



Designation: D3920 – 18

Standard Test Method for Strontium in Water¹

This standard is issued under the fixed designation D3920; 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 (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of dissolved and total recoverable strontium in water and wastewater by atomic absorption spectroscopy.

1.2 The test method is applicable in the range from 0.1 to 1 mg/L of strontium. The range may be extended by dilution of the original sample.

1.3 Round-robin data were obtained in natural and reagent water matrices. It is the user's responsibility to ensure the validity of the test method for waters of untested matrices.

1.4 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.

1.5 *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.* Specific precautionary statements are given in 8.4 and 8.9.

1.6 *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:*²

D1129 Terminology Relating to Water

D1193 Specification for Reagent Water

D1976 Test Method for Elements in Water by Inductively-Coupled Argon Plasma Atomic Emission Spectroscopy

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 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.

D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
D3370 Practices for Sampling Water from Closed Conduits
D4691 Practice for Measuring Elements in Water by Flame Atomic Absorption Spectrophotometry
D4841 Practice for Estimation of Holding Time for Water Samples Containing Organic and Inorganic Constituents
D5673 Test Method for Elements in Water by Inductively Coupled Plasma—Mass Spectrometry
D5810 Guide for Spiking into Aqueous Samples
D5847 Practice for Writing Quality Control Specifications for Standard Test Methods for Water Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *total recoverable strontium, n*—a descriptive term relating to the forms of strontium that are determinable by the digestion procedure described in this test method.

3.2.2 *laboratory control sample, n*—a solution with a certified concentration of the strontium.

4. Summary of Test Method

4.1 Strontium is determined by atomic absorption spectrophotometry. The sample is aspirated into an air-acetylene flame following the addition of lanthanum chloride/potassium chloride solution. Samples containing particulate matter that may clog the aspirator capillary or burner, thus producing inaccurate results, are filtered through a 0.45- μ m membrane filter prior to testing.

5. Significance and Use

5.1 Although most potable supplies contain little strontium, some well waters in the midwestern part of the United States have levels as high as 39 mg/L.³

5.2 This test method affords a reliable means of accurately determining strontium and correcting calcium results obtained by the methods cited in 6.2.

³ *Standard Method for the Examination of Water and Wastewater*, 14th Ed. American Public Health Assn., Washington, DC 20005.

*A Summary of Changes section appears at the end of this standard

5.3 ICP-MS or ICP-AES may also be appropriate but at a higher instrument cost. See Test Methods [D1976](#) and [D5673](#).

6. Interferences

6.1 Chemical interference caused by silicon, aluminum, and phosphate is controlled by adding lanthanum chloride. Potassium chloride is added to suppress the ionization of strontium.

NOTE 1—A nitrous oxide-acetylene flame has been used successfully by some to remove chemical interferences.

6.2 Strontium chemically resembles calcium and causes a positive error in gravimetric and titrimetric methods for calcium determination.

7. Apparatus

7.1 *Atomic Absorption Spectrophotometer* for use at 460.7 nm. A general guide for the use of flame atomic absorption applications is given in Practice [D4691](#).

NOTE 2—The manufacturer's instructions should be followed for setting instrumental parameters.

7.2 *Strontium Hollow-Cathode Lamp*.

8. Reagents and Materials

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, where such specifications are available.⁴ 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 [D1193](#), Type I, II, and III water. Type I is preferred and more commonly used. 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.

NOTE 3—The user must ensure the type of reagent water chosen is sufficiently free of interferences. The water should be analyzed using the test method.

8.3 *Hydrochloric Acid* (sp gr 1.19)—Concentrated hydrochloric acid (HCl).

8.4 *Lanthanum Chloride/Potassium Chloride Solution*—Dissolve 11.73 g of lanthanum oxide (La_2O_3) in a minimum amount of concentrated hydrochloric acid (approximately 50 mL). Add 1.91 g of potassium chloride (KCl). Allow solution to cool to room temperature and dilute to 100 mL with water.

⁴ *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 *Annual Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

(**Warning**—Add acid slowly and in small portion to control the reaction rate upon mixing.)

8.5 *Nitric Acid* (sp gr 1.42)—Concentrated HNO_3 .

8.6 *Strontium Solution, Stock* (1.0 mL = 1.0 mg Sr)—Dissolve 2.415 g of strontium nitrate ($\text{Sr}(\text{NO}_3)_2$) in a 1-L flask containing 10 mL of concentrated HCl and 700 mL of water. Dilute to 1000 mL with water. A purchased strontium stock solution of appropriate known purity is also acceptable.

8.7 *Strontium Solution, Standard* (1 mL = 0.010 mg Sr)—Dilute 5.0 mL of strontium solution standard to 500 mL with water.

8.8 *Oxidant*—Air that has been cleaned and dried through a suitable filter to remove oil, water, and other foreign substances, is the usual oxidant.

8.9 *Fuel*—Standard, commercially available acetylene is the usual fuel. Acetone, always present in acetylene cylinders, can be prevented from entering the burner system by replacing the cylinder when the pressure reaches 490 kPa (70 psig). (**Warning**—Purified grade acetylene containing a special proprietary solvent other than acetone should not be used with poly (vinyl chloride) tubing as weakening of the walls may result and cause a potentially hazardous situation.)

8.10 *Filter Paper*—Purchase suitable filter paper. Typically the filter papers have a pore size of 0.45- μm membrane. Material such as fine-textured, acid-washed, ashless paper, or glass fiber paper are acceptable. The user must first ascertain that the filter paper is of sufficient purity to use without adversely affecting the bias and precision of the test method.

9. Sampling

9.1 Collect the samples in accordance with instructions in Practices [D3370](#). The holding time for the samples may be calculated in accordance with Practice [D4841](#).

9.2 To preserve the samples add concentrated HNO_3 (sp gr 1.42) to a pH of 2 or less immediately at the time of collection; normally about 2 mL/L is required. If only dissolved strontium is to be determined, filter (8.10) the samples at time of collection through a 0.45- μm membrane filter before acidification.

NOTE 4—Alternatively, the pH may be adjusted in the laboratory within 14 days of collection. This could reduce hazards of working with acids in the field when appropriate.

10. Standardization

10.1 An effective way to clean all glassware to be used for preparation of standard solutions or in the digestion step, or both, is by soaking the glassware for 2 h first with HNO_3 (1 + 1) and then rinsing with reagent water.

10.2 Prepare a blank and at least four working standards to bracket the expected strontium concentration range of the samples to be analyzed by diluting the standard strontium solution (8.6) to the desired concentrations. Select concentrations that will give a zero, middle, and maximum points for the analytical curve.

10.3 Pipette 10.0 mL of each standard into a 50-mL beaker or flask and add 1.0 mL of lanthanum chloride/potassium chloride solution. Mix well by swirling.

10.4 To test the suitability of reagents used in the analysis, zero the instrument while aspirating reagent water. Aspirate the zero standard and record the response. If the zero standard produces a response sufficient to affect the detection limit or accuracy, or both, of the test method, the contaminated reagent should be identified and replaced with a grade of suitable quality before proceeding.

10.5 Aspirate the blank (zero standard) and adjust the instrument reading to zero. Aspirate standards and record the instrument reading for each. Aspirate reagent water between each standard.

NOTE 5—Best results have been obtained with a slightly fuel rich flame.

10.6 Read directly in concentration if this capability is provided with the instrument or measure the absorbance of the standards or construct an analytical curve by plotting the absorbance of standards versus milligrams of strontium per litre.

11. Procedure

11.1 For total recoverable strontium, add 5 mL of concentrated nitric acid (8.5) to 100 mL of the sample in a 250-mL Erlenmeyer flask, and mix well. Heat the sample (between 65°C and 95°C) on a steam bath/hot plate below boiling in a well-ventilated fume hood until the volume is reduced to 15 to 20 mL, making certain that the samples do not boil.

NOTE 6—When testing samples of brine or samples containing a large amount of solids, the amount of reduction in volume is left to the discretion of the analyst.

NOTE 7—Many laboratories have found block digestion systems a useful way to digest samples for trace metals analysis. Systems typically consist of either a metal or graphite block with wells to hold digestion tubes. The block temperature controller must be able to maintain uniformity of temperature across all positions of the block. The digestion block must be capable of maintaining a temperature between 65°C and 95°C. For trace metals analysis, the digestion tubes should be constructed of polypropylene and have a volume accuracy of at least 0.5 %. All lots of tubes should come with a certificate of analysis to demonstrate suitability for their intended purpose. If a block digestion system is used, reduced volumes of samples and reagents will be required. Make sure that the reagent volumes maintain the same proportions as in the macro method.

11.2 If color in the digested solution indicates the presence of partially oxidized materials, add additional nitric acid and approximately 90 mL of reagent water to the cooled solution and repeat the digestion as before. Repeat this step several times if necessary.

11.3 Cool and filter the digested solution through a suitable filter (such as fine-textured, acid-washed ashless paper; 8.10) into a 100-mL volumetric flask. Wash the filter paper 2 to 3 times and make up to volume with reagent water. A reagent blank (100 mL of reagent water and 5 mL of concentrated nitric acid) should be carried through the digestion process and treated as instructed in 10.4. An unacceptable high response could indicate that the nitric acid was of poor quality.

NOTE 8—If only dissolved strontium is to be determined, filter portion of the sample through a 0.45- μ m membrane filter and proceed with 11.4.

11.4 Pipette 10.0 mL of sample, or a dilution of the sample, into a 50-mL beaker or flask.

11.5 Add 1.0 mL of lanthanum chloride/potassium chloride solution (8.4) to each sample. Mix well by swirling.

11.6 Aspirate each sample and record its absorbance or concentration. Aspirate reagent water between each sample.

11.7 For instruments that do not readout directly in concentration, determine the strontium concentration of the aspirated solution from the analytical curve (10.6).

12. Calculation

12.1 Where dilutions have been made, calculate the concentration of strontium in the original sample as follows:

$$\text{Sr, mg/L} = A \times \frac{B}{C} \quad (1)$$

where:

- A = Sr read from the analytical curve (10.6), mg/L,
- B = total final volume of the diluted sample, and
- C = volume of original sample diluted.

13. Precision and Bias⁵

13.1 The overall precision (reagent and waters of choice) and the single-operator precision for reagent water, based on data from eight participating laboratories involving twelve operators, varies with the quantity measured within the designated range of the test method as shown in Fig. 1.

13.2 The single-operator precision for waters of choice can be defined by the expression $0.023 \leq S_o \leq 0.026$, with the mean precision value of 0.024 mg/L over the designated range.

13.3 Recoveries of known amounts of strontium in a series of prepared standards were as given in Table 1.

13.4 This test method was evaluated with reagent and natural water matrices. These data may not apply to waters of other matrices.

13.5 Precision and bias for this test method conforms to Practice D2777 – 77, which was in place at the time of collaborative testing. Under the allowances made in 1.4 of D2777 – 13, these precision and bias data do meet existing requirements for interlaboratory studies of Committee D19 test methods.

NOTE 9—The nitric acid digestion steps were not performed in the round-robin of this test method. It is an approved, recommended practice for determining total recoverable metals by atomic absorption spectrometry; however, its use can be expected to increase the variability of final results. The user should verify its suitability for a matrix of interest by evaluating recovery for spikes that have been taken through the digestion process (Guide D5810).

14. Quality Control (QC)

14.1 In order to be certain that analytical values obtained using these test methods are valid and accurate within the confidence limits of the test, the following QC procedures must

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D19-1054. Contact ASTM Customer Service at service@astm.org.