



# Standard Test Method for Nuclear-Grade Activated Carbon<sup>1</sup>

This standard is issued under the fixed designation D3803; 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 a very stringent procedure for establishing the capability of new and used activated carbon to remove radio-labeled methyl iodide from air and gas streams. The single test method described is for application to both new and used carbons, and should give test results comparable to those obtained from similar tests required and performed throughout the world. The conditions employed were selected to approximate operating or accident conditions of a nuclear reactor which would severely reduce the performance of activated carbons. Increasing the temperature at which this test is performed generally increases the removal efficiency of the carbon by increasing the rate of chemical and physical adsorption and isotopic exchange, that is, increasing the kinetics of the radioiodine removal mechanisms. Decreasing the relative humidity of the test generally increases the efficiency of methyl iodide removal by activated carbon. The water vapor competes with the methyl iodide for adsorption sites on the carbon, and as the amount of water vapor decreases with lower specified relative humidities, the easier it is for the methyl iodide to be adsorbed. Therefore, this test method is a very stringent test of nuclear-grade activated carbon because of the low temperature and high relative humidity specified. This test method is recommended for the qualification of new carbons and the quantification of the degradation of used carbons.

1.1.1 Guidance for testing new and used carbons using conditions different from this test method is offered in **Annex A1**.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.*

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D28 on Activated Carbon and is the direct responsibility of Subcommittee D28.04 on Gas Phase Evaluation Tests.

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## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D1193 Specification for Reagent Water

D2652 Terminology Relating to Activated Carbon

D2854 Test Method for Apparent Density of Activated Carbon

E300 Practice for Sampling Industrial Chemicals

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

### 2.2 Code of Federal Regulations:

CFR Title 49, Section 173.34, “Qualification, Maintenance, and Use of Cylinders”<sup>3</sup>

CFR Title 49, Part 178, Subpart C, “Specifications for Cylinders”<sup>3</sup>

### 2.3 Military Standards:

MIL-F-51068D Filter, Particulate High Efficiency, Fire Resistant<sup>4</sup>

MIL-F-51079A Filter, Medium Fire Resistant, High Efficiency<sup>4</sup>

MIL-STD-45662 Calibration Systems Requirements<sup>4</sup>

### 2.4 Other Standards:

ANSI/ASME N45.2.6 Qualifications of Inspection, Examination, and Testing Personnel for Nuclear Power Plants<sup>5</sup>

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *counter efficiency (CE)*—the fraction of the actual number of disintegrations of a radioactive sample that is recorded by a nuclear counter.

3.1.2 *efficiency (E)*—the percentage of the contaminant removed from a gas stream by an adsorption bed; expressed mathematically as  $E = 100 - P$ , where E and P are given in percent.

<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> Published by the General Service Administration, 18th and “F” St., N. W., Washington, DC 20405.

<sup>4</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil>.

<sup>5</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

3.1.3 *penetration (P)*—the percentage of the contaminant ( $\text{CH}_3\text{I}$ ) which passes through the equilibrated test bed of standard depth, and is collected on the backup beds during the feed and elution periods under specified conditions.

3.1.4 *relative humidity (RH)*—for the purpose of this test method, relative humidity is defined as the ratio of the partial pressure of water in the gas to the saturation vapor pressure of water at the gas temperature and pressure. At temperatures below  $100^\circ\text{C}$ , this is the normal definition and relative humidity can range from 0 to 100 %.

3.2 *Definitions*—for additional terms relating to this standard, see Terminology D2652.

#### 4. Summary of Test Method

4.1 Both new and used carbons are first exposed to humid air (pressure, approximately 1 atm; temperature,  $30.0^\circ\text{C}$ ; relative humidity, 95 %) for a *pre-equilibration* period of 16 h. During this pre-equilibration period, the test system may be run unattended with the required parameter monitoring and adequate control devices. Following pre-equilibration, the air flow is continued for a two-hour *equilibration* period, during which the acceptable variability of all parameters is reduced. The test system must be closely monitored and controlled during the final four hours of the test. Qualification of personnel to perform this testing must meet or exceed ANSI/ASME N45.2.6—1978, Level II, which requires a combination of education and actual test system operation experience. During the *challenge* or feed period, radio-labeled methyl iodide at a mass concentration of  $1.75 \text{ mg/m}^3$  of humid air flow is passed through the beds for a period of 60 min. Following the feed period, humid air flow without test adsorbate is continued at the same conditions for a 60-min elution period. Throughout the entire test, the effluent from the sample bed passes through two backup beds containing carbon having a known high efficiency for methyl iodide. The two backup beds trap essentially all the radio-labeled methyl iodide that passes the test bed and provide a differential indication of their efficiency. At the end of the elution period, the gamma activity of  $^{131}\text{I}$  in the test and backup beds is measured by a gamma counter, and the percent of adsorbate penetrating the test bed is determined.

#### 5. Significance and Use

5.1 The results of this test method give a conservative estimate of the performance of nuclear-grade activated carbon used in all nuclear power plant HVAC systems for the removal of radioiodine.

#### 6. Apparatus

##### 6.1 Sample Preparation Apparatus:

6.1.1 *Riffle Sampler*, in accordance with 32.5.2 of Practice E300.

6.1.2 *Feed Funnel and Vibrator*, in accordance with the Procedure Section of Test Method D2854.

##### 6.2 Sample and Backup Bed Assemblies:

6.2.1 The sample bed canister and backup bed canisters must each be either a single unit capable of containing carbon

to a depth of  $50 \pm 1 \text{ mm}$ , or they may be assembled from two separate units each capable of containing carbon to a depth of 25 mm. Two backup canisters, each of  $50 \pm 1 \text{ mm}$  total depth, are required. Canisters may be reused after being decontaminated to remove residual radioactivity. An acceptable bed construction is shown in Fig. 1 with critical dimensions noted.

6.2.2 Clamping assemblies are needed for sample and backup beds. The only requirements for these assemblies are that they provide a smooth sealing face, uniform alignment of bed canisters, and sufficient clamping force so that the leak test in 10.2 can be met. A suggested design for clamping assemblies is shown in Fig. 2.

6.3 A schematic of a generalized test system is shown in Fig. 3. This system is designed to operate at approximately  $30^\circ\text{C}$  and 95 % relative humidity, with a gas flow of  $24.7 \text{ L/min}$

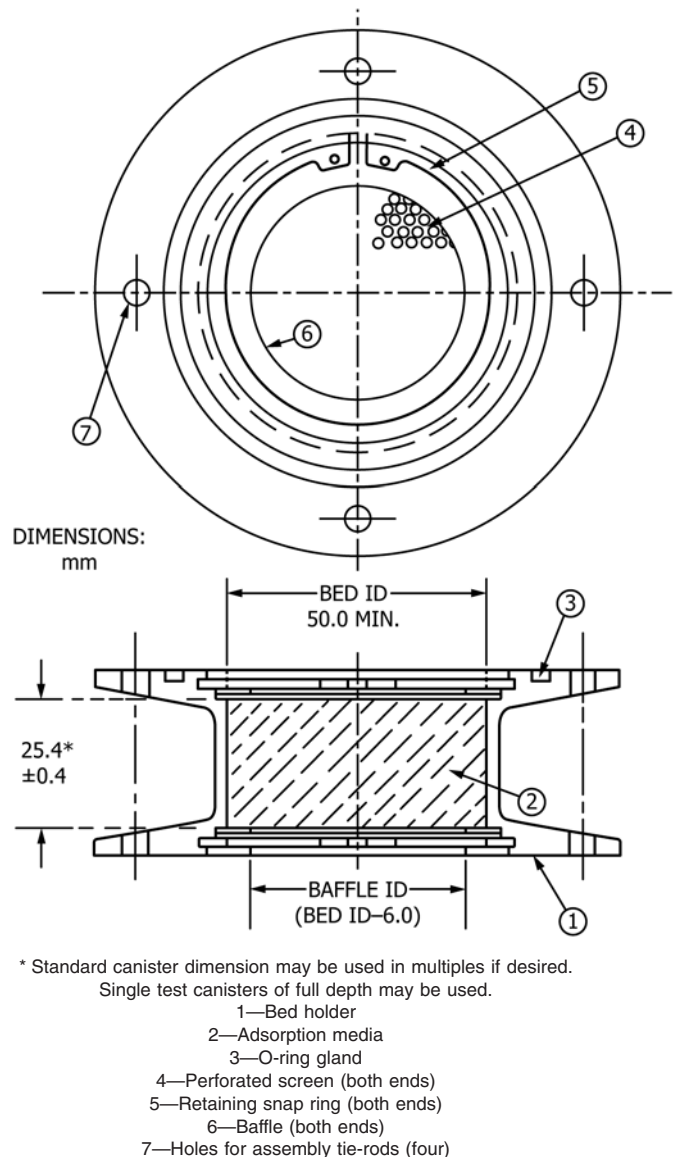


FIG. 1 Adsorption Media Test Bed Holder (Canister)

TABLE 1 Parameter Specifications

NOTE 1—Temperature, relative humidity, pressure, and gas velocity are to remain constant within the specified maximum variations throughout the entire test, that is, for each test period. Parameter excursions outside the limits specified in this table will invalidate the test results. If results based on a test containing such variations must be reported, then these variations must be noted in the comments section of the external report form and flagged in the parameter monitoring portion of the internal report.

Parameter	Pre-Equilibration (First 16 h)	Equilibration, Challenge, and Elution (Final 4 h)
Temperature, °C	30.0 ± 0.4	30.0 ± 0.2
Range	29.6 to 30.4	29.8 to 30.2
Relative humidity, %	91.0 to 96.0	93.0 to 96.0
Flow, m/min	12.2 ± 0.6	12.2 ± 0.3
Face velocity, m/min	11.6 to 12.8	11.9 to 12.5
Absolute pressure, kPa	101 ± 5	101 ± 5
Bed diameter and depth, mm	50 ± 1	50 ± 1
Adsorbate concentration, mg/m <sup>3</sup>	...	1.75 ± 0.25
Test durations:		
Pre-equilibration, h	16.0 ± 0.1	...
Equilibration, min	...	120 ± 1
Challenge, min	...	60 ± 1
Elution, min	...	60 ± 1

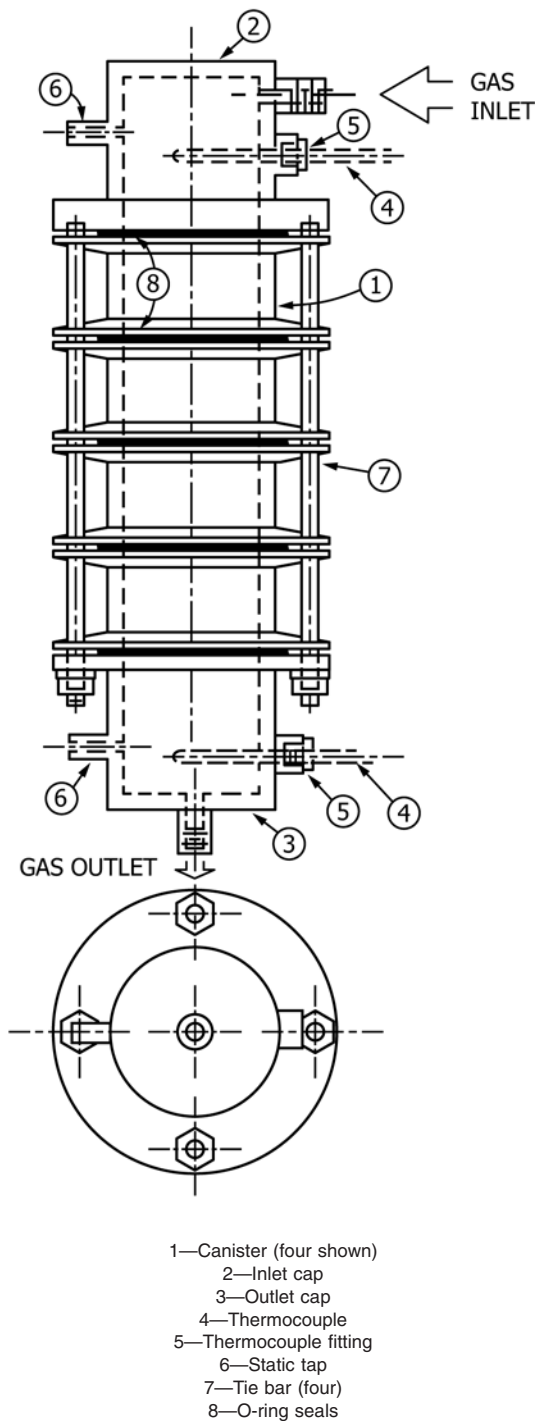


FIG. 2 Canister Assembly (Test or Backup Beds)

at atmospheric pressure. If test conditions which differ significantly from these are required, then separate calibrations or instrumentation, or both, may be required.

6.4 *Saturator System*—This system may be a controlled temperature saturator (bubbler) or spray chamber (environmental condition generator), or any other device of sufficient stability and capacity to supply the required mass flow of water vapor at test conditions.

6.5 *Flow Generator*—This system may be an air compressor upstream of the test system or a vacuum pump downstream of the test system. A dryer, carbon adsorber, and HEPA (high-efficiency particulate air) filter are required for either system to condition the inlet air. Flow measurement and control should be accurate and stable to within ±2 % of specified flow rate. System capacity shall meet or exceed the volumetric flow requirements as calculated from the specified face velocity. A surge tank and pressure control valve should be employed in either type of system to ensure stable and accurate flow measurement and control. For safety, it is important that the pressure system be equipped with a pressure relief valve. It is important that the pipe diameter and inlet air filters for a vacuum system be designed and maintained to minimize the pressure drop from ambient to ensure that the specifications for absolute pressure at the test bed are met (see Table 1).

6.6 *Moisture Separator*—A moisture separator should be used to protect the HEPA filter by removing large quantities of entrained particulate water, if present, after humidification. A HEPA filter (or equivalent) is required to function as a final droplet trap to remove small amounts of fine particulate water from the carrier gas ahead of the test bed.

6.7 *Adsorbate Supply*—This system shall consist of a stainless steel cylinder, pressure gage, pressure regulator, and a flow regulator capable of providing a steady flow of the challenge gas, that is, radio-labeled methyl iodide in dry nitrogen, for the duration of the test feed period. The point of injection into the main gas flow of the system must be such that the cross-sectional distribution of the adsorbate at the face of the test bed can be ensured to be homogeneous. A mixing chamber, baffles, glass beads, etc. should be used to achieve adequate mixing.

6.8 *Constant Temperature Cabinet*—An enclosure and associated thermoregulatory system must be used that is capable of maintaining the inlet gas stream temperature from the point of humidity control to the test bed, and the surface temperature of