ROCKY MOUNTAIN OILFIELD TESTING CENTER

PROJECT TEST RESULTS

STWA, INC.
VISCOSITY REDUCTION TECHNOLOGY

Prepared for:

Industry Publication

Prepared by:

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May 21, 2012

ABSTRACT

May 21, 2012

The Rocky Mountain Oilfield Testing Center (RMOTC) conducted a 24-hour field test on the STWA in-line viscosity reduction device at the Naval Petroleum Reserve No. 3 (NPR-3) located 35 miles north of Casper in Natrona County, Wyoming. The in-line viscosity reduction device is designed to reduce the line-loss and increase the flow rate of crude oil traveling through a commercial pipeline, thereby reducing the energy required for crude oil transportation. Reductions in line-loss and gains in pump operation efficiency (i.e., reduced power consumption) were observed on the 4.4 mile 6” schedule 80 metal buried pipeline test loop.

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INTRODUCTION:

The Rocky Mountain Oilfield Testing Center (RMOTC) conducted a field test on the STWA in-line viscosity reduction device (Applied Oil Technology, AOT) at the Naval Petroleum Reserve No. 3 (NPR-3) located 35 miles north of Casper in Natrona County, Wyoming.

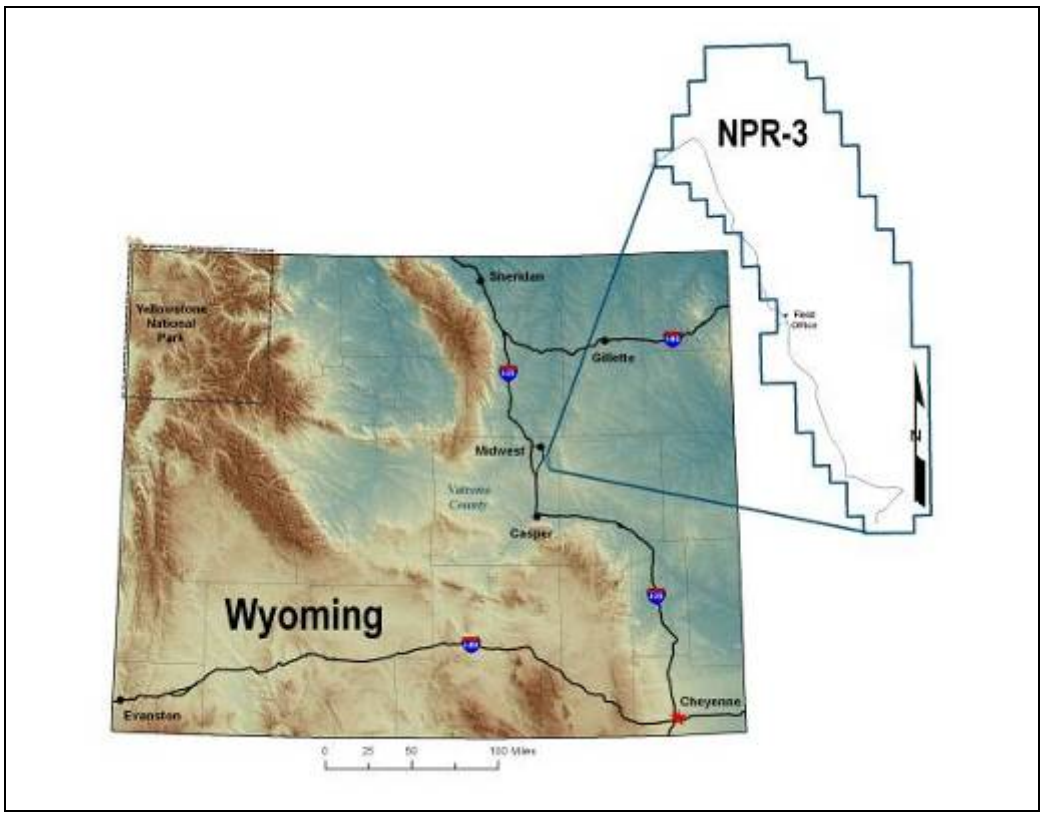


Figure 1. State Map of NPR-3

STWA, Inc. (STWA) of Santa Barbara, California, together with Temple University of Philadelphia's physics department designed and created the AOT device to reduce the energy required to transport crude oil through commercial pipelines.

The device exposes passing crude oil to a precisely controlled electric field to reduce the oil viscosity. This is intended to reduce line-loss (fluid drag) and pressure, without changing the oil temperature or composition. In a commercial pipeline operation, the intended results would translate into reduced pump power required to maintain constant flow rates. The device would thereby deliver energy savings for crude oil transportation.

Figure 2. STWA AOT 1.2V at night during successful 24hr testing 05/02/2012 – 05/03/2012

TEST RESULTS:

Test results are detailed within Appendix A.

OBSERVATIONS:

In 2011, the AOT device was installed on a flow loop located at the RMOTC field test site in NPR-3. The flow loop – a 4.4 mile, 6 inch, schedule 80 metal buried pipeline – was modified specifically to support this viscosity reduction test. RMOTC validated overall system integrity after AOT installation, and filled the loop with field-produced API 34° oil to facilitate testing. The initial phase of testing in 2011 is detailed within *"STWA Final Report: Viscosity Reduction Test"* dated October 19, 2011, subsequent testing is detailed within *"STWA, Inc Viscosity Reduction Technology"* dated April 04, 2012.

The AOT device was removed in April 2012 and reworked to include a new, vertically-oriented, electrically-isolated chassis/skid design. The reworked device, referred to as the AOT 1.2V, was reinstalled on the test loop in May 2012. RMOTC again validated overall system integrity after the AOT 1.2V installation, and filled the loop with field-produced API 34° oil to facilitate this next phase of

testing. The test was conducted for 24 consecutive hours, beginning at 12 noon on May 02, 2012 and concluding at 12 noon on May 03, 2012.

A positive displacement pump, driven by an electric motor operating at 30 Hz and controlled by a Variable Frequency Drive was used to circulate oil through the loop to establish baseline performance. Baseline performance was measured as follows:

BASELINE (11:30 am 05/02/2012)

- 13.9°C oil temperature (@ port #3)
- 0.85 g/cm3 oil density
- 59.904 centipoise (cp) viscosity
- 1690.84 Reynolds #
- 0.03785090 friction loss
- 84.093200 cm/s velocity
- 210 gal/min flow rate
- 15.031 psi/mile pressure drop
- 15.9 kW power consumption

After establishing baseline performance, the AOT 1.2V device was turned on and operated for 12 hours continuously. AOT performance was measured as follows:

UNTREATED (10:30 pm 05/02/2012)

- 11.0°C oil temperature (reduced 2.9°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 105.6 cp viscosity (increased 76.28% from baseline)
- 959.17 Reynolds # (decreased 43.27% from baseline)
- 0.06672434 friction loss (increased 76.28% from baseline)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 26.50 psi/mile pressure drop (increased 76.28% from baseline)
- 34.5 kW power consumption (increased 116.38% from baseline)

TREATED (10:30 pm 05/02/2012)

- 11.0°C oil temperature (reduced 2.9°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 47.8 cp viscosity (reduced 20.21% from baseline at 13.9°C, reduced 54.73% from untreated oil at 11.0°C)
- 2119.0036 Reynolds # (increased 25.32% from baseline at 13.9°C, increased 120.92% from untreated oil at 11.0°C)

- 0.03020287 friction loss (reduced 20.21% from baseline at 13.9°C, reduced 54.73% from untreated oil at 11.0°C)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 11.994 psi/mile pressure drop (reduced 20.21% from baseline at 13.9°C, reduced 54.73% from untreated oil at 11.0°C)
- 15.6 kW power consumption (reduced 2.06% from baseline at 13.9°C, reduced 54.73% from untreated oil at 11.0°C)

UNTREATED (12:00 am 05/03/2012)

- 10.9°C oil temperature (reduced 3.0°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 108.10 cp viscosity (increased 80.46% from baseline)
- 936.99 Reynolds # (decreased 44.58% from baseline)
- 0.0683040 friction loss (increased 80.46% from baseline)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 27.125 psi/mile pressure drop (increased 80.46% from baseline)
- 32.6 kW power consumption (increased 104.39% from baseline)

TREATED (12:00 am 05/03/2012)

- 10.9°C oil temperature (reduced 3.0°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 51.8 cp viscosity (reduced 13.53% from baseline at 13.9°C, reduced 52.08% from untreated oil at 10.9°C)
- 1955.37 Reynolds # (increased 15.64% from baseline at 13.9°C, increased 108.69% from untreated oil at 10.9°C)
- 0.0327303 friction loss (reduced 13.53% from baseline at 13.9°C, reduced 52.08% from untreated oil at 10.9°C)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 12.997 psi/mile pressure drop (reduced 13.53% from baseline at 13.9°C, reduced 52.08% from untreated oil at 10.9°C)
- 15.8 kW power consumption (decreased 2.08% from baseline at 13.9°C, reduced 52.08% from untreated oil at 10.9°C)

UNTREATED (04:00 am 05/03/2012)

- 10.9°C oil temperature (reduced 3.0°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 118.060 cp viscosity (increased 97.08% from baseline)
- 857.94 Reynolds # (decreased 49.26% from baseline)
- 0.0745973 friction loss (increased 97.08% from baseline)

- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 29.624 psi/mile pressure drop (increased 97.08% from baseline)
- 36.0 kW power consumption (increased 126.09% from baseline)

TREATED (04:00 am 05/03/2012)

- 10.9°C oil temperature (reduced 3.0°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 51.8 cp viscosity (reduced 13.53% from baseline at 13.9°C, reduced 56.12% from untreated oil at 10.9°C)
- 1955.37 Reynolds # (increased 15.64% from baseline at 13.9°C, increased 127.92% from untreated oil at 10.9°C)
- 0.0327303 friction loss (reduced 13.53% from baseline at 13.9°C, reduced 56.12% from untreated oil at 10.9 C)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 12.997 psi/mile pressure drop (reduced 13.53% from baseline at 13.9°C, reduced 56.12% from untreated oil at 10.9 C)
- 15.8kW power consumption (decreased 0.80% from baseline at 13.9°C, reduced 56.12% from untreated oil at 10.9 C)

UNTREATED (11:00 am 05/03/2012)

- 13.6°C oil temperature (reduced .3°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 62.210 cp viscosity (increased 3.85% from baseline)
- 1628.17 Reynolds # (decreased 3.71% from baseline)
- 0.0393080 friction loss (increased 3.85% from baseline)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 15.6100 psi/mile pressure drop (increased 3.85% from baseline)
- 17.0 kW power consumption (increased 6.46% from baseline)

TREATED (11:00 am 05/03/2012)

- 13.6°C oil temperature (reduced .3°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 59.8 cp viscosity (reduced 0.17% from baseline at 13.9°C, reduced 3.87% from untreated oil at 13.6°C)
- 1693.79 Reynolds # (increased 0.17% from baseline at 13.9°C, increased 4.03% from untreated oil at 13.6°C)
- 0.0377852 friction loss (reduced 0.17% from baseline at 13.9°C, reduced 3.87% from untreated oil at 13.6°C)
- 84.093200 cm/sec velocity (unchanged)

- 210 gal/min flow rate (unchanged)
- 15.0053 psi/mile pressure drop (reduced 0.17% from baseline at 13.9°C, reduced 3.87% from untreated oil at 13.6°C)
- 16.3 kW power consumption (increased 2.34% from baseline at 13.9°C, reduced 3.87% from untreated oil at 13.9°C)

UNTREATED (12:00 pm 05/03/2012) – end of test

- 14.5°C oil temperature (increased 1.6°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 53.120 cp viscosity (decreased 11.32% from baseline)
- 1906.78 Reynolds # (increased 12.77% from baseline)
- 0.0335644 friction loss (decreased 11.32% from baseline)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 13.329 psi/mile pressure drop (decreased 11.32% from baseline)
- 15.8 kW power consumption (decreased 0.58% from baseline)

TREATED (12:00 pm 05/03/2012) – end of test

- 14.5°C oil temperature (increased 1.6°C from baseline)
- 0.85 g/cm3 oil density (unchanged)
- 53.0 cp viscosity (reduced 11.53% from baseline at 13.9°C, reduced 0.23% from untreated oil at 14.5°C)
- 1911.10 Reynolds # (increased 13.03% from baseline at 13.9°C, increased 0.23% from untreated oil at 14.5°C)
- 0.0334885 friction loss (reduced 11.53% from baseline at 13.9°C, reduced 0.23% from untreated oil at 14.5°C)
- 84.093200 cm/sec velocity (unchanged)
- 210 gal/min flow rate (unchanged)
- 13.2990 psi/mile pressure drop (reduced 11.53% from baseline at 14.5°C, reduced 0.23% from untreated oil at 14.5°C)

When the AOT was disengaged, viscosity, friction loss, and pressure drop were observed to remain suppressed, returning to baseline values after approximately 11 hours before the temperature viscosity reduction effect supplanted the AOT viscosity reduction effect.

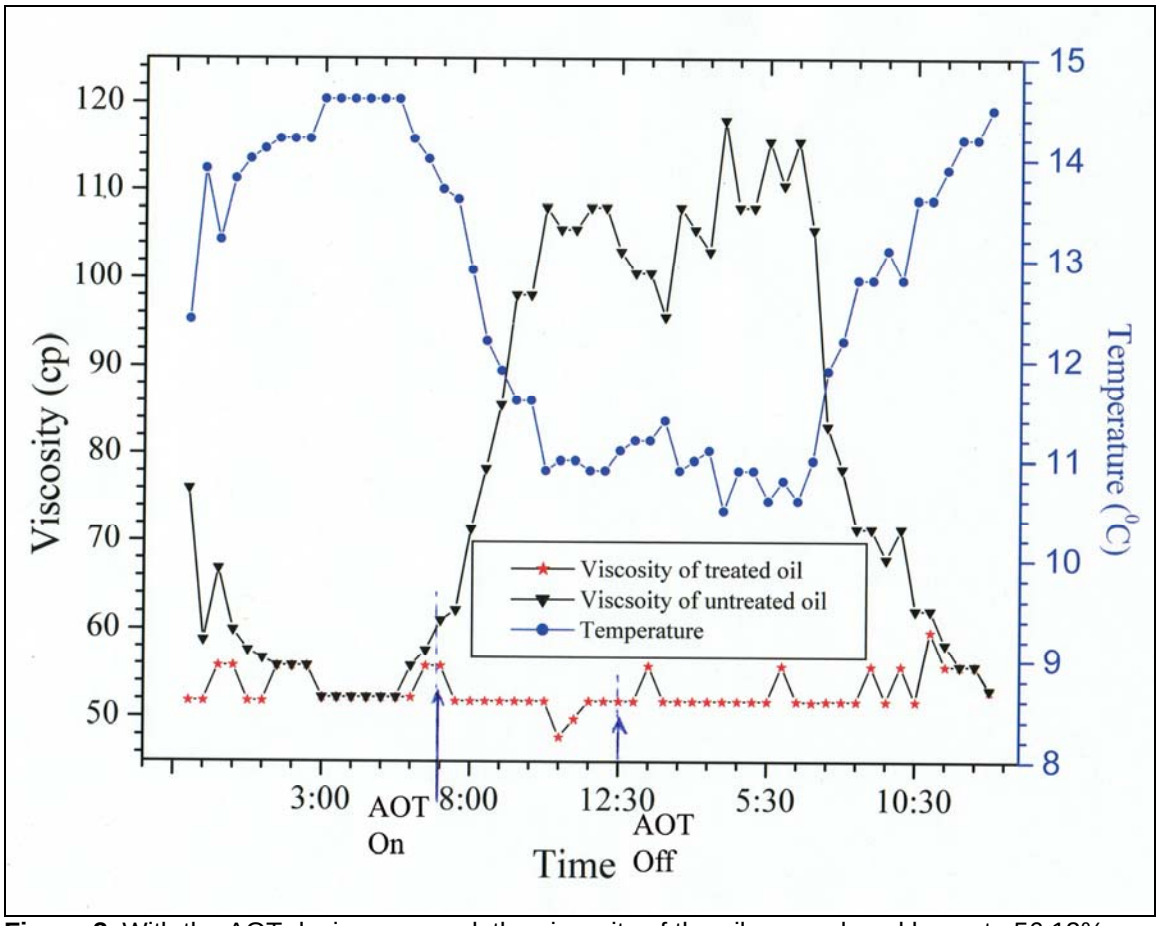


Figure 3. With the AOT device engaged, the viscosity of the oil was reduced by up to 56.12% compared to untreated oil at the same temperature. The viscosity was reduced to 51.8 cP from 118.060 cP at the 04:00 am measurement. Overall reduced viscosity low was 47.8 cP at 10:30 pm 05/02/2012.

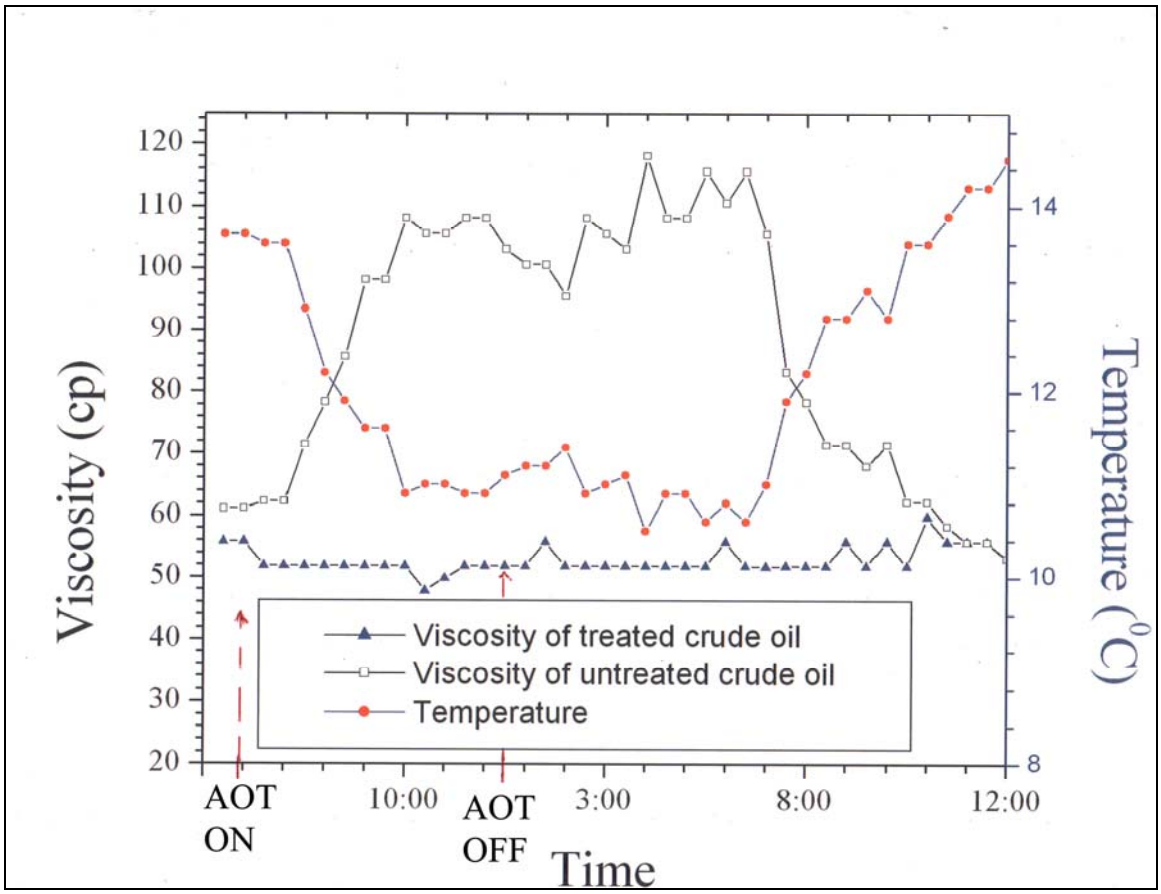


Figure 4. During the 24-hour test, the viscosity of the untreated oil increased as the temperature decreased throughout the night. The viscosity of the untreated oil reached an overall high of 118.06 cP at 04:00 am 05/03/2012. The AOT treated viscosity of the oil at that time was 51.8 cP, a 56.12% reduction in viscosity. The AOT treated oil demonstrated a suppressed viscosity throughout the night, regardless of temperature reduction.

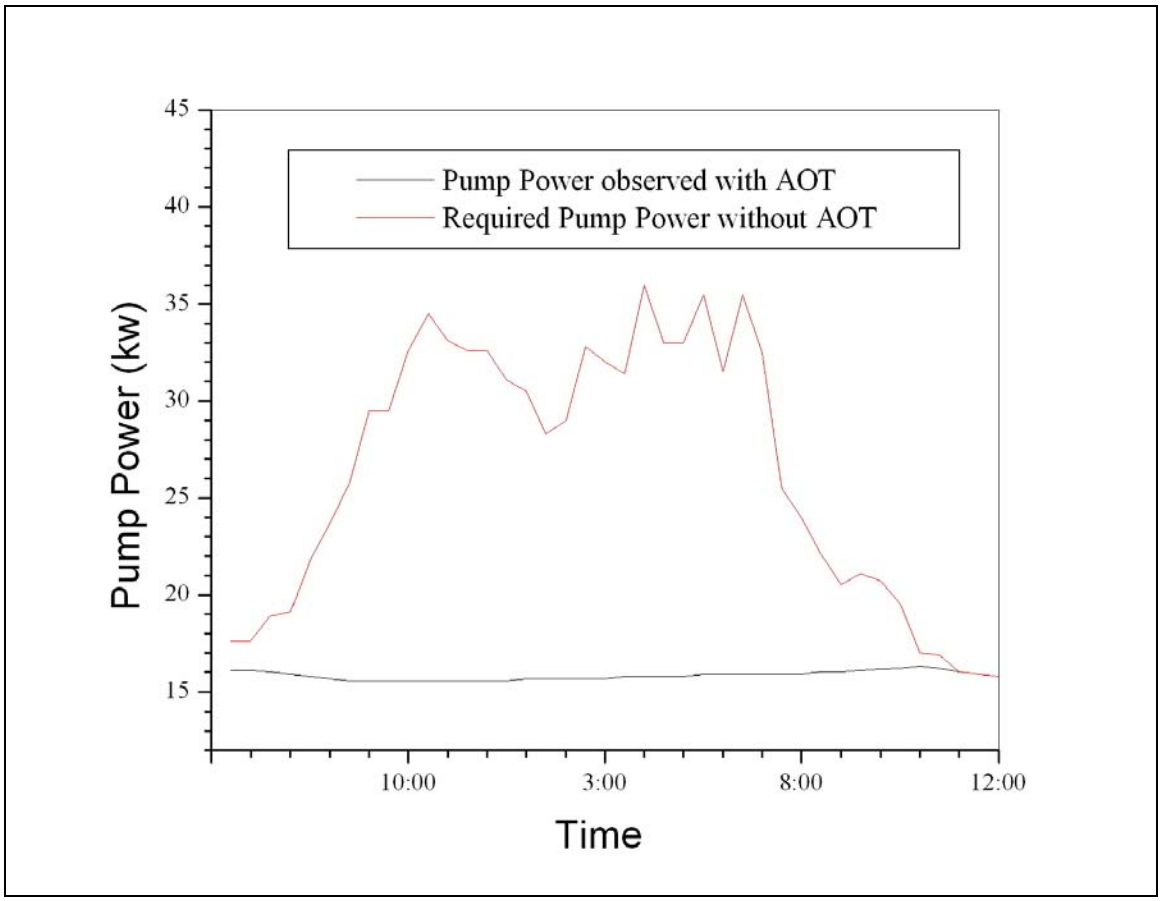


Figure 5. Pump power requirements were reduced throughout the test, reaching an overall maximum reduction of -56.12%, reducing from an untreated oil power requirement of 36.0kW to 15.8kW at 04:00 am 05/03/2012. Power requirements for untreated oil increased during the colder temperatures encountered during the 24-hour test, reaching an overall high of +126.09%, increasing from a baseline of 15.9kW to 36.0kW at 04:00am 05/03/2012.

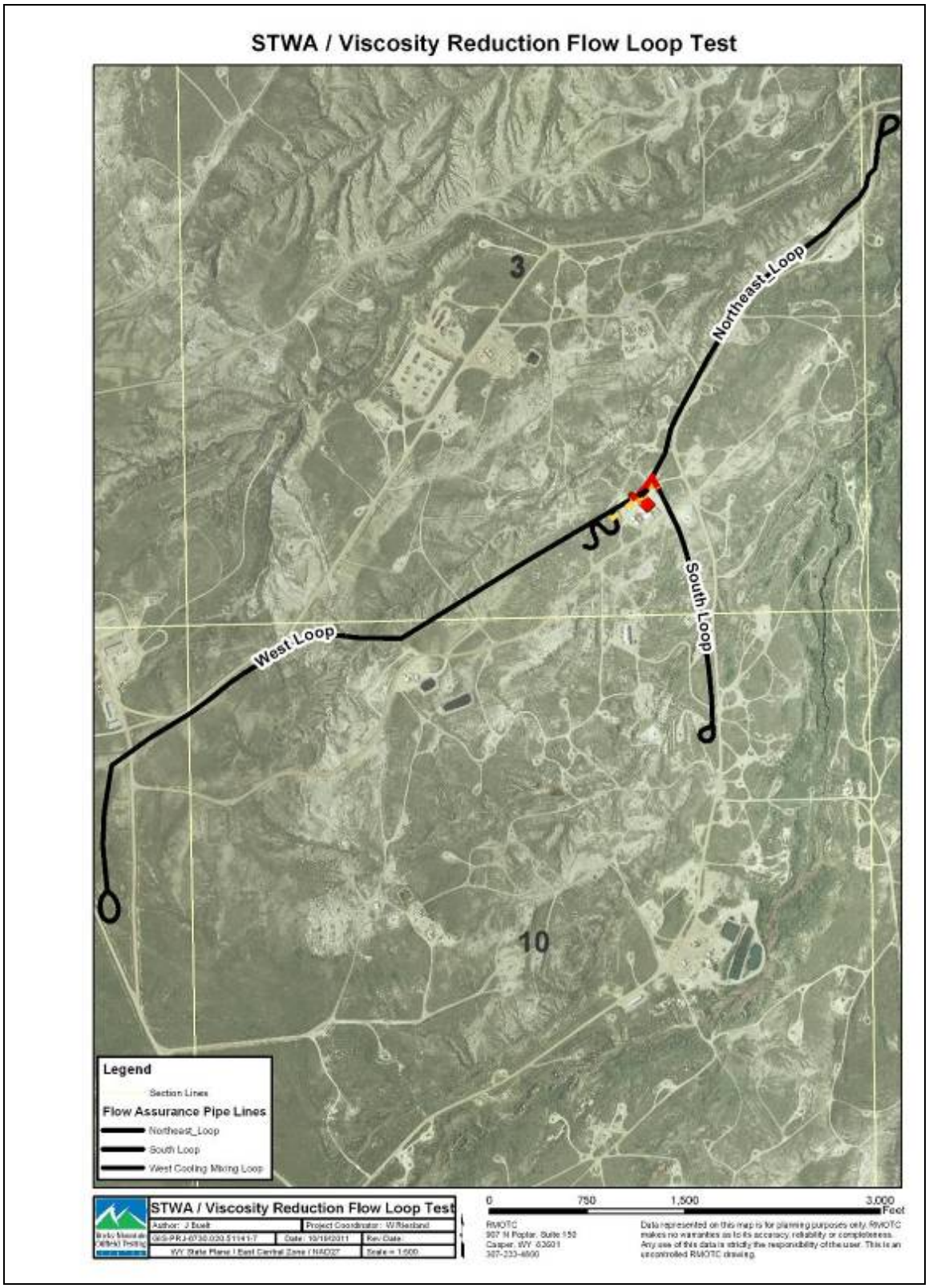


Figure 6. NPR-3 Flowloop Map

CONCLUSION:

Test results indicate that the viscosity reduction device operated successfully and that the AOT 1.2V delivers improved performance over the original AOT 1.1 tested in October 2011 and AOT 1.2H tested in March 2012. Pipeline line-loss and pump motor power consumption were reduced for a given flow rate during the observed test. The device may hold potential for energy savings and increased pipeline flow rates for the oil production and transportation industry.

Figure 7. STWA AOT 1.2V at completion of 24 hour test, May 03, 2012.

This research was co-funded by STWA, Inc. and the Pipeline Research Council International (PRCI). Work was directed by Clarke Turner, Brian Haight, Wes Lintz, Wes Riesland, George Hughes, and Jeanette Buelt.

APPENDIX A

US DOE – STWA AOT TEST DATA
05022012 - 05032012

US DOE RMOTC - STWA AOT TEST DATA 050212-050312 - **FLOW LOOP DATA OVERVIEW**

US DOE - STWA AOT TEST 050212-050312 - COMPARISONS

PIPELINE SPECS						VISCOSITY						REYNOLDS #						FRICTION LOSS						PRESSURE DROP						POWER CONSUMPTION					
TIME	Diameter	Density	Flow Rate (GPM)	Velocity (cm/sec)	Temperature (@ PORT #3)	BASELINE	UNTREATED (cP)	TREATED (cP)	Baseline vs Untreated (%)	Treated vs Baseline (%)	Treated vs Untreated (%)	BASELINE	UNTREATED	TREATED	Baseline vs Untreated (%)	Treated vs Baseline (%)	Treated vs Untreated (%)	BASELINE	UNTREATED	TREATED	Baseline vs Untreated (%)	Treated vs Baseline (%)	Treated vs Untreated (%)	BASELINE	UNTREATED	TREATED	Baseline vs Untreated (%)	Treated vs Baseline (%)	Treated vs Untreated (%)	BASELINE	UNTREATED	TREATED	Baseline vs Untreated (%)	Treated vs Baseline (%)	Treated vs Untreated (%)
11:30 AM	5.57886785	0.850	210	84.093200	13.9	59.904	59.904	59.8	0.00%	-0.17%	-0.17%	1,690.84	1,690.84	1,693.79	0.00%	0.17%	0.17%	0.0378509	0.0378509	0.0377852	0.00%	-0.17%	-0.17%	15.0313875	15.0313875	15.0052913	0.00%	-0.17%	-0.17%	15.9	15.9	15.9	0.00%	-0.17%	-0.17%
10:30 PM	5.57886785	0.850	210	84.093200	11.0	59.904	105.600	47.8	76.28%	-20.21%	-54.73%	1,690.84	959.17	2,119.00	-43.27%	25.32%	120.92%	0.0378509	0.0667243	0.0302029	76.28%	-20.21%	-54.73%	15.0313875	26.4976382	11.9941961	76.28%	-20.21%	-54.73%	15.9	34.5	15.6	116.38%	-2.06%	-54.73%
12:00 AM	5.57886785	0.850	210	84.093200	10.9	59.904	108.100	51.8	80.46%	-13.53%	-52.08%	1,690.84	936.99	1,955.37	-44.58%	15.64%	108.69%	0.0378509	0.0683040	0.0327303	80.46%	-13.53%	-52.08%	15.0313875	27.1249497	12.9978945	80.46%	-13.53%	-52.08%	15.9	32.6	15.6	104.39%	-2.06%	-52.08%
4:00 AM	5.57886785	0.850	210	84.093200	10.9	59.904	118.060	51.8	97.08%	-13.53%	-56.12%	1,690.84	857.94	1,955.37	-49.26%	15.64%	127.92%	0.0378509	0.0745973	0.0327303	97.08%	-13.53%	-56.12%	15.0313875	29.6241588	12.9978945	97.08%	-13.53%	-56.12%	15.9	36.0	15.8	126.09%	-0.80%	-56.12%
11:00 AM	5.57886785	0.850	210	84.093200	13.6	59.904	62.210	59.8	3.85%	-0.17%	-3.87%	1,690.84	1,628.17	1,693.79	-3.71%	0.17%	4.03%	0.0378509	0.0393080	0.0377852	3.85%	-0.17%	-3.87%	15.0313875	15.6100196	15.0052913	3.85%	-0.17%	-3.87%	15.9	17.0	16.3	6.46%	2.34%	-3.87%
12:00 PM	5.57886785	0.850	210	84.093200	14.5	59.904	53.120	53.0	-11.32%	-11.53%	-0.23%	1,690.84	1,906.78	1,911.10	12.77%	13.03%	0.23%	0.0378509	0.0335644	0.0334885	-11.32%	-11.53%	-0.23%	15.0313875	13.3291150	13.2990040	-11.32%	-11.53%	-0.23%	15.9	15.8	15.8	-0.58%	-0.80%	-0.23%
MAX/MIN									97.08%	-20.21%	-56.12%				-49.26%	0.17%	127.92%				97.08%	-20.21%	-56.12%				97.08%	-20.21%	-56.12%				126.09%	-2.06%	-56.12%

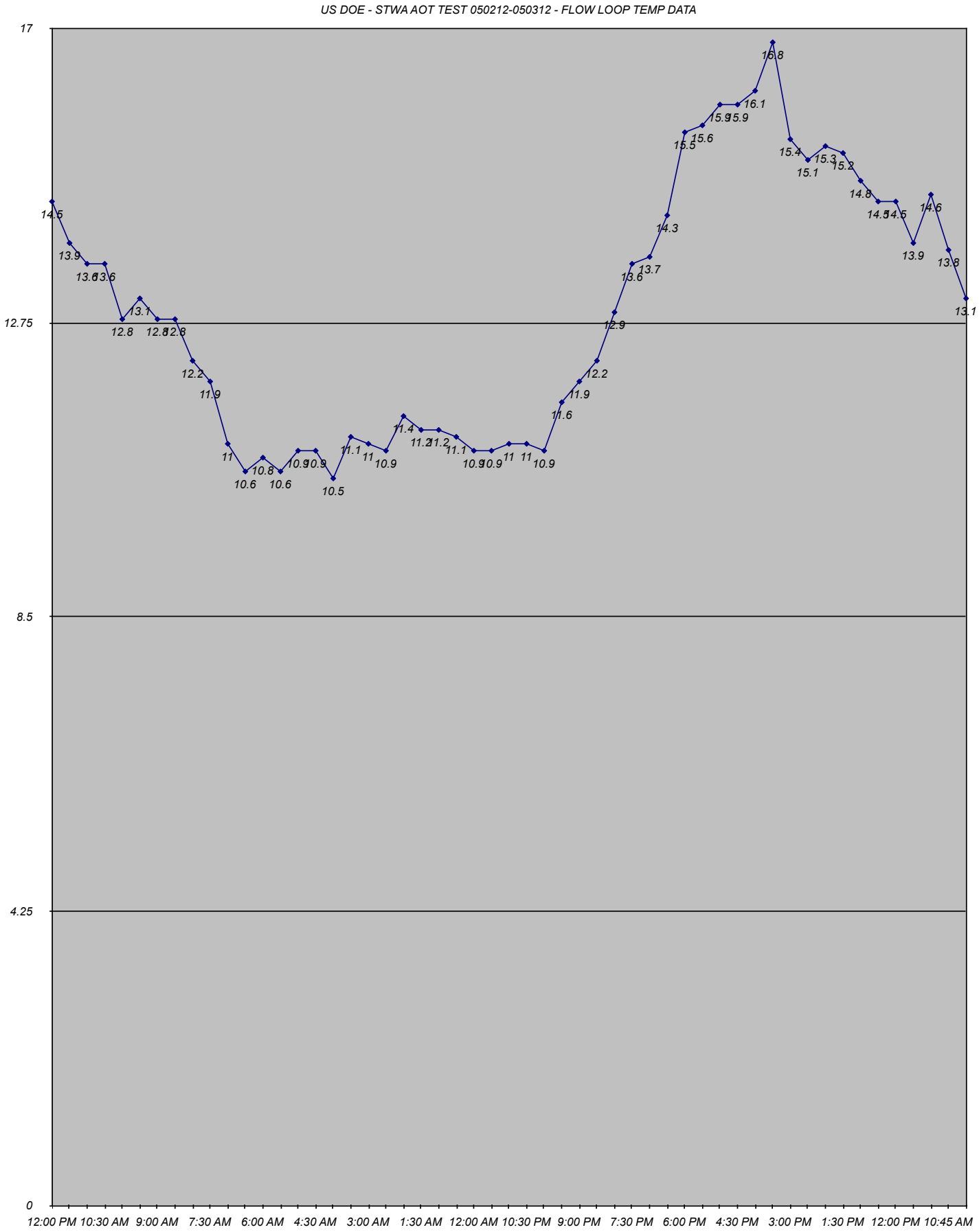
US DOE - STWA AOT TEST 050212-050312 - FLOW LOOP TEMP DATA

STWA Test Data			TEMPERATURES (FLUKE TYPE J THERMOCOUPLE)						
	AOT power	I/O	TIME	T1 (C)	T2 (C)	T3 (C)	T4 (C)	T5 (C)	T6 (C)
Data not used from 10:30 to 11:30am. Temp/ pressure stabilization protocol during this time	off	0	10:30 AM	12.4	12.4	13.1	13.4	12.7	11.6
	off	0	10:45 AM	12.7	13.2	13.8	12.5	12.4	11.9
	off	0	11:00 AM	13.9	14.1	14.6	13.6	13	13.4
Pipeflow Stabilized	off	0	11:30 AM	13.2	13.5	13.9	14	13	12.5
	AOT on at (CLASSIFIED, below threshold)	1	12:00 PM	13.8	14.1	14.5	14.6	13.9	13.3
	AOT on at (CLASSIFIED, below threshold)	1	12:30 PM	14	13.8	14.5	14.4	14.2	13.6
	AOT on at (CLASSIFIED, below threshold)	1	1:00 PM	14.1	14.3	14.8	14.6	14.6	13.9
	AOT on at (CLASSIFIED, below threshold)	1	1:30 PM	14.2	14.2	15.2	14.8	14.8	14
	AOT on at (CLASSIFIED, below threshold)	1	2:00 PM	14.8	14.6	15.3	14.9	14.7	14.4
	AOT on at (CLASSIFIED, below threshold)	1	2:30 PM	14.2	14.3	15.1	14.8	14.4	14
	AOT on at (CLASSIFIED, below threshold)	1	3:00 PM	14.6	15	15.4	16	15.5	15
	AOT on at (CLASSIFIED, below threshold)	1	3:30 PM	16	16.4	16.8	16.3	16	15.2
	AOT on at (CLASSIFIED, below threshold)	1	4:00 PM	15.5	15.8	16.1	15.8	15.3	14.8
	AOT on at (CLASSIFIED, below threshold)	1	4:30 PM	15.2	15.5	15.9	15.6	15.2	14.7
	AOT on at (CLASSIFIED, below threshold)	1	5:00 PM	15.3	15.5	15.9	15.7	15	14.9
	AOT on at (CLASSIFIED, below threshold)	1	5:30 PM	15.1	15.1	15.6	15.4	14.8	14.7
Engage Closed Loop Mode for Viscosity reduction effect persistence test			6:00 PM	14.9	15.2	15.5	15.2	14.6	14.3
	AOT on at (CLASSIFIED, at threshold)	1	6:30 PM	14	13.8	14.3	14.6	14.3	13.8
	AOT on at (CLASSIFIED, at threshold)	1	7:00 PM	13.4	13.5	13.7	13.8	13.7	13.4
AOT power increased to setting above min threshold (Power Setting Classified)	AOT on at (CLASSIFIED, at above threshold)	1	7:30 PM	13.6	13.8	13.6	13.7	13.8	13.4
	AOT on at (CLASSIFIED, at above threshold)	1	8:00 PM	12.8	13	12.9	13	12.8	12.9
	AOT on at (CLASSIFIED, at above threshold)	1	8:30 PM	12.2	12.2	12.2	12.2	12	12.3
	AOT on at (CLASSIFIED, at above threshold)	1	9:00 PM	11.8	11.8	11.9	11.9	11.8	11.8
	AOT on at (CLASSIFIED, at above threshold)	1	9:30 PM	11.3	11.3	11.6	11.5	11.4	11.3

US DOE - STWA AOT TEST 050212-050312 - FLOW LOOP TEMP DATA									
STWA Test Data			TEMPERATURES (FLUKE TYPE J THERMOCOUPLE)						
	AOT power	I/O	TIME	T1 (C)	T2 (C)	T3 (C)	T4 (C)	T5 (C)	T6 (C)
	AOT on at (CLASSIFIED, at above threshold)	1	10:00 PM	10.9	10.9	10.9	10.9	10.8	10.9
	AOT on at (CLASSIFIED, at above threshold)	1	10:30 PM	10.9	10.9	11	11	11	10.9
	AOT on at (CLASSIFIED, at above threshold)	1	11:00 PM	10.9	10.9	11	10.9	11	10.9
	AOT on at (CLASSIFIED, at above threshold)	1	11:30 PM	10.7	10.7	10.9	10.9	10.8	10.7
	AOT on at (CLASSIFIED, at above threshold)	1	12:00 AM	10.8	10.8	10.9	10.9	10.8	10.8
Return to Baseline Visc Test Protocol	AOT OFF	0	12:30 AM	11.3	11.3	11.1	10.8	11.1	11
	aot off	0	1:00 AM	11.3	11.4	11.2	11	10.9	11.3
	aot off	0	1:30 AM	11.3	11.5	11.2	11.3	10.9	11.1
	aot off	0	2:00 AM	11.6	11.3	11.4	11.3	11	11.3
	aot off	0	2:30 AM	10.8	11	10.9	10.5	10.2	11.3
	aot off	0	3:00 AM	11	10.8	11	10.8	10.7	10.9
	aot off	0	3:30 AM	11.2	11.3	11.1	11	10.7	11.4
	aot off	0	4:00 AM	11	11	10.5	10.4	10.2	11.1
	aot off	0	4:30 AM	11	11.2	10.9	10.8	10.5	10.9
	aot off	0	5:00 AM	11.1	11.2	10.9	10.8	10.4	11
	aot off	0	5:30 AM	10.6	10.7	10.6	10.5	10.4	10.8
	aot off	0	6:00 AM	10.8	11	10.8	10.7	10.5	11.3
	aot off	0	6:30 AM	10.9	11	10.6	10.5	10.4	11.3
	aot off	0	7:00 AM	11.2	11.3	11	10.9	10.9	11.1
	aot off	0	7:30 AM	11.8	11.3	11.9	11.8	11.5	11.9

US DOE - STWA AOT TEST 050212-050312 - FLOW LOOP TEMP DATA

STWA Test Data			TEMPERATURES (FLUKE TYPE J THERMOCOUPLE)						
	AOT power	I/O	TIME	T1 (C)	T2 (C)	T3 (C)	T4 (C)	T5 (C)	T6 (C)
	aot off	0	8:00 AM	12.2	12.2	12.2	12.2	12.2	12.2
	aot off	0	8:30 AM	12.6	12.7	12.8	12.6	12.5	12.8
	aot off	0	9:00 AM	12.8	12.8	12.8	12.8	12.6	12.8
	aot off	0	9:30 AM	13.1	13.2	13.1	13	12.6	13.2
	aot off	0	10:00 AM	12.6	12.7	12.8	12.6	12.4	12.6
	aot off	0	10:30 AM	13.4	13.5	13.6	13.3	13	13.5
	aot off	0	11:00 AM	13.4	13.5	13.6	13.3	13	13.5
	aot off	**0**	11:30 AM	13.5	13.7	13.9	13.7	13.2	13.2
AOT viscosity reduction effect returns to zero between 11:30 and 12:00pm.	aot off	0	12:00 PM	14.2	14.4	14.5	14.4	13.9	14.2


US DOE - STWA AOT TEST 050212-050312 - FLOW LOOP TEMP DATA
17
12.75
8.5
4.25
0
12:00 PM
10:30 AM
9:00 AM
7:30 AM
6:00 AM
4:30 AM
3:00 AM
1:30 AM
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10:30 PM
9:00 PM
7:30 PM
6:00 PM
4:30 PM
3:00 PM
1:30 PM
12:00 PM
10:45 AM
TEMPERATURE 1

US DOE - STWA AOT TEST 050212-050312 - VISCOSITY DATA

TIME	Viscosity TREATED ACTUAL VISCOSITY OBSERVED (Calc R. Tao, Chair, Dept. of Physics, Temple Univ.) (poise)	UNTREATED Viscosity for Average Temp from Bench-Mount Brookfield viscometer measurement at 40rpm shear (poise)	Net Change Actual - Expected (40rpm shear)	*What Viscosity WAS* (TREATED) in (cP)	*What Viscosity SHOULD HAVE BEEN*: (UNTREATED) in (cP)	Net Change (Treated - Untreated)	NET VISCOSITY Change (Actual - Expected) (%) (40rpm shear)
10:30 AM	**0.598**	**0.6797**	-0.081700	59.8	67.970	-8.170	**12.02%**
10:45 AM	**0.598**	**0.59904**	-0.001040	59.8	59.904	-0.104	**0.17%**
11:00 AM	**0.598**	**0.59904**	-0.001040	59.8	59.904	-0.104	**0.17%**
11:30 AM	**0.598**	**0.59904**	-0.001040	59.8	59.904	-0.104	**0.17%**
12:00 PM	**0.558**	**0.59904**	-0.041040	55.8	59.904	-4.104	**6.85%**
12:30 PM	**0.518**	**0.576**	-0.058000	51.8	57.600	-5.800	**10.07%**
1:00 PM	**0.518**	**0.56704**	-0.049040	51.8	56.704	-4.904	**8.65%**
1:30 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
2:00 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
2:30 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
3:00 PM	**0.528**	**0.522**	0.006000	52.8	52.200	0.600	**1.15%**
3:30 PM	**0.528**	**0.522**	0.006000	52.8	52.200	0.600	**1.15%**
4:00 PM	**0.528**	**0.522**	0.006000	52.8	52.200	0.600	**1.15%**
4:30 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
5:00 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
5:30 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
6:00 PM	**0.558**	**0.5581**	-0.000100	55.8	55.810	-0.010	**0.02%**
6:30 PM	**0.558**	**0.576**	-0.018000	55.8	57.600	-1.800	**3.12%**
7:00 PM	**0.558**	**0.61056**	-0.052560	55.8	61.056	-5.256	**8.61%**
7:30 PM	**0.518**	**0.6221**	-0.104100	51.8	62.210	-10.410	**16.73%**
8:00 PM	**0.518**	**0.7142**	-0.196200	51.8	71.420	-19.620	**27.47%**
8:30 PM	**0.518**	**0.78336**	-0.265360	51.8	78.336	-26.536	**33.87%**

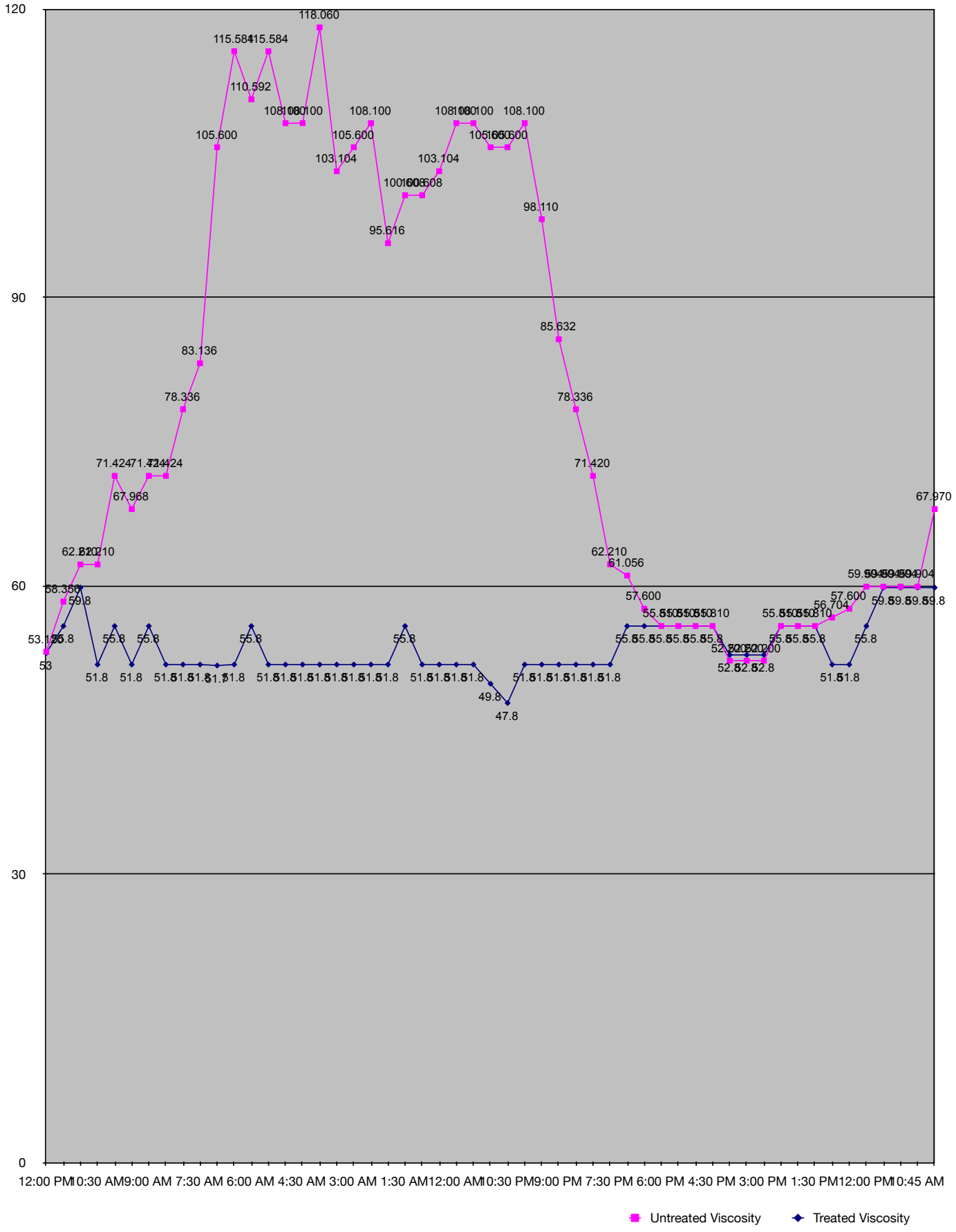
US DOE - STWA AOT TEST 050212-050312 - VISCOSITY DATA

	Viscosity						
TIME	**TREATED ACTUAL VISCOSITY OBSERVED (Calc R. Tao, Chair, Dept. of Physics, Temple Univ.) (poise)**	**UNTREATED Viscosity for Average Temp from Bench-Mount Brookfield viscometer measurement at 40rpm shear (poise)**	**Net Change Actual - Expected (40rpm shear)**	***What Viscosity WAS* (TREATED) in (cP)**	***What Viscosity SHOULD HAVE BEEN*: (UNTREATED) in (cP)**	**Net Change (Treated - Untreated)**	**NET VISCOSITY Change (Actual - Expected) (%) (40rpm shear)**
9:00 PM	**0.518**	**0.85632**	-0.338320	51.8	85.632	-33.832	**39.51%**
9:30 PM	**0.518**	**0.9811**	-0.463100	51.8	98.110	-46.310	**47.20%**
10:00 PM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**
10:30 PM	**0.478**	**1.056**	-0.578000	47.8	105.600	-57.800	**54.73%**
11:00 PM	**0.498**	**1.056**	-0.558000	49.8	105.600	-55.800	**52.84%**
11:30 PM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**
12:00 AM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**
12:30 AM	**0.518**	**1.03104**	-0.513040	51.8	103.104	-51.304	**49.76%**
1:00 AM	**0.518**	**1.00608**	-0.488080	51.8	100.608	-48.808	**48.51%**
1:30 AM	**0.558**	**1.00608**	-0.448080	55.8	100.608	-44.808	**44.54%**
2:00 AM	**0.518**	**0.95616**	-0.438160	51.8	95.616	-43.816	**45.82%**
2:30 AM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**
3:00 AM	**0.518**	**1.056**	-0.538000	51.8	105.600	-53.800	**50.95%**
3:30 AM	**0.518**	**1.03104**	-0.513040	51.8	103.104	-51.304	**49.76%**
4:00 AM	**0.518**	**1.1806**	-0.662600	51.8	118.060	-66.260	**56.12%**
4:30 AM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**
5:00 AM	**0.518**	**1.081**	-0.563000	51.8	108.100	-56.300	**52.08%**

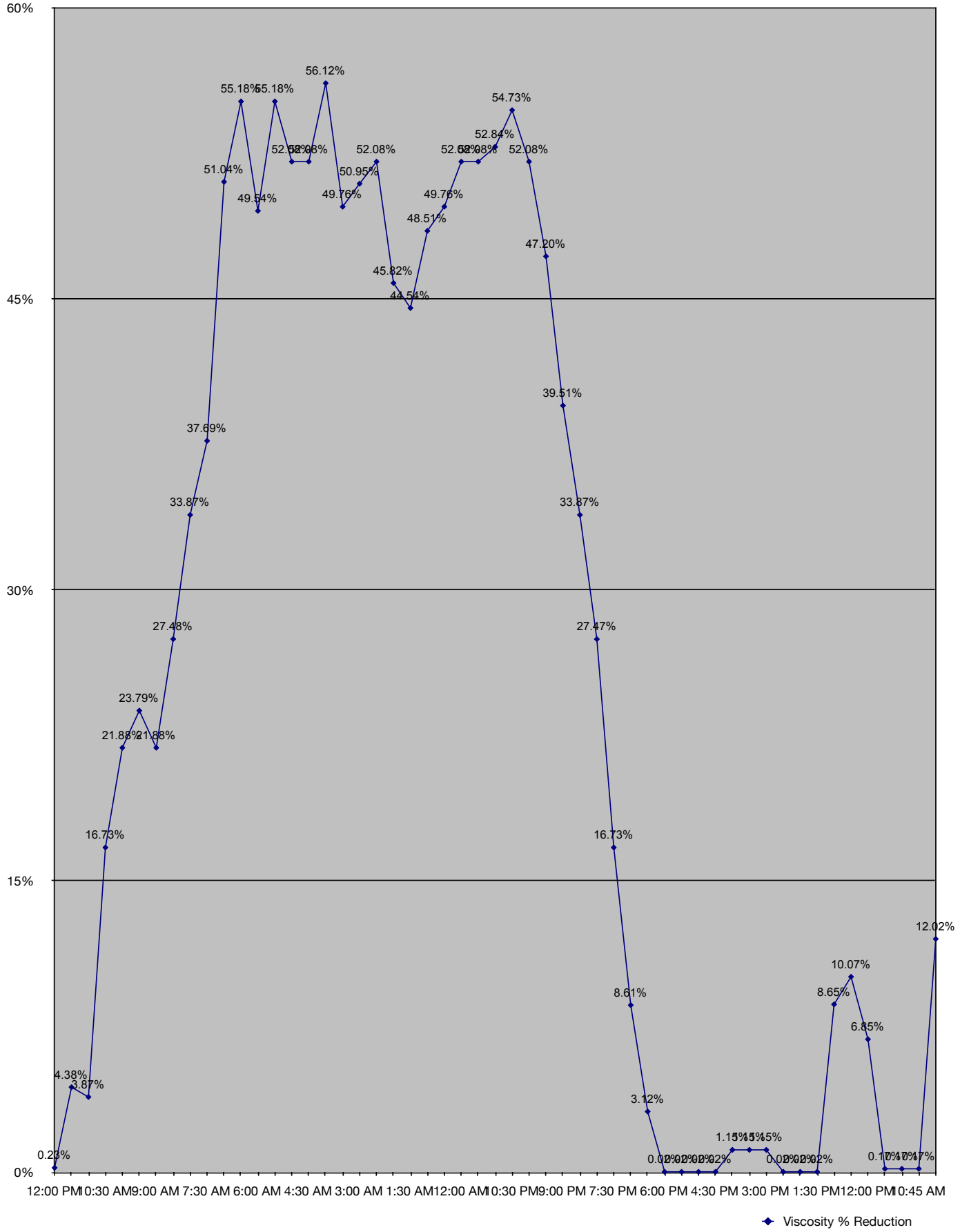
US DOE - STWA AOT TEST 050212-050312 - VISCOSITY DATA

TIME	Viscosity TREATED ACTUAL VISCOSITY OBSERVED (Calc R. Tao, Chair, Dept. of Physics, Temple Univ.) (poise)	UNTREATED Viscosity for Average Temp from Bench-Mount Brookfield viscometer measurement at 40rpm shear (poise)	Net Change Actual - Expected (40rpm shear)	*What Viscosity WAS* (TREATED) in (cP)	*What Viscosity SHOULD HAVE BEEN*: (UNTREATED) in (cP)	Net Change (Treated - Untreated)	NET VISCOSITY Change (Actual - Expected) (%) (40rpm shear)
5:30 AM	**0.518**	**1.15584**	-0.637840	51.8	115.584	-63.784	**55.18%**
6:00 AM	**0.558**	**1.10592**	-0.547920	55.8	110.592	-54.792	**49.54%**
6:30 AM	**0.518**	**1.15584**	-0.637840	51.8	115.584	-63.784	**55.18%**
7:00 AM	**0.517**	**1.056**	-0.539000	51.7	105.600	-53.900	**51.04%**
7:30 AM	**0.518**	**0.83136**	-0.313360	51.8	83.136	-31.336	**37.69%**
8:00 AM	**0.518**	**0.78336**	-0.265360	51.8	78.336	-26.536	**33.87%**
8:30 AM	**0.518**	**0.71424**	-0.196240	51.8	71.424	-19.624	**27.48%**
9:00 AM	**0.558**	**0.71424**	-0.156240	55.8	71.424	-15.624	**21.88%**
9:30 AM	**0.518**	**0.67968**	-0.161680	51.8	67.968	-16.168	**23.79%**
10:00 AM	**0.558**	**0.71424**	-0.156240	55.8	71.424	-15.624	**21.88%**
10:30 AM	**0.518**	**0.6221**	-0.104100	51.8	62.210	-10.410	**16.73%**
11:00 AM	**0.598**	**0.6221**	-0.024100	59.8	62.210	-2.410	**3.87%**
11:30 AM	**0.558**	**0.58356**	-0.025560	55.8	58.356	-2.556	**4.38%**
12:00 PM	**0.53**	**0.5312**	-0.001200	53	53.120	-0.120	**0.23%**
	Max Viscosity Treated (050312 11:00am)(poise)	**Max Viscosity Untreated(050312 4:00am)(poise)**		**Max Viscosity Treated (cP) (050312 11:00am)**	**Max Viscosity Untreated(cP) (050312 4:00am)**		**MAX Viscosity Reduction**
	0.598	**1.1806**		**59.8**	**118.060**		**56.12%**
	MIN Viscosity Treated (050212 10:30pm)	**MIN Viscosity Untreated (050212 3:00pm)**		**MIN Viscosity Treated(050212 10:30pm)**	**MIN Viscosity Untreated (050212 3:00pm)**		
	0.478	**0.522**		**47.8**	**52.200**		

US DOE - STWA AOT TEST 050212-050312 - VISCOSITY TREATED VS UNTREATED



US DOE - STWA AOT TEST 050212-050312 - VISCOSITY REDUCTION %

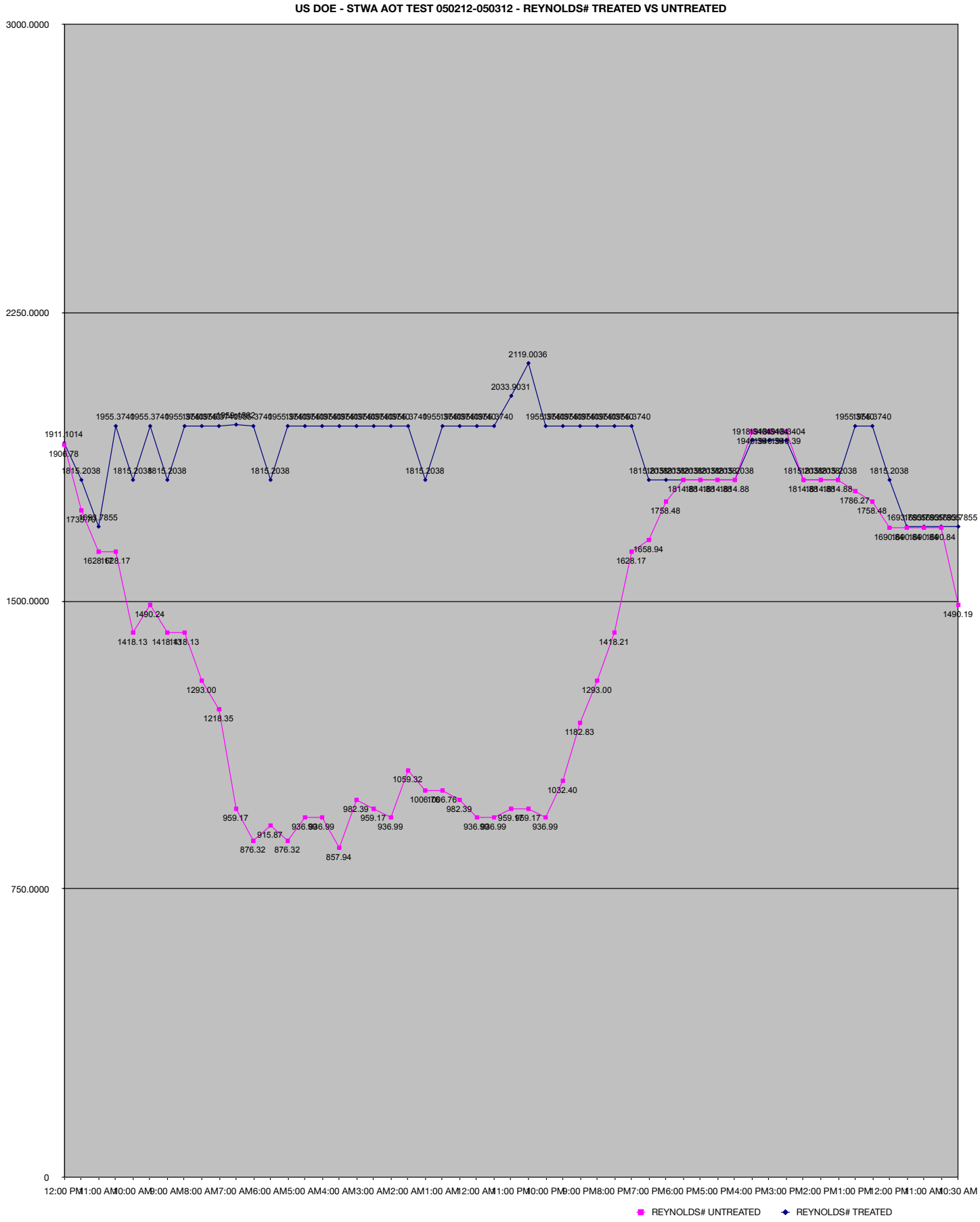


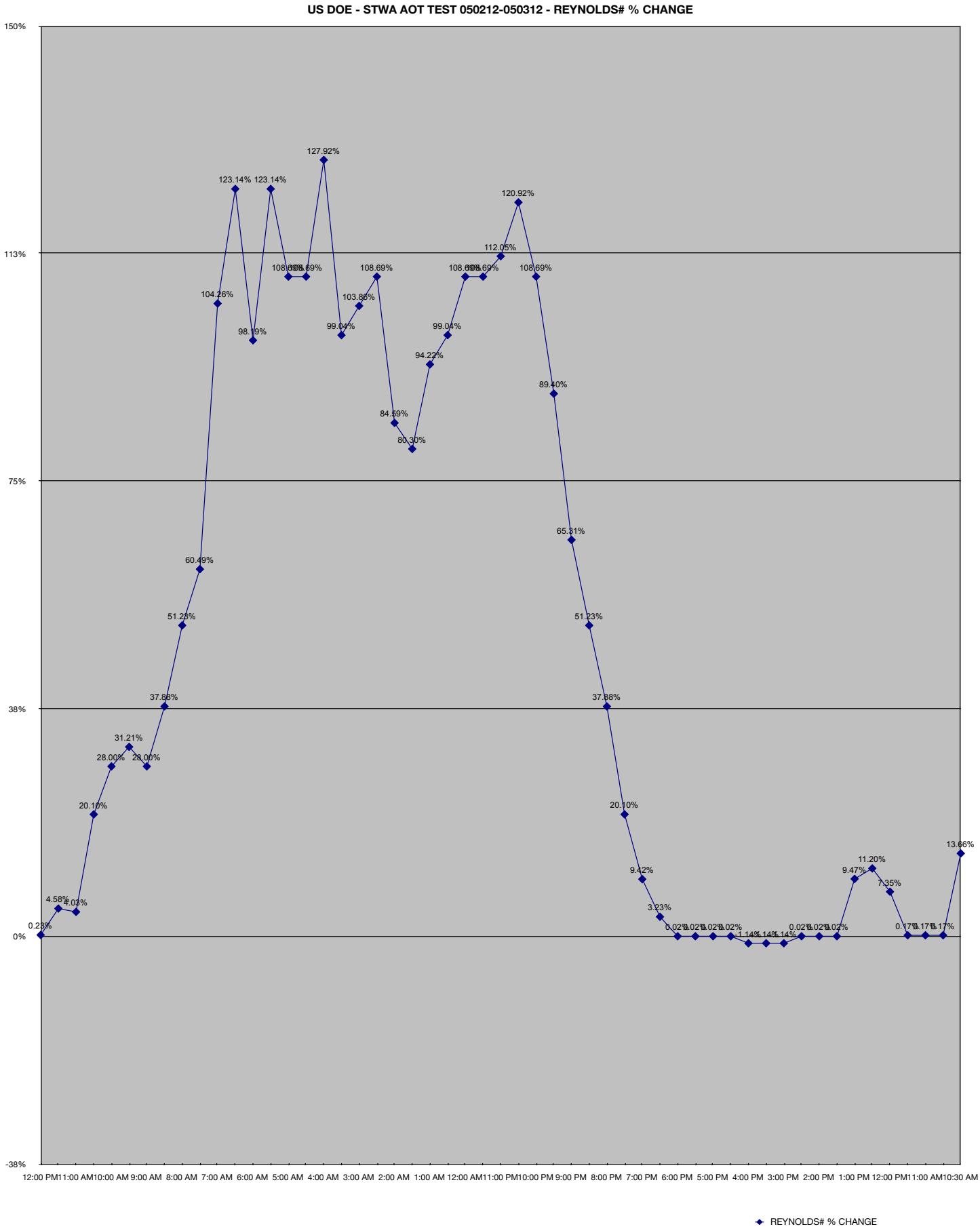
US DOE - STWA AOT TEST 050212-050312 - REYNOLDS # / FRICTION LOSS DATA

	Pipeline, Power, Reynolds											
TIME	DIAMETER	DENSITY	FLOWRATE (GPM)	VELOCITY (CM/ SEC)	TREATED REYNOLDS # as function of actual viscosity (R. Tao)	UNTREATED REYNOLDS # as function of untreated viscosity (R. Tao)	TREATED FRICTION LOSS (Calc R. Tao, Chair, Dept. of Physics, Temple Univ.)	UNTREATED Friction Loss as function of expected viscosity with 40rpm shear	Reynolds # Change Actual vs. Expected (TREATED vs. UNTREATED)	Reynolds # % Change	Friction Loss Change Actual vs. Expected	Friction Loss % Change
10:30 AM	5.57886785	0.850	210	84.093200	1693.7855	1490.19	0.03778519	0.04294748	203.593	13.66%	-0.005162	12.02%
10:45 AM	5.57886785	0.850	210	84.093200	1693.7855	1690.84	0.03778519	0.03785090	2.941	0.17%	-0.000066	0.17%
11:00 AM	5.57886785	0.850	210	84.093200	1693.7855	1690.84	0.03778519	0.03785090	2.941	0.17%	-0.000066	0.17%
11:30 AM	5.57886785	0.850	210	84.093200	1693.7855	1690.84	0.03778519	0.03785090	2.941	0.17%	-0.000066	0.17%
12:00 PM	5.57886785	0.850	210	84.093200	1815.2038	1690.84	0.03525775	0.03785090	124.359	7.35%	-0.002593	6.85%
12:30 PM	5.57886785	0.850	210	84.093200	1955.3740	1758.48	0.03273031	0.03639510	196.895	11.20%	-0.003665	10.07%
1:00 PM	5.57886785	0.850	210	84.093200	1955.3740	1786.27	0.03273031	0.03582895	169.109	9.47%	-0.003099	8.65%
1:30 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
2:00 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
2:30 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
3:00 PM	5.57886785	0.850	210	84.093200	1918.3404	1940.39	0.03336217	0.03298306	-22.050	-1.14%	0.000379	1.15%
3:30 PM	5.57886785	0.850	210	84.093200	1918.3404	1940.39	0.03336217	0.03298306	-22.050	-1.14%	0.000379	1.15%
4:00 PM	5.57886785	0.850	210	84.093200	1918.3404	1940.39	0.03336217	0.03298306	-22.050	-1.14%	0.000379	1.15%
4:30 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
5:00 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
5:30 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
6:00 PM	5.57886785	0.850	210	84.093200	1815.2038	1814.88	0.03525775	0.03526407	0.325	0.02%	-0.000006	0.02%
6:30 PM	5.57886785	0.850	210	84.093200	1815.2038	1758.48	0.03525775	0.03639510	56.725	3.23%	-0.001137	3.12%
7:00 PM	5.57886785	0.850	210	84.093200	1815.2038	1658.94	0.03525775	0.03857880	156.262	9.42%	-0.003321	8.61%
7:30 PM	5.57886785	0.850	210	84.093200	1955.3740	1628.17	0.03273031	0.03930797	327.205	20.10%	-0.006578	16.73%
8:00 PM	5.57886785	0.850	210	84.093200	1955.3740	1418.21	0.03273031	0.04512739	537.167	37.88%	-0.012397	27.47%
8:30 PM	5.57886785	0.850	210	84.093200	1955.3740	1293.00	0.03273031	0.04949733	662.375	51.23%	-0.016767	33.87%
9:00 PM	5.57886785	0.850	210	84.093200	1955.3740	1182.83	0.03273031	0.05410738	772.541	65.31%	-0.021377	39.51%
9:30 PM	5.57886785	0.850	210	84.093200	1955.3740	1032.40	0.03273031	0.06199172	922.978	89.40%	-0.029261	47.20%
10:00 PM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	108.69%	-0.035574	52.08%
10:30 PM	5.57886785	0.850	210	84.093200	2119.0036	959.17	0.03020287	0.06672434	1159.833	120.92%	-0.036521	54.73%
11:00 PM	5.57886785	0.850	210	84.093200	2033.9031	959.17	0.03146659	0.06672434	1074.733	112.05%	-0.035258	52.84%
11:30 PM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	108.69%	-0.035574	52.08%
12:00 AM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	108.69%	-0.035574	52.08%
12:30 AM	5.57886785	0.850	210	84.093200	1955.3740	982.39	0.03273031	0.06514722	972.984	99.04%	-0.032417	49.76%
1:00 AM	5.57886785	0.850	210	84.093200	1955.3740	1006.76	0.03273031	0.06357010	948.611	94.22%	-0.030840	48.51%

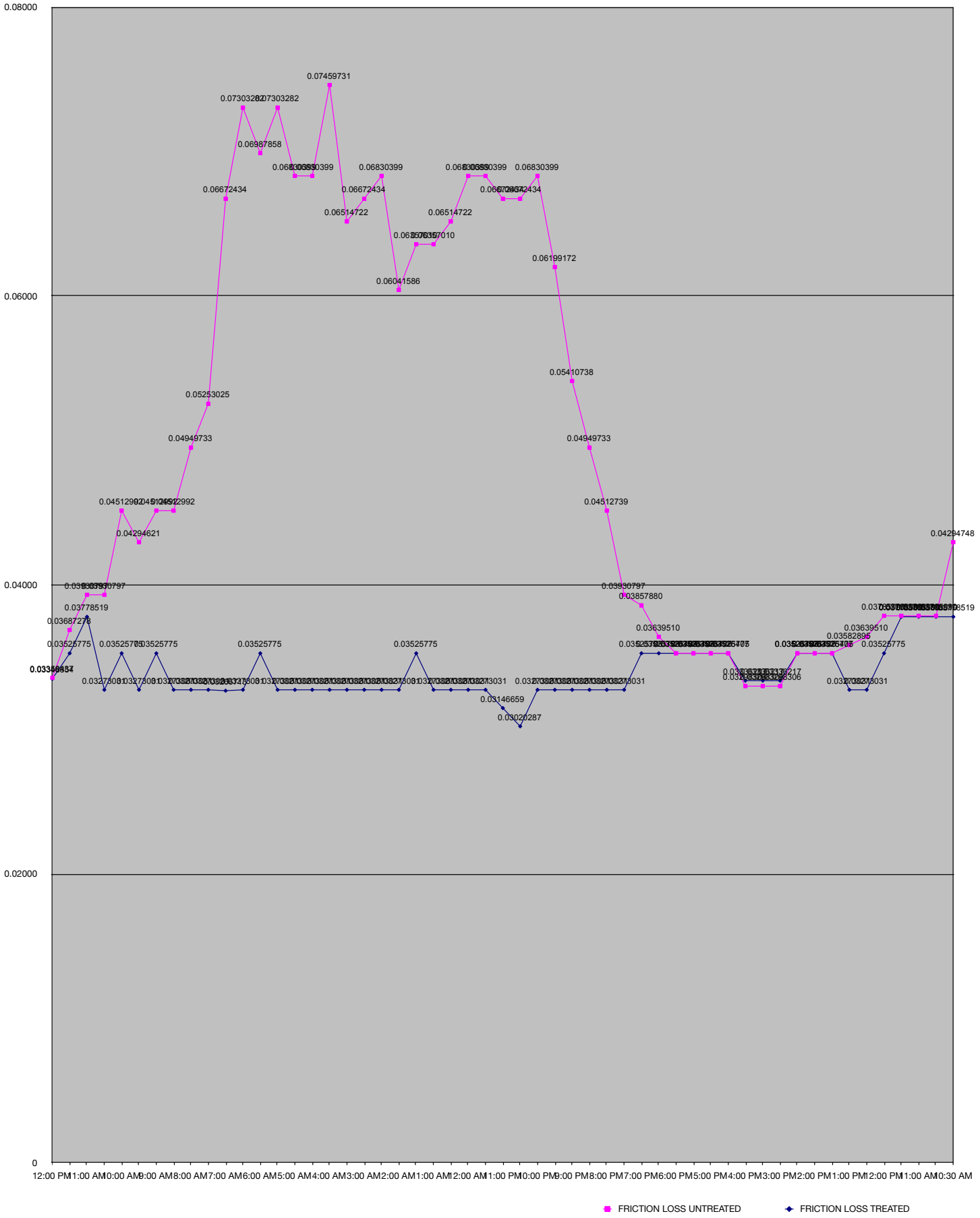
US DOE - STWA AOT TEST 050212-050312 - REYNOLDS # / FRICTION LOSS DATA

	Pipeline, Power, Reynolds											
TIME	DIAMETER	DENSITY	FLOWRATE (GPM)	VELOCITY (CM/ SEC)	TREATED REYNOLDS # as function of actual viscosity (R. Tao)	UNTREATED REYNOLDS # as function of untreated viscosity (R. Tao)	TREATED FRICTION LOSS (Calc R. Tao, Chair, Dept. of Physics, Temple Univ.)	UNTREATED Friction Loss as function of expected viscosity with 40rpm shear	Reynolds # Change Actual vs. Expected (TREATED vs. UNTREATED)	Reynolds # % Change	Friction Loss Change Actual vs. Expected	Friction Loss % Change
1:30 AM	5.57886785	0.850	210	84.093200	1815.2038	1006.76	0.03525775	0.06357010	808.441	**80.30%**	-0.028312	**44.54%**
2:00 AM	5.57886785	0.850	210	84.093200	1955.3740	1059.32	0.03273031	0.06041586	896.049	**84.59%**	-0.027686	**45.82%**
2:30 AM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	**108.69%**	-0.035574	**52.08%**
3:00 AM	5.57886785	0.850	210	84.093200	1955.3740	959.17	0.03273031	0.06672434	996.204	**103.86%**	-0.033994	**50.95%**
3:30 AM	5.57886785	0.850	210	84.093200	1955.3740	982.39	0.03273031	0.06514722	972.984	**99.04%**	-0.032417	**49.76%**
4:00 AM	5.57886785	0.850	210	84.093200	1955.3740	857.94	0.03273031	0.07459731	1097.434	**127.92%**	-0.041867	**56.12%**
4:30 AM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	**108.69%**	-0.035574	**52.08%**
5:00 AM	5.57886785	0.850	210	84.093200	1955.3740	936.99	0.03273031	0.06830399	1018.386	**108.69%**	-0.035574	**52.08%**
5:30 AM	5.57886785	0.850	210	84.093200	1955.3740	876.32	0.03273031	0.07303282	1079.056	**123.14%**	-0.040303	**55.18%**
6:00 AM	5.57886785	0.850	210	84.093200	1815.2038	915.87	0.03525775	0.06987858	899.329	**98.19%**	-0.034621	**49.54%**
6:30 AM	5.57886785	0.850	210	84.093200	1955.3740	876.32	0.03273031	0.07303282	1079.056	**123.14%**	-0.040303	**55.18%**
7:00 AM	5.57886785	0.850	210	84.093200	1959.1562	959.17	0.03266713	0.06672434	999.986	**104.26%**	-0.034057	**51.04%**
7:30 AM	5.57886785	0.850	210	84.093200	1955.3740	1218.35	0.03273031	0.05253025	737.028	**60.49%**	-0.019800	**37.69%**
8:00 AM	5.57886785	0.850	210	84.093200	1955.3740	1293.00	0.03273031	0.04949733	662.375	**51.23%**	-0.016767	**33.87%**
8:30 AM	5.57886785	0.850	210	84.093200	1955.3740	1418.13	0.03273031	0.04512992	537.246	**37.88%**	-0.012400	**27.48%**
9:00 AM	5.57886785	0.850	210	84.093200	1815.2038	1418.13	0.03525775	0.04512992	397.076	**28.00%**	-0.009872	**21.88%**
9:30 AM	5.57886785	0.850	210	84.093200	1955.3740	1490.24	0.03273031	0.04294621	465.138	**31.21%**	-0.010216	**23.79%**
10:00 AM	5.57886785	0.850	210	84.093200	1815.2038	1418.13	0.03525775	0.04512992	397.076	**28.00%**	-0.009872	**21.88%**
10:30 AM	5.57886785	0.850	210	84.093200	1955.3740	1628.17	0.03273031	0.03930797	327.205	**20.10%**	-0.006578	**16.73%**
11:00 AM	5.57886785	0.850	210	84.093200	1693.7855	1628.17	0.03778519	0.03930797	65.617	**4.03%**	-0.001523	**3.87%**
11:30 AM	5.57886785	0.850	210	84.093200	1815.2038	1735.70	0.03525775	0.03687278	79.506	**4.58%**	-0.001615	**4.38%**
12:00 PM	5.57886785	0.850	210	84.093200	1911.1014	1906.78	0.03348854	0.03356437	4.317	**0.23%**	-0.000076	**0.23%**
					MAX Reynolds # Treated	MAX Reynolds # Untreated	MAX Friction Loss Treated	MAX Friction Loss Untreated	MAX Reynolds # Change	**MAX Reynolds # % Change**	MAX Friction Loss Change	**MAX Friction Loss % Change**
					2119.0036	1940.39	0.03778519	0.0745973	1159.83	**127.92%**	-0.0418670	**56.12%**
					MIN Reynolds # Treated	MIN Reynolds # Untreated						
					1693.7855	857.94						


US DOE - STWA AOT TEST 050212-050312 - REYNOLDS# TREATED VS UNTREATED
3000.0000
2250.0000
1500.0000
750.0000
0
12:00 PM
11:00 AM
10:00 AM
9:00 AM
8:00 AM
7:00 AM
6:00 AM
5:00 AM
4:00 AM
3:00 AM
2:00 AM
1:00 AM
12:00 AM
11:00 PM
10:00 PM
9:00 PM
8:00 PM
7:00 PM
6:00 PM
5:00 PM
4:00 PM
3:00 PM
2:00 PM
1:00 PM
12:00 PM
11:00 AM
10:30 AM
REYNOLDS# UNTREATED
REYNOLDS# TREATED


US DOE - STWA AOT TEST 050212-050312 - REYNOLDS# % CHANGE
150%
113%
75%
38%
0%
-38%
12:00 PM
11:00 AM
10:00 AM
9:00 AM
8:00 AM
7:00 AM
6:00 AM
5:00 AM
4:00 AM
3:00 AM
2:00 AM
1:00 AM
12:00 AM
11:00 PM
10:00 PM
9:00 PM
8:00 PM
7:00 PM
6:00 PM
5:00 PM
4:00 PM
3:00 PM
2:00 PM
1:00 PM
12:00 PM
11:00 AM
10:30 AM
0.23%
4.58%
4.03%
20.10%
28.00%
31.21%
28.00%
37.88%
51.23%
60.49%
104.26%
123.14%
98.19%
123.14%
127.92%
99.04%
103.86%
108.69%
84.59%
80.30%
94.22%
99.04%
112.05%
120.92%
89.40%
65.31%
51.23%
37.88%
20.10%
9.42%
3.23%
9.47%
11.20%
7.35%
13.66%
REYNOLDS# % CHANGE

US DOE - STWA AOT TEST 050212-050312 - FRICTION LOSS TREATED VS UNTREATED

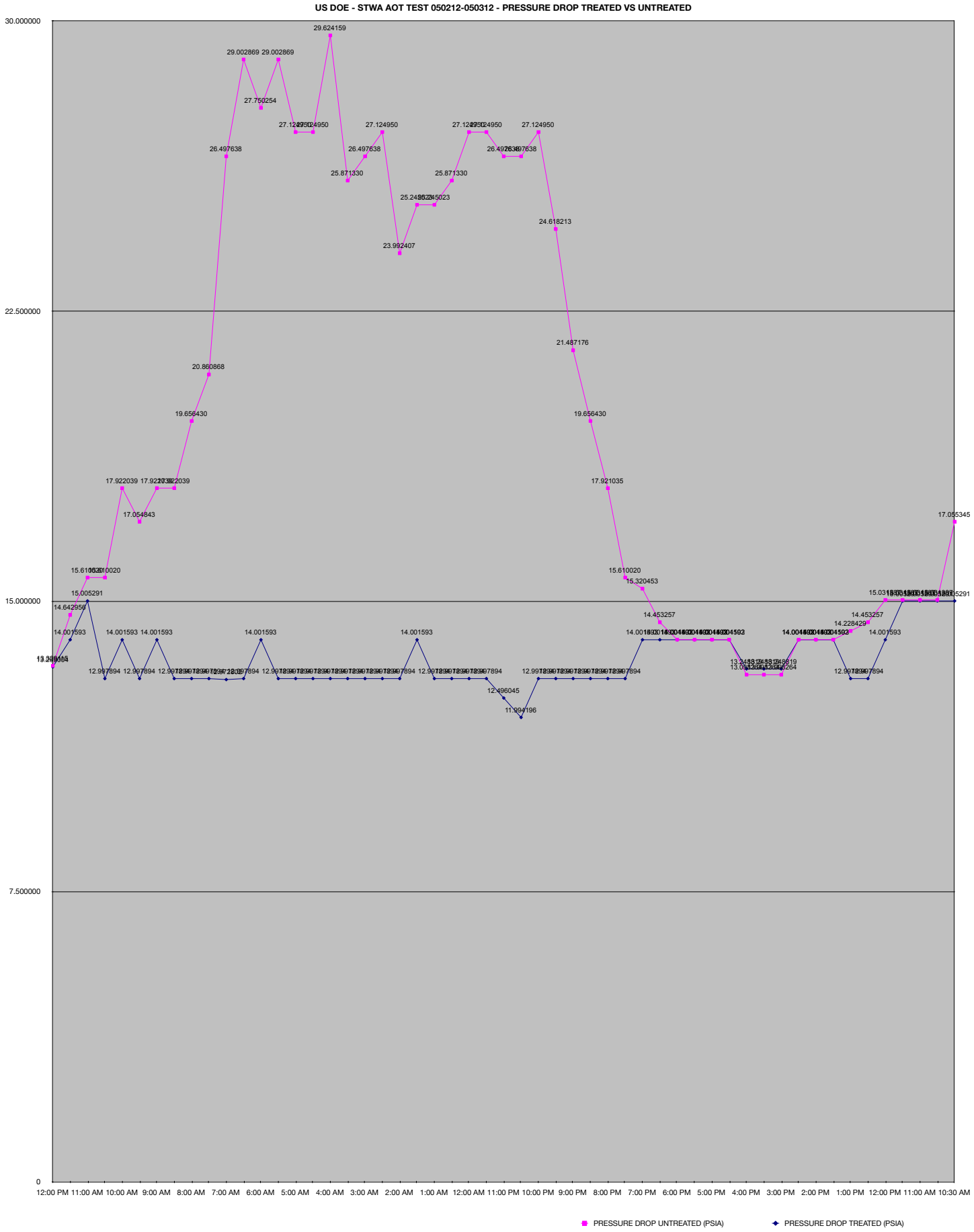


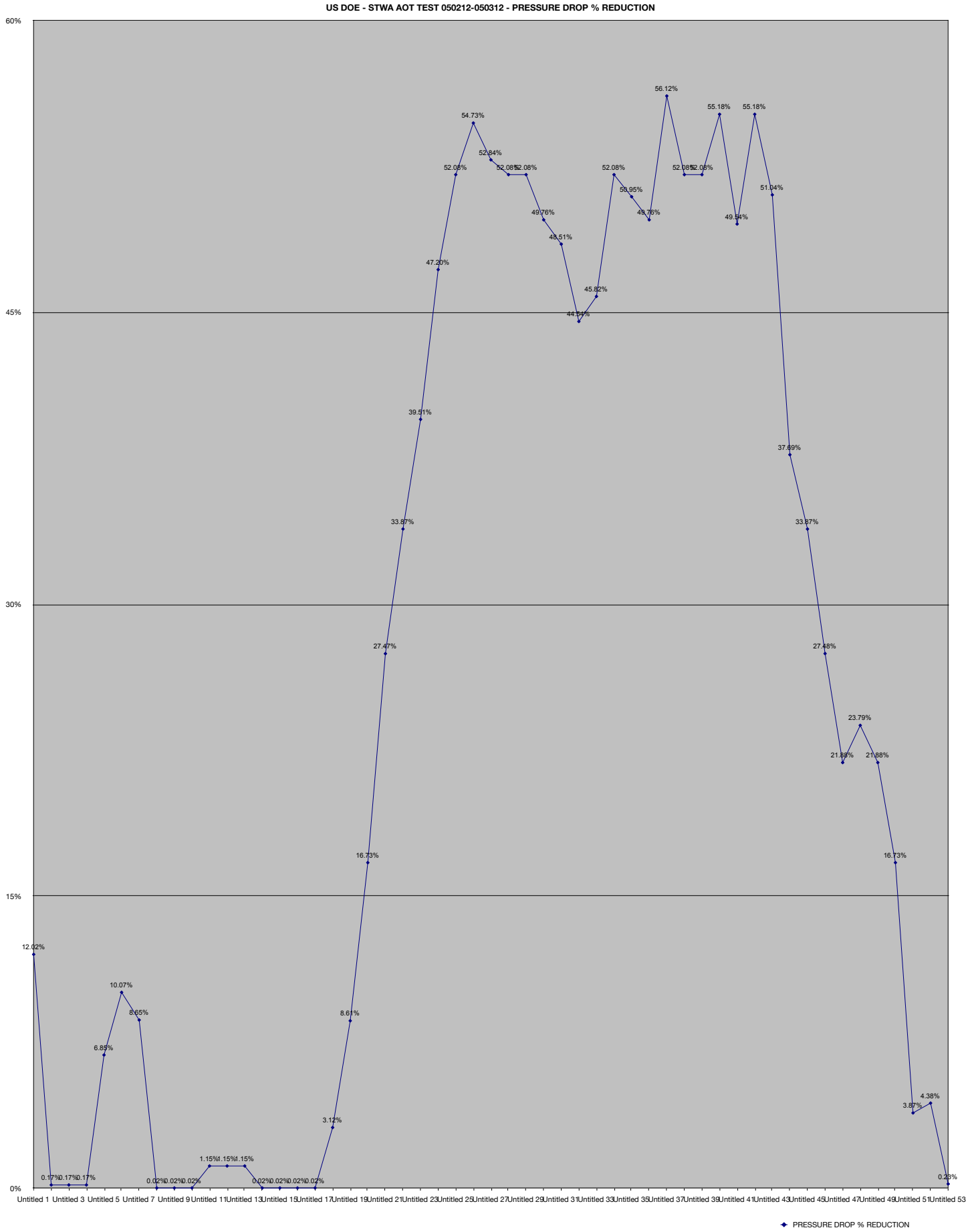
US DOE - STWA AOT TEST 050212-050312 - PRESSURE DATA

	Pressure Data										
TIME	P1 (PSIA)	Inlet P2* (AFT PUMP) (PSIA)	P3 (PSIA)	P4 (PSIA)	P5 (PSIA)	Outlet P6* (END OF LINE) (PSIA)	TOTAL TREATED PRESSURE DROP (PSIA)	TREATED P-Drop #3-#4 (PSIA)(1291m)	UNTREATED Expected #3-#4 (PSIA)(1291m)	P-Drop Change (Treated vs Untreated) #3-#4 (PSIA)	P-Drop Change (Treated vs Untreated) #3-#4 (%)
10:30 AM	4	135	130	117	91	4	131	15.005291	17.055345	-2.050054	12.02%
10:45 AM	4	135	130	117	91	4	131	15.005291	15.031387	-0.026096	0.17%
11:00 AM	4	130	124	111	91	3	127	15.005291	15.031387	-0.026096	0.17%
11:30 AM	**4**	**130**	**126**	**111**	**88**	**3**	**127**	**15.005291**	**15.031387**	**-0.026096**	**0.17%**
12:00 PM	5	131	127	113	89	3	128	14.001593	15.031387	-1.029795	**6.85%**
12:30 PM	5	130	126	113	92	2	128	12.997894	14.453257	-1.455363	**10.07%**
1:00 PM	4	129	124	111	91	2	127	12.997894	14.228429	-1.230534	**8.65%**
1:30 PM	4	126	123	109	88	2	124	14.001593	14.004102	-0.002509	**0.02%**
2:00 PM	4	127	123	109	87	2	125	14.001593	14.004102	-0.002509	**0.02%**
2:30 PM	4	135	130	116	92	2	133	14.001593	14.004102	-0.002509	**0.02%**
3:00 PM	4	135	130	117	92	2	133	13.248819	13.098264	0.150555	**1.15%**
3:30 PM	4	134	130	117	92	2	132	13.248819	13.098264	0.150555	**1.15%**
4:00 PM	4	134	130	117	92	2	132	13.248819	13.098264	0.150555	**1.15%**
4:30 PM	5	134	130	116	92	2	132	14.001593	14.004102	-0.002509	**0.02%**
5:00 PM	4	134	130	116	93	2	132	14.001593	14.004102	-0.002509	**0.02%**
5:30 PM	4	134	130	116	93	2	132	14.001593	14.004102	-0.002509	**0.02%**
6:00 PM	4	134	130	116	92	2	132	14.001593	14.004102	-0.002509	**0.02%**
6:30 PM	6	134	130	117	93	2	132	14.001593	14.453257	-0.451664	**3.12%**
7:00 PM	6	134	130	117	93	2	132	14.001593	15.320453	-1.318860	**8.61%**
7:30 PM	6	132	128	115	93	2	130	12.997894	15.610020	-2.612125	**16.73%**
8:00 PM	6	131	127	114	92	2	129	12.997894	17.921035	-4.923141	**27.47%**
8:30 PM	7	130	126	113	91	2	128	12.997894	19.656430	-6.658535	**33.87%**
9:00 PM	7	130	126	113	91	3	127	12.997894	21.487176	-8.489281	**39.51%**
9:30 PM	6	130	126	113	90	3	127	12.997894	24.618213	-11.620318	**47.20%**
10:00 PM	7	130	126	113	90	2	128	12.997894	27.124950	-14.127055	**52.08%**
10:30 PM	**7**	**130**	**125**	**113**	**90**	**2**	**128**	**11.994196**	**26.497638**	**-14.503442**	**54.73%**
11:00 PM	7	129.5	125.5	113	90	2	127.5	12.496045	26.497638	-14.001593	**52.84%**
11:30 PM	7	130	126	113	90	3	127	12.997894	27.124950	-14.127055	**52.08%**
12:00 AM	**7**	**130**	**126**	**113**	**90**	**2**	**128**	**12.997894**	**27.124950**	**-14.127055**	**52.08%**
12:30 AM	6	129	126	113	90	2	127	12.997894	25.871330	-12.873436	**49.76%**
1:00 AM	7	129	126	113	90	2	127	12.997894	25.245023	-12.247128	**48.51%**
1:30 AM	6	130	126	113	89	1	129	14.001593	25.245023	-11.243430	**44.54%**
2:00 AM	6	131	126	113	89	1	130	12.997894	23.992407	-10.994512	**45.82%**
2:30 AM	6	131	126	113	89	1	130	12.997894	27.124950	-14.127055	**52.08%**
3:00 AM	6	131	126	113	90	1	130	12.997894	26.497638	-13.499744	**50.95%**
3:30 AM	6	131	126	113	90	1	130	12.997894	25.871330	-12.873436	**49.76%**
4:00 AM	**6**	**131**	**126**	**113**	**90**	**1**	**130**	**12.997894**	**29.624159**	**-16.626264**	**56.12%**
4:30 AM	6	131	126	113	90	1	130	12.997894	27.124950	-14.127055	**52.08%**

US DOE - STWA AOT TEST 050212-050312 - PRESSURE DATA

	Pressure Data										
TIME	P1 (PSIA)	**Inlet P2* (AFT PUMP) (PSIA)**	**P3 (PSIA)**	**P4 (PSIA)**	**P5 (PSIA)**	**Outlet P6* (END OF LINE) (PSIA)**	**TOTAL TREATED PRESSURE DROP (PSIA)**	**TREATED P-Drop #3-#4 (PSIA)(1291m)**	**UNTREATED Expected #3-#4 (PSIA)(1291m)**	**P-Drop Change (Treated vs Untreated) #3-#4 (PSIA)**	**P-Drop Change (Treated vs Untreated) #3-#4 (%)**
5:00 AM	6	131	126	113	90	1	130	12.997894	27.124950	-14.127055	**52.08%**
5:30 AM	6	131	126	113	90	1	130	12.997894	29.002869	-16.004975	**55.18%**
6:00 AM	6	132	127	113	90	2	130	14.001593	27.750254	-13.748661	**49.54%**
6:30 AM	5	132	127	114	92	2	130	12.997894	29.002869	-16.004975	**55.18%**
7:00 AM	6	133	127	114	92	2	131	12.972802	26.497638	-13.524836	**51.04%**
7:30 AM	5	133	127	114	91	2	131	12.997894	20.860868	-7.862973	**37.69%**
8:00 AM	5	133	127	114	91	2	131	12.997894	19.656430	-6.658535	**33.87%**
8:30 AM	5	132	127	114	91	2	130	12.997894	17.922039	-4.924144	**27.48%**
9:00 AM	5	133	128	114	91	2	131	14.001593	17.922039	-3.920446	**21.88%**
9:30 AM	5	134	128	115	91	2	132	12.997894	17.054843	-4.056949	**23.79%**
10:00 AM	5	134	129	115	91	2	132	14.001593	17.922039	-3.920446	**21.88%**
10:30 AM	5	134	129	116	91	2	132	12.997894	15.610020	-2.612125	**16.73%**
11:00 AM	**5**	**135**	**131**	**116**	**92**	**2**	**133**	**15.005291**	**15.610020**	**-0.604728**	**3.87%**
11:30 AM	5	134	130	116	92	2	132	14.001593	14.642956	-0.641363	**4.38%**
12:00 PM	**5**	**130**	**125.5**	**112**	**92**	**1**	**129**	**13.299004**	**13.329115**	**-0.030111**	**0.23%**
								TREATED MAX P-Drop per mile (PSIA)	UNTREATED MAX P-Drop per mile (PSIA)	MAX P-Drop Change (PSIA)	**MAX P-Drop Change (%)**
								15.0053	29.6242	-16.6263	**56.12%**


US DOE - STWA AOT TEST 050212-050312 - PRESSURE DROP TREATED VS UNTREATED
30.000000
22.500000
15.000000
7.500000
0
12:00 PM 11:00 AM 10:00 AM 9:00 AM 8:00 AM 7:00 AM 6:00 AM 5:00 AM 4:00 AM 3:00 AM 2:00 AM 1:00 AM 12:00 AM 11:00 PM 10:00 PM 9:00 PM 8:00 PM 7:00 PM 6:00 PM 5:00 PM 4:00 PM 3:00 PM 2:00 PM 1:00 PM 12:00 PM 11:00 AM 10:30 AM
PRESSURE DROP UNTREATED (PSIA)
PRESSURE DROP TREATED (PSIA)


US DOE - STWA AOT TEST 050212-050312 - PRESSURE DROP % REDUCTION
60%
45%
30%
15%
0%
12.02%
0.17%
0.17%
0.17%
6.85%
10.07%
8.65%
0.02%
0.02%
0.02%
1.15%
1.15%
1.15%
0.02%
0.02%
0.02%
0.02%
3.12%
8.61%
16.73%
27.47%
33.87%
39.51%
47.20%
52.08%
54.73%
52.84%
52.08%
52.08%
49.76%
48.51%
44.54%
45.82%
52.08%
50.95%
49.76%
56.12%
52.08%
52.08%
55.18%
49.54%
55.18%
51.04%
37.69%
33.87%
27.48%
21.88%
23.79%
21.88%
16.73%
3.87%
4.38%
0.23%
Untitled 1
Untitled 3
Untitled 5
Untitled 7
Untitled 9
Untitled 11
Untitled 13
Untitled 15
Untitled 17
Untitled 19
Untitled 21
Untitled 23
Untitled 25
Untitled 27
Untitled 29
Untitled 31
Untitled 33
Untitled 35
Untitled 37
Untitled 39
Untitled 41
Untitled 43
Untitled 45
Untitled 47
Untitled 49
Untitled 51
Untitled 53
PRESSURE DROP % REDUCTION

US DOE - STWA AOT TEST 050212-050312 - POWER DATA

	POWER			
TIME	TREATED Observed Pump Power Required (kW)	UNTREATED Required Pump Power Required (kW)	NET Power Difference (Treated vs Untreated)	% Change (Treated vs Untreated)
10:30 AM	15.900	18.072	-2.172	**12.02%**
10:45 AM	15.900	15.928	-0.028	**0.17%**
11:00 AM	15.800	15.827	-0.027	**0.17%**
11:30 AM	15.900	15.928	-0.028	**0.17%**
12:00 PM	16.100	17.284	-1.184	**6.85%**
12:30 PM	16.000	17.792	-1.792	**10.07%**
1:00 PM	15.900	17.405	-1.505	**8.65%**
1:30 PM	15.500	15.503	-0.003	**0.02%**
2:00 PM	15.600	15.603	-0.003	**0.02%**
2:30 PM	16.400	16.403	-0.003	**0.02%**
3:00 PM	16.400	16.214	0.186	**1.15%**
3:30 PM	16.300	16.115	0.185	**1.15%**
4:00 PM	16.300	16.115	0.185	**1.15%**
4:30 PM	16.300	16.303	-0.003	**0.02%**
5:00 PM	16.300	16.303	-0.003	**0.02%**
5:30 PM	16.300	16.303	-0.003	**0.02%**
6:00 PM	16.4	16.403	-0.003	**0.02%**
6:30 PM	16.2	16.723	-0.523	**3.12%**
7:00 PM	16.1	17.617	-1.517	**8.61%**
7:30 PM	15.9	19.095	-3.195	**16.73%**
8:00 PM	15.8	21.784	-5.984	**27.47%**
8:30 PM	15.7	23.743	-8.043	**33.87%**
9:00 PM	15.6	25.789	-10.189	**39.51%**

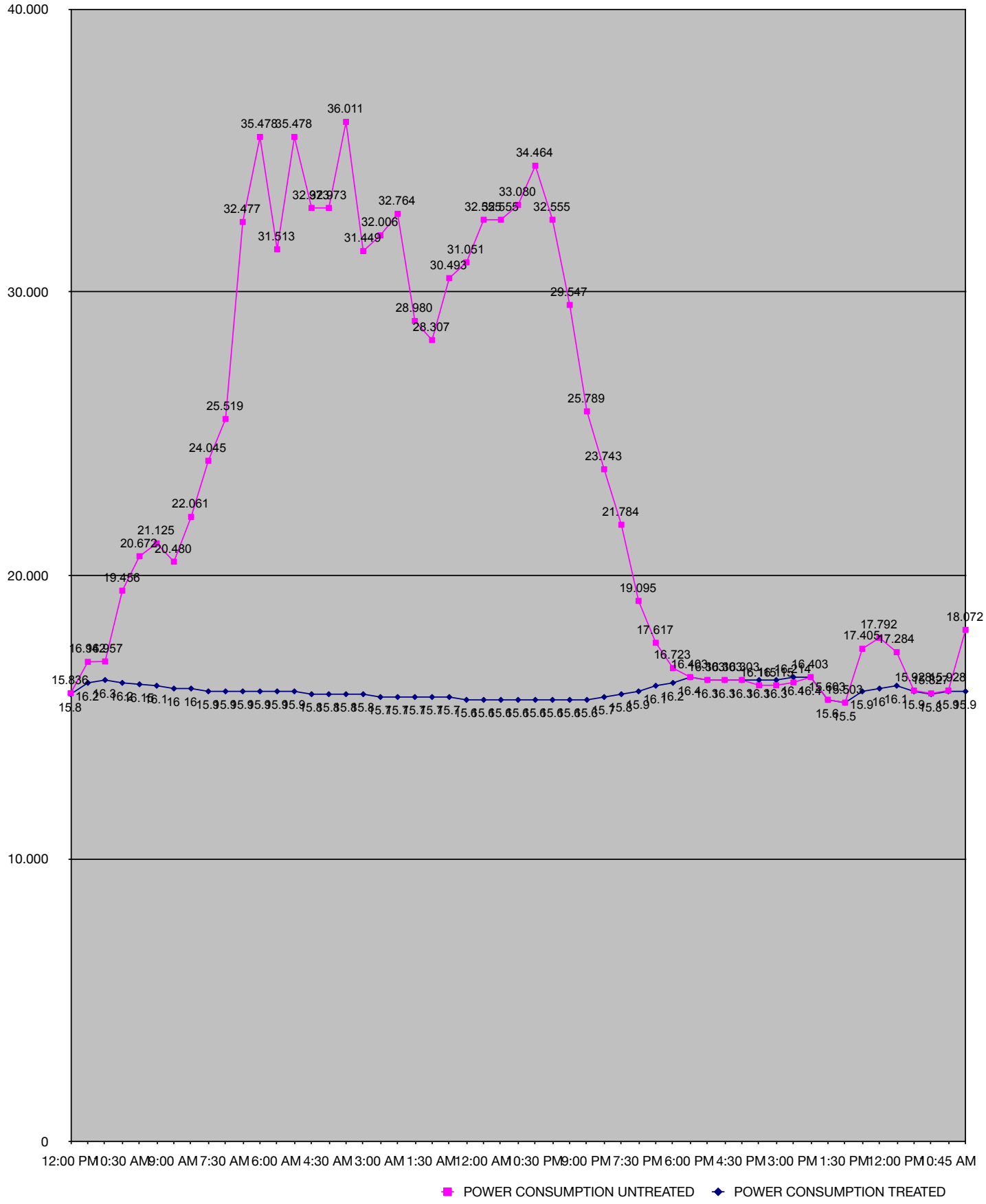
US DOE - STWA AOT TEST 050212-050312 - POWER DATA

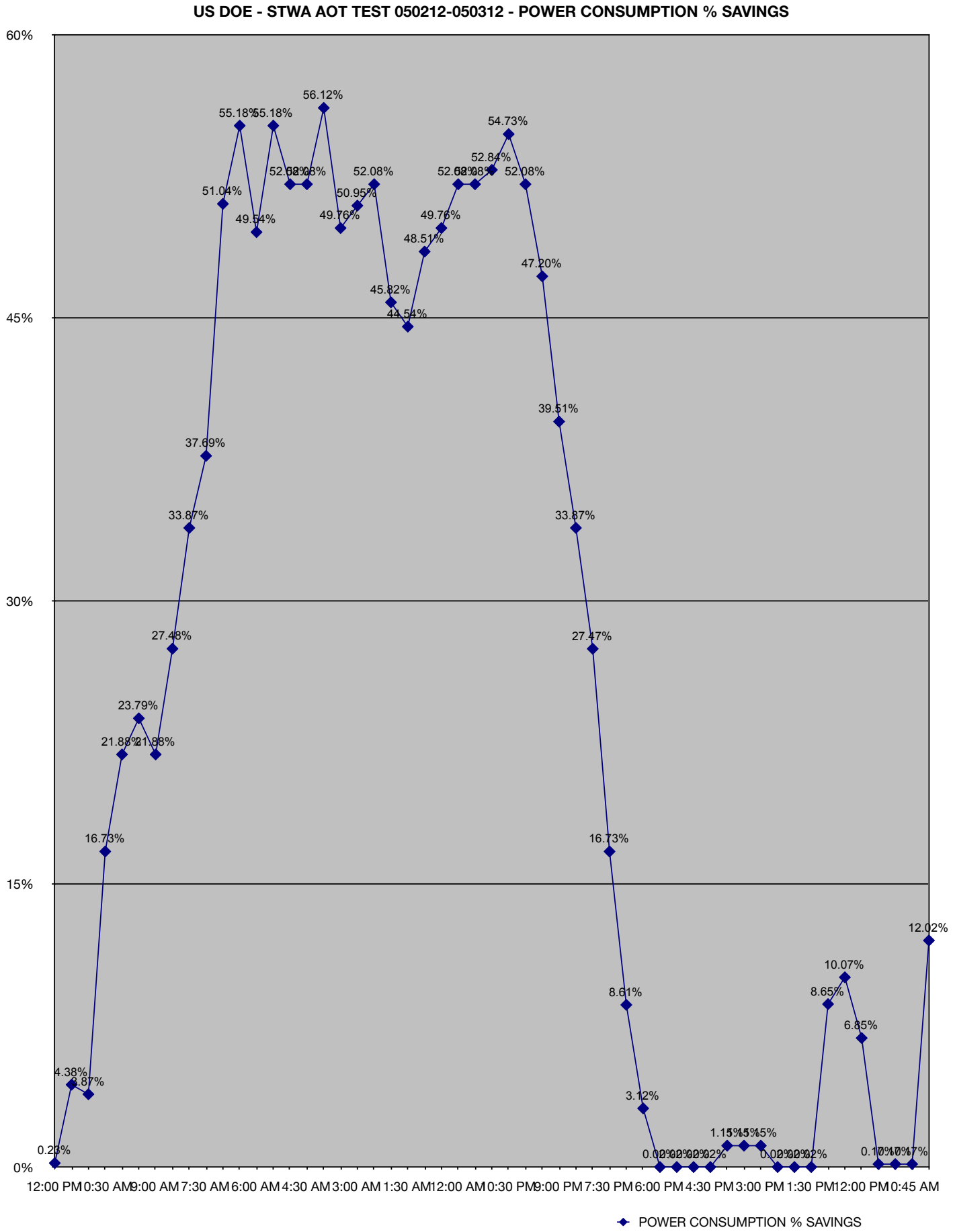
	POWER			
TIME	TREATED Observed Pump Power Required (kW)	UNTREATED Required Pump Power Required (kW)	NET Power Difference (Treated vs Untreated)	% Change (Treated vs Untreated)
9:30 PM	15.6	29.547	-13.947	**47.20%**
10:00 PM	15.6	32.555	-16.955	**52.08%**
10:30 PM	15.6	34.464	-18.864	**54.73%**
11:00 PM	15.6	33.080	-17.480	**52.84%**
11:30 PM	15.6	32.555	-16.955	**52.08%**
12:00 AM	15.6	32.555	-16.955	**52.08%**
12:30 AM	15.6	31.051	-15.451	**49.76%**
1:00 AM	15.7	30.493	-14.793	**48.51%**
1:30 AM	15.7	28.307	-12.607	**44.54%**
2:00 AM	15.7	28.980	-13.280	**45.82%**
2:30 AM	15.7	32.764	-17.064	**52.08%**
3:00 AM	15.7	32.006	-16.306	**50.95%**
3:30 AM	15.8	31.449	-15.649	**49.76%**
4:00 AM	15.8	36.011	-20.211	**56.12%**
4:30 AM	15.8	32.973	-17.173	**52.08%**
5:00 AM	15.8	32.973	-17.173	**52.08%**
5:30 AM	15.9	35.478	-19.578	**55.18%**
6:00 AM	15.9	31.513	-15.613	**49.54%**

US DOE - STWA AOT TEST 050212-050312 - POWER DATA

	POWER			
TIME	**TREATED Observed Pump Power Required (kW)**	**UNTREATED Required Pump Power Required (kW)**	**NET Power Difference (Treated vs Untreated)**	**% Change (Treated vs Untreated)**
6:30 AM	15.9	35.478	-19.578	**55.18%**
7:00 AM	15.9	32.477	-16.577	**51.04%**
7:30 AM	15.9	25.519	-9.619	**37.69%**
8:00 AM	15.9	24.045	-8.145	**33.87%**
8:30 AM	16	22.061	-6.061	**27.48%**
9:00 AM	16	20.480	-4.480	**21.88%**
9:30 AM	16.1	21.125	-5.025	**23.79%**
10:00 AM	16.15	20.672	-4.522	**21.88%**
10:30 AM	16.2	19.456	-3.256	**16.73%**
11:00 AM	16.3	16.957	-0.657	**3.87%**
11:30 AM	16.2	16.942	-0.742	**4.38%**
12:00 PM	15.8	15.836	-0.036	**0.23%**
	MAX Power Consumption w/ AOT ON (kW)	MAX Power Consumption w/ AOT OFF (kW)	MAX Power Savings Due to AOT (kW)	**MAX Power Savings Due to AOT (%)**
	16.4	36.011	-20.211	**56.12%**

US DOE - STWA AOT TEST 050212-050312 - POWER CONSUMPTION TREATED VS UNTREATED




US DOE - STWA AOT TEST 050212-050312 - POWER CONSUMPTION % SAVINGS
60%
45%
30%
15%
0%
12:00 PM
10:30 AM
9:00 AM
7:30 AM
6:00 AM
4:30 AM
3:00 AM
1:30 AM
12:00 AM
10:30 PM
9:00 PM
7:30 PM
6:00 PM
4:30 PM
3:00 PM
1:30 PM
12:00 PM
10:45 AM
POWER CONSUMPTION % SAVINGS