Designation: D 1126 – 02

Standard Test Method for Hardness in Water[1]

This standard is issued under the fixed designation D 1126; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of hardness in water by titration. This test method is applicable to waters that are clear in appearance and free of chemicals that will complex calcium or magnesium. The lower detection limit of this test method is approximately 2 to 5 mg/L as $CaCO_3$; the upper limit can be extended to all concentrations by sample dilution. It is possible to differentiate between hardness due to calcium ions and that due to magnesium ions by this test method.

1.2 This test method was tested on reagent water only. It is the user's responsibility to ensure the validity of the test method for waters of untested matrices.

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 1066 Practice for Sampling Steam[2]

D 1129 Terminology Relating to Water[2]

D 1193 Specification for Reagent Water[2]

D 3370 Practices for Sampling Water from Closed Conduits[2]

D 5847 Practice for Writing Quality Control Specifications for Standard Test Methods for Water Analysis[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *equivalent per million (epm)*, *n*—a unit chemical equivalent weight of solute per million unit weights of solution.

3.1.2 *laboratory control sample*, *n*—a solution with certified hardness.

3.1.3 For definitions of other terms used in this test method, refer to Terminology D 1129.

4. Summary of Test Method

4.1 Calcium and magnesium ions in water are sequestered by the addition of disodium ethylenediamine tetraacetate. The end point of the reaction is detected by means of Chrome Black T[4], which has a red color in the presence of calcium and magnesium and a blue color when they are sequestered.

5. Significance and Use

5.1 Hardness salts in water, notably calcium and magnesium, are the primary cause of tube and pipe scaling, which frequently causes failures and loss of process efficiency due to clogging or loss of heat transfer, or both.

5.2 Hardness is caused by any polyvalent cations, but those other than Ca and Mg are seldom present in more than trace amounts. The term hardness was originally applied to water in which it was hard to wash; it referred to the soap-wasting properties of water. With most normal alkaline water, these soap-wasting properties are directly related to the calcium and magnesium content.

6. Interferences

6.1 The substances shown in Table 1 represent the highest concentrations that have been found not to interfere with this determination.

6.2 The test method is not suitable for highly colored waters, which obscure the color change of the indicator.

[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] 3–Hydroxy–4-(1–hydroxy-2–napththyl) azo-7–nitro–1 naphthalenesulfonic acid, sodium salt, Color Index 14645.

TABLE 1 Freedom of Reaction from Interferences

Substance	Maximum Concentration Without Interference in the Total Hardness Test, mg/L	Maximum Concentration Without Interference in the Calcium Hardness Test, mg/L
Aluminum, Al^{+++}	20	5
Ammonium, NH_4^+	[A]	2 000
Bicarbonate, HCO_3^-	...	500
Bromine, Br	...	2
Cadmium, Cd^{++}	20	...
Carbonate, CO_3^{--}	1 000	50
Chloride, Cl^-	10 000	...
Chlorine, Cl	...	2
Chromate, CrO_4^{--}	500	500
Cobalt, Co^{++}	0.3	...
Copper, Cu^{++}	20	2
Iron, ferric, Fe^{+++}	10[B]	20
Iron, ferrous, Fe^{++}	10[B]	20
Lead, Pb^{++}	20	5
Manganese, Mn^{++}	1[C]	10[C]
Nickel, Ni^{++}	0.5[D]	...
Nitrate, NO_3^-	500	500
Nitrite, NO_2^-	500	500
Phosphate, PO_4^{---}	100	...
Silicate, SiO_3^{--}	200	100
Strontium, Sr^{++}	[E]	[E]
Sulfate, SO_4^{--}	10 000	10 000
Sulfite, SO_3^{--}	500	500
Tannin, Quebracho	200	50
Tin, stannic, Sn^{++++}	10	5
Tin, stannous, Sn^{++}	10	5
Zinc, Zn^{++}	20	5

[A] No data are available.
[B] Iron will not interfere in concentrations up to 200 mg/L. However, the red color of the end point may return in about 30 s.
[C] Manganese will not interfere in concentrations up to 10 mg/L if a few crystals of $K_4Fe(CN)_6 \cdot 3H_2O$ are added to the buffer immediately before use.
[D] Accurate results can be obtained in the presence of 1 mg/L nickel, but the end point is slow under these conditions.
[E] If strontium is present, it will be titrated with calcium and magnesium.

7. Reagents

7.1 *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] 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.

7.2 *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.

7.3 *Ammonium Hydroxide Solution (1 + 4)*—Mix 1 volume of NH_4OH (sp gr 0.90) with 4 volumes of water.

7.4 *Buffer Solution*—Prepare the buffer solution in three steps as follows:

7.4.1 Dissolve 40 g of sodium tetraborate ($Na_2B_4O_7 \cdot 10H_2O$) in 800 mL of water.

7.4.2 Dissolve 10 g of sodium hydroxide (NaOH), 10 g of sodium sulfide ($Na_2S \cdot 9H_2O$), and 10 g of potassium sodium tartrate ($KNaC_4O_6 \cdot 4H_2O$) in 100 mL of water.

7.4.3 When cool mix the two solutions and add 1 g of magnesium disodium ethylenediamine tetraacetate, having a magnesium-to-EDTA mole ratio of 1 to 1. Make up to 1 L with water. Keep the solution bottle stoppered when not in use. The reagent will be effective for at least 1 month.

7.5 *Calcium Solution, Standard (1 mL = 0.20 mg $CaCO_3$)*—Dissolve 0.2000 g of $CaCO_3$ in 3 to 5 mL of HCl (1 + 4). Dilute to 1 L with water.

7.6 *Calcium Indicator*—Use powdered hydroxynaphthol blue,[6] or grind solid hydroxynaphthol blue to 40 to 50 mesh size.

7.7 *Hardness Indicator*—The hardness indicator can be prepared, stored, and used in liquid or powder form.

7.7.1 *Hardness Indicator Solution*—Dissolve 0.5 g of Chrome Black T[3] in 50 mL of diethanolamine or triethanolamine. Store the solution in a dark-colored bottle. This solution has a storage life of several months.

7.7.2 *Hardness Indicator Powder*—Grind 0.5 g of Chrome Black T[3] with 100 g of powdered sodium chloride. Use a dark-colored bottle for storage. The powder has a storage life of at least 1 year.

7.8 *Hydrochloric Acid (1 + 4)*—Mix 1 volume of concentrated hydrochloric acid (sp gr 1.19) with 4 volumes of water.

7.9 *Disodium Ethylenediamine Tetraacetate (Na_2H_2 EDTA) Solution, Standard (1 mL = 1.0 mg $CaCO_3$)*—Dissolve 3.8 g of disodium ethylenediamine tetraacetate dihydrate in approximately 800 mL of water. Adjust the pH of the solution to 10.5 with NaOH solution (50 g/L). Determine the concentration of this solution using the standard calcium solution, and that procedure in Section 9 that will be used for the sample analysis (9.1, 9.2, or 9.3). Adjust the concentration of the EDTA so that 1 mL will be equivalent to 1.0 mg of $CaCO_3$. Store the standard EDTA in polyethylene, plastic, or hard rubber bottles and restandardize monthly.

7.10 *Sodium Hydroxide Solution (50 g/L)*—Dissolve 50 g of sodium hydroxide in water and dilute to 1 L.

8. Sampling

8.1 Collect the sample in accordance with Practice D 1066 or Practices D 3370 as applicable.

9. Procedure

9.1 *Hardness*—Measure 50 mL of clear sample into an opaque white container or a clear colorless container utilizing a white background. Adjust the pH of the sample to 7 to 10 by adding NH_4OH solution or HCl solution. Add 0.5 mL of buffer

[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. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

[6] 3–Hydroxy-4 (2–hydroxy–4 sulfo–1 naphthyl) azo–2, 7–naphthalenedisulfonic acid, trisodium salt.