September 2001

Environmental Technology Verification Report

Baghouse Filtration Products

BHA Group, Inc.
QP131 Filter Sample

Prepared by

ETS, Incorporated

RTI INTERNATIONAL

Under a Cooperative Agreement with

EPA United States Environmental Protection Agency

ETV ETV ETV

Environmental Technology Verification Report

Baghouse Filtration Products

BHA Group, Inc. QP131 Filter Sample

Prepared by

Air Pollution Control Technology Verification Center

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EPA Cooperative Agreement CR 826152-01-3

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Research Triangle Park, NC 27711

September 2001

Notice

This document was prepared by ETS, Inc. (ETS) under a contract with RTI with funding from Cooperative Agreement No. CR826152-01-3 with the U.S. Environmental Protection Agency (EPA). The document has been subjected to RTI/EPA's peer and administrative reviews and has been approved for publication. Mention of corporation names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products.

Availability of Verification Statement and Report

Copies of the public Verification Statement and Verification Report are available from the following:

1. **RTI**
   P.O. Box 12194
   Research Triangle Park, NC 27709-2194

   http://etv.rti.org/apct/documents.cfm
   http://www.epa.gov/etv *(click on partners)*

2. **USEPA / APPCD**
   MD-4
   Research Triangle Park, NC 27711

   Website: http://www.epa.gov/etv/library.htm *(electronic copy)*
   http://www.epa.gov/ncepihom/

Abstract

Baghouse filtration products (BFPs) were evaluated by the Air Pollution Control Technology (APCT) Verification Center. The performance factor verified was the mean outlet particle concentration for the filter fabric as a function of the size of those particles equal to and smaller than 2.5 µm in aerodynamic diameter ($PM_{2.5}$). The APCT Verification Center developed a generic verification protocol for testing baghouse filtration products that is based on a modified Verein Deutscher Ingenieure (VDI) Method 3926. The protocol was developed by RTI and ETS, Inc. (ETS), reviewed by a technical panel of experts, and approved by the U.S. Environmental Protection Agency (EPA). The protocol addresses several issues that VDI Method 3926 does not cover, including periodic testing, acquisition of BFP samples for testing, and product definition. A test/quality assurance plan and a standard operating procedure were prepared to address the test procedure, quality assurance, quality control requirements for obtaining verification data of sufficient quantity and quality to satisfy the data quality objectives.

ETS performed tests on BHA Group's filter sample QP131 during January 30 - February 2, 2001. Mean outlet particle concentrations for total mass and $PM_{2.5}$ were determined. In addition, the following verification parameters were measured and reported: initial residual pressure drop, residual pressure drop increase, average residual pressure drop, average filtration cycle time, and mass gain of the filter sample.

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List of Abbreviations and Acronyms

APCT	Air Pollution Control Technology
APPCD	Air Pollution Prevention and Control Division
BFP	baghouse filtration product
cfm	cubic feet per minute
cm	centimeters
cm w.g.	centimeters of water gauge
dia.	diameter
DP	pressure drop
dscmh	dry standard cubic meters per hour
EPA	U.S. Environmental Protection Agency
ETS	ETS, Inc.
ETV	Environmental Technology Verification
FEMA	Filtration Efficiency Media Analyzer
fpm	feet per minute
ft^3	cubic feet
g	grams
G/C	gas-to-cloth ratio (filtration velocity)
gr	grains
gr/dscf	grains per dry standard cubic foot
g/dscm	grams per dry standard cubic meter
g/h	grams per hour
g/m^2	grams per square meter
h	hours
in.	inches
in. w.g.	inches of water gauge
kPa	kilopascals

m	meters
mbar	millibars
min	minutes
m/h	meters per hour
m^3/h	cubic meters per hour
mm	millimeters
MPa	megapascals
ms	milliseconds
NA	not applicable
Pa	pascals
PM	particulate matter
$PM_{2.5}$	particulate matter 2.5 micrometers in aerodynamic diameter or smaller
psi	pounds per square inch
psia	pounds per square inch absolute
PTFE	polytetrafluoroethylene
QA	quality assurance
QC	quality control
RTI	Research Triangle Institute
s	seconds
scf	standard cubic feet
scfm	standard cubic feet per minute
VDI	Verein Deutscher Ingenieure
µg	micrograms
µm	micrometers
°C	degrees Celsius
°F	degrees Fahrenheit
°R	degrees Rankine

Acknowledgments

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SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved technologies through performance verification and information dissemination. The ETV Program is intended to assist and inform those involved in the design, distribution, permitting, and purchase of environmental technologies.

EPA's partner in the Air Pollution Control Technology (APCT) Verification Center is RTI. With the full participation of the technology developer, the APCT Verification Center develops plans, conducts tests, collects and analyzes data, and reports findings. The evaluations are conducted according to a rigorous protocol and under quality assurance (QA) and quality control (QC) oversight. The APCT Verification Center verifies the performance of commercial-ready technologies used to control air pollutant emissions, with an emphasis on technologies for controlling particulate matter, volatile organic compounds, nitrogen oxides, and hazardous air pollutants. The program develops standardized verification protocols and test plans, conducts independent testing of technologies, and prepares verification test reports and statements for broad dissemination.

SECTION 2
VERIFICATION TEST DESCRIPTION

The baghouse filtration products were tested in accordance with the APCT "Generic Verification Protocol for Baghouse Filtration Products"[1] and the "Test/QA plan for the Verification Testing of Baghouse Filtration Products."[2] This protocol incorporated all requirements for quality management, quality assurance, procedures for product selection, auditing of the test laboratories, and reporting format. The Generic Verification Protocol describes the overall procedures to be used for verification testing and defines the data quality objectives. The values for inlet dust concentration, raw gas flow rate, and filtration velocity used for current verification testing have been revised since posting of the Generic Verification Protocol. The protocol is being revised to include these and other changes under recommendation or concurrence of the Baghouse Filtration Products Technical Panel. The test/QA plan details how the test laboratory at ETS, Inc. (ETS) will implement and meet the requirements of the Generic Verification Protocol.

Mean outlet particle concentration was determined from the Filtration Efficiency Media Analyzer (FEMA) test apparatus. The test apparatus consists of a brush-type dust feeder that disperses test dust into a vertical rectangular duct (raw-gas channel). A radioactive polonium-210 alpha source is used to neutralize the dust electrically before its entry into the raw-gas channel. A portion of the gas flow is extracted from the raw-gas channel through the test filter, which is mounted vertically at the entrance to a horizontal duct (clean-gas channel). The clean-gas flow is separated using an aerodynamic "Y" so that a representative sample of the clean gas flows through an Andersen impactor that determines the outlet particle concentration.

The particle size was measured while a fine dust was injected into the air stream upstream of the filter fabric sample.

The following series of tests was performed on three separate, randomly selected filter fabric samples:

- Dust characterization (first sample fabric verification test only),
- Conditioning period,
- Recovery period, and
- Performance test period.

To simulate long-term operation, the test filter was first subjected to a conditioning period, which consists of 10,000 rapid pulse cleaning cycles under continuous dust loading. During this period, the time between cleaning pulses is maintained at 3 seconds. No filter performance parameters are measured in this period.

The conditioning period is immediately followed by a recovery period, which allows the test filter fabric to recover from rapid pulsing. The recovery period consists of 30 normal filtration cycles under continuous and constant 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 in. w.g.) is reached. At this point the test filter is cleaned by a pulse of compressed air from the clean-gas side of the fabric. The next filtration cycle begins immediately after the cleaning is complete.

Performance testing occurs for a 6-hour period immediately following the recovery period (a cumulative total of 10,030 filtration cycles after the test filter has been installed in the test apparatus). During the performance test period, normal filtration cycles are maintained and, as in the case of the conditioning and recovery periods, the test filter is subjected to continuous and constant dust loading.

The filtration velocity (glass-to-cloth ratio [G/C]) and inlet dust concentrations are maintained at 180 ± 9 m/h (9.8 ± 0.5 fpm) and 18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf), respectively, throughout all phases of the test.

Additional details on the test procedure are provided in Appendix A.

2.1 SELECTION OF FILTRATION SAMPLE FOR TESTING

Filter fabric samples of QP131 were supplied to ETS directly from the manufacturer (BHA Group) with a letter signed by Alan Smithies, Director of Product Development, BHA Group, attesting that the filter media were selected at random in an unbiased manner from commercial-grade media and were not treated in any manner different from the media provided to customers. The manufacturer supplied the test laboratory with nine 46 x 91 cm (18 x 36 in.) filter samples. The test laboratory randomly selected three samples and prepared them for testing by cutting one test specimen of 150 mm (5.9 in.) diameter from each selected sample for insertion in the test rig sample holder. The sample holder has an opening of 140 mm (5.5 in.) in diameter, which is the dimension used to calculate the face area of the tested specimen.

SECTION 3
DESCRIPTION OF FILTER FABRIC

The BHA Group QP131 filter fabric is a polyester needlefelt substrate with an expanded, microporous polytetrafluoroethylene (PTFE) membrane, thermally laminated to the filtration/dust-cake surface. This product is traditionally used to capture fine particulate in ambient and hot gas filtration applications.

SECTION 4
VERIFICATION OF PERFORMANCE

4.1 QUALITY ASSURANCE

The verification tests were conducted in accordance with an approved test/QA plan.[2] The EPA Quality Assurance Manager conducted an independent assessment of the test laboratory in February 2000 and found that the test laboratory was equipped and being operated as specified in the test/QA plan.

The ETS QA Officer and APCT QA staff have reviewed the results of this test and have found that the results meet data quality objectives in the test/QA plan. In addition, it should be noted that, because of the highly efficient nature of the filter medium being tested, one or more of the impactor substrate weighings for these results were near the reproducibility of the balance. As a result of this occurrence, the tests do not meet the data quality objectives stated in the test/QA plan for mass gain associated with outlet concentrations. The true values of the outlet concentrations may be more than plus or minus 15 percent of the reported values. Data on calibration certificates for the flow meters, flow transducers, weights, low- and high-resolution balances, thermometer, and humidity logger are provided in Appendix B.

4.2 RESULTS

Table 3 summarizes the mean outlet particle concentration measurements for the verification test periods. Measurements were conducted during the 6-hour performance test period. The performance test period followed a 10,000-cycle conditioning period and a 30-cycle recovery period. Upstream and downstream particle concentration information for each verification test period is provided in Appendix C.

The average residual pressure drop across each filter sample at the nominal 180 m/h (9.8 fpm) filtration velocity (for a flowrate of 5.8 m^3/h [3.4 cfm]) is also shown in Table 3. This DP ranged from 6.13 to 6.31 cm w.g. (2.41 to 2.48 in. w.g.) for the three filter samples tested. The residual DP increase ranged from 0.43 to 0.45 cm w.g. (0.17 to 0.18 in. w.g.) for the samples tested. All three verification runs were used to compute the averages given in Table 3. The $PM_{2.5}$ concentration average for the three runs is 0.0000068 g/dscm. The total PM concentration average for the three runs is 0.0000388 g/dscm.

Table 3. Summary of Verification Results for BHA Group QP131

Test Run Number	2V02-R1	2V02-R2	2V02-R3	Average*
$PM_{2.5}$ (g/dscm)**	0.0000127	0.0000078	0.0000000	0.0000068
Total PM (g/dscm)	0.0000540	0.0000327	0.0000296	0.0000388
Average Residual DP (cm w.g.)	6.13	6.19	6.31	6.21
Initial Residual DP (cm w.g.)	5.87	5.93	6.02	5.94
Residual DP Increase (cm w.g.)	0.44	0.43	0.45	0.44
Mass Gain of Sample Filter (g)	0.14	0.14	0.12	0.13
Average Filtration Cycle Time (s)	74	76	72	74

*All three verification runs were used to compute averages.

** Standard conditions: 101.3 kPa (14.7 psia) and 20°C (68°F). One or more of the impactor substrate weight changes for these results were near the reproducibility of the balance.

4.3 LIMITATIONS AND APPLICATIONS

This verification report addresses two aspects of baghouse filtration product performance: outlet particle concentration and pressure drop. Users may wish to consider other performance parameters such as service life and cost when selecting a baghouse filtration fabric for their application.

In accordance with the generic verification protocol, this verification statement is applicable to the baghouse filtration product manufactured between September 28, 2001 and 3 years thereafter.

SECTION 5
REFERENCES

1. Generic Verification Protocol for Baghouse Filtration Products, RTI, Research Triangle Park, NC, February 2000. Available at http://etv.rti.org/apct/pdf/baghouseprotocol.pdf.

2. Test/QA Plan for the Verification Testing of Baghouse Filtration Products, ETS, Inc., Roanoke, VA, February 1999.

Appendix A

DESCRIPTION ON THE TEST RIG AND THE METHODOLOGY

DESCRIPTION OF THE TEST RIG AND METHODOLOGY

TEST APPARATUS

The tests were conducted in ETS's FEMA test apparatus (Figure A-1). The test apparatus consists of a brush-type dust feeder that disperses test dust into a vertical rectangular duct (raw-gas channel). The dust feed rate is continuously measured and recorded via an electronic scale located beneath the dust feed mechanism. The scale has a continuous read-out with a resolution of 10 g. A radioactive polonium-210 alpha source is used to neutralize the dust electrically before its entry into the raw-gas channel. An optical photo sensor monitors the concentration of dust and ensures that the flow is stable for the entire duration of the test. The optical photo sensor does not measure concentration. A portion of the gas flow is extracted from the raw-gas channel through the test filter, which is mounted vertically at the entrance to a horizontal duct (clean-gas channel). The clean-gas channel flow is separated in two gas streams, a sample stream and a bypass stream. An aerodynamic "Y" is used for this purpose. The aerodynamic "Y" is designed for isokinetic separation of the clean gas with 40 percent of the clean gas entering the sample-gas channel without change in gas velocity. The sample-gas channel contains an Andersen impactor for particle separation and measurement. The bypass channel contains an absolute filter. The flow within the two segments of the "Y" is continuously monitored and maintained at selected rates by adjustable valves. Two vacuum pumps maintain air flow through the raw-gas and clean-gas channels. The flow rates, and thus the G/C through the test filter, are kept constant and measured using mass flow controllers. A pressure transducer is used to measure the average residual pressure drop of the filter sample. The pressure transducer measures the differential pressure across the filter samples 3 seconds after the cleaning pulse. The pressure drop measurements are averaged as stated in Appendix C, section 4.4.1.[1] High-efficiency filters are installed upstream of the flow controllers and pumps to prevent contamination or damage caused by the dust. The cleaning system consists of a compressed-air tank set at 0.5 MPa (75 psi), a quick-action diaphragm valve, and a blow tube (25.4 mm [1.0 in.] dia.) with a nozzle (3 mm [0.12 in.] dia.) facing the downstream side of the test filter.

CONTROL TESTS

Two types of control tests were performed during the verification test series. The first was a dust characterization, which was performed at the beginning of the first verification test. The reference dust that was used during the verification tests was Pural NF aluminum oxide dust. The Pural NF dust was oven dried for 2 hours and sealed in an airtight container prior to its insertion into the FEMA apparatus. The dust characterization results had to meet the requirements of a 1.5 µm maximum mass mean diameter and at least 66 percent less than 2.5 µm to continue the verification test series.

The second control test, the reference value test, is performed quarterly using the reference fabric and the FEMA apparatus. The reference value test determines the weight gain of the reference fabric as well as the maximum pressure drop. The results of the test verify that the FEMA apparatus is operating within the required parameters. The reference value test measurements must meet the following requirements of weight gain of reference fabric equal to 0.93 ± 0.09 g and a reference fabric maximum pressure drop of 1.84 ± 0.18 cm w.g. to proceed with verification testing.

The results of the control tests are summarized in Table A-1.

Table A-1. Summary of Control Test Results

	Requirement	Measured Value	Met Requirements?
Mass Mean Diameter, µm	< 1.5	1.08	Yes
% Less than 2.5 µm	> 66	74.73	Yes
Weight Gain, g	0.93 ± 0.09	1.02	Yes
Maximum Pressure Drop, cm w.g.	1.84 ± 0.18	1.90	Yes

ANALYSIS

The equations used for verification analysis are described below.

A_f = Exposed area of sample filter, m^2
C_{ds} = Dry standard outlet particulate concentration of total mass, g/dscm
$C_{2.5ds}$ = Dry standard outlet particulate concentration of $PM_{2.5}$, g/dscm
d = Diameter of exposed area of sample filter, m
F_a = Dust feed concentration corrected for actual conditions, g/m^3
F_s = Dust feed concentration corrected for standard conditions, g/dscm
G/C = Gas-to-cloth ratio, m/h
M_t = Total mass gain from Andersen impactor, g
$M_{2.5}$ = Total mass gain of particles equal to or less than 2.5 µm diameter from Andersen impactor, g. This value may need to be linearly interpolated from test data.
N = Number of filtration cycles in a given performance test period
P_{avg} = Average residual pressure drop, cm w.g.
P_i = Residual pressure drop for ith filtration cycle, cm w.g.
P_s = Absolute gas pressure as measured in the raw gas channel, mbar
Q_a = Actual gas flow rate, m^3/h
Q_{ds} = Dry standard gas flow rate, dscmh
$Q_{2.5ds}$ = Dry standard gas flow rate for 2.5 µm particles, dscmh
Q_{st} = Standard gas flow rate for a specific averaging time, t, dscmh
t = Specified averaging time or sampling time, s
t_c = Average filtration cycle time, s
T_s = Raw gas channel temperature, °F
w_f = Weight of dust in feed hopper following specified time, g. Because of vibrations causing short-term fluctuations to the feed hopper, it is recommended that this value be measured as a 1-min average.
w_i = Weight of dust in feed hopper at the beginning of the specified time, g. Because of vibrations causing short-term fluctuations to the feed hopper, it is recommended that this value be measured as a 1-min average.

Conversion factors and standard values used in the equations are listed below.

460 = 0 °F, in °R
1013 = Standard atmospheric pressure, mbar
528 = Standard temperature, °R

Area of Sample Fabric - A_f
$A_f = (\pi * d^2)/4$

Actual Gas Flow Rate - Q_a
$$Q_a = Q_{ds} * \left\lceil \frac{(T_s + 460) * 1013}{P_s * 528} \right\rceil$$

Gas-to-Cloth Ratio - G/C
$$G/C = Q_a / A_f$$

Standard Dust Feed Concentration - F_s, for a specified time – t
$F_s = (w_i - w_f) / (Q_{st} * t)$

Actual Raw Gas Dust Concentration - F_a
$$F_a = F_s * \left\lceil \frac{(T_s + 460) * 1013}{P_s * 528} \right\rceil$$

Dry Standard Clean Gas Particulate Concentration, Total Mass – C_{ds}
$C_{ds} = M_t / [Q_{ds} * t * (1 - \%H_2O/100)]$

Dry Standard Clean Gas Particulate Concentration, PM-2.5 - $C_{2.5ds}$
$C_{2.5ds} = M_{2.5} / [Q_{2.5ds} * t * (1 - \%H_2O/100)]$

Filtration Cycle Time - t_c
$t_c = t/N$

Average Residual Pressure Drop - P_{avg}
$P_{avg} = \Sigma P_i/N$

REFERENCES

1. Test/QA Plan for the Verification Testing of Baghouse Filtration Products, ETS, Inc., Roanoke, VA, February 1999.

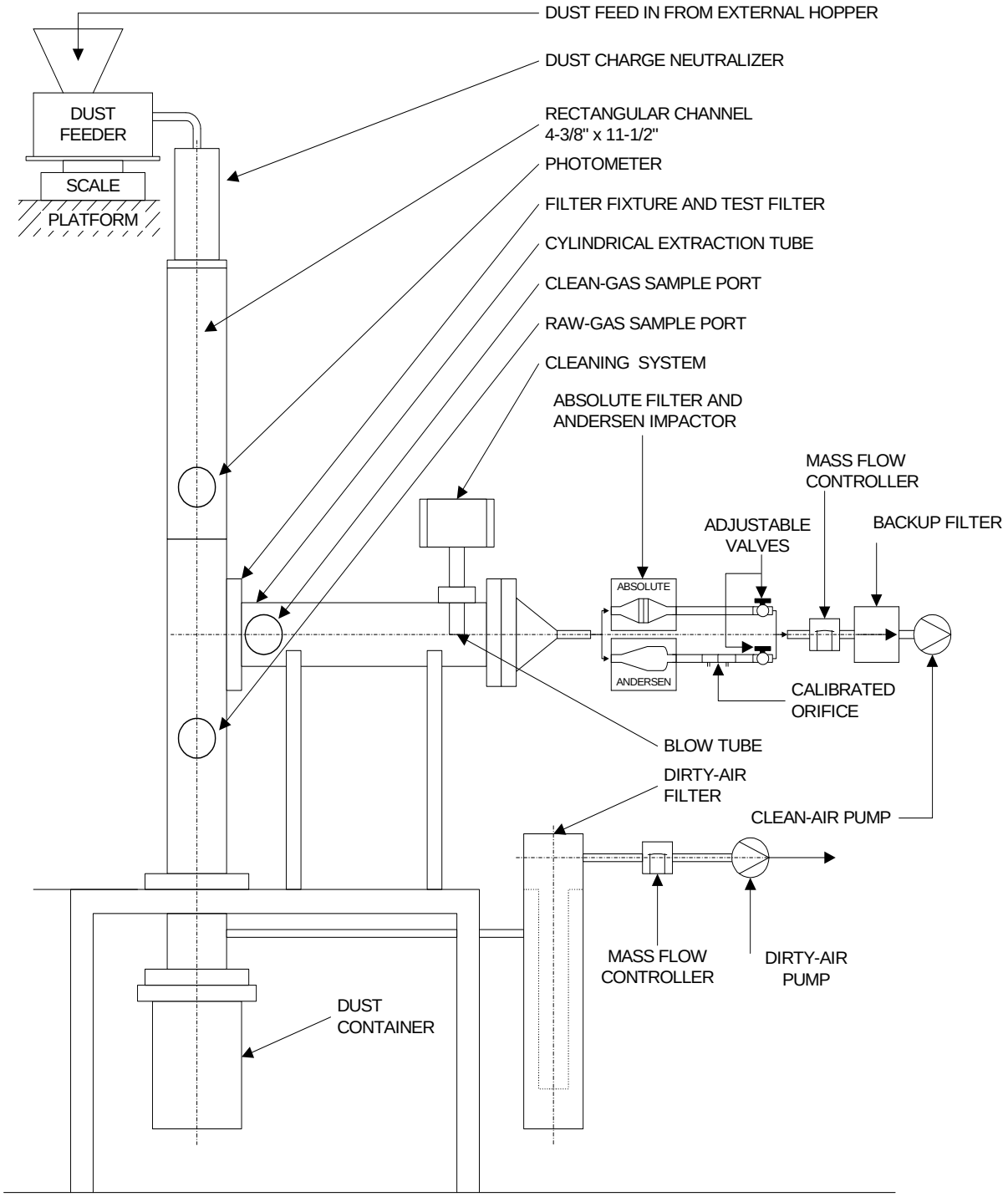


Figure A-1. Diagram of FEMA test apparatus

Appendix B

DATA ON CERTIFICATES OF CALIBRATION

Table B-1. Status of Instrument Calibrations for Baghouse Filtration Products Verification Tests.

Instrument	Measured Parameter	Manufacturer and Model No.	Serial No.	Certificate No.	Date of Certification	Certificate Expiration Date	NIST Traceable ?	Current For Test?
High Resolution Balance	Impactor Substrate Weight	Precisa 262SMA-FR	16157	914	11/29/2000	11/29/2001	YES	YES
Low Resolution Balance	Sample Filter Weight	Mettler P 1210N	562968	913	11/29/2000	11/29/2001	YES	YES
2,000 g Weight	Dust Feed Weight Cell	Troemner 2,000 g	37672	152227B	11/29/2000	11/29/2001	YES	YES
100 g Weight	Low Resolution Balance	Troemner 100 g	37670	152227	11/29/2000	11/29/2001	YES	YES
1 g Weight	High Resolution Balance	Troemner 1 g	45300	161484	11/29/2000	11/29/2001	YES	YES
1 mg Weight	High Resolution Balance	Troemner 1 mg	37080	151748	11/29/2000	11/29/2001	YES	YES
Thermocouple	FEMA Temperature	LTG GmbH "K" Type	T-1	Calibrated Against Thermometer	01/03/2001	04/03/2001	YES	YES
	Mercury Thermometer*	VWR Scientific	3C2082	992117	12/29/1999	NA	YES	YES

(continued)

Table B-1. Status of Instrument Calibrations for Baghouse Filtration Products Verification Tests (continued).

Instrument	Measured Parameter	Manufacturer and Model No.	Serial No.	Certificate No.	Date of Certification	Certificate Expiration Date	NIST Traceable ?	Current For Test?
Relative Humidity	Lab Relative Humidity	ACR Systems, Inc. SR2	66884	19655	11/23/2000	11/23/2001	YES	YES
Pressure Transducer	ΔP Across Sample Filter	Hastings 223BD-00010AABS	000320459	STDNN SET #4B	12/23/2000	12/23/2001	YES	YES
	Barometric Pressure	Hastings 223BD-00010AABS	145265	STDNN SET #4B	12/23/2000	12/23/2001	YES	YES
Flow Meters	Clean Gas	Hastings HFC-203	123917	Calibrated Against Dry Gas Meter	01/05/2001	04/05/2001	YES	YES
	Raw Gas	Hastings HFC-203	119148	Calibrated Against Dry Gas Meter	01/05/2001	04/05/2001	YES	YES
	Sample Gas	Hastings 223BD-00010 AABS	000320459	Calibrated Against Dry Gas Meter	01/05/2001	04/05/2001	YES	YES
	Dry Gas Meter*	Rockwell S-275	009548	Letter of 07/10/2000	07/10/2000	08/10/2001	YES	YES
Charge Neutralizer	Not applicable	NRD, LLC Nuclecel P-2031	A2AP708	4638	12/06/2000	12/07/2001	YES	YES

*This device is used locally to calibrate other instruments (for temperature or gas flow, as appropriate).

Note: Each of the certificates described in Table B-1 is on file at ETS, Inc.

Appendix C

VERIFICATION TESTING SHEETS

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
SUMMARY OF RESULTS AT 9.8 FPM

RUN ID.	**2V02-R1**	**2V02-R2**	**2V02-R3**	Average
FABRIC DESIGNATION	**QP131-1**	**QP131-3**	**QP131-5**	
MANUFACTURER	**BHA Group**	**BHA Group**	**BHA Group**	
DUST FEED	**Pural NF**	**Pural NF**	**Pural NF**	
QUICKCHECK				
Mass Mean Diameter	1.08			1.08
% Less than PM 2.5	74.73			74.73
CONDITIONING PERIOD				
Date Started	1/30/2001	1/31/2001	2/1/2001	
Time Started	13:38	15:26	15:04	
Time Ended	21:58	23:46	23:24	
Test Duration (min.)	500	500	500	500
RECOVERY PERIOD				
Date Started	1/31/2001	2/1/2001	2/2/2001	
Time Started	8:11	7:48	8:22	
Time Ended	8:51	8:28	9:03	
Test Duration (min.)	40	40	41	40
PERFORMANCE TEST PERIOD				
Date Started	1/31/2001	2/1/2001	2/2/2001	
Time Started	9:09	8:46	9:22	
Time Ended	15:09	14:46	15:22	
Test Duration (min.)	360	360	360	360
VERIFICATION TEST RESULTS				
Mean Outlet Particle Conc. PM 2.5 (g/dscm)	0.0000127	0.0000078	0.0000000	0.0000068
Mean Outlet Particle Conc. Total mass (g/dscm)	0.0000540	0.0000327	0.0000296	0.0000388
Initial Residual Pressure Drop (cm w.g.)	5.87	5.93	6.02	5.94
Change in Residual Pressure Drop (cm w.g.)	0.44	0.43	0.45	0.44
Average Residual Pressure Drop (cm w.g.)	6.13	6.19	6.31	6.21
Mass Gain of Filter Sample (g)	0.14	0.14	0.12	0.13
Average Filtration Cycle Time (s)	74	76	72	74

RTI/ETV PRELIMINARY TESTING
DUST CHARACTERIZATION - PURAL NF
ANDERSEN IMPACTOR PARTICLE SIZING
GRAVIMETRIC ANALYTICAL DATA AND RESULTS

RUN NUMBER: **2V02**
TEST DATE: 01/30/2001

Filter I.D. Sample I.D.	Wash Vol.(ml)	Stage	Tare Filter Mass (g)	Tare Beaker Mass (g)	Total Tare Mass (g)	Total Final Mass (g)	Mass Difference (g)	Negative Difference? (g)
VDI-00-70	50	Acetone Wash	NA	0	0	0	0.00000	NA
VDI-00-70-1		1	1.09283	0	1.09283	1.09381	0.00098	NA
VDI-00-70-2		2	1.03796	0	1.03796	1.03839	0.00043	NA
VDI-00-70-3		3	1.03964	0	1.03964	1.04218	0.00254	NA
VDI-00-70-4		4	1.06727	0	1.06727	1.06867	0.00140	NA
VDI-00-70-5		5	0.95689	0	0.95689	0.96142	0.00453	NA
VDI-00-70-6		6	0.90271	0	0.90271	0.91171	0.00900	NA
VDI-00-70-7		7	1.22483	0	1.22483	1.23305	0.00822	NA
VDI-00-70-8		8	1.17258	0	1.17258	1.17723	0.00465	NA
VDI-00-70-F		9	1.24738	0	1.24738	1.25354	0.00616	NA
						Total	0.03791	

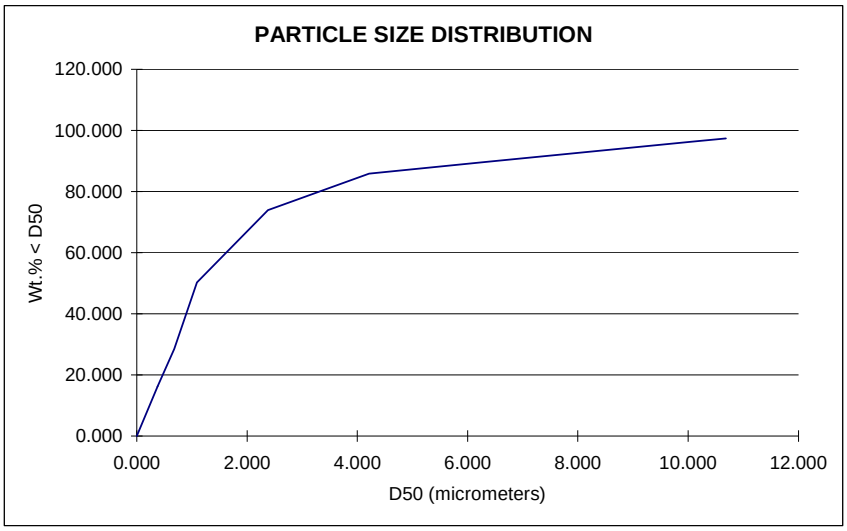
IMPACTOR PARTICLE SIZING RESULTS

Impactor Flow Rate: 0.172 cfm
Isokinetics: 98.84 %
Viscosity of Gas: 0.000163 poise

STAGE	Particulate Mass (g)	Cumulative % Less Than Diameter	D50 Cut Point (micrometers)*
1	0.00098	97.41	10.68
2	0.00043	96.28	10.07
3	0.00254	89.58	6.29
4	0.00140	85.89	4.21
5	0.00453	73.94	2.38
6	0.00900	50.20	1.09
7	0.00822	28.51	0.67
8	0.00465	16.25	0.38
9	0.00616		

Mass Mean Diameter, micrometers	1.08
% Less Than PM 2.5	74.73

* Calculated as an aerodynamic diameter using a particle density of 2.65 g/ml.



Dust Characterization

FOR TEST SERIES	**2V02**
DUST TYPE	Pural NF

DATE	01/30/2001	
START TIME	11:14	
END TIME	11:19	
STACK LENGTH	111	mm
STACK WIDTH	291	mm
STACK AREA	0.0323	m^2
NOZZLE I.D.	1.797	in.
	0.046	m
METER BOX GAMMA	0.9813	
BAROMETRIC PRESSURE	28.50	in. Hg
TEST DURATION	5	min.
METER VACUUM	2.0	in. Hg

DATA (FOR RAW GAS CHANNEL)

Actual Flow	5.83	m^3/hr
	3.43	cfm
Std. Flow	5.47	scm/hr
	3.22	scfm
Raw Gas Pressure	964.33	mbar
Sample Gas Temperature	24.6	° C
	76.3	° F

INTERMEDIATE RESULTS

Metered Volume	0.874	ft^3
Volume @ Std.Cond.	0.805	scf
Volume at Raw Gas Conditions	0.860	scf
Water	0.95	%
Isokinetics	98.8	%

METHOD 3 DATA

%O2	20.9	Md	28.84	
%CO2	0.0	Ms	28.73	
%CO	0.0	Ps	28.47	in. Hg
%N2	79.1			
O2+CO2	20.9			

POINT	STACK TEMP (° F)	DP (in. w.g.)	DH (in. w.g.)	METER VOLUME (liters)	METER TEMPERATURE INLET (° F)	OUTLET (° F)
1	76.3	1E-05	6.125	3118.94	75	75
				3143.68	75	76
			Volume Change:	24.74	75	
					(Avg. of 4 temps.)	

Md - Dry Molecular Weight
Ms - Molecular Weight in Stack
Ps - Static Pressure
DH - Orifice Pressure Drop
DP - Pressure Drop

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

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

CONDITIONING TEST PERIOD

RUN ID.	2V02-R1	NUMBER OF PULSES	10000
FABRIC DESIGNATION	QP131-1	PULSE INTERVAL	3 s
MANUFACTURER	BHA Group		
DUST FEED	Pural NF	Moisture	1.02 %WV
DATE STARTED	1/30/2001		
TIME STARTED	13:38		
TIME ENDED	21:58		
TEST DURATION	500 min.		

QA/QC DATA

Test Duration (min.)		Time		Dust Feed (g) Initial	Final	Total	Average Gas Flow (sm^3/hr) Raw	Clean	Total	Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/h)
0-60		13:38	14:38	1765.4	1663.2	102.2	2.78	2.65	5.43	25.0	961.52	19.0	184.5
61-120		14:39	15:38	1663.2	1553.2	110.0	2.78	2.65	5.43	25.3	961.40	20.5	184.8
121-180		15:39	16:38	1553.2	1445.4	107.8	2.78	2.65	5.43	25.4	961.14	20.1	184.9
181-240		16:39	17:38	1445.4	1339.6	105.8	2.78	2.64	5.42	25.3	961.44	19.7	184.0
241-300		17:39	18:38	1339.6	1235.6	104.0	2.78	2.64	5.42	24.9	961.84	19.4	183.7
301-360		18:39	19:38	1235.6	1131.2	104.4	2.78	2.64	5.42	24.6	962.04	19.5	183.5
361-420		19:39	20:38	1131.2	1029.4	101.8	2.78	2.64	5.42	24.5	962.34	19.0	183.4
421-480		20:39	21:38	1029.4	928.5	100.9	2.78	2.64	5.42	24.3	962.38	18.8	183.2
441-500	*	20:59	21:58	993.9	896.8	97.1	2.78	2.64	5.42	24.2	962.41	18.1	183.2
AVERAGE FOR 500 MINUTE RAW DATA						104.2	2.78	2.64	5.42	24.9	961.79	19.4	184.0
ACCEPTANCE						100 +/- 20				25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

* 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: _____

Sharon M. Winemiller - ETS, Inc.

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

RECOVERY PERIOD

RUN ID.	2V02-R1	NUMBER OF PULSES	30
FABRIC DESIGNATION	QP131-1	AVG. PULSE INTERVAL	80 s
MANUFACTURER	BHA Group	AVG . RESIDUAL DP	590.07 Pa
DUST FEED	Pural NF	MAX. PRESSURE DROP	1000 Pa
DATE STARTED	1/31/2001		
TIME STARTED	8:11 *	Moisture	1.04 % WV
TIME ENDED	8:51		
TEST DURATION	40 min.		

QA/QC DATA

Test Duration (min.)	Time			Dust Feed (g) Initial	Final	Total	Average Gas Flow (sm^3/hr) Raw	Clean	Total	Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/hr)
1-40	8:12	*	8:51	890.6	832.8	57.8	2.81	2.67	5.48	23.6	965.06	10.7	184.2

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

DATA PROCESSING OPERATOR: _____

Sharon M. Winemiller - ETS, Inc.

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VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

PERFORMANCE TEST PERIOD

RUN ID.	2V02-R1	NUMBER OF PULSES	292
FABRIC DESIGNATION	QP131-1	AVG. PULSE INTERVAL	74 s
MANUFACTURER	BHA Group	AVG. RESIDUAL DP	600.65 Pa
DUST FEED	Pural NF	INITIAL RESIDUAL DP	575.4 Pa
DATE STARTED	1/31/2001	CHANGE IN DP	42.7 Pa
TIME STARTED	9:09	MAX. PRESSURE DROP	1000 Pa
TIME ENDED	15:09		
TEST DURATION	360 min.	Moisture	1.04 %WV

QA/QC DATA

Test Duration			Dust Feed (g)			Average Gas Flow (sm^3/hr)				Avg. Temp	Avg Press	Dust Conc.	G/C Ratio
(min.)	Time		Initial	Final	Total	Raw	Clean	Total	Sample	(° C)	(mbar)	(g/dscm)	(m/h)
0-60	9:09	10:09	1640.2	1543.2	97.0	2.79	2.66	5.45	1.06	24.06	966.28	18.0	183.7
61-120	10:10	11:09	1543.2	1435.5	107.7	2.80	2.66	5.46	1.06	24.39	966.71	19.9	183.9
121-180	11:10	12:09	1435.5	1326.3	109.2	2.80	2.66	5.46	1.07	24.67	966.93	20.2	184.0
181-240	12:10	13:09	1326.3	1223.2	103.1	2.80	2.66	5.46	1.07	25.07	967.10	19.1	184.2
241-300	13:10	14:09	1223.2	1118.5	104.7	2.80	2.66	5.46	1.07	25.34	967.06	19.4	184.4
301-360	14:10	15:09	1118.5	1011.3	107.2	2.80	2.66	5.46	1.07	25.57	967.45	19.8	184.5
AVERAGE FOR 360 MINUTE RAW DATA					104.8	2.80	2.66	5.46	1.06	24.85	966.92	19.4	184.0
ACCEPTANCE					100 +/- 20					25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

GRAVIMETRIC DATA

IMPACTOR SUBSTRATES		SAMPLE FILTER	
Backup Filter (PM 2.5)	0.00008 g	Tare Mass	11.41 g
Total Mass Gain	0.00034 g	Final Mass	11.55 g
		Mass Gain	0.14 g

OUTLET CONCENTRATION

Total Volume Sampled	6.83 m^3
Mean Outlet Particle Concentration - PM 2.5	0.0000117 g/m^3
Mean Outlet Particle Concentration - Total Mass	0.0000498 g/m^3

DATA PROCESSING OPERATOR:

Sharon M. Winemiller - ETS, Inc.

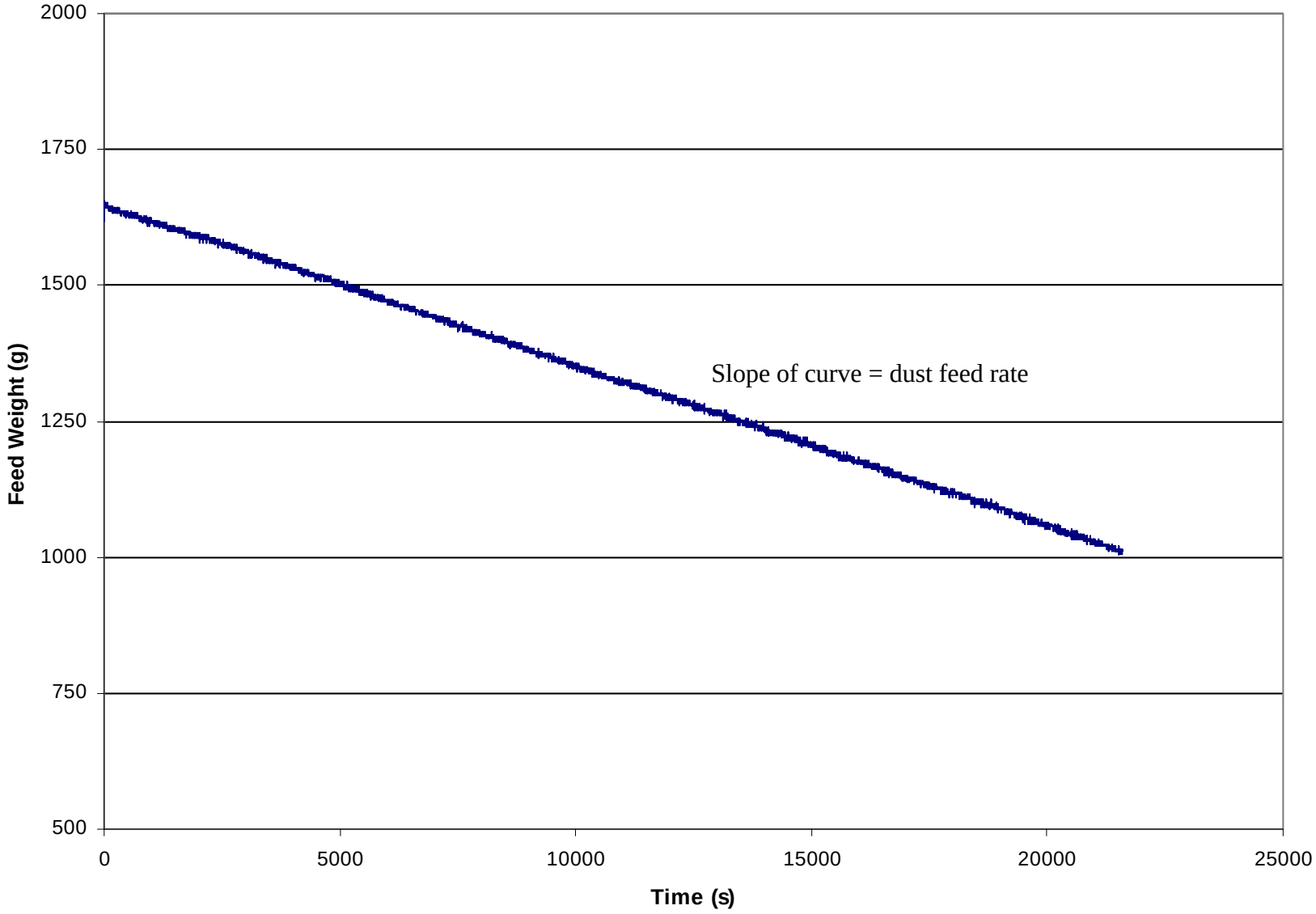

Figure C-1. Change in Pural NF dust scale reading with time during performance period 2V02-R1

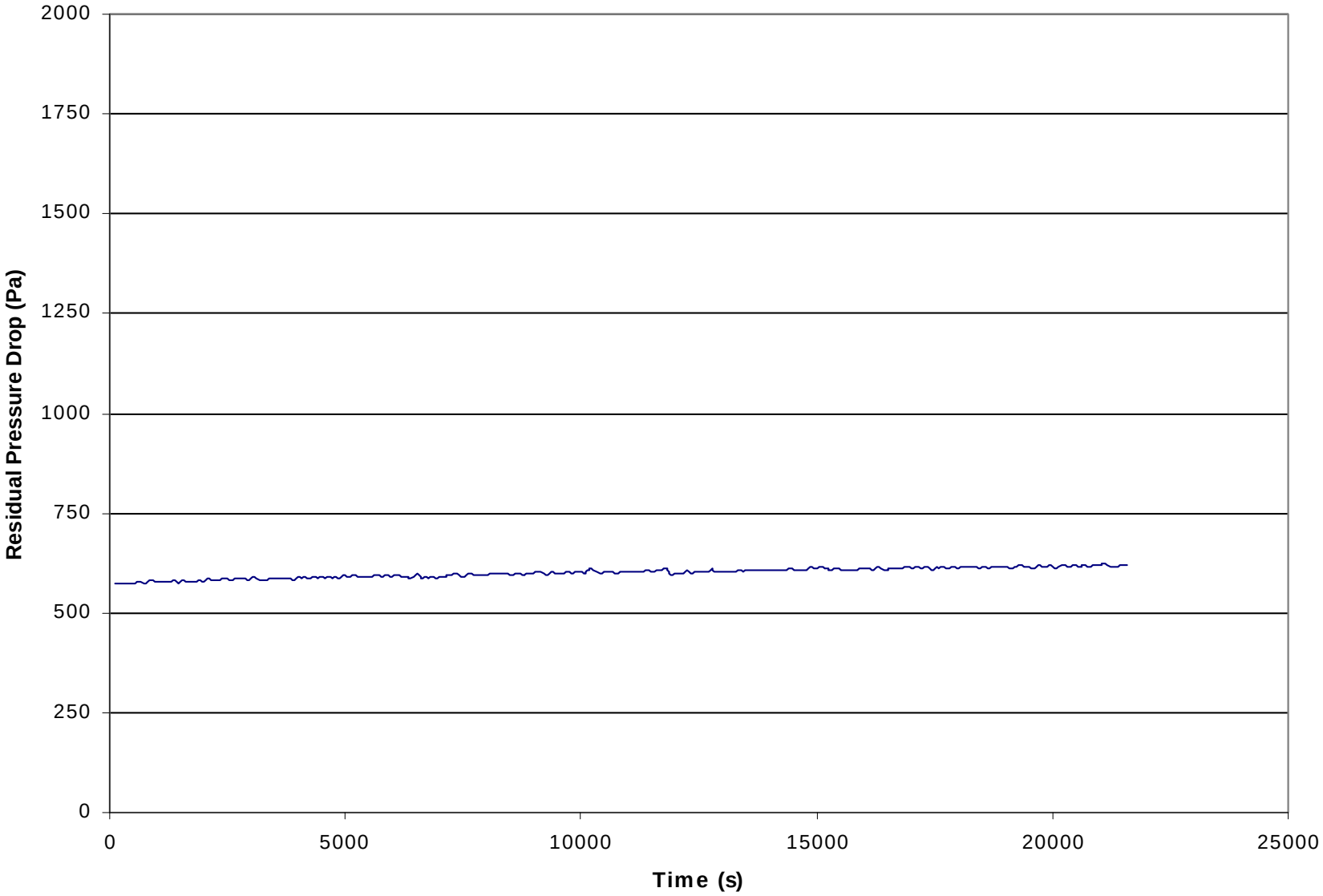

Figure C-2. Residual pressure drop across filter fabric during performance period 2V02-R1

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

CONDITIONING TEST PERIOD

RUN ID.	2V02-R2	NUMBER OF PULSES	10000
FABRIC DESIGNATION	QP131-3	PULSE INTERVAL	3 s
MANUFACTURER	BHA Group		
DUST FEED	Pural NF	Moisture	1.09 %WV
DATE STARTED	1/31/2001		
TIME STARTED	15:26		
TIME ENDED	23:46		
TEST DURATION	500 min.		

QA/QC DATA

Test Duration (min.)	Time		Dust Feed (g) Initial	Final	Total	Average Gas Flow (sm^3/hr) Raw	Clean	Total	Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/h)
0-60	15:26	16:26	1747.0	1656.8	90.2	2.79	2.66	5.45	25.3	968.03	16.7	184.2
61-120	16:27	17:26	1656.8	1551.7	105.1	2.80	2.66	5.46	25.1	968.81	19.5	183.9
121-180	17:27	18:26	1551.7	1445.5	106.2	2.80	2.66	5.46	24.9	969.88	19.7	183.6
181-240	18:27	19:26	1445.5	1339.0	106.5	2.80	2.66	5.46	24.5	970.75	19.7	183.2
241-300	19:27	20:26	1339.0	1238.4	100.6	2.80	2.66	5.46	24.3	971.29	18.6	182.9
301-360	20:27	21:26	1238.4	1137.0	101.4	2.80	2.66	5.46	24.0	971.38	18.8	182.8
361-420	21:27	22:26	1137.0	1036.0	101.0	2.80	2.65	5.45	23.9	971.74	18.7	181.9
421-480	22:27	23:26	1036.0	939.0	97.0	2.80	2.65	5.45	23.7	971.98	18.0	181.8
441-500 *	22:47	23:46	1001.2	905.5	95.7	2.80	2.65	5.45	23.7	972.18	17.8	181.7
AVERAGE FOR 500 MINUTE RAW DATA					101.0	2.80	2.66	5.45	24.4	970.56	18.7	182.9
ACCEPTANCE					100 +/- 20				25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

* 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: _____

Sharon M. Winemiller - ETS, Inc.

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

RECOVERY PERIOD

RUN ID.	2V02-R2		NUMBER OF PULSES	30
FABRIC DESIGNATION	QP131-3		AVG. PULSE INTERVAL	81 s
MANUFACTURER	BHA Group		AVG . RESIDUAL DP	600.47 Pa
DUST FEED	Pural NF		MAX. PRESSURE DROP	1000 Pa
DATE STARTED	2/1/2001			
TIME STARTED	7:48 *		Moisture	0.85 % WV
TIME ENDED	8:28			
TEST DURATION	40 min.			

QA/QC DATA

Test Duration (min.)	Time			Dust Feed (g) Initial	Final	Total	Average Gas Flow (sm^3/hr) Raw	Clean	Total	Avg. Temp (° C)	Avg Press (mbar)	Dust Conc. (g/dscm)	G/C Ratio (m/hr)
1-40	7:49	*	8:28	905.0	847.3	57.7	2.85	2.71	5.56	23.2	978.67	10.5	184.3

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

DATA PROCESSING OPERATOR: _____

Sharon M. Winemiller - ETS, Inc.

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

PERFORMANCE TEST PERIOD

RUN ID.	2V02-R2	NUMBER OF PULSES	284
FABRIC DESIGNATION	QP131-3	AVG. PULSE INTERVAL	76 s
MANUFACTURER	BHA Group	AVG. RESIDUAL DP	606.37 Pa
DUST FEED	Pural NF	INITIAL RESIDUAL DP	580.9 Pa
DATE STARTED	2/1/2001	CHANGE IN DP	41.9 Pa
TIME STARTED	8:46	MAX. PRESSURE DROP	1000 Pa
TIME ENDED	14:46		
TEST DURATION	360 min.	Moisture	0.85 %WV

QA/QC DATA

Test Duration			Dust Feed (g)			Average Gas Flow (sm^3/hr)				Avg. Temp	Avg Press	Dust Conc.	G/C Ratio
(min.)	Time		Initial	Final	Total	Raw	Clean	Total	Sample	(° C)	(mbar)	(g/dscm)	(m/h)
0-60	8:46	9:46	1658.9	1570.6	88.3	2.84	2.71	5.55	1.08	23.67	979.71	16.0	184.4
61-120	9:47	10:46	1570.6	1469.8	100.8	2.85	2.71	5.56	1.08	24.17	980.10	18.3	184.6
121-180	10:47	11:46	1469.8	1367.5	102.3	2.85	2.71	5.56	1.08	24.60	980.21	18.6	184.9
181-240	11:47	12:46	1367.5	1263.0	104.5	2.84	2.71	5.55	1.08	24.95	979.79	19.0	185.2
241-300	12:47	13:46	1263.0	1156.0	107.0	2.84	2.71	5.55	1.08	25.18	978.85	19.4	185.5
301-360	13:47	14:46	1156.0	1051.6	104.4	2.84	2.71	5.55	1.08	25.38	978.23	19.0	185.7
AVERAGE FOR 360 MINUTE RAW DATA					101.2	2.84	2.71	5.56	1.08	24.66	979.48	18.4	185.3
ACCEPTANCE					100 +/- 20					25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

GRAVIMETRIC DATA

IMPACTOR SUBSTRATES		SAMPLE FILTER	
Backup Filter (PM 2.5)	0.00005 g	Tare Mass	11.74 g
Total Mass Gain	0.00021 g	Final Mass	11.88 g
		Mass Gain	0.14 g

OUTLET CONCENTRATION

Total Volume Sampled	6.87 m^3
Mean Outlet Particle Concentration - PM 2.5	0.0000073 g/m^3
Mean Outlet Particle Concentration - Total Mass	0.0000306 g/m^3

DATA PROCESSING OPERATOR:

Sharon M. Winemiller - ETS, Inc.

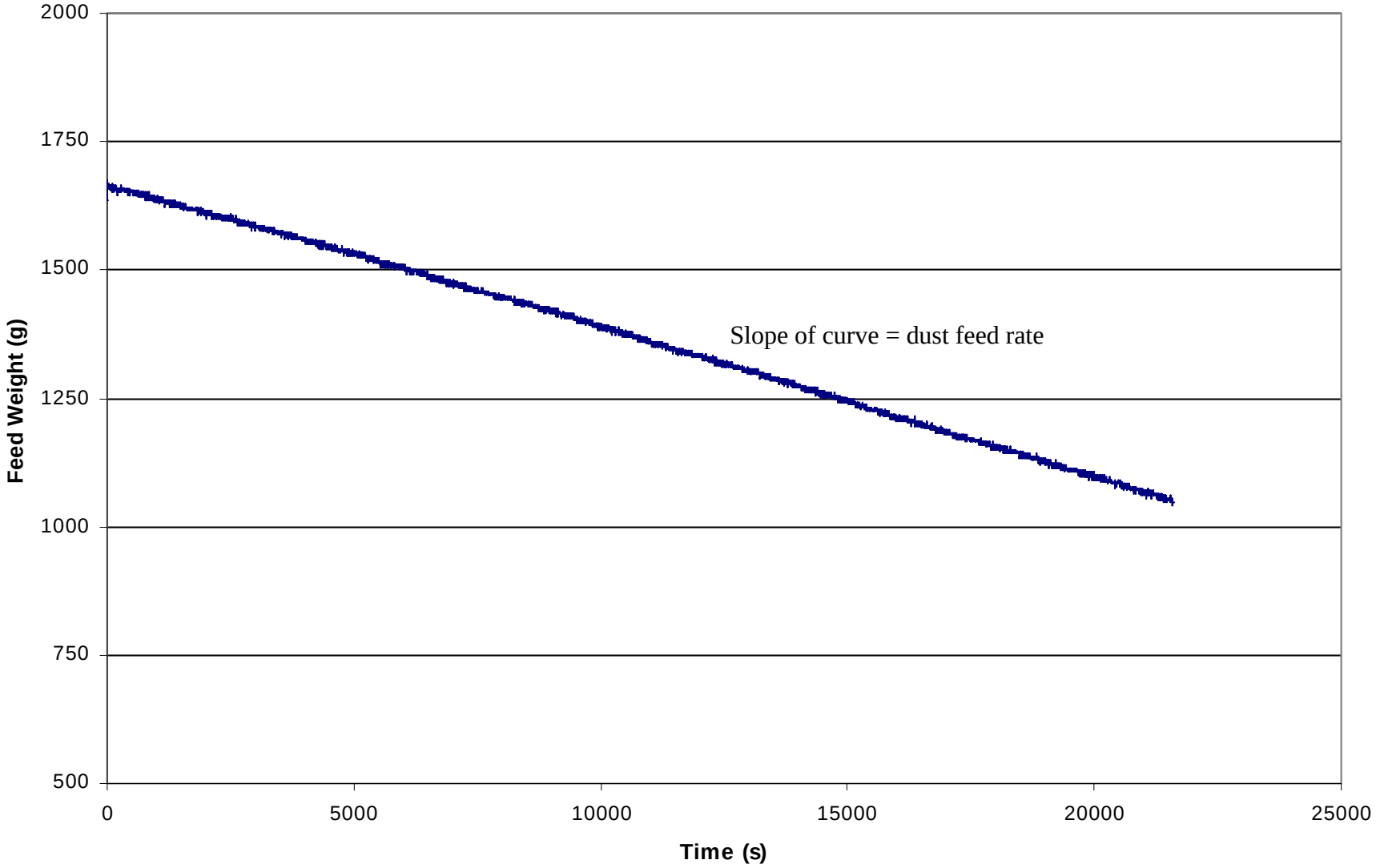

Figure C-3. Change in Pural NF dust scale reading with time during performance period 2V02-R2

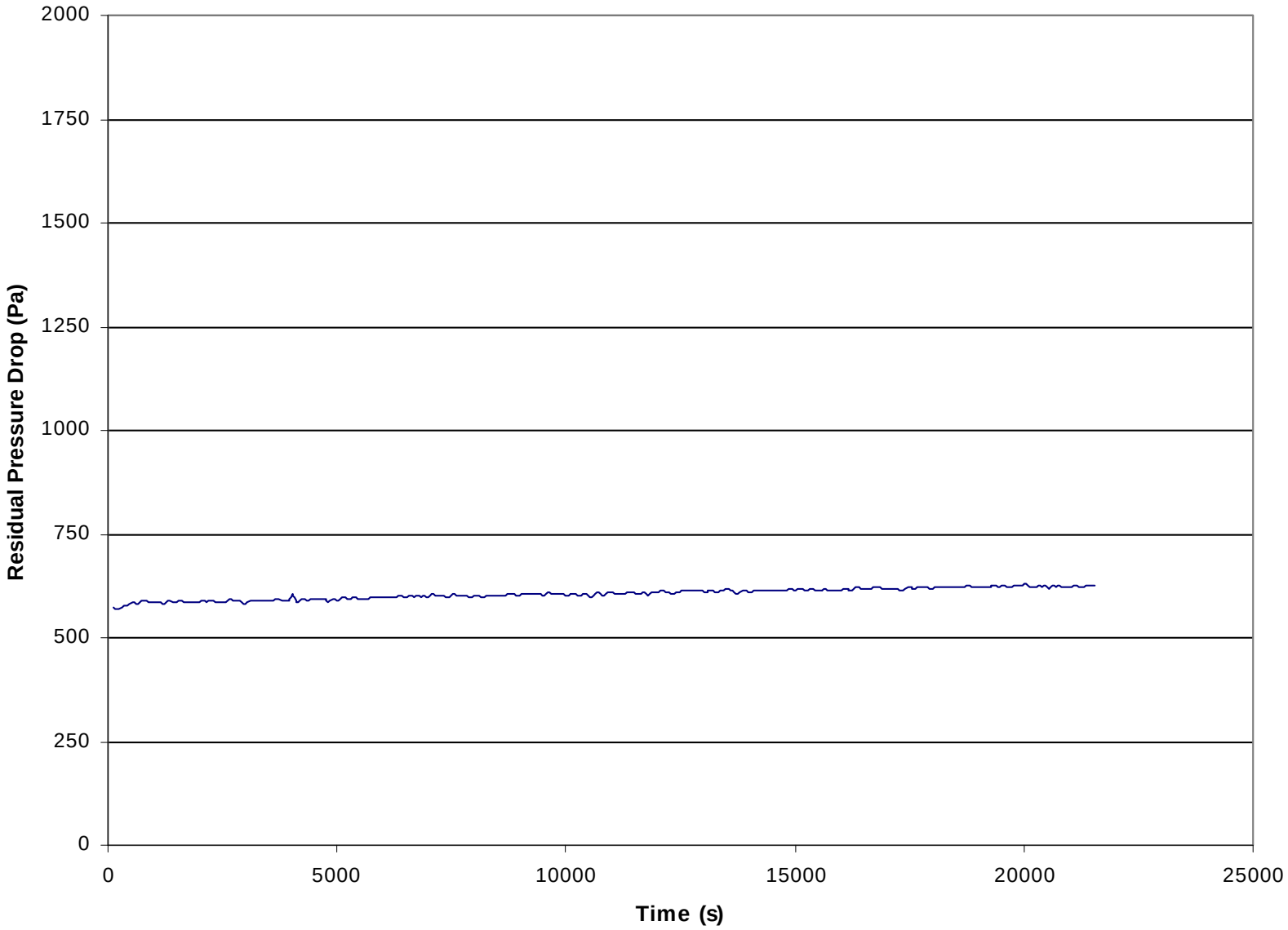

Figure C-4. Residual pressure drop across filter fabric during performance period 2V02-R2

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

CONDITIONING TEST PERIOD

RUN ID.	2V02-R3	NUMBER OF PULSES	10000
FABRIC DESIGNATION	QP131-5	PULSE INTERVAL	3 s
MANUFACTURER	BHA Group		
DUST FEED	Pural NF	Moisture	1.12 %WV
DATE STARTED	2/1/2001		
TIME STARTED	15:04		
TIME ENDED	23:24		
TEST DURATION	500 min.		

QA/QC DATA

Test Duration			Dust Feed (g)			Average Gas Flow (sm^3/hr)			Avg. Temp	Avg Press	Dust Conc.	G/C Ratio
(min.)	Time		Initial	Final	Total	Raw	Clean	Total	(° C)	(mbar)	(g/dscm)	(m/h)
0-60	15:04	16:04	1670.0	1579.5	90.5	2.81	2.67	5.48	25.3	978.88	16.7	182.8
61-120	16:05	17:04	1579.5	1477.4	102.1	2.81	2.68	5.49	25.2	979.47	18.8	183.3
121-180	17:05	18:04	1477.4	1372.7	104.7	2.81	2.68	5.49	24.9	979.95	19.3	183.0
181-240	18:05	19:04	1372.7	1268.3	104.4	2.81	2.68	5.49	24.5	980.08	19.2	182.8
241-300	19:05	20:04	1268.3	1167.7	100.6	2.81	2.68	5.49	24.1	980.04	18.5	182.6
301-360	20:05	21:04	1167.7	1065.0	102.7	2.81	2.68	5.49	23.9	979.94	18.9	182.4
361-420	21:05	22:04	1065.0	968.6	96.4	2.81	2.68	5.49	23.7	980.06	17.8	182.3
421-480	22:05	23:04	968.6	872.7	95.9	2.81	2.68	5.49	23.5	979.85	17.7	182.2
441-500 *	22:25	23:24	935.0	841.6	93.4	2.81	2.68	5.49	23.5	979.64	17.2	182.2
AVERAGE FOR 500 MINUTE RAW DATA					99.4	2.81	2.68	5.49	24.3	979.76	18.3	182.7
ACCEPTANCE					100 +/- 20				25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

* 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: _____

Sharon M. Winemiller - ETS, Inc.

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

RECOVERY PERIOD

RUN ID.	2V02-R3	NUMBER OF PULSES	30
FABRIC DESIGNATION	QP131-5	AVG. PULSE INTERVAL	83 s
MANUFACTURER	BHA Group	AVG . RESIDUAL DP	596.47 Pa
DUST FEED	Pural NF	MAX. PRESSURE DROP	1000 Pa
DATE STARTED	2/2/2001		
TIME STARTED	8:22 *	Moisture	0.81 % WV
TIME ENDED	9:03		
TEST DURATION	41 min.		

QA/QC DATA

Test Duration				Dust Feed (g)			Average Gas Flow (sm^3/hr)			Avg. Temp	Avg Press	Dust Conc.	G/C Ratio
(min.)	Time			Initial	Final	Total	Raw	Clean	Total	(° C)	(mbar)	(g/dscm)	(m/hr)
1-41	8:23	*	9:03	839.6	783.2	56.4	2.84	2.71	5.55	22.9	975.73	10.3	184.4

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

DATA PROCESSING OPERATOR: _____

Sharon M. Winemiller - ETS, Inc.

VERIFICATION TESTING OF BAGHOUSE FILTRATION PRODUCTS
DETAILED SUMMARY OF DATA AND RESULTS

PERFORMANCE TEST PERIOD

RUN ID.	2V02-R3	NUMBER OF PULSES	300
FABRIC DESIGNATION	QP131-5	AVG. PULSE INTERVAL	72 s
MANUFACTURER	BHA Group	AVG. RESIDUAL DP	617.72 Pa
DUST FEED	Pural NF	INITIAL RESIDUAL DP	590.1 Pa
DATE STARTED	2/2/2001	CHANGE IN DP	43.6 Pa
TIME STARTED	9:22	MAX. PRESSURE DROP	1000 Pa
TIME ENDED	15:22		
TEST DURATION	360 min.	Moisture	0.81 %WV

QA/QC DATA

Test Duration	Time		Dust Feed (g)			Average Gas Flow (sm^3/hr)				Avg. Temp	Avg Press	Dust Conc.	G/C Ratio
(min.)			Initial	Final	Total	Raw	Clean	Total	Sample	(° C)	(mbar)	(g/dscm)	(m/h)
0-60	9:22	10:22	1606.0	1516.7	89.3	2.83	2.70	5.53	1.08	23.56	975.57	16.3	184.4
61-120	10:23	11:22	1516.7	1417.7	99.0	2.83	2.70	5.53	1.08	24.27	975.04	18.0	185.0
121-180	11:23	12:22	1417.7	1314.3	103.4	2.83	2.70	5.53	1.09	24.69	974.08	18.9	185.4
181-240	12:23	13:22	1314.3	1206.1	108.2	2.83	2.70	5.53	1.09	24.85	972.45	19.7	185.8
241-300	13:23	14:22	1206.1	1103.8	102.3	2.83	2.70	5.53	1.08	24.91	971.97	18.7	185.9
301-360	14:23	15:22	1103.8	1003.5	100.3	2.83	2.70	5.53	1.08	24.88	973.35	18.3	185.7
AVERAGE FOR 360 MINUTE RAW DATA					100.4	2.83	2.70	5.54	1.08	24.53	973.74	18.3	185.6
ACCEPTANCE					100 +/- 20					25 +/- 2		18.4 +/- 3.6	180 +/- 9.0

GRAVIMETRIC DATA

IMPACTOR SUBSTRATES		SAMPLE FILTER	
Backup Filter (PM 2.5)	0.00000 g	Tare Mass	11.74 g
Total Mass Gain	0.00019 g	Final Mass	11.86 g
		Mass Gain	0.12 g

OUTLET CONCENTRATION

Total Volume Sampled	6.91 m^3
Mean Outlet Particle Concentration - PM 2.5	0.0000000 g/m^3
Mean Outlet Particle Concentration - Total Mass	0.0000275 g/m^3

DATA PROCESSING OPERATOR:

Sharon M. Winemiller - ETS, Inc.

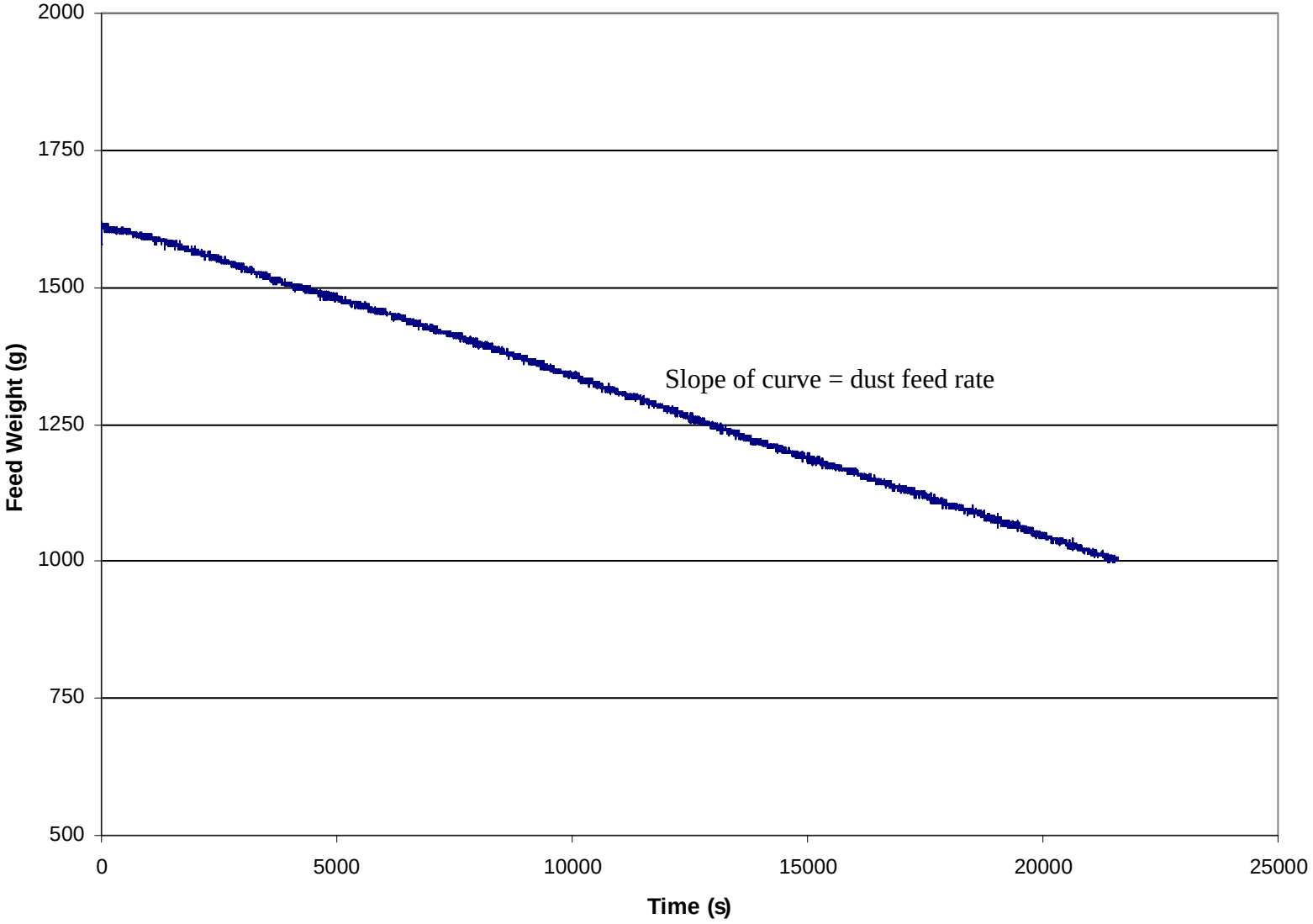

Figure C-5. Change in Pural NF dust scale reading with time during performance period 2V02-R3

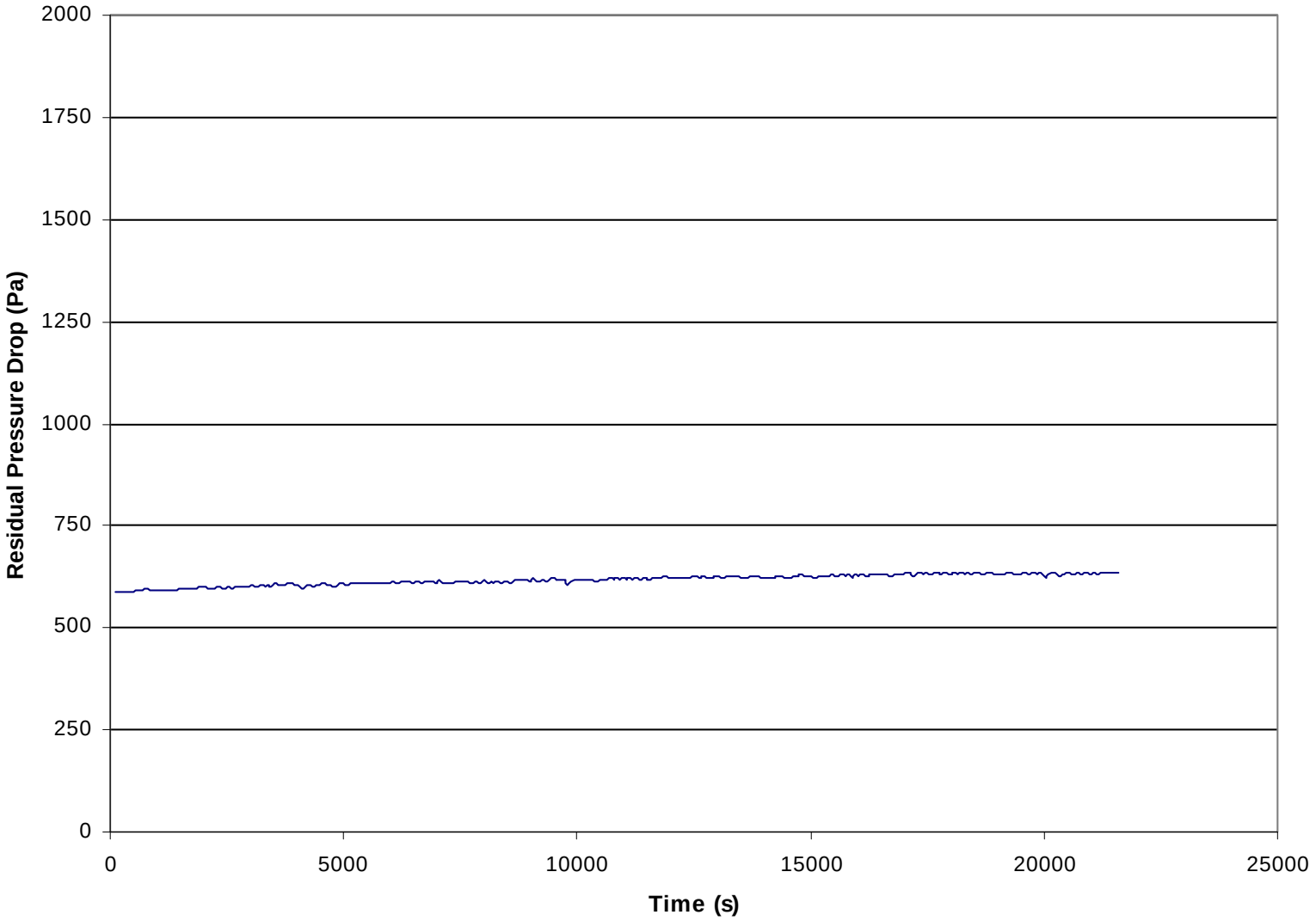

Figure C-6. Residual pressure drop across filter fabric during performance period 2V02-R3

Appendix D

FABRIC MANUFACTURE'S SUBMITTAL LETTER

BHA Group, Inc.
8800 East 63rd Street
Kansas City, Missouri USA 64133-4883
TEL +1-816-356-8400 ext. 1523
FAX +1-816-246-1183
www.bhagroup.com

January 16, 2001

Mr. Jack Mycock
ETS Inc.
1401 Municipal Road NW.
Roanoke, Virginia 24012 - 1309

Dear Jack,

Please be advised we have today shipped to your attention samples of BHA filtration media for inclusion in the 2nd round of Baghouse Verification Product testing. You should already have received a faxed copy of our acceptance of the ETS Inc, terms and conditions, which was signed by Mr. Tony Thill our V.P. of Business Development, yesterday.

The samples of media shipped to you are made of a polyester needlefelt substrate with a expanded, micro-porous membrane, thermally laminated to the filtration/dust cake surface. This product is traditionally converted into filter bags and used to capture fine particulate in many ambient and hot gas filtration applications. Our product code for this media is QP131. This is standard product for BHA, that we produce several thousand yards of media per month. This sample media was taken from a 250yd master roll produced in early December 2000. Per your instructions, we have sent (9) samples at 18 x 36" in dimension. The nine samples are made up of 3 samples from the beginning, middle and end of the master roll.

The samples have been labeled per your instructions in item 9, of the DRAFT version of the "generic verification protocol for baghouse filtration products" document from 11/1/99. Hopefully these samples are accepted with your full approval.

With regards to the cost of the testing, it is our understanding that 50% of the cost will be covered by the EPA and 50% covered by BHA. This equates to $5,000, and I have attached the relevant purchase order to this letter.

Should you have any comments or questions, please do not hesitate to call,

Best Regards,

Alan Smithies
Technical Director – Product Development
e-mail asmithies@bhatechnologies.com

World Leader in Innovative Filtration Technology