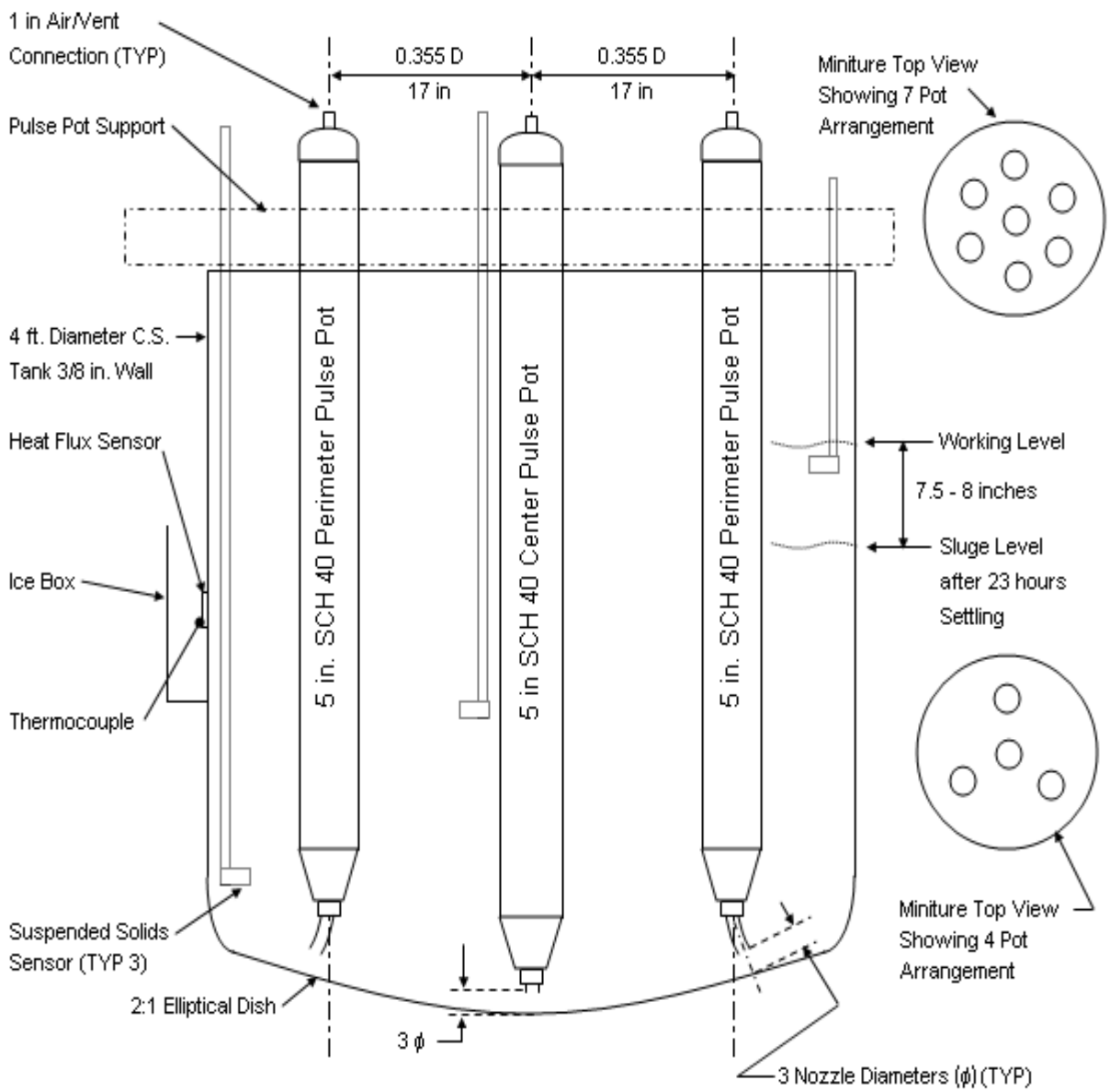
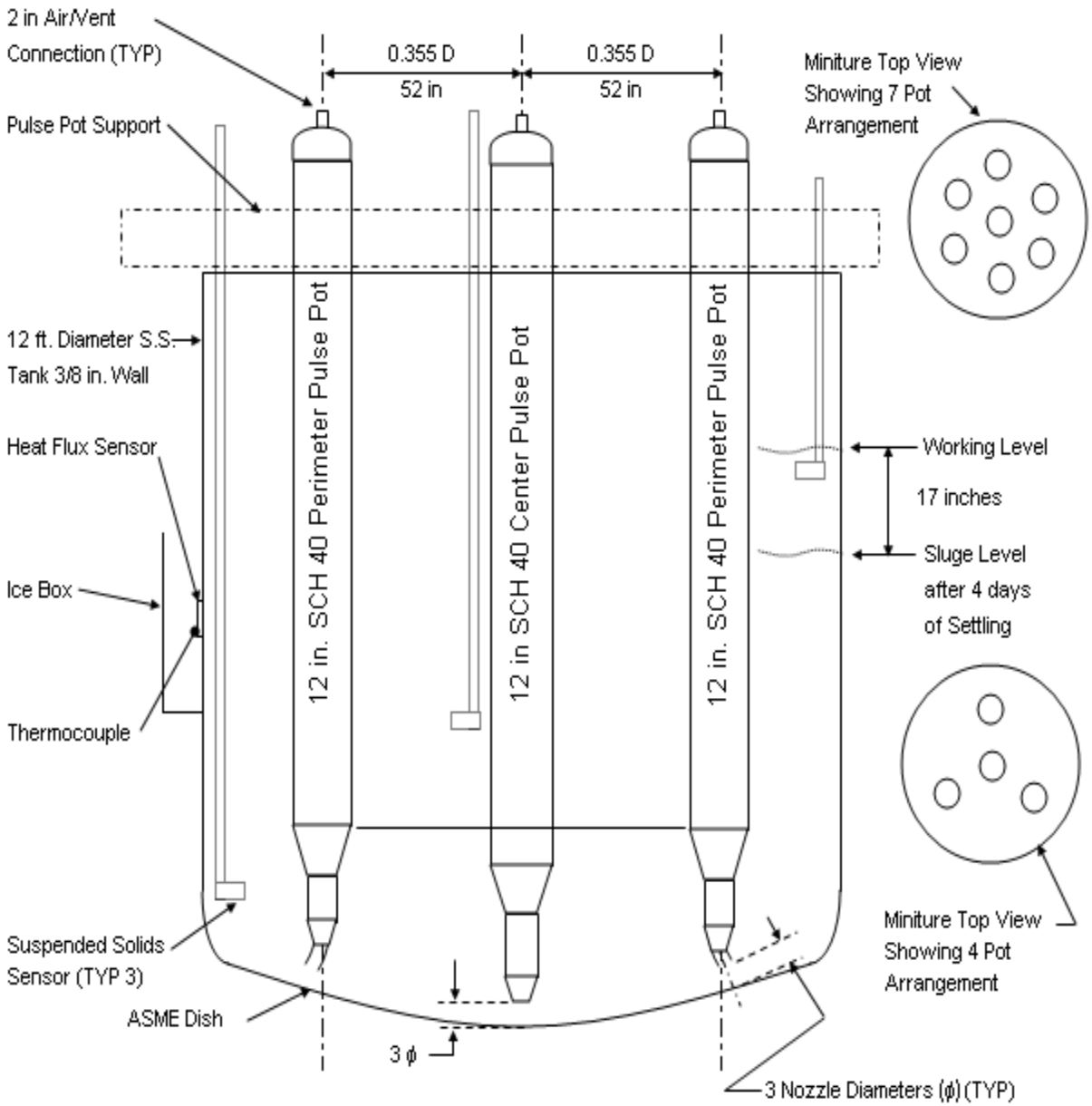
Mixing Within the Salt Waste Processing Facility [SWPF] – Air Pulse Agitators (APA's)

Sam Shicks
Parsons
1080 Silver Bluff Road
Aiken, SC. 29803
(803) 643-2428 Office
(803) 643-2253 Fax
(803) 443-8017 Mobile
E-mail: Sam.Shicks@parsons.com

1/5 Scale Prototype (Tank ID = 47.25 in)



5/8 Scale Prototype (Tank ID = 12 ft)



Test Simulant

Item	1/5 Scale	5/8 Scale
Solids (MST/SRS Sludge Simulant)	8 w.t.%	5 w.t.%
Solution Density	9.83 lbm/gal	10.18 lbm/gal
Solution Viscosity	9 CP	18 CP
Mean Solids Settling Rate	0.35 in/hr	0.17 in/hr
Dilution = Sodium Hydroxide/Sodium Nitrate		
Solution Sodium Concentration	3.3 M	5.6 M

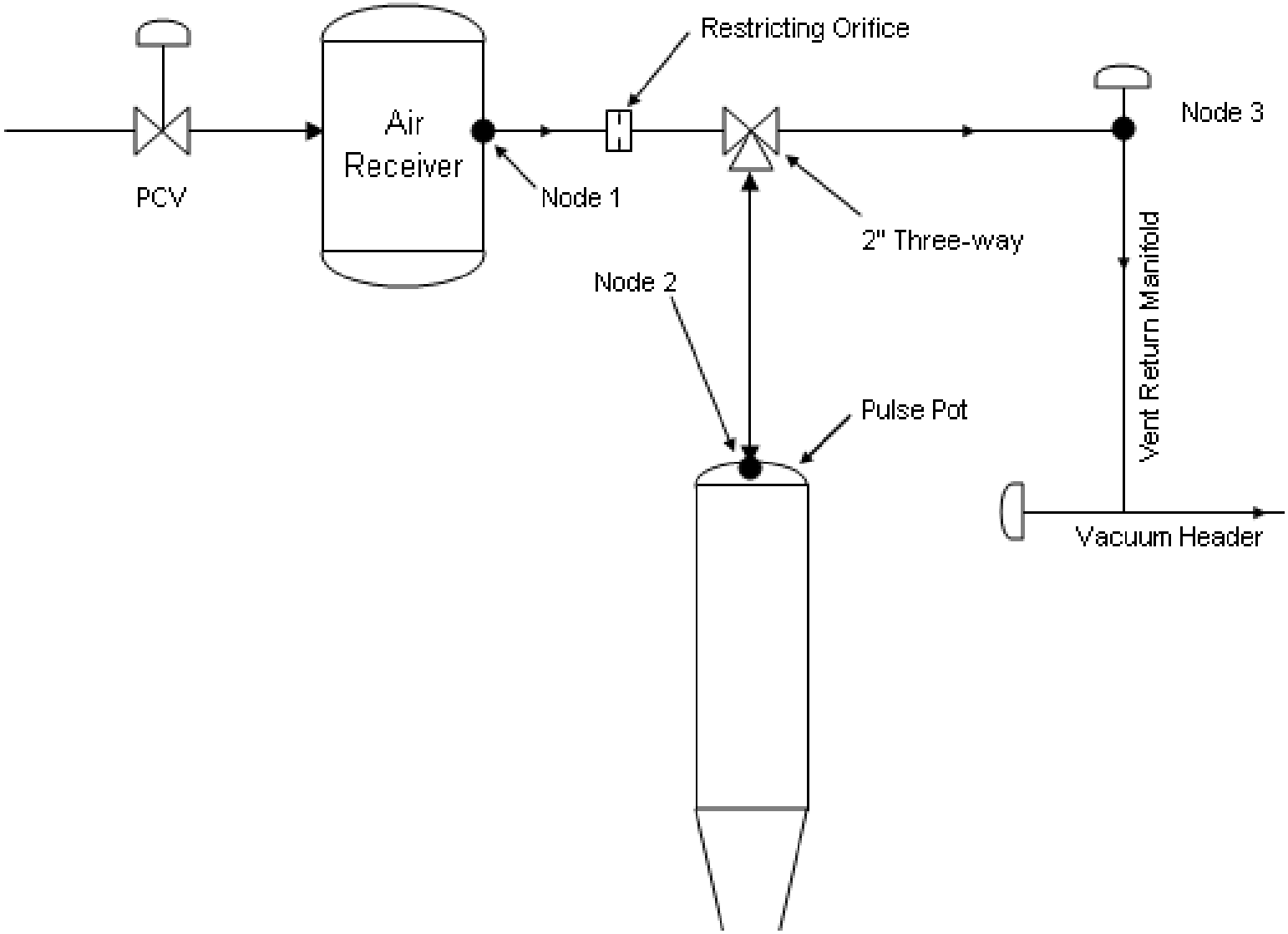
5/8 Scale Perimeter Pot Test Nozzle

5/8 Scale Center Pot Test Nozzle

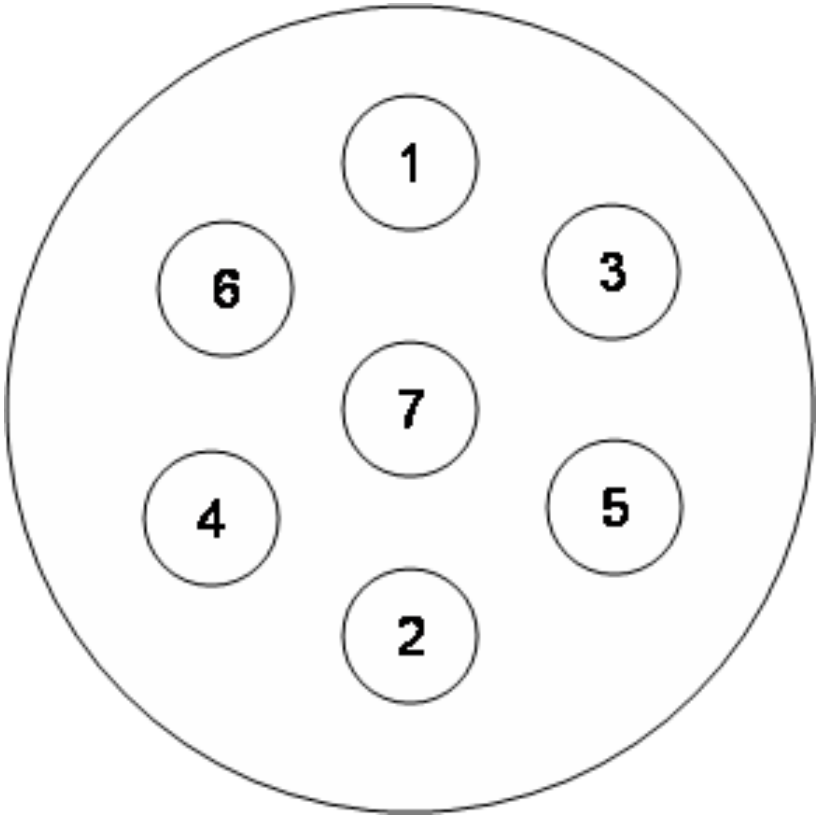
Markland 502-TP Submersible Solids Sensor

Markland 502-TP Submersible Solids Sensor

Baseline Components

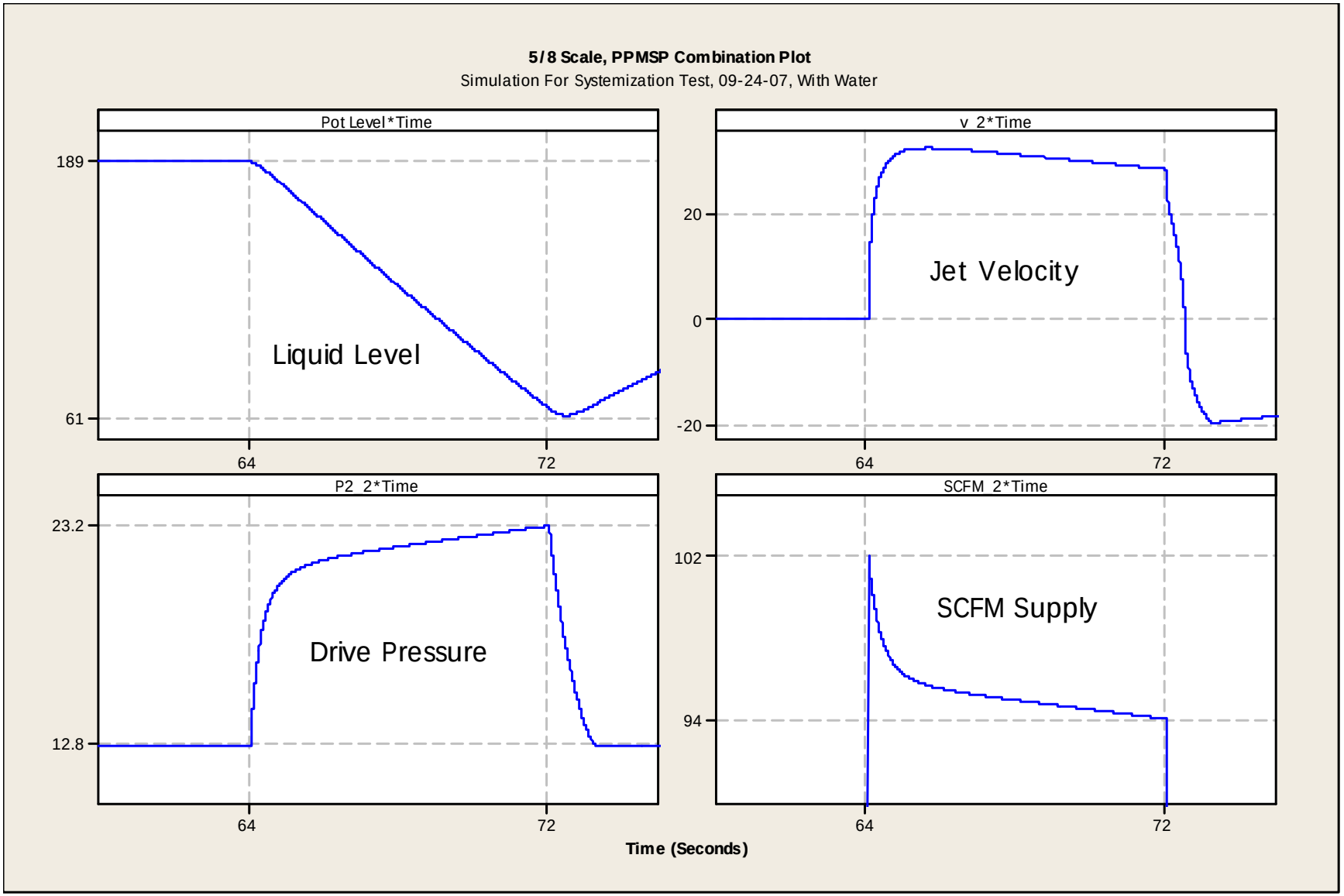


Baseline Operating Mode

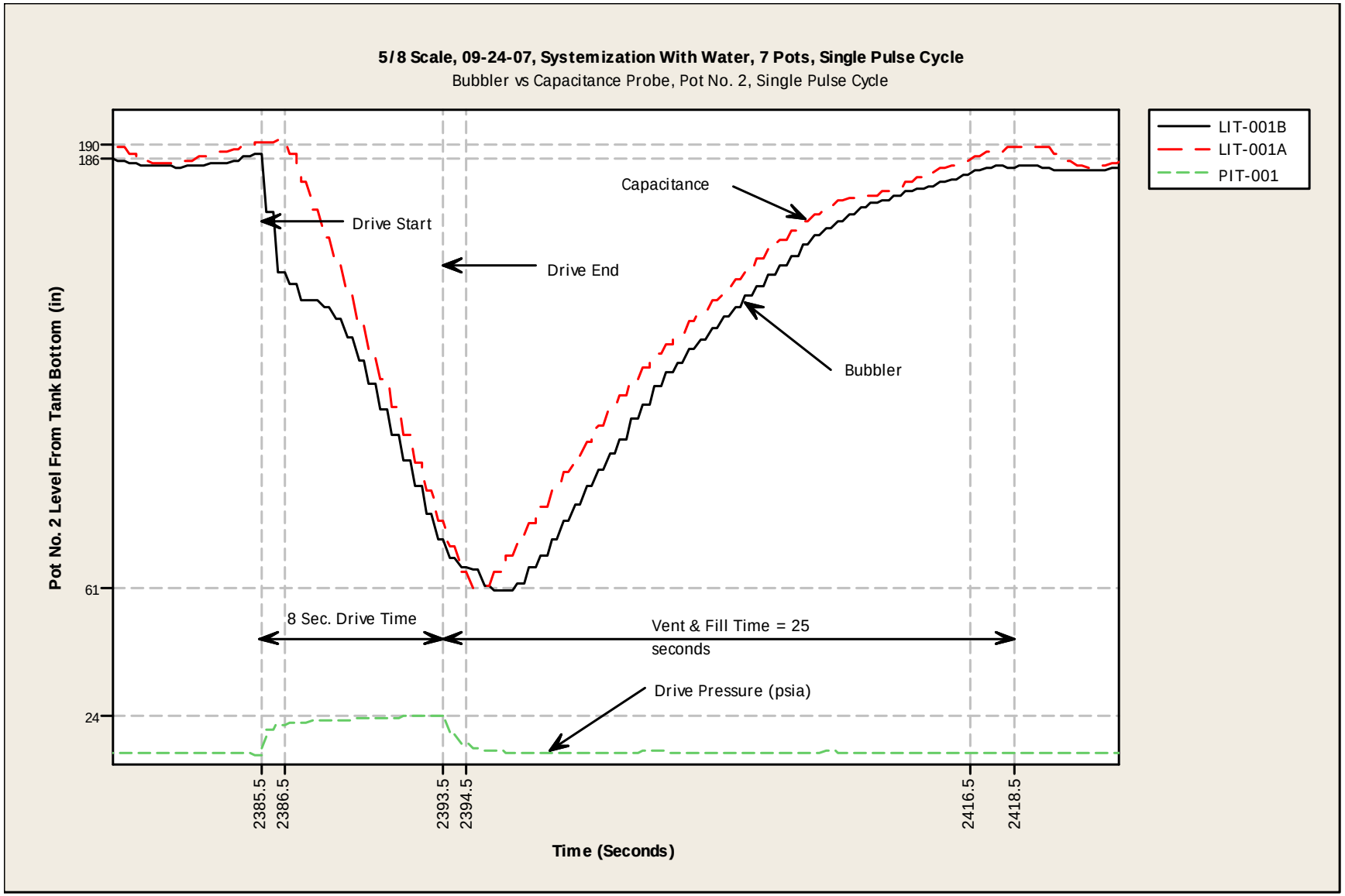


Pots are pulsed one at a time in a cross-fire sequence

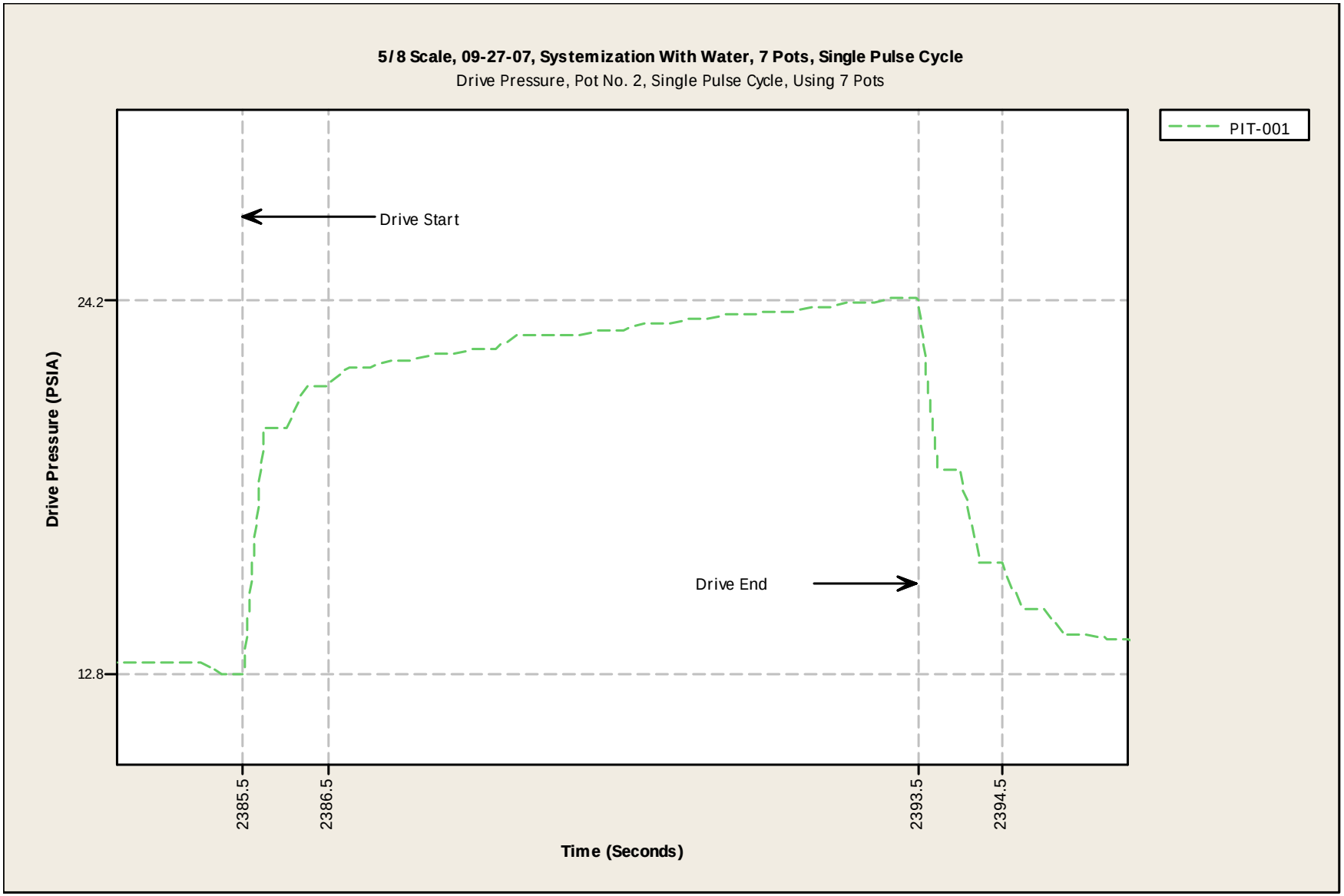
PPMSP Simulation Results



Measured Liquid Level In Pot



Measured Drive Pressure In Pot



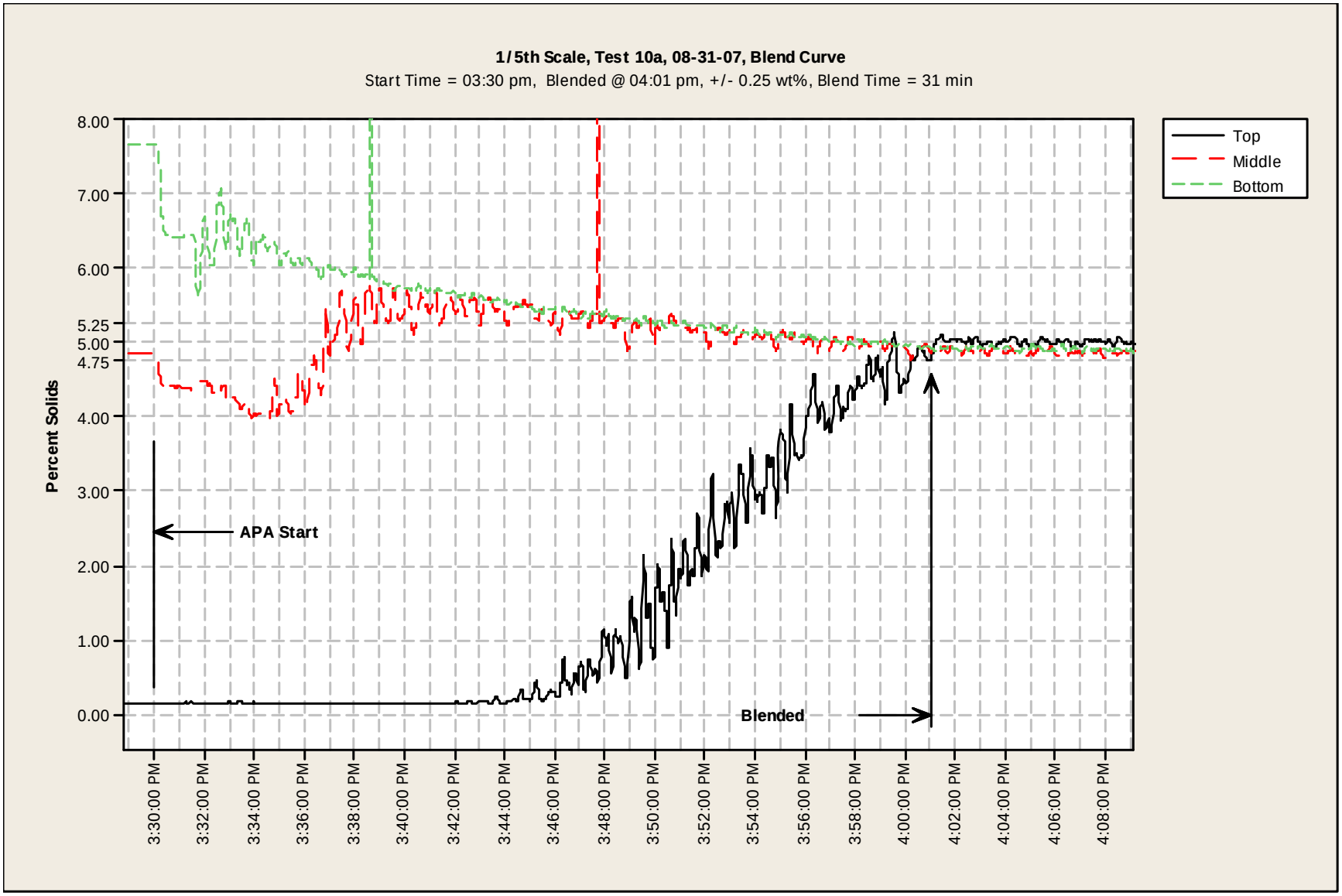
1/5 Scale Blend Tests

- 3 Tests (3/4 in Nozzle)(4-Pots)(High Level)
- 3 Tests (3/4 in Nozzle)(4-Pots)(Mid Level)
- 3 Tests (3/4 in Nozzle)(7-Pots)(High Level)
- 3 Tests (3/4 in Nozzle)(7-Pots)(Low Level)
- 3 Tests (1 in Nozzle)(4-Pots)(High Level)
- 3 Tests (1 in Nozzle)(4-Pots)(Mid Level)
- 3 Tests (1 in Nozzle)(7-Pots)(High Level)
- 3 Tests (1 in Nozzle)(7-Pots)(Low Level)

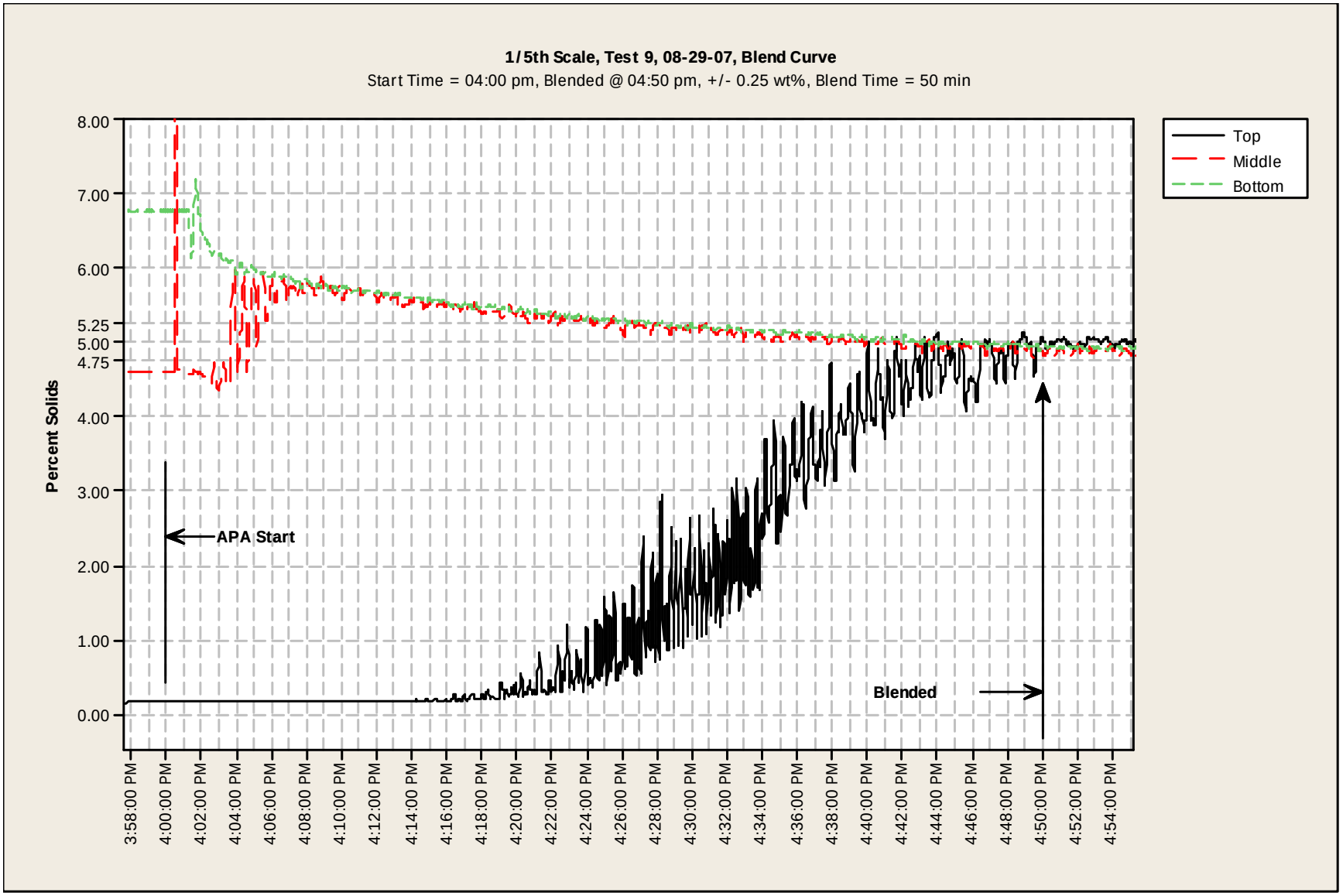
5/8 Scale Blend Tests

- 2 Tests (7-Pots)(High Level)
- 3 Tests (4-Pots)(High Level)

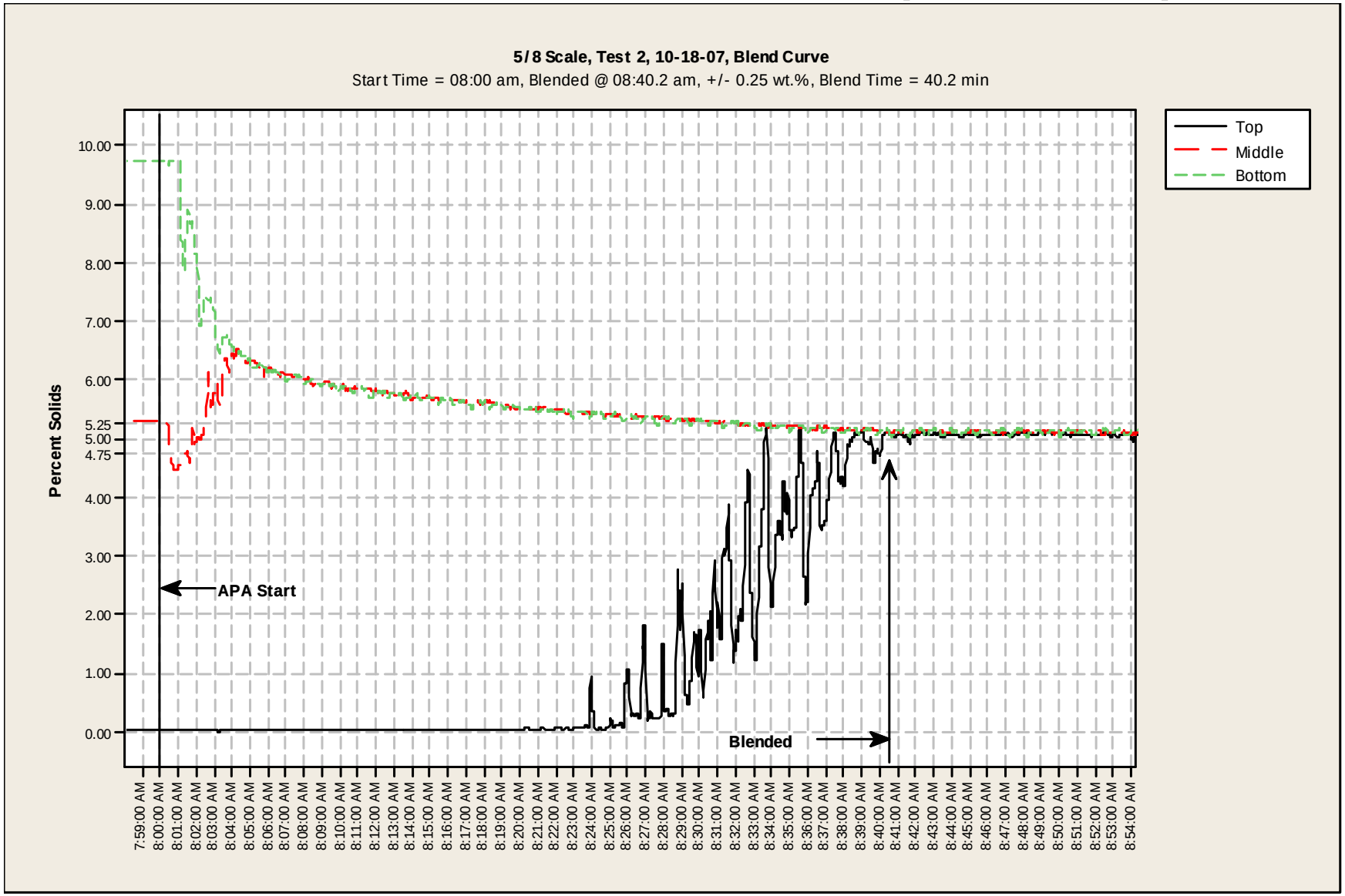
1/5 Scale Blend Curve (TEST 10a)



1/5 Scale Blend Curve (TEST 9)



5/8 Scale Blend Curve (TEST 2)



Technical Basis

First:

Listed

Variables

1.	σ	Average rate of circulation (ft^3/sec)
2.	υ	Average jet velocity (ft/sec)
3.	V	Volume of liquid inside test tank (ft^3)
4.	W_L	Working level of liquid inside test tank (ft)
5.	S_L	Initial sludge level inside test tank (ft)
6.	ϕ	Internal diameter of pulse jet nozzle (ft)
7.	γ	Specific weight of test fluid (lbf/ft^3)
8.	A	Liquid surface area inside the test tank (ft^2)
9.	P	Average jet power (ft-lbf/sec)
10.	D	Internal diameter of test tank (ft)
11.	S	Total suspended solids concentration (lbm/ft^3)
12.	R	Solids setting rate (ft/sec)
13.	μ	Dynamic viscosity of test liquid ($lbf\text{-}sec/ft^2$)
14.	D_H	Tank hydraulic diameter (ft)
15.	ω	Pulse jet frequency (1/sec)

Technical Basis

Then:
Dimensional
Analysis

$$\Pi_t = \frac{t\ \sigma^4\ \gamma^3}{P^3} = \frac{t\ a\ g^3}{v^5}$$

$$\Pi_V = \frac{V\ \sigma^3\ \gamma^3}{P^3} = \frac{V\ g^3}{v^6}$$

$$\Pi_L = \frac{L\ \sigma\ \gamma}{P} = \frac{L\ g}{v^2}$$

$$\Pi_S = \frac{S\ \sigma^7\ \gamma^4}{g_c\ P^5} = \frac{S\ a^2\ g^4}{\rho\ v^8}$$

$$\Pi_R = \frac{R\ P^2}{\sigma^3\ \gamma^2} = \frac{R\ v^3}{a\ g^2}$$

$$\Pi_\mu = \frac{\mu\ \sigma^5\ \gamma^3}{P^4} = \frac{\mu\ a\ g_c\ g^3}{\rho\ v^7}$$

$$\Pi_{Ai} = \frac{A_i\ \sigma^2\ \gamma^2}{P^2} = \frac{A_i\ g^2}{v^4}$$

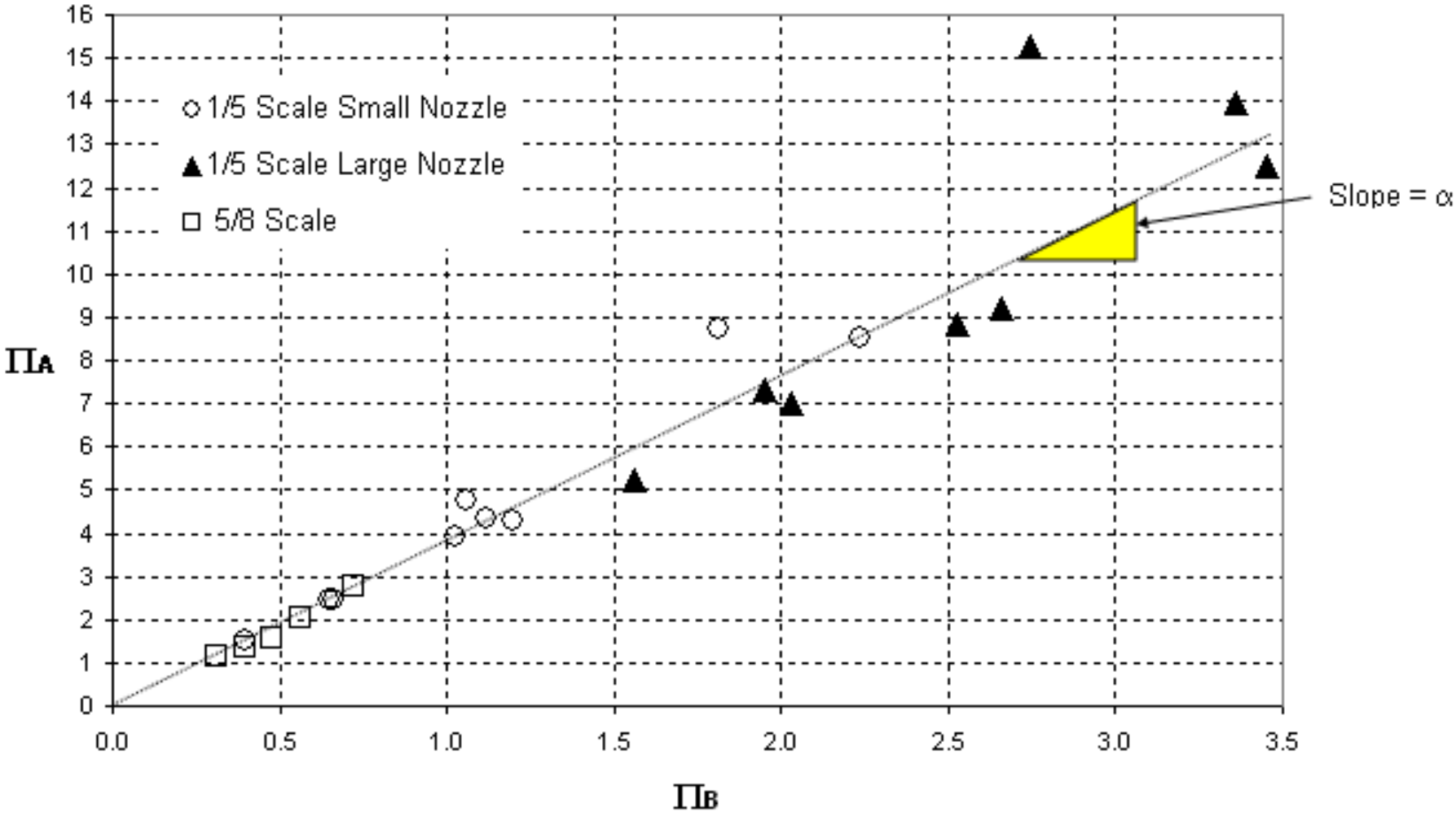
$$\Pi_\omega = \frac{\omega\ P^3}{\sigma^4\ \gamma^3} = \frac{\omega\ v^5}{a\ g^3}$$

?

$$\Pi_3 = \Pi_1^{a} \times \Pi_2^{b}$$

Π_A	$= \dfrac{\sigma \quad t}{V}$	Turnovers to blend
Π_{B1}	$= \dfrac{W_L}{D}$	The ratio of the working level to the tank internal diameter
Π_{B4}	$= \dfrac{W_L}{D_H}$	The ratio of the working level to the hydraulic diameter
Π_{C1}	$= \dfrac{v}{\sqrt{S_L\, g}}$	Froude number based on the initial sludge level
Π_{C4}	$= \dfrac{v}{\sqrt{D_H\, g}}$	Froude number based on the hydraulic diameter

Blend Scale-Up Model



Blend Scale-Up Model

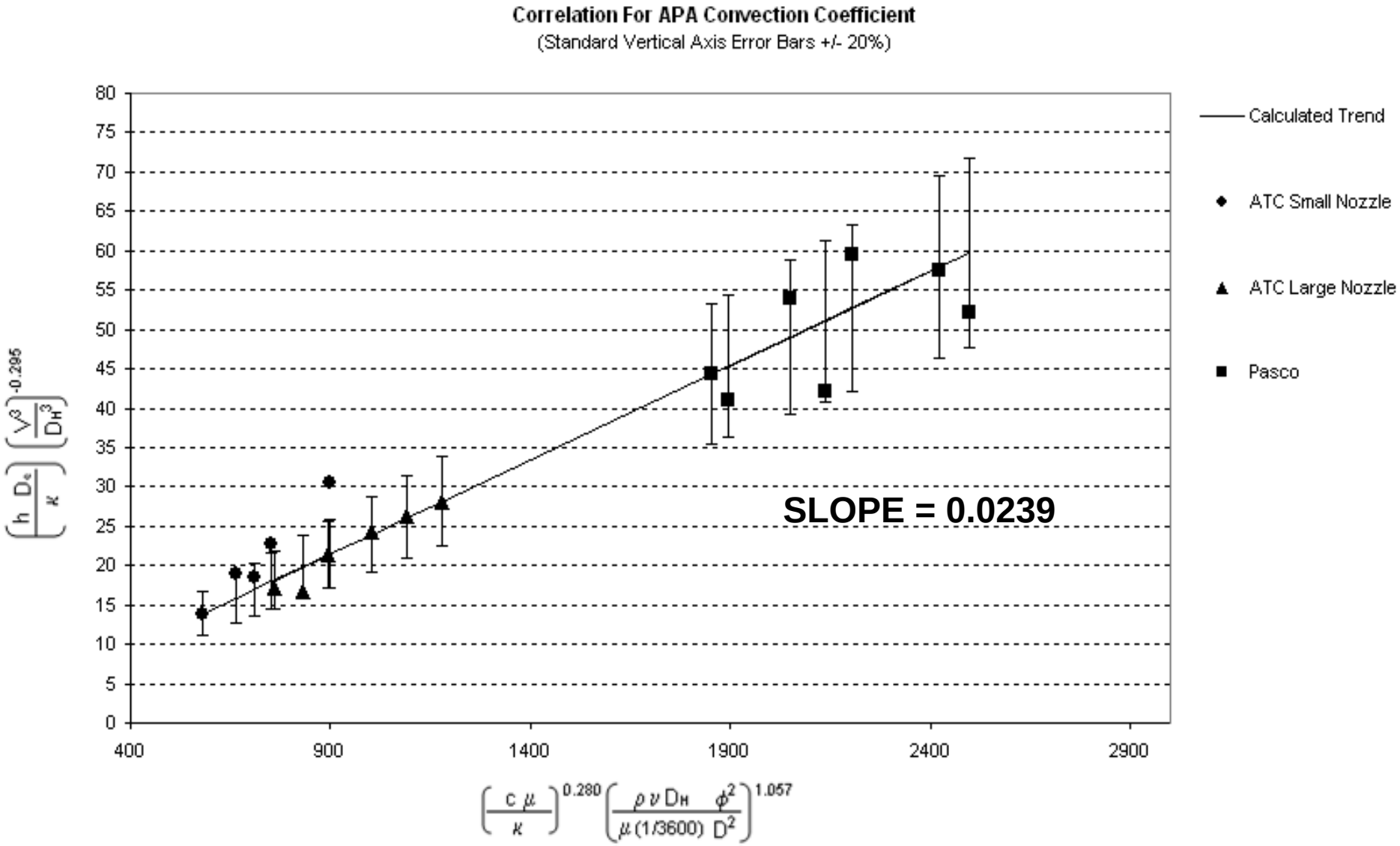
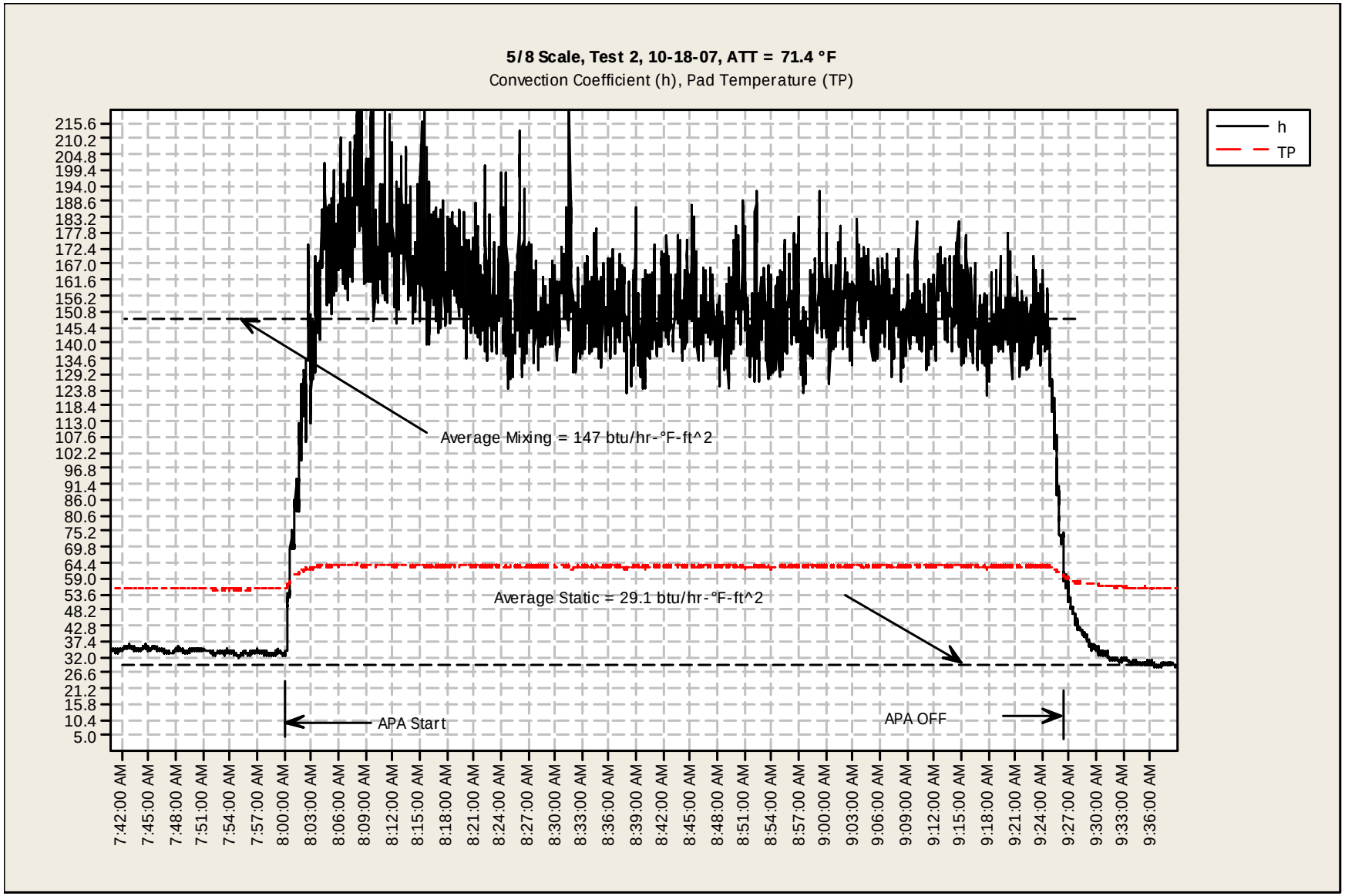
The SWPF APA Blend Model is represented by the linear expression

$$\frac{\sigma \quad t}{V} = 3.82 \left(\frac{W_L}{D}\right)^{3.20} \left(\frac{W_L}{D_H}\right)^{5.88} \left(\frac{\nu}{\sqrt{S_L\, g}}\right)^{4.01} \left(\frac{\nu}{\sqrt{D_H\, g}}\right)^{-7.68}$$

The limitations to the accuracy of this equation are such that

1.0 5 < (wt.% Solids) < 8
2.0 1/5 Scale < dynamic viscosity < 5/8 Scale
3.0 1/5 Scale < Specific Gravity < 5/8 Scale
4.0 1.95 < D_H < 8.58
5.0 0.684 < S_L/W_L < 0.875
6.0 0.933 < W_L/D < 1.43
7.0 Used for SWPF LRW Simulated Sludge
8.0 1.0 < (σ t /V) < 9.5
9.0 0.19 < (ϕ / D) < 0.254

Convection Coefficient



Convection Coefficient