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Flow Loop Friction Testing (RFA-800-21-11-046-03-FL-AQS)

The friction reduction performance of four systems are reported herein:

- 1 – A dry polymer powder (Anionic Powder) at 2 lbs/1000 gals
- 2 - A dry polymer powder (Anionic Powder) at 6 lbs/1000 gals;
- 3 - AquaSmart ProProp-2 PPT polymer coated proppant
- 4 - AquaSmart ProProp-6 PPT polymer coated proppant

The base fluid for the tests was lab prepared synthetic produced water (SPW) comprised of Cypress , TX tap water brined with NaCl & CaCl₂ such that the Total Dissolved Solids content was ~75k mg/l. The recipe for the SPW is listed. AquaSmart provided the sand (40/70 regional West Texas), dry polymer and coated proppant used for these tests.

Testing Procedure

The testing protocol called for the friction pressures to be measured across a ~20 ft. run of stainless-steel tubing within the flow loop apparatus. Proppant concentrations of 1, 2, and 3 Pounds of Proppant Added per gallon of fluid (PPA) were tested for each fluid/slurry. The test pump rate target was 32.4 gpm, which recreates an analogous reference shear rate for a frac treatment of 100 bpm down 4.5 in. ID casing of ~1807 sec⁻¹. Data were logged by in-house data logging software at one second intervals. The dP measurements were recorded prior to proppant addition, and at each of the above concentrations. The proppant concentrations were measured utilizing a nuclear densitometer downstream of the triplex main pump. The test concentrations were brought to stabilized levels, and the dP valves were opened for approximately 2 minutes for each concentration, then closed as concentration levels were increased to the next PPA.

For the fluids prepared by gelling the base brine with powdered polymer (Tests 1 & 2), the fluids were prepared by shearing in the flow loop at ~25 gpm, until viscosity stabilized.

Following each fluid batch, the system was purged at maximum pump rate (~60 gpm) using fresh water, prior to mixing the subsequent batch. The degree of friction reduction is plotted versus PPA in the following graphs and listed in the tabular data.



Test Results Summary

Of the four tests evaluated in this report, the tests using the polymer coating on the proppant grains (Tests 3 & 4) provided greater friction reduction at all proppant concentrations than the pre-gelled fluid with uncoated proppant (Tests 1 & 2). The degree of friction reduction disparity, increased with increasing proppant concentration (See Table-3 and associated data plots).

Table-1 Testing matrix for this test battery

Test Stage	Polymer	Base Fluid	Proppant	Proppant Loading PPA
1	2 PPT Anionic Powder	75k TDS	40/70	1, 2, 3
2	6 PPT Anionic Powder	75k TDS	40/70	1, 2, 3
3	ProProp-2 PPT	75k TDS	40/70	1, 2, 3
4	ProProp-6 PPT	75k TDS	40/70	1, 2, 3

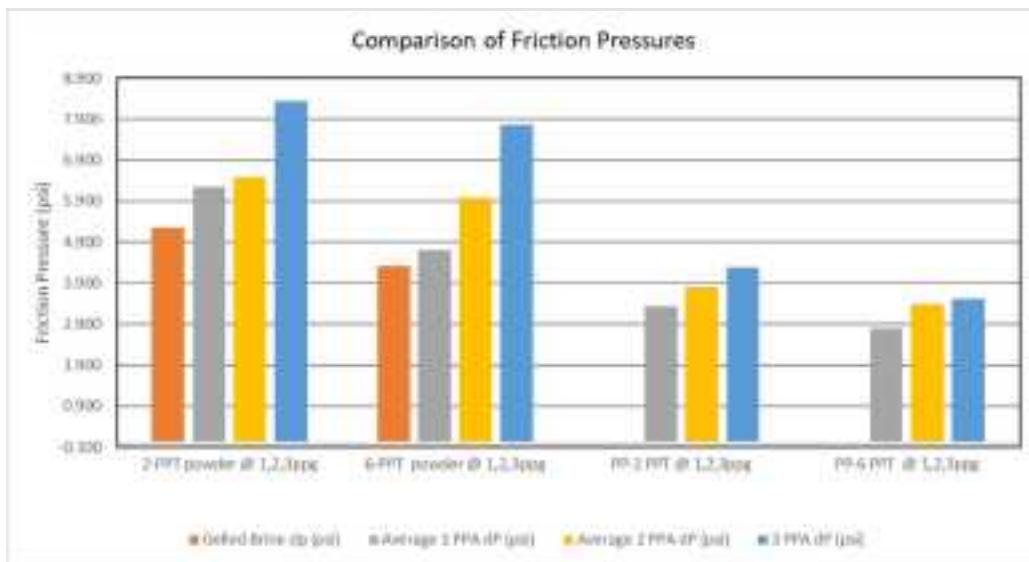
Table-2 Base fluid recipe for SPW – This recipe was designed to provide a synthetic brine with ~75k mg/l TDS.

mg/L	API
Na ⁺	22,799.05
Ca ²⁺	6,155.93
Cl ⁻	46,045.09
TDS	75,000.07
SG	1.0445
Density	8.7089 ppg

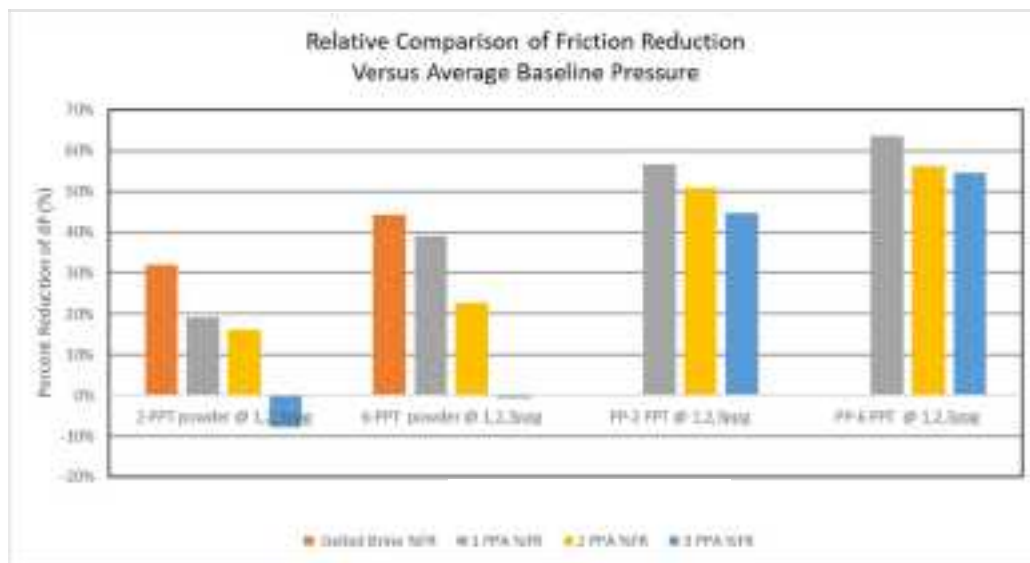


Table-3 Tabular results and plotted data from all tests

Average Baseline Brine dP = 7.723 psi									
Test No.	Test Description	Gelled Brine dp (psi)	Gelled Brine %FR	Average 1 PPA dP (psi)	1 PPA %FR	Average 2 PPA dP (psi)	2 PPA %FR	3 PPA dP (psi)	3 PPA %FR
1	2-PPT powder @ 1,2,3ppg	5.246	32%	6.241	19%	6.479	16%	8.329	-8%
2	6-PPT powder @ 1,2,3ppg	4.306	44%	4.711	39%	5.972	23%	7.763	-1%
3	PP-2 PPT @ 1,2,3ppg	N/A	N/A	3.346	57%	3.802	51%	4.275	45%
4	PP-6 PPT @ 1,2,3ppg	N/A	N/A	2.803	64%	3.384	56%	3.508	55%



Comparison of measured dP's for the 2-PPT & 6-PPT Dry Powder and ProProp equivalent



Comparison of the percent of dP reduced for the 2-PPT & 6-PPT Dry Powder and ProProp equivalent

Figure-1 Friction Reduction Test Data Plots for 2 lbs/1000 gals Dry Powder

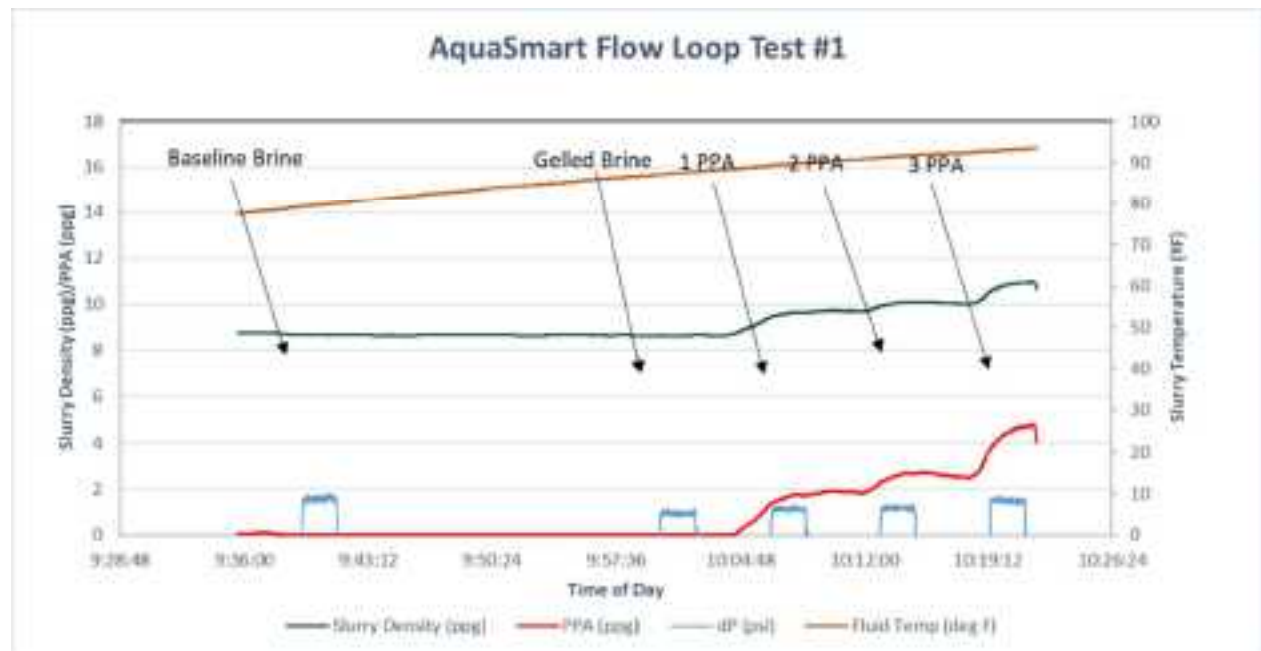
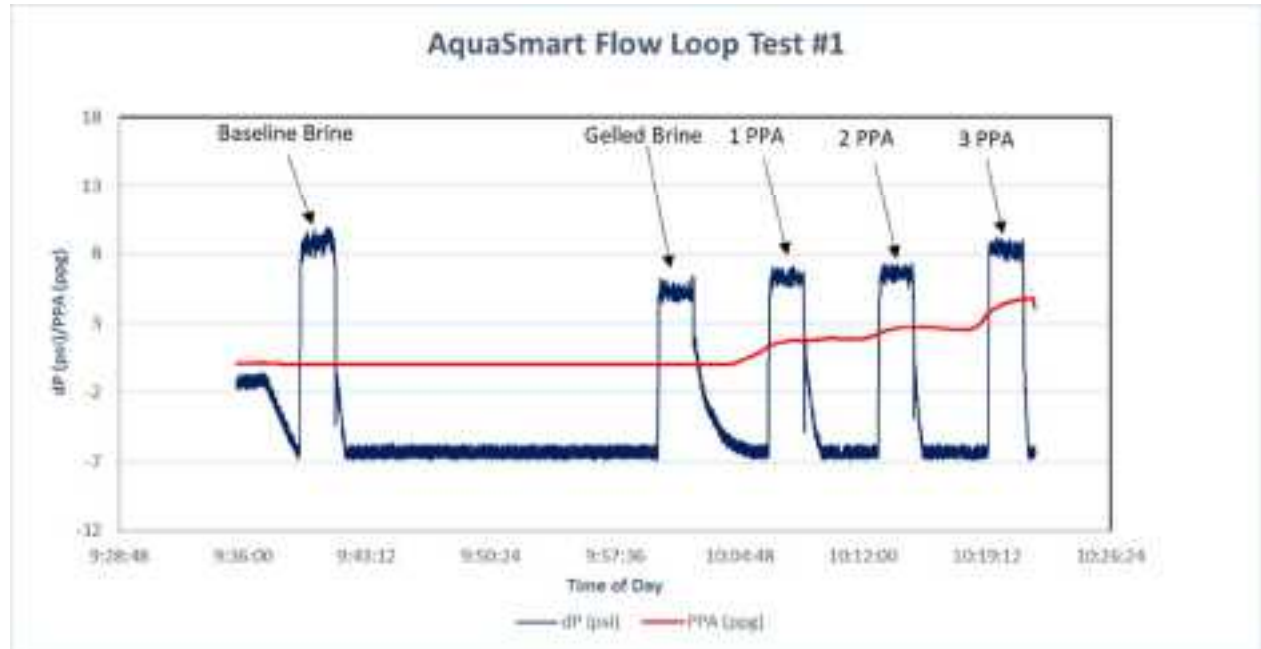


Figure-2 Friction Reduction Test Data Plots for 6 lbs/1000 gals Dry Powder

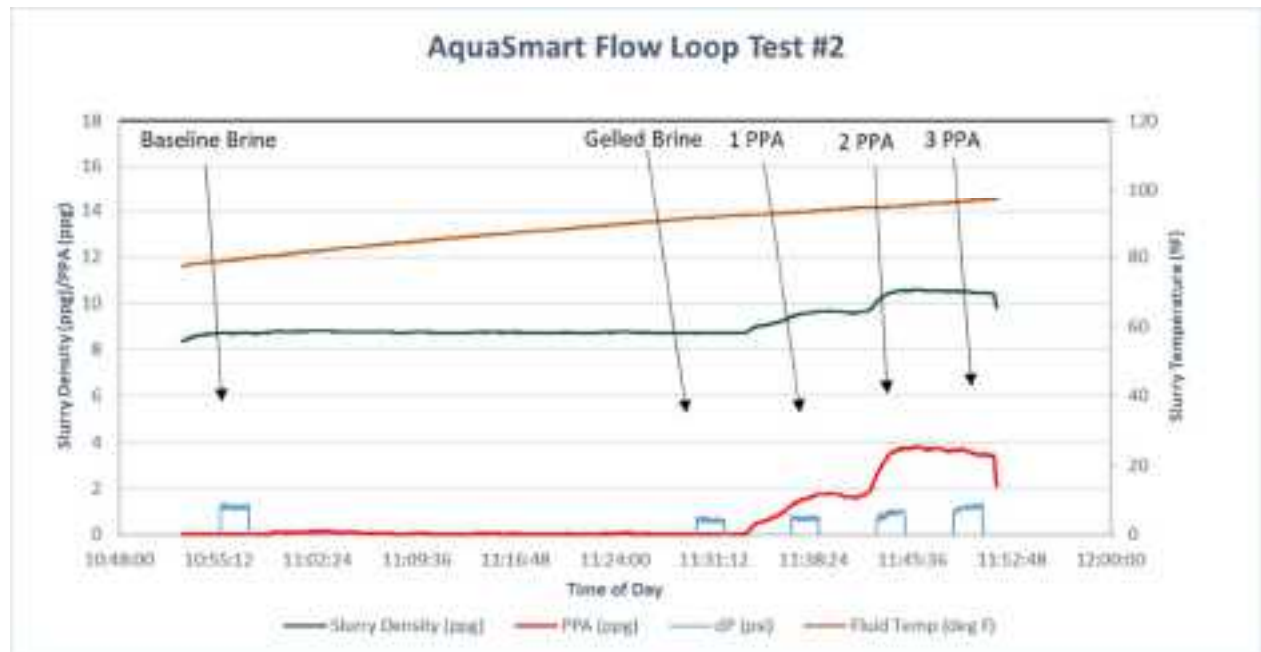
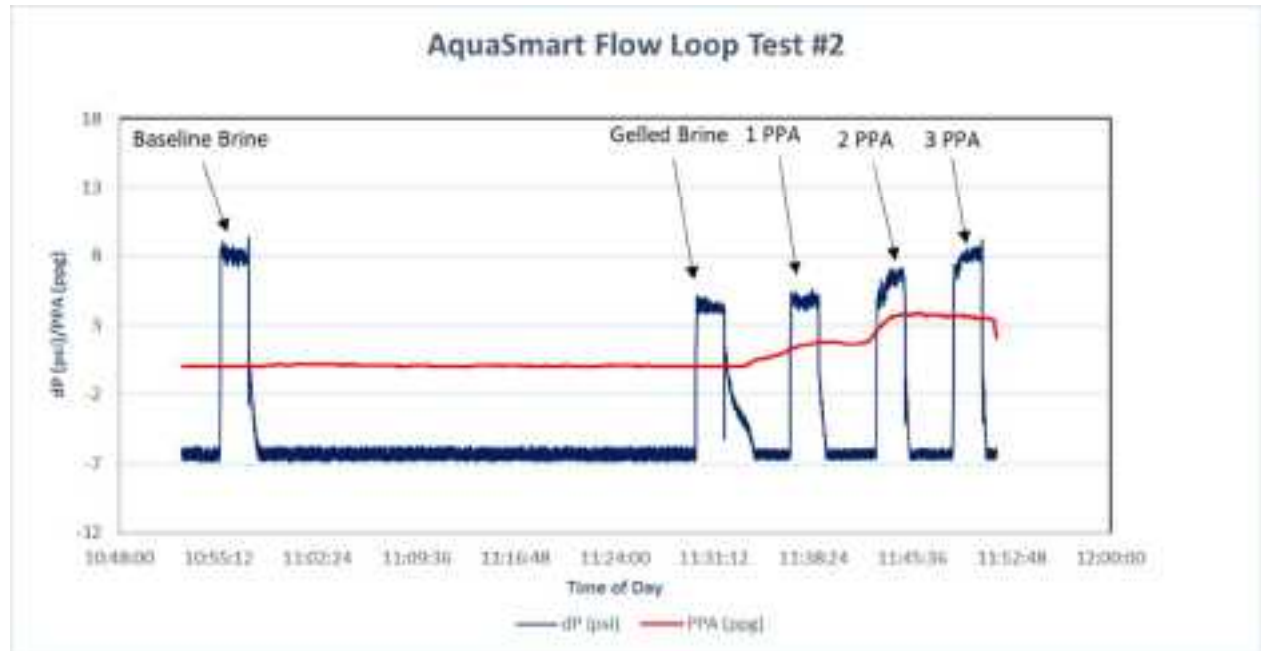


Figure-3 Friction Reduction Plot for ProProp-2 PPT

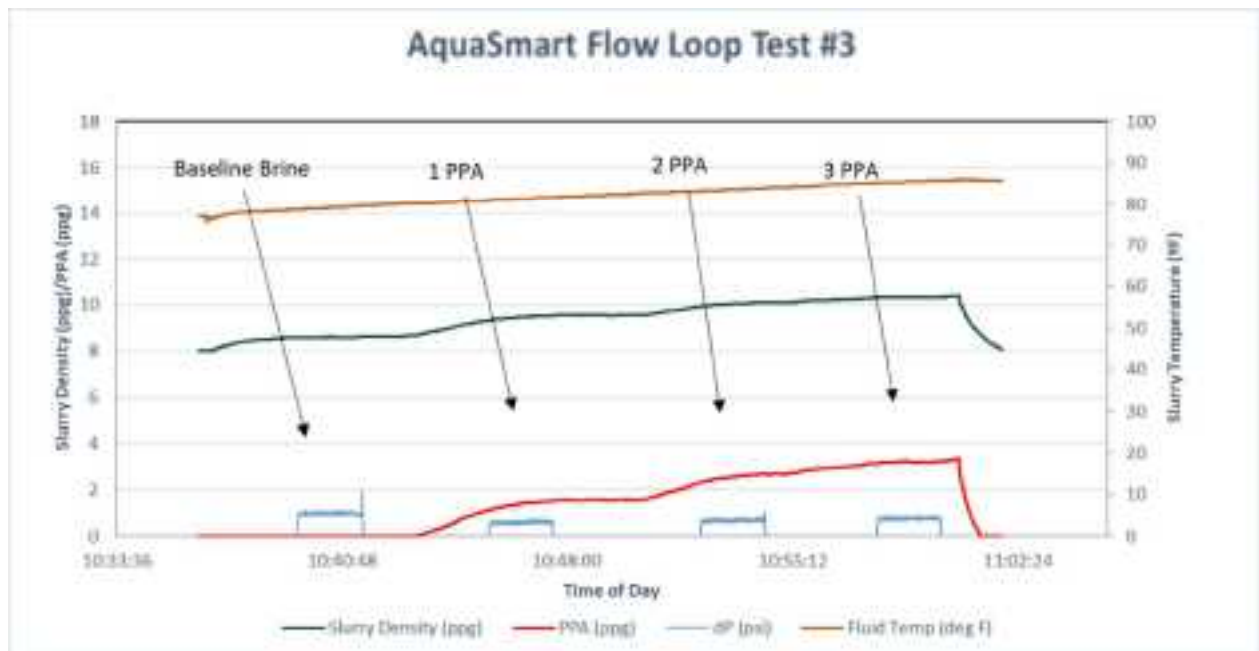
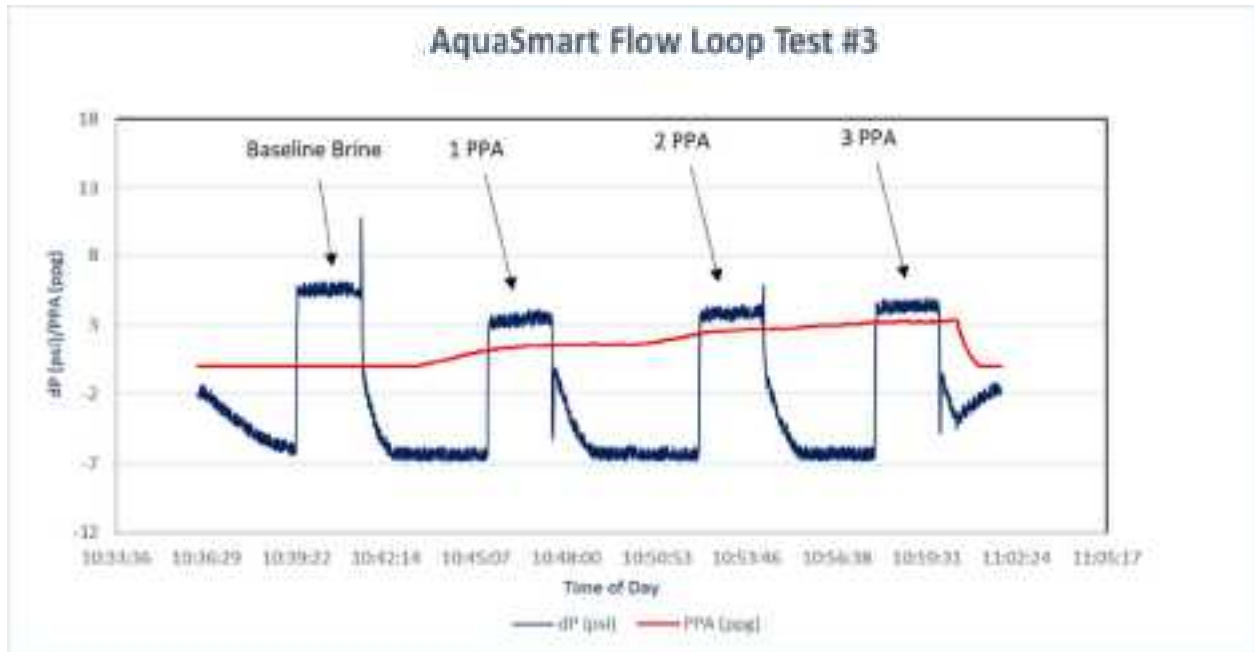


Figure-4 Friction Reduction Plot for ProProp-6 PPT

