

**Filtration Performance Screening using
ASTM/ETV Test Methodology
Conducted for
Process Systems & Components Inc.**



ETS, INC.

***Pollution Control Consultants Specializing
In Testing, Training, Troubleshooting and
Testimony***

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ETS CONTRACT NUMBER 08-703-L

TABLE OF CONTENTS

	<u>PAGE</u>
1.0 INTRODUCTION	1
2.0 TEST PROGRAM	1
3.0 TEST PROCEDURE	2
4.0 TEST APPARATUS AND TEST DESCRIPTION	2
5.0 TEST RESULTS	3

LIST OF TABLES

TABLE I - SUMMARY OF TEST RESULTS (METRIC UNITS)	4
TABLE II - SUMMARY OF TEST RESULTS (ENGLISH UNITS)	5

LIST OF FIGURES

FIGURE 1 - FILTRATION PERFORMANCE TEST APPARATUS

LIST OF APPENDICES

APPENDIX A - TEST DATA AND RESULTS

CLIENT: Proces Systems

SITE: N/A

CLIENT P.O. NO: 100-1239

FABRIC TYPES: "Fiber-Lite" Felt

CLIENT CONTACT: John Wroblewski

BAGHOUSE TYPE: Pulse Jet

ETS CONTRACT NO: 08-703-L

PROGRAM: Filtration Performance Screening

DATE: December 4, 2008

APPLICATION: N/A

1.0 INTRODUCTION

ETS, Inc. was retained by Process Systems & Components Inc. to conduct screening tests on a sample of Fiber-Lite felt.

2.0 TEST PROGRAM

The testing was conducted in the ETS Filtration Performance Test Apparatus to determine the filter sample's performance with respect to the following parameters:

- ◆ Outlet particulate emissions (PM 2.5)
- ◆ Outlet particulate emissions (total mass)
- ◆ Initial residual pressure drop
- ◆ Increase in residual pressure drop
- ◆ Average residual pressure drop
- ◆ Mass weight gain of the filter sample
- ◆ Average filtration cycle time
- ◆ Number of filtration cycles

3.0 TEST PROCEDURE:

Testing was conducted in accordance with ASTM Test Method D6830-02 and with the test specifications and conditions as detailed in the Generic Verification Protocol for Baghouse Filtration Products (BFP) developed by the Air Pollution Control Technology Verification Center (APCTVC) which is part of the U.S. EPA's Environmental Technology Verification (ETV) Program and is operated in partnership between RTI and EPA. The protocol was adapted from the German VDI Method 3926, and modified for ETV and is available at etv.rti.org/apct/pdf/GVP_Revised.pdf. There was one exception to the protocol specification:

- ◆ The test program consisted of one run rather than three runs as specified in the protocol.

4.0 TEST APPARATUS AND TEST DESCRIPTION:

The test apparatus is shown in Figure 1. The test run consisted of three test phases. To simulate long term operation, the filter sample was first subjected to a conditioning period which consisted of 10,000 rapid pulse cleaning cycles under continuous dust loading. During this period, the time between cleaning cycles is maintained at three seconds. No filter performance parameters are measured during the conditioning period. The conditioning period was immediately followed by a recovery period, which allows the filter sample to recover from the rapid pulsing. The recovery period consisted of 30 normal filtration cycles under continuous dust loading. During a normal filtration cycle, the dust cake is allowed to form on the test filter until a differential pressure of 1,000 Pa (4.0 inch w.g.) is reached. At this point, the test filter is cleaned by a pulse of compressed air. Immediately after pulse cleaning the pressure fluctuates rapidly inside the test duct. Some of the released dust immediately re-deposits on the test filter. The pressure then stabilizes and returns to normal. Thus, the residual pressure drop across the filter is measured three seconds after conclusion of the cleaning pulse. It is monitored and recorded continuously throughout the recovery and

performance test period. The performance test period immediately followed the recovery period for a cumulative total of 10,030 cycles after the test filter was installed in the test apparatus. The performance test period is six hours in duration and during this phase normal filtration cycles and constant dust loading are maintained and recorded. Outlet mass and PM 2.5 dust concentrations are measured using an inertial impactor located downstream of the test filter. The weight gain of each impactor stage substrate is measured to within 0.00001 grams. Test conditions throughout the test were as follows:

- ◆ Test dust: Pural NF Alumina (1.5 ± 1.0 micron mass mean diameter)
- ◆ Inlet dust feed rate: 100 ± 20 grams/hr. ($18.4 \pm$ grams/scm)
- ◆ Filtration Velocity: 120 ± 6 m/hr.
- ◆ Gas Temperature: $25^{\circ} \text{C} \pm 2^{\circ} \text{C}$
- ◆ Pulse Cleaning Pressure: 75 psi

5.0 TEST RESULTS:

The following table summarizes the results measured during the performance test phase of the test runs. Detailed information for the conditioning, recovery and performance test phases is provided in Tables I and II and Appendices A through D.

PARAMETER	Fiber-Lite
PM2.5 Emissions (g/dscm)	0.0001091
Total Mass Emissions (g/dscm)	0.0001091
Initial Residual Pressure Drop (cm w.g.)	2.14
Residual Pressure Drop Increase (cm w.g.)	0.17
Average Residual Pressure Drop (cm w.g.)	2.22
Filter Sample Weight Gain (grams)	1.50
Average Filtration Cycle Time (seconds)	282
Number of Filtration Cycles (or Pulses)	76

TABLE I

SUMMARY OF TEST RESULTS (METRIC UNITS)

**TESTING OF BAGHOUSE FILTRATION PRODUCTS
PROCESS SYSTEMS**

ETS CONTRACT NUMBER: 08-703

DATE: December, 2008

RUN ID.	703-R1
FABRIC DESIGNATION	Fiber-Lite
MANUFACTURER	Process Systems
DUST FEED	Pural NF
 <u>CONDITIONING PERIOD</u>	
Date Started	12/1/2008
Time Started	10:27
Time Ended	18:47
Test Duration (min.)	500
 <u>RECOVERY PERIOD</u>	
Date Started	12/2/2008
Time Started	7:42
Time Ended	10:06
Test Duration (min.)	144
 <u>PERFORMANCE TEST PERIOD</u>	
Date Started	12/2/2008
Time Started	10:12
Time Ended	16:12
Test Duration (min.)	360
 <u>VERIFICATION TEST RESULTS</u>	
Mean Outlet Particle Conc. PM 2.5 (g/dscm)	0.0001091
Mean Outlet Particle Conc. Total mass (g/dscm)	0.0001091
Initial Residual Pressure Drop (cm w.g.)	2.14
Change in Residual Pressure Drop (cm w.g.)	0.17
Average Residual Pressure Drop (cm w.g.)	2.22
Mass Gain of Filter Sample (g)	1.50
Average Filtration Cycle Time (s)	282
Number of Pulses	76
 <u>RESIDUAL PRESSURE DROP</u>	
At Start of: Conditioning Period (cm w.g.)	0.15
Recovery Period (cm w.g.)	1.89
Performance Test Period (cm w.g.)	2.14
Pulse Pressure (psi)	75
 <u>REMOVAL EFFICIENCY (%)</u>	
Dust Conc (g/dscm)	18.10
PM 2.5 *	99.99922
Total Mass **	99.99940

* $(\text{Dust Concentration} * 0.7735) - \text{PM 2.5 Outlet Concentration} * 100$
Dust Concentration * 0.7735

** $\frac{\text{Dust Concentration} - \text{Total Mass Outlet Concentration}}{\text{Dust Concentration}} * 100$

TABLE II

SUMMARY OF TEST RESULTS (ENGLISH UNITS)

TESTING OF BAGHOUSE FILTRATION PRODUCTS

PROCESS SYSTEMS

ETS CONTRACT NUMBER: 08-703 DATE: December, 2008

RUN ID.	703-R1
FABRIC DESIGNATION	Fiber-Lite
MANUFACTURER	Process Systems
DUST FEED	Pural NF

CONDITIONING PERIOD

Date Started	12/1/2008
Time Started	10:27
Time Ended	18:47
Test Duration (min.)	500

RECOVERY PERIOD

Date Started	12/2/2008
Time Started	7:42
Time Ended	10:06
Test Duration (min.)	144

PERFORMANCE TEST PERIOD

Date Started	12/2/2008
Time Started	10:12
Time Ended	16:12
Test Duration (min.)	360

VERIFICATION TEST RESULTS

Mean Outlet Particle Conc. PM 2.5 (gr/dscf)	0.0000477
Mean Outlet Particle Conc. Total mass (gr/dscf)	0.0000477
Initial Residual Pressure Drop (in. w.g.)	0.84
Change in Residual Pressure Drop (in. w.g.)	0.07
Average Residual Pressure Drop (in. w.g.)	0.87
Mass Gain of Filter Sample (g)	1.50
Average Filtration Cycle Time (s)	282
Number of Pulses	76

RESIDUAL PRESSURE DROP

At Start of: Conditioning Period (in. w.g.)	0.06
Recovery Period (in. w.g.)	0.74
Performance Test Period (in. w.g.)	0.84

REMOVAL EFFICIENCY (%)

Dust Conc (gr/dscf)	7.91
PM 2.5 *	99.99922
Total Mass **	99.99940

* $\frac{\text{Dust Concentration} * 0.7735}{\text{Dust Concentration} * 0.7735} - \text{PM 2.5 Outlet Concentrator} * 100$

** $\frac{\text{Dust Concentration} - \text{Total Mass Outlet Concentrator} * 100}{\text{Dust Concentration}}$

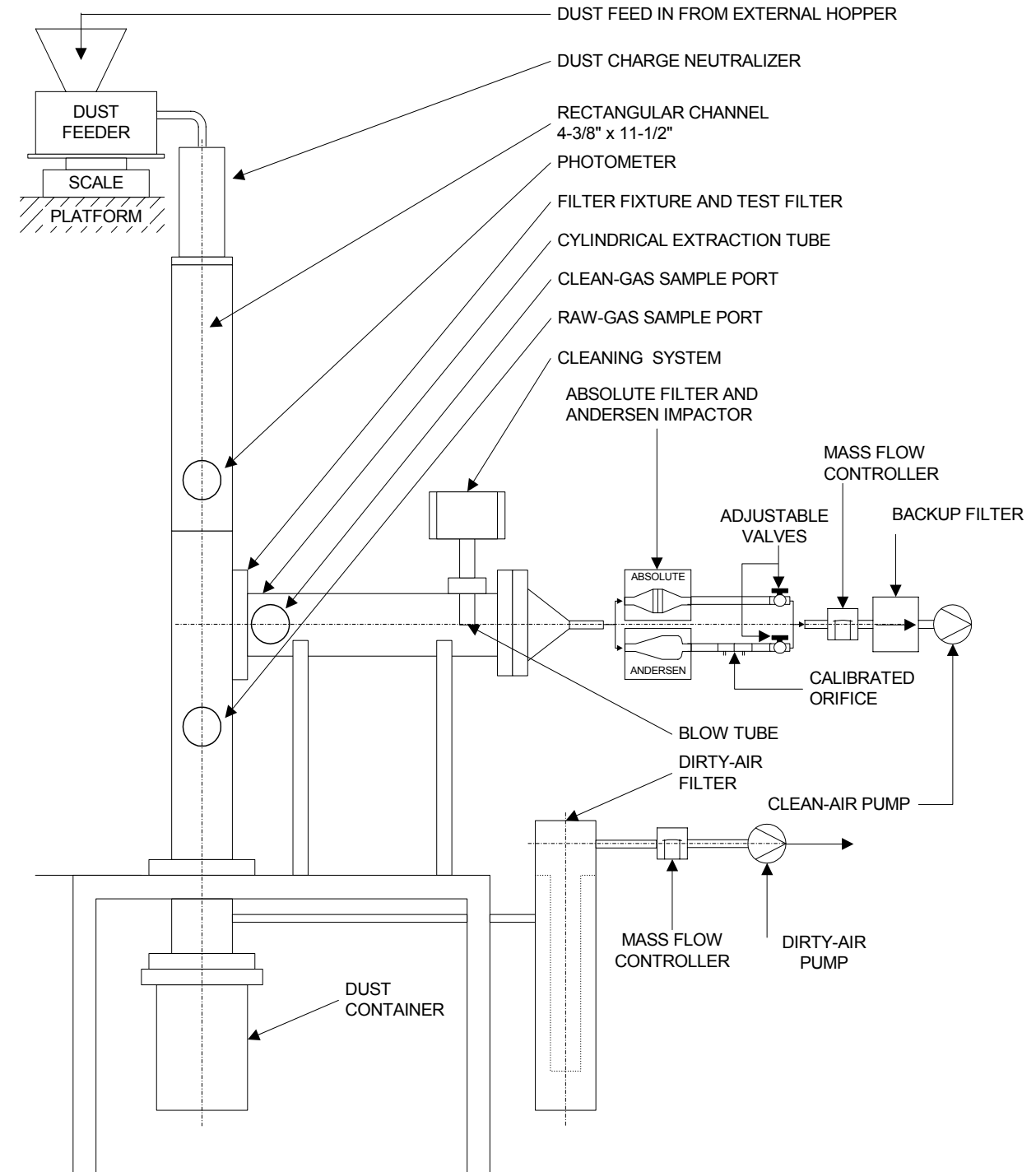


Figure 1 Filtration Performance Test Apparatus



REPORT CERTIFICATION

This report was prepared under my direct supervision. I have reviewed all details of this report and hereby certify that it is authentic and accurate.

Signature *T. Williamson* Date *12-4-08*

Terry G. Williamson, Manager - Fabric Filtration Laboratory, ETS, Inc.



I have reviewed all the testing details and results in this report, and confirm that they are authentic and accurate.

Signature *John D. McKenna* Date *12-4-08*

John D. McKenna, Ph.D., Principal, ETS, Inc.

TESTING OF BAGHOUSE FILTRATION PRODUCTS
 DETAILED SUMMARY OF DATA AND RESULTS

CONDITIONING PERIOD - 2 M/MIN

RUN ID.	703-R1	NUMBER OF PULSES	10000
FABRIC DESIGNATION	08-703-1 Fiber-Lite	PULSE INTERVAL	3 s
MANUFACTURER	Process Systems		
DUST FEED	Pural NF	Moisture	1.03 %WV
DATE STARTED	12/1/2008		
TIME STARTED	10:27		
TIME ENDED	18:47		
TEST DURATION	500 min.		

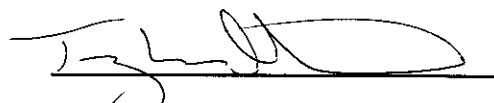
QA/QC DATA

Test Duration (min.)	Time		Dust Feed (g)			Average Gas Flow (sm ³ /hr)			Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/h)
			Initial	Final	Total	Raw	Clean	Total				
0-60	10:27	11:27	1911.1	1809.3	102	3.72	1.74	5.46	24	962.02	18.8	121
61-120	11:28	12:27	1809.3	1711.0	98	3.74	1.73	5.47	25	962.46	18.2	120
121-180	12:28	13:27	1711.0	1601.2	110	3.74	1.73	5.47	24	963.79	20.3	120
181-240	13:28	14:27	1601.2	1490.8	110	3.74	1.73	5.47	23	964.54	20.4	119
241-300	14:28	15:27	1490.8	1387.8	103	3.74	1.73	5.47	23	965.54	19.0	119
301-360	15:28	16:27	1387.8	1291.0	97	3.74	1.73	5.47	23	967.36	17.9	119
361-420	16:28	17:27	1291.0	1194.8	96	3.74	1.73	5.47	23	968.58	17.8	119
421-480	17:28	18:27	1194.8	1108.9	86	3.74	1.73	5.47	23	969.58	15.9	119
441-500 *	17:48	18:47	1164.4	1081.5	83	3.74	1.73	5.47	23	969.95	15.3	119
AVERAGE OF COMPLETE 500 MINUTE RAW DATA					100	3.74	1.73	5.47	24	965.67	18.4	119

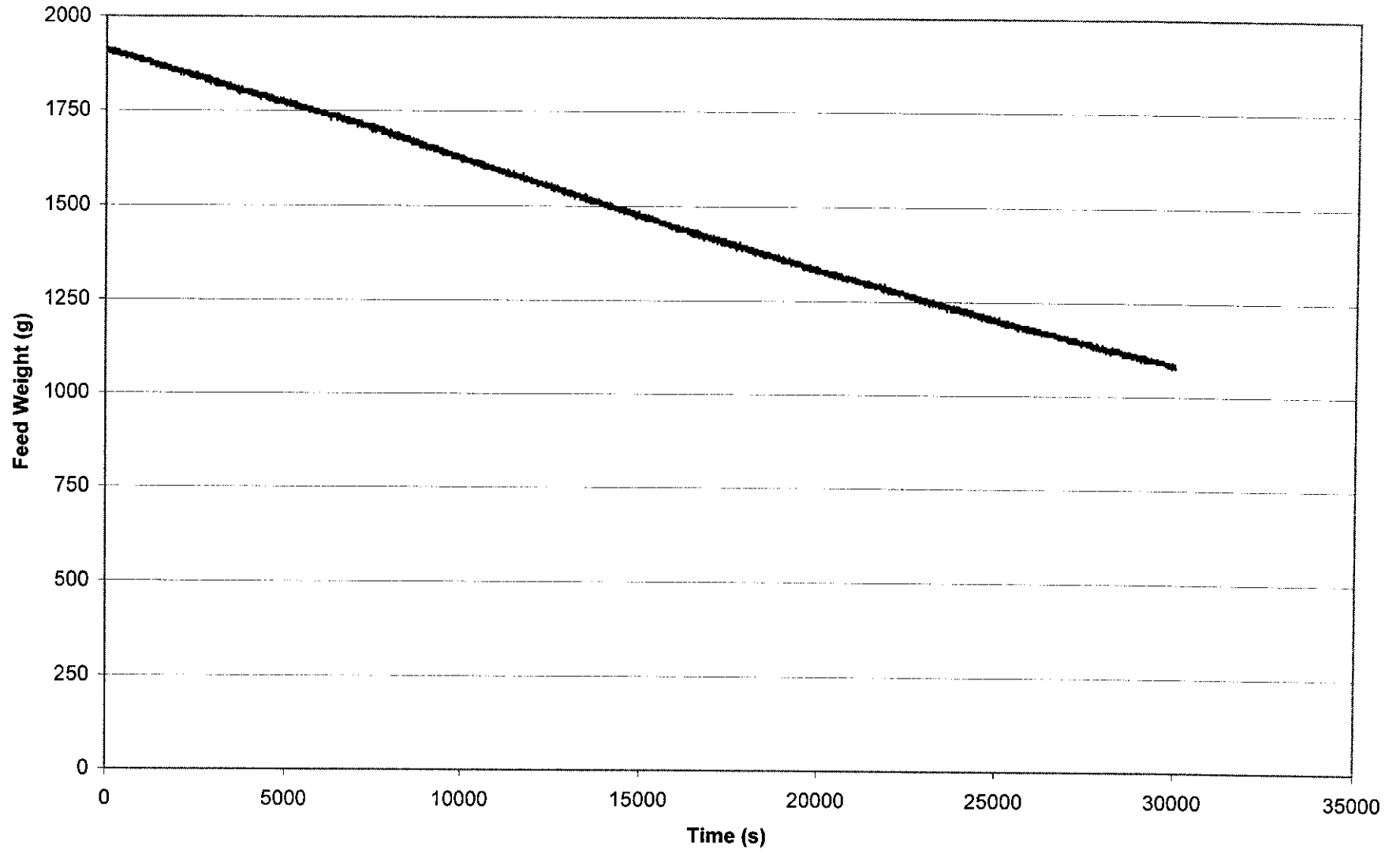
ACCEPTANCE	100	25	18.4	120
	+/- 20	+/- 2	+/- 3.6	+/- 6

* Test duration is a rolling 60 minute average. The last 60 minute frame was determined by counting 60 minutes back from the last minute of the test.

DATA PROCESSING OPERATOR:


 Terry Williamson - ETS, Inc.

Change in Pural NF dust scale reading with time during conditioning period 703-R1



TESTING OF BAGHOUSE FILTRATION PRODUCTS
 DETAILED SUMMARY OF DATA AND RESULTS

RECOVERY PERIOD - 2 M/MIN

RUN ID.	703-R1	NUMBER OF PULSES	30
FABRIC DESIGNATION	08-703-1 Fiber-Lite	AVG. PULSE INTERVAL	287 s
MANUFACTURER	Process Systems	AVG. RESIDUAL ΔP	195.73 Pa
DUST FEED	Pural NF	INITIAL RESIDUAL ΔP	185.20 Pa
DATE(S)	12/2/2008	FINAL RESIDUAL ΔP	205.90 Pa
TIME STARTED	7:42 *	CHANGE IN ΔP	20.70 Pa
TIME ENDED	10:06	MAX. PRESSURE DROP	1000 Pa
TEST DURATION	144 min.	% Moisture	0.95 %WV

QA/QC DATA

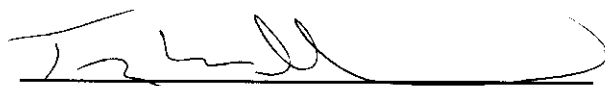
Test Duration (min.)	Time		Dust Feed (g)			Average Gas Flow (sm ³ /hr)			Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/h)
			Initial	Final	Total	Raw	Clean	Total				
1-144	7:43 *	10:06	1941.8	1700.5	241	3.78	1.75	5.53	25	978.56	44.1	120
1-60	7:43 *	8:42	1941.8	1850.1	92	3.78	1.75	5.53	24	978.24	16.7	119
61-120	8:43	9:42	1850.1	1741.7	108	3.78	1.75	5.53	25	978.68	19.8	120
84-144	9:06 **	10:06	1807.4	1700.5	107	3.78	1.75	5.53	25	978.97	19.5	120
AVERAGE FOR 144 MINUTE RAW DATA					101	3.77	1.75	5.52	25	978.56	18.4	120

ACCEPTANCE	100	25	18.4	120
	+/- 20	+/- 2	+/- 3.6	+/- 6

* First minute is not considered in calculations due to equipment stabilization.

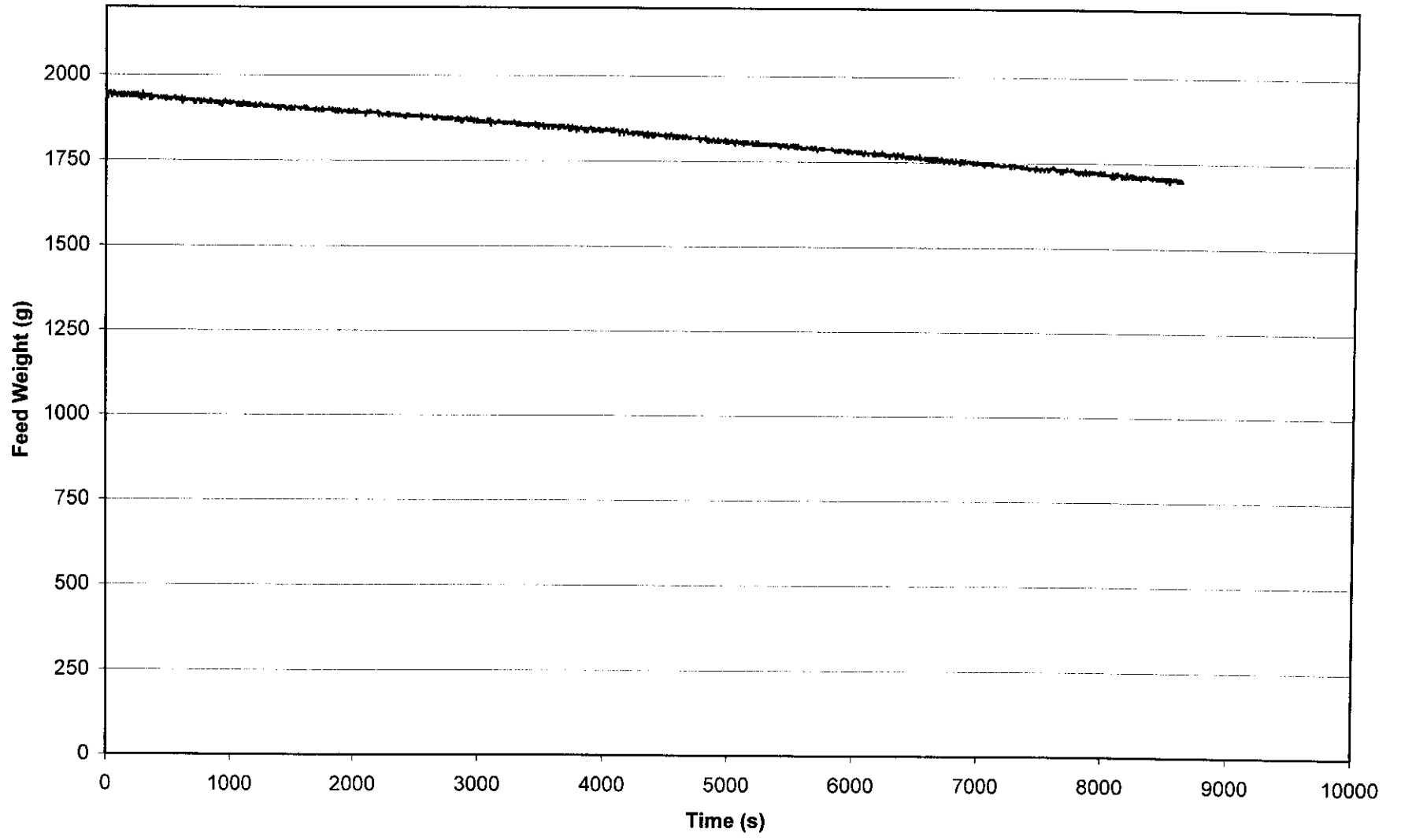
** Test duration is a rolling 60 minute average. The last 60 minute frame was determined by counting 60 minutes back from the last minute of the test.

DATA PROCESSING OPERATOR:

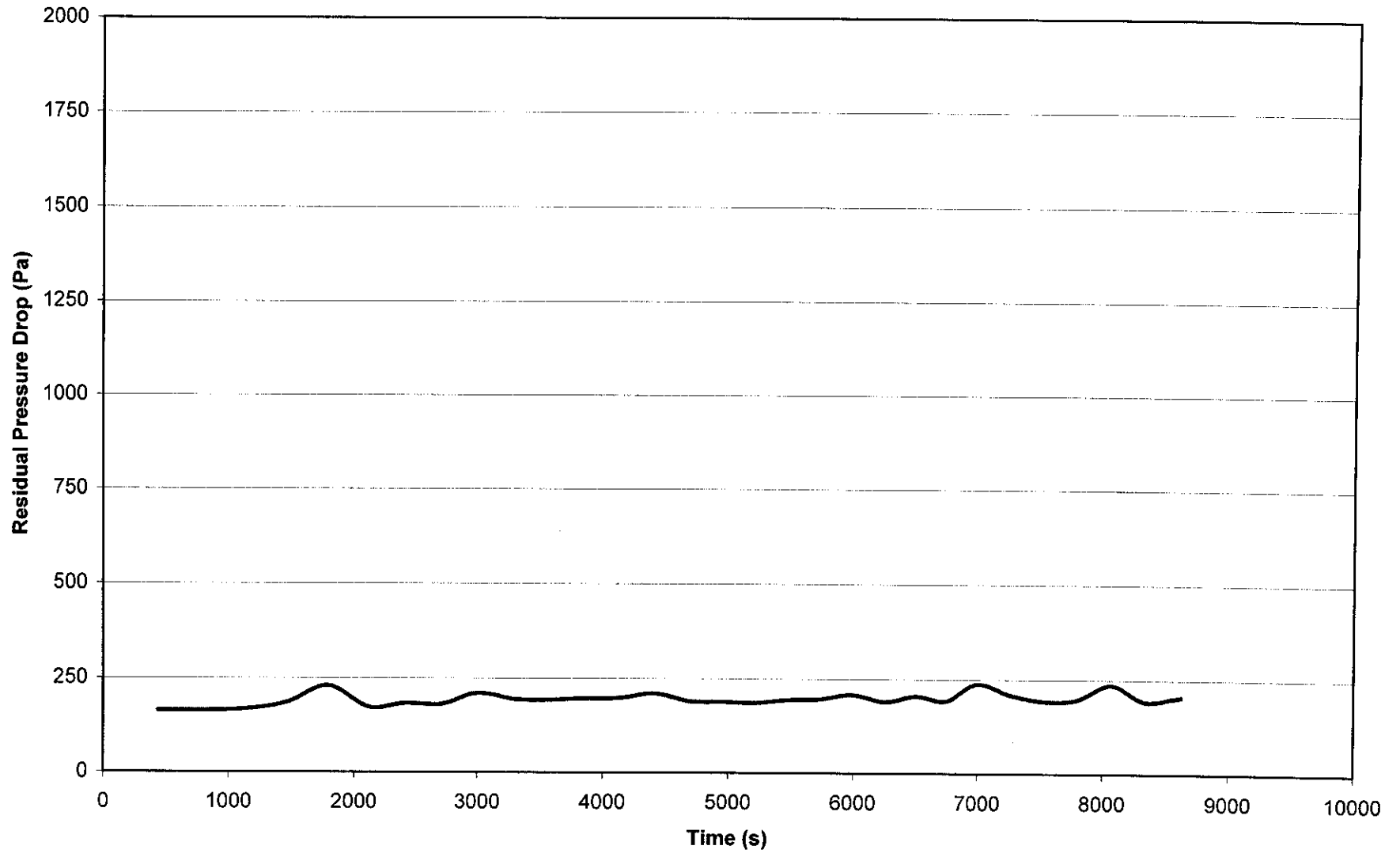


Terry Williamson - ETS, Inc.

Change in Pural NF dust scale reading with time during recovery period 703-R1



Residual pressure drop across filter fabric during recovery period 703-R1



TESTING OF BAGHOUSE FILTRATION PRODUCTS
 DETAILED SUMMARY OF DATA AND RESULTS

PERFORMANCE TEST PERIOD - 2 M/MIN

RUN ID.	703-R1	NUMBER OF PULSES	76
FABRIC DESIGNATION	08-703-1 Fiber-Lite	AVG. PULSE INTERVAL	282 s
MANUFACTURER	Process Systems	AVG. RESIDUAL ΔP	217.46 Pa
DUST FEED	Pural NF	INITIAL RESIDUAL ΔP	209.20 Pa
DATE STARTED	12/2/2008	FINAL RESIDUAL ΔP	225.50 Pa
TIME STARTED	10:12	CHANGE IN ΔP	16.30 Pa
TIME ENDED	16:12	MAX. PRESSURE DROP	1000 Pa
TEST DURATION	360 min.	Moisture	0.95 %WV

QA/QC DATA

Test Duration (min.)	Time	Dust Feed (g)			Average Gas Flow (sm ³ /hr)				Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/h)	
		Initial	Final	Total	Raw	Clean	Total	Sample					
0-60	10:12	11:12	1700.5	1590.3	110	3.76	1.76	5.52	1.09	26	979.36	20.2	121
61-120	11:13	12:12	1590.3	1494.1	96	3.76	1.76	5.52	1.08	25	979.29	17.6	120
121-180	12:13	13:12	1494.1	1400.0	94	3.76	1.76	5.52	1.08	24	979.08	17.2	120
181-240	13:13	14:12	1400.0	1302.7	97	3.76	1.76	5.52	1.08	24	979.20	17.8	120
241-300	14:13	15:12	1302.7	1207.2	96	3.76	1.76	5.52	1.08	23	979.30	17.5	120
301-360	15:13	16:12	1207.2	1107.5	100	3.76	1.76	5.52	1.08	23	979.61	18.2	120
AVERAGE OF COMPLETE 360 MINUTE RAW DATA					99	3.76	1.76	5.52	1.08	24	979.31	18.1	120

ACCEPTANCE	100 +/- 20	25 +/- 2	18.4 +/- 3.6	120 +/- 6
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GRAVIMETRIC DATA

IMPACTOR SUBSTRATES		SAMPLE FILTER	
Backup Filter (PM 2.5)	0.00070 g	Tare Mass	11.31 g
Total Mass Gain	0.00070 g	Final Mass	12.81 g
		Mass Gain	1.50 g

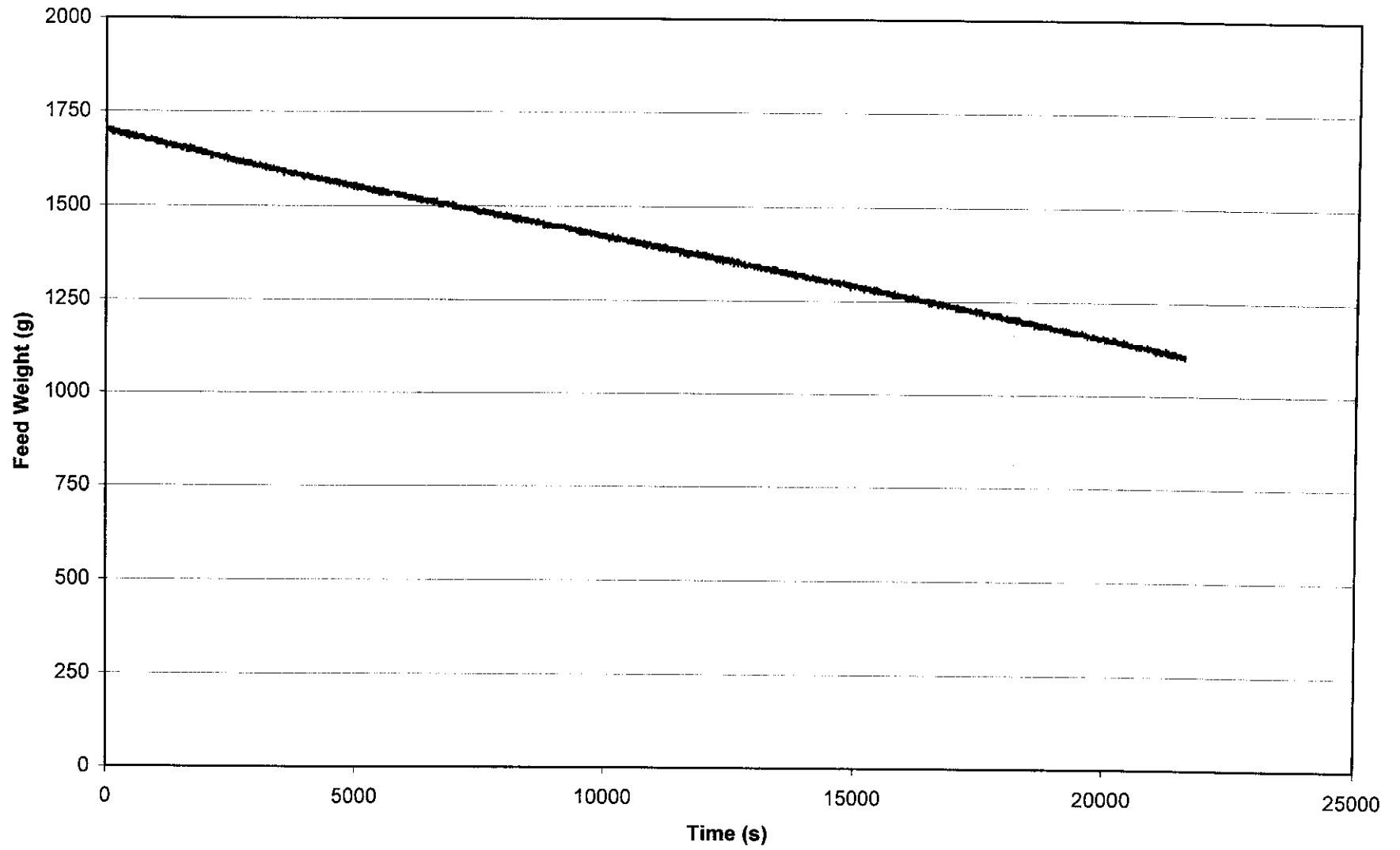
OUTLET CONCENTRATION

Total Volume Sampled	6.85 m ³
Mean Outlet Particle Concentration - PM 2.5	0.0001022 g/m ³
Mean Outlet Particle Concentration - Total Mass	0.0001022 g/m ³

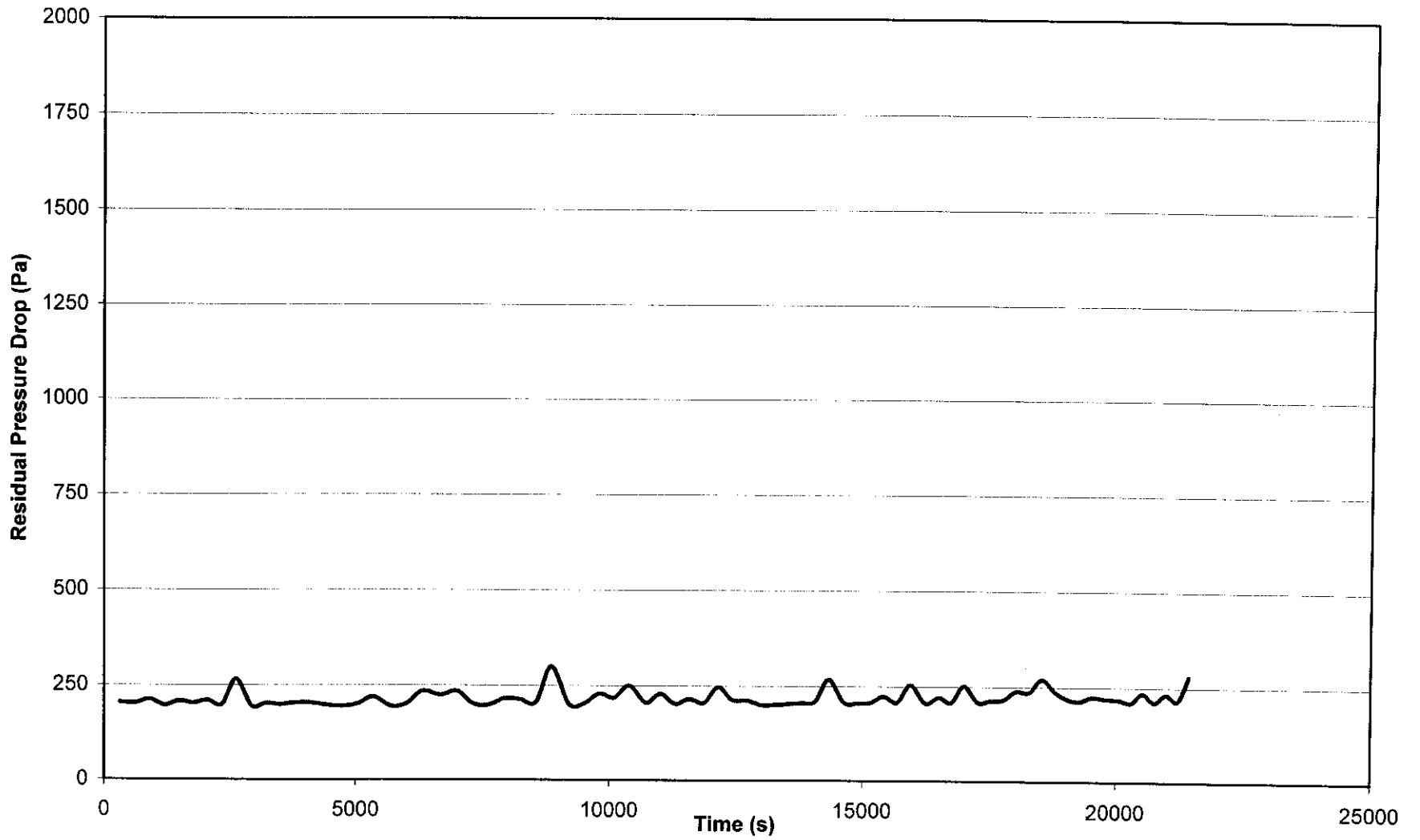
DATA PROCESSING OPERATOR:


 Terry Williamson - ETS, Inc.

Change in Pural NF dust scale reading with time during performance test period 703-R1



Residual pressure drop across filter fabric during performance test period 703-R1



**TESTING OF BAGHOUSE FILTRATION PRODUCTS
FABRIC PERFORMANCE TESTING**

GRAVIMETRIC ANALYTICAL DATA AND RESULTS

RUN NUMBER: 703-R1
TEST DATE: 12/02/2008

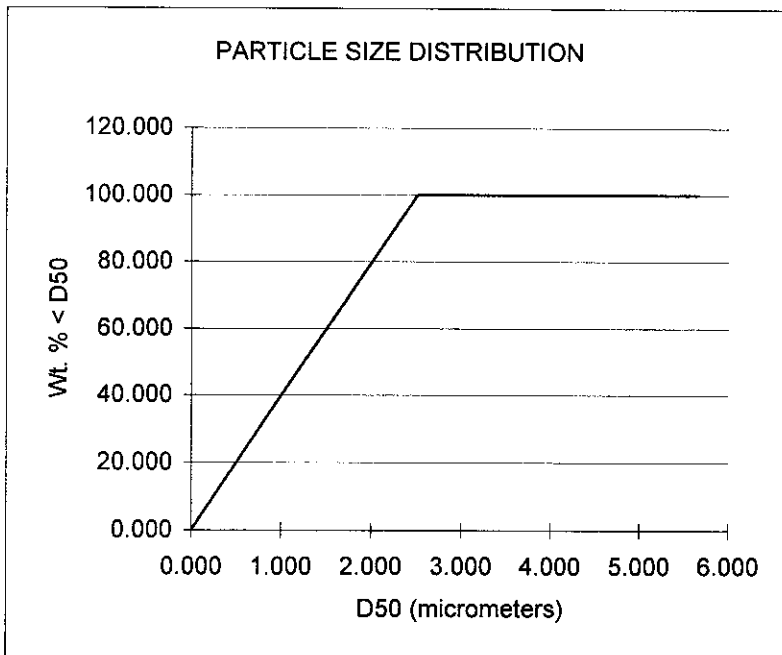
Filter I.D. Sample I.D.	Wash Vol.(ml)	Stage	Tare Mass (g)	Final Mass (g)	Mass Difference (g)*	Negative Difference? (g)
VDI-08-88						
VDI-08-88-1		1	1.05451	1.05451	0.00000	N/A
VDI-08-88-2		2	1.04427	1.04427	0.00000	N/A
VDI-08-88-3		3	1.02173	1.02173	0.00000	N/A
VDI-08-88-4		F	1.07862	1.07932	0.00070	N/A

Total 0.00070

* Final Mass < Tare Mass: assume mass difference - 0.00000.

IMPACTOR PARTICLE SIZING RESULTS

STAGE	Particulate Mass (g)	Cumulative % Less Than Diameter	D50 Cut Point (micrometers)
1	0.00000	100.00	5.66
2	0.00000	100.00	5.33
3	0.00000	100.00	2.51
F	0.00070		



TESTING OF BAGHOUSE FILTRATION PRODUCTS

FABRIC PERFORMANCE TESTING

JOB ID

RUN NUMBER **703-R1**

DATE 12/02/08
 START TIME 10:12
 END TIME 16:12
 TEST DURATION 360 min.

GAS COMPOSITIONAL DATA

%O2	20.9	Md	28.84
%CO2	0.0	Ms	28.73
%CO	0.0	Ps	28.69
%N2	79.1		

AMBIENT CONDITIONS

Barometric 28.951 in. Hg
 Gas Moisture Content 0.95 %

SAMPLING DATA

Gas Sample Volume 241.92 ft³
 Volume @ Std.Cond. 228.83 dscf

RAW DATA (FOR CLEAN GAS CHANNEL)

Actual Flow 1.14 m³/hr
 0.67 cfm
 Std. Flow 1.08 sm³/hr
 0.64 scfm
 Raw Gas Pressure 979.31 mbar
 Average Fabric Pressure Drop 765.31 Pa
 7.65 mbar
 Sample Gas Pressure 971.66 mbar
 28.69 in. Hg
 Sample Gas Temperature 24.1 °C
 75.3 °F

Md - Dry Molecular Weight

Ms - Molecular Weight in Stack

Ps - Static Pressure

Note All measurements are primary measurements and might be converted in subsequent calculations.

BAGHOUSE FILTRATION PRODUCTS VERIFICATION TESTING

TEST RUN ID: 703-R1
 TEST FACILITY: ETS

FABRIC ID: 08-703-1
 DUST: NF

Conditioning Period

1.03%

Int DP = 1SP₄

CONDITIONING - 0-10000 PULSES

DATE: 12-1-08
 START TIME: 10:27
 STOP TIME: 18:47
 RUN TIME: 8 hrs - 20 min.

AMBIENT CONDITIONS

Temperature (F): 70
 Pressure (in Hg) 28.415

Wet Bulb (F): 55
 Humidity (%RH): 38

Recovery Period

0.95%

DP = 195.73

Int = 287.4

Int = 185.2

Fin = 205.9

Inc = 20.7

FABRIC RECOVERY - 10000-10030 PULSES

DATE: 12-2-08
 START TIME: 7:42
 STOP TIME: 10:06
 RUN TIME: 8625 sec.

AMBIENT CONDITIONS

Temperature (F): 71
 Pressure (in Hg) 28.951

Wet Bulb (F): 55
 Humidity (%RH): 36

Performance Test Period

#76

0.95%

DP = 217.46

Int = 282.04

Int = 209.2

Fin = 225.5

Inc = 16.3

PERFORMANCE TEST PERIOD - 6-HOURS

DATE: 12-2-08
 START TIME: 10:12
 STOP TIME: 16:12
 RUN TIME: 6 hrs.

AMBIENT CONDITIONS

Temperature (F): 71
 Pressure (in Hg) 28.951

Wet Bulb (F): 55
 Humidity (%RH): 36

Operator Signature: _____

ETS, Inc

HIGH RESOLUTION ANALYTICAL BALANCE DATA SHEET (USE ONE PER IMPACTOR SET)

TEST FACILITY: ETS
 IMPACTOR SET ID: 08-88
 FABRIC ID: 08-703-1
 TEST RUN ID: 703-21

PRE-WEIGHING

Date: 9-17-08
 Start Time: 10:44
 Stop Time: 10:49

POST-WEIGHING

Date: 12-4-08
 Start Time: 9:30
 Stop Time: 9:35

CONDITIONING

Date Time
 Conditioning Start: 9-9-08 14:00
 Conditioning Stop: 9-17-08 9:55
 Conditioning Successful?: yes/no
 (Attach Temperature and Humidity Data)

CONDITIONING

Date Time
 Conditioning Start: 12-2-08 16:31
 Conditioning Stop: 12-4-08 9:24
 Conditioning Successful?: yes/no
 (Attach Temperature and Humidity Data)

CALIBRATION DATA:

Time: 9:55
 Response to 1g weight: 1.00000
 Within 0.00005g? yes/no

CALIBRATION DATA:

Time: 9:24
 Response to 1g weight: 1.00001
 Within 0.00005g? yes/no

Stage

0
1
2
3
4
5
6
7
8

Filter

Pre-Weight* (g)
1.05451
1.04427
1.02173
1.07862

Post-Weight* (g)
1.05451
1.04427
1.02173
1.07932

Weight Gain (g)
0.00000
0.00000
0.00000
0.00070

* Including labeled weigh foils

Operator Signature: T. Z...

LOW RESOLUTION ANALYTICAL BALANCE DATA SHEET

TEST FACILITY: ETS
 FABRIC ID: 08-703
Process Systems

CALIBRATION (PRE)


Date: 12-1-08
 Time: 10:23
 Response to 100g Wt.: 99.99
 Within 0.05 g? yes/no

CALIBRATION (POST)

Fabric Sample ID	Test Run ID
08-703-1	703-R1
08-703-2	

Pre-Weight (g)	Post Weight (g)	Weight Gain (g)
11.31	12.81	1.50
10.66		

Date	Time	Calibration (g)	Response Within 0.05 g
12-3-08	8:05	100.00	Yes/No
			Yes/No
			Yes/No
			Yes/No
			Yes/No
			Yes/No
			Yes/No
			Yes/No
			Yes/No

Operator Signature: 
 ETS, Inc