Use of a Power Fluidic Low Level Mixer to Improve the Efficacy of Enhanced Chemical Cleaning

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Overview and Summary

Current baseline approach to heel retrieval in large underground storage tanks is chemical dissolution using oxalic acid

Effectiveness of the process is dependent upon contact time between acid and heel

- **Need prolonged and efficient mixing throughout tank volume**

Standard mixer pumps cease operation when tank level drops below 30 inches

- **Need for low level mixing system**

Power fluidic mixing systems can operate down to as low as 1-2" from tank floor

- **Objective of this large scale demonstration is to prove principle of operation of fluidic mixer for Enhanced Chemical Cleaning**

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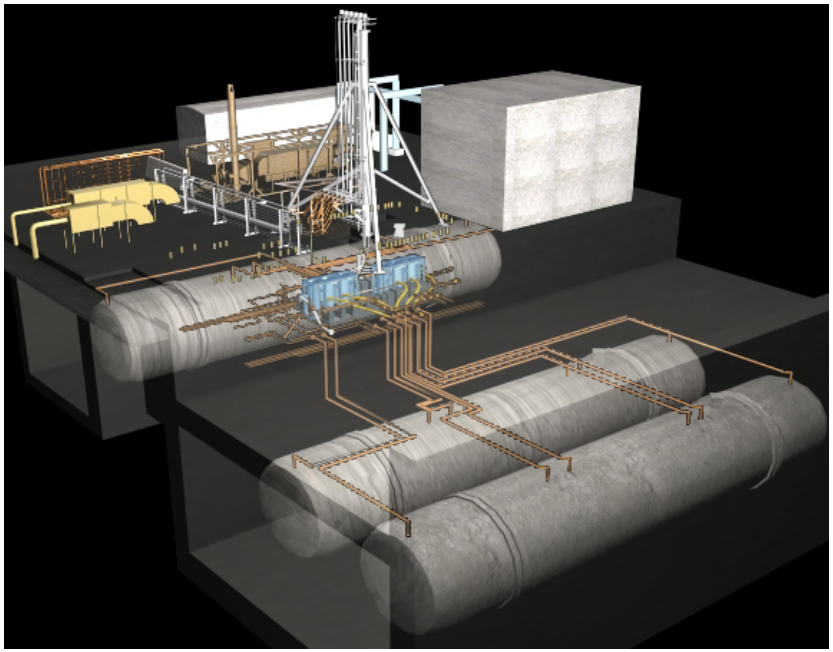
Power Fluidics ™

Principal: use clean air to move radioactive fluids

Deployed systems worldwide

- Oak Ridge [C-Tanks, W-Tanks]
- Idaho [TRA Tanks]
- Los Alamos [TA-50, Generals]
- Hanford [WTP, CTF]
- Savannah River [FPT-1]
- Sellafield, UK
- Chalk River, Canada



Applications

- Mixing
- Transfer
- Mobilization
- Agitation
- Sampling
- Sluicing
- Washing

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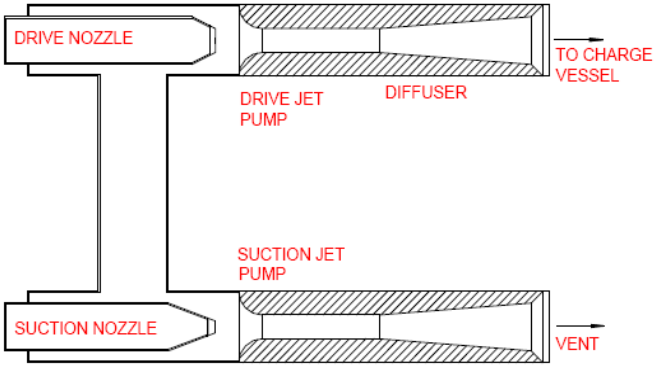
Power Fluidics ™

Typical System Elements

- **Jet Pump Pair**
- **Charge Vessel**
- **Process Valves**
- **Barometric Protection Tower**
- **Reverse Flow Diverter**
- **PRESCON™ Controls**
- **Discharge Nozzle**
- **Wash Nozzles**



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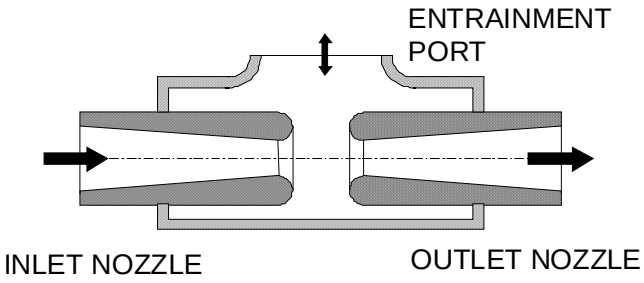

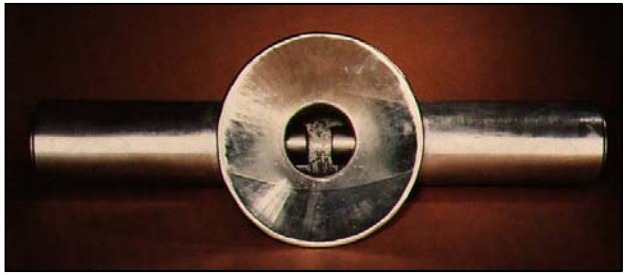

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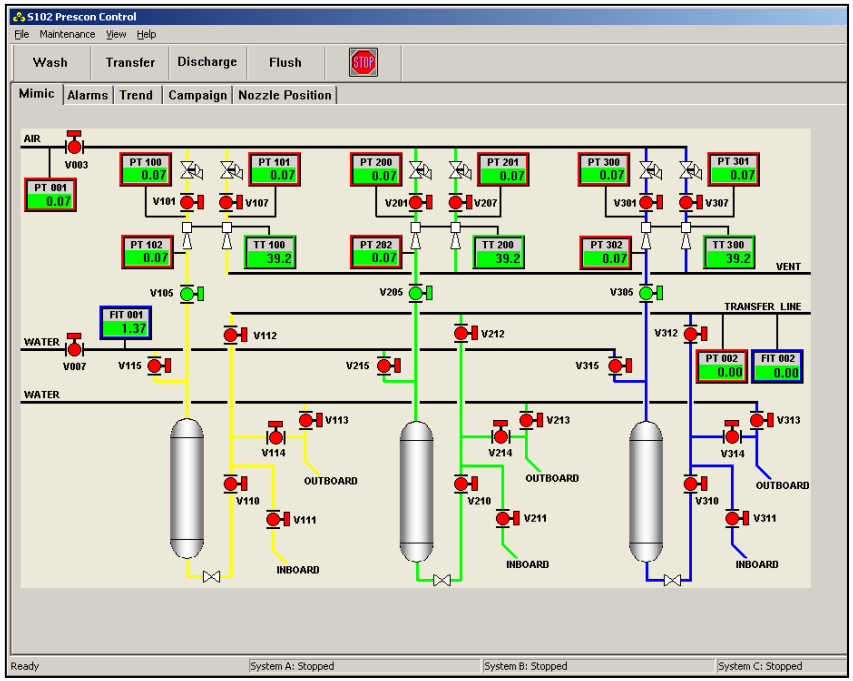

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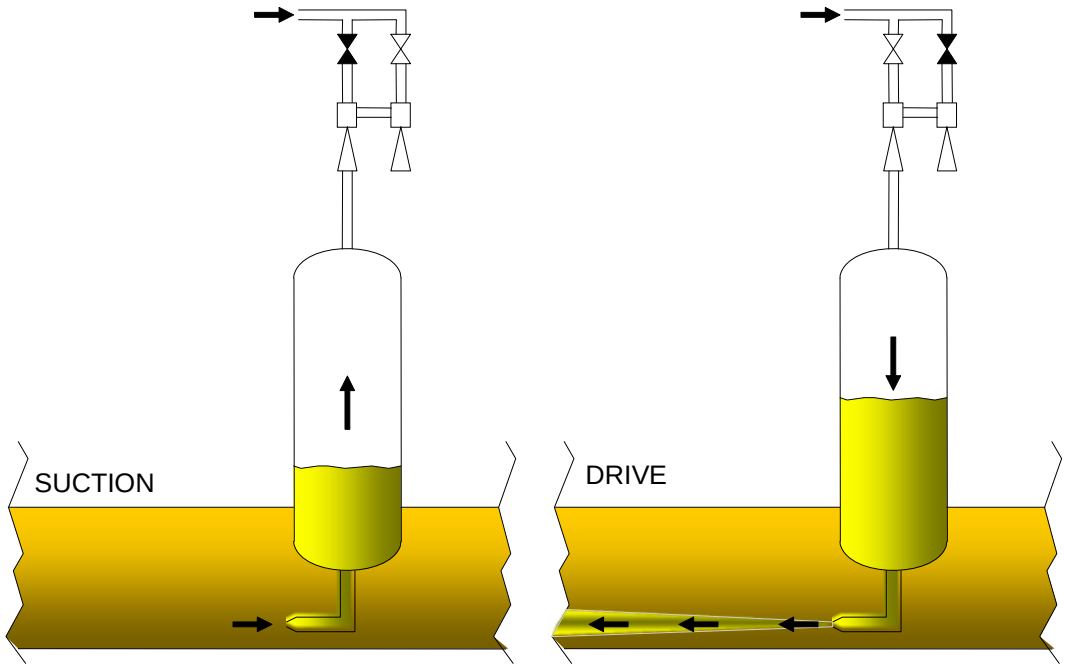
Power Fluidic System Operating Cycle

Suction phase
Drive phase
Vent phase



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Power Fluidics ™

Typical System Configurations

Process Valves

- Packaged in ISO container
- Clean equipment

PRESCON Controller

- Packaged in Control Station
- Remote operation

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Typical System Configurations

Charge Vessel adjacent to or inside tank

- **Hot equipment co-located in ISO container**
  - Jet Pump Pair
  - Charge Vessel
  - Barometric protection tower
- **Tower maintains barrier**
- **No moving parts in tank**
- **Shielded container**

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Typical System Configurations

Charge Vessel located adjacent to tank

Charge Vessel located inside tank

- **Hot equipment located in tank**
- **Rely on isolation valves for barrier**
- **Requires valves in the tank**
- **Jet Pump located in dedicated skid or in tank**
- **Limits CV dimensions vs. riser**

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Typical System Configurations

Standard In-Tank Equipment

- RFD's
- Discharge Nozzles
- Wash Nozzles
- Cameras
- No moving parts in contact with waste
- Above or below liquid discharge

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Typical System Configurations

Off-Gas HEPA Filtration

- Skid mounted
- Manages vent air
- Vs. existing tank ventilation

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Power Fluidics ™

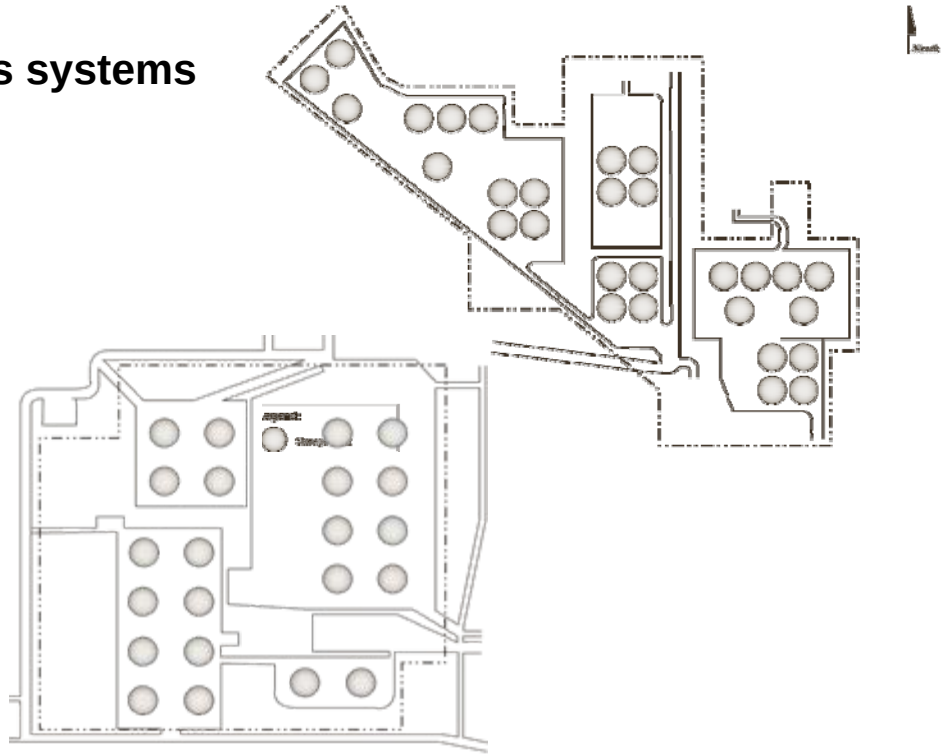
Power Fluidic System = Life Cycle Cost Advantage

Re-Deployable Equipment

- Process, control, and off-gas systems
- Majority of system cost
- Little to no decontamination
- Small re-deployment cost

Replacement Equipment

- Charge vessel and nozzles
- Low cost content
- Unique to each tank



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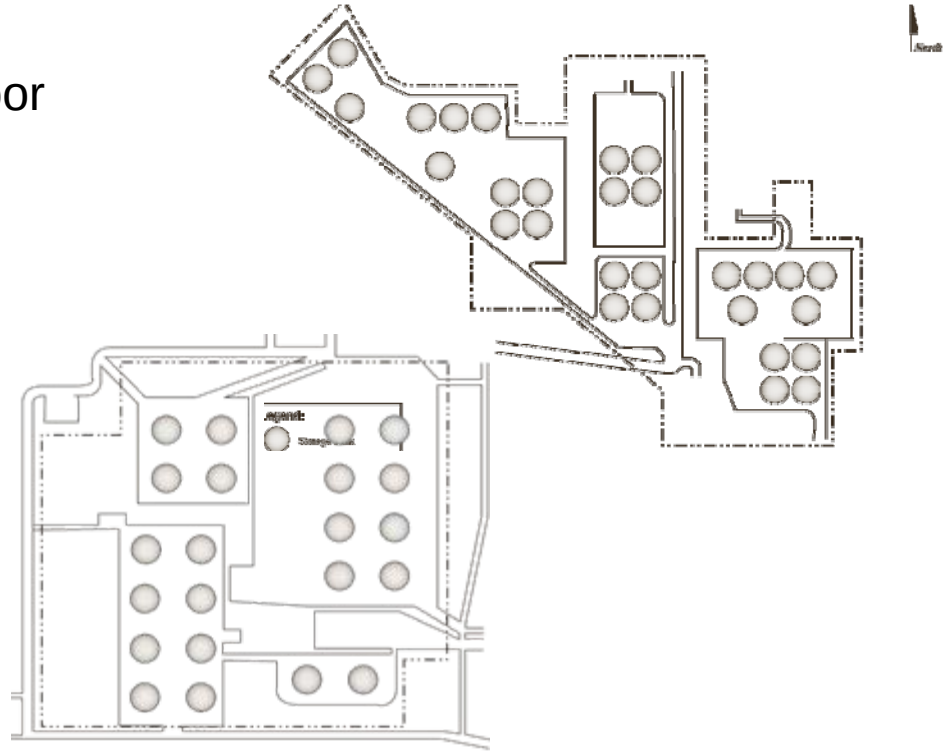
Enhanced Chemical Cleaning Application

Enhanced Chemical Cleaning

- **Targets residual waste**
  - Solids, sludges on tank floor
- **Process:**
  - 1% Oxalic acid (dilute)
  - 12” to 24” acid depth
  - Maintain reaction rate
  - 6+ month campaign



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ECC Application

ECC Mixing Duty

- **HLW Type I tanks**
  - Limited number of risers
  - Obstructed by cooling coils
  - Obstructed by tank support columns

- **Success criteria**
  - Provide sufficient bulk fluid velocity to refresh acid boundary layer, move particles from reaction site, and maintain reaction rate
    - Scalar velocity = 0.2 ft/sec
    - Sequence of sweeps to reach majority of tank
    - Homogenous mixing not required

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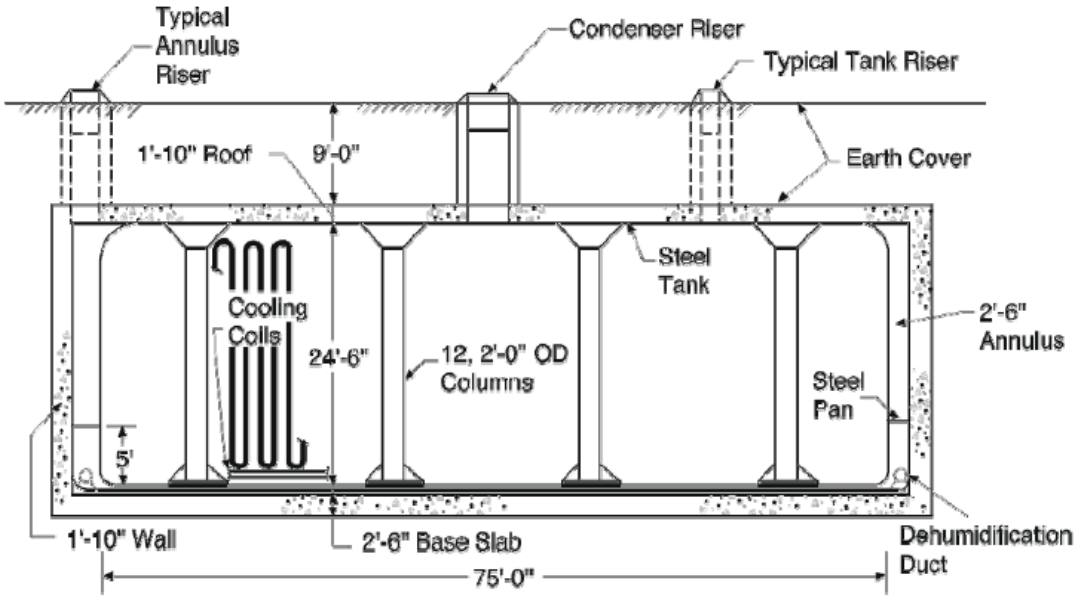
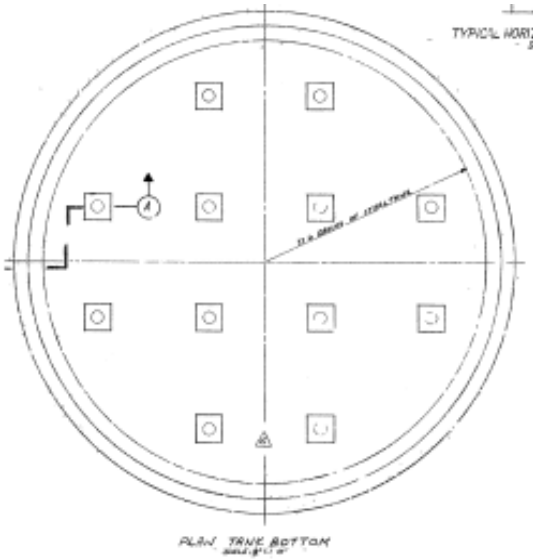
ECC Application

HLW Type I tanks





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NuVision Engineering Demonstration Program

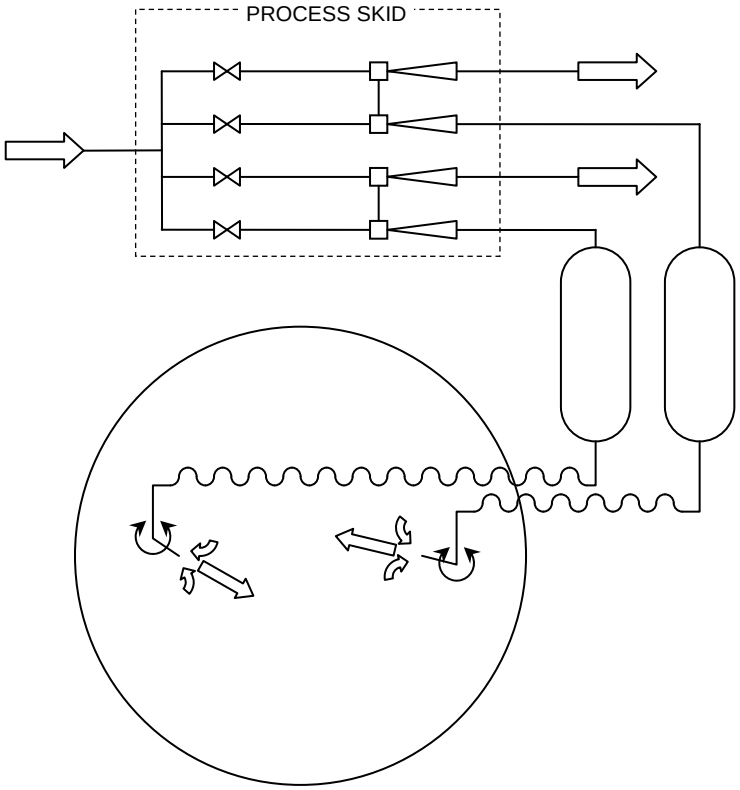
Demonstrate capability of Power Fluidic mixing system to improve contact-time between heel and acid

Design & Fabricate

- **System specific to ECC application**
- **Support ECC value proposition**

Validate performance at near full scale

Provide CFD analysis to confirm



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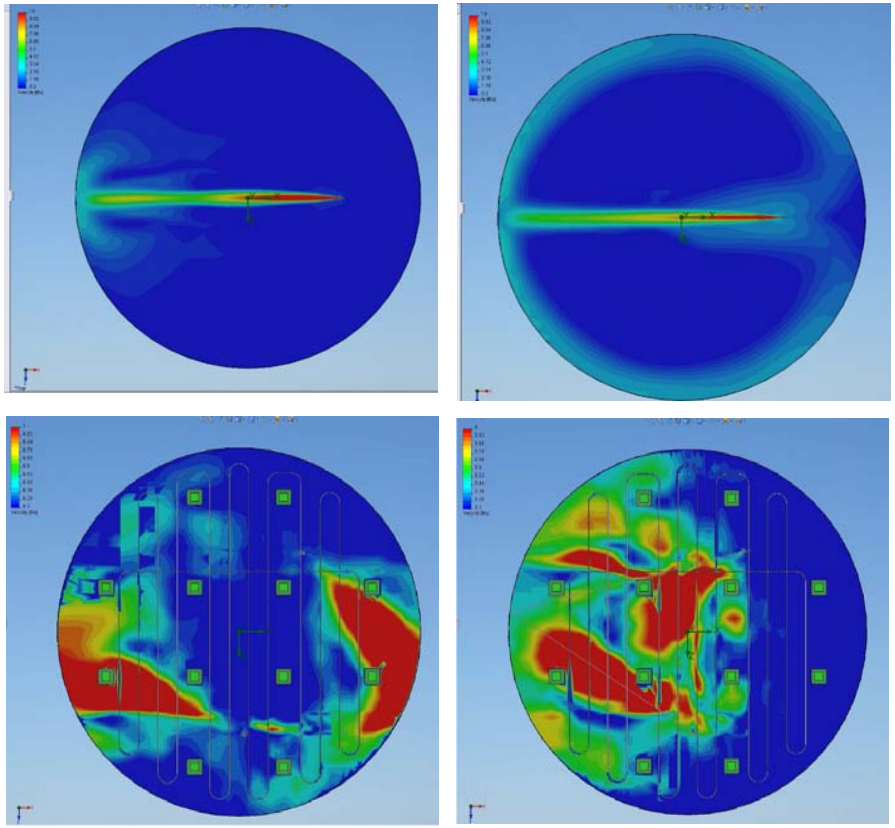
Computational Fluid Dynamics

Previous Work

- **Single Phase**
- **Closed Surface**
- **Limited mesh geometry**
- **EFD.Lab**

Future Work

- **FIU DOE Fellows**
- **Two Phase**
- **Open Free Surface**
- **FLUENT**



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NuVision Engineering Demonstration Program

System Configuration

Two Mixing Systems

- (2) Jet Pumps
- (2) Charge Vessels
- (2) Discharge Nozzles
- (1) Integrated Controller

- Charge Vessels
  - Located outside tank for Demo
  - Located inside tank for Deployment
- Horizontal Discharge Nozzles
  - Located in tank below fluid
  - Rotate about vertical riser axis
- Process Skid / Controller
  - Open frame skid for Demo
  - Will be in ISO container for deployment

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Demonstration Scaling

Near full scale (80% Linear)

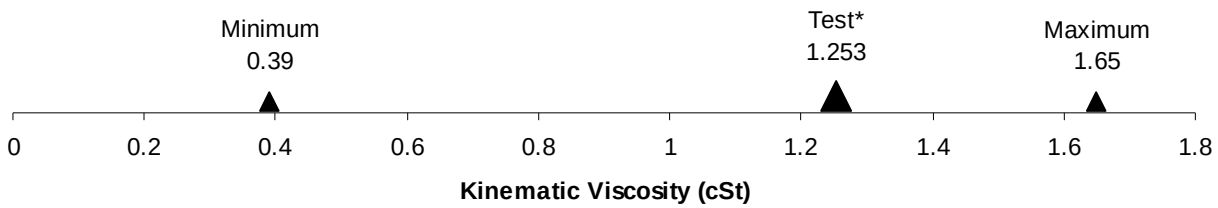
Maintain dynamic similitude

- **Reynolds Number**
- **Strouhal Number**
- **Inertia / Pressure Force Ratio**

Conservative test

Scaled parameters

- **Tank diameter**
- **Nozzle diameter**
- **Discharge / Suction phase time**
- **Charge Vessel volume**



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NuVision Engineering Demonstration Program

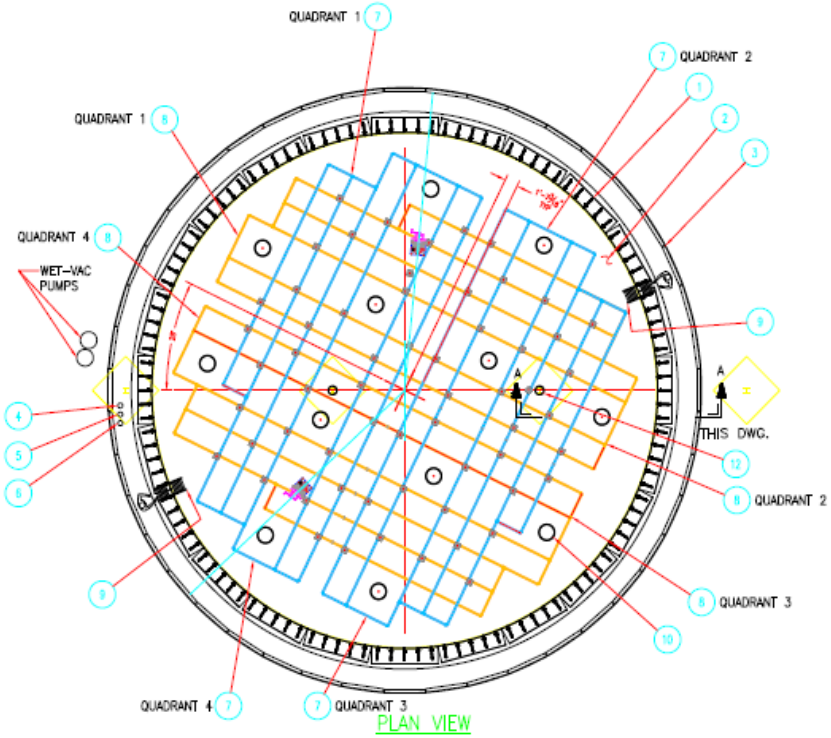
Demonstration Site

60Ft Diameter Test Tank

- **Up to 3 ft depth capacity**
- **55,000 Gal water**
- **Temporary Wood/PVC Liner**

Leak Detection & Handling

- **Leak detection cables**
- **VacuBoom annulus system**
- **Submersible pumps**



Layout based on Tank 8

Obstructions

Bottom 2 layers of cooling coils

Columns

Maintain riser locations

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Demonstration Site

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Performance Verification

Campaigns

- Single nozzle plume characteristics
- Tank wide convection cells
- Coordinated targeted sweeps

Data

- Scalar velocity [0.2 ft/sec]
- Qty. 5 Thermal flow meter devices
- Data collection

Visualization

- Flow streamers
- Indicate flow patterns

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Test Program

- **Multiple Campaigns Planned**
  - Single Jet, Fixed location
  - Multiple Jets, Simultaneous, Fixed location
  - Multiple Jets, Alternating pulses, Fixed location
  - Multiple Jets, Circulating Flow

Demonstration

- **Planned for July at Mooresville, NC location**

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Questions?

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