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Development of the Rotary Microfilter for Radioactive Waste Applications

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EM-21 Technology Exchange

EM Office of Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

Introduction

SRS developing processes to treat radioactive liquid waste

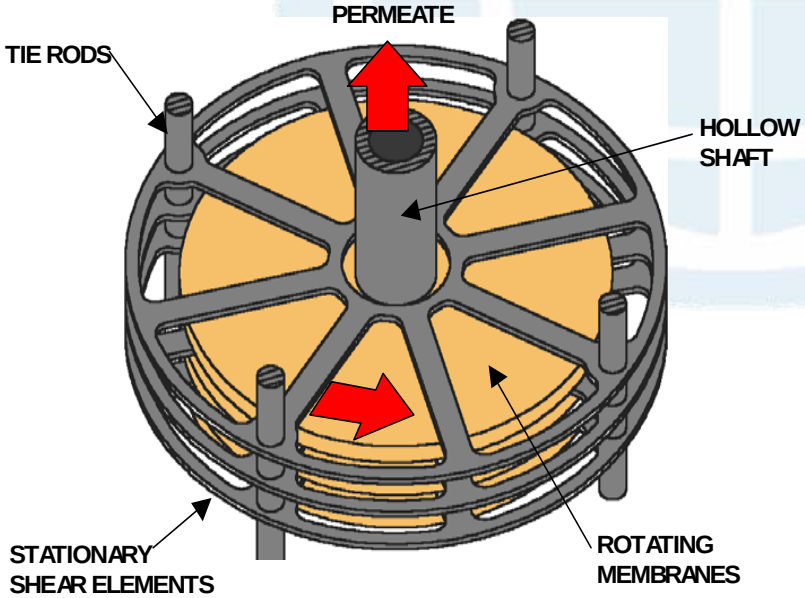
Crossflow filter testing has shown filtration rates less than desired

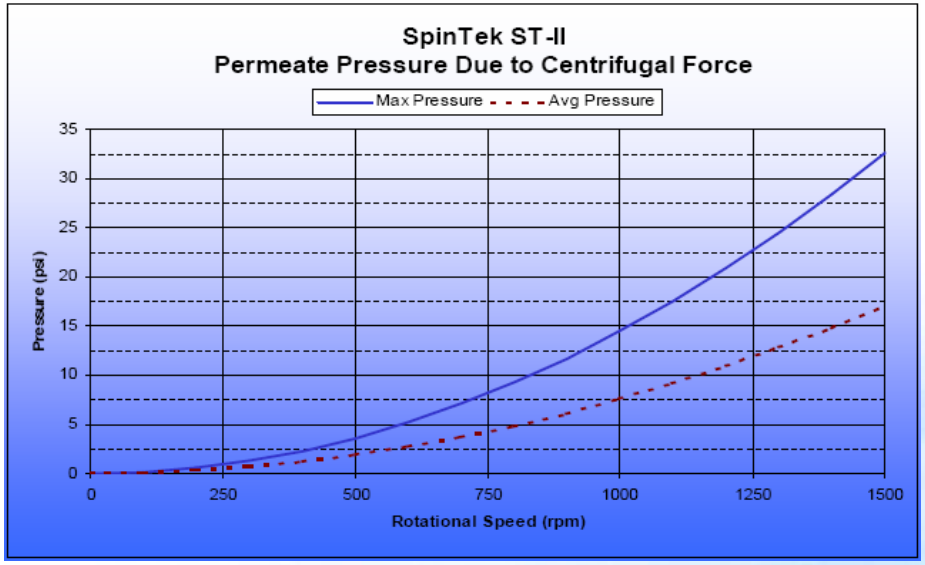
Funded by EM-21 to investigated methods to improve separation of sludge solids from high level waste salt solution

Identified rotary microfilter as a potential alternative to a crossflow filter

SpinTek Rotary Microfilter

- 1 - 25 filter disks
- ~11 inch diameter
  - ~1 sq ft filter media per disk
- 1170 rpm
- 60 ft/s tip speed
- Turbulence promoters / baffles above and below disks increase shear at the membrane surface and reduce cake buildup
- 40 psi pressure drop across filter





Filter Modifications for Radioactive Service

Testing showed improved filtration rates over the baseline crossflow filter

Commercial off-the-shelf design less than ideal for radioactive service

- **Large number of small parts**
- **Extensive use of polymers in design.**

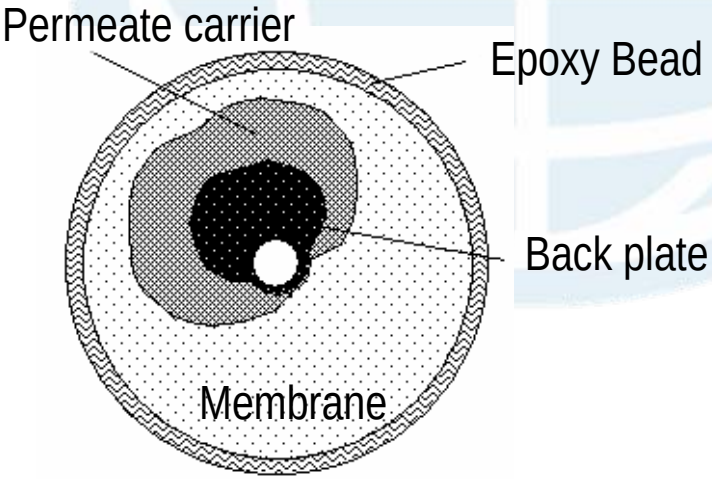
Received funding from DOE EM-21 to develop the technology for radioactive service

Design modified to make more reliable in radioactive service

- **Materials of construction and joining**
- **Fabrication tolerances**
- **Selection of a mechanical seal - reduced number of slurry seals from 2 to 1**
- **Consolidation of internal parts**

Reconfigured design to allow removal of entire stack of filter disks and all wear parts as a single piece

Patent application filed on design improvements and technology licensed



Rotary Filter Testing Summary

Procured 1-Disk "Speedy" rotary filter for Actual Waste Testing

- **SRS Actual Waste + MST, Actual Waste + Permanganate**

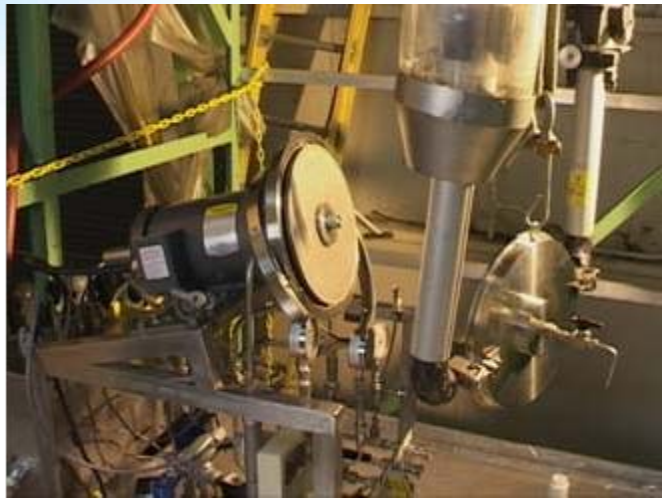
Conducted project to procure and test 3-Disk "pilot scale" rotary filter

- **Installed at FRED Facility USC**
  - SRS simulants, SRS simulants + MST, SRS Simulants + Permanganate
  - 4500 hour total run time
  - 1000 hour continuous test
- **Moved to SRNL**
  - Membrane testing (0.1, 0.5, 1.0 micron filter Pall membrane, Mott membrane)
  - Sludge washing SRS Sludge Batch 4 simulants

Procured 2 X 25-Disk full scale rotary filters with updated design for DOE applications (SCIX with ORNL)

- **Installed one filter - ~500 hours total run time**
  - SRS simulant, Hanford simulant, SRS simulant + MST
  - Pre-filter and sludge washing

SRS Rotary Filter Testing

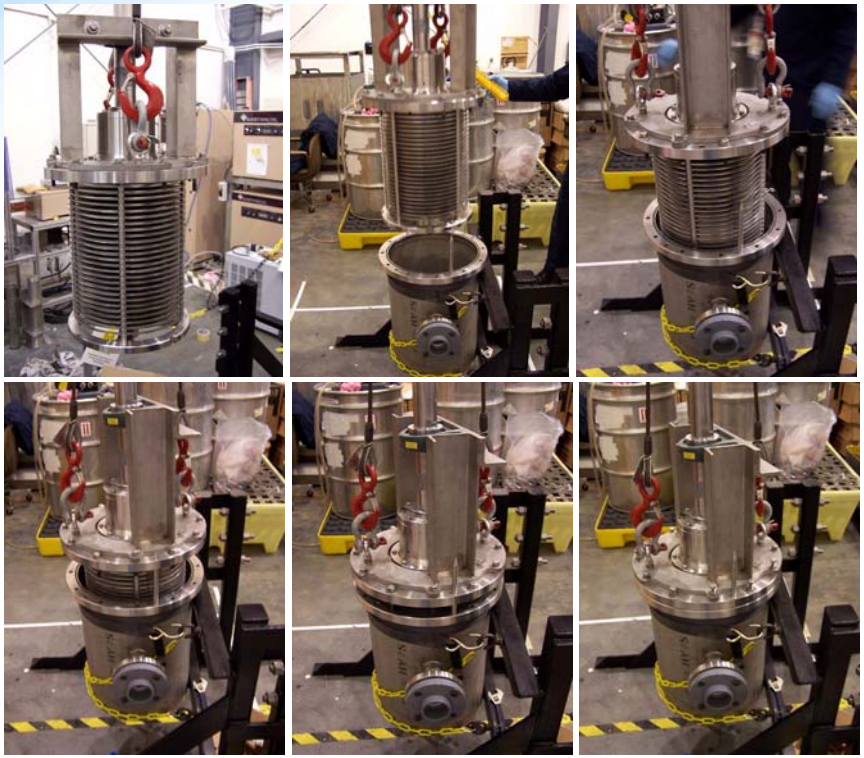


Single Disk Actual Waste Testing

3-Disk Pilot Scale Simulant Testing

25-Disk Full Scale Simulant Testing

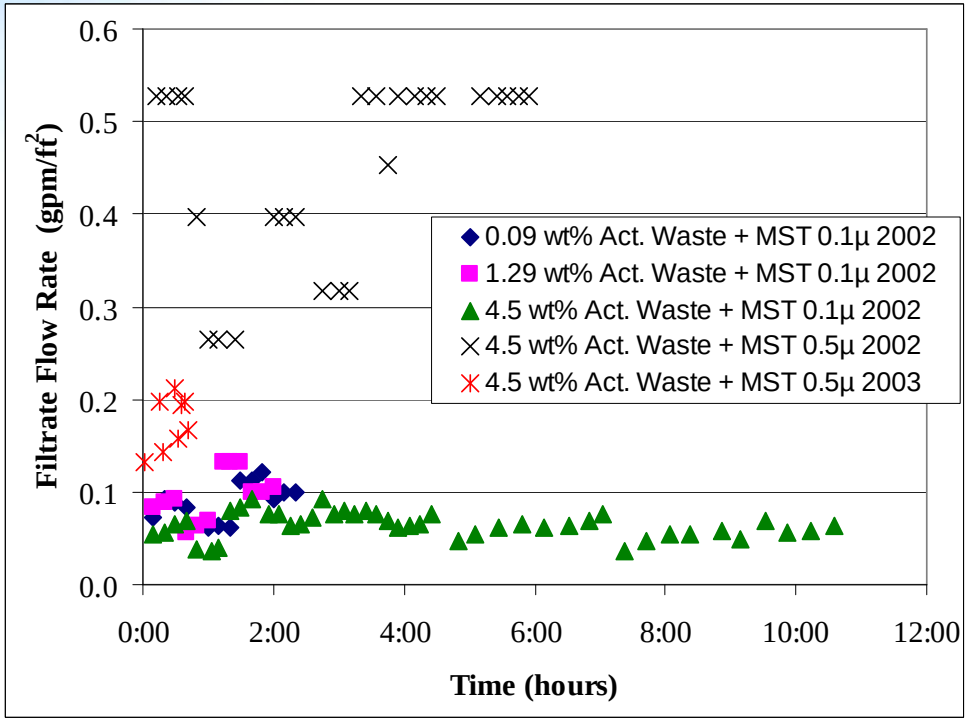
Process Highlights



Installation of Filter Stack
for 25 disk unit

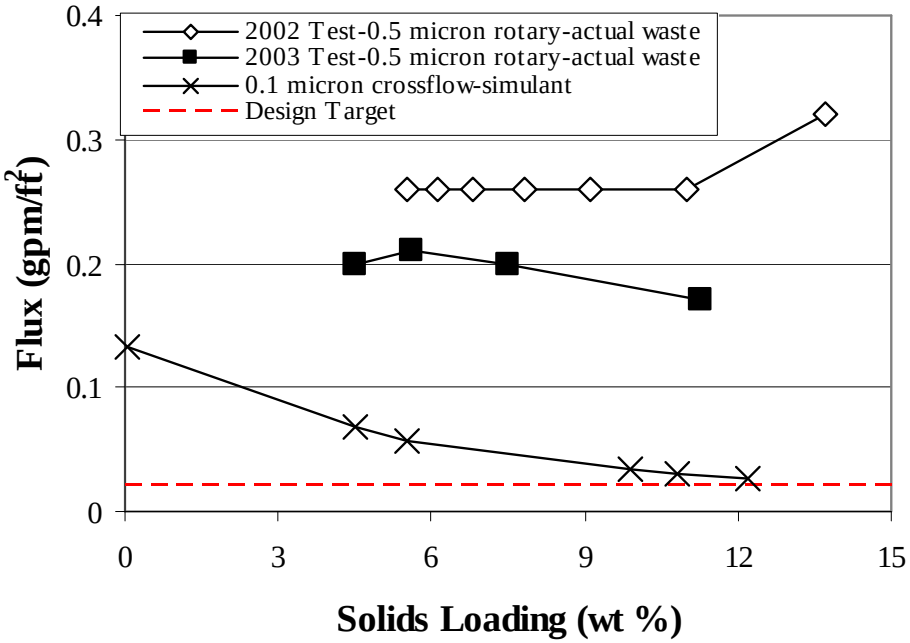
Filtration of “difficult” feeds
SRS SB4 Washing
3 Disk Filter
Yield Stress: 31.0 Pa
Consistency: 13.2 cP

Test Data - Actual Waste

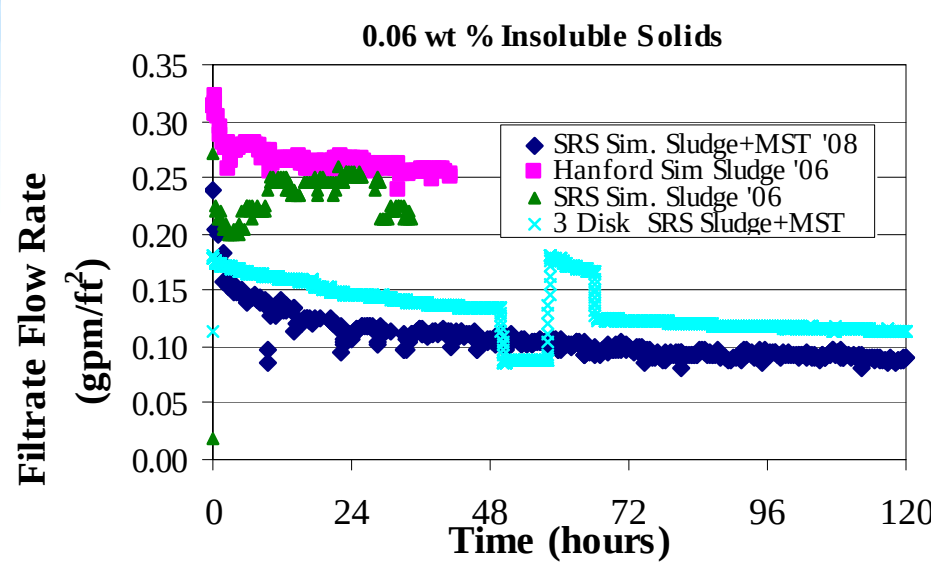


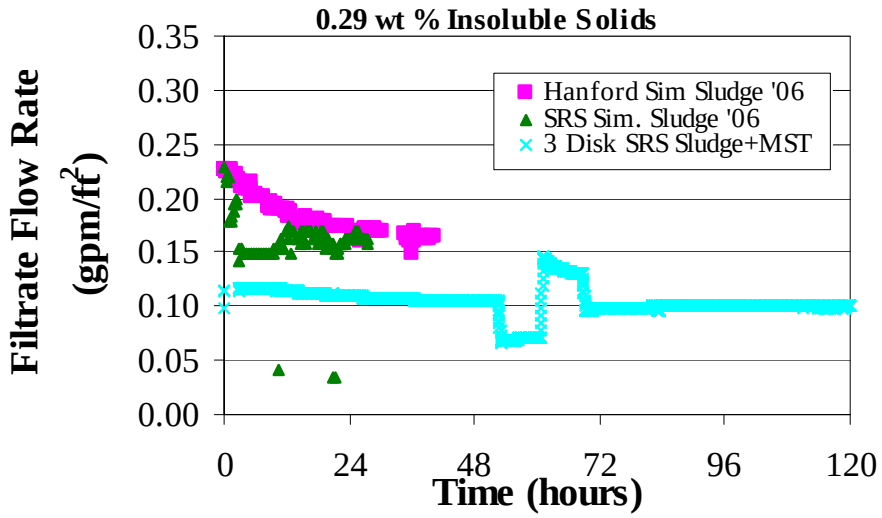
Summary of single disk actual waste testing

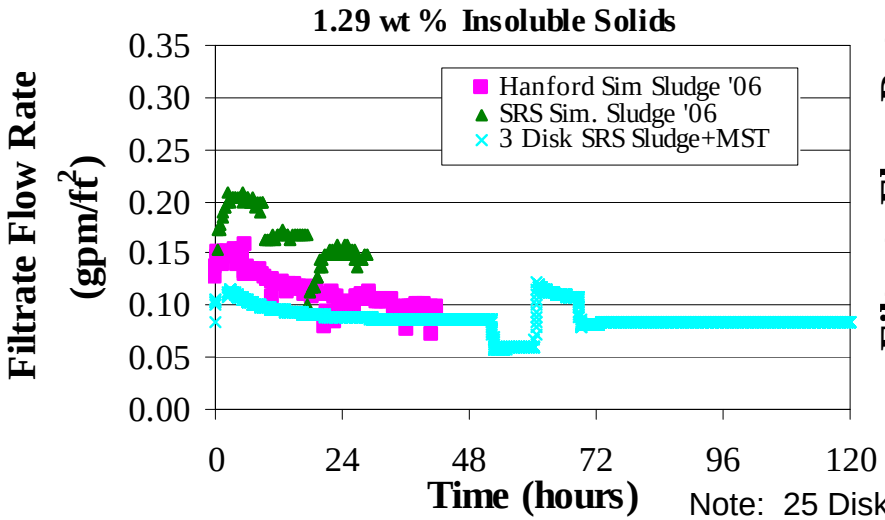
Filter disk from actual waste test

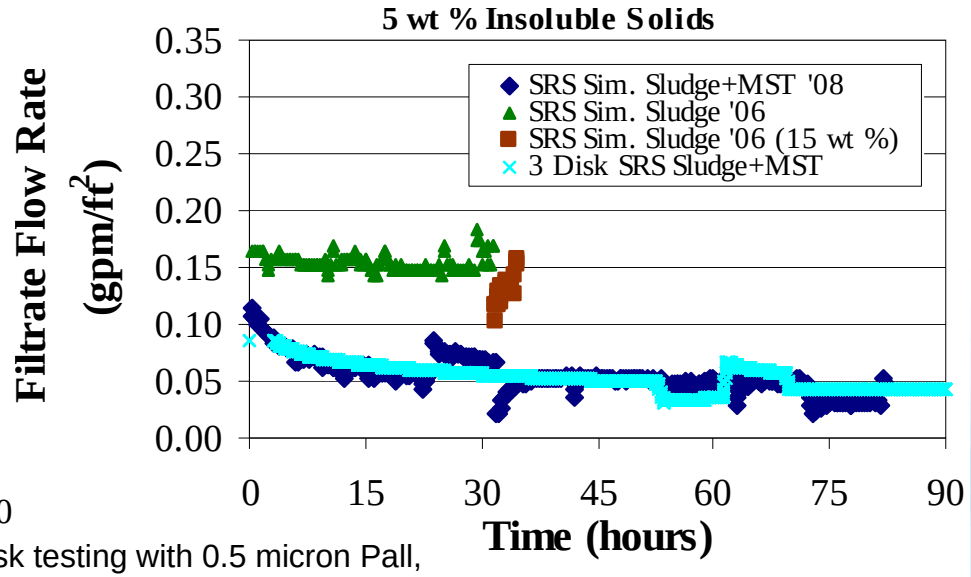


Test Data 25 Disk – Simulant Flux per Square Foot of Filter Media



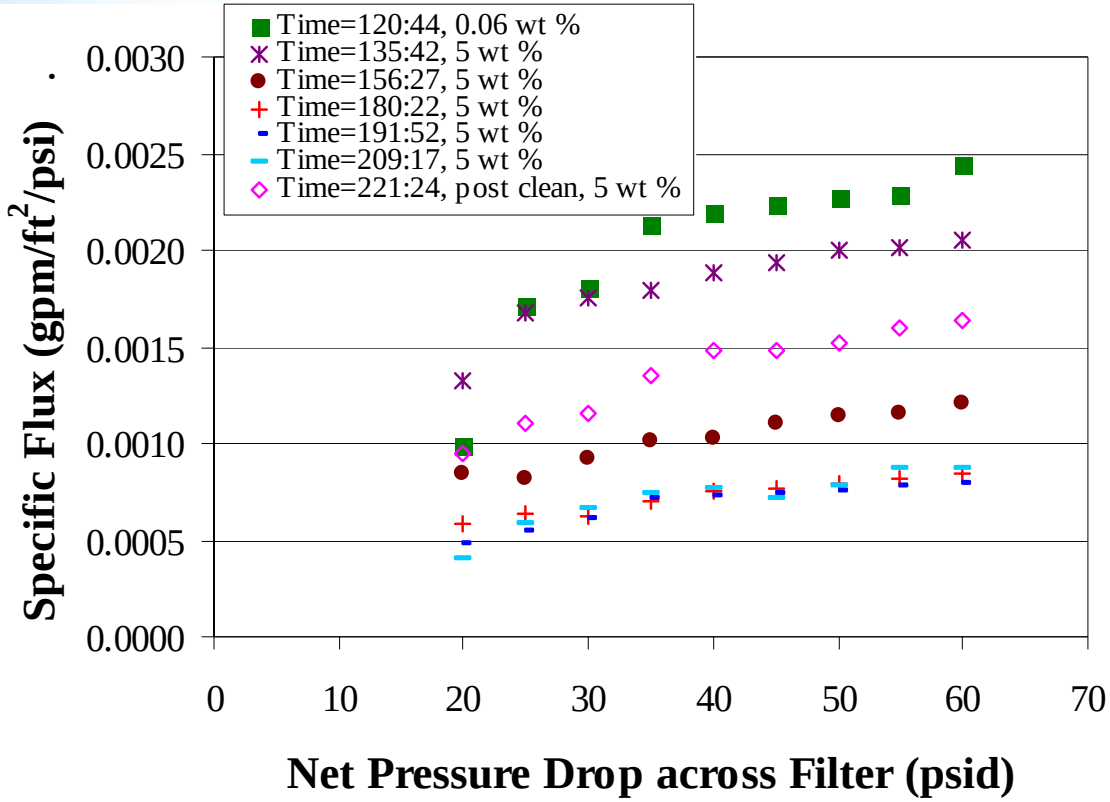






Note: 25 Disk testing with 0.5 micron Pall, 3 Disk testing shown with 0.1 micron Mott

Filter Media Utilization – Optimizing Applied Pressure



For this feed: Increasing pressure drop increased the utilization of the filter membrane (more flux per media area with additional pressure applied)

Long term, will this increase fouling rate?

In-Situ Cleaning

Initial Disk – Filter disk after test campaign (SRS simulant + MST)

- **1st Acid Strike - Filter housing filled with 4 M HNO_3 overnight**
- **2nd Acid Strike - Filter housing filled with acid for second night**
- **3rd Acid Strike - Filter operated (5-8 gpm. 15-20 psi, 1170 rpm) with acid for 10 minutes**

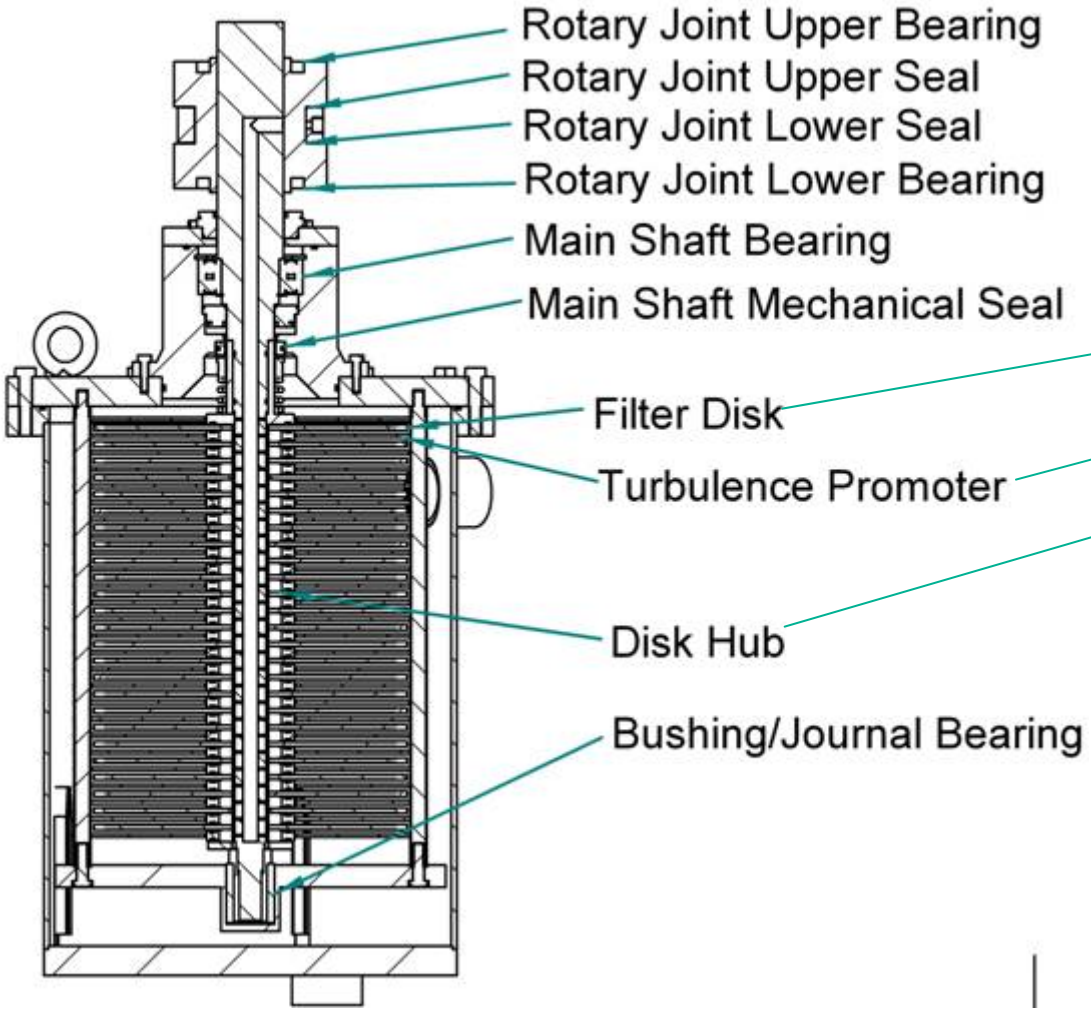
Disk #24 Top

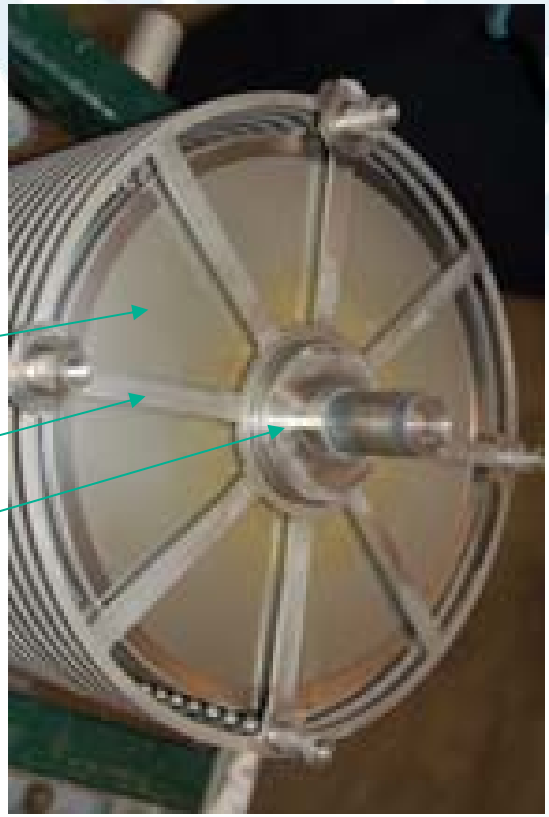
Initial disk | 1st acid strike | 2nd acid strike | 3rd acid strike Rotor operated for 10 min

Flux restored to over 80% of original at that solids loading

Disk #24 Bottom

Filter Layout





Mechanical Seal

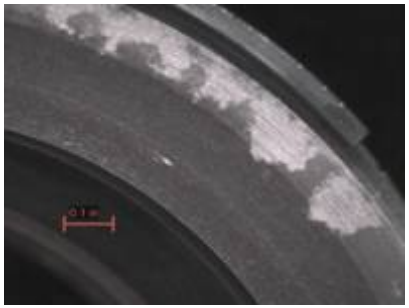
During operation, primary concern is lifetime of the mechanical seal

Leakage from main shaft mechanical seal is expected to be first indication of wear on rotary filter but will not be the ultimate failure of the filter

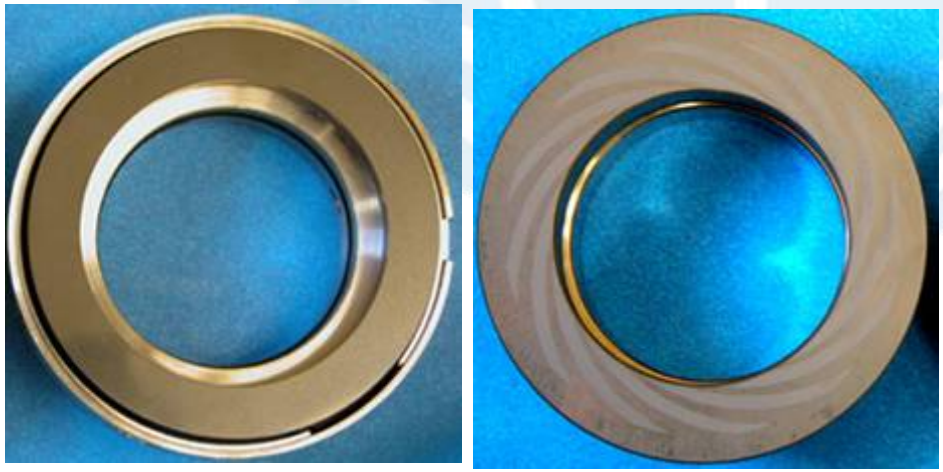
Selection of John Crane 28LD gas cooled, non-contact seal

Two instances of process fluid passing the main shaft seal (Type 1 Si-C/Si-C and 28LD), both due to disassembly/inspection of the seal between tests

Blisters on seal face due to contaminant after disassembly



Air Seal - new



Air Seal – post testing 230 hours

Rotary Joint

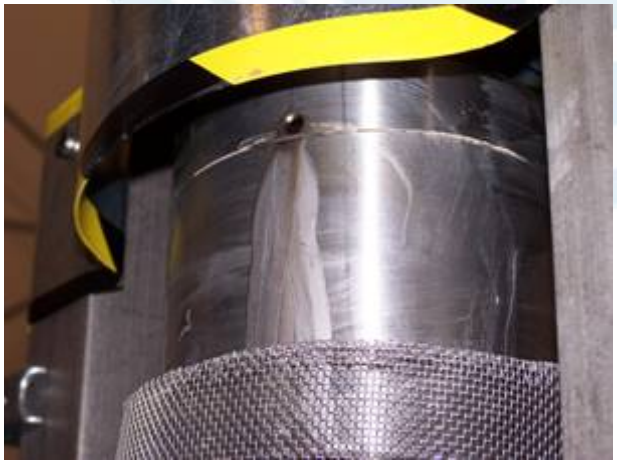
Rotary Joint = Double mechanical seal.

Rotary joint showed visible passing of fluid over mechanical seal faces

- **Leak rate was low enough that the fluid evaporated on rotary joint outer surface.**
- **Manufacturer recommends at least one atmosphere of pressure across the seal face during operation to keep the seal faces properly set.**

Discharge located mid-way between seals

- **Upper seal showed evidence of running dry due to trapped air**
- **Raise discharge port and shield internal bearings to extend lifetime**



Rotary Joint

Bushing/Journal Bearing

Original bushing – Graphite

- **poor wear characteristics**

Upgraded material to Silicon Carbide

- **additional sleeve to prevent shaft wear**

Performed well – no measurable wear to 0.001” (hand micrometer)

Upgrade to include cooling channels and retain shaft journal with locking ring

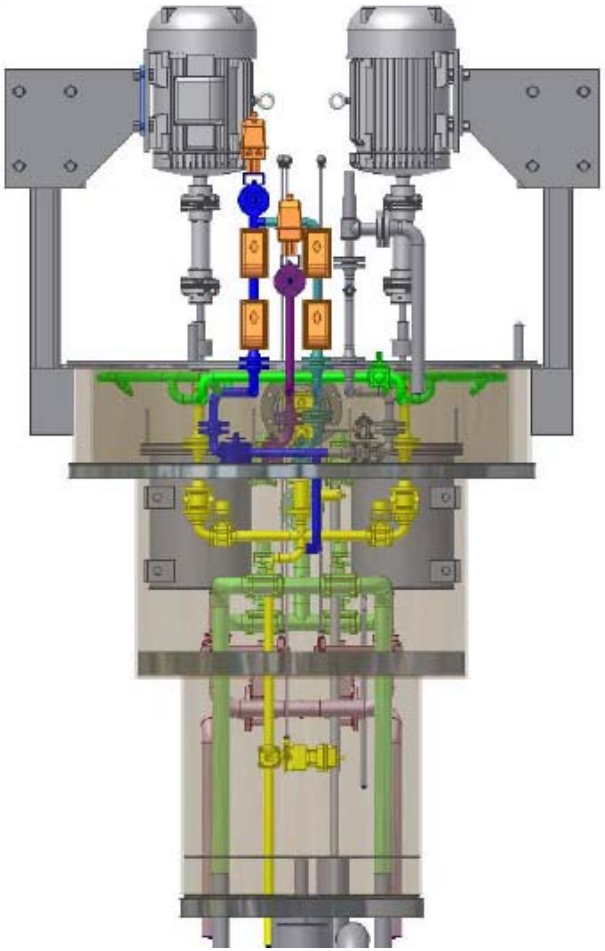
Summary of Wear Components for 25 Disk Filter

		Test Program				
		2006 SRS SB2 and Tank 8F Sludge Only	Preparation for Hanford Testing	2007 Hanford Simulant	2008 SRS Tank 8F + MST	Total Hours
Test Duration (hours)		129	26	124	227*	506
Main Shaft Seal	Type 1 Si-C/Si-C	123	NA	NA	NA	123
	28LD Gas Seal	NA	26	124	NA	150
	28LD Gas Seal	NA	NA	NA	230	230
Rotary Joint		129	26	124	230	509
Bushing/Journal Bearing	Graphite	129	NA	NA	NA	129
	Si-C/Si-C	NA	26	124	230	380

* Three hours of testing preparation not included in test time

NA=Not Applicable

Deployment Design – Pump/Filter Module

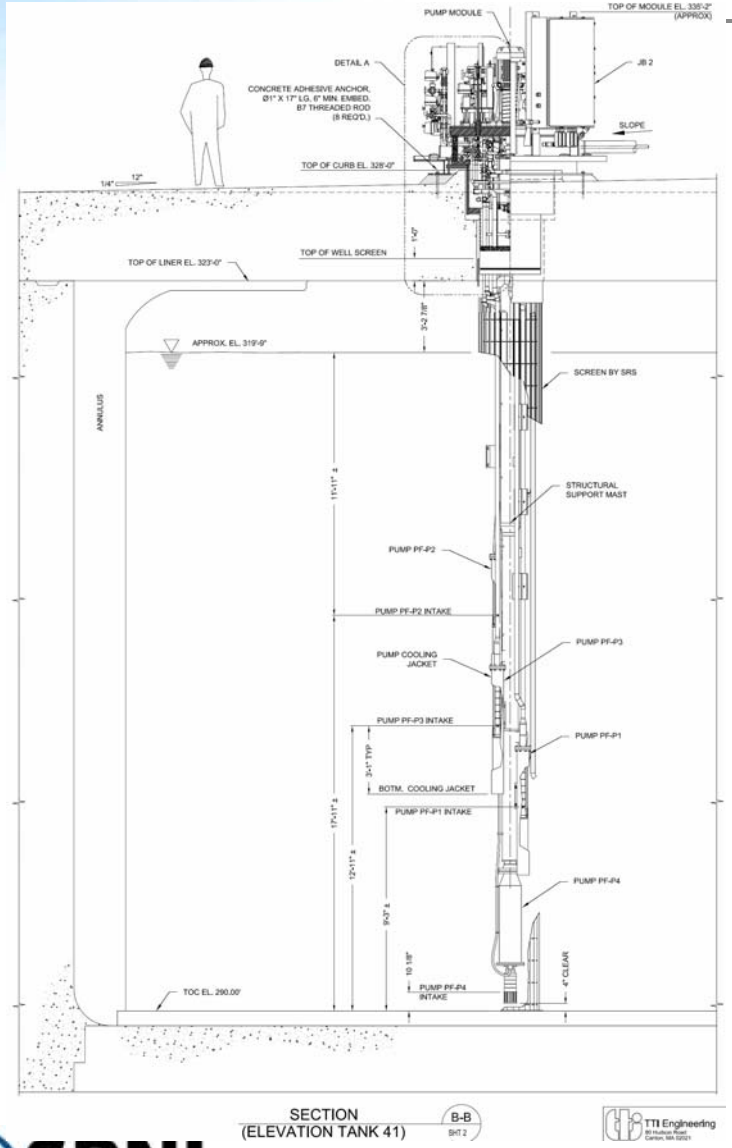


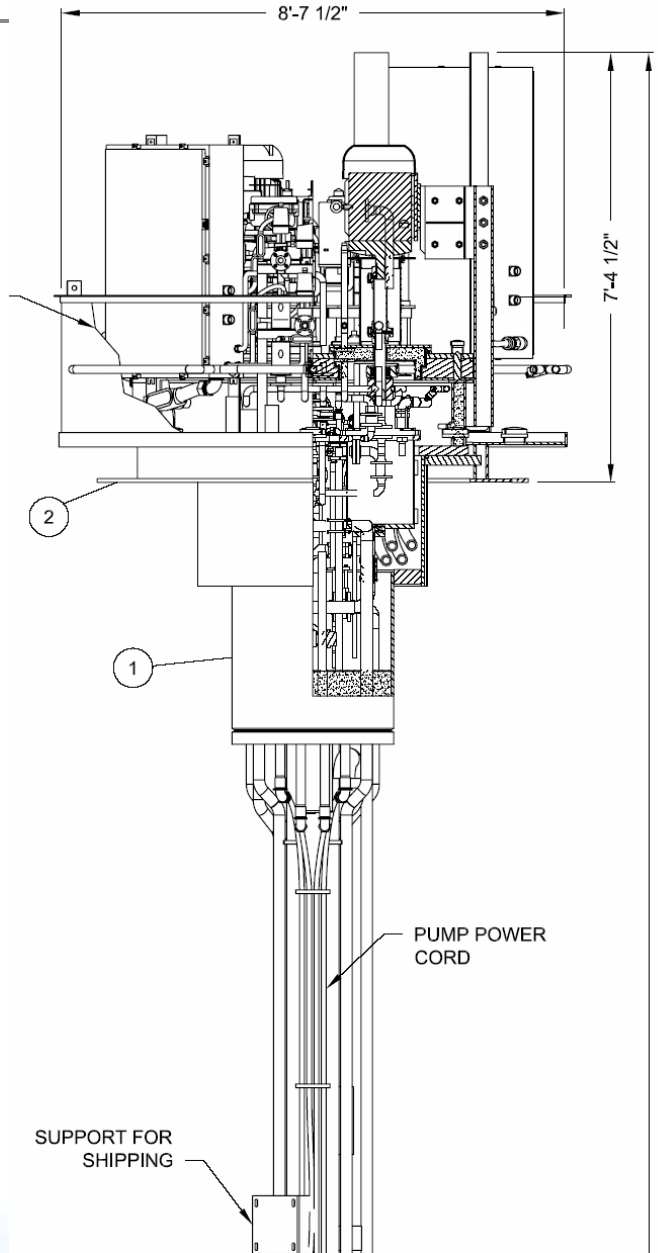
SRNL, ORNL, TTI, and SRS LWO developed design to place 2 rotary filters in tank riser as prefilter to ion exchange process

Design is for two filters to be installed into a Type B riser and the plug assembly of a waste tank.

The filtrate would be transferred out, with the concentrated solids returned to the waste tank.

Pump Filter Module





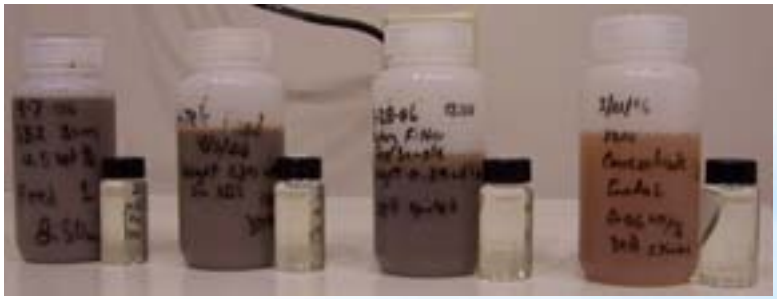
Path Forward

Next Generation filter to be built by SpinTek

- **Motor Stand to reduce vibration**
- **Reduce tolerances on components**
  - **Disk/shaft interface**
  - **Disk hubs**
- **Upgrade Rotary Joint**
  - **Move discharge port**
  - **Bearing guard**
- **Upgrade Journal**
  - **Add retaining ring**
  - **Include cooling channels**
- **Reduce volume at shaft seal (minimize contact with process fluid)**

~1000 hour endurance Testing to be completed at Vendor

- **SRS Sludge Batch 6 simulant**
- **4 solids loadings (5 wt %, 10 wt %, 15 wt %, 20 wt %)**

Questions?

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