicted from pilot-scale data.

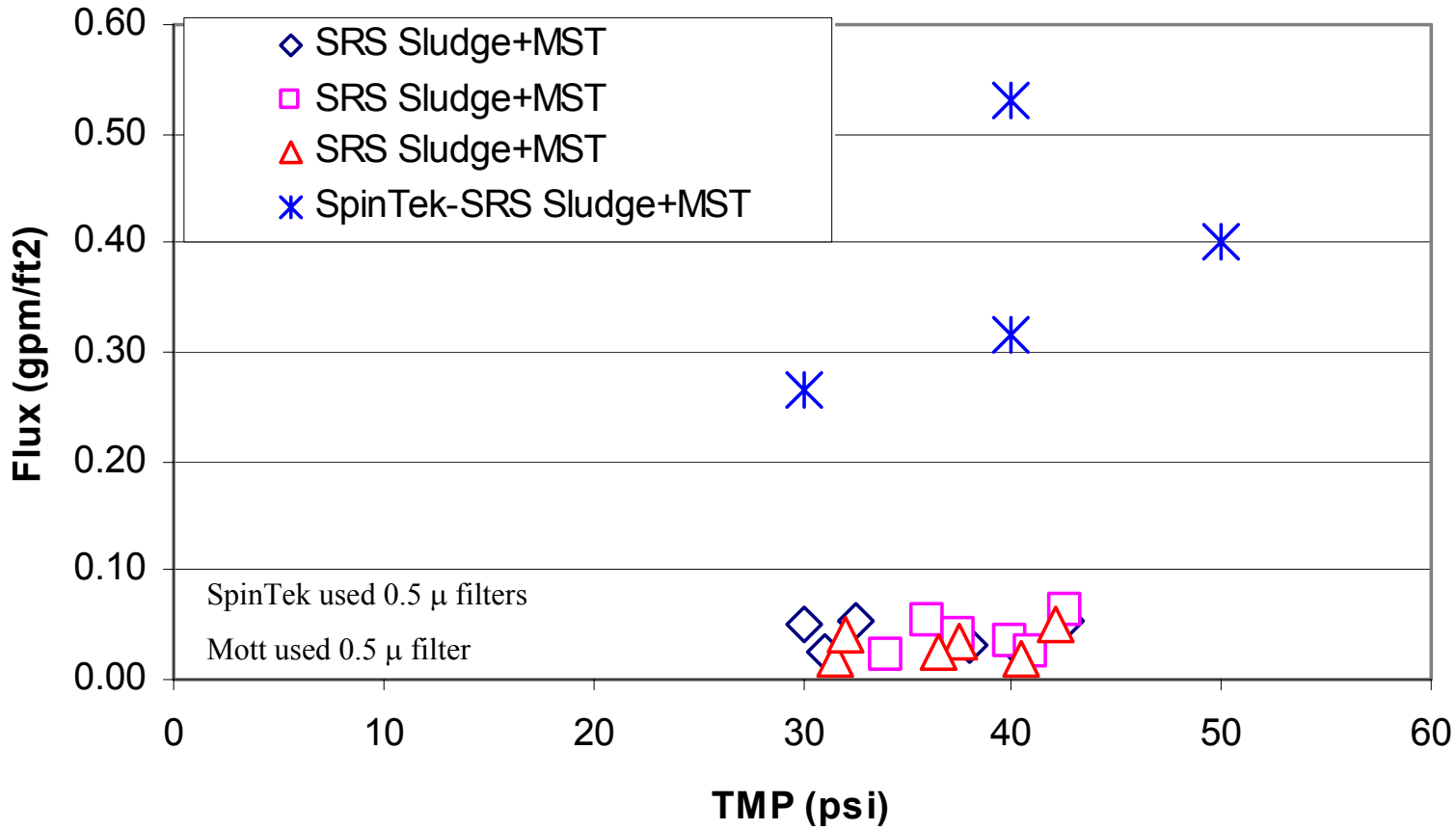
Path Forward

- Procure 0.05 gpm unit for actual waste test
- Procure 0.5 gpm unit for pilot-scale testing

SpinTek Filter for Actual Waste Testing

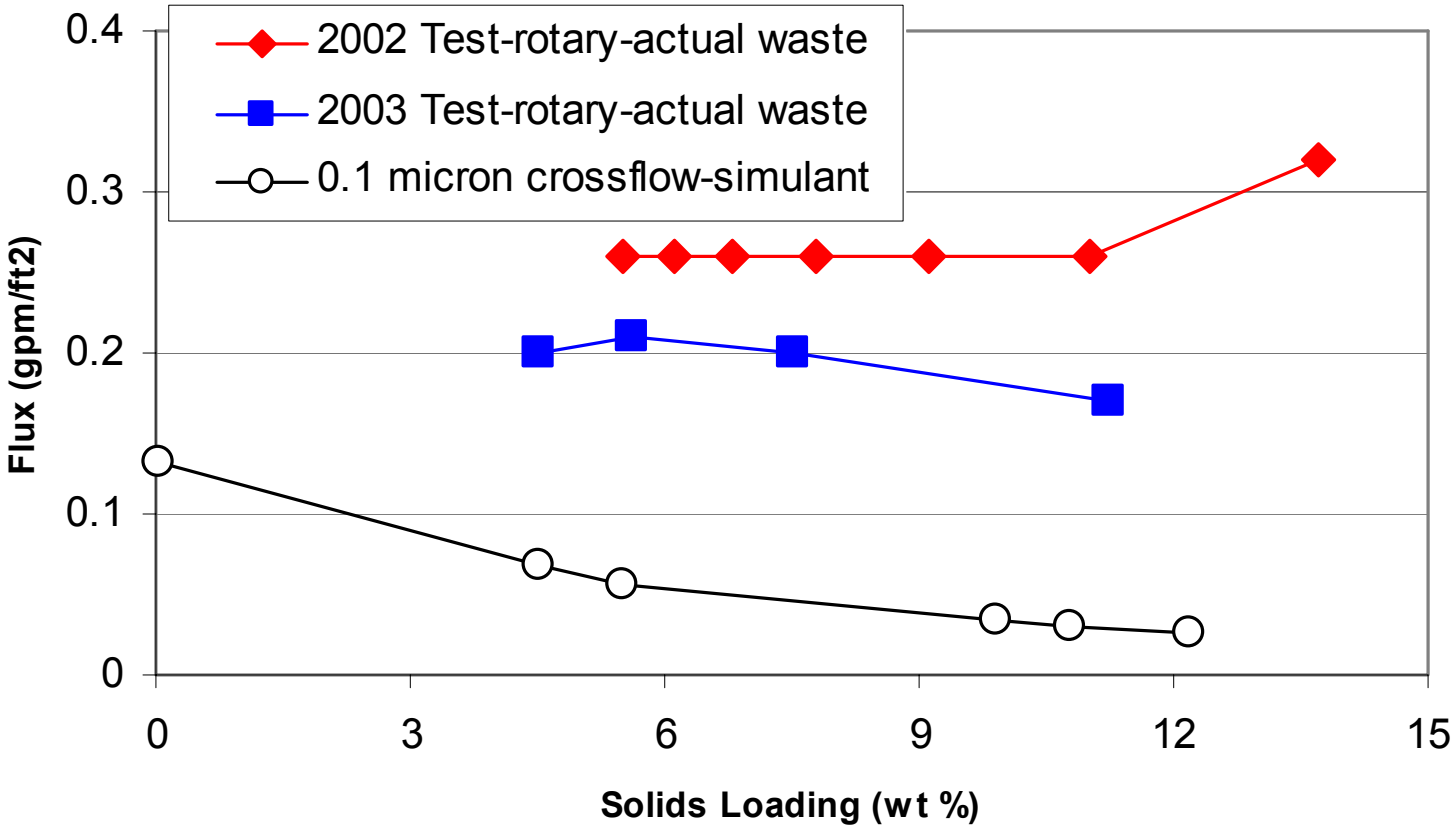
- Equilibrated feed solution
  - SRS supernate
  - SRS sludge
- Added 0.55 g/L MST - mixed for 24 hrs
- Operated filter at
  - 30, 40, 50 psig TMP and
  - 1170 rpm filter speed
- Collected filtrate samples
- Measured filter flux
- Added additional sludge and MST
- Performed additional filter tests

Actual Waste MST Data - 4.5 wt%



6 - 10X increase in filter flux at 4.5 wt % solids loading with 0.5 μ SpinTek

SpinTek Actual Waste Test

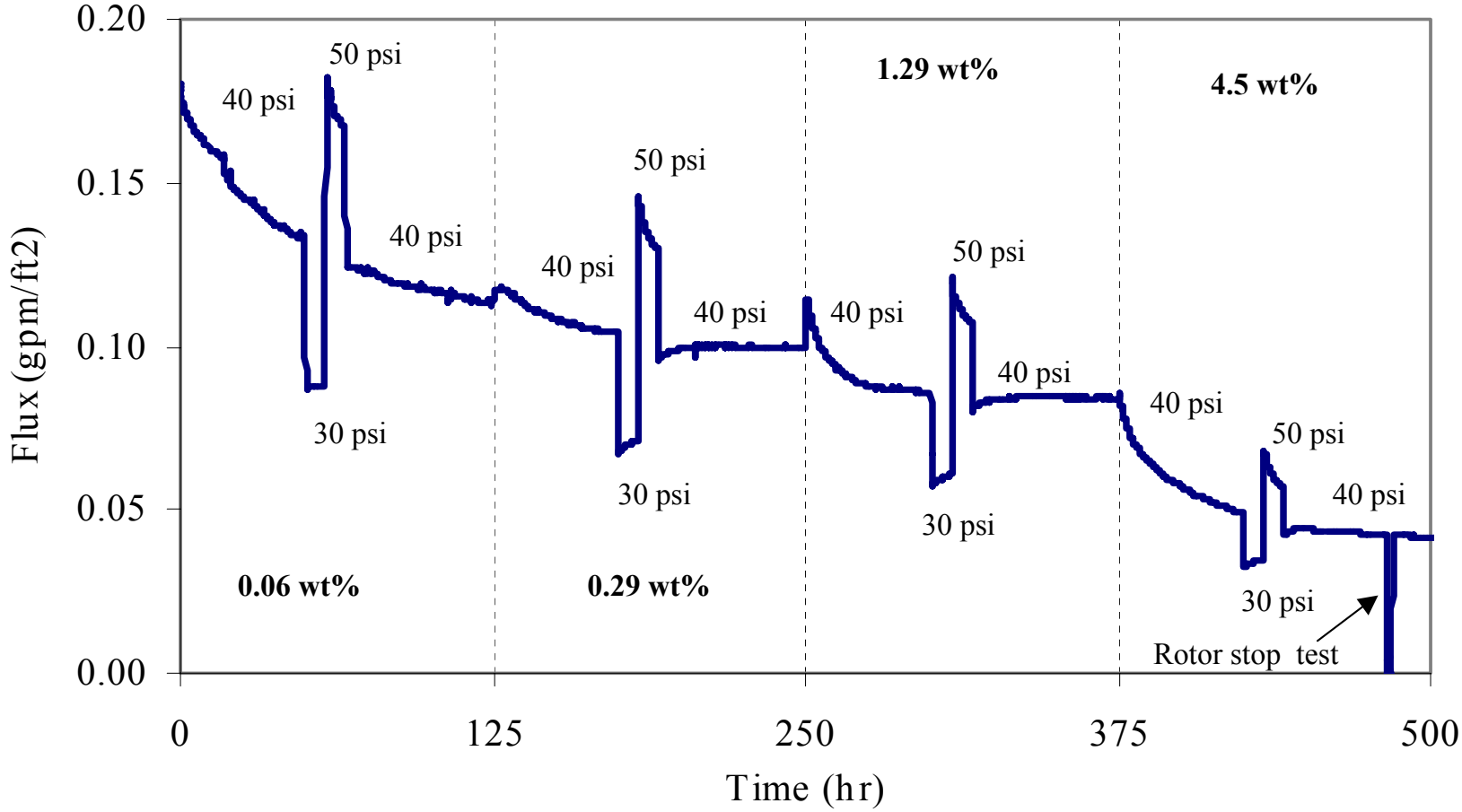


Pilot Testing

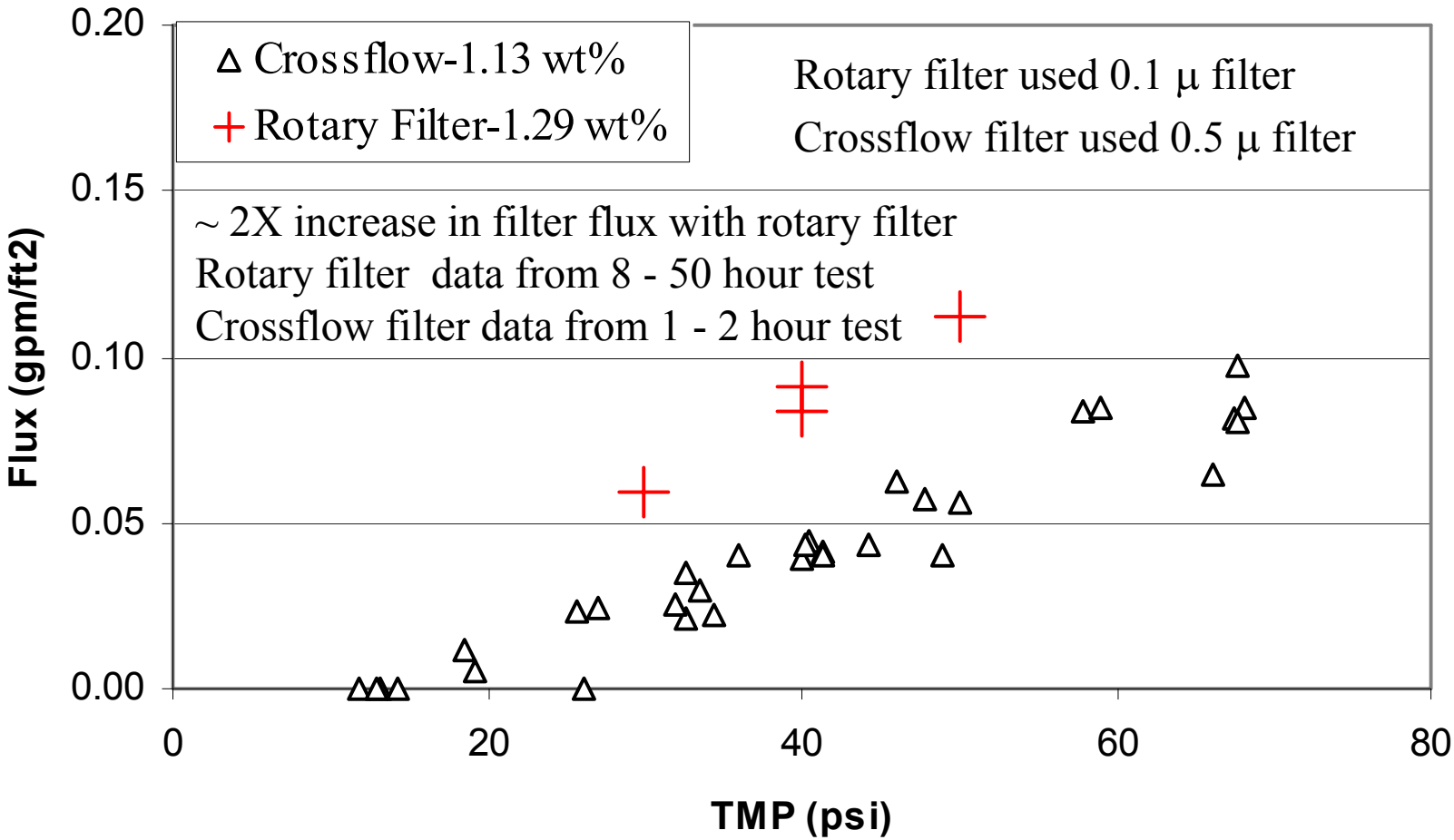
- 3 disk filter unit
- 0.1 μ filter sintered stainless steel membrane
- Prepared feed solution at lowest solids concentration (0.09 wt %)
- Operated filter for 125 hours varying TMP periodically
- Measured filter flux and filtrate turbidity
- Added additional solids and ran for additional 125 hours (0.29 wt %)
- Added additional solids and ran for additional 125 hours (1.29 wt %)
- Added additional solids and ran for additional 125 hours (4.5 wt %)
- Conducted 2 hour rotor stop test

Pilot-Scale Rotary Filter Unit

Pilot-Scale Data (MST)



Pilot-Scale Data (MST)



Operability

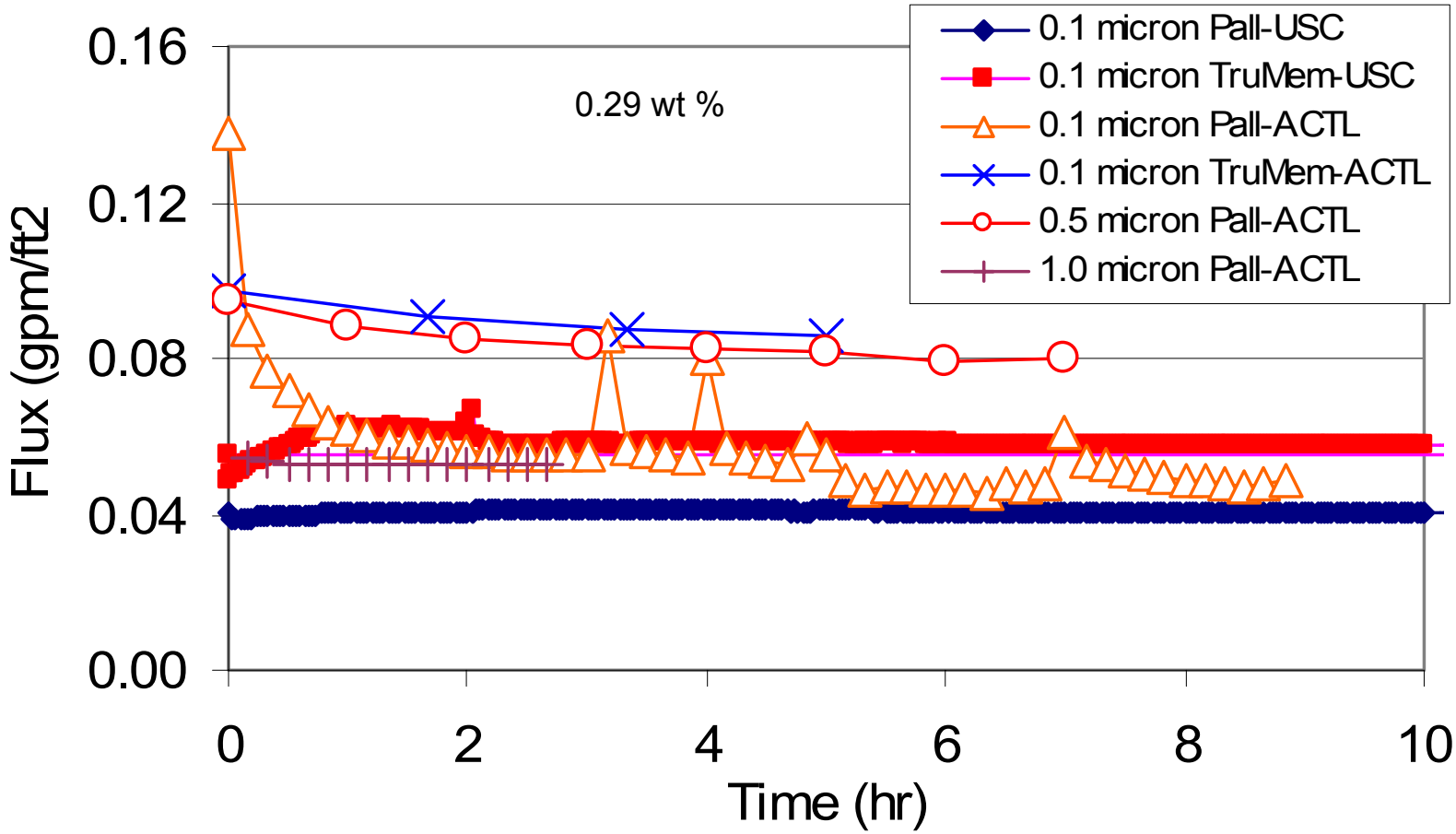
- Performed tests at nominal solids concentrations of 0.06, 0.28, 1.29, and 4.5 wt %
- Completed 500-hour test with no problems
- Stopped the rotor for two hours and restarted it without incident.
- After filter cleaning, inspection of the disk revealed only a small amount of particles on surface of the filter near center of disk

Filter Disk Following 500 Hour Test

Filter Media Selection

- 2003 USC Pilot Testing
  - Irradiated disks
  - 0.5 micron Mott SS
  - 0.1 micron Mott SS
  - 0.1 micron TruMem® ceramic
  - Ceramic produced highest flux
- Alternative Crossflow Filter Media Evaluation
  - Compared Mott, Graver, GKN, and Pall media
  - Pall and Graver media produced highest flux
  - Graver media not available in flat sheets
- 2004 USC Pilot Testing
  - Welded disks
  - 0.1 micron Mott SS
  - 0.1 micron TruMem ® ceramic
  - 0.1 micron Pall SS
  - Ceramic produced highest flux
  - Pall media produced higher flux than Mott media
- 2005 SRNL Tests
  - Scoping Tests (Stirred Cell)
  - Rotary Filter Tests

Comparison of Media in 3-Disk Rotary Filter



0.1 μ TruMem and 0.5 μ Pall produce highest flux

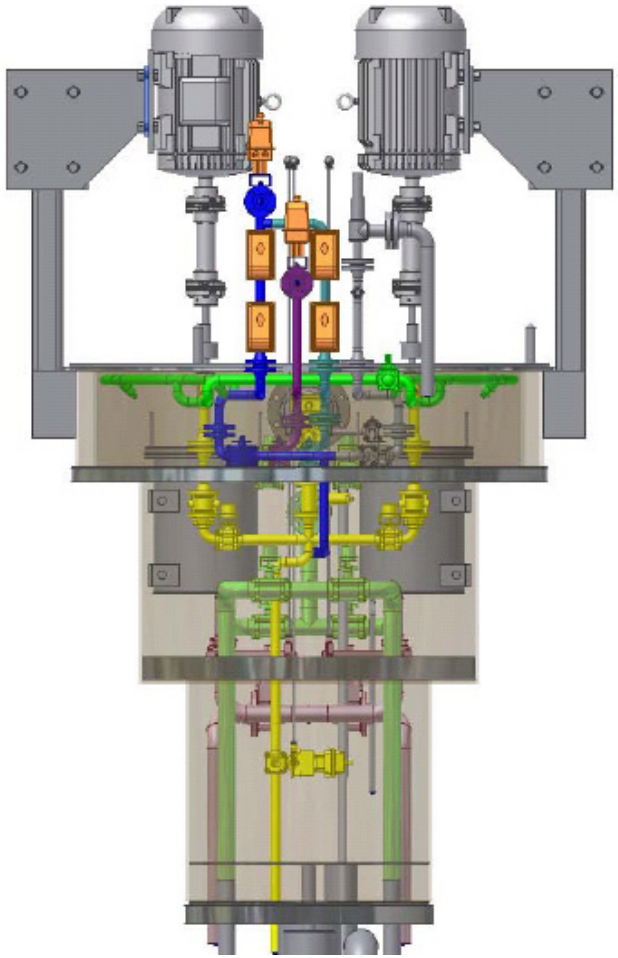
Recommendation

- **Recommend Pall PMM M050 filter media for rotary microfilter (0.5 μ nominal)**
  - **Highest flux of SS media tested**
  - **Met turbidity criteria**
  - **Demonstrated fabrication with three disks**
  - **More durable than TruMem media**

Filter Modifications for Radioactive Service

- Removable disk stack
- Stainless steel support plate
- Stainless steel rather than ceramic membranes
- Stainless steel mesh
- Welding membranes to support plate
- Alternative mechanical seal
- Patented design improvements and licensed technology
- Funded by EM-21

Deployment Design – Pump/Filter Module



- SRNL, ORNL, TTI, and SRS LWO developed design to place 2 rotary filters in tank riser as prefilter to ion exchange process
- Pump/Filter module at 100% design for SRS Waste Tank Type B riser

Full-Scale Rotary Filter at SRNL

Motor

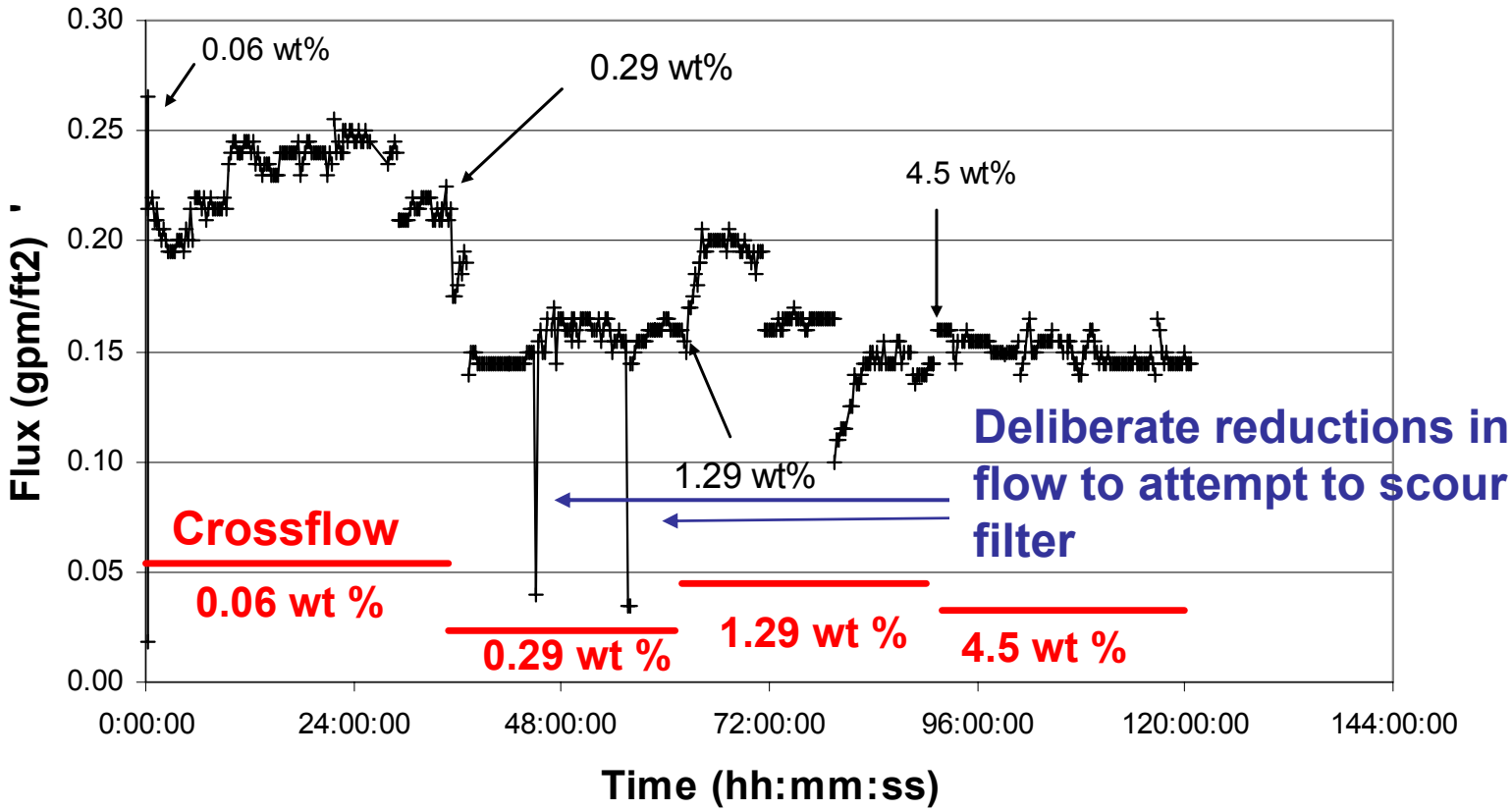
25 disk filter unit

Manufacturer Recommends 25 – 50 gpm pump – *much smaller than pump requirements for crossflow filter*

Small Column Ion Exchange (SCIX) Prefilter Test

- Reused 5.6 M sodium salt from previous filter test
- Added Sludge Batch 2 sludge (target 0.06 – 4.5 wt % solids)
- Feed pressure 40 – 95 psi
- TMP 40 psi
- Temperature 30 – 40 °C
- Feed flow rate ~ 25 gpm

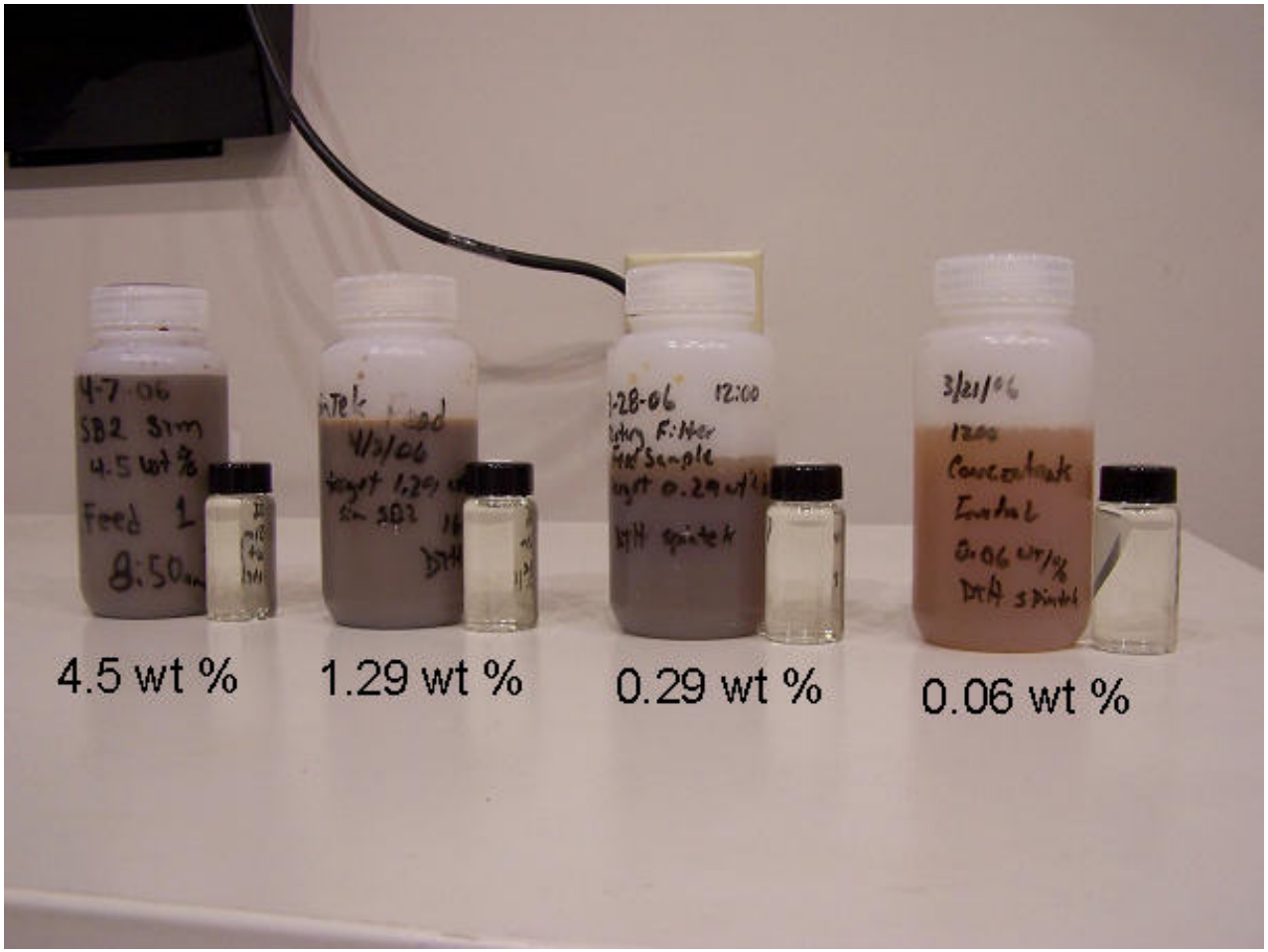
SCIX Prefilter Test Data



Flux significantly above crossflow filter

Flux > 0.2 gpm/ft^2 (10 gpm) with simulated SCIX feed (0.06 wt % solids)

Filter Feed and Filtrate



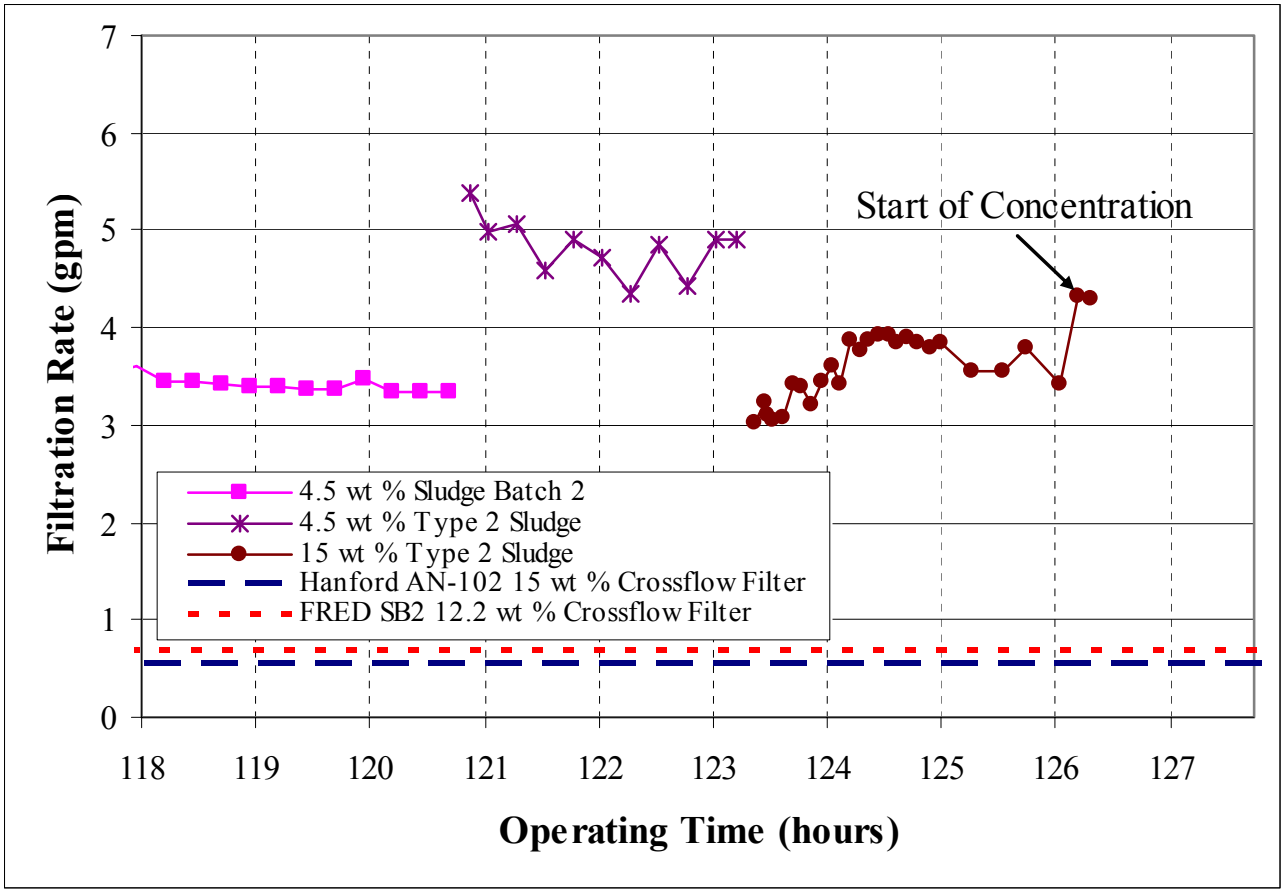
No visible solids in filtrate

Sludge Washing

Objective: Remove the soluble solids (Na) from sludge to prepare for processing in the Defense Waste Processing Facility

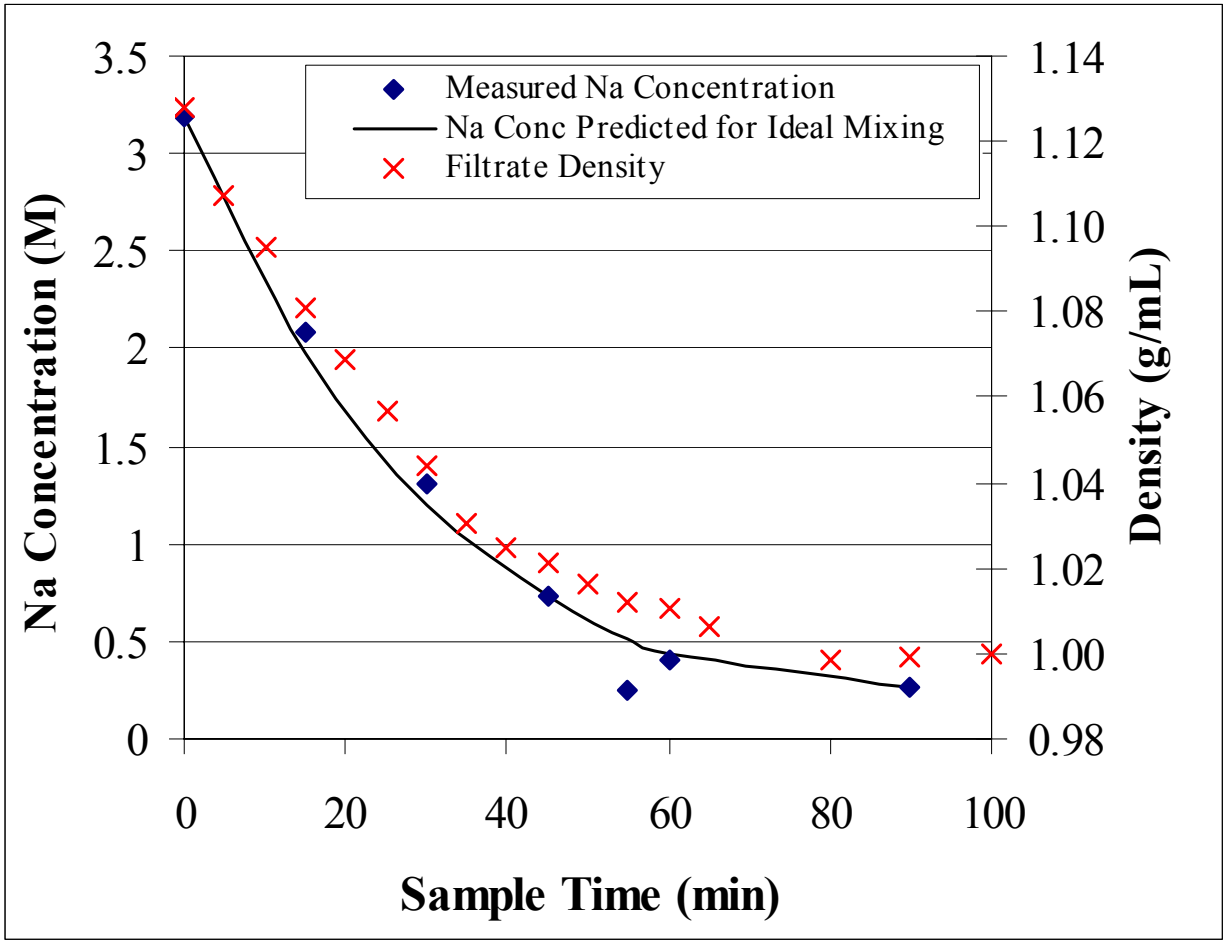
- **Placed 80 gallons of simulated sludge (with 3 M sodium supernate) in filter feed tank**
- **Operated filter at ~ 18 gpm feed rate, 40 psi TMP, 27-33 °C**
- **Filtrate removed from system**
- **Added inhibited water (0.01 M NaOH, 0.011 M NaNO3) to feed tank at same rate filtrate was withdrawn**
- **Filtrate samples collected and analyzed for sodium and density**
- **Filtrate rate measured**
- **Following washing, recirculated filtrate for 2 hours**
- **Concentrated solids to ~ 20 wt % and recirculated for 2 hours**

Filtration Rate During Sludge Washing



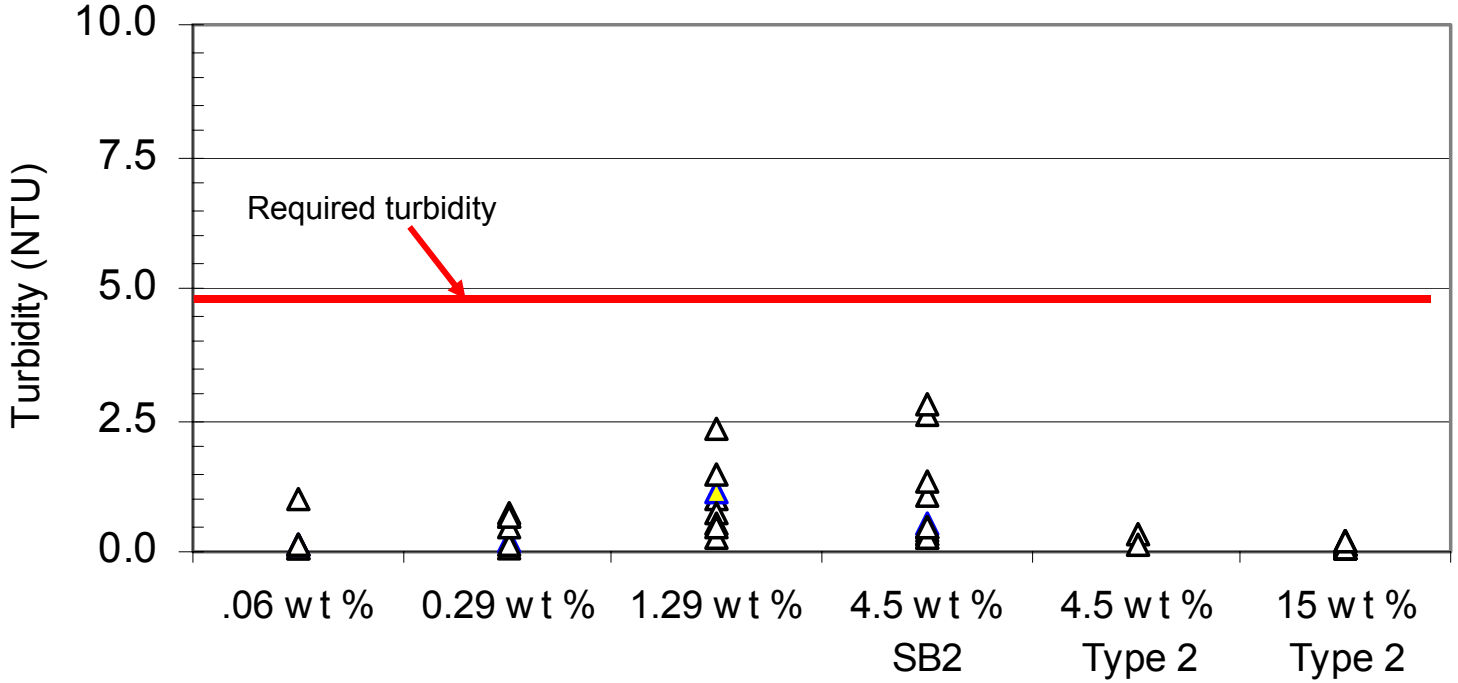
Filtrate rate decreased slightly as solids loading increased from 4.5 wt % to 15 wt % (flow rates corrected to 35 °C)

Sodium Concentration During Washing



Filter system behaves as Continuous Stirred Tank Reactor (CSTR)

Filtrate Turbidity

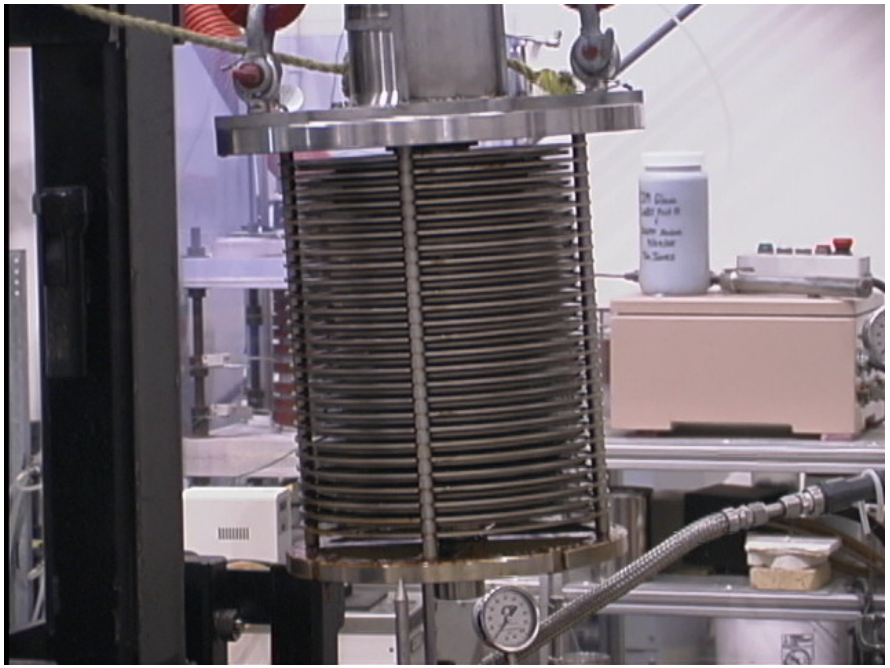


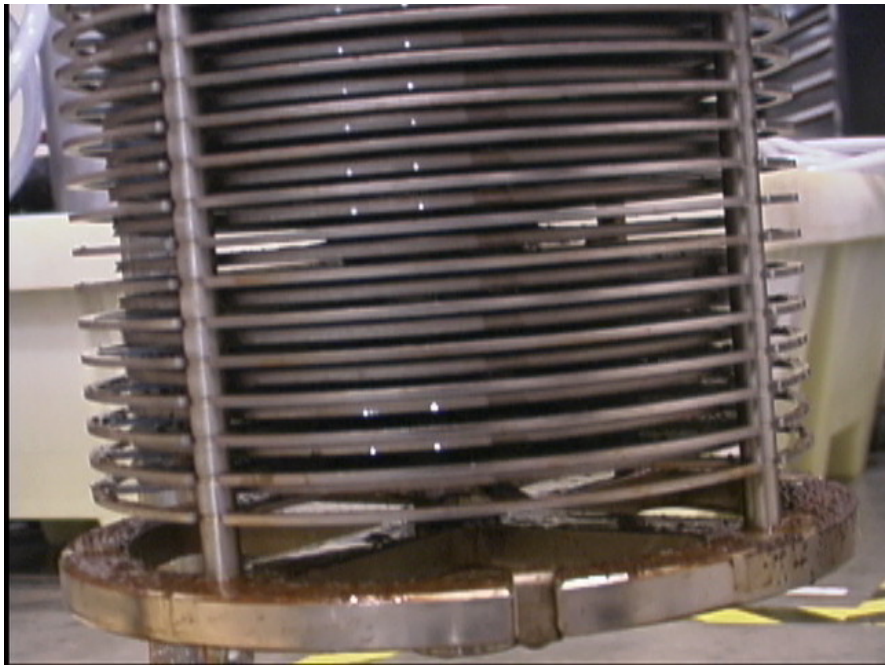
All samples < 5 NTU

Video of Filter Stack Removal after Rinsing

Video of removal of filter stack after rinsing

Filter Stack after Rinsing with Water





Bulk of slurry rinsed from filter stack. Filter cake still evident on disks.
684 g of sludge (dried weight) on filter disks.

Conclusions

- Rotary filter flux 2.5 – 6.5X higher in vendor scoping tests
- Rotary filter flux 6 – 10X higher in actual waste tests
- Rotary filter flux ~ 2X higher in pilot-scale tests
- Pilot-scale unit ran over 4000 hours with no significant operating problems
- Rotary filter upgraded for radioactive service
- Design developed to place two filters in SRS Tank riser
- Rotary filter flux ~ 6X higher in full scale tests

Path Forward

- Replace SiC rotary seal with air seal
- Upgrade bushing
- Perform Tests for Hanford Supplemental Pretreatment
  - Tank AN-105
  - Oct – Dec 2007
- Perform Tests for SRS Modular Salt Processing
  - Dec 2007 – Feb 2008
- Perform Tests for SRS Sludge Washing
  - Jan 2007 – Feb 2008
- Obtain additional operating time
- EM-20 Funded

Acknowledgements

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Q & A

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