



Designation: D4084 – 07 (Reapproved 2017)

## Standard Test Method for Analysis of Hydrogen Sulfide in Gaseous Fuels (Lead Acetate Reaction Rate Method)<sup>1</sup>

This standard is issued under the fixed designation D4084; 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 covers the determination of hydrogen sulfide ( $H_2S$ ) in gaseous fuels. It is applicable to the measurement of  $H_2S$  in natural gas, liquefied petroleum gas (LPG), substitute natural gas, landfill gas, sewage treatment off gasses, recycle gas, flare gasses, and mixtures of fuel gases. This method can also be used to measure the hydrogen sulfide concentration in carbon dioxide. Air does not interfere. The applicable range is 0.1 to 16 parts per million by volume (ppm/v) (approximately 0.1 to 22 mg/m<sup>3</sup>) and may be extended to 100 %  $H_2S$  by manual or automatic volumetric dilution.

1.2 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

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

D1193 Specification for Reagent Water

D1914 Practice for Conversion Units and Factors Relating to Sampling and Analysis of Atmospheres

D2420 Test Method for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method)

D3609 Practice for Calibration Techniques Using Permeation Tubes

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.05 on Determination of Special Constituents of Gaseous Fuels.

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<sup>2</sup> 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.

D7166 Practice for Total Sulfur Analyzer Based On-line/At-line for Sulfur Content of Gaseous Fuels

E2165 Practice for Establishing an Uncertainty Budget for the Chemical Analysis of Metals, Ores, and Related Materials (Withdrawn 2007)<sup>3</sup>

### 3. Summary of Test Method

3.1 Measurement of  $H_2S$  is accomplished by ratiometrically comparing a reading of an unknown sample with that of a known standard using a differential colorimetric detection. Pure  $H_2S$  is used as a primary standard and mixed volumetrically with a sulfur free matrix gas that is ideally similar in composition to the sample gas. A gaseous sample at constant flow is humidified and passed over lead-acetate-impregnated paper.  $H_2S$  reacts with lead acetate to form a brown stain on the paper. The rate of reaction and resulting rate of color change is proportional to the concentration of  $H_2S$  in the sample. The analyzer is comprised of an optical system, a photon detection system, a signal differentiation system of first order, and a signal output system. When there is no change in the color of the tape, and no resulting change in photodetector output,  $E$ , the first derivative,  $dE/dt$ , is zero. This results in an analyzer that automatically zeroes when there is no  $H_2S$ .

### 4. Significance and Use

4.1 This test method is useful in determining the concentration of hydrogen sulfide in gaseous samples and in verifying compliance with operational needs and/or environmental limitations for  $H_2S$  content. The automated performance operation of this method allows unattended measurement of  $H_2S$  concentration. The user is referred to Practice D7166 for unattended on-line use of instrumentation based upon the lead acetate reaction rate method.

### 5. Apparatus

5.1 *Volumetric Measuring Devices*—A graduated 10-L cylinder (see Fig. 1) having a movable piston for volumetrically measuring test gas. Gastight syringes of 0.1 and 0.5-mL volume for volumetrically measuring 100 %  $H_2S$ . Gas tight

<sup>3</sup> The last approved version of this historical standard is referenced on www.astm.org.

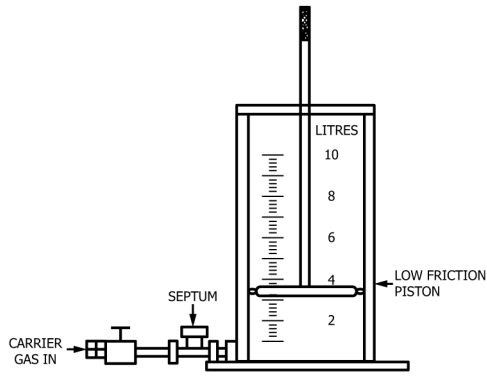


FIG. 1 Calibration Sample Preparation Cylinder with Movable Piston

5.2 *Sample Pump*—A pump capable of providing more than 8 mL/s (approximately 1 ft<sup>3</sup>/h) or less than 1 mL/s at 70 kPa (approximately 10.15 psig). Gas-wetted parts are ideally constructed from either aluminum or polytetrafluorethylene (PTFE). Stainless steel may be used when higher safety than afforded by aluminum or PTFE is required.

5.3 *Colorimetric Rate of Reaction Sensor*—Select a device of sufficient sensitivity to measure a minimum rate of change of color density corresponding to 0.1-ppm H<sub>2</sub>S by volume in the sample gas. (See Fig. 2.)

5.4 *Recorder*, having an adjustable span of 1 to 10-V full scale with an input impedance of 1 MΩ or higher. A printer or other output means, such as a data logger or Distributed Control System (DCS), can be used.

## 6. Reagents and Materials

NOTE 1—**Warning:** Hydrogen Sulfide contained in lecture bottles, permeation tubes or compressed gas cylinders may be flammable and harmful or fatal if ingested or inhaled. Lecture bottles, permeation tubes and compressed gas standards should only be handled in well ventilated

syringes of other volumes can be used. These graduated devices are not needed when the permeation tube method of dynamic mixing is used to prepare the reference sample since this method will generate a reference mixture.

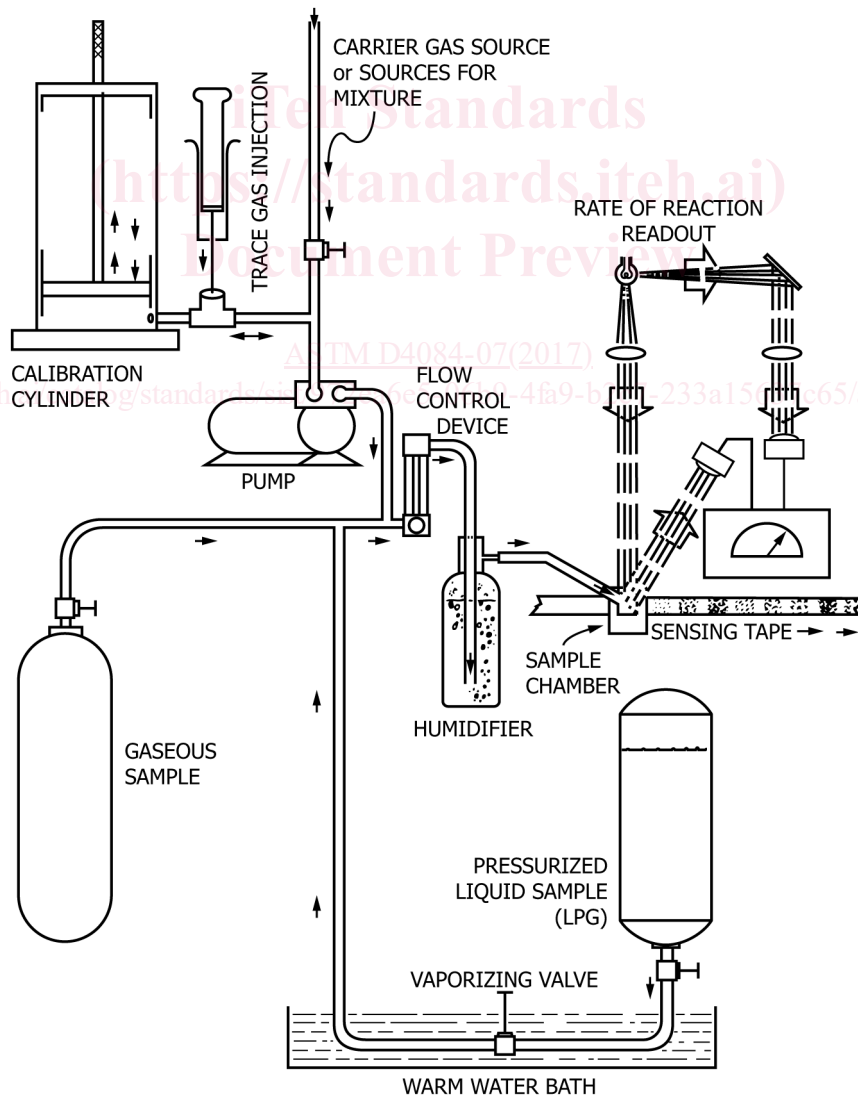


FIG. 2 Flow System for H<sub>2</sub>S Measurement Showing Calibration, LPG, and Gaseous Sample Connections

locations away from sparks and flames. Improper handling of compressed gas cylinders containing air, nitrogen or hydrocarbons can result in explosion. Rapid release of nitrogen or hydrocarbon gasses can result in asphyxiation. Compressed air supports combustion.

**6.1 Acetic Acid Solution**—Add 50 mL of glacial acid ( $\text{CH}_3\text{COOH}$ ) to distilled water or dionized water to make 1 L of solution (5 %). Type II distilled water as specified in Specification **D1193** is satisfactory for the dilution. Water dionized to 1 megaohm-centimeter is also satisfactory for the dilution.

### 6.2 Reference Gas:

**6.2.1 Hydrogen Sulfide Source**—99.5 % by volume purity or better. An alternative  $\text{H}_2\text{S}$  source is an  $\text{H}_2\text{S}$  mixture obtained using permeation tube procedures. Hydrogen sulfide generated from a solid heated to generate  $\text{H}_2\text{S}$  may be used instead of a  $\text{H}_2\text{S}$  source if desired.  $\text{H}_2\text{S}$  contained in permeation tubes or compressed gas cylinders may be flammable and harmful or fatal if ingested or inhaled. Permeation tubes and compressed gas standards should only be handled in well ventilated locations away from sparks and flames. (**Warning**—Hydrogen sulfide is an extremely toxic gas.)

**6.2.2 Dilution Gases**—Chemically pure grade or purified gas. Blend or obtain a sulfur-free gas of the same relative density as the sample gas to be analyzed. Blends of gases, of similar composition to the sample gas, are prepared from pure gases by mixing, using a 10-L cylinder with piston. Pipeline gas scrubbed through activated charcoal and sodium hydroxide-asbestos absorbent is satisfactory.

**6.2.3 Gas Mixtures**—Another alternative  $\text{H}_2\text{S}$  source is a certified  $\text{H}_2\text{S}$  mixture obtained from a gas standard vendor. Such mixtures are in a sulfur free carrier gas that is of the same type, or a close approximation, as the gas to be analyzed. These mixtures can be either a primary standard, which is then diluted to the desired  $\text{H}_2\text{S}$  concentration using a 10-L cylinder with a piston, or a standard in a pressurized cylinder containing the desired  $\text{H}_2\text{S}$  concentration. Because of the potential for degradation,  $\text{H}_2\text{S}$  mixtures obtained from a gas standard vendor must be properly stored and used only within the stated certification period. In the event of a discrepancy,  $\text{H}_2\text{S}$  mixtures prepared from a 99.5 % by volume or better purity  $\text{H}_2\text{S}$  lecture bottle or obtained using permeation tube procedures must be used.

**6.2.3.1 Compressed Gas Standards**—The protocol for compressed gas standards contained in the appendix can be used to ensure uniformity in compressed gas standard manufacture and provide for traceability to a NIST or NMi reference material.

**6.2.3.2 Compressed gas standard regulators** must be appropriate for the delivery of sulfur gases and attached fittings must be passivated or inert to sulfur gases.

**6.3 Lead Acetate Sensing Paper**—Prepare in accordance with Test Method **D2420**, using appropriate size strips and drying in an  $\text{H}_2\text{S}$ -free environment. Commercially available test paper has been found satisfactory. Used Lead Acetate Sensing Paper should be disposed of in accordance with local, state, and/or federal environmental regulations.

**6.4 Permeation Devices**—Hydrogen Sulfide standards can be prepared using a permeation tube gravimetrically calibrated and certified at a convenient operating temperature. At constant

temperature, calibration gases covering a wide range of concentration can be generated by varying and accurately measuring the flow rate of diluent gas passing over the tubes. These calibration gases are used to calibrate the analyzer.

**6.4.1 Permeation System Temperature Control**—Permeation devices are maintained at the calibration temperature within  $0.1^\circ\text{C}$ .

**6.4.2 Permeation System Flow Control**—The permeation flow system measures diluent gas flow over the permeation tubes within  $\pm 2$  percent.

**6.4.3 Permeation tubes** are inspected and weighed to the nearest 0.01 mg on at least a monthly basis using a balance calibrated against NIST traceable “S” class weights or the equivalent. Analyte concentration is calculated by weight loss and dilution gas flow rate as per Practice **D3609**. These devices are discarded when the liquid contents are reduced to less than ten (10) percent of the initial volume or when the permeation surface is unusually discolored or otherwise compromised. Used permeation tubes should be disposed of in accordance with local, state, and/or federal environmental regulations.

## 7. Sampling

**7.1** Because of the chemical activity and adsorptive properties of  $\text{H}_2\text{S}$ , it is highly desirable to connect the test apparatus directly to the sample source using minimum lengths of stainless steel, hastalloy, aluminum or fluorocarbon sample lines. Do not use copper containing, that is, brass or copper flow system parts. In the event that direct sampling is not practical, clean aluminum, stainless steel, or fluorocarbon lined sample containers may be used. Tedlar bags with inert fittings such as polypropylene or equivalent and silica lined sample containers can also be used for sample collection. Tedlar bags containing sample require protection from light and heat. The collection of samples that are either in two phases or that will form two phases before analysis can be performed must be avoided. The presence of liquids causes  $\text{H}_2\text{S}$  to partition unequally between the liquid and gas phases. Such a partition of  $\text{H}_2\text{S}$  results in inaccurate measurement of  $\text{H}_2\text{S}$  content. Samples must be analyzed with as little delay as possible and reported as “proximate analyses from cylinders” with length of residence time noted. Because of the broad reactivity of  $\text{H}_2\text{S}$ , an extended delay between obtaining the sample and analyzing the sample can result in inaccurate results.

**NOTE 2**—Each new sample container to be used for a test specimen can be filled with a sample and analyzed over a period of time and the resulting data examined to determine the rate of deterioration of the sample. Repeated filling with a representative sample will tend to passivate a container. Approximately 10 L (approximately  $\frac{1}{3}$  ft<sup>3</sup>) of sample, at atmospheric pressure, is convenient for analysis and will normally not deteriorate appreciably within 1 h. Slow instrument response to changes in  $\text{H}_2\text{S}$  concentration indicates the need for a thorough cleaning of the flow system. (See **Appendix X1** for a suggested cleaning procedure.) Errors caused by ambient temperature and pressure changes are compensated for by comparison to a reference standard prepared at the time of analysis. Preparation of the reference sample is described in **Section 11**.

## 8. Instrument Preparation

**8.1** Fill a humidifier or humidifying bubbler to the full mark with acetic acid solution. The acetic acid minimizes some interfering species. Set the range of the analyzer for the range