



# Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel<sup>1</sup>

This standard is issued under the fixed designation E2515; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method is applicable for the determination of particulate matter emissions from solid-fuel-burning appliances including woodstoves, pellet-burning appliances, factory-built fireplaces, masonry fireplaces, masonry heaters, indoor furnaces, and indoor and outdoor hydronic heaters within a laboratory environment.

1.2 Analytes will be a particulate matter (PM) with no CAS number assigned. For data quality objectives, see [Appendix X1](#).

1.3 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.

1.4 *This test method 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:*<sup>2</sup>

[D2986 Practice for Evaluation of Air Assay Media by the Monodisperse DOP \(Diocetyl Phthalate\) Smoke Test](#)<sup>3</sup>

[E2558 Test Method for Determining Particulate Matter Emissions from Fires in Low Mass Wood-Burning Fireplaces](#)

[E2618 Test Method for Measurement of Particulate Emissions and Heating Efficiency of Outdoor Solid Fuel-Fired Hydronic Heating Appliances](#)

[E2779 Test Method for Determining Particulate Matter Emissions from Pellet Heaters](#)

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.54 on Solid Fuel Burning Appliances.

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

<sup>3</sup> Withdrawn. The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

[E2780 Test Method for Determining Particulate Matter Emissions from Wood Heaters](#)

[E2817 Test Method for Test Fueling Masonry Heaters](#)

2.2 *AISI Documents:*<sup>4</sup>

[AISI 316 Stainless Steel](#)

2.3 *NIST Documents:*<sup>5</sup>

[NIST Monograph 175 Standard Limits of Error](#)

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *laboratory environment*—the area or room that is used for the storage, weighing, assembly, disassembly, and desiccation of filters and related equipment (sample recovery and analysis).

3.1.2 *particulate matter (PM)*—all gas-borne matter resulting from combustion of solid fuel, as specified in the appliance operation test method, that is collected and retained by the specified filter and probe system under the conditions of the test.

3.1.3 *test facility*—the area in which the tested appliance is installed, operated, and sampled for emissions.

## 4. Summary of Test Method

4.1 The total flue-gas exhaust from a solid fuel burning appliance is collected along with ambient dilution air with a collection hood. Duplicate sampling trains are used to extract gas samples from the dilution tunnel for determination of particulate matter concentrations. Each sample train has two glass fiber filters in series. The samples are withdrawn at a consistently proportional rate from sampling points located at the centroid of a sampling tunnel. During sampling, the filters are maintained at a temperature less than 32°C (90°F). The mass of the sampled particulate matter is determined gravimetrically after the removal of uncombined water. The total particulate matter mass collected on the filters and in the probe and front filter housing are multiplied by the ratio of the dilution tunnel flow to sample flow to determine the total particulate emissions during a test.

<sup>4</sup> Available from American Iron and Steel Institute (AISI), 1140 Connecticut Ave., NW, Suite 705, Washington, DC 20036, <http://www.steel.org>.

<sup>5</sup> Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

4.2 The sampling system for this test method consists of duplicate dual-filter dry sampling trains. Both of the particulate sampling trains are operated simultaneously at a sample flow rate not to exceed 0.007 m<sup>3</sup>/min (0.25 cfm/min). The total particulate results obtained from the two sampling trains are averaged to determine the particulate emissions and are compared as a quality control check on the data validity.

4.3 The particulate concentration results for each sampling train is adjusted by the particulate concentration result from a single room air sample blank collected and processed the same as the dilution tunnel particulate sampling trains described in 4.2, except that only one filter is used in the sampling train. A metering system as described in 6.1.1.4 shall be used to determine the volume of room air collected. The sample flow rate shall not exceed 0.007 m<sup>3</sup>/min (0.25 cfm).

4.4 Appliances tested by this test method are to be fueled and operated as specified in appliance-specific test methods such as, but not limited to, Test Methods E2558, E2618, E2779, E2780, or E2817.

## 5. Safety

5.1 *Disclaimer*—This test method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to performing this test method.

## 6. Equipment and Supplies

6.1 *Sample Collection*—The following equipment is required for sample collection:

6.1.1 *Particulate Sampling Train*—Two separate, complete particulate sampling trains (also referred to as “sampling trains”) are required for each test run. The filter face velocity shall not exceed 150 mm/sec (30 ft/min) during the test run. The dry gas meter shall be calibrated for the same flow rate

range as encountered during the test runs. The sampling train configuration is shown in Fig. 1 and consists of the following components.

6.1.1.1 *Filter Holder Assembly*—The filter holder assembly is shown in Fig. 2 and consists of the following components:

(1) *Filter Holders*—The primary (front) filter holder shall be aluminum or PTFE.<sup>6</sup> The backup (rear) filter holder may be made of materials such as polycarbonate.<sup>7</sup> With such plastic materials, it is recommended not to use solvents when cleaning the filter holder parts. Mild soap and distilled water can be used for cleaning plastic filter holder parts. The two filter holders shall be placed in series with the backup filter holder located 25 to 100 mm (1 to 4 in.) downstream from the primary filter holder. The filter holders shall be capable of holding a filter with 47 mm diameter. The holder design shall provide a positive seal against leakage from the outside or around the filters. The use of a porous glass or ceramic frit to support the first (front) filter is not allowed. Any type of filter support is allowed for the second (rear) filter.

(2) *Probe Assemblies*—Probe assemblies shall consist of the following components assembled to provide a leak-tight seal:

(a) Front half of front filter holder as specified in 6.1.1.1(1).

(b) *Probe*—The probe shall be constructed from seamless stainless steel (that is, AISI 316 or grade more corrosion resistant) 6.35 mm (¼ in.) outside diameter (O.D.) and 0.30 to 0.45 m (12 to 18 in.) in length, with a wall thickness such that the total weight of the probe and front filter housing can be weighed to an accuracy of 0.1 mg.

<sup>6</sup> The Pall (Gelman) 1235 filter holder has been found suitable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

<sup>7</sup> The Pall (Gelman) 1119 filter holder has been found suitable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

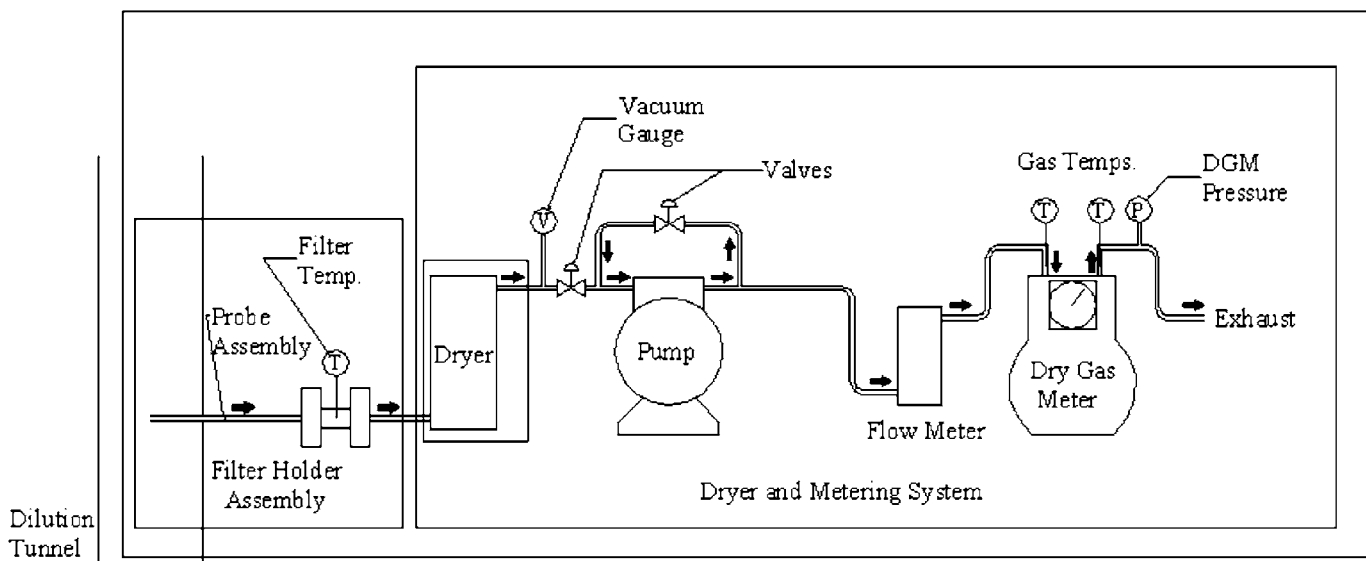


FIG. 1 Particulate Sampling Train

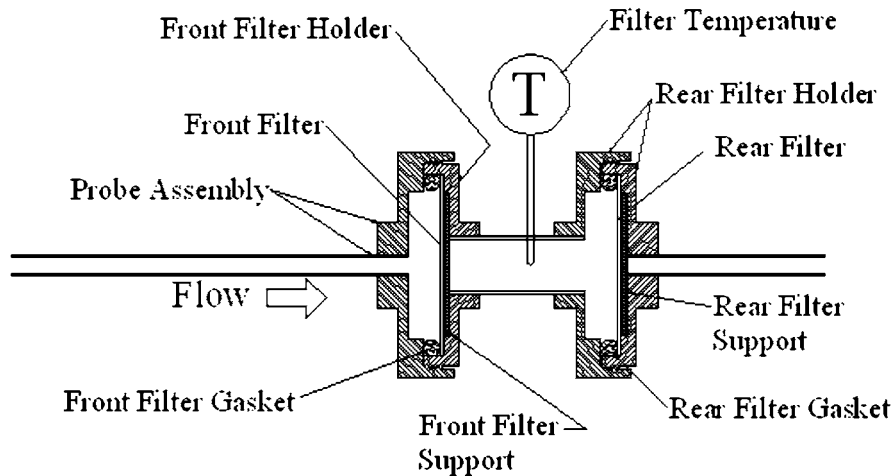


FIG. 2 Filter Holder Assembly

(3) Filters in accordance with 7.1.1.

(4) Filter Gaskets.

6.1.1.2 *Filter Temperature Monitoring System*—A temperature sensor capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2. The sensor shall be installed at the exit side of the front filter holder so that the sensing tip of the temperature sensor is in direct contact with the sample gas as shown in Fig. 2.

6.1.1.3 *Dryer*—Any system capable of removing water from the sample gas to less than 1.5 % moisture (volume percent) prior to the metering system. The system shall include a temperature sensor for demonstrating that sample gas temperature exiting the dryer is less than 27°C (80°F). See Fig. 1 for location of the dryer.

6.1.1.4 *Metering System*—The metering system shall include a vacuum gauge, leak-free pump, temperature sensors capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2, gas metering system capable of measuring the total volume sampled to within ± 2 % of the measured value, and related equipment, as shown in Fig. 1.

6.1.2 *Barometer*—Mercury, aneroid, or other barometer capable of measuring atmospheric pressure with an accuracy of ±2.5 mm Hg (0.1 in.). Must meet calibration requirements specified in 8.3.

NOTE 1—The barometric pressure reading may be obtained from a nearby National Weather Service station. In this case, the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be made at a rate of minus 2.5 mm Hg (0.1 in.) per 30 m (100 ft) elevation increase or plus 2.5 mm Hg (0.1 in) per 30 m (100 ft) elevation decrease.

6.1.3 *Dilution Tunnel Gas Temperature Measurement*—A temperature sensor capable of measuring with an accuracy of 2.2°C (4.0°F) or 0.75 % of the reading, which ever is greater and meeting the calibration requirements specified in 8.2.

6.1.4 *Pitot Tube*—A standard Pitot tube designed according to the criteria given in 6.1.4.1 shall be used to measure flow in

the dilution tunnel. Pitot tubes will have an assumed Pitot coefficient of 0.99 and be designed according to these specifications:

6.1.4.1 Standard Pitot design (see Appendix X2 for an example);

6.1.4.2 Hemispherical, ellipsoidal, or conical tip;

6.1.4.3 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes;

6.1.4.4 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90° bend;

6.1.4.5 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration; and

6.1.4.6 90° bend, with curved or mitered junction.

6.1.5 *Differential Pressure Gauge*—An inclined manometer or equivalent shall be readable to the nearest 0.127 mm (0.005 in.) water for Δp values greater than 2.54 mm (0.10 in.) water, and to the nearest 0.025 mm (0.001 in.) water for Δp values less than 2.54 mm (0.10 in.) water.

6.1.6 *Dilution Tunnel*—The dilution tunnel apparatus is shown in Fig. 3 and Fig. 4 and consists of the following components:

6.1.6.1 *Hood*—Constructed of steel. Hood shall be large enough to capture all of the flue-gas flow exiting the top of the appliance chimney. The dilution tunnel hood shall be conical with a minimum diameter at the entrance of at least four times the tunnel diameter. The height of the conical section shall be at least three tunnel diameters. A skirt can be used around the inlet to the conical section to insure capture of the flue-gas exhaust as shown in 9.2.4 as long as the requirements of 9.2.3 are met. The outlet of the conical section shall be sized to mate with the mixing section of the dilution tunnel. (See Fig. 3 and Fig. 4.)

6.1.6.2 *90° Elbows*—Steel 90° elbows should be used for connecting mixing section, the sampling section, and the optional damper assembly. There shall be at least two 90° elbows upstream of the sampling section. (See Fig. 3 and Fig.