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

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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 in parenthesis are for information only.

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D461 Test Methods for Felt (Withdrawn 2003)[3]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
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F740 Definitions of Terms Relating to Filtration (Withdrawn 2002)[3]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 of Terms Specific to This Standard:*

3.1.1 *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.

3.1.2 *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.

3.1.3 *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).

3.1.4 *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

[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. Availble from Beuth Verlag GmbH, 10772 Berlin, Germany.

specimen. The filtration cycle is the time period between two consecutive cleaning or pulse cycles.

3.1.5 *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.

3.1.6 *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.

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

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

3.1.9 *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.

3.1.10 *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.

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

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 A30 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.

6.1.4 The relative humidity and temperature at which the test is conducted is known to have an effect on the test 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).

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.

7.1.15.2 High resolution analytical balance, capable of measurement to 0.00001 grams. The balance must be equipped