Standard Test Method for Characterizing the Pressure Drop and Filtration Performance of Cleanable Filter Media[1]

This standard is issued under the fixed designation D6830; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method characterizes the operational performance of cleanable filter media under specified laboratory conditions.

1.2 This test method determines the airflow resistance, drag, cleaning requirements, and particulate filtration performance of pulse cleaned filter media.

1.3 This test method determines the comparative performance of cleanable filter media.

1.4 The results obtained from this test method are useful in the design, construction, and selection of filter media.

1.5 The results obtained by this test method should not be used to predict absolute performance of full scale fabric filter (baghouse) facilities, however these results will be useful in selection of proper filter media and identification of recommended operating parameters for these full scale fabric filter facilities.

1.6 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D461 Test Methods for Felt (Withdrawn 2003)[3]

D737 Test Method for Air Permeability of Textile Fabrics

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

E832 Specification for Laboratory Filter Papers

F740 Definitions of Terms Relating to Filtration (Withdrawn 2002)[3]

2.2 *Other Standards:*

Draft Generic Verification Protocol for Baghouse Filtration Products[4]

Standard Operating Procedures for Verification Testing of Baghouse Filtration Products Using LTG/FEMA Test Apparatus, Draft, December[5]

VDI 3926, Part 2 Testing of Filter Media for Cleanable Filters under Operational Conditions[6]

3. Terminology

3.1 *Definitions*—For definitions of other terms used in this test method, refer to Terminologies D123, D1356, and F740, as well as 11.1 of this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fabric conditioning period*—the period during which the fabric specimen is conditioned within the test apparatus by subjecting it to 10 000 rapid compressed air cleaning pulses at 3-5 seconds between pulses. During the conditioning period the specimen is subjected to test method specifications for dust and gas flow rates.

3.2.2 *fabric recovery period*—time period following the conditioning period during which the fabric is allowed to recover from rapid pulsing. The fabric recovery period requires 30 filtration cycles under normal filtration cycles. During the recovery period the fabric is subjected to test method specifications for dust and gas flow rates.

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[1] This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.03 on Ambient Atmospheres and Source Emissions.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Generic Verification Protocol for Baghouse Filtration Products, RTI, Research Triangle Park, NC, September 2001.

[5] Test/QA Plan for the Verification Testing of Baghouse Filtration Products, ETS, Inc., October 2000.

[6] Verein Deutscher Ingenieure (VDI 3926, Part 2), "Testing of Filter Media For Cleanable Filters under Operational Conditions," December, 1994. Available from Beuth Verlag GmbH, 10772 Berlin, Germany.

3.2.3 *filtration velocity*—volumetric is the flow rate per unit face area. Also referred to as gas-to-cloth ratio (G/C), or air-to-cloth ratio (A/C).

3.2.4 *filtration cycle*—a cycle in the filtration process in which the particulate matter is allowed to form a dust cake on the face area of the test specimen with no disturbances from a pulse of compressed air to clean the dust cake from the test specimen. The filtration cycle is the time period between two consecutive cleaning or pulse cycles.

3.2.5 *filtration cycle time*—the duration of time, measured in seconds or minutes, defined by one filtration cycle. Also referred to as time between cleaning cycles, or pulse cycles.

3.2.6 *normal filtration cycle*—a filtration cycle specified for this test method in which the dust cake is allowed to form on the test specimen until a differential pressure of 1000 Pa (4 in. w.g.) is reached. At this point, the test specimen is cleaned by a pulse of compressed air from the clean gas side. After the pulse action is completed the next filtration cycle begins continuing until the pressure differential reaches 1000 Pa, thus initiating the next pulse.

3.2.7 *PM- particulate matter*—also used interchangeably with "dust" when referring to test dust specifications or inlet particulate matter flow rates.

3.2.8 *PM 2.5*—particulate matter nominally 2.5 micrometres and less in equivalent aerodynamic diameter.

3.2.9 *performance test period*—a 120 minute test period following the fabric recovery period (360 minutes minimum for PM 2.5 measurements) during which measurements for particulate emissions, residual pressure drop, number of filtration cycles, and filtration cycle time are monitored and recorded. During the performance test period pulse cleaning is triggered at a differential pressure of 1000 Pa (4 in. w.g.) measured across the test specimen. Gas and dust flows are maintained at test specification flow rates.

3.2.10 *residual pressure drop*—the air flow resistance measured across the test specimen, as measured three seconds after cleaning the test specimen with a pulse of compressed air, Also referred to as residual differential pressure, P, residual delta P, or dP_r, or Δp_r.

4. Summary of Test Method

4.1 A fabric filter sample is challenged with a standard dust (particulate matter) under simulated baghouse conditions at specified rates for air and dust flow.

4.2 The test consists of three test runs. Each run consists of three sequential phases or test periods during which dust and gas flow rates are continuously maintained to test specification.

4.2.1 The test phases are:

4.2.1.1 A conditioning period consisting of 10 000 rapid pulse filtration cycles to simulate long term operation,

4.2.1.2 A 30 normal filtration cycle recovery period to allow the test specimen to recover from rapid pulsing, and

4.2.1.3 A two-hour performance test period, consisting of normal filtration cycles, during which measurements for particulate emissions are determined by gravimetric measurement of the particulate matter which passes through the test specimen.

4.3 PM 2.5 emission determinations can also be conducted by employing a cascade impactor and modifying the clean gas duct of the test apparatus to insure that isokinetic sampling rates through the impactor are maintained.

4.3.1 If measuring for PM 2.5 it is advised that the performance test period be increased from 120 minutes to at least 360 minutes to allow for adequate weight gains on each collection stage of the impactor.

4.4 Initial residual pressure drop, average residual pressure drop, residual pressure drop increase, number of filtration cycles, and average filtration cycle time are monitored and recorded during the performance test period. Table 1 and Table 2 provide test specifications and test conditions respectively. Table 3 provides a listing of results that will be obtained from this test.

5. Significance and Use

5.1 This test method determines the comparative performance of filter media. The results can be used for design, manufacturing, construction and selection of filter media.

5.2 Results obtained by this test method should not be used to predict absolute performance on full scale fabric filter (baghouse) facilities, however these results will be useful in selection of proper filter media and identification of recommended operating parameters for these full scale fabric filter facilities.

5.3 Dust types vary greatly; therefore, the results obtained using the standard dust should not be extrapolated to other dust types.

6. Interferences

6.1 Any variations in the test conditions or test apparatus that may alter the physical properties of the dispersed test dust particles may affect the precision of the test results.

6.1.1 These properties include static charge, cohesion, effective particle size, or any other property that affects the ability of the dust particles to actually reach the surface of the test specimen or that affects the interaction between the dust particles and the filtration surface during the filtration or pulse cleaning process.

6.1.2 The test dust is known to have minor differences in particle size from shipment to shipment and lot number to lot number. It is not fully understood what impact, if any, these deviations have on the test results. With each new shipment and every three months thereafter, the dust particle size should be characterized using the handling, preparation, and testing procedures specified in this test method. In addition the impact of the dust on differential pressure and weight gain values of a reference fabric should be established and testing of the dust and reference fabric should be conducted quarterly thereafter to allow for comparisons with the established values.

6.1.3 Inadequate dispersion of the test dust may affect the precision of test results. Any surface with which the dust contacts after it leaves the feeder should be made in strict accordance with the specification. The use of alternate materials for internal surfaces of the raw and clean gas duct may cause the charge on the dust particles to be altered triboelectrically, which may affect the results.

TABLE 1 Test Specifications

Constant Parameter	Nominal Value	Acceptable Bias[A]	Acceptable Precision[B]	Instrument	Frequency
Test Dust Particle SizePercentag (Pural NF)	50 % < 2.5 µm (Avg. 3 runs)	+40 % –10 % (Avg. 3 runs)	±0.0001 g Filter mass Gain per weighing	Andersen Impactor, Model 50-900 (as Determined by Analytical Balance)	Quarterly and Each New Batch
Test Dust Mass Mean Aerodynamic Diameter (Pural NF)	1.5 µm (Avg. 3 runs)	±1 µm (Avg. 3 runs)	±0.0001 g Filter mass Gain per weighing	Andersen Impactor, Model 50-900 (as Determined by Analytical Balance)	Quarterly and Each New Batch
Filter Sample Diameter, mm (in.) (Exposed diameter is 140 mm, 5.51 in.)	150 (5.88)	±1.6 (1⁄16)	±1.6 (1⁄16)	Filter Cutter	Each Test Specimen
Inlet Raw Gas Flowrate, m^3/h (cfm)	5.8 (3.4)	±0.3 (0.2)	±0.01 (0.006)	Mass Flow Controller	Each Test. Calibrate @ 6 Month
Clean Gas Flowrate, m^3/h (cfm)	1.8 (1.10)	±0.9 (0.06)	±0.01 (0.006)	Mass Flow Controller	Each Test. Calibrate @ 6 Month
Sample Gas Flowrate, m^3/h (cfm)	1.13 (0.67)	±0.06 (0.03)	±0.01 (0.006)	Mass Flow Controller	Each Test. Calibrate @ 6 Month
Filtration Velocity (G/C Ratio),[C] m/h (fpm)	120 (6.6)	±6 (0.3)	±1.2 (0.07)	Mass Flow Controller and Filter Sample Area	Each Test. Calibrate Every 6 Months
Pressure Drop Trigger for Cleaning	1000 Pa (4.0 in. w.g)	±0.127 cm w.g (0.05 in. w.g)	±0.127 cm w.g (0.05 in. w.g)	Pressure Transducer	Each Test
Rapid Pulse Cleaning Cycles (0–10 000), s	3	±1	±1	Datalogger Clock	Beginning of Each Test
Pulse Duration, ms	50.0	±5.0	±1.0	Pulse Regulator	Each Test
Pulse Cleaning Pressure, MPa (psi)	0.5 (75.0)	±0.03 (5.0)	±0.007 (1.0)	Pulse Regulator	Each Test
Gas Temperature, °F (°C)	77 (25)	±4 (2)	±1	Thermocouple	Each Test
Inlet Dust Concentration, g/dscm (gr/dscf)	18.4 (8.0)	±3.6 (1.6)	±0.22 (0.1)	Dust Load Cell and Mass Flow Controller	Continuously
Minimum Aggregate Mass Gain for Impactor Substrate Filters, g	0.0001		±0.00005	Andersen Impactor, Model 50-900 (as Determined by Analytical Balance)	Each Test
Charge Neutralizer				Polonium-210 Alpha Source	Replace Annually
Dust Feeder Operation, g/h	100	±20	±20	Dust Load Cell	Each Dust Loading Operation

[A] Acceptable bias = For the test to be valid, the instrument reading must record a value within listed range. For example, the ±4 degrees accuracy means that the temperature reading of the gas must be within the range of 73 to 81°F.

[B] Precision = The precision of the instrument reading. For example, the thermometer or thermocouple that is used to measure temperature must record temperature within 1 degree of actual.

[C] Filtration Velocity (G/C) = Clean Gas Stream Volume / Exposed Area of Filter Sample = 1.10 cfm / 0.166 ft^2 = 6.6 fpm. 1.85 m^3/h/ 0.01539 m^2 = 120 m/h.

TABLE 2 Test Conditions

Test Parameter	Value
Dust concentration	18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf)
Filtration velocity (G/C)	(G/C) 120 ± 6 m/h (6.6 ± 0.5 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°C (78 ± 4°F)
Relative humidity	50 ± 10 %
Raw gas stream flow rate	5.8 m^3/h (3.4 cfm)
Sample gas stream flow rate (For impactor tests only)	1.13 m^3/h (0.67 cfm)
Number of filtration cycles	
During conditioning period	10 000 cycles
During recovery period	30 cycles
Performance test duration	2 h, (note 6 h minimum when using impactor)

TABLE 3 Reporting of Test Results

Parameter	Value[A]
Outlet particle concentration at standard conditions[B]	
Total mass, g/dscm (gr/dscf)	
PM 2.5 (optional), g/dscm (gr/dscf)	
Average residual pressure drop, cm w.g. (in. w.g.)	
Initial residual pressure drop, cm w.g. (in. w.g.)	
Residual pressure drop increase, cm w.g. (in. w.g.)	
Filtration cycle time, s	
Mass gain of test sample filter, g (gr)	
Number of cleaning cycles	

[A] Values shown are for three tests.
[B] Standard conditions: 101.3 kPa (14.7 psia) and 20°C (68°F).

6.1.4 The relative humidity and temperature at which the test is conducted is known to have an effect on the test results. As there are no quantitative relationship that have been established that would allow the correction of test results for variations in these parameters, it is recommended that the test be conducted in a conditioned room with a relative humidity between 40 and 65 % and at a temperature between 23 and 27°C (73.4 to 80.6°F). In the absence of a conditioned room, the relative humidity and temperature should be as tightly controlled as possible and their levels recorded throughout the test.

7. Apparatus

7.1 *General Description*—The test apparatus consists of a brush-type dust feeder that disperses dust into a vertical rectangular duct (raw gas channel). The dust feed is continuously measured and recorded via an electronic scale located beneath the dust feed mechanism. 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 the inlet dust and ensures that the dust flow is consistent throughout the test. A portion of the dust laden raw gas flow is extracted from the raw gas channel through the test specimen, which is mounted vertically at the entrance to a horizontal duct (clean gas channel). Two vacuum pumps maintain gas flow through the raw gas and clean gas channels. The flow rates, and thus the filtration velocity (G/C) are kept constant using mass flow controllers. High efficiency filters are installed upstream of the flow controllers and pumps to prevent contamination or damage caused by the dust. The test specimen is cleaned periodically by pulsing with compressed air. The cleaning system consists of a compressed air tank, a quick action diaphragm valve, and a blow tube with nozzle facing the downstream side of the test specimen. The dust that penetrates the test specimen is captured on a high efficiency filter. The pressure drop across the test specimen is measured and recorded every three seconds throughout the test. Fig. 1 provides a schematic of the test apparatus. The test apparatus consists of the following components.

7.1.1 A continuous dust feeding system capable of providing dust feed rates ranging from 80 to 120 grams per hour.

7.1.2 A Polonium-210 alpha source for neutralizing the test dusts that have been electrostatically charged by dispersion (dust charge neutralizer).

7.1.3 A dust feed hopper with a minimum capacity of 2.0 kilogram of aluminum oxide test dust.

7.1.4 A scale beneath the dust feed mechanism including the dust feed hopper with a continuos readout capable of measurement to the nearest 10 gram.

7.1.5 A vertical raw dust channel with a rectangular cross-section (rectangular channel).

7.1.6 A photometric concentration monitor located directly above the filter sample to monitor the concentration and dispersion of the test dust in the raw gas channel.

7.1.7 A thermocouple located in the raw gas channel upstream of the filter test specimen.

7.1.8 Capability to measure and record the static pressure (relative to ambient) in the raw gas channel in addition to the pressure drop across the filter test specimen.

7.1.9 A process controller to allow for automatic adjustment of operational parameters, an electronic data logger, and a dedicated computer for recording and computation of data such as residual pressure drop and filtration cycle time for each filtration cycle during the performance test period , dust feed weight, raw gas flow rate, and clean gas flow rate on a one minute average.

7.1.10 A removable cylindrical, horizontally arranged clean gas channel with a holder for the filter test specimen. The clean gas channel will be complete with mass flow controller, clean gas extraction pump and filter to protect the pump.

7.1.11 A filter medium cleaning system with compressed air tank, diaphragm valve, actuator, and blow tube (cleaning system).

7.1.12 A raw gas extraction unit with deflector separation, dust container, air filter, and pump.

7.1.13 An absolute filter installed in the cleaned gas exit section for gravimetric determination of dust concentration in the clean gas (absolute filter). Note that by inserting a suitable impactor in place of the absolute filter, particle size determinations of the clean gas dust emissions can be made.

7.1.14 Flow meters for the raw and clean gas channels.

7.1.15 *Analytical Balances and Associated Equipment:*

7.1.15.1 Low resolution analytical balance, capable of measurement to within 0.01 grams. For weighing of filter test specimen.

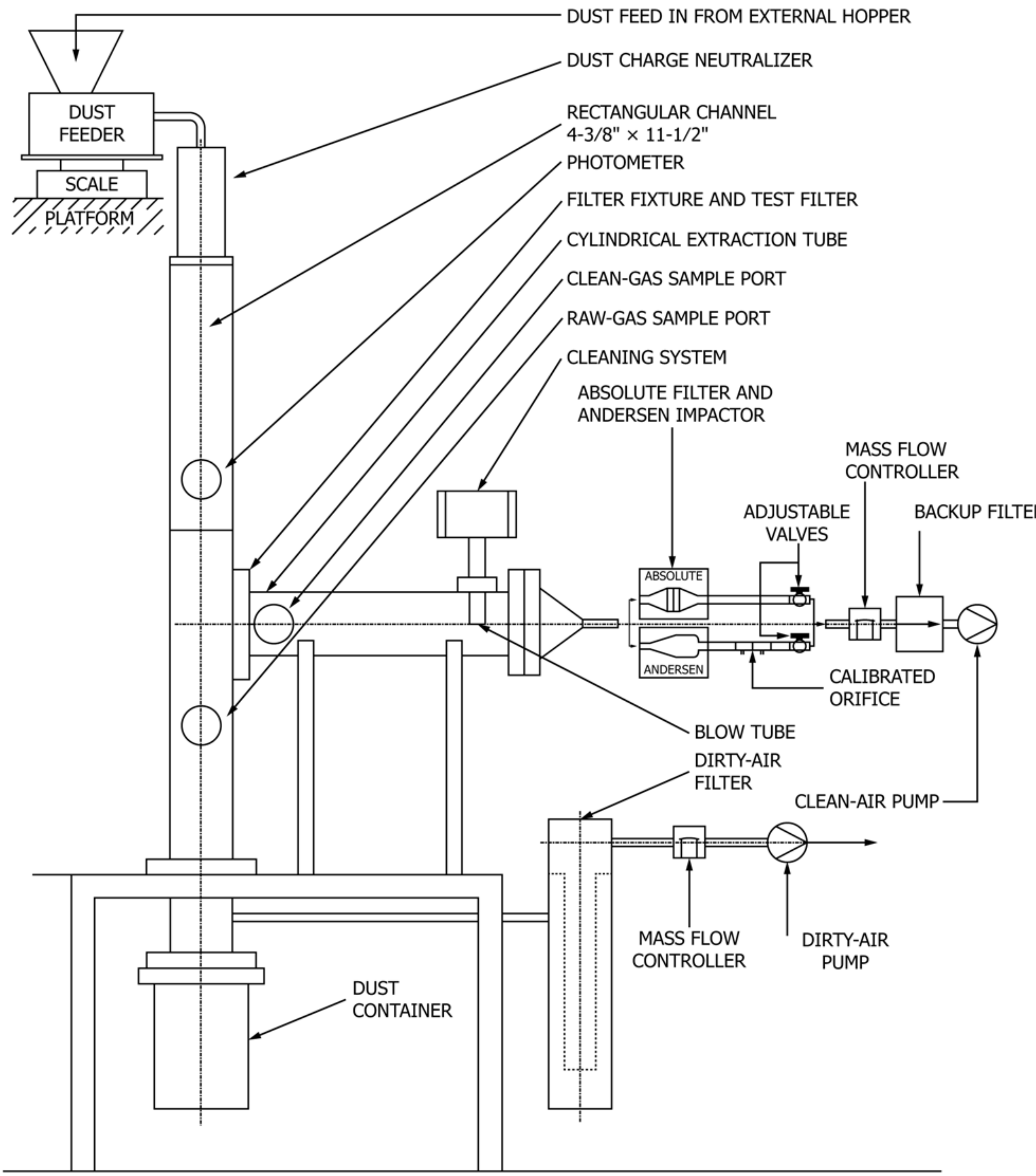

FIG. 1 Test Apparatus

7.1.15.2 High resolution analytical balance, capable of measurement to 0.00001 grams. The balance must be equipped with an anti-static device within the enclosure for weighing the absolute filter or impactor substrates.

7.1.15.3 Dust feed scale calibration weight: 2 kg span weight, must meet ASTM Class 4 with NIST/NVLAP traceable certificate.

7.1.15.4 Low resolution analytical balance calibration weight: 100 g span weight, must meet ASTM Class 4 with NIST/NVLAP traceable certificate.

7.1.15.5 High resolution analytical balance calibration weight: 1 mg daily check weight and 50 g span weight for calibration: Calibration weight must meet ASTM Class 1 standards with NIST/NVLAP traceable certification.

7.1.16 Continuous temperature and humidity monitor with data logging capability.

7.1.17 An absolute filter assembly and filter paper. The absolute filter is a 293 mm A/E glass paper.

7.1.18 Impactor (optional) for capturing total particulate matter and measuring particulate matter having a mean aerodynamic diameter of 2.5 micron. The collection substrates and backup filter will be of glass fiber.

7.1.19 A barometer capable of reading atmospheric pressure to within 2.5 mm (0.1 in.) Hg.

7.1.20 Sling psychrometer or ambient humidity measurement monitor capable of measuring ambient humidity to within 1 % relative humidity.

8. Reagents and Materials

8.1 The test dust will be aluminum oxide (calcined alumina) Pural NF or equivalent. The dust shall have a nominal mass mean diameter of 1.5 microns, an a minimum of 40 percent less than 2.5 microns.

8.2 *Compressed Air*—The test specimen should be pulsed with clean, dry, oil free compressed air.

8.3 Aluminum foil.

8.4 Permanent marker for labeling.

8.5 Tweezers for handling absolute filters and impactor substrates.

8.6 Recovery brush for recovery of loose dust from absolute filter holder and impactor plates.

8.7 Single thickness class 100 wipes.

8.8 Reagent grade acetone.

8.9 Paraffin film or teflon tape for sealing the absolute filter holder or the impactor assembly when not in use.

8.10 *Reference Fabric*—The testing organization should obtain a roll of fabric to be used as a historical reference for future testing (see 9.1.2). This fabric should reasonably represent the performance of fabrics expected to be received for testing, and there should be sufficient quantity that test specimens (see 9.1.2) will be available for several years.

9. Procedure

9.1 *Preparation:*

9.1.1 Prepare data sheets for each test as shown in Attachment A. All raw data shall be recorded on the data sheets for inclusion in the test report.

9.1.2 Prepare the test specimen by cutting a 150 mm (5.88 in.) diameter sample from the fabric swatch to be tested. Use the clamping ring from the apparatus test specimen holder as a template. The outer diameter of the sample should match that of the clamping ring when laid flat. Make sure that the sample is homogeneous and free from seams or imperfections.

9.1.3 The sample shall be weighed and transported with a labeled, sealable lightweight container such as aluminum foil or plastic bag. The container is necessary to capture any loose dust from the sample after testing is completed. Weigh the sample and container to the nearest 0.01 g (pre-weighing).

9.1.4 Cut aluminum foil into sections sufficient to completely contain the absolute filter (and any impactor substrates used) and any loose dust captured on the filter.

9.1.5 Label each foil to match its corresponding filter with a permanent marker that will not rub off during handling.

9.2 *Conditioning:*

9.2.1 The filters and weigh foils must be equilibrated to a constant temperature between 18 and 20°C (64 and 77°F) and relative humidity to 40-60 % for at least 24 hours prior to weighing.

9.2.1.1 Place each filter and its corresponding foil in an open petri dish with the foil unfolded and the filter open to the atmosphere.

9.2.1.2 Arrange the petri dishes on a clean tray or surface. Cover the petri dishes with dust free wipes or dust free boxes with one side open to atmosphere.

9.2.1.3 Allow filters, foils, and petri dishes to equilibrate for 24 hours at a constant temperature between 18 and 25°C (64 and 77°F) and relative humidity of 40 to 60 %. The temperature and relative humidity must be continuously measured and recorded.

9.3 *Pre-Weighing:*

9.3.1 Maintain the temperature and relative humidity ranges used during the conditioning of the filters and foils. Prior to each weighing, and every hour during extended weighings, calibrate the balance using the zero and span functions of the balance. Check each calibration using the 1 g calibration weight. The balance should weigh the calibration weight to the nearest 0.00005 g. If not, repeat the calibration procedure or adjust the balance. Weigh the filters within the foils. Keep the filters and weigh foils in a closed petri dish to cover and protect the filter and weigh foil during handling. After conditioning, always handle the filters and weigh foil with tweezers. The filters and weigh foils should not contact any surface except the clean petri dish, tweezers, and the filter holder or impactor during handling.

9.3.2 Prior to each use rinse all internal surfaces of the absolute filter holder or impactor with acetone. Dry these surfaces with single thickness class 100 wipes, taking care that there is no contamination of these surfaces from ambient dusts, oils, or fibers. Assemble the filter holder or impactor and install the absolute filter or impactor substrates per the manufacturers operating manual. When using the impactor to determine Pm 2.5 emissions, and to eliminate the cumulative error caused by multiple weighings, it is advised to eliminate the three impactor stages that separate less than 2.5 µm particle sizes. The backup filter may be moved forward to eliminate unnecessary stages and the remaining stages may be loaded with substrates behind the backup filter, or a suitable spacer may be used. Seal the openings of the filter holder or impactor with paraffin film or teflon tape to prevent sample contamination until ready for use.

9.4 *Test Apparatus:*

9.4.1 Prior to the start of testing the test dust should be characterized to determine if the dust meets the specified parameters for mass mean diameter and percent less than 2.5 µm as described in 8.1. This characterization should consist of three impactor test runs conducted in the raw gas channel upstream of the filter test specimen. The procedures for conducting these tests are described in Appendix C, section 4.3.3 of the "Draft Test/QA Plan for the Verification Testing of Baghouse Filtration Products," 10/26/00. The dust characterization should be conducted with each new shipment of test dust and every three months thereafter.

9.4.2 Prior to the first test and once each calender quarter thereafter, the test laboratory should verify the accuracy of the test apparatus by running a set of three (3) thirty normal filtration cycle tests with a reference fabric and comparing the results with established values for final residual pressure drop and fabric sample weight gain. The baseline data (established values) shall have been developed by the test laboratory on a reference fabric of their choice and the data spreadsheet should be maintained and kept on file at the laboratory. The test procedure and data quality objectives for these reference accuracy tests is described in Section 2.4 of the "Generic Verification Protocol for Baghouse Filtration Products," 9/01.

9.4.3 Prior to each test or series of tests, determine the instrument settings necessary to obtain a filtration velocity of 120 metres per hour (6.6 FPM) measured in the clean gas channel and a dust feed rate of 100 g/h ± 20 g/h, measured at the dust feed scale, and a raw gas volume of 5.8 ± 0.3 m^3/h (3.4 ± 0.2 cfm). It is not necessary to establish a tare weight of the fabric sample before performing this operation.

10. Test Procedure

10.1 A test consists of three sequential phases the conditioning period, the recovery period and the performance test period.

10.1.1 *Conditioning Period*—Load the sample filter specimen in the test apparatus as specified in the "Generic Verification Protocol for Baghouse Filtration Products," 9/01, Attachment A, VDI Method 3926, Part 2. Subject the specimen to 10 000 pulses at 3-5 seconds per pulse intervals in a controlled laboratory setting under the test conditions listed in Table 1 and Table 2. The conditioning period may be stopped and restarted provided that the test conditions for dust flow rate, raw gas flow rate, and filtration velocity are met. In the event these requirements are not met, the test is void and repeated using a new filter test specimen.

10.1.2 *Fabric Recovery Period*—Continue to operate the test apparatus under the conditions specified in 10.2.2, Table 1, and Table 2 except that the test specimen is now subjected to thirty normal filtration cycles rather than 10 000 rapid pulse cycles. The recovery period does not need to immediately follow the conditioning period, but must proceed without additional handling, dust loading, or pulsing of the test specimen. If the specifications for dust flow rate, raw gas flow rate, and filtration velocity are not met during this test phase, the test is void and should be repeated using a new test specimen.

10.1.3 *Performance Test Period*—Prior the performance test period load the dust feed hopper with enough test dust to ensure smooth operation for the two hour performance test period (six hour minimum for PM 2.5 measurements). Load absolute filter or impactor in place at the end of the clean gas channel. Operate the test apparatus at the conditions specified in 10.2.2, Table 1, and Table 2. In the event the specifications for dust flow rate, raw gas flow rate, and filtration velocity are not met, the test is considered void and should be repeated using a new test specimen.

10.1.3.1 During the performance test period the test specimen is subjected to normal filtration cycle pulsing. Continue following the dust loading, filtration velocity, and data capture requirements of 10.2.2. At a minimum the following parameters must be measured and recorded.

Parameter	Units	Recorded Frequency
Residual Pressure Drop	Pa	Once/filtration cycle
Filtration Cycle Time	seconds	Once/filtration cycle
Number filtration cycles	#	Once/filtration cycle
Raw Gas Flow	m^3/h	Once/minute
Clean Gas Flow	m^3/h	Once/minute

All critical flow rates are continuously monitored throughout all phases of the test and all rates are calculated on a block average for each 60 consecutive minutes during the test period and for the last 60 minutes of the test. For example, if a test ran 125 minutes, measurements would get averaged for 1-60, 61-120, and 66-125 minutes. These block averages will be the basis for all flow rates recorded during all three periods (phases) of the test.

10.2 *Sample Recovery and Handling:*

10.2.1 *Test Specimen:*

10.2.1.1 Manually pulse the test specimen ten times while the test apparatus is not in operation. This will facilitate removal of the test specimen.

10.2.1.2 Remove the test specimen holder assembly from the test apparatus and place it on a flat surface with the collection side up. Brush or wipe any excess dust from the test specimen holder, taking care not to add weight to the specimen.

10.2.1.3 Remove the test specimen from the specimen assembly and place the specimen in its labeled weigh container.

10.2.1.4 Weigh the specimen to the nearest 0.01 g.

10.2.2 *Absolute Filter or Impactor Substrates:*

10.2.2.1 Remove filter holder or impactor assembly from test apparatus and transport to clean dry surface.

10.2.2.2 Recover filter or each impactor stage substrate into the corresponding weigh foil using clean tweezers, taking care not to lose any sample. Brush any excess dust or filter fibers that remain on the filter support member or impactor stages into the corresponding weigh foils using the recovery brush.

10.2.2.3 Condition the filters or impactor samples using the procedures listed in 9.2.

10.2.2.4 Record the post-weight of the filter or each substrate using the weighing and handling procedures of 9.3.1 and 9.3.2.

11. Calculation

11.1 The following is a list defining the terms used in the calculation of test results.

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 impactor, g
$M_{2.5}$ = Total mass gain of particles equal to or less than 2.5 µm diameter from 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, EF
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.

11.2 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

11.3 *Equations:*

11.3.1 Area of Sample Fabric – A_f

$$A_f = (\pi * d^2)/4$$

11.3.2 Actual Gas Flow Rate – Q_a

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

11.3.3 Gas-to-Cloth Ration-G/C

$$G/C = Q_a / A_f$$

11.3.4 Standard Dust Feed Concentrations-F_s, for a specified time-t

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

11.3.5 Actual Raw Gas Dust Concentration-F_a

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

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

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

11.3.7 Dry Standard Clean Gas Particulate Concentration, Total Mass-PM-2.5 – $C_{2.5ds}$

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

11.3.8 Filtration Cycle Time– t_c

$$t_c = t/N$$

11.3.9 Average Residual Pressure Drop- P_{avg}

$$P_{avg} = * P_i / N$$

12. Precision and Bias

12.1 Table 1 provides the test specifications for the test method. All experimental variables must fall within the specified ranges for a valid test.

12.2 *Precision*—The precision for data from a test (see 4.2) is calculated as the standard deviation of the three test runs, relative to the arithmetic average of the three runs. Based on intra-laboratory testing the method was able to achieve precision of 38 % to 150 % for filter media providing particulate removal efficiencies ranging from 99.998 to 99.999 %.

12.3 *Bias*—The bias of a measurement system is checked using a laboratory-chosen reference fabric (see 8.10 and 9.1.2) as the most practical approach. As noted in 9.1.2, continued monitoring of the weight gain under conditions specified in Table 1 should be within 10 % of the arithmetic average for the measurement process to be considered "in control." Based on intra-laboratory testing, the measurement system is able to achieve a bias of 3.5 % to 12 %.

13. Keywords

13.1 baghouse; dry filtration; dust collection; fabric filter; fabric testing; filter bags; filter media