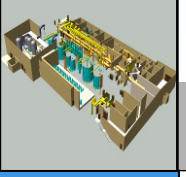
Cross Flow Filter (CFF)
Full Scale Test (FST)
Overview

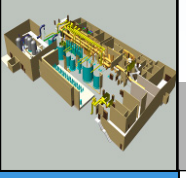
Savannah River/Hanford/Idaho Technical Exchange

Bill Brasel, Deputy Design Build Manager
Skip Singer, Test & Commissioning Manager
October 9, 2007



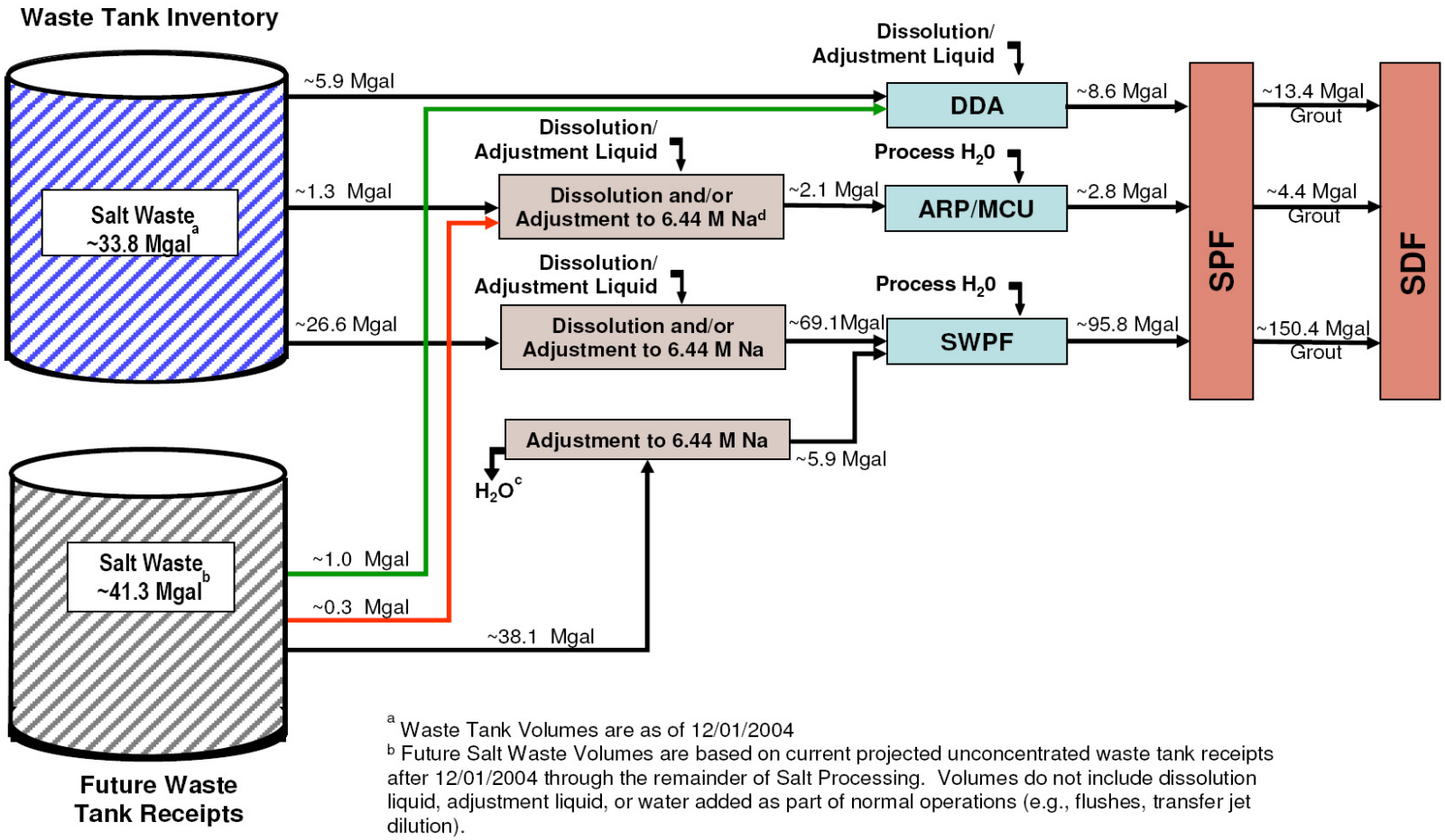
Presentation Overview

- This presentation will cover:
  - Simplified Process discussion
  - Test system and equipment design
  - Test objectives and description
  - Test Results
  - Questions and Answers

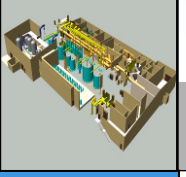


SWPF Alpha Sorption Process Overview

- SWPF will process SRS salt waste not processed by ARP/MCU

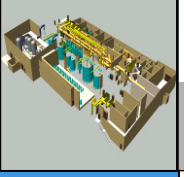


[a] Waste Tank Volumes are as of 12/01/2004
[b] Future Salt Waste Volumes are based on current projected unconcentrated waste tank receipts after 12/01/2004 through the remainder of Salt Processing. Volumes do not include dissolution liquid, adjustment liquid, or water added as part of normal operations (e.g., flushes, transfer jet dilution).
[c] Water will be removed through operation of Tank Farm Evaporators
[d] Salt Solutions are adjusted to sodium (Na) molarity (M) of 6.44



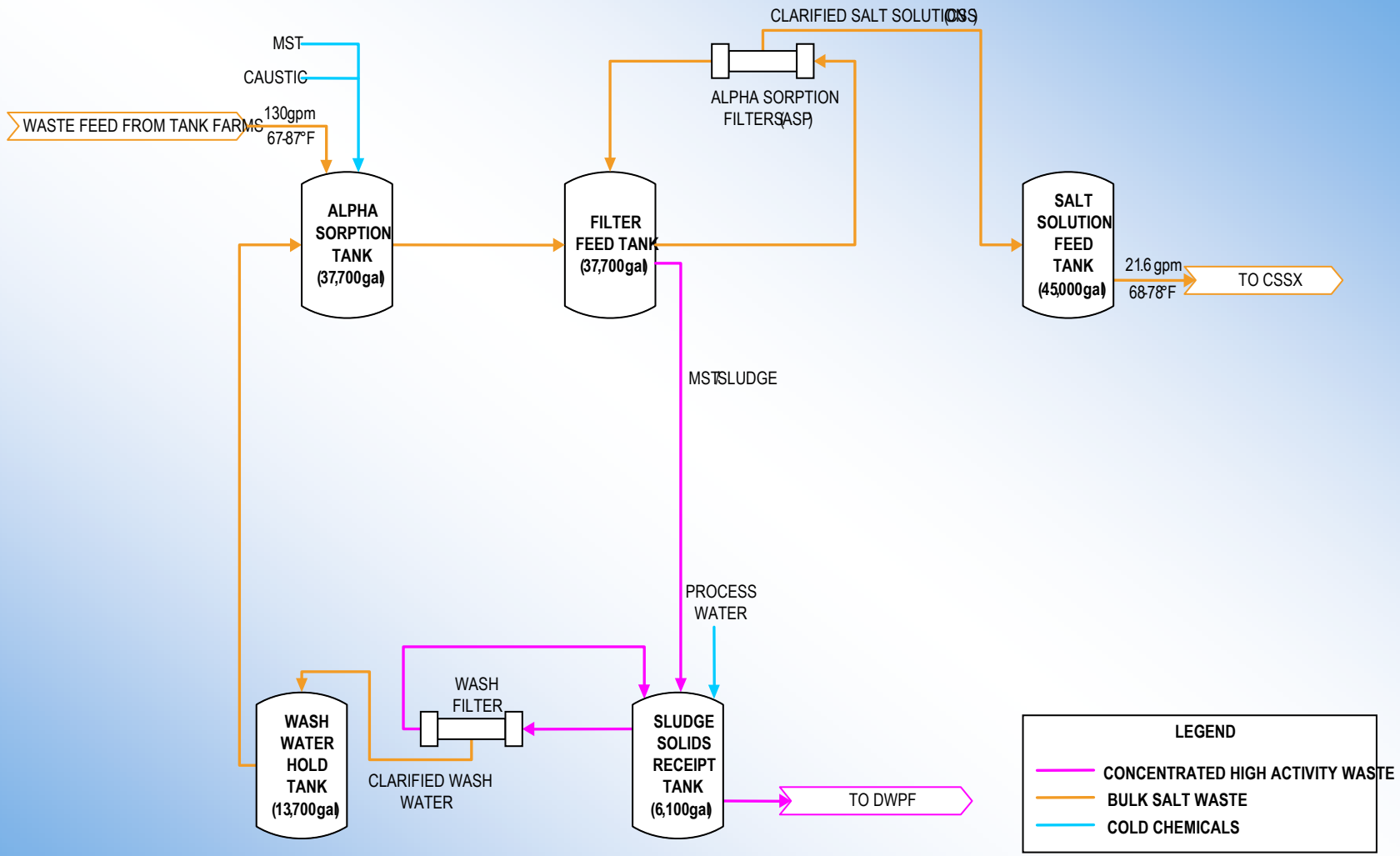
Alpha Sorption Process Overview

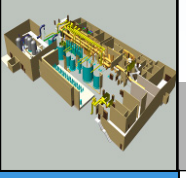
- SWPF uses two-stage treatment process:
  - Monosodium Titanate (MST) Adsorption with filtration (Strontium and Actinide removal)
  - Caustic Side Solvent Extraction (Cesium Removal)
- MST Adsorption with filtration is used to treat initial waste feed in the Alpha Strike Process
- MST Adsorption with filtration can be used to treat decontaminated Salt Solution in the Alpha Finishing Process
- Both MST Adsorption Processes use nearly identical CFF system consisting of an Alpha Strike Tank, Filter Loop Recirc pump and Feed Pump, and a vertically mounted Cross Flow Filter



SWPF

Alpha Strike Process





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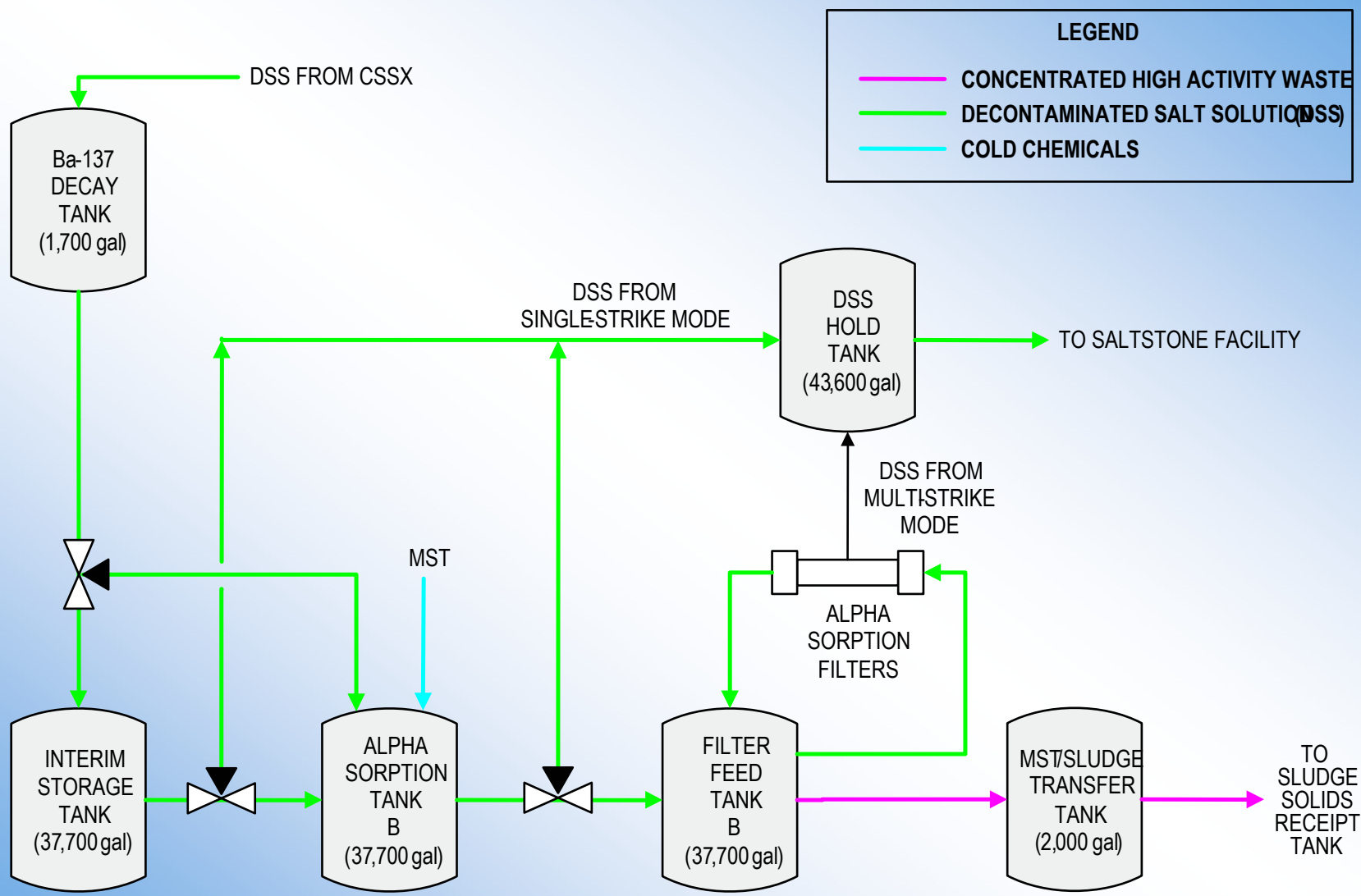
Alpha Finishing Process



SWPF Cross Flow Filter Full Scale Test

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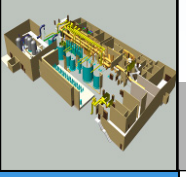
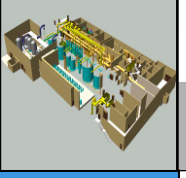


Filtration Test Loop Equipment

- **Primary Components**
  - P-102-1, Feed Pump: 60 gpm, 15 hp
  - P-102-2, Loop Recirc Pump: 1,200 gpm, 100 hp, sized to maintain 9-13 ft/s Axial velocity through filter tubes
  - FLT-102, Cross Flow Filter: 216 ft^2, ½ in. OD tubes, 10 ft long (220 total tubes)
  - TK-102: 12 ft diameter x 14 ft T/T, dished bottom, ~11,500 gallons capacity with Air Pulse Agitators
  - HX-101: 204,000 BTU/hr, sized to maintain loop contents at 73°F



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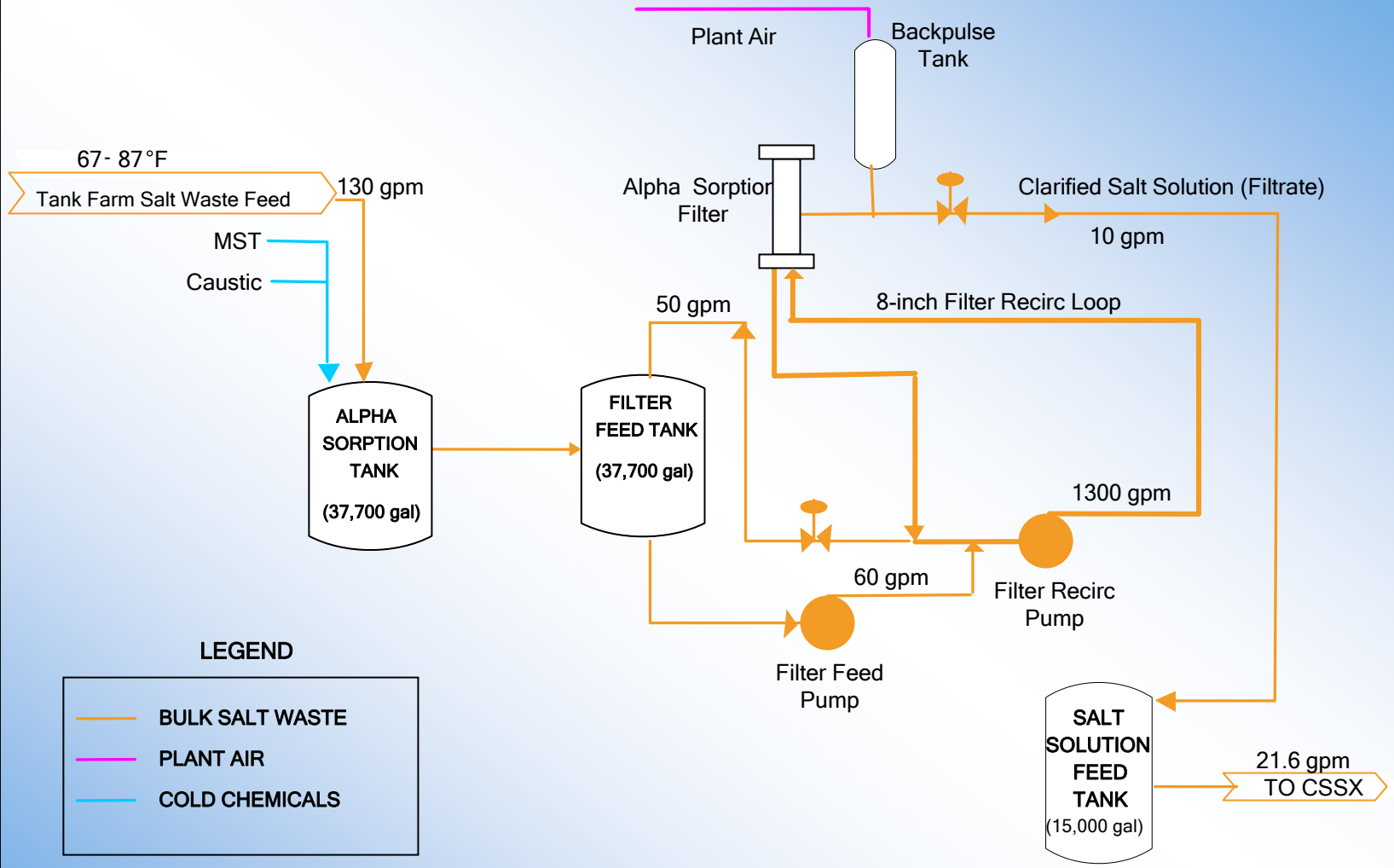
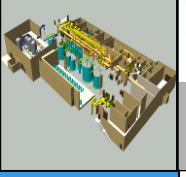
Alpha Filtration Loop Flow



Feed Tank with Air Pulse Agitators

SWPF Cross Flow Filter Full Scale Test



Filtration Loop and Feed Tank

SWPF Cross Flow Filter Full Scale Test

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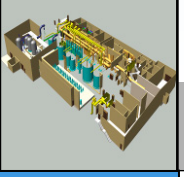

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Cross Flow Filter

SWPF Cross Flow Filter Full Scale Test

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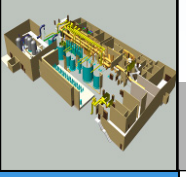

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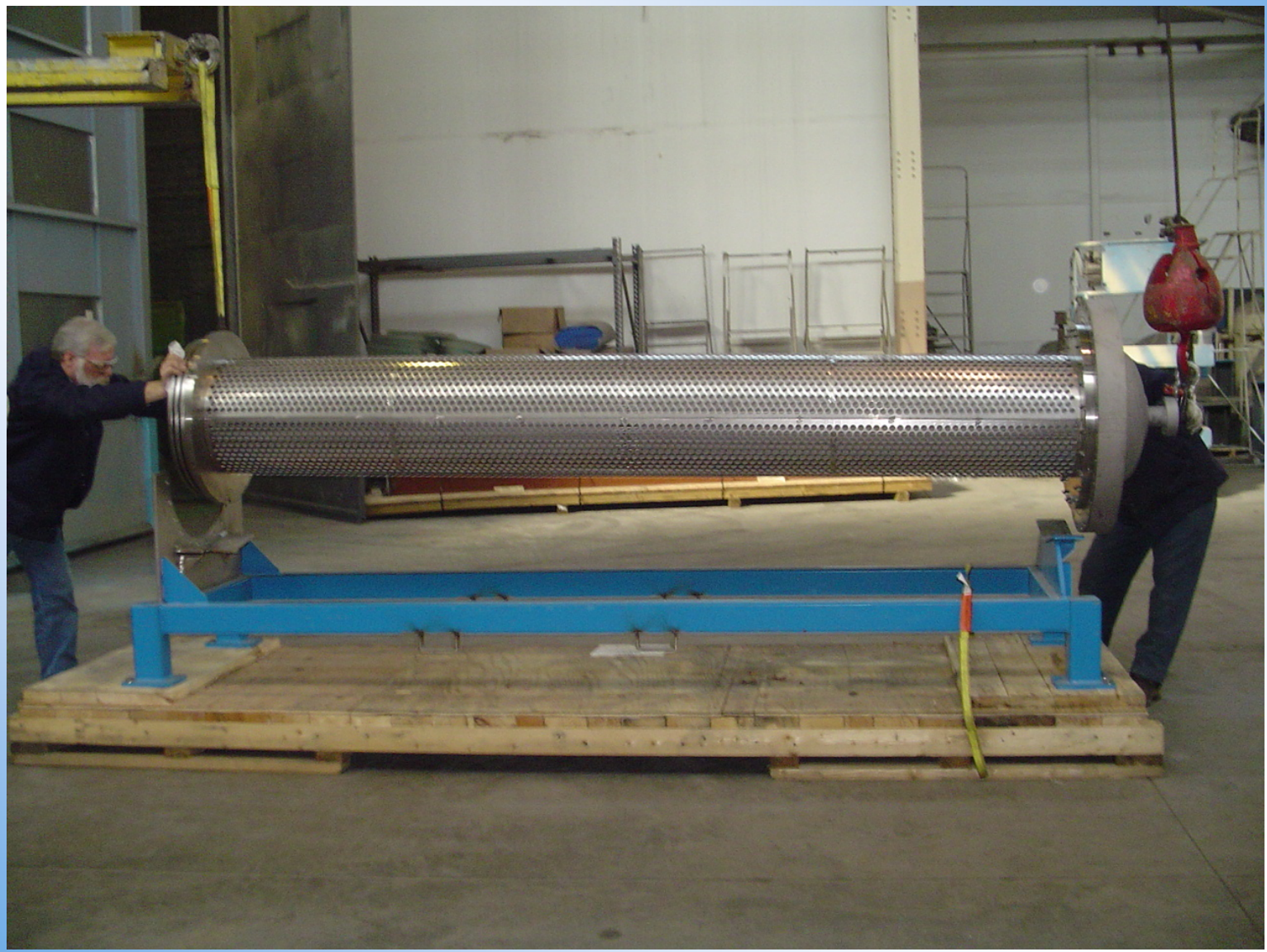
CFF Tube Bundle



SWPF Cross Flow Filter Full Scale Test

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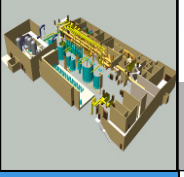
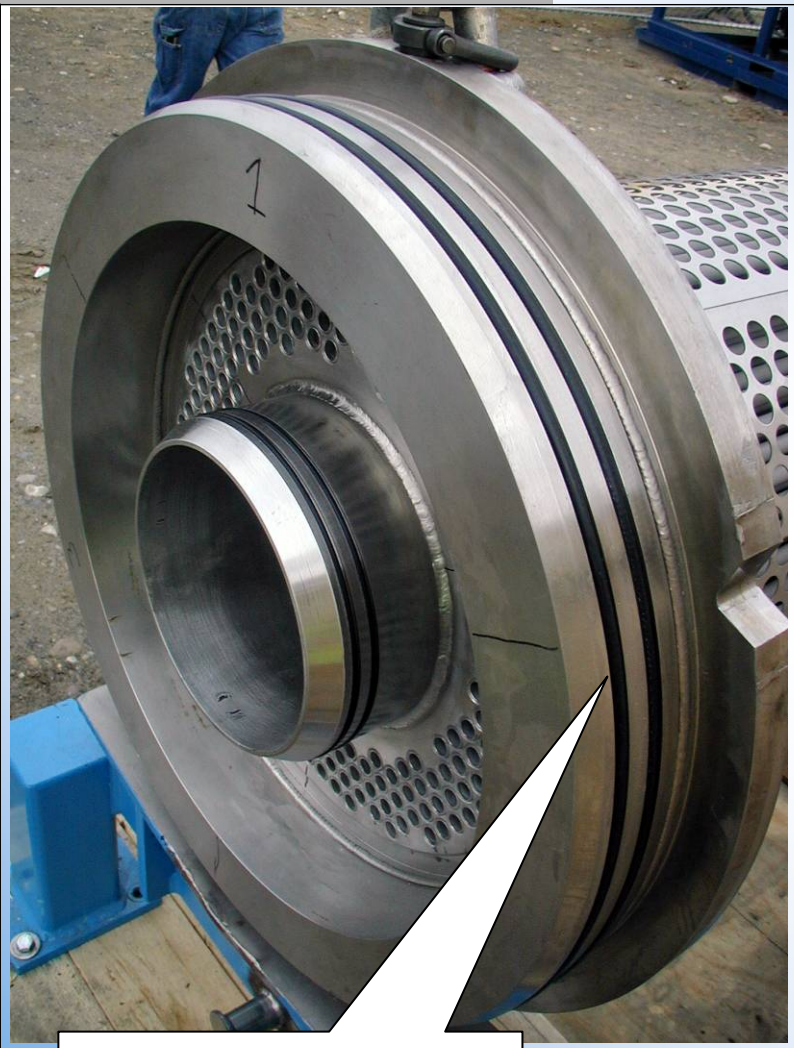
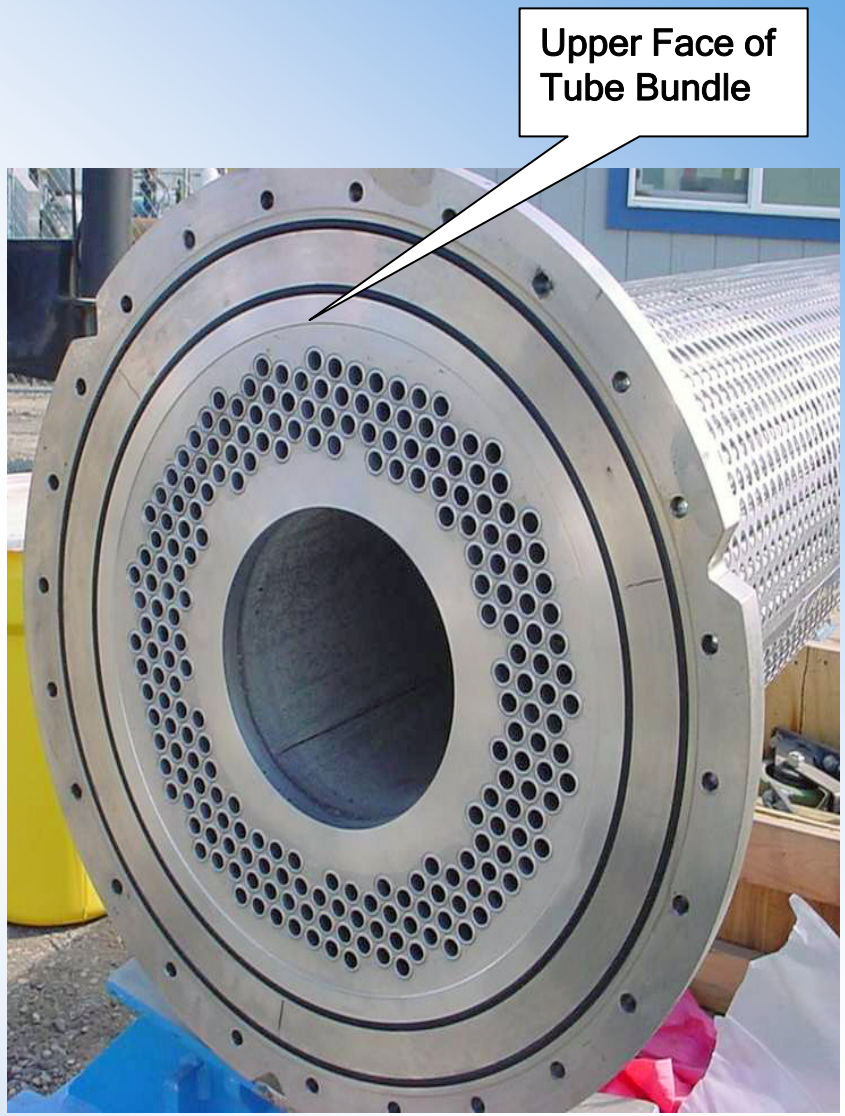


SWPF CFF Tube Bundle





CFF Filter Tube Media

- SWPF Pall ACCUSEP Filter Media
  - Absolute 0.1 micron
  - Sintered stainless steel
  - Zirconia coating

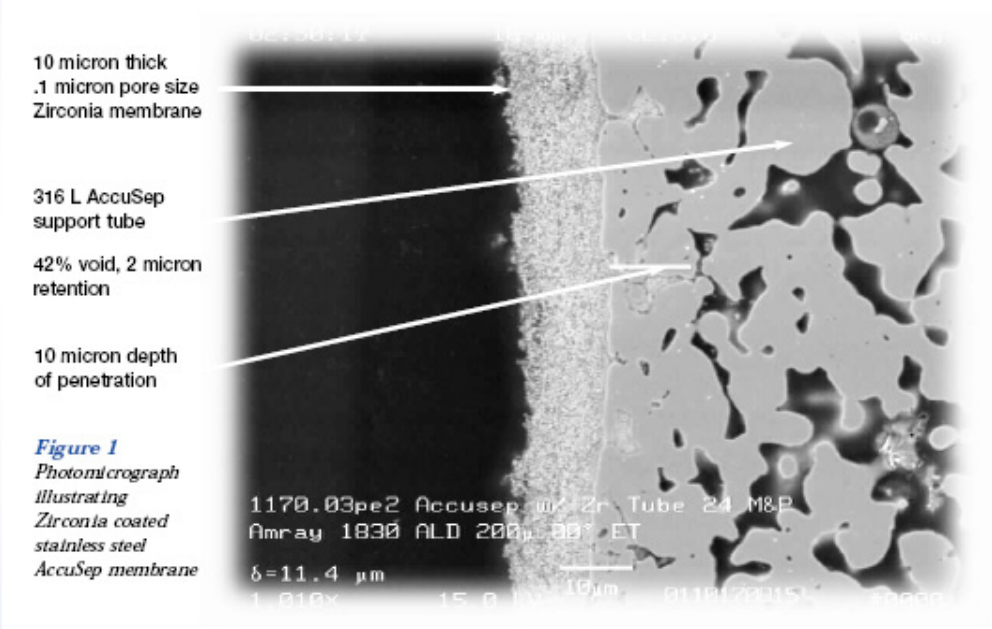
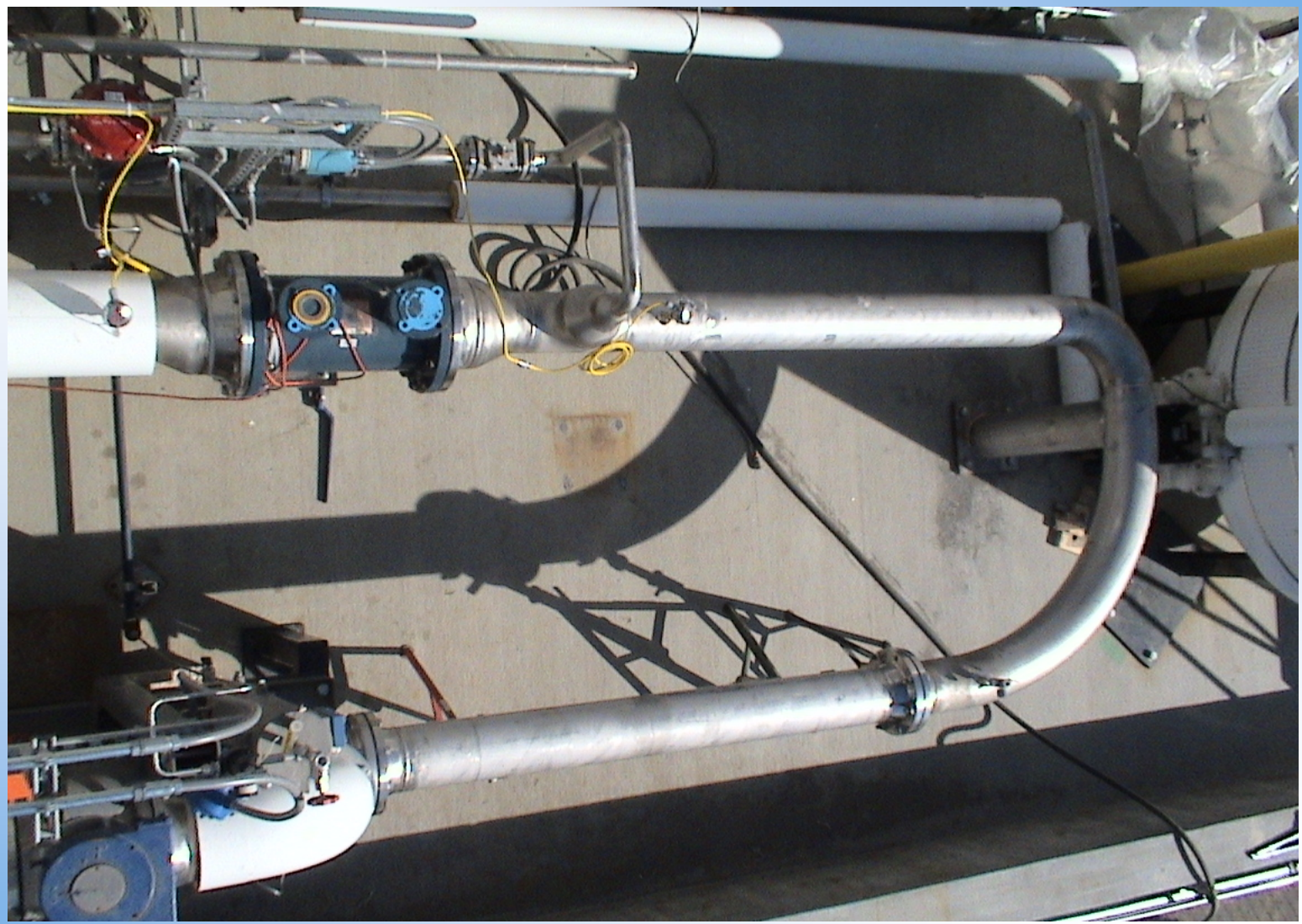
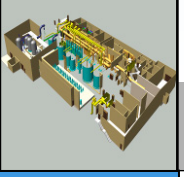


Figure 1
Photomicrograph illustrating Zirconia coated stainless steel AccuSep membrane

CFF Loop 8-Inch pipe and HX



SWPF Cross Flow Filter Full Scale Test



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CFF Loop Recirc Pump

SWPF Cross Flow Filter Full Scale Test

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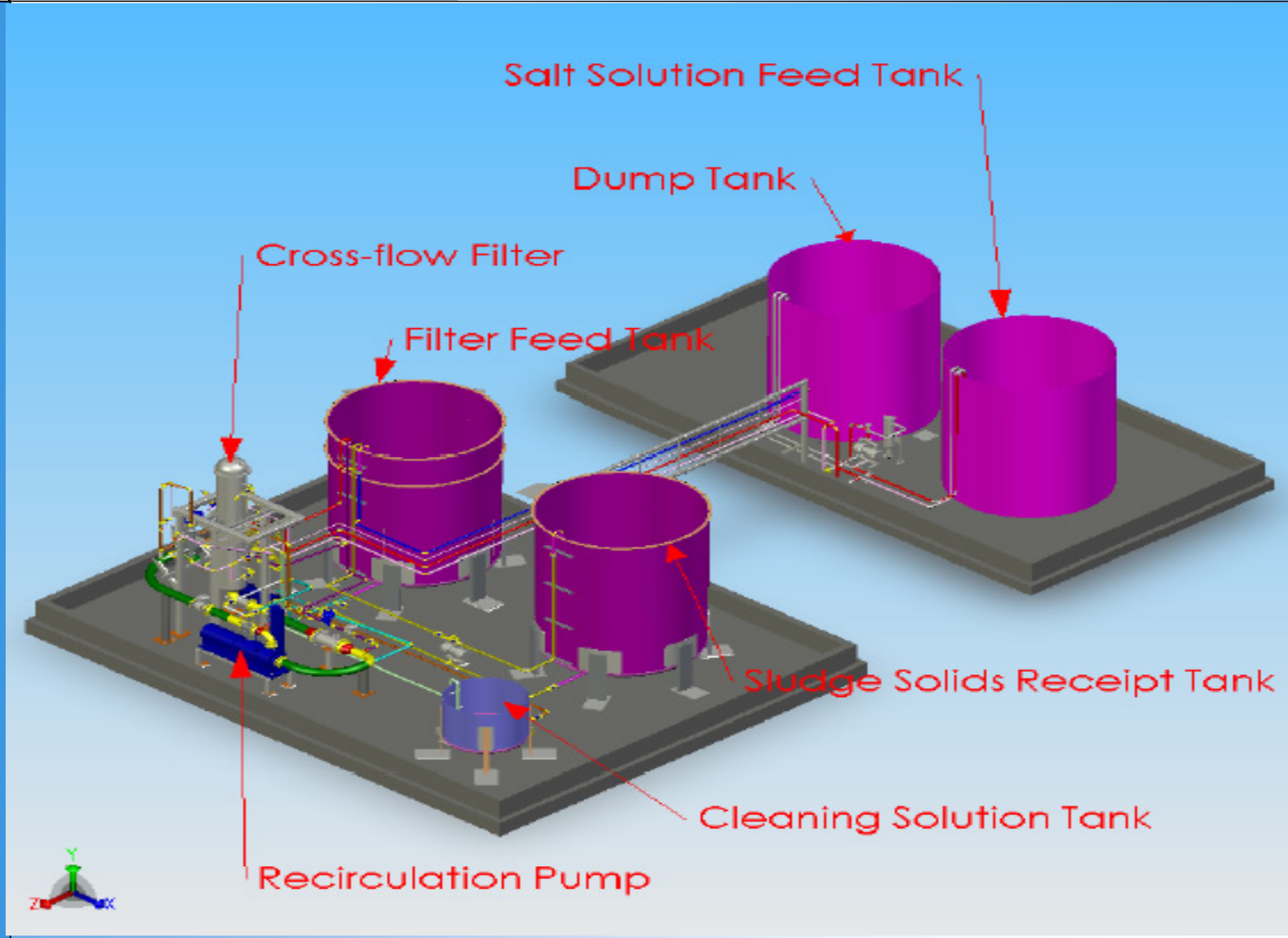
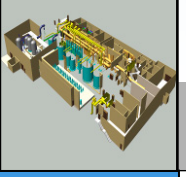
Air Pulse Agitators inside Feed Tank

SWPF Cross Flow Filter Full Scale Test

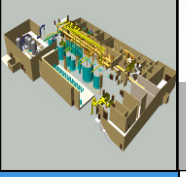
Test Equipment Arrangement





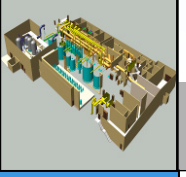
Test Objective Summary

- Objective - Operate full-scale filter test loop to determine filtration performance and efficiency, optimum filtration operating parameters, and optimum backpulsing and chemical cleaning methods
- Filtration Operating Parameters to evaluate included:
  - Axial Velocity (Recirc Pump Flowrate)
  - Transmembrane Pressure (TMP)
  - Filtrate Flow Control Modes
    - > Varying Filtrate backpressure
    - > Varying Feed Pump Speed Control



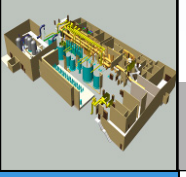
Test Objective Summary

- Backpulsing methods to evaluate included:
  - Short vs. long duration pulses
  - Series of short duration pulses
- Filter draining and flushing (0.02M NaOH) effectiveness evaluated
- Chemical cleaning with 0.5M Oxalic Acid evaluated
- Behavior of concentrated solutions in filter loop at end of filtration run evaluated
- Confirmed operation of two-pumps-in-series flow scheme
- Confirmed ability to re-suspend settled solids
- Degradation of MST evaluated



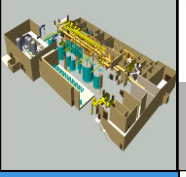
SWPF Test Description Summary

- Filter loop is full scale with support system line lengths and geometries sized to minimize system volume since feed tank is 1/3 scale
- Feed solution prepared from MST and simulated sludge in NaOH and $NaNO_3$ with Na+ concentration of 5.6M and suspended solids concentration of 0.071 wt%
- Specific Gravity and viscosity compared to CSSX simulant
- Solution filtered until concentration has increased to 7 wt% solids
- Transient data from temperature, pressure, and flow transducers monitored by PLC and collected by data acquisition system
- Conducted workup test series to establish some parameters to be used in actual test matrix



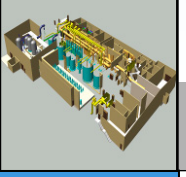
Test Description Summary

- Conducted test series over range of three TMP settings (12, 20, & 35 psi)
- Conducted test series over range of three Filter Flux settings (13, 15, & 17 gpm)
- Conducted test series over range of three axial velocities (9, 11, & 13 ft/sec)
- Conducted three tests at preferred settings to evaluate filter performance during operation w/o cleaning
- Conducted test that processed with MST only, simulating AFP operations



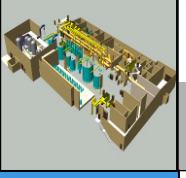
Test Description Summary

- Conducted solids washing test simulating process for lower sodium ion concentration from 5.6M to 0.5M
- Conducted test to operate system at maximum solids concentration (20 wt%)
- Conducted test to evaluate APA ability re-suspend solids following long period of settling
- Conducted MST degradation test during processing to evaluate potential for MST reuse
- Conducted steady-state filter performance test
- Evaluated chemical cleaning effectiveness throughout test



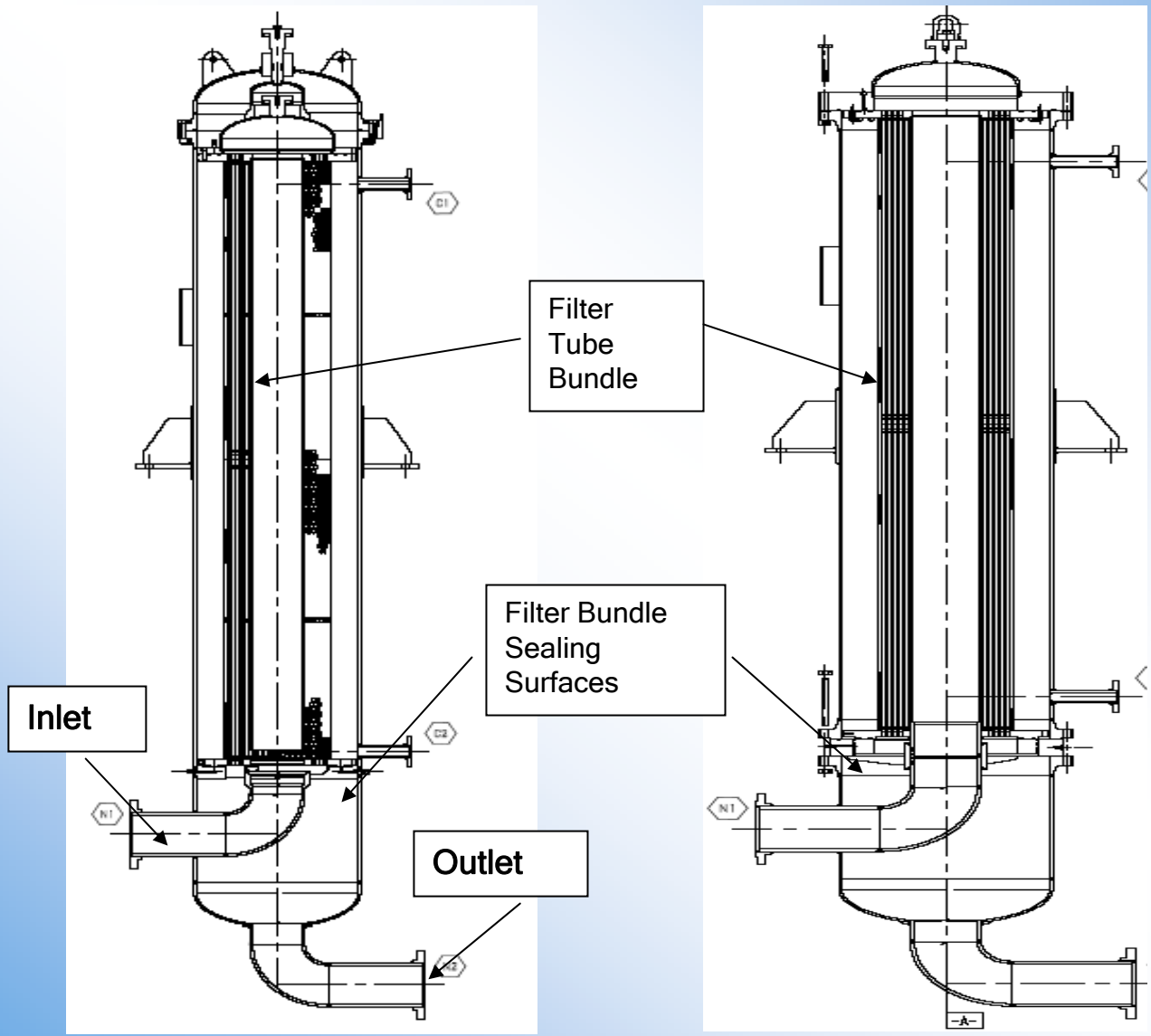
Test Equipment Issues

- **Filter Seal Leakage**
  - Attempts to seal filter tube bundle to housing were unsuccessful using manufacturer's initial design
  - Seal re-designed from flat-face o-ring seal to piston o-ring seal
  - Vessel head to vessel and vessel head to filter mating redesigned
  - Design changes required remanufacture of filter vessel and modifications to filter tube bundles
  - New vessel and seal design proved effective during actual testing
- **Filter Vessel Flange warped during vessel manufacturing**



SWPF

Initial (Left) and Final (Right) Vendor Filter Design



SWPF Cross Flow Filter Full Scale Test

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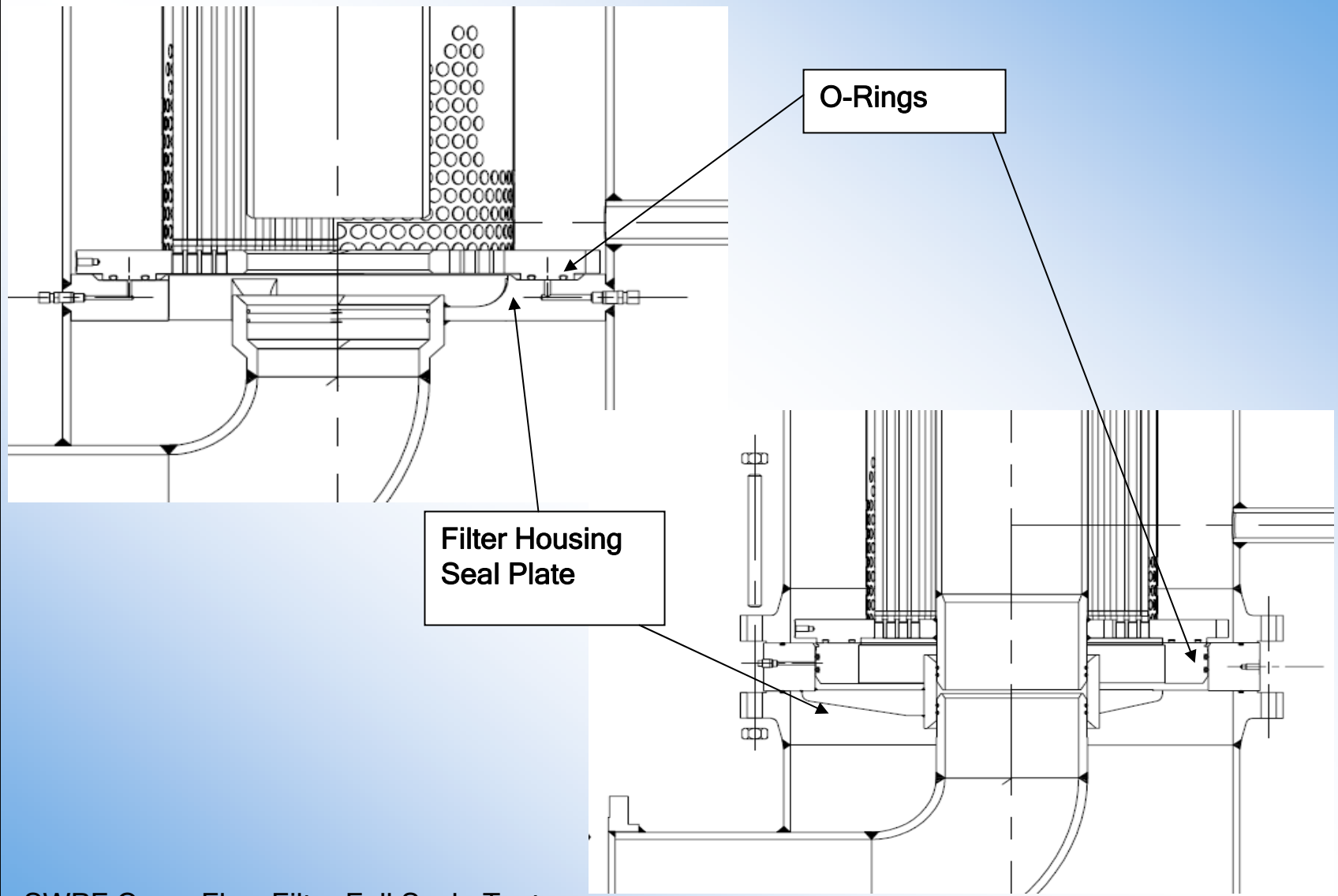
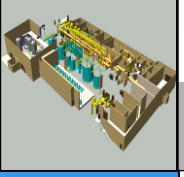
Old (Left) and New (Right) Seal





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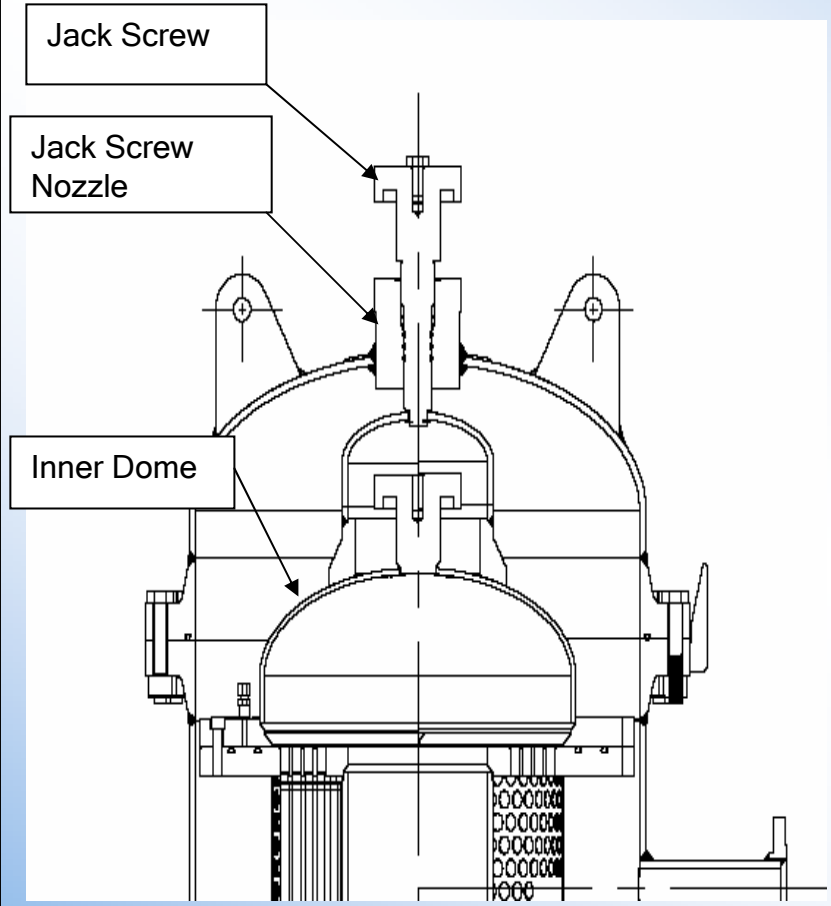

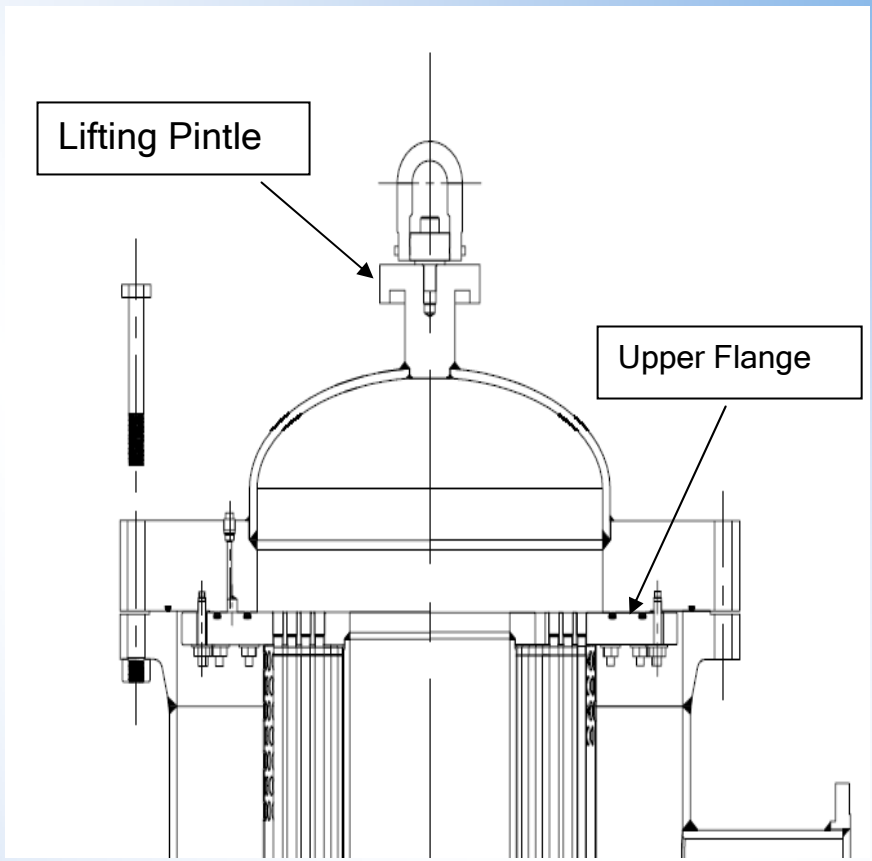

SWPF Cross Flow Filter Full Scale Test

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New Integral Top Head

SWPF Cross Flow Filter Full Scale Test

Test Equipment Issues

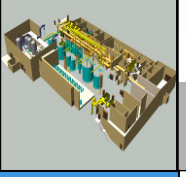
- Filter Tube failure

  Root cause:
  Manufacturing process defect

  Carbon sensitization of grain boundaries resulted in accelerated corrosion

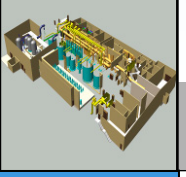
  Isolated incident that had not occurred before

  Working with manufacturer, additional testing underway



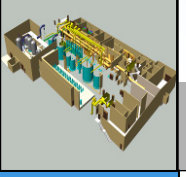
CFF Preliminary Overall Test Results

- Filter works better than expected
  - Max. filtrate rate ~25 gpm
  - Flux approx. 2x larger than design specification
  - Filter fouling tendency with simulated waste and MST less than expected
  - Backpulsing effectiveness better than expected with single short burst as effective as long or multiple bursts
  - Cleaning regime effective in returning baseline filter performance



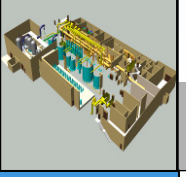
CFF Preliminary Test Results

- **Test Series 1 (TMP vs. Flux Degradation) Conclusions:**
  - As expected, increased TMP resulted in decreased processing time
  - Processing time varied from 7-15 hours
  - No negative characteristic were associated with increased TMP
- **Test Series 2 (Constant Filter Flux) Conclusions:**
  - Processing flow was directly proportional to filtrate flow
  - Higher filtrate flows required higher TMPs



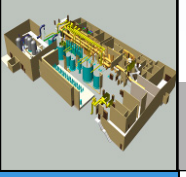
CFF Preliminary Test Results

- **Test Series 3 (Axial Velocity vs. Flux Degradation) Conclusions:**
  - Higher axial velocity reduces fouling rate and increases the effectiveness of backpulsing
  - Processing time decreases with higher axial velocities
- **Test Series 4 (Long-term Operation w/o Cleaning) Conclusions:**
  - As expected, filter performance degraded on each test with test 4D showing the lowest filtrate flows
  - Initial data review indicates that periodic backpulsing may be beneficial during normal operation, even though the filter is not fully fouled



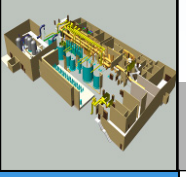
CFF Preliminary Test Results

- **Test Series 5 (MST Only Test) Conclusions:**
  - Elevated filtrate turbidity following backpulsing persisted until filter fouling caused another backpulse, this cycle persisted until test was terminated
  - Viscosity for feed samples increased proportionally with solids concentration
  - Filtrate flow degraded between each concentration cycle (chemical cleaning was not performed between runs)
- **Test Series 6 (Solids Washing Test) Conclusions:**
  - Filtrate flow increased from 6.5 to 23.5 gpm during test
  - No adverse/unexpected system behavior was noted and as expected, filtrate flow was inversely proportional to Sodium concentration



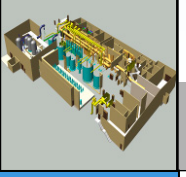
CFF Preliminary Test Results

- **Test Series 8 (Maximum Solids Test) Conclusions:**
  - Normal fouling criteria imposed for other tests were not used, filtrate flow decreased from 10.5 to 5.5 gpm during the test
  - No signs of catastrophic plugging during this test run
  - Test stopped at a calculated solids concentration of 20 wt%
  - Ending viscosity of 2800 cP (4X highest previous value)
- **Test Series 9 (Solids Re-suspension Test) Conclusions:**
  - FFT mixing with APAs evaluated following 2.5 months of settling
  - Results indicated an even solids distribution was achieved and that mixing was adequate



CFF Preliminary Test Results

- **Test 10 (MST Degradation Test) Conclusions:**
  - Results indicate that particle size did not degrade over time
  - Conclusion is that neither exposure to salt solution nor mechanical shearing causes degradation of the MST particles
- **Test Series 11 (Steady-state Performance Test) Conclusions:**
  - Relationships between solids concentrations, TMP, axial velocity, and filtrate flow were established
  - Filtrate flux is inversely proportional to solids concentration and is directly proportional to TMP and axial velocity
  - In all cases there is a slight degradation of flux over time, as expected



Conclusion

- Questions and Comments on presentation material
- Contact Information:

Salt Waste Processing Facility

Parsons (Prime Contractor)

Bill Brasel – Deputy Design Build Manager

Phone – (803) 643-2326

Email – bill.brasel@parsons.com

Skip Singer – Test & Commissioning Manager

Phone – (803) 643-2352

Email – skip.singer@parson.com