Waste Properties for Simulant Development

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EM Waste Processing
Technical Exchange
Atlanta GA
Nov 16-18, 2010

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Agenda

- Hanford Waste Design Basis and Gap Analysis
- Development of New Methods
- Summary

Hanford Waste Design Basis and Gap Analysis

- Update waste slurry/sludge property bases
  - Particle size distribution (PSD)
  - Particle size and density distribution (PSDD)
  - Rheology
  - Solid settling behavior
- Complete a data gap analysis
  - Tanks and waste types
  - Analytical methods
  - Data analysis methods

Need/Benefit

- Waste properties are needed to develop appropriate simulants:
  - DNFSB concern: “Without further comprehensive waste characterization, the uncertainties associated with the range of particle sizes, densities and fluid viscosities remain” (1)
- Lack of accurate waste properties can lead to inadequate simulants and designs
- Large uncertainties can lead to inadequate or excessive conservatism in designs

(1) DNFSB technical staff report regarding the Waste Treatment and Immobilization Plant Project Pretreatment Facility; Oct 7, 2010.

Approach

- Identify key waste properties needed for simulant specification:
  - Pipeline critical velocity
  - Solids settling velocity
  - Effective cleaning radius
  - Vessel wall/bottom erosion
  - Critical suspension velocity
  - Suspended solid cloud height
  - Suspended solid concentration
  - Filtration
  - Gas generation, retention and release
- Collect and analyze available data and identify data gaps
- Summarize results in a report

Examples of Waste Properties Significant to Waste Storage, Mobilization, Suspension and Transfer Operations

Phenomena		Waste Properties					
		Solids Density	Solids Size	Shear Strength	Liquid Density	Liquid Viscosity	Waste Chemistry
Solids Settling		2	1		3	3	
Critical Suspension Velocity	Meyer et al. (2009) model	1	3		2	4	
	Onishi (2008) model	3	3	1	2	3	
Suspended Solids Cloud Height	Meyer et al. (2009) model	1	3		2	4	
	Onishi (2008) model	2	5	1	2	2	
Suspended Solids Concentration	Meyer et al. (2009) model	1	3		2	4	
	Onishi (2008) model	2	5	1	2	2	
Jet Erosion of Wall			1				
Gas Generation, Retention and Release	Gas Generation/ Steady-State Release						1
	Gas Retention			3	1	2	
Effective Cleaning Radius				1	1		
Pump Suction*	Cohesive solids	√	√	√	√	√	√
	Non-cohesive solids	√	√		√	√	
Pipeline Critical Velocity		1	3		2	4	
Pipeline Erosion			1				
Solids Filtration			2			1	
Solids Dissolution							1

*: No specific order of importance is given
√: Important

Note: Relative Importance is based on value of exponential in correlations for each application.

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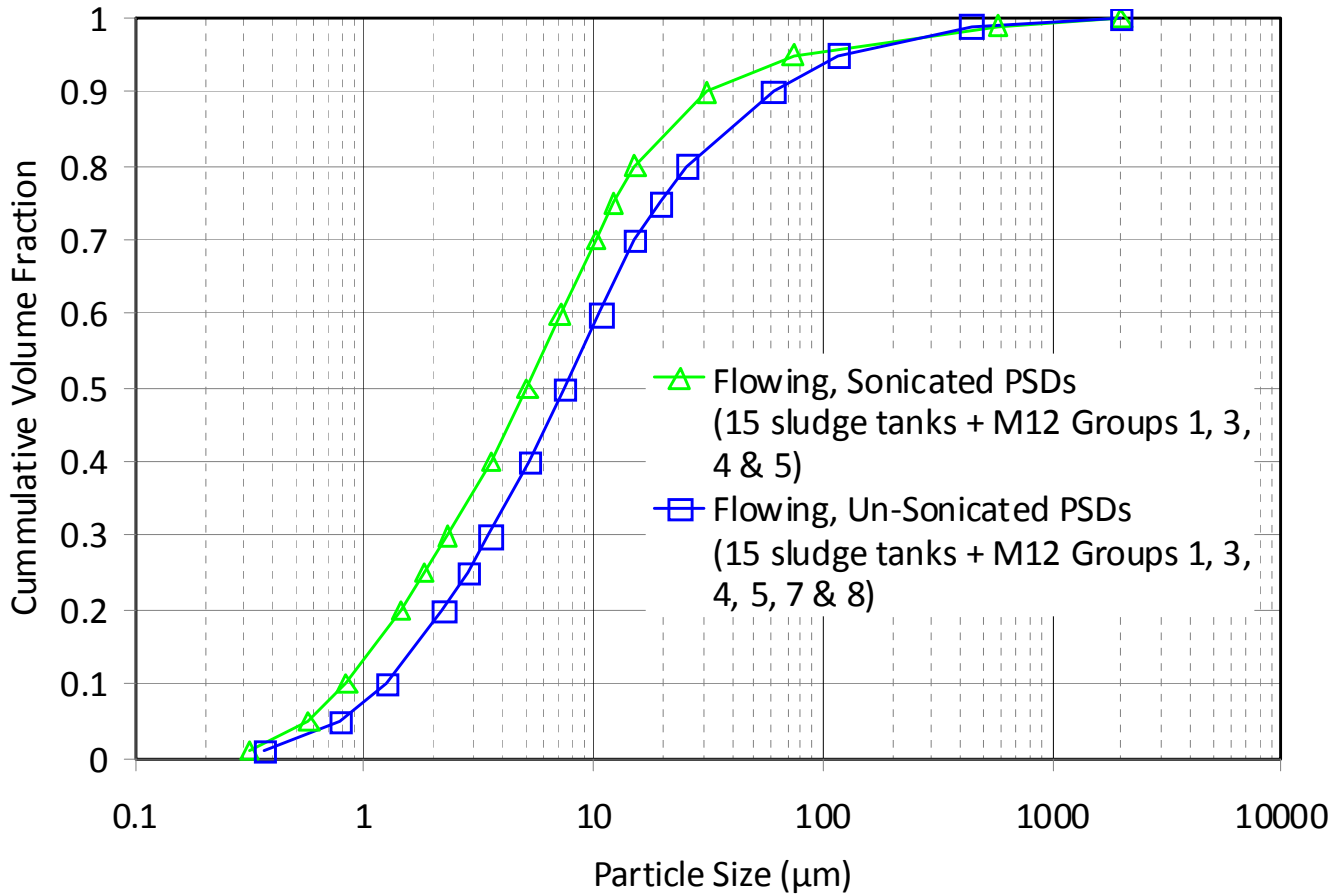
Composite Sludge PSD (solid size) Sonicated and Un-sonicated



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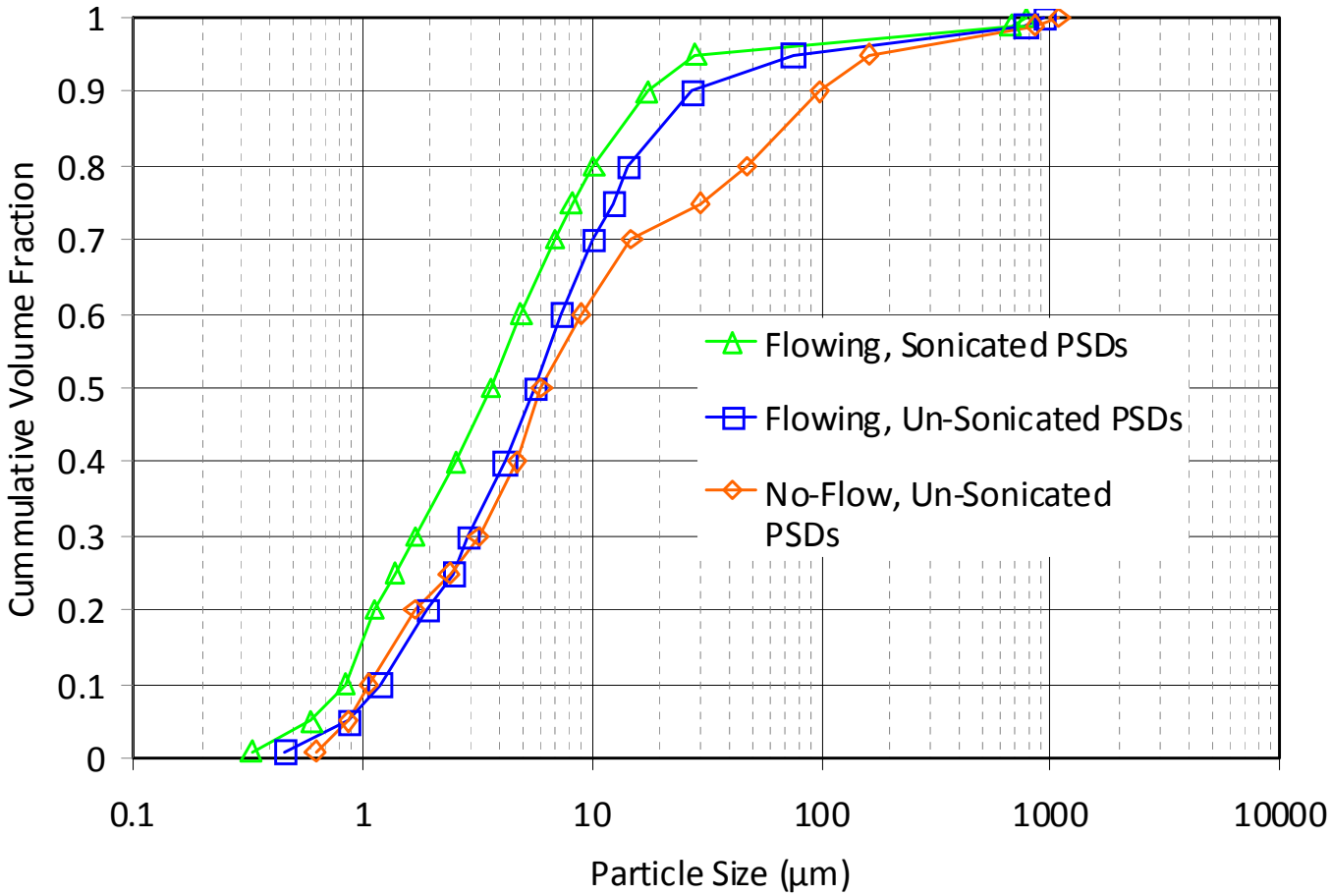
Composite Sludge PSD (solid size) Sonicated, Un-Sonicated, No-Flow



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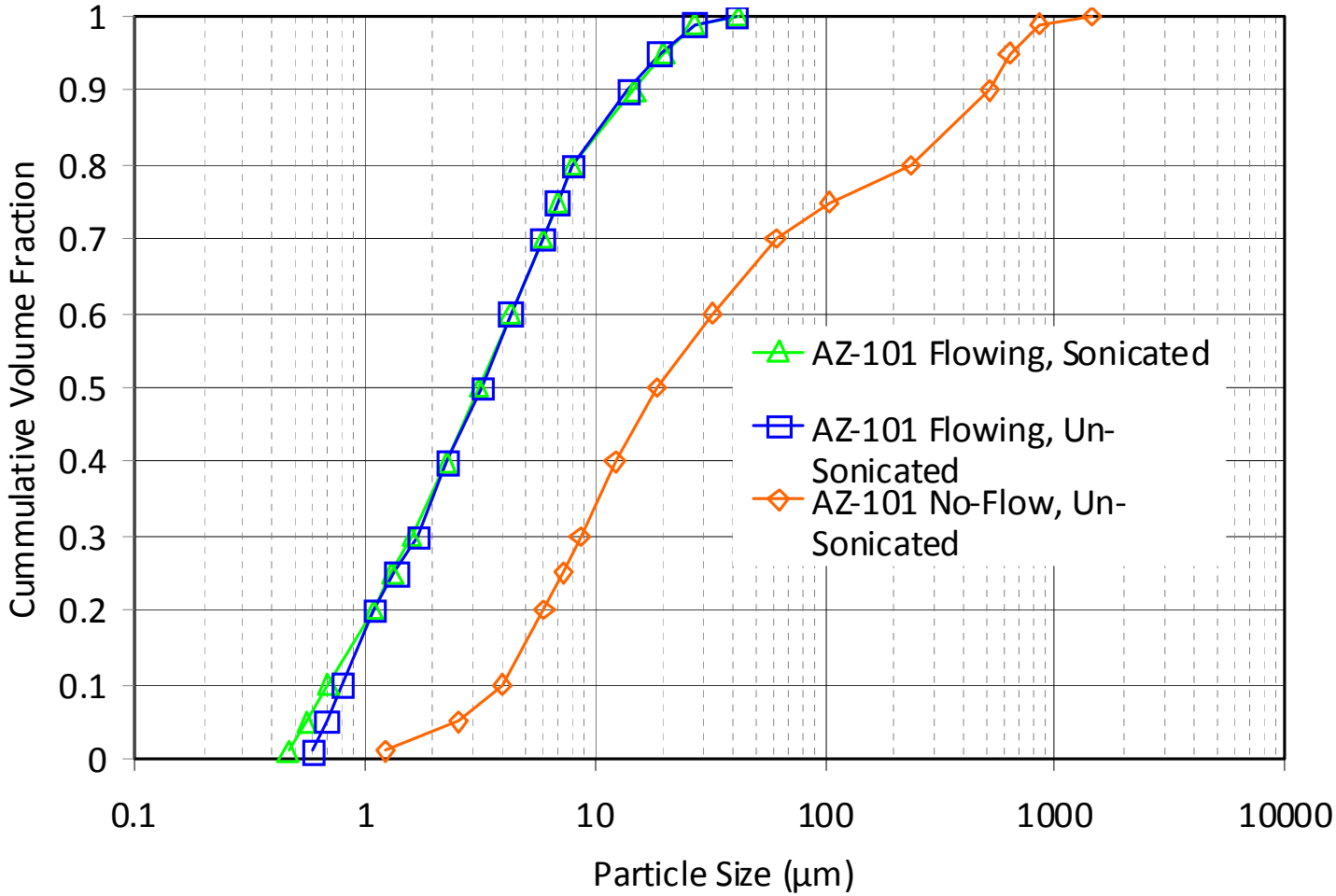
PSDs: AZ-101



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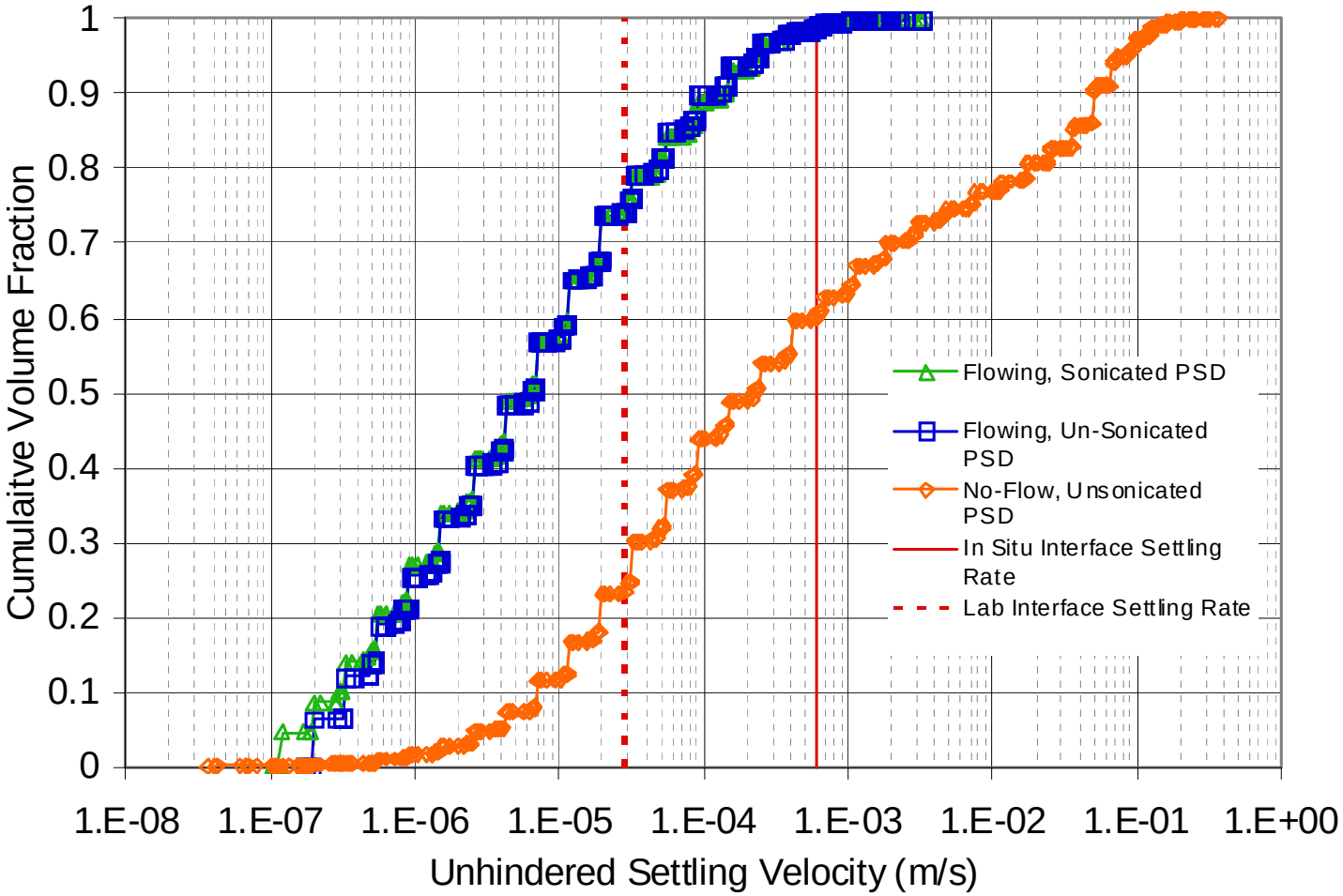
Settling Velocity: AZ-101 PSD Type



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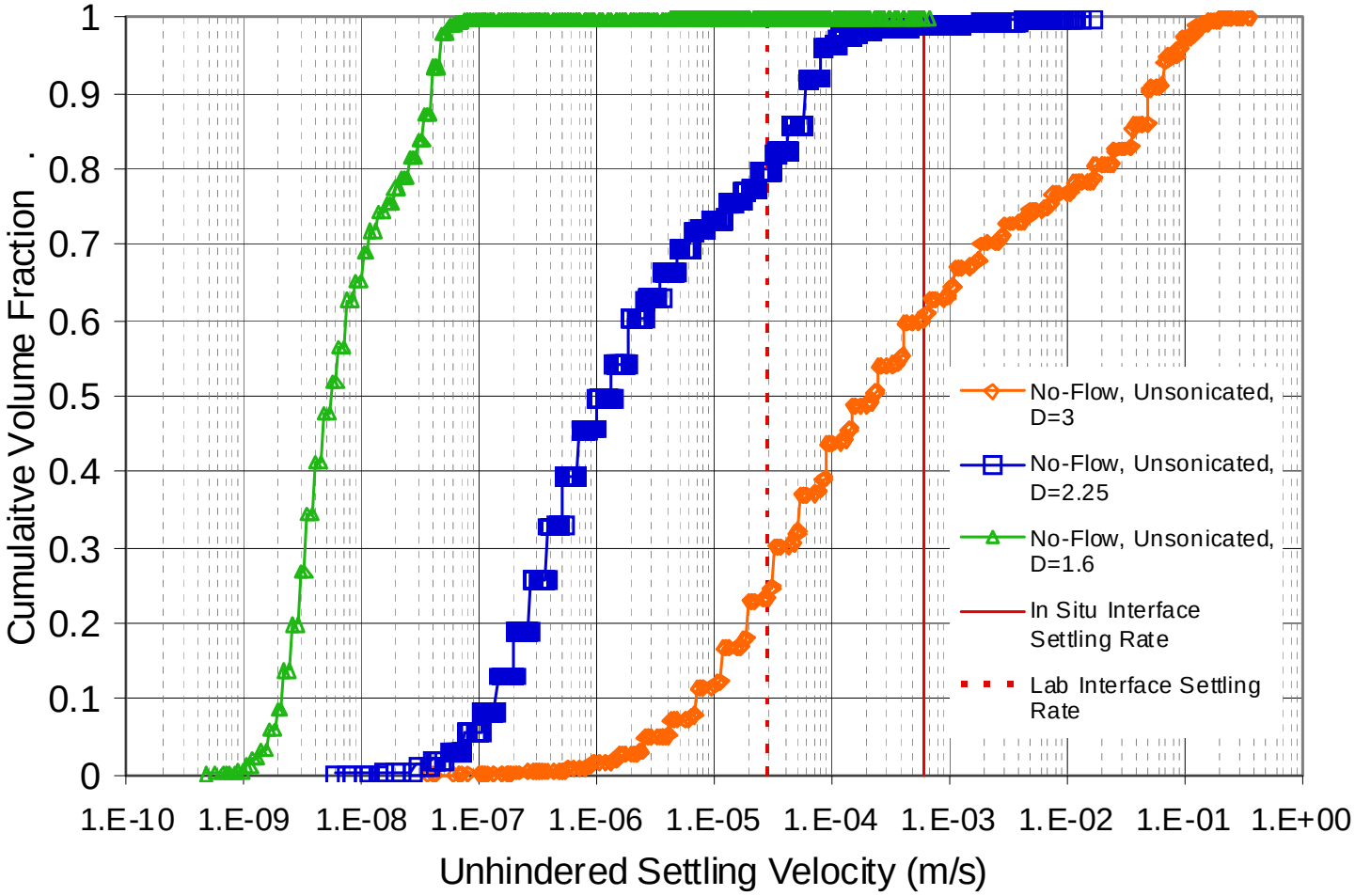
Settling Velocity: AZ-101 Fractal Dimension (D)



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Gaps (partial list)

- Characterization of tanks and waste types.
- Standard simulant(s) that are tank waste specific for assessing PSD instruments, accuracy, precision and uncertainty.
- Critical shear stress for erosion: used to estimate the rate at which cohesive sludge is eroded or mobilized.
- Shear strength as a function of time.
- Measure of solids agglomeration – fractal dimension.
- Density of amorphous solid phase compounds
  - ~50% of solids are amorphous and not identifiable by XRD, SEM, etc.
- Analytical method to simultaneously determine particle size and density distribution.

Development of New Method: Particle Size and Density Distribution Measurements

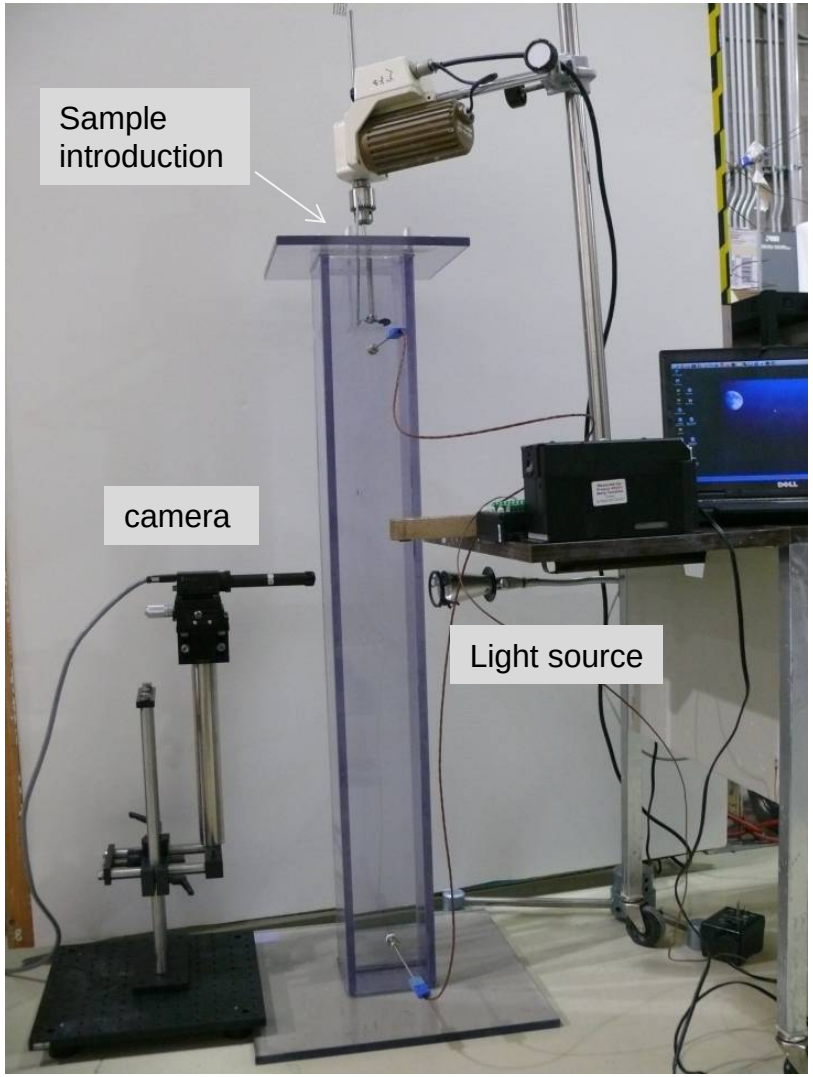
- Objective: Develop an analytical method to simultaneously measure particle size and density distribution in samples with mixed densities and particle sizes
- Need: *"Uncertainties in particle size and density present significant challenges for defining simulants to use in testing programs that ultimately define the design inputs and requirements for mixing in the Pretreatment Facility vessels"* *(1)*

(1) DNFSB technical staff report regarding the Waste Treatment and Immobilization Plant Project Pretreatment Facility; Oct 7, 2010.

Concept

- Completed literature review and industry survey
  - Technique similar to sedimentation image analysis appears most promising
  - SEM/EDS “automated feature analysis” and other solids analysis techniques are also useful
- Need to measure more than one attribute
  - Measure particle size and shape photographically
  - Determine density from settling velocity, particle size and shape

Capabilities of Particle Size and Velocity (PSVS) Test Stand



- Settling column: 4x4-in; 48-in tall
- Two Cameras: 118, 1000 Hz frame rate; resolution (~5 μm)
- Mixing chamber for sample introduction
- Two light sources: pulsed and continous
- Automated image capture and analysis system with commercially available software
- Dual temperature measurement

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Settling image (Proof of Concept)

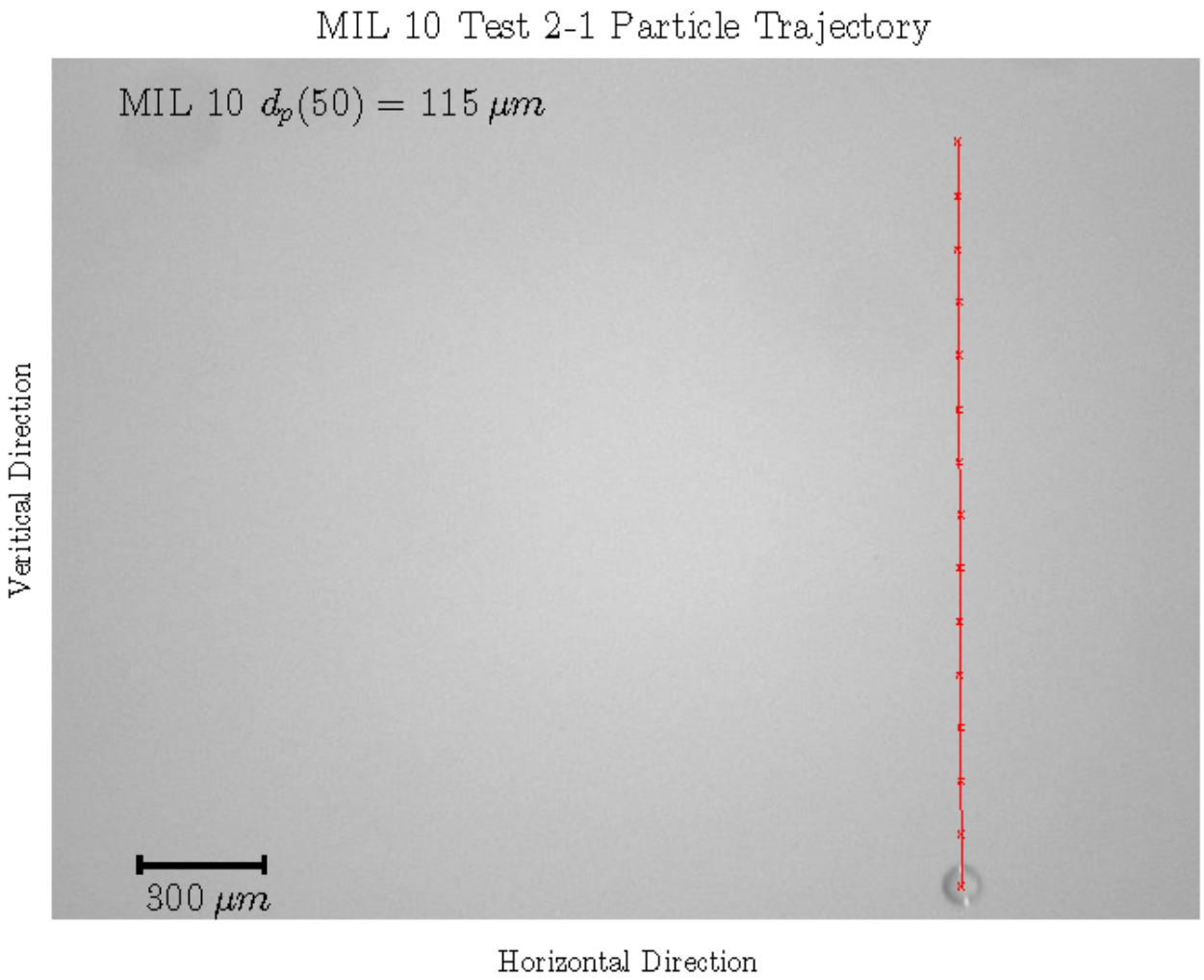

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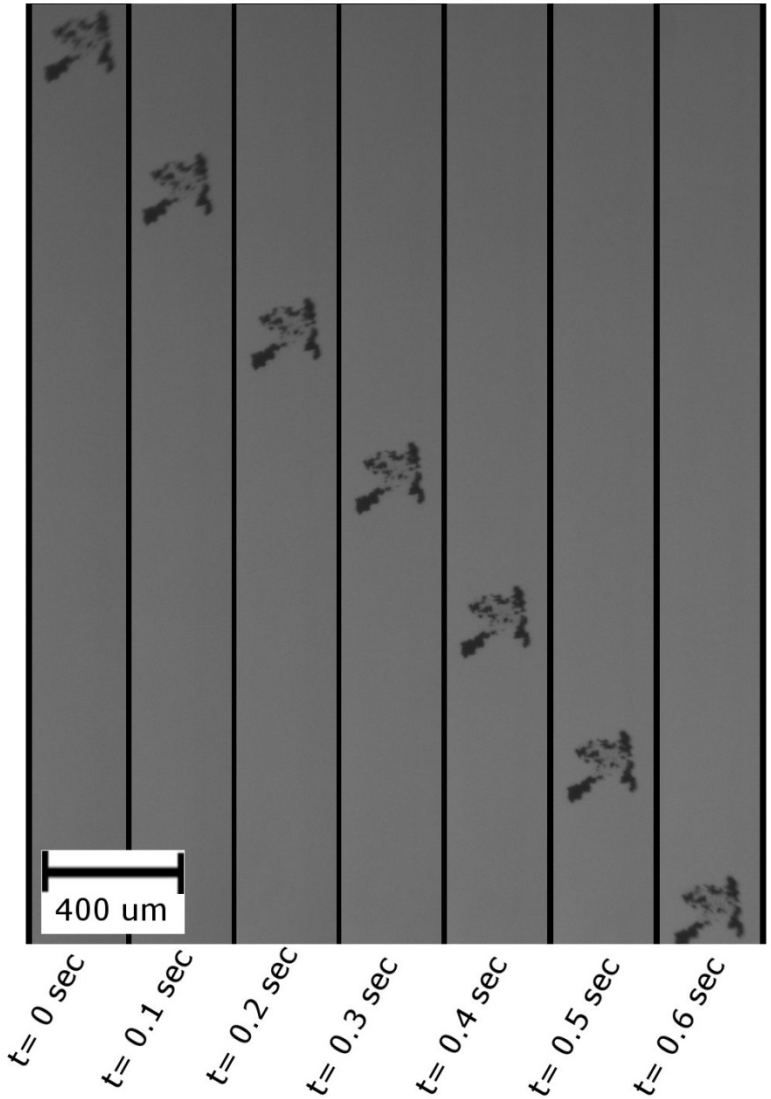
Image SequenceTungsten Carbide Agglomerate (Proof of Concept)



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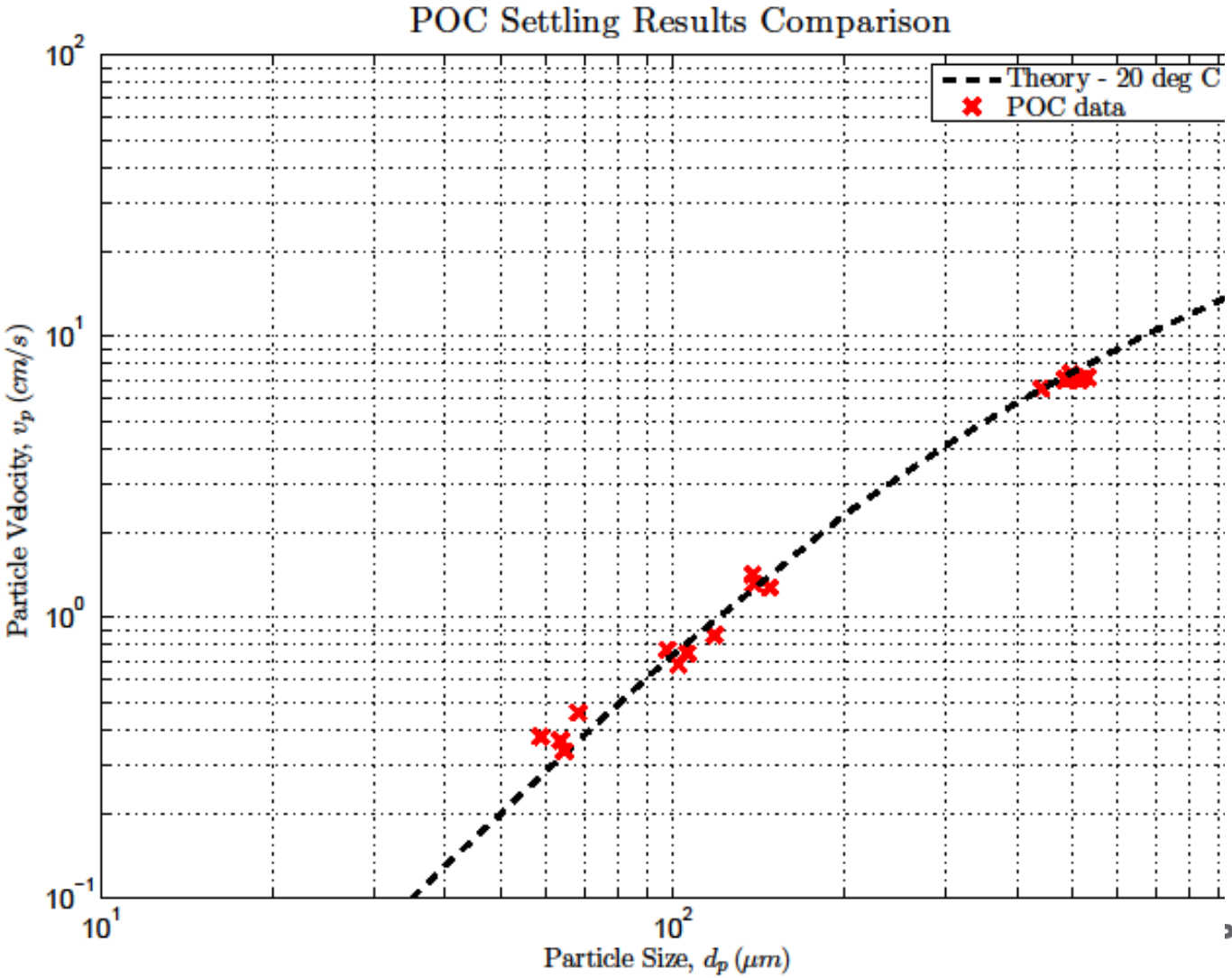
Settling Velocity Comparison to Correlations (Proof of Concept)



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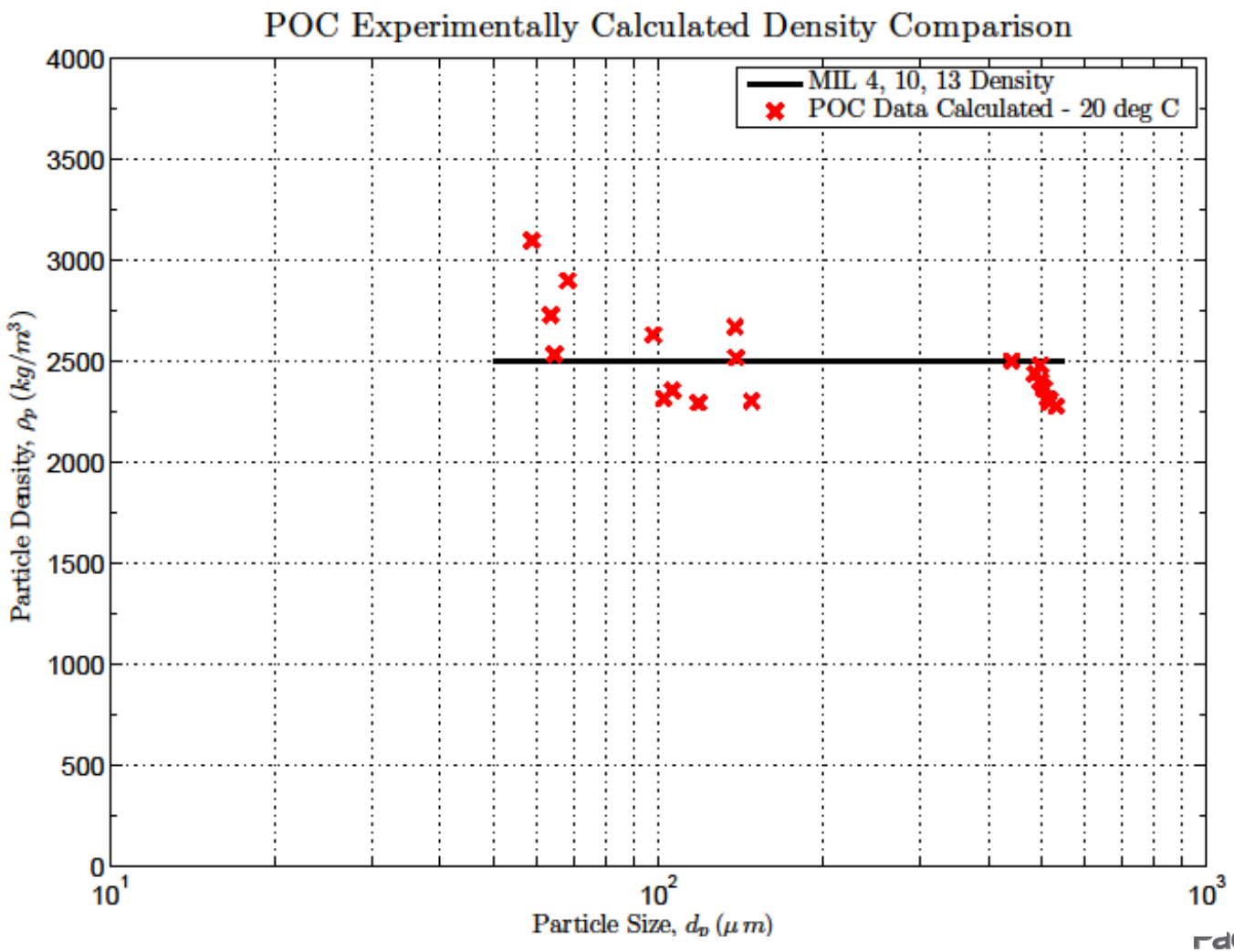
Calculated Density Comparison (Proof of Concept)



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Summary

- Update of Hanford waste slurry/sludge property basis is being completed and data gaps identified
- Successful proof of concept testing completed using known size and density material to validate optical approach

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Q&A

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