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MST Mixing and Kinetics Studies in Support of SCIX Deployment at SRS

Michael Poirier, Zafar Qureshi, Michael Williams, Tim Steeper, and Michael Restivo

E&CPT Research Programs, SRNL

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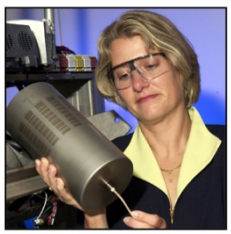
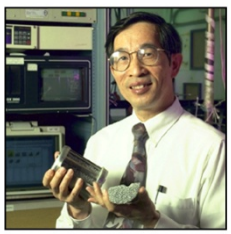

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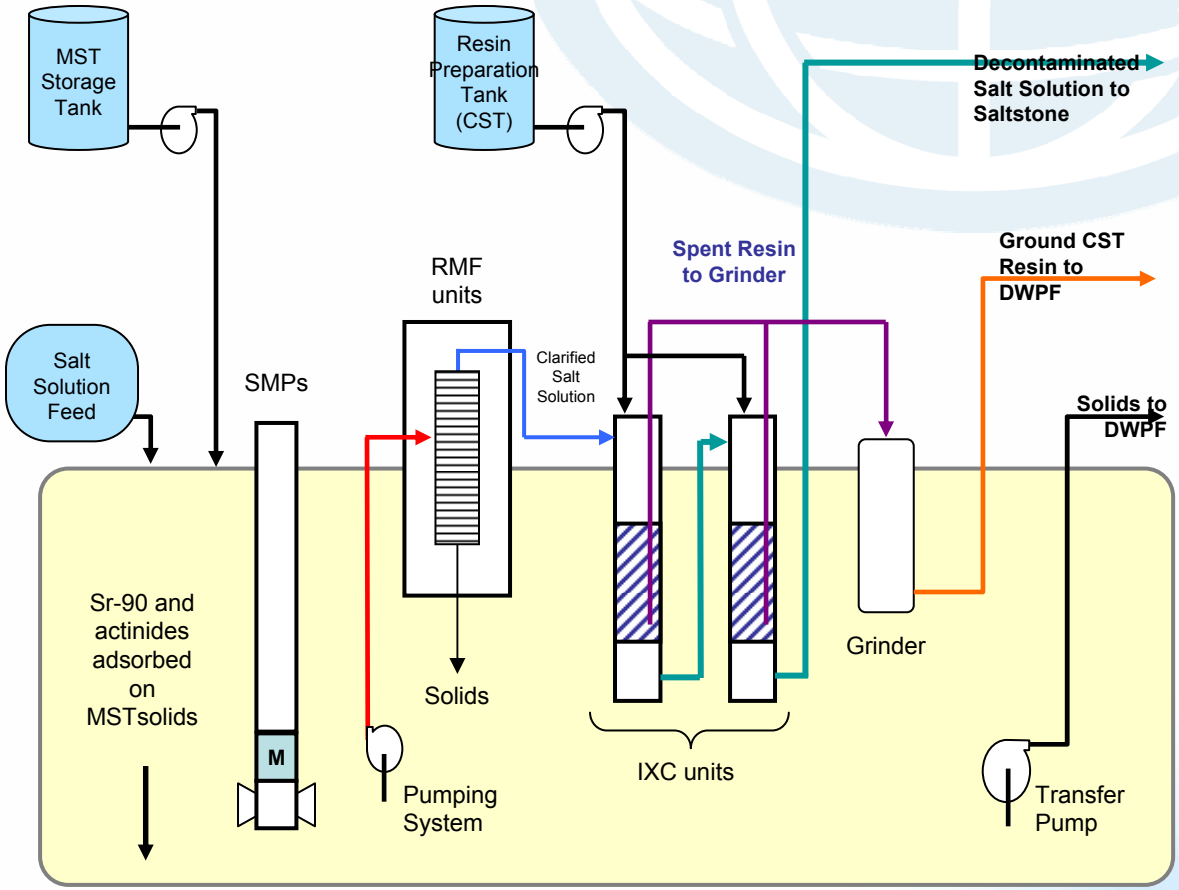
Introduction

- **SRR developing SCIX process to remove cesium, strontium, and select actinides from SRS Liquid Waste**
- **Process uses existing waste tank (i.e., Tank 41H)**
  - Adds MST to waste tank to chemically sorb strontium and select actinides
  - Removes MST and entrained sludge with in-riser rotary microfilter
  - Removes cesium from RMF filtrate with CST ion-exchange column
- **RMF returns concentrated solids (i.e., MST and entrained sludge) to waste tank**
- **Loaded CST ground to reduce its size and transferred into a waste tank (e.g., Tank 40H, 41H or 51H)**
- **MST, sludge, and CST (if transferred to Tank 41H) will be periodically transported to sludge tank, and ultimately transported to DWPF**

SCIX Process

Basic Operating Strategy

1. Add MST to waste tank
2. Mix tank contents
3. Filter sludge and MST/actinides from salt solution through the RMF
4. Pass clarified salt solution through ion exchanger
5. Transfer decontaminated salt solution to Saltstone Processing Facility
6. Transfer sludge and MST/actinide tank heel to DWPF (when necessary)
7. Transfer spent ion exchange media to DWPF (when necessary)



MST: Monosodium Titanate RMF: Rotary Micro-filter CST: Crystalline Silicotitanate IXC: Ion Exchange Column

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Introduction (cont.)

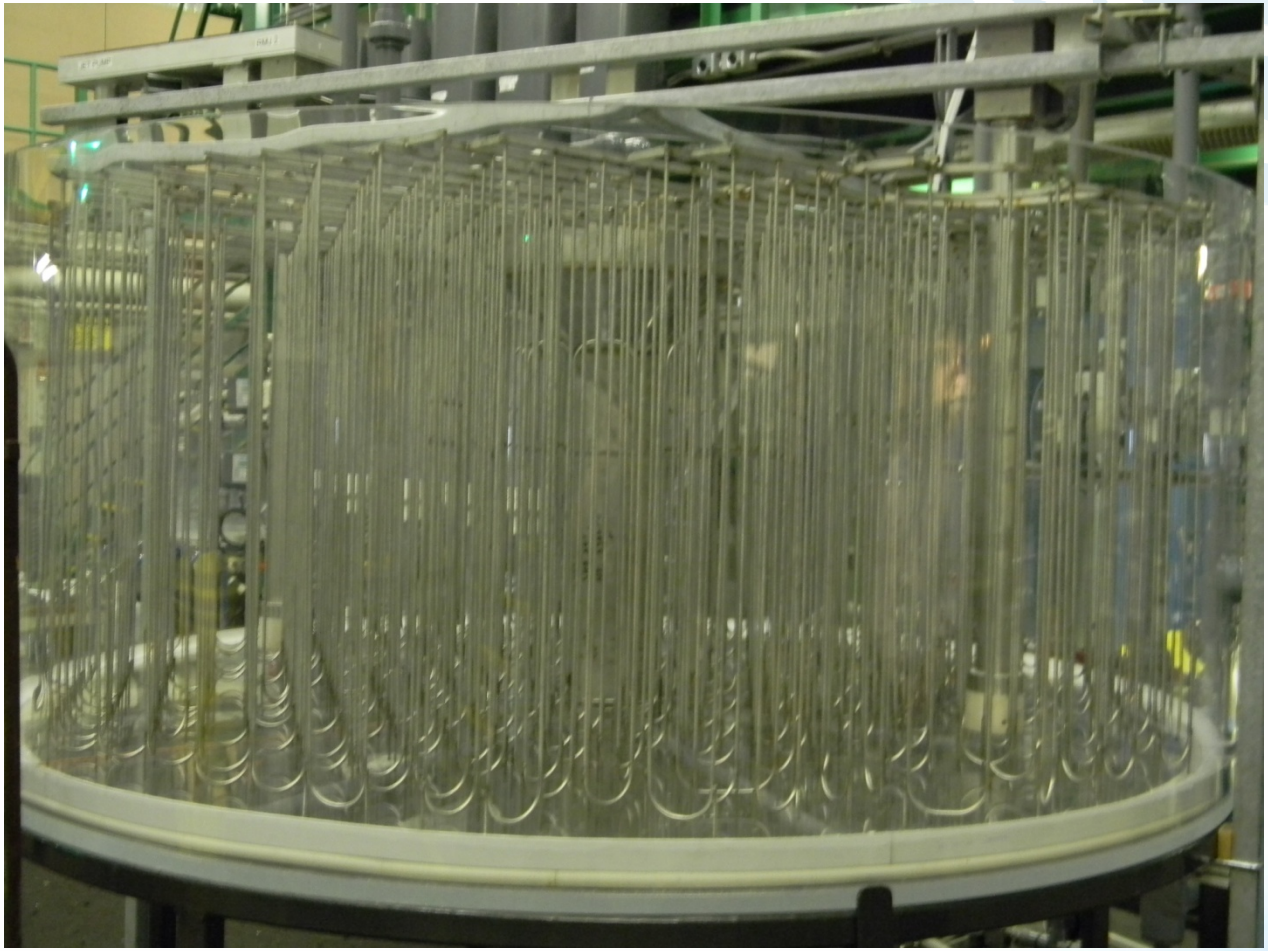
- **Mixing, resuspension, and transport of solid particles necessary for successful implementation of SCIX**
  - Suspend MST for strontium/actinide sorption
  - Remove settled solids from tank
    - Prevent tank closure problem
- **Previous SRNL and ORNL testing showed sludge and MST slurries that sat for extended times at high temperatures developed high shear strength**
- **Objectives of Pilot-Scale Testing**
  - Determine pump parameters required to initially suspend MST for Sr sorption
  - Determine time required for Sr sorption
  - Determine pump parameters required to resuspend settled solids (MST, CST, Sludge)
- **Consistent with SCIX Technology Maturation Plan**

Pilot Scale Test Facility Design

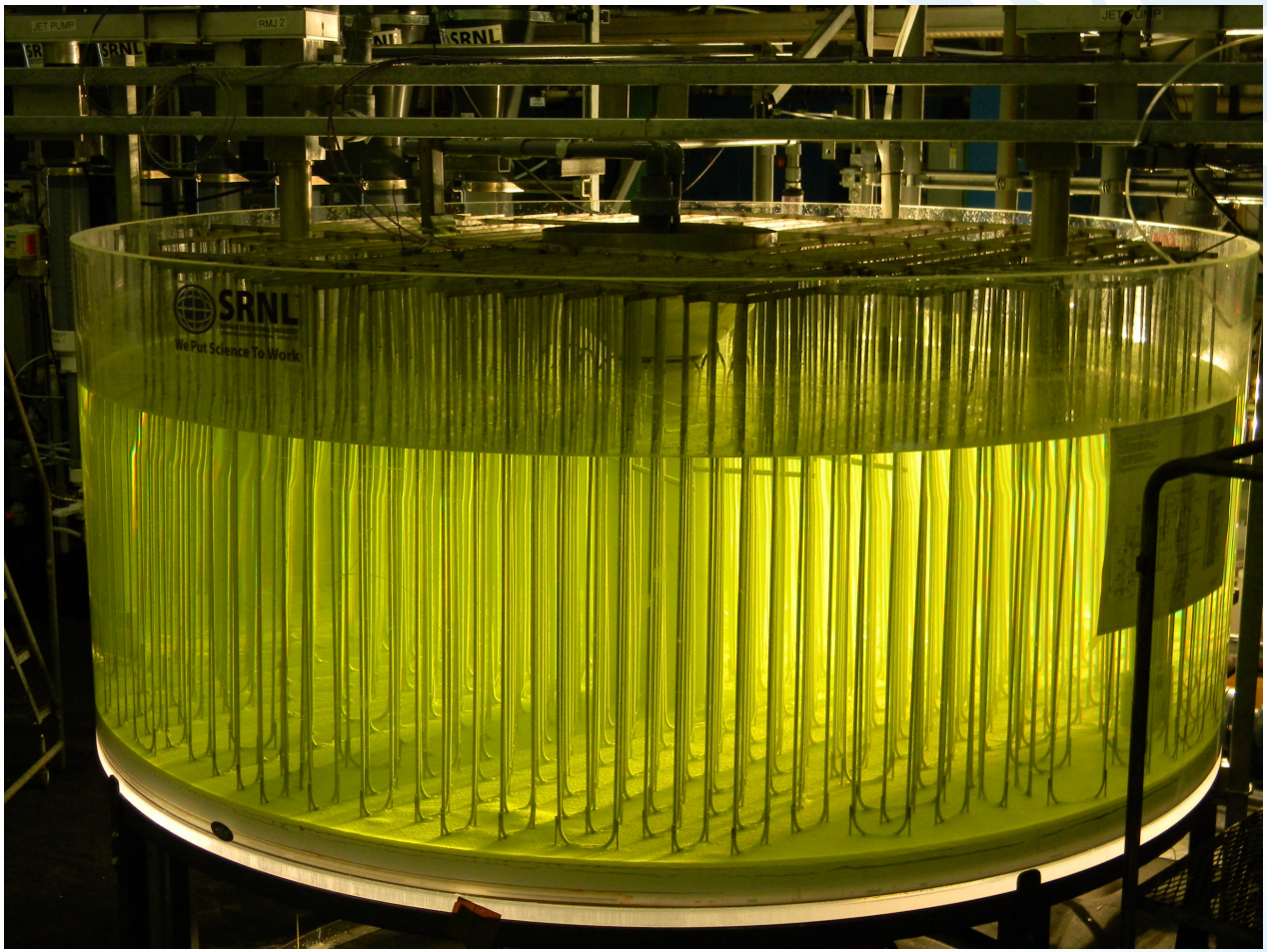
- **Scaled tank (~1/10th geometrically scaled), 8' DIA, 41" H**

  (*minimum recommended for pilot scale mixing)*
- **Made of 1" thick acrylic for visual observations**
- **Tank bottom heated through transparent heating jacket at bottom (up to 45 °C)**
- **Prototypic cooling coils and tank center column**
- **Two or three rotating mixing pumps with interchangeable pump heads located at appropriate risers**
- **System capable of achieving jet velocities of up to 80 ft/s**
- **Cleaning radius measured directly through the clear tank bottom at three different radial locations for each pump**

Pilot-Scale Waste Tank



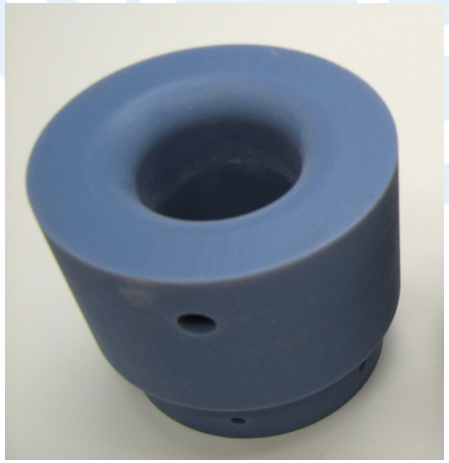
Pilot Scale Tank with Salt Solution and Settled MST

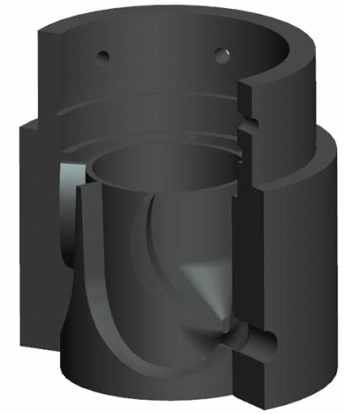


Test Outline

1. **Perform visual initial suspension tests using three different mixing pump heads**
   - Submersible Mixing Pump (SMP)
   - Quad Volute Pump
   - Standard Pump
2. **Perform MST sorption tests with five MST strikes**
3. **Perform resuspension tests with varying settling times**
   a) MST in salt solution
   b) MST and CST in salt solution
   c) MST, CST and sludge in salt solution

This talk describes Tests 1 and 3a





MST Initial Suspension/Resuspension Test Protocol

- **Add solid particles to tank**
  - MST, CST, and/or simulated sludge
- **Allow particles to settle for specified time at specified temperature**
  - Overnight and 25 °C
  - 4 weeks and 45 °C
- **Start pilot-scale pumps at low flow rate and measure cleaning radius**
- **Increase flow rate, measuring cleaning radius as function of U_0D, until all particles suspended or maximum U_0D reached**

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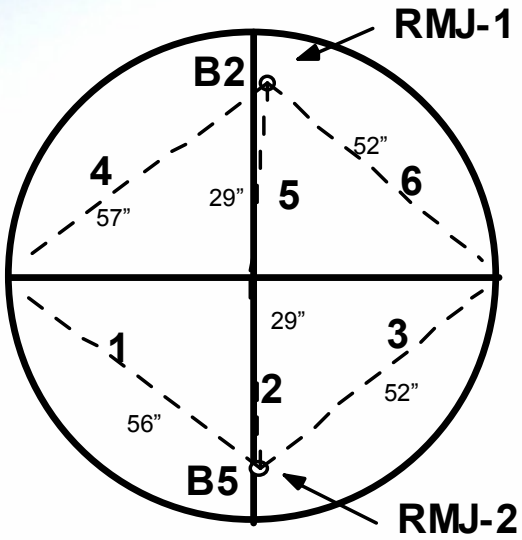
Scaling Test Data – MST Suspension

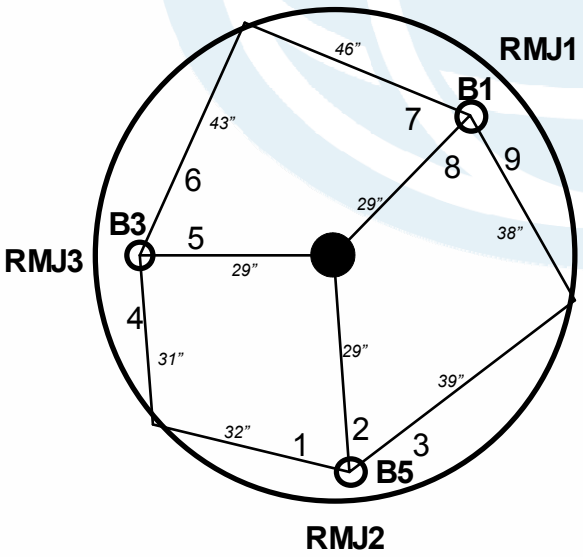
- **Need to scale test results to full-scale tank**

  $$U_{0\text{-full-scale}} = U_{0\text{-pilot-scale}}[T_{\text{full-scale}}/T_{\text{pilot-scale}}]^n$$

- **Equal Jet Velocity**
  - $n = 0$
  - $U_{0\text{-full-scale}} = U_{0\text{-pilot-scale}}$
- **Equal Shear Stress**
  - $n = 1/23$ or $1/9$
  - $n = 1/9$ most conservative
  - $U_{0\text{-full-scale}} = 1.3\ U_{0\text{-pilot-scale}}$
- **$U_{0\text{-full-scale}} = 1.3\ U_{0\text{-pilot-scale}}$ applicable to this case and most conservative**
- **SRNL Internal Panel reviewing scaling**

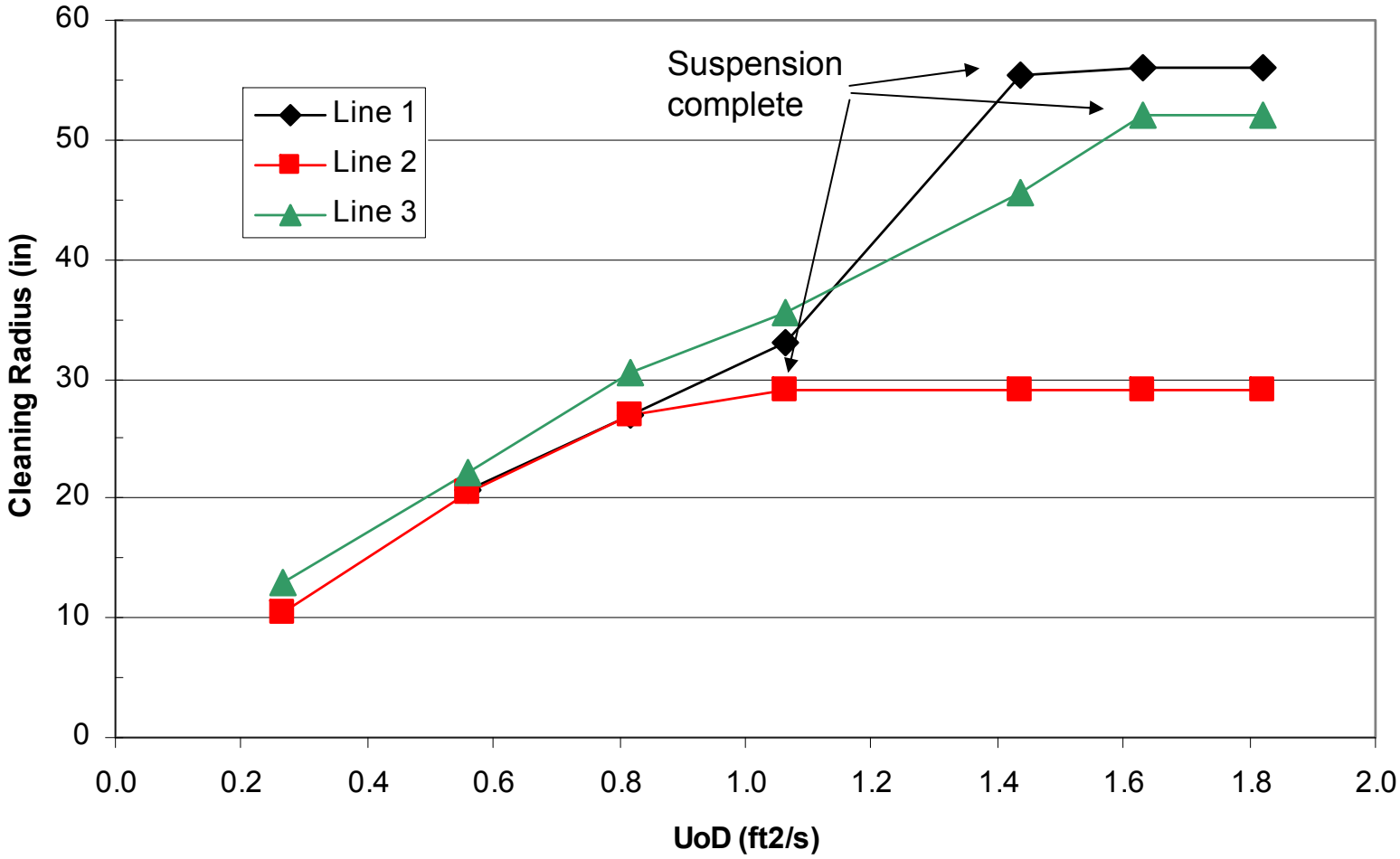
Cleaning Radius Measurement Locations





- Measure cleaning radius along each of the radial lines
- Required cleaning radius varies
- Recorded cleaning radius based on minimum of those measured that are less than distances indicated

Sample Cleaning Radii with 2 SMPs



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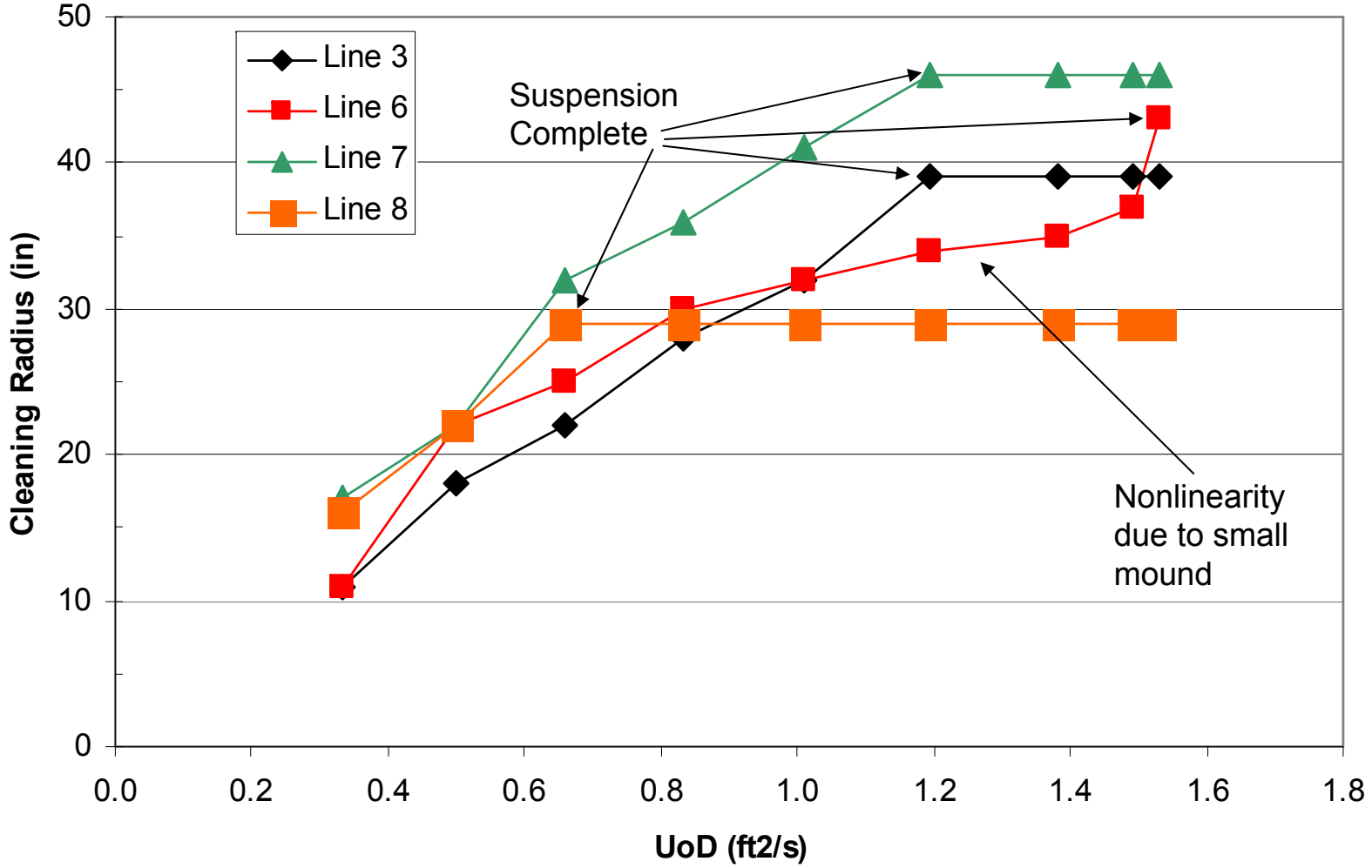
Sample Cleaning Radii with 3 SMPs



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Pump Parameters Needed to Initially Suspend MST

Pump	2 Standard	2 Quad Volute	2 SMP
$U_0D_{pilot\text{-}scale}$	Did not suspend	1.56 ft^2/s (56.1 ft/s)	1.82 ft^2/s (53.6 ft/s)
$U_0D_{full\text{-}scale}$ (n = 1/9)	Will not suspend	22.05 ft^2/s (73 ft/s)	25.7 ft^2/s (70 ft/s)
Max $U_0D_{full\text{-}scale}$	13.6 ft^2/s (109 ft/s)	21.7 ft^2/s (72 ft/s)	29.0 ft^2/s (79 ft/s)

MST Resuspension Test

Pump Parameters Needed to Resuspend MST after Settling for Four Weeks at 45 °C

Pump	2 SMP
$U_0D_{pilot\text{-}scale}$	2.40 ft^2/s (70.6 ft/s)
$U_0D_{full\text{-}scale}$ (n = 1/9)	33.7 ft^2/s (92 ft/s)
Max $U_0D_{full\text{-}scale}$	29.0 ft^2/s (79 ft/s)

Pump Parameters Needed to Initially Suspend MST (3 Pumps)

Pump	3 SMP	3 Quad Volute (pred.)
$U_0D_{pilot\text{-}scale}$	1.53 ft^2/s (45.1 ft/s)	1.53 ft^2/s (55.0 ft/s)
$U_0D_{full\text{-}scale}$ (n = 1/9)	21.6 ft^2/s (59 ft/s)	21.6 ft^2/s (71.5 ft/s)
Max $U_0D_{full\text{-}scale}$	29.0 ft^2/s (79 ft/s)	21.7 ft^2/s (71.8 ft/s)

Conclusions

- **Two standard slurry pumps will not provide sufficient power to suspend MST in SRS waste tank**
- **Two Quad Volute slurry pumps will not provide sufficient power to suspend MST in SRS waste tank**
- **Two SMPs will provide sufficient power to suspend MST in SRS waste tank**
  - Required pump discharge velocity is very close to maximum discharge velocity of pump (within 12 %)
- **Two SMPs will not provide sufficient power to resuspend MST that has settled at 45 °C for four weeks**
- **Three SMPs will provide sufficient power to suspend MST in an SRS waste tank**
  - Required pump discharge velocity is 75% of maximum discharge velocity of pump

Path Forward

- **Perform MST resuspension tests with three pumps**
  - 4 weeks
  - 45 °C
- **Perform MST+CST resuspension tests with three pumps**
  - 4 weeks
  - 45 °C
- **Perform MST+CST+sludge resuspension tests with three pumps**
  - 4 weeks
  - 45 °C