US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

Environmental Technology Verification

Baghouse Filtration Products

Donaldson Company, Inc.
Tetratex® 6282 Filtration Media
(Tested March - April 2011)

Prepared by

RTI International

ETS Incorporated

Under a Cooperative Agreement with
U.S. Environmental Protection Agency

US EPA ARCHIVE DOCUMENT

Environmental Technology Verification Report

Baghouse Filtration Products

Donaldson Company, Inc.
Tetratex® 6282 Filtration Media
(Tested March - April 2011)

Prepared by

RTI International
ETS Incorporated

EPA Cooperative Agreement CR 83416901-0

EPA Project Officer
Michael Kosusko
Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

US EPA ARCHIVE DOCUMENT

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**BAGHOUSE FILTRATION PRODUCTS**
APPLICATION:	**CONTROL OF $PM_{2.5}$ EMISSIONS BY BAGHOUSE FILTRATION PRODUCTS**
TECHNOLOGY NAME:	**Tetratex® 6282 Filtration Media**
COMPANY:	**Donaldson Company, Inc.**
ADDRESS:	**85 Railroad Dr. Ivyland, PA 18974** — **PHONE: (215) 396-8349 FAX: (215) 396-0516**
WEB SITE:	**http://www.donaldson.com**
E-MAIL:	**Anil.Suthar@Donaldson.com Karen.Bentley@Donaldson.com**

The U.S. Environmental Protection Agency (EPA) created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. The ETV Program seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

The ETV Program works in partnership with recognized standards and testing organizations; stakeholder groups, which consist of buyers, vendor organizations, permitters, and other interested parties; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Air Pollution Control Technology Center (APCT Center) is operated by RTI International[*] (RTI), in cooperation with EPA's National Risk Management Research Laboratory (NRMRL). The APCT Center evaluates the performance of baghouse filtration products (BFPs) used primarily to control $PM_{2.5}$ emissions (i.e., particles 2.5 µm and smaller in aerodynamic diameter). This verification statement summarizes the test results for Donaldson Company, Inc.'s Tetratex 6282 filtration media.

VERIFICATION TEST DESCRIPTION

All tests were performed in accordance with the APCT Center *Generic Verification Protocol for Baghouse Filtration Products*, available at http://www.epa.gov/etv/pubs/05_vp_bfp.pdf. The protocol is based on and describes modifications to the equipment and procedures described in Verein Deutscher Ingenieure (VDI) 3926, Part 2, *Testing of Filter Media for Cleanable Filters under Operational Conditions*, December 1994. The VDI document is available from Beuth Verlag GmbH, 10772 Berlin, Germany. The protocol also includes requirements for quality management and QA, procedures for product selection, auditing of the test laboratories, and the test reporting format.

Outlet particle concentrations from a test fabric were measured with an impactor equipped with appropriate substrates to filter and measure $PM_{2.5}$ within the dust flow. Outlet particle concentrations were determined by weighing the mass increase of dust collected in each impactor filter stage and dividing by the gas volumetric flow through the impactor.

Particle size was measured while injecting the test dust into the air upstream of the baghouse filter sample. The test dust was dispersed into the flow using a brush-type dust feeder. The particle size distributions in the air were determined both upstream and downstream of the test filter fabric to provide accurate results for penetration through the test filter of $PM_{2.5}$. All tests were performed using a constant 18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf) loading rate, a 120 ± 6.0 m/h (6.6 ± 0.3 fpm) filtration velocity [identical to gas-to-cloth ratio (G/C[**])], and aluminum oxide test dust with a measured mass mean aerodynamic diameter maximum of 1.5 µm (average of three impactor runs). All BFPs are tested in their initial (i.e., clean) condition.

Each of the three test runs consisted of the following segments:

- Conditioning period—10,000 rapid-pulse cleaning cycles
- Recovery period—30 normal-pulse cleaning cycles
- Performance test period—6-hour filter fabric test period with impactor.

VERIFIED TECHNOLOGY DESCRIPTION

Donaldson Company, Inc. provided the following information about their product. The Donaldson Tetratex 6282 is an ePTFE laminate on PPS. **Figure 1** is a photograph of the fabric. Sample material was received as nine 46 x 91 cm (18 x 36 in.) swatches marked with the manufacturer's model number, year and month of manufacture, and cake side. Three of the swatches were selected at random for preparing three test specimens 150 mm (5.9 in.) in diameter.

[*] RTI International is a trade name of Research Triangle Institute.
[**] Filtration velocity and gas-to-cloth ratio are used interchangeably and are defined as the gas flow rate divided by the surface area of the cloth.

US EPA ARCHIVE DOCUMENT

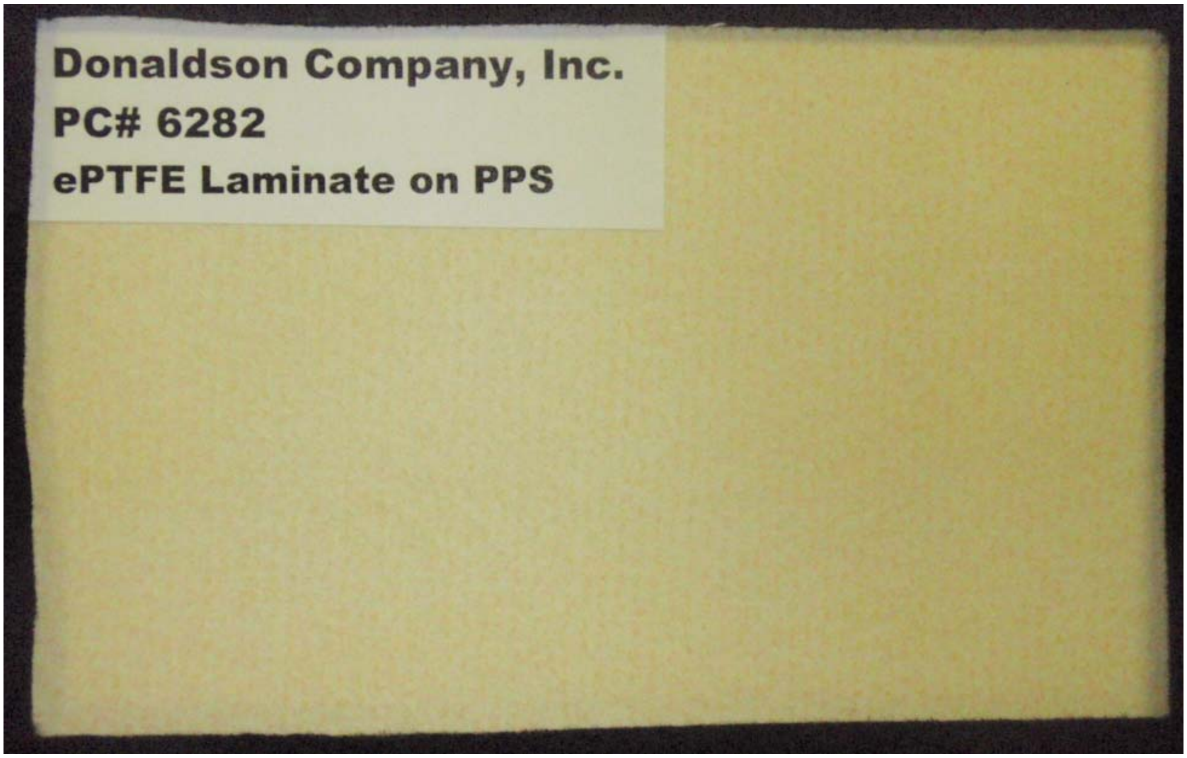

Figure 1. Photograph of Donaldson Company, Inc.'s Tetratex 6282 filtration media.

VERIFICATION OF PERFORMANCE

Verification testing of the Donaldson Company, Inc.'s Tetratex 6282 filtration media was performed during the period of March 24, 2011 to April 1, 2011, for standard test conditions at the test facility of ETS Incorporated, 1401 Municipal Road NW, Roanoke, VA 24012. Test conditions are listed in **Table 1**. The overall test results summarized in **Table 2** represent the averages of three individual tests.

The APCT Center quality manager has reviewed the test results and the quality control (QC) data and has concluded that the data quality objectives given in the generic verification protocol and test/QA plan have been attained.

This verification statement addresses five aspects of filter fabric performance: filter outlet $PM_{2.5}$ concentration, filter outlet total mass concentration, pressure drop, filtration cycle time, and mass gain on the filter fabric. Users may wish to consider other performance parameters, such as temperature, service life, and cost when selecting a filter fabric for their application.

US EPA ARCHIVE DOCUMENT

Table 1. Test Conditions for Baghouse Filtration Products
Brand/Model: Donaldson Company, Inc.'s Tetratex 6282 Filtration Media

Test Parameter	Value
Dust concentration	18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf)
Filtration velocity (G/C)	120 ± 6 m/h (6.6 ± 0.3 fpm)
Pressure loss before cleaning	1,000 ± 12 Pa (4 ± 0.05 in. w.g.)
Tank pressure	0.5 ± 0.03 MPa (75 ± 5 psi)
Valve opening time	50 ± 5 ms
Air temperature	25 ± 2 ^{o}C (77 ± 4 ^{o}F)
Relative humidity	50 ± 10%
Total raw gas stream flow rate	5.8 ± 0.3 m^3/h (3.4 ± 0.2 cfm)
Sample gas stream flow rate	1.13 ± 0.06 m^3/h (0.67 ± 0.03 cfm)
Number of cleaning cycles • During conditioning period	 10,000 cycles
• During recovery period	30 cycles
Performance test duration	6 h ± 1 s

Beginning of table description. Table 1 is titled Test Conditions for Baghouse Filtration Products; the Brand/Model is listed as Donaldson Company, Inc.'s Tetratex 6282 Filtration Media. The table describes the test conditions that are specified in the QA/QC requirements for the test; all conditions were achieved for this test. The table lists the test parameters in one column and their values in the next column. The test parameters include such items as the dust concentration, filtration velocity, flow rates, air temperature and humidity, and the number of cleaning cycles during the test. End of table description.

Table 2. Baghouse Filtration Product Three-Run Average Test Results for Donaldson Company, Inc.'s Tetratex 6282 Filtration Media

Verification Parameter	At Verification Test Conditions
Outlet particle concentration at standard conditions[a] $PM_{2.5}$, g/dscm (gr/dscf) Total mass, g/dscm[b] (gr/dscf)	 <0.0000167[c] (<0.0000073) <0.0000167[c] (<0.0000073)
Average residual pressure drop (Δ P), cm w.g. (in. w.g.)	2.98 (1.17)
Initial residual Δ P, cm w.g. (in. w.g.)	2.92 (1.15)
Residual Δ P increase, cm w.g. (in. w.g.)	0.13 (0.05)
Filtration cycle time, s	196
Mass gain of test sample filter, g (gr)	0.22 (3.34)

Verification Parameter	At Verification Test Conditions
Number of cleaning cycles	110

[a] 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.
[b] Total mass includes the mass of $PM_{2.5}$ and larger particles that passed through the fabric.
[c] The measured value was determined to be below the detection limit of 0.0000167 grams per cubic meter. The detection limit is for a 6-hour test and based on VDI 3926.

Beginning of table description. Table 2 is titled Baghouse Filtration Product Three-Run Average Test Results for Donaldson Company, Inc.'s Tetratex 6282 Filtration Media. The table lists the verified test results for this product. The table lists the verification parameters in one column and their values at the verification test conditions in the next column. The verification parameters listed include the outlet particle concentration, the pressure drop characteristics, the filtration cycle time, the mass gain of the test sample, and number of cycles during the test. End of table description.

In accordance with the generic verification protocol, this verification statement is applicable to filter media manufactured between the signature date of the verification statement and 3 years thereafter.

<u>*signed by Sally Gutierrez*</u> <u>*7/19/2011*</u>
Sally Gutierrez Date
Director
National Risk Management Research Laboratory
Office of Research and Development
United States Environmental Protection Agency

<u>*signed by Jason Hill*</u> <u>*6/30/2011*</u>
Jason Hill Date
Director
Air Pollution Control Technology Center
RTI International

NOTICE: ETV verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. EPA and RTI make no express or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of commercial product names does not imply endorsement.

US EPA ARCHIVE DOCUMENT

Notice

This document was prepared by RTI International* (RTI) and its subcontractor ETS Incorporated (ETS) with partial funding from Cooperative Agreement No. CR 83416901-0 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.

* RTI International is a trade name of Research Triangle Institute.

US EPA ARCHIVE DOCUMENT

Foreword

The Environmental Technology Verification (ETV) Program, established by the U.S. Environmental Protection Agency (EPA), is designed to accelerate the development and commercialization of new or improved technologies through third-party verification and reporting of performance. The goal of the ETV Program is to verify the performance of commercially ready environmental technologies through the evaluation of objective and quality-assured data in order to provide potential purchasers and permitters an independent, credible assessment of the technology that they are buying or permitting.

The Air Pollution Control Technology Center (APCT Center) is part of the EPA's ETV Program and is operated as a partnership between RTI International (RTI) and EPA. The APCT Center verifies the performance of commercially ready air pollution control technologies. Verification tests use approved protocols, and verified performance is reported in verification statements signed by EPA and RTI officials. RTI contracts with ETS Incorporated (ETS) to perform verification tests on baghouse filtration products, including filter media.

Baghouses are air pollution control devices used to control particulate emissions from stationary sources and are among the technologies evaluated by the APCT Center. The APCT Center developed (and EPA approved) the *Generic Verification Protocol for Baghouse Filtration Products* to provide guidance on these verification tests.

The following report reviews the performance of Donaldson Company, Inc.'s Tetratex® 6282 filtration media. ETV testing of this technology was conducted during March and April 2011 at ETS. All testing was performed in accordance with an approved test/quality assurance (QA) plan that implements the requirements of the generic verification protocol at the test laboratory.

US EPA ARCHIVE DOCUMENT

Availability of Verification Statement and Report

Copies of this verification report are available from the following:

- RTI International
  Discovery and Analytical Sciences
  P.O. Box 12194
  Research Triangle Park, NC 27709-2194

- U.S. Environmental Protection Agency
  Air Pollution Prevention and Control Division (E343-02)
  109 T. W. Alexander Drive
  Research Triangle Park, NC 27711

Web Site: http://www.epa.gov/etv/vt-apc.html (electronic copies)

US EPA ARCHIVE DOCUMENT

Table of Contents

US EPA ARCHIVE DOCUMENT

List of Figures

List of Tables

US EPA ARCHIVE DOCUMENT

List of Abbreviations and Acronyms

APCT Center	Air Pollution Control Technology Center
BFP	baghouse filtration product
cfm	cubic feet per minute
cm	centimeters
cm w.g.	centimeters of water gauge
dia.	diameter
ΔP	pressure drop
dscmh	dry standard cubic meters per hour
EPA	U.S. Environmental Protection Agency
ETS	ETS Incorporated
ETV	Environmental Technology Verification
FEMA	filtration efficiency media analyzer
fpm	feet per minute
g	grams
g/dscm	grams per dry standard cubic meter
g/m^3	grams per cubic meter
G/C	gas-to-cloth ratio (filtration velocity)
gr	grains
gr/dscf	grains per dry standard cubic foot
GVP	generic verification protocol
h	hours
in.	inches
in. w.g.	inches of water gauge
kPa	kilopascals
m	meters
m/h	meters per hour
m^3/h	cubic meters per hour
mbar	millibars
min.	minutes
mm	millimeters
MPa	megapascals
ms	milliseconds

US EPA ARCHIVE DOCUMENT

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
QA	quality assurance
QC	quality control
RTI	RTI International
s	seconds
scf	standard cubic feet
t	time
VDI	Verein Deutscher Ingenieure
w.g.	water gauge
µm	micrometers
°C	degrees Celsius
°F	degrees Fahrenheit
°R	degrees Rankine

US EPA ARCHIVE DOCUMENT

Acknowledgments

The authors acknowledge the support of all those who helped plan and conduct the verification activities. In particular, we would like to thank Michael Kosusko, U.S. Environmental Protection Agency's (EPA's) Project Officer, and Bob Wright, EPA's Quality Manager, who both work as part of EPA's National Risk Management Research Laboratory in Research Triangle Park, NC. Finally, we would like to acknowledge the assistance and participation of Donaldson Company, Inc. personnel, who supported the test effort.

For more information on Donaldson Company, Inc.'s Tetratex 6282, contact the following:

Anil Suthar
Donaldson Company, Inc.
85 Railroad Drive
Ivyland, PA 18974
(215) 396-8349
Anil.Suthar@Donaldson.com

Or

Karen Bentley
Donaldson Company, Inc.
85 Railroad Drive
Ivyland, PA 18974
(215) 396-8349
Karen.Bentley@Donaldson.com

For more information on verification testing of baghouse filtration products, contact the following:

Jason Hill
RTI International
P.O. Box 12194
Research Triangle Park, NC 27709-2194
(919) 541-7443
APCTVC@rti.org

US EPA ARCHIVE DOCUMENT

1.0 INTRODUCTION

This report reviews the pressure drop (ΔP) and filtration performance of Donaldson Company, Inc.'s Tetratex® 6282 filtration media. Environmental Technology Verification (ETV) testing of this technology/product was conducted during a series of tests in March and April 2011 by ETS Incorporated (ETS), under contract with the Air Pollution Control Technology Center (APCT Center). The objective of the APCT Center and the ETV Program is to verify, with high data quality, the performance of air pollution control technologies. Control of fine-particle emissions from various industrial and electric utility sources employing baghouse control technology is within the scope of the APCT Center. An APCT Center program area was designed by RTI International (RTI) and a technical panel of experts to evaluate the performance of particulate filters for fine-particle (i.e., $PM_{2.5}$) emission control. Based on the activities of this technical panel, the *Generic Verification Protocol for Baghouse Filtration Products* was developed. This protocol was chosen as the best guide to verify the filtration performance of baghouse filtration products (BFPs). The specific test/quality assurance (QA) plan for the ETV test of the technology was developed and approved in May 2000, followed by an approved update in February 2006. The goal of the test was to measure filtration performance of both $PM_{2.5}$ and total particulate matter (PM), as well as the ΔP characteristics of the Donaldson Company, Inc. technology identified above.

Section 2 of this report documents the procedures used for the test and the conditions over which the test was conducted. A description of Donaldson Company, Inc.'s Tetratex 6282 filtration media is presented in Section 3. The results of the test are summarized and discussed in Section 4, and references are presented in Section 5.

This report contains summary information and data from the test and the verification statement. Complete documentation of the test results is provided in a separate data package report and an audit of data quality report. These reports include the raw test data from product testing and supplemental testing, equipment calibrations results, and QA and quality control (QC) activities and results. Complete documentation of QA/QC activities and results, raw test data, and equipment calibrations results are retained in ETS's files for 7 years.

US EPA ARCHIVE DOCUMENT

2.0 VERIFICATION TEST DESCRIPTION

The BFPs were tested in accordance with the APCT Center Generic Verification Protocol for Baghouse Filtration Products[1] and the Test/QA Plan for the Verification Testing of Baghouse Filtration Products.[2] These documents incorporate all the requirements for quality management, QA, procedures for product selection, auditing of the test laboratories, and reporting format. The Generic Verification Protocol (GVP) describes the overall procedures 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 in consultation with the technical panel since posting of the GVP. These revisions are documented in Section 4.1. The test/QA plan details how the test laboratory at ETS implemented and met the requirements of the GVP.

2.1 Description of the Test Rig and Methodology

The tests were conducted in ETS's filtration efficiency media analyzer (FEMA) test apparatus (**Figure 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 readout 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 absolute concentration, and is, therefore, not the primary concentration measurement for the test. 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% 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 gas-to-cloth ratio (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 ΔP of the filter sample. The pressure transducer measures the differential pressure across the filter samples every 3 seconds; the residual ΔP measurements are those taken 3 seconds after the cleaning pulse. The ΔP measurements are then averaged, as described in Appendix C, Section 4.4.1 of the GVP.[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.

Mean outlet particle concentration is determined when 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. Outlet particle concentrations were determined by weighing the mass increase of dust collected in each impactor filter stage and dividing by the gas volumetric flow through the impactor.

The particle size was measured while a fine dust was injected into the air stream upstream of the filter fabric sample. The particle size distributions in the air were determined both upstream and downstream of the test filter fabric to provide accurate results for penetration through the test filter of $PM_{2.5}$.

US EPA ARCHIVE DOCUMENT

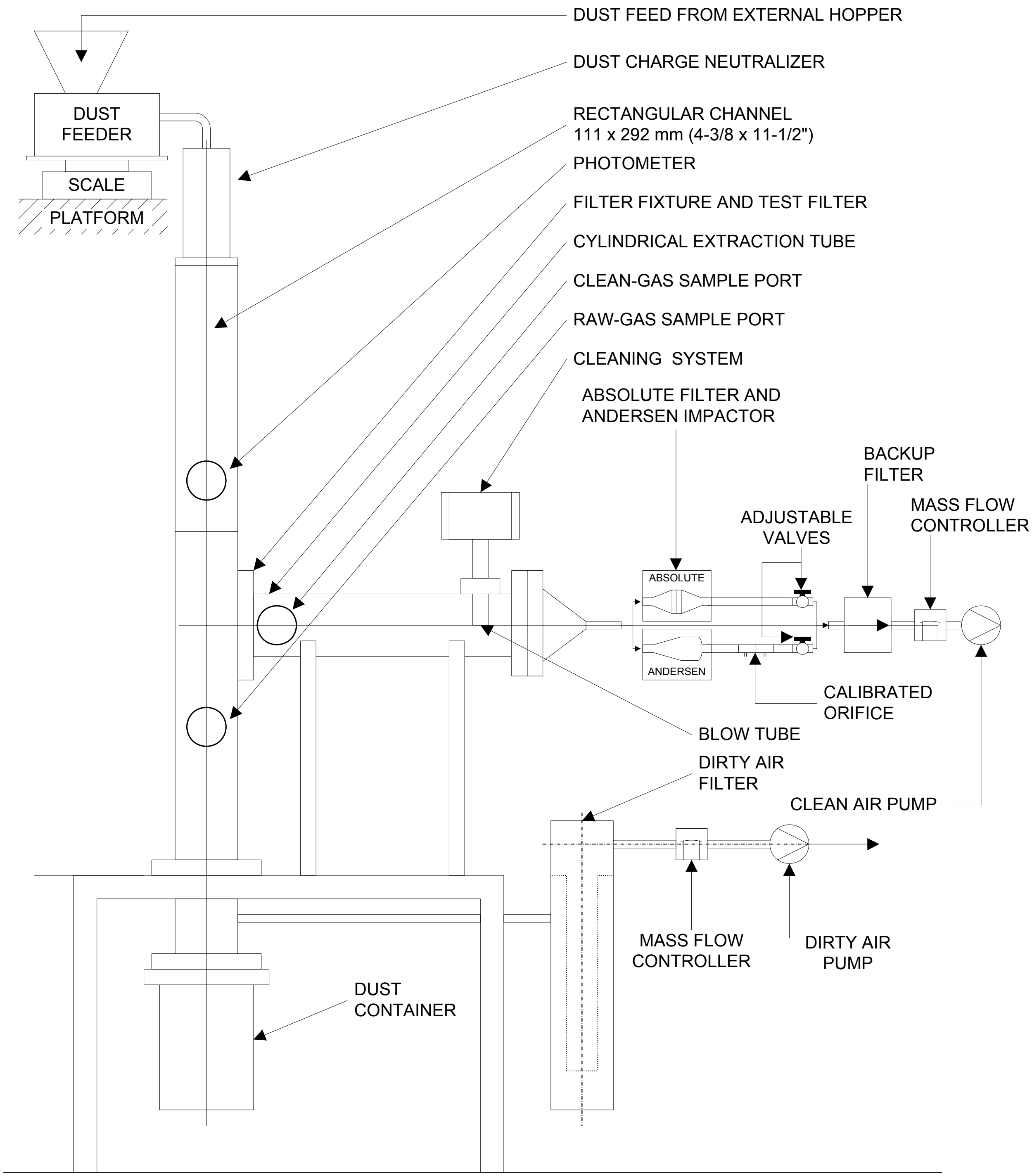

Figure 1. Diagram of filtration efficiency media analyzer test apparatus.

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

- Conditioning period
- Recovery period
- 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 was maintained at 3 seconds. No filter performance parameters are measured in this period.

The conditioning period is immediately followed by a recovery period, which allowed 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 occurred for a 6-hour period immediately following the recovery period (a cumulative total of 10,030 filtration cycles after the test filter had 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 (G/C) and inlet dust concentrations were maintained at 120 ± 6 m/h (6.6 ± 0.3 fpm) and 18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf), respectively, throughout all phases of the test.

2.2 Selection of Filtration Sample for Testing

Filter fabric samples of Tetratex 6282 filtration media were supplied to ETS directly from the manufacturer (Donaldson Company, Inc.), with a letter signed by Mark Rigby, general manager, Donaldson Company, Inc., 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 140 mm (5.5 in.) in diameter, which is the dimension used to calculate the face area of the tested specimen.

2.3 Control Tests

Two types of control tests were performed during the verification test series. The first was a dust characterization, which is performed monthly. The reference dust 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 criteria for the dust characterization test are a maximum mass mean diameter of 1.5 ± 1.0 µm and a concentration between 40% and 90% of particles less than 2.5 µm. These criteria must be met in order 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 ΔP (final residual pressure drop). The results of the test verified that the FEMA apparatus was operating consistently within the required parameters. The average fabric maximum ΔP (average of the repeated measurements of final residual pressure drop conducted during the quarter applicable to this test) in a reference value test must be 0.60 cm w.g. ± 40%, and the fabric weight gain average must be

US EPA ARCHIVE DOCUMENT

1.12 g ± 40%. Three reference value control test runs were conducted. The results of the control tests are summarized in **Table 1**.

Table 1. Summary of Control Test Results

Controlled Parameter	Requirement	Measured Value	Criteria Met
Mass mean diameter, µm	1.5 ± 1.0	1.75	Yes
% Less than 2.5 µm	40%–90%	66.27%	Yes
Weight gain, g	1.12 ± 40%	0.88	Yes
Maximum pressure drop, cm w.g.	0.60 ± 40%	0.40	Yes

Beginning of table description. Table 1 is titled Summary of Control Test Results. The table lists the results of measurements meant to characterize the operation of the test apparatus. The mass mean diameter of the challenge aerosol, the percent less than 2.5 micrometers in diameter, the weight gain of a reference fabric and the maximum pressure drop of the reference fabric were measured. In columns, the table lists the QA/QC requirements, the values measured during the control tests, and whether or not the criteria were met. For this test, all criteria were met. End of table description.

2.4 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

dia. = 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 ΔP, cm w.g.

P_i = Residual ΔP for *i*th 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

US EPA ARCHIVE DOCUMENT

w_f = Weight of dust in feed hopper following specified time, g. Because of vibrations causing short-term fluctuations to the feed hopper, this value is measured as a 1-min. average.

w_i = Weight of dust in feed hopper at the beginning of the specified time, g. Due to vibrations causing short-term fluctuations to the feed hopper, this value is measured as a 1-min. average.

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

460 = 0 °F, in °R

1,013 = Standard atmospheric pressure, mbar

528 = Standard temperature, °R

Area of Sample Fabric, A_f

$$A_f = \frac{(\pi * d^2)}{4}$$

Actual Gas Flow Rate, Q_a

$$Q_a = Q_{ds} * \left[\frac{(T_s + 460) * 1013}{P_s * 528} \right]$$

Gas-to-Cloth Ratio, G/C

$$\frac{G}{C} = \frac{Q_a}{A_f}$$

Standard Dust Feed Concentration, F_s, for a specified time, t

$$F_s = \frac{(w_i - w_f)}{(Q_{st} * t)}$$

Actual Raw Gas Dust Concentration, F_a

$$F_a = F_s * \left[\frac{(T_s + 460) * 1013}{P_s * 528} \right]$$

Dry Standard Clean Gas Particulate Concentration, Total Mass, C_{ds}

$$C_{ds} = \frac{M_t}{\left[Q_{ds} * t * \left(1 - \frac{\%H_2O}{100} \right) \right]}$$

Dry Standard Clean Gas Particulate Concentration, $PM_{2.5}$, $C_{2.5ds}$

$$C_{2.5ds} = \frac{M_{2.5}}{\left[Q_{2.5ds} * t * \left(1 - \frac{\%H_2O}{100} \right) \right]}$$

US EPA ARCHIVE DOCUMENT

Filtration Cycle Time, t_c

$$t_c = \frac{t}{N}$$

Average Residual Pressure Drop, P_{avg}

$$P_{avg} = \frac{\Sigma P_i}{N}$$

US EPA ARCHIVE DOCUMENT

3.0 DESCRIPTION OF FILTER FABRIC

The Donaldson Company, Inc. Tetratex 6282 is an ePTFE laminate on PPS. **Figure 2** is a photograph of the fabric. Sample material was received as nine 46 x 91 cm (18 x 36 in.) swatches marked with the manufacturer's model number, year and month of manufacture, and cake side (the upstream side of the fabric, which is exposed to the particle-laden air, on which the filter cake builds up). Three of the swatches were selected at random for preparing three test specimens 150 mm (5.9 in.) in diameter.

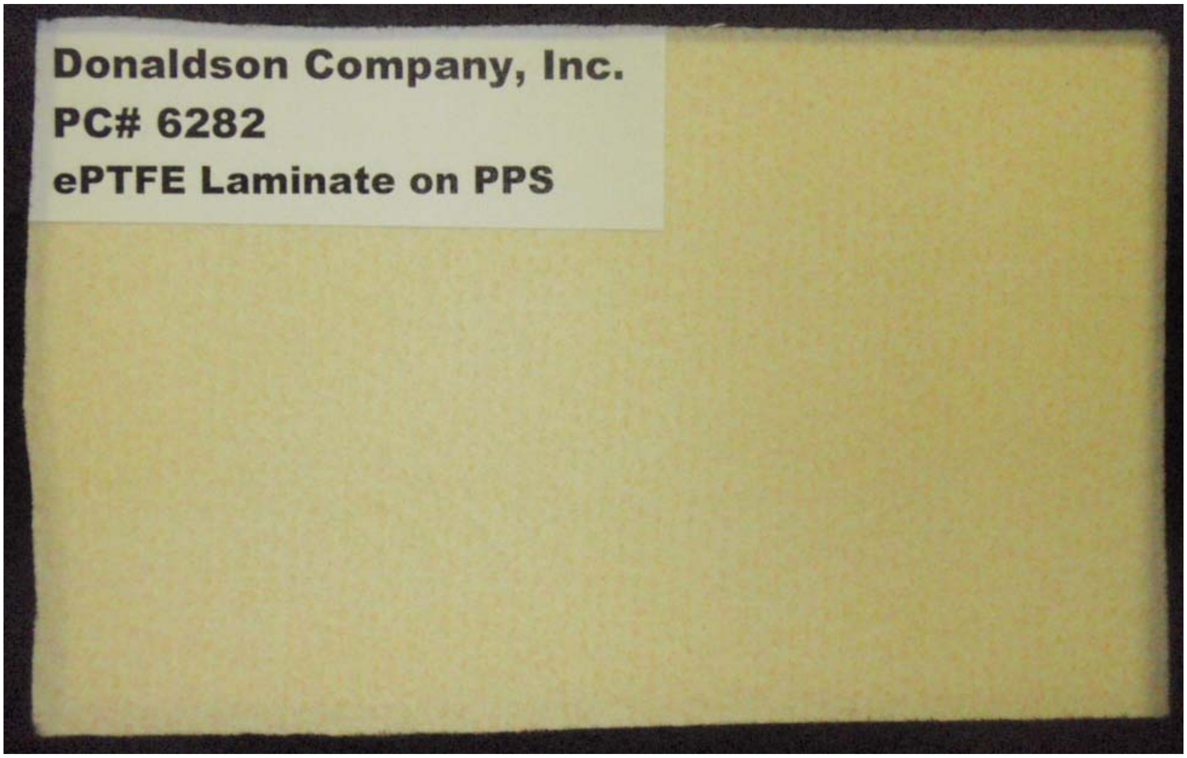

Figure 2. Photograph of Donaldson Company, Inc.'s Tetratex 6282 filtration media.

4.0 VERIFICATION OF PERFORMANCE

4.1 Quality Assurance

The verification tests were conducted in accordance with an approved test/QA plan.[2] The EPA quality manager conducted an independent assessment of the test laboratory in June 2005 and found that the test laboratory was equipped and operated as specified in the test/QA plan.

The ETS QA officer and the APCT Center's QA staff have reviewed the results of this test and have found that the results meet the overall data quality objectives as stated in the test/QA plan. It should be noted that, because of the highly efficient nature of the filter medium being tested, the impactor substrate weighings for these results were below the reproducibility of the balance. The relative percent error in the post-filter weighing measurements cannot be computed because most of the values were near zero. As a result of this occurrence, the tests do not meet the data quality objectives (DQOs) stated in the test/QA plan for mass gain associated with outlet concentrations. However, as stated in the test protocol, "for highly efficient fabrics, the mass gains stated for these quality objectives may not be achieved in the specified test duration. For these tests it is acceptable for the indicated DQO not to be met."

Data on calibration certificates for the flow meters, flow transducers, weights, low- and high-resolution balances, thermometer, and humidity logger are maintained at ETS in a separate data package.

Deviations from the test plan include organizational personnel changes.

The ETS QA officer and the APCT Center's QA staff have also reviewed the results of the control tests, which are summarized in Section 2.3, Table 1. The dust characterization control test met the appropriate requirements of the test/QA plan and verification protocol. The reference fabric tests met maximum ΔP and weight gain requirements established for reference fabric performance in the GVP, indicating the measurement system is operating in control.

4.2 Results

Table 2 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.

Table 2 summarizes the three verification tests that were performed under standard verification test conditions. The average residual ΔP across each filter sample at the nominal 120 m/h (6.6 fpm) filtration velocity [for a flow rate of 5.8 m^3/h (3.4 cfm)] is also shown in Table 2. This ΔP ranged from 2.82 to 3.22 cm w.g. (1.11 to 1.27 in. w.g.) for the three filter samples tested. The residual ΔP increase ranged from 0.09 to 0.17 cm w.g. (0.04 to 0.07 in. w.g.) for the samples tested. All three standard condition verification runs were used to compute the averages given in Table 2. The $PM_{2.5}$ outlet particle concentration average for the three runs is <0.0000167 g/dscm. The total PM concentration average for the three runs is <0.0000167 g/dscm.

US EPA ARCHIVE DOCUMENT

Table 2. Summary of Verification Results for Donaldson Company, Inc.'s Tetratex 6282 Filtration Media

Test Run Number	5V3-R1	5V3-R2	5V3-R3	Average[a]
$PM_{2.5}$ (g/dscm)[b]	<0.0000167[c]	<0.0000167	<0.0000167	<0.0000167
Total PM (g/dscm)	<0.0000167[c]	<0.0000167	<0.0000167	<0.0000167
Average residual Δ P (cm w.g.)	3.22	2.90	2.82	2.98
Initial residual Δ P (cm w.g.)	3.14	2.83	2.78	2.92
Residual Δ P increase (cm w.g.)	0.17	0.12	0.09	0.13
Mass gain of sample filter (g)	0.21	0.17	0.27	0.22
Average filtration cycle time (s)	185	209	195	196
Number of cleaning cycles	116	103	110	110

[a] All three verification runs were used to compute averages.

[b] One or more of the impactor substrate weight changes for these results was near the reproducibility limit of the balance.

[c] The measured value was determined to be below the detection limit of 0.0000167 grams per cubic meter. The detection limit is for a six-hour test and based on VDI 3926.

Beginning of table description. Table 2 is titled Summary of Verification Results for Donaldson Company, Inc.'s Tetratex 6282 Filtration Media. The table lists the verified test results for the three replicate test runs and their averages. The table lists the particle concentrations downstream of the sample filters, the pressure drop characteristics, the mass gain of the sample filter, the average filtration cycle time, and the number of cleaning cycles during the test. In separate columns, results for these parameters are listed for each of the three test runs and their averages. End of table description.

4.3 Limitations and Applications

This verification report addresses two aspects of BFP performance: outlet particle concentration and ΔP. 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 GVP, the verification statement, which summarizes this test report, is applicable to BFPs manufactured between the signature date of the verification statement and three years thereafter.

US EPA ARCHIVE DOCUMENT

5.0 REFERENCES

1. RTI International. 2001. *Generic Verification Protocol for Baghouse Filtration Products*, RTI International, Research Triangle Park, NC, February. Available at http://www.epa.gov/etv/pubs/05_vp_bfp.pdf.

2. ETS Incorporated and RTI International. 2006. *Test/QA Plan for the Verification Testing of Baghouse Filtration Products (Revision 2)*, ETS Incorporated, Roanoke, VA, and RTI International, Research Triangle Park, NC, February. Available at http://www.epa.gov/etv/pubs/600etv06095.pdf.

US EPA ARCHIVE DOCUMENT