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# Standard Test Method for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon<sup>1</sup>

This standard is issued under the fixed designation D 6646; 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 intended to evaluate the performance of virgin, newly impregnated or in-service, granular or pelletized activated carbon for the removal of hydrogen sulfide from an air stream, under the laboratory test conditions described herein. A humidified air stream containing 1 % (by volume) hydrogen sulfide is passed through a carbon bed until 50 ppm breakthrough of H<sub>2</sub>S is observed. The H<sub>2</sub>S adsorption capacity of the carbon per unit volume at 99.5 % removal efficiency (g H<sub>2</sub>S/cm<sup>3</sup> carbon) is then calculated. This test is not necessarily applicable to non-carbon adsorptive materials.

1.2 This standard as written is applicable only to granular and pelletized activated carbons with mean particle diameters (MPD) less than 2.5 mm. See paragraph 5.3 if activated carbons with larger MPDs are to be tested.

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.*

## 2. Referenced Documents

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

D 2652 ~~Definition of Terms Relating to Activated Carbon~~ Terminology Relating to Activated Carbon

D 2854 ~~Determination of Apparent Density of Activated Carbon~~<sup>2</sup> Test Method for Apparent Density of Activated Carbon

D 2867 Test For Methods for Moisture in Activated Carbon

E 300 Practice for Sampling Industrial Chemicals

## 3. Terminology

3.1 Terms relating to this standard are defined in D 2652.

## 4. Summary of Test Method

4.1 Breakthrough capacity is determined by passing a stream of humidified air containing 1 volume % hydrogen sulfide through a sample of granular or pelletized activated carbon of known volume under specified conditions until the concentration of hydrogen sulfide in the effluent gas reaches 50 ppmv.

## 5. Significance and Use

5.1 This method ~~was developed to compare~~ compares the performance of granular or pelletized activated carbons used in odor control applications, such as sewage treatment plants, pump stations, etc. The method ~~is a means of determining~~ determines the relative breakthrough performance of activated carbon for removing hydrogen sulfide from a humidified gas stream. Other organic contaminants present in field operations may affect the H<sub>2</sub>S breakthrough capacity of the carbon; ~~these are not addressed by this test. It is unlikely that this test will exactly simulate actual conditions encountered in an odor control application, and it is therefore meant only as a relative comparison method.~~ S breakthrough capacity of the carbon; these are not addressed by this test. This test does not simulate actual conditions encountered in an odor control application, and is therefore meant only to compare the hydrogen sulfide breakthrough capacities of different carbons under the conditions of the laboratory test.

5.2 This test does not duplicate conditions that an adsorber would encounter in practical service. The mass transfer zone in the

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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*, Vol 15.01, volume information, refer to the standard's Document Summary page on the ASTM website.

23 cm column used in this test is proportionally much larger than that in the typical bed used in industrial applications. This difference favors a carbon that functions more rapidly for removal of H<sub>2</sub>S over a carbon with slower kinetics. Also, the 1 % H<sub>2</sub>S challenge gas concentration used here engenders a significant temperature rise in the carbon bed. This effect may also differentiate between carbons in a way that is not reflected in the conditions of practical service.

5.3 This standard as written is applicable only to granular and pelletized activated carbons with mean particle diameters less than 2.5 mm. Application of this standard to activated carbons with mean particle diameters (MPD) greater than 2.5 mm will require a larger diameter adsorption column. The ratio of column inside diameter to MPD should be greater than 10 in order to avoid wall effects. In these cases it is suggested that bed superficial velocity and contact time be held invariant at the conditions specified in this standard (4.77 cm/sec and 4.8 sec). Although not covered by this standard, data obtained from these tests may be reported as in paragraph 12 along with additional information about column diameter, volume of carbon, and volumetric flow rate used.

5.4 For pelletized carbons, it is felt that the equivalent spherical diameter of the pellet is the most suitable parameter for determining the appropriate adsorption column inside diameter. The equivalent spherical diameter is calculated according to the following equation.

$$D_{eqv} = \frac{3 \times d \times h}{d + 2 \times h} \quad (1)$$

where:

$d$  = the diameter, and

$h$  = the length of the pellet in mm.

An average of 50 to 100 measurements is recommended to determine the average length of a pellet. Annex A3 is a table to guide the user in selecting bed diameter and flow rates from typical equivalent diameters (or MPD) of pelletized carbon.

## 6. Apparatus and Materials

6.1 ( $5 \pm 1$ ) % *Hydrogen Sulfide in Nitrogen Mixture*. The concentration of hydrogen sulfide in the gas test mixture must be known. It is recommended that gas cylinders specifically manufactured for holding hydrogen sulfide gas be used. Analyzed and certified hydrogen sulfide in nitrogen gas mixtures can be purchased from specialty gas suppliers. Annex A1 and Annex A2 present methods that may be used to check the hydrogen sulfide concentration of hydrogen sulfide/nitrogen gas mixtures. It is recommended that the hydrogen sulfide concentration be checked if gas cylinders are stored for more than three months, particularly after being partially depleted. Other organic contaminants that may be present in the hydrogen sulfide tank can affect the adsorption capacity of the carbon being tested.

6.2 *Hydrogen Sulfide Detector*. The hydrogen sulfide detector used in this test must be demonstrated to reliably detect 50 ppm hydrogen sulfide in a humidified air stream. In addition to certain “solid state” detectors, electrochemical type hydrogen sulfide sensors, e.g., Ecolyzer Model 6400 or Interscan LD-17, have been evaluated and fit this requirement. Other means of hydrogen sulfide detection may be selected, as long as they are carefully calibrated and evaluated for this application.

6.3 *Adsorption Tube*. The adsorption tube is shown in Fig. 1. Adsorption tubes are not commercially available; however, they can be custom fabricated by a scientific glassblower. The perforated support shown is necessary to support the carbon bed and to enhance diffusion of the gases. (Adjust dimensions accordingly from Annex A3, specifically diameter.)

6.4 *Flowmeter (0-500 mL/min Nitrogen; see Annex A3 for Guide to Higher Flow Range for Particles > 2.5 mm MPD)*. For hydrogen sulfide/N<sub>2</sub> control, it is recommended that the wettable parts of this flow meter be made of PTFE or other corrosion resistant material. Rotameter floats should be made from non-metallic materials such as glass or sapphire.

6.5 *Flowmeter (0-2000 mL/min Air; see Annex A3 for Guide to Higher Flow Range for Particles > 2.5 mm MPD)*.

NOTE 1—Mass flow controllers have been found to be more reliable than flowmeters and are highly recommended due to their ability to automatically maintain precise gas flow rates. Rotameters are satisfactory for this method, but may require more frequent attention in maintaining proper test gas flows for the duration of the test.

6.6 *Two Stage Cylinder Regulator, Suitable for Corrosive Gas Service, for Hydrogen Sulfide Gas Cylinder*.

6.7 *Air Line Pressure Regulator—Low Pressure*. To maintain up to 10 psig pressure for up to 2 liters of air/min flow rate (see Annex A3 for guide to airflow for tubes used for particles >2.5 mm MPD)

6.8 *Two Metering Valves*. Suitable valves are the Whitey SS-21-RS4 (H<sub>2</sub>S/N<sub>2</sub>) and B-21-RS4 (air). Other similar valves may be used. If the rotameters in 6.4 and 6.5 are equipped with their own high quality metering valves, these valves are not needed.

6.9 *Source of Dry, Contaminant-Free Air Capable of Delivering up to 2 liters/min Through the Test System* (higher flow for larger particles, >2.5 mm MPD, see Table A3.2.)

6.10 *Gas Bubbler*. (Ace Glass cat #5516 gas washing bottle equipped with gas dispersion fritted tube, cat. #7202, porosity code “C”, or equivalent to this.) The glass bubbler should be immersed in a constant temperature bath regulated at 25°C to ensure the generation of a 80 % RH air stream for the final gas mixture (after mixing with dry H<sub>2</sub>S/N<sub>2</sub>). The porous bubbler should be immersed under at least 3 inches of water to consistently saturate the air stream with water during the course of the test. (A larger gas washing bottle should be used if larger particles than 2.5 mm (Equivalent Diameter) and a larger bed are used. Increase size proportionately with air flow).

6.11 *Hydrogen Sulfide Calibration Gas Mixture*, 20 to 50 ppmv, in nitrogen, to be used as a span or calibration gas for the

# Adsorption Tube

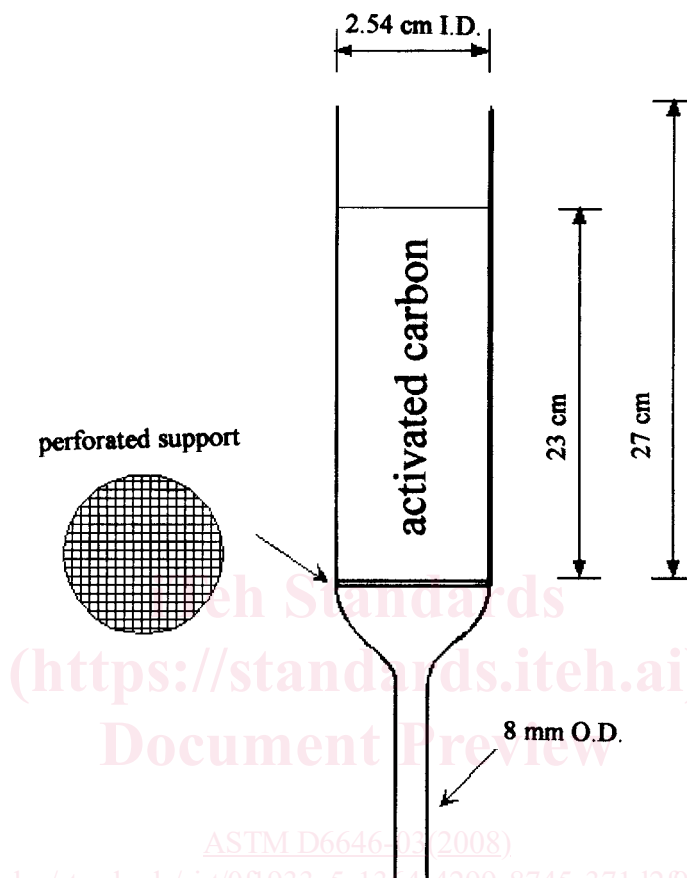


FIG. 1 Schematic of Adsorption Tube

hydrogen sulfide detector. (Available from specialty gas supply companies.)

6.12 *Timer*. A count up timer that can be tripped at the 50 ppmv set point of the H<sub>2</sub>S monitor and is capable of retaining the tripped time.

6.13 *Vibratory Feeder* (see ASTM D 2854).

6.14 *Powder Funnel*.

6.15 *Temperature Controlled Water Bath* to maintain the water bubbler at 25°C ± 2°C.

6.16 Other miscellaneous hardware needed to set up the apparatus in Fig. 2. Polyethylene tubing is suitable for carrying the H<sub>2</sub>S/N<sub>2</sub> flow. Clamped ball and socket joints are convenient for quick connect and disconnect of the absorption column and calibration bubbler (see Annex A2) from the system.

## 7. Safety Precautions

7.1 Several potential hazards are associated with conducting this test procedure. It is not the purpose of this standard to address all potential health and safety hazards encountered with its use. The user is responsible for establishing appropriate health and safety practices before use of this test procedure. Determine the applicability of Federal and State regulations before attempting to use this standard test method.

7.2 Personnel conducting the hydrogen sulfide adsorption capacity procedure should be aware of potential safety and health hazards associated with the chemicals used in this procedure. The “Material Safety Data Sheet” (MSDS) for each reagent listed in Section 6 should be read and understood. Special precautions to be taken during use of each reagent are included on the MSDS. First aid procedures for contact with a chemical are also listed on its MSDS. The MSDS for each reagent may be obtained from the manufacturer.

7.3 Safety and health hazard information on reagents used in this procedure may also be obtained from:

7.3.1 *Sax’s Dangerous Properties of Industrial Materials* / Richard J. Lewis, Sr., New York : J. Wiley, 2000.

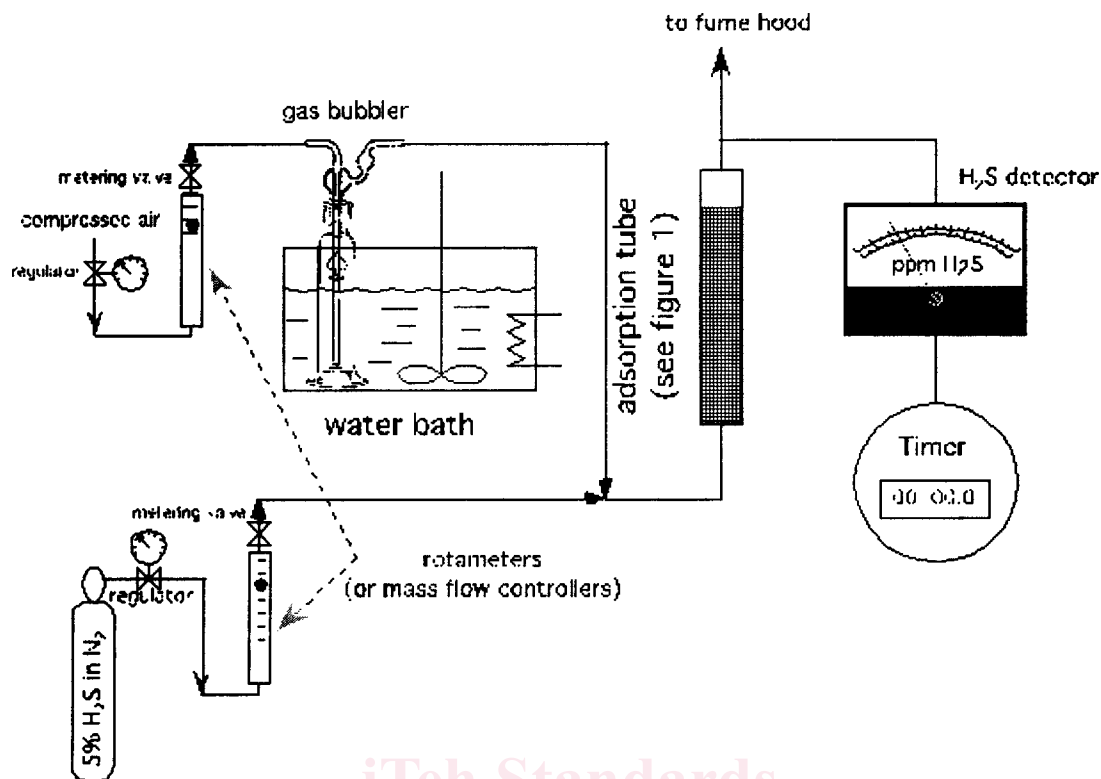


FIG. 2 Schematic of Apparatus for Determination of H<sub>2</sub>S Breakthrough Capacity

7.3.2 NIOSH/OSHA Pocket Guide to Chemical Hazards, 1997, U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C. Available from U.S. Government Printing Office, Washington, D.C. or at <http://www.cdc.gov/niosh/npg/npg.html>.

## 8. Sampling

8.1 Guidance in sampling granular activated carbon is given in recommended Practice E 300.

## 9. Calibration

9.1 Calibration of flowmeters, mass flow controllers, and hydrogen sulfide detectors shall be performed by standard laboratory methods.

NOTE 2—The test apparatus (Fig. 1) has metering valves at the rotameter outlets. This is done to minimize changes in gas flow rates caused by small backpressure changes during this long duration test. However, placement of metering valves in this position invalidates the atmospheric pressure calibration usually supplied by the rotameter manufacturer. The apparatus in A2.4.2 may be used to calibrate the rotameters. During this calibration, the gas delivery pressure must be the same as that used during the actual test.

9.2 Determine the percent H<sub>2</sub>S in the H<sub>2</sub>S/nitrogen tank using the methods outlined in Annex A1 or Annex A2 if the H<sub>2</sub>S/nitrogen tank was not certified by the manufacturer.

## 10. Procedure

10.1 Assemble the test apparatus as shown in the schematic diagram of Fig. 2.

10.2 Adjust the H<sub>2</sub>S/N<sub>2</sub> and air flow rates to generate a 1.0 % H<sub>2</sub>S stream at a total flow rate of 1450 cm<sup>3</sup>/min at the one-inch diameter adsorption tube (see Annex A3 for higher flowrates with larger than 2.5 mm (Equivalent Diameter) particles). This adjustment will depend on the concentration of H<sub>2</sub>S in the H<sub>2</sub>S/N<sub>2</sub> gas mixture.

10.3 Determine the H<sub>2</sub>S concentration of the actual mixed test gas using method(s) as outlined in Annex A1 or Annex A2 of this procedure. This test should be repeated if any adjustment is made on the flow meter(s).

10.4 Obtain a representative sample of the as-received granular or pelletized activated carbon to be tested. A 300 cm<sup>3</sup> sample is sufficient for apparent density, moisture and replicate performance testing. (A larger amount should be used if the particles larger than 2.5 mm (Equivalent Diameter) and a larger diameter bed are used).

10.5 Reduce the sample size to an aliquot for testing using the riffing procedure described in E 300.

10.6 Determine the apparent density of the sample by ASTM D 2854.

10.7 Use an adsorption tube whose volume has been calibrated to contain 116 mL (see Annex A3 for larger volumes) when filled from the top of the carbon support to a bed depth of approximately 22.9. (The calibrated volume for an adsorption tube can be