



Designation: D 516 – 02

Standard Test Method for Sulfate Ion in Water¹

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1. Scope

1.1 This turbidimetric test method covers the determination of sulfate in water in the range from 1 to 40 mg/L of sulfate ion (SO_4^{--}).

1.2 This test method was used successfully with drinking, ground, and surface waters. It is the user's responsibility to ensure the validity of this test method for waters of untested matrices.

1.3 Former gravimetric and volumetric test methods have been discontinued. Refer to **Appendix X1** for historical information.

1.4 *This standard does not purport to address 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:*

D 1066 Practice for Sampling Steam²

D 1129 Terminology Relating to Water²

D 1192 Specification for Equipment for Sampling Water and Steam in Closed Conduits²

D 1193 Specification for Reagent Water²

D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water²

D 3370 Practices for Sampling Water from Closed Conduits²

D 5847 Practice for Writing Quality Control Specifications for Standard Test Methods of Water Analysis³

E 60 Practice for Photometric and Spectrophotometric Methods for the Chemical Analysis of Metals⁴

E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near Infrared Spectrophotometers⁵

¹ This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.05 on Inorganic Constituents in Water.

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² *Annual Book of ASTM Standards*, Vol 11.01.

³ *Annual Book of ASTM Standards*, Vol 11.02.

⁴ *Annual Book of ASTM Standards*, Vol 03.05.

⁵ *Annual Book of ASTM Standards*, Vol 03.06.

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology **D 1129**.

4. Summary of Test Method

4.1 Sulfate ion is converted to a barium sulfate suspension under controlled conditions. A solution containing glycerin and sodium chloride is added to stabilize the suspension and minimize interferences. The resulting turbidity is determined by a nephelometer, spectrophotometer, or photoelectric colorimeter and compared to a curve prepared from standard sulfate solutions.

5. Significance and Use

5.1 The determination of sulfate is important because it has been reported that when this ion is present in excess of about 250 mg/L in drinking water, it causes a cathartic action (especially in children) in the presence of sodium and magnesium, and gives a bad taste to the water.

6. Interferences

6.1 Insoluble suspended matter in the sample must be removed. Dark colors that can not be compensated for in the procedure interfere with the measurement of suspended barium sulfate (BaSO_4).

6.2 Polyphosphates as low as 1 mg/L will inhibit barium sulfate precipitation causing a negative interference. Phosphonates present in low concentrations, depending on the type of phosphonate, will also cause a negative interference. Silica in excess of 500 mg/L may precipitate along with the barium sulfate causing a positive interference. Chloride in excess of 5000 mg/L will cause a negative interference. Aluminum, polymers, and large quantities of organic material present in the test sample may cause the barium sulfate to precipitate nonuniformly. In the presence of organic matter certain bacteria may reduce sulfate to sulfide. To minimize the action of sulfate reducing bacteria, samples should be refrigerated at 4°C when the presence of such bacteria is suspected.

6.3 Although other ions normally found in water do not appear to interfere, the formation of the barium sulfate suspension is very critical. Determinations that are in doubt may be checked by a gravimetric method in some cases, or by the procedure suggested in **Note 2**.

7. Apparatus

7.1 *Photometer*—One of the following which are given in order of preference.

7.1.1 Nephelometer or turbidimeter;

7.1.2 Spectrophotometer for use at 420 nm with light path of 4 to 5 cm;

7.1.3 Filter photometer with a violet filter having a maximum near 420 nm and a light path of 4 to 5 cm.

7.2 *Stopwatch*, if the magnetic stirrer is not equipped with an accurate timer.

7.3 *Measuring Spoon*, capacity 0.2 to 0.3 mL.

7.4 Filter photometers and photometric practices prescribed in this test method shall conform to Practice [E 60](#); spectrophotometer practices shall conform to Practice [E 275](#).

8. Reagents

8.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society.⁶ Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

8.2 *Purity of Water*—Unless otherwise indicated, reference to water shall be understood to mean reagent water conforming to Specification [D 1193](#), Type I. Other reagent water types may be used provided it is first ascertained that the water is of sufficiently high purity to permit its use without adversely affecting the precision and bias of the test method. Type II water was specified at the time of round robin testing of this test method.

8.3 *Barium Chloride*—Crystals of barium chloride ($\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$) screened to 20 to 30 mesh. To prepare in the laboratory, spread crystals over a large watch glass, desiccate for 24 h, screen to remove any crystals that are not 20 to 30 mesh, and store in a clean, dry jar.

8.4 *Conditioning Reagent*—Place 30 mL of concentrated hydrochloric acid (HCl, sp gr 1.19), 300 mL reagent water, 100 mL 95 % ethanol or isopropanol and 75 g sodium chloride (NaCl) in a container. Add 50 mL glycerol and mix.

8.5 *Sulfate Solution, Standard* (1 mL = 0.100 mg SO_4^{--})—Dissolve 0.1479 g of anhydrous sodium sulfate (Na_2SO_4) in water, and dilute with water to 1 L in a volumetric flask.

9. Sampling

9.1 Collect the sample in accordance with Practice [D 1066](#), Specification [D 1192](#), and Practices [D 3370](#), as applicable.

10. Calibration

10.1 Follow the procedure given in Section 11, using appropriate amounts of the standard sulfate solution prepared in accordance with [8.5](#) and prepare a calibration curve showing

sulfate ion content in milligrams per litre plotted against the corresponding photometer readings ([Note 1](#)). Prepare standards by diluting with water 0.0, 2.0, 5.0, 10.0, 15.0, 20.0, 30.0, and 40.0 mL of standard sulfate solution to 100-mL volumes in volumetric flasks. These solutions will have sulfate ion concentrations of 0.0, 2.0, 5.0, 10.0, 15.0, 20.0, 30.0, and 40.0 mg/L (ppm), respectively.

NOTE 1—A separate calibration curve must be prepared for each photometer and a new curve must be prepared if it is necessary to change the cell, lamp, or filter, or if any other alterations of instrument or reagents are made. Check the curve with each series of tests by running two or more solutions of known sulfate concentrations.

11. Procedure

11.1 Filter the sample if it is turbid, and adjust the temperature to between 15 and 30°C.

11.2 Pipet into a 250-mL beaker 100 mL or less of the clear sample containing between 0.5 and 4 mg of sulfate ion ([Note 2](#)). Dilute to 100 mL with water if required, and add 5.0 mL of conditioning reagent ([Note 1](#)).

NOTE 2—The solubility of BaSO_4 is such that difficulty may be experienced in the determination of sulfate concentrations below about 5 mg/L (ppm). This can be overcome by concentrating the sample or by adding 5 mL of standard sulfate solution (1 mL = 0.100 mg SO_4^{--}) to the sample before diluting to 100 mL. This will add 0.5 mg SO_4 to the sample, which must be subtracted from the final result.

11.3 Mix in the stirring apparatus.

11.4 While the solution is being stirred, add a measured spoonful of BaCl_2 crystals (0.3 g) and begin timing immediately.

11.5 Stir exactly 1.0 min at constant speed.

NOTE 3—The stirring should be at a constant rate in all determinations. The use of a magnetic stirrer has been found satisfactory for this purpose.

11.6 Immediately after the stirring period has ended, pour solution into the cell and measure the turbidity at 30-s intervals for 4 min. Record the maximum reading obtained in the 4-min period.

11.7 If the sample contains color or turbidity, run a sample blank using the procedure [11.2](#) through [11.6](#) without the addition of the barium chloride.

11.8 If interferences are suspected, dilute the sample with an equal volume of water, and determine the sulfate concentration again. If the value so determined is one half that in the undiluted sample, interferences may be assumed to be absent.

12. Calculation

12.1 Convert the photometer readings obtained with the sample to milligrams per litre sulfate ion (SO_4^{--}) by use of the calibration curve described in Section 10.

13. Precision and Bias⁷

13.1 The precision and bias data presented in this test method meet the requirements of Practice [D 2777](#) – 86.

13.2 The overall and single-operator precision of the test method, within its designated range, varies with the quantity

⁶ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

⁷ Supporting data are available from ASTM. Request RR:D-19-1145.