Designation: D 3352 – 94 (Reapproved 1999)

Standard Test Method for Strontium Ion in Brackish Water, Seawater, and Brines[1]

This standard is issued under the fixed designation D 3352; 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 soluble strontium ion in brackish water, seawater, and brines by atomic absorption spectrophotometry.

1.2 Samples containing from 5 to 2100 mg/L of strontium may be analyzed by this test method.

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:*

D 1129 Terminology Relating to Water[2]
D 1193 Specification for Reagent Water[2]
D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water[2]
D 3370 Practices for Sampling Water from Closed Conduits[2]

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 This test method is dependent on the fact that metallic elements, in the ground state, will absorb light of the same wavelength they emit when excited. When radiation from a given excited element is passed through a flame containing ground state atoms of that element, the intensity of the transmitted radiation will decrease in proportion to the amount of the ground state element in the flame. A hollow cathode lamp whose cathode is made of the element to be determined provides the radiation. The metal atoms[3] to be measured are placed in the beam of radiation by aspirating the specimen into an oxidant-fuel flame. A monochromator isolates the characteristic radiation from the hollow cathode lamp and a photosensitive device measures the attenuated transmitted radiation.

4.2 Since the variable and sometimes high concentrations of matrix materials in the waters and brines affect absorption differently, it is difficult to prepare standards sufficiently similar to the waters and brines. To overcome this difficulty, the method of additions is used in which three identical samples are prepared and varying amounts of a standard added to two of them. The three samples are then aspirated, the concentration readings recorded, and the original sample concentration calculated.

5. Significance and Use

5.1 This test method[4] can be used to determine strontium ions in brackish water, seawater, and brines.

6. Interferences

6.1 The chemical suppression caused by silicon, aluminum, and phosphate is controlled by adding lanthanum. The lanthanum also controls ionization interference.

7. Apparatus

7.1 *Atomic Absorption Spectrophotometer*—The instrument shall consist of atomizer and burner, suitable pressure-regulating devices capable of maintaining constant oxidant and fuel pressure for the duration of the test, a hollow cathode lamp for each metal to be tested, an optical system capable of isolating the desired line of radiation, an adjustable slit, a photomultiplier tube or other photosensitive device as a light measuring and amplifying device, and a read-out mechanism for indicating the amount of absorbed radiation.

7.1.1 *Multi-Element Hollow Cathode Lamps* are available and have been found satisfactory.

7.2 *Pressure-Reducing Valves*—The supplies of fuel and oxidant shall be maintained at pressures somewhat higher than the controlled operating pressure of the instrument by suitable valves.

[1] This test method is under the jurisdiction of ASTM Committee D-19 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] For additional information on atomic absorption, see the following references: Angino, E. E., and Billings, G. K., *Atomic Absorption Spectrophotometry in Geology*, Elsevier Publishing Co., New York, N.Y., 1967. Dean, J. A., and Rains, T. C., Editors, *Flame Emission and Atomic Absorption Spectrometry Vol 1 − Theory,* Marcel Dekker, New York, NY, 1969.

[4] Additional information is contained in the following references: Fletcher, G. F., and Collins, A. G., "Atomic Absorption Methods of Analysis of Oilfield Brines: Barium, Calcium, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Potassium, Sodium, Strontium, and Zinc," U.S. Bureau of Mines, Report of Investigations 7861, 1974, 14 pp. Collins, A. G., *Geochemistry of Oilfield Waters*, Elsevier Publishing Co., Amsterdam. The Netherlands, 1975.

TABLE 1 Compositions of Artificial Brine Samples

Sample No.	g/L			
	1	2	3	4
Sr	0.060	0.100	1.600	2.100
NaCl	24.0	170.0	80.0	200.0
KCl	0.5	2.0	1.5	3.0
KBr	1.0	2.0	2.0	2.0
KI	0.1	0.5	0.5	1.0
$CaCl_2$	1.5	3.0	2.0	5.0
$MgCl_2$	4.5	5.0	2.0	1.0
$BaCl_2$	0.05	1.0	0.5	0.5

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,[5] where such specifications are available. 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, references to water shall be understood to mean reagent water conforming to Specification D 1193, Type III.

8.3 *Lanthanum Solution* (5 % La)—Wet 58.65 g of lanthanum oxide (La_2O_3) with water. Add 250 mL of concentrated hydrochloric acid (sp gr 1.19) very slowly until the material is dissolved. Dilute solution to 1 litre with water.

8.4 *Strontium Solution, Standard* (1 mL = 1 mg Sr)—Dissolve 2.415 g of strontium nitrate [$Sr(NO_3)_2$] in 10 mL of concentrated hydrochloric acid (sp gr 1.19) and about 700 mL of water. Dilute solution to 1 L with water. One millilitre of this solution contains 1 mg of strontium.

8.5 *Oxidant, for Atomic Absorption Spectrophotometer*:

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

8.5.2 *Nitrous Oxide* may be required as an oxidant for refractory-type metals.

8.6 *Fuel, for Atomic Absorption Spectrophotometer*:

8.6.1 *Acetylene*—Standard, commercially available acetylene is the usual fuel. Acetone, always present in acetylene cylinders, can be prevented from entering and damaging the burner head by replacing a cylinder which only has 100 psig of acetylene remaining.

9. Sampling

9.1 Collect the sample in accordance with Practices D 3370.

10. Procedure

10.1 Strontium is determined at the 460.7-nm wavelength with an air-acetylene flame.

TABLE 2 Determination of Precision and Bias of Strontium Ion

Amount Added, mg/L	Amount Found, mg/L	S_O	S_T	± Bias	Statistically Significant (95 % Confidence Level)
60	63.48	2.96	8.49	+ 5.8	yes
100	99.5	4.12	11.84	−0.5	no
1600	1665.6	54.87	157.3	+ 4.1	no
2100	2167.2	71.12	203.9	+ 3.2	no

10.2 *Preliminary Calibration*—Using micropipets prepare standard strontium solutions containing 1 to 10 mg/L of strontium using the standard strontium solution and 50-mL volumetric flasks. Before making up to volume, add to each of these and to a blank, 5 mL of the lanthanum solution. Aspirate these standards and the blank (for background setting) and adjust the curvature controls, if necessary, to obtain a linear relationship between absorbance and the actual concentration of the standards.

10.3 Transfer an aliquot of water or brine (previously filtered through a 0.45-µm filter) to a 50-mL volumetric flask. The specific gravity of the water or brine can be used to estimate the strontium content of the sample and, thereby, serve as a basis for selecting the aliquot size that will contain about 0.1 mg of strontium. Fig. 1 shows the relationship between strontium concentration and specific gravity for some oilfield brines from the Smackover formation. The concentrations of strontium in the Smackover brines will not necessarily correlate with the concentrations found in other formations. Therefore, the user of this test method may find it necessary to draw a similar curve for brine samples taken from other formations. Add 5 mL of the lanthanum stock solution, dilute to volume, and aspirate. Calculate the approximate sample concentration from the preliminary calibration readings, and determine the aliquot size that will contain about 0.1 mg of strontium.

10.4 Transfer equal aliquots containing about 0.1 mg of strontium to three 50-mL volumetric flasks. Add no strontium standard to the first flask. With a micropipet add 0.1 mg to the second and 0.2 mg to the third.

10.5 Add 5 mL of the lanthanum solution to each of the three flasks and dilute to volume. Aspirate and record the absorbance readings for each sample.

11. Calculation

11.1 Calculate the concentration of strontium ion in the original sample in milligrams per litre as follows:

$$\text{Strontium concentration, mg/L} = \frac{V_1(A_s \times C_{std})}{V_2(A_{std} - A_s)}$$

where:

V_1 = volume of the diluted samples, mL,
V_2 = volume of the original sample, mL,
A_s = absorbance of dilute sample,
A_{std} = absorbance of one of the standard additions, and
C_{std} = concentration of the same standard addition as A_{std}, mg/L.

Since there are two standard additions, calculate for each and average the two results.

[5] *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.