ROCKY MOUNTAIN OILFIELD TESTING CENTER

PROJECT TEST RESULTS

STWA, INC.
VISCOSITY REDUCTION TECHNOLOGY

Prepared for:

Industry Publication

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ABSTRACT

April 04, 2012

The Rocky Mountain Oilfield Testing Center (RMOTC) conducted a 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.

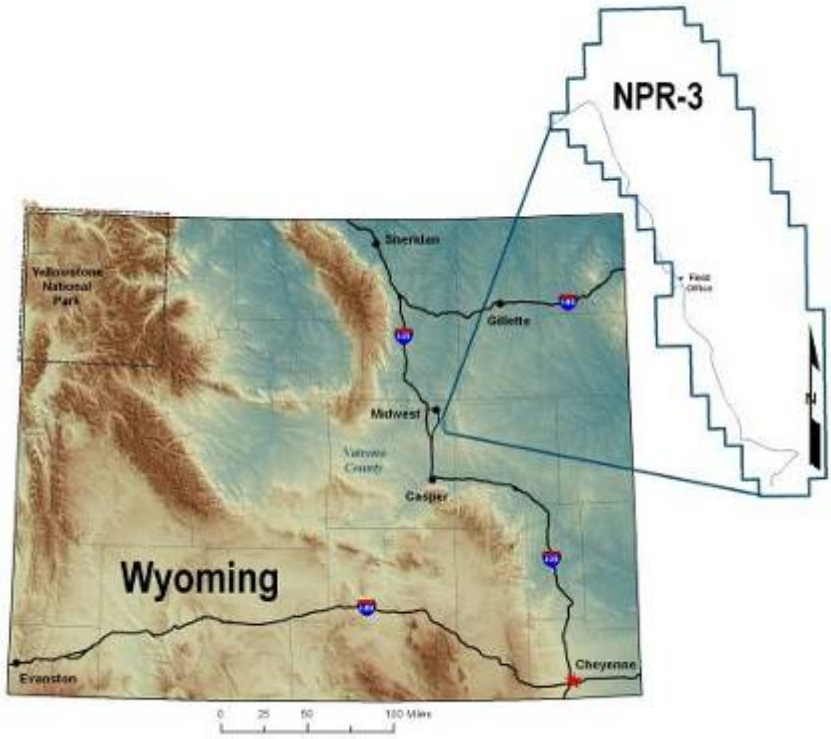


Figure 1. State Map of NPR-3

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, and would thereby deliver energy savings for crude oil transportation.

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.

The AOT device was removed in January 2012 and reworked to include new components, some of which were composed of alternate materials. The reworked device, referred to as the AOT 1.2H prototype, was reinstalled on the test loop in March 2012. RMOTC again validated overall system integrity after the AOT 1.2H installation, and filled the loop with field-produced API 34° oil to facilitate this second phase of testing. The test was conducted on March 29, 2012.

A 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:

- 11.1-12.1 C oil temperature
- 0.8459 g/cm3 oil density
- 81.6 centipoise (cp) viscosity
- 1205.237 Reynolds #
- 0.053 friction
- 82.09 cm/s velocity
- 205 gal/min flow rate
- 1,379,000 dyne/cm2
- 24.8 psi/mile pressure drop

After establishing baseline performance, the AOT 1.2H device was turned on and operated for 3.8 hours. AOT performance was measured as follows:

- 11.1-12.1 C oil temperature (unchanged)
- 0.8459 g/cm3 oil density (unchanged)
- 48.95 cp viscosity (reduced 40%)
- 2009.138 Reynolds # (increased 67%)
- 0.032 friction (reduced 38%)
- 82.09 cm/s velocity
- 205 gal/min flow rate (unchanged)
- 827,400 dyne/cm2 pressure (reduced 40%)
- 14.87 psi/mile pressure drop (reduced 40%)

When the AOT was disengaged, viscosity and pressure were observed to revert slowly back to baseline.

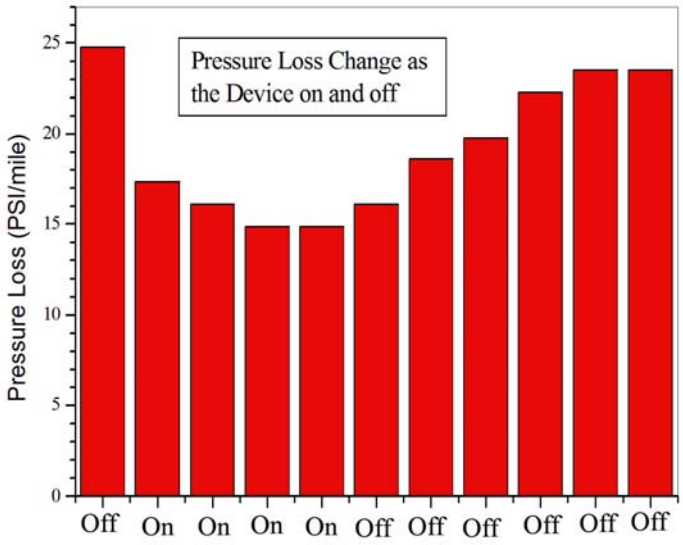


Fig.1 When the AOT device is turned on, the pressure loss is reduced by 40%, from 24.8 psi/mile down to 14.87 psi/mile. After the device turned off, the crude oil in the section was replaced by untreated crude oil and the pressure loss returns to the original value.

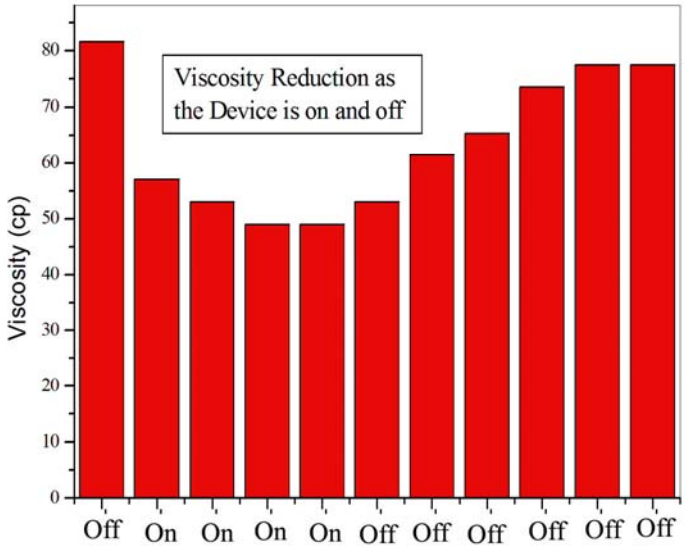


Fig.2. The original viscosity was 81.6 cp. After the AOT device was turned on, it was reduced by 40%, down to 48.95cp. After the AOT device was turned off, the crude oil in the section was gradually replaced by untreated crude oil and the viscosity returned to the original value.

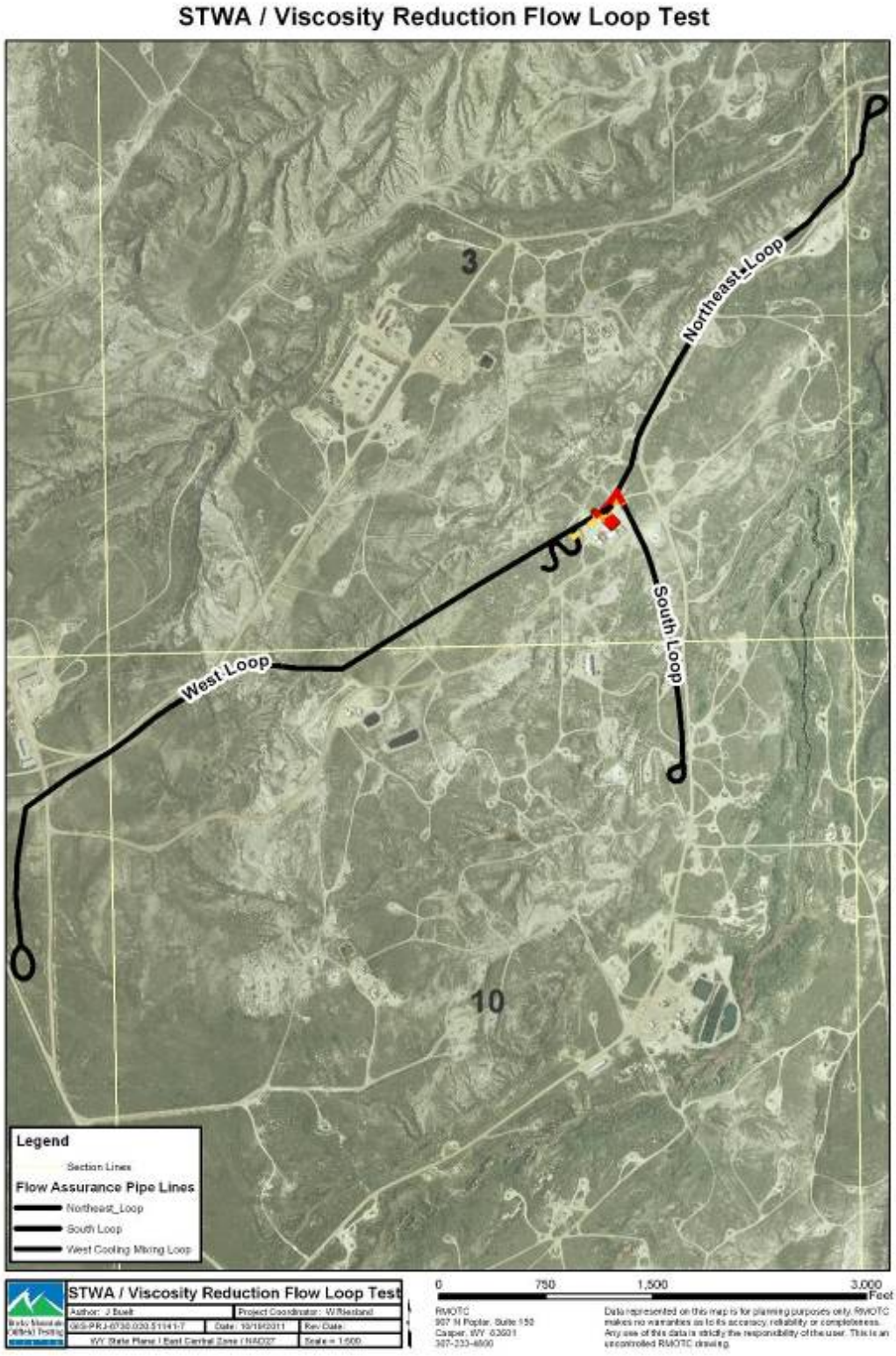


Figure 2. NPR-3 Flowloop Map

CONCLUSION:

Test results indicate that the viscosity reduction device operated successfully and that the AOT 1.2H prototype delivers improved performance over the original AOT prototype tested in October 2011. 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.

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.

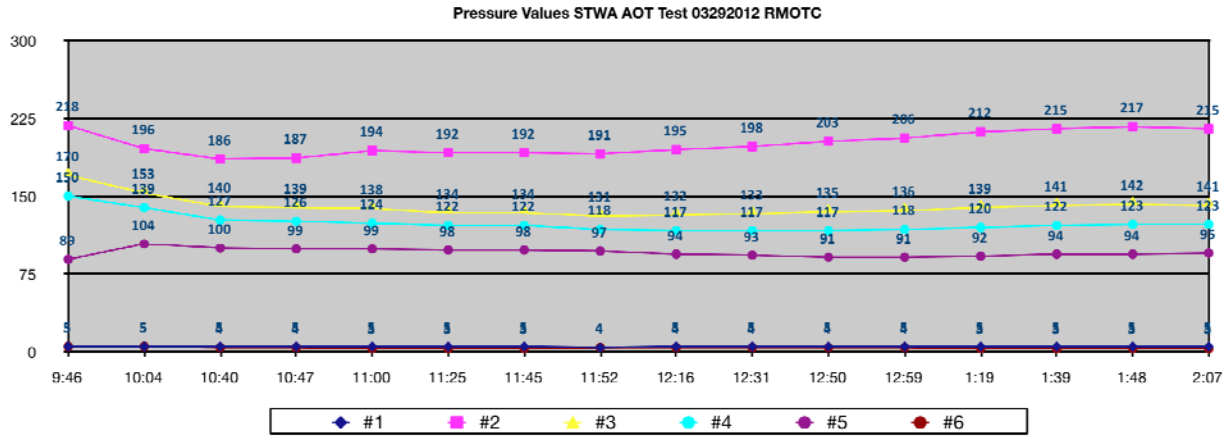
APPENDIX A

Raw Data

Pressure Values STWA AOT Test 03292012 RMOTC

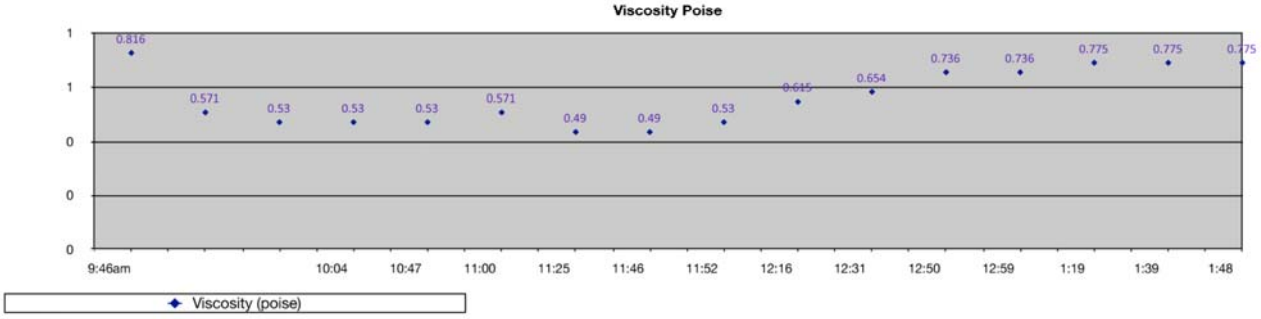
	Pressure (PSI)							
Time	#1	#2	#3	#4	#5	#6	Flow rate	Velocity
9:46	5	218	170	150	89	5	205	82.0910458185
10:04	5	196	153	139	104	5		
10:40	5	186	140	127	100	4		
10:47	5	187	139	126	99	4		
11:00	5	194	138	124	99	3		
11:25	5	192	134	122	98	3		
11:45	5	192	134	122	98	3		
11:52	4	191	131	118	97	4		
12:16	5	195	132	117	94	4		
12:31	5	198	133	117	93	4		
12:50	5	203	135	117	91	4		
12:59	5	206	136	118	91	4		
1:19	5	212	139	120	92	3		
1:39	5	215	141	122	94	3		
1:48	5	217	142	123	94	3		
2:07	5	215	141	123	95	3		

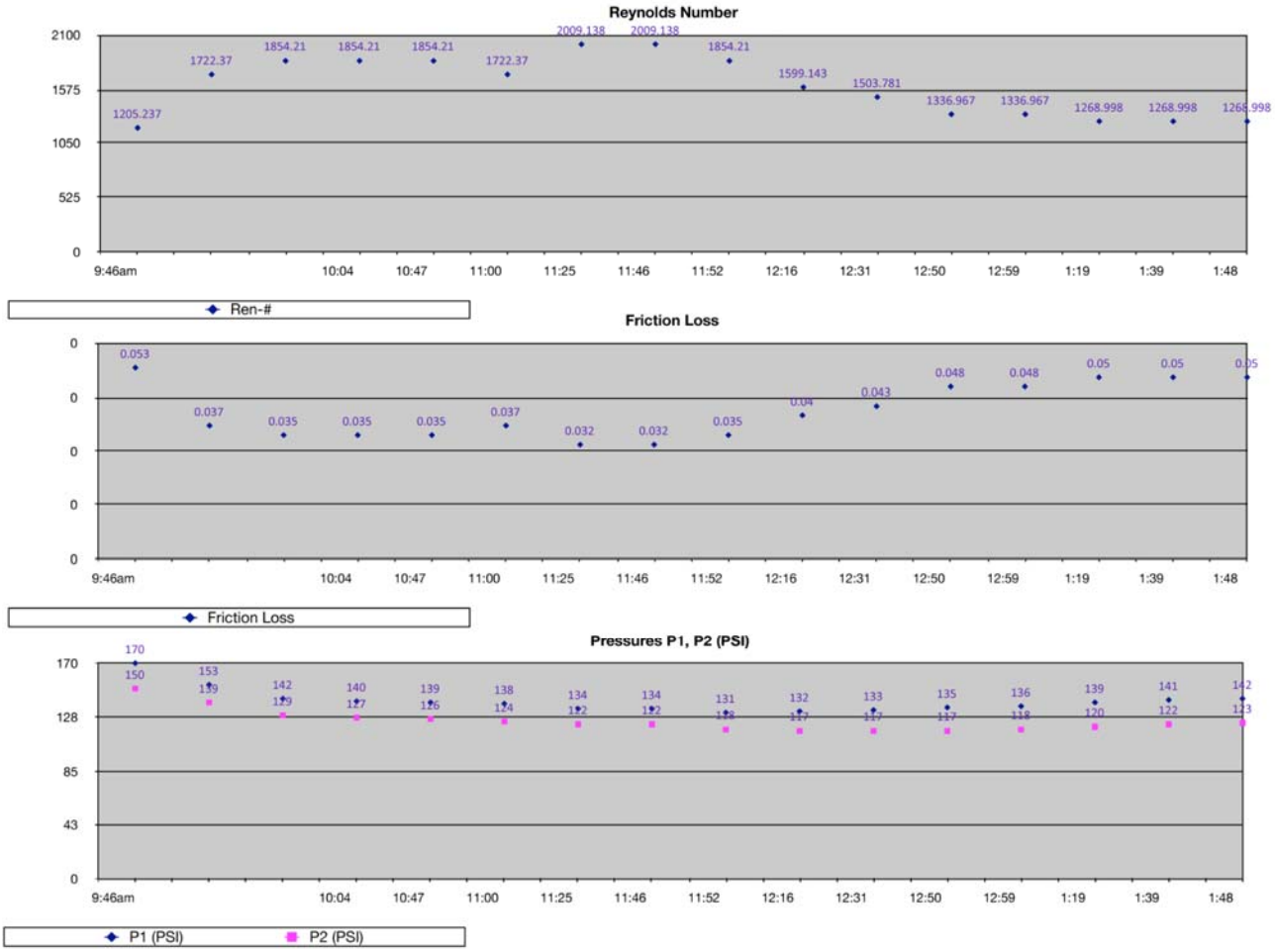
Note: 10:00 turned on the AOT device



R. TAO Calculation STWA AOT Test 03292102 RMOTC

	Diameter (in)	Density (g/cm^3)	Flowrate (gallon/min)	Velocity (cm/s)	Length (m)	Viscosity (poise)	Ren-#	Friction Loss	P1 (PSI)	P2 (PSI)	Pressure Loss (dyne/cm^2)	Calculated Loss	Pres Loss
9:46am	5.575886784565	0.8459	205	82.09104543828	1291	0.816	1205.2366	0.05310160619	170	150	1379000	1379643.370717	24.78698683191
	5.575886784565	0.8459	205	82.09104543828	1291	0.571	1722.3697	0.03715810923	153	139	965300	965412.2116168	17.35089078234
	5.575886784565	0.8459	205	82.09104543828	1291	0.5304	1854.2102	0.03451604402	142	129	896350	896768.190966	16.11154144074
10:04	5.575886784565	0.8459	205	82.09104543828	1291	0.5304	1854.2102	0.03451604402	140	127	896350	896768.190966	16.11154144074
10:47	5.575886784565	0.8459	205	82.09104543828	1291	0.5304	1854.2102	0.03451604402	139	126	896350	896768.190966	16.11154144074
11:00	5.575886784565	0.8459	205	82.09104543828	1291	0.571	1722.3697	0.03715810923	138	124	965300	965412.2116168	17.35089078234
11:25	5.575886784565	0.8459	205	82.09104543828	1291	0.4895	2009.1381	0.03185445617	134	122	827400	827616.9484876	14.87219209915
11:46	5.575886784565	0.8459	205	82.09104543828	1291	0.4895	2009.1381	0.03185445617	134	122	827400	827616.9484876	14.87219209915
11:52	5.575886784565	0.8459	205	82.09104543828	1291	0.5304	1854.2102	0.03451604402	131	118	896350	896768.190966	16.11154144074
12:16	5.575886784565	0.8459	205	82.09104543828	1291	0.615	1599.1432	0.04002143114	132	117	1034250	1039804.746312	18.59024012393
12:31	5.575886784565	0.8459	205	82.09104543828	1291	0.654	1503.7815	0.04255937555	133	117	1103200	1105743.583883	19.82958946553
12:50	5.575886784565	0.8459	205	82.09104543828	1291	0.7356	1336.9672	0.04786953617	135	117	1241100	1243707.920955	22.30828814872
12:59	5.575886784565	0.8459	205	82.09104543828	1291	0.7356	1336.9672	0.04786953617	136	118	1241100	1243707.920955	22.30828814872
1:19	5.575886784565	0.8459	205	82.09104543828	1291	0.775	1268.9975	0.05043351078	139	120	1310050	1310323.054296	23.54763749032
1:39	5.575886784565	0.8459	205	82.09104543828	1291	0.775	1268.9975	0.05043351078	141	122	1310050	1310323.054296	23.54763749032
1:48	5.575886784565	0.8459	205	82.09104543828	1291	0.775	1268.9975	0.05043351078	142	123	1310050	1310323.054296	23.54763749032




Reynolds Number
2100
1575
1050
525
0
1205.237
1722.37
1854.21
1854.21
1854.21
1722.37
2009.138
2009.138
1854.21
1599.143
1503.781
1336.967
1336.967
1268.998
1268.998
1268.998
9:46am
10:04
10:47
11:00
11:25
11:46
11:52
12:16
12:31
12:50
12:59
1:19
1:39
1:48
Ren-#
Friction Loss
0.053
0.037
0.035
0.035
0.035
0.037
0.032
0.032
0.035
0.04
0.043
0.048
0.048
0.05
0.05
0.05
Friction Loss
Pressures P1, P2 (PSI)
170
150
153
142
140
139
138
134
134
131
132
133
135
136
139
141
142
128
85
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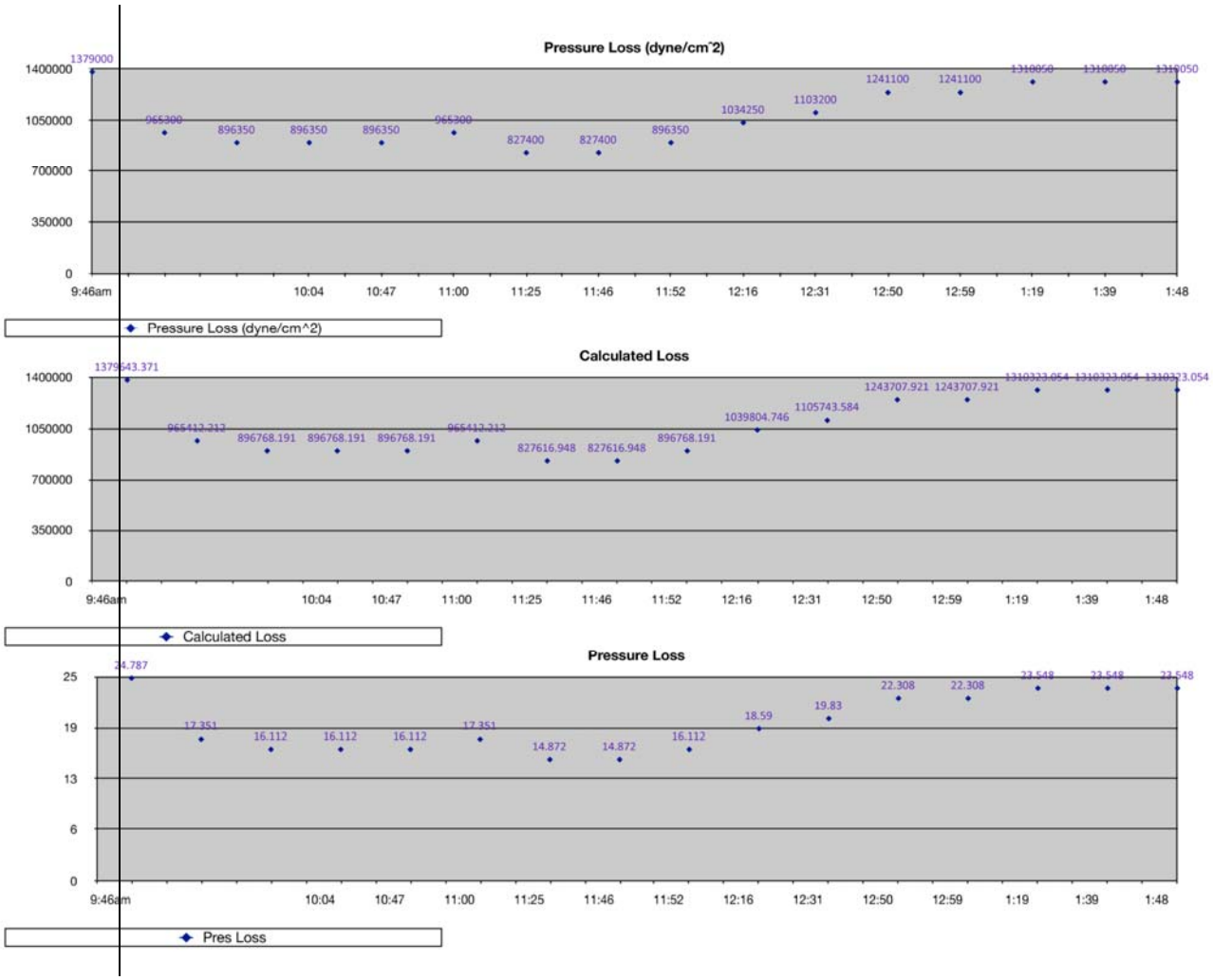
P1 (PSI)
P2 (PSI)


Pressure Loss (dyne/cm^2)
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1400000
1050000
700000
350000
0
9:46am
10:04
10:47
11:00
11:25
11:46
11:52
12:16
12:31
12:50
12:59
1:19
1:39
1:48
Pressure Loss (dyne/cm^2)
Calculated Loss
1379643.371
1400000
1050000
700000
350000
0
9:46am
10:04
10:47
11:00
11:25
11:46
11:52
12:16
12:31
12:50
12:59
1:19
1:39
1:48
Calculated Loss
Pressure Loss
24.787
25
19
13
6
0
9:46am
10:04
10:47
11:00
11:25
11:46
11:52
12:16
12:31
12:50
12:59
1:19
1:39
1:48
Pres Loss