



Standard Test Method for Cyanogen Chloride in Water¹

This standard is issued under the fixed designation D4165; 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 cyanogen chloride in water. Cyanogen chloride is normally present only at very low concentrations; it is a very labile and sparsely soluble gaseous compound. Water samples may contain cyanogen chloride after the chlorination of waste waters containing cyanide or thiocyanate compounds.

1.2 Cyanogen chloride is unstable. A quick test using a spot plate or comparator as soon as the sample is collected may be the best test, reducing the loss of cyanogen chloride during the time lapse between sampling and analysis. (See Fig. 1 for a typical decay curve for cyanogen chloride in a solution.)

1.3 This test method has been used successfully with reagent water. The analyst is responsible for determining whether the test method is applicable to the water matrix being tested. Reference is made to Test Method D of Test Methods D2036 which is based on similar chemical reactions and has been evaluated by collaborative testing in this matrix.

1.4 The lower limit of detectability is 0.005 mg CN⁻/L.

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements are given in Note 1 and Note 2 and Section 9.

2. Referenced Documents

2.1 *ASTM Standards:*²

D1129 Terminology Relating to Water

D1193 Specification for Reagent Water

D2036 Test Methods for Cyanides in Water

D3370 Practices for Sampling Water from Closed Conduits

¹ This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.06 on Methods for Analysis for Organic Substances 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.

D3856 Guide for Management Systems in Laboratories Engaged in Analysis of Water

D4210 Practice for Intralaboratory Quality Control Procedures and a Discussion on Reporting Low-Level Data (Withdrawn 2002)³

D5789 Practice for Writing Quality Control Specifications for Standard Test Methods for Organic Constituents (Withdrawn 2002)³

D5847 Practice for Writing Quality Control Specifications for Standard Test Methods for Water Analysis

E60 Practice for Analysis of Metals, Ores, and Related Materials by Spectrophotometry

E275 Practice for Describing and Measuring Performance of Ultraviolet and Visible Spectrophotometers

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D1129.

4. Summary of Test Method

4.1 The water sample is mixed with a pyridine-barbituric acid solution and the color produced is measured with a spectrophotometer.

5. Significance and Use

5.1 The presence of cyanogen chloride in chlorinated sanitary and industrial effluents and therefore receiving waters is of concern because of its toxicity to aquatic life.

5.2 This test method provides an analytical procedure for measuring cyanogen chloride in water.

5.3 This test method is applicable for clean metal finishing and chlorinated sanitary and industrial effluents, and also can be used to establish process control of cyanide destruction by chlorination in waste water treatment facilities.

6. Interferences

6.1 Color and turbidity can interfere.

7. Apparatus

7.1 *Spectrophotometer or Filter Photometer*, suitable for measurement in the region of 578 nm, using 1.0-cm absorption

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

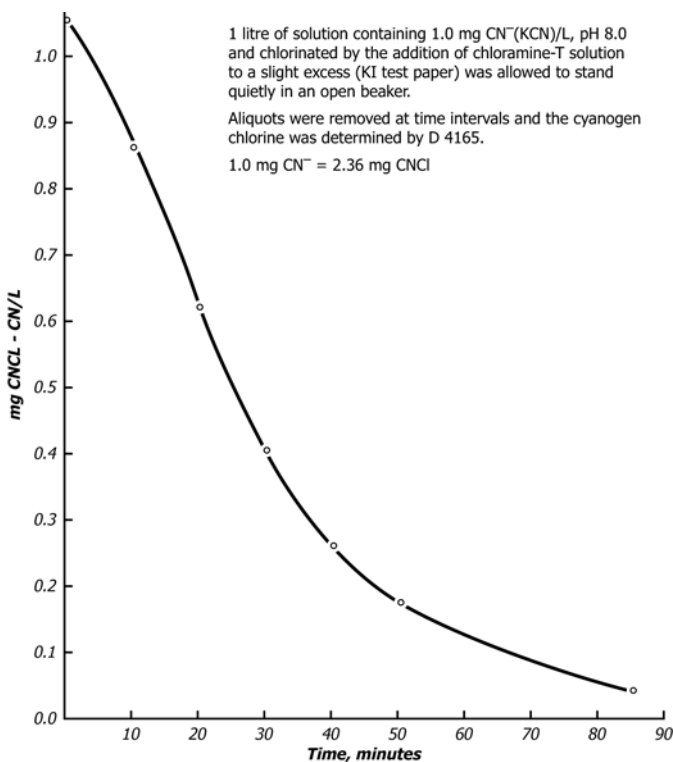


FIG. 1 Cyanogen Chloride Stability

cells. Filter photometers and photometric practices used in this test method shall conform to Practice E60. Spectrophotometers shall conform to Practice E275.

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, 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, references to water shall be understood to mean reagent water that meets the purity specifications of Type I or Type II water presented in Specification D1193.

8.3 Barbituric Acid.

8.4 *Chloramine-T Solution* (10 g/L)—Dissolve 1.0 g of the white colored, water-soluble grade powder chloramine-T in 100 mL of water. Store in an amber bottle under refrigeration. Prepare fresh weekly.

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 *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.

8.5 *Cyanide Solution, Stock* (1 mL = 250 µg CN⁻)—Dissolve 0.6258 g of potassium cyanide (KCN) in 40 mL of sodium hydroxide solution (40 g/L). Dilute to 1 L with water. Mix thoroughly; standardize with standard silver nitrate solution (see Section 8 of Test Methods D2036).

NOTE 1—**Warning:** Because KCN is highly toxic, avoid contact or inhalation. Do not pipet by mouth (see Section 9).

8.5.1 *Cyanide Solution I, Standard* (1 mL = 25 µg CN⁻)—Dilute a calculated volume (approximately 100 mL) of KCN stock solution to 1 L with NaOH solution (1.6 g/L).

8.5.2 *Cyanide Solution II, Standard* (1 mL = 2.5 µg CN⁻)—Dilute exactly 100 mL of cyanide Solution I to 1 L with NaOH solution (1.6 g/L).

8.5.3 *Cyanide Solution III, Standard* (1 mL = 0.25 µg CN⁻)—Dilute exactly 100 mL of cyanide Solution II to 1 L with NaOH solution (1.6 g/L). Prepare fresh solution daily and protect from light.

8.6 *Phosphate Buffer*—Dissolve 138 g of sodium dihydrogen phosphate (NaH₂PO₄·H₂O) in water and dilute to 1 L. Refrigerate this solution.

8.7 Pyridine.

NOTE 2—**Warning:** Pyridine may cause irritation to the skin and respiratory tract. Do not pipet by mouth (see Section 9).

8.8 *Pyridine-Barbituric Acid Reagent*—Place 15 g of barbituric acid in a 250-mL volumetric flask and add just enough water to wash the sides of the flask and wet the barbituric acid. Add 75 mL of pyridine and mix. Add 15 mL of hydrochloric acid (sp gr 1.19), mix, and cool to room temperature. Dilute to volume with water and mix until all of the barbituric acid is dissolved. This solution is usable for about 6 months if stored in a cold, dark place.

8.9 *Sodium Hydroxide Solution* (40 g/L)—Dissolve 40 g of sodium hydroxide in water and dilute to 1 L with water.

8.10 *Sodium Hydroxide Solution* (1.6 g/L)—Dilute 40 mL of NaOH (40 g/L) solution to 1 L with water.

9. Hazards

9.1 **Warning:** Because of the toxicity of cyanogen chloride and cyanide, great care must be exercised in its handling. Acidification of cyanide solutions produces toxic hydrocyanic acid (HCN). All manipulations should be done in a well-ventilated hood so that any HCN gas that might escape is safely vented.

9.2 **Warning:** Many of the reagents used in this test method are highly toxic. These reagents and their solutions must be disposed of properly (such as potassium cyanide and pyridine).

10. Sampling and Sample Preservation

10.1 Collect the sample in accordance with Practices D3370.

10.2 Collect a separate sample in a closed container. DO NOT ADD NaOH, as cyanogen chloride will be hydrolyzed to cyanate at pH 12 or more. As soon as possible after collection, analyze in accordance with Section 12. If the sample should be preserved and the pH is high, reduce the pH to the 8.0 to 8.5

range with careful additions of phosphate buffer when the sample is collected, and immediately cool to 4°C.

11. Standardization

11.1 Prepare a series of cyanide standard solutions by pipetting aliquots of cyanide Solution III into 50-mL volumetric flasks (see **Note 1**). Dilute to approximately 20 mL with NaOH solution (1.6 g/L).

NOTE 3—Aliquots should cover the concentration range expected in the samples.

11.2 Place 20 mL of NaOH solution (1.6 g/L) in a flask for a blank. (The procedure described in 11.3 through 11.6 should be performed on the blank also.)

11.3 Add 2 mL of chloramine-T solution and 4 mL of phosphate buffer, stopper, and mix by inversion two or three times.

11.4 Add 5 mL of pyridine-barbituric acid reagent, dilute to volume with water, mix thoroughly, and allow to stand exactly 8 min for color development.

11.5 Measure the absorbance at 578 nm in a 1.0-cm cell using water as a reference.

11.6 Calculate the slope and intercept of the calibration curve (see 13.1.1).

12. Procedure

12.1 Conduct the analysis immediately after sampling because cyanogen chloride is a volatile and labile compound. If spectrophotometric facilities are not available at the sampling site, the spot test described in Annex of Test Methods **D2036**, omitting the chloramine-T addition, should be used to establish the presence of cyanogen chloride.

12.2 Check the pH of the sample. If the pH is high and has not been adjusted at the time of sampling, measure out approximately a 50 to 100-mL volume and with careful additions of phosphate buffer, reduce the pH into the 8.0 to 8.5 range.

12.3 Pipet 20.0 mL of the sample into a 50-mL volumetric flask. If more than 0.25 mg CN⁻/L is known to be present, use a smaller aliquot, diluted to 20 mL with water. The accuracy of this test method is improved in the lower concentration; it is best not to exceed the concentration limit of 0.25 mg CN⁻/L.

12.4 Add 1 mL of phosphate buffer, stopper, and mix by inversion one time. Allow to stand 2 min.

12.5 Add 5 mL of pyridine-barbituric acid reagent, stopper and mix by inversion one time, allow the color to develop for 3 min, dilute to volume with water, mix thoroughly, and allow to stand an additional 5 min.

12.6 Measure the absorbance at 578 nm in a 1.0-cm cell in accordance with 11.5.

13. Calculation

13.1 Calculate the concentration of cyanogen chloride (CNCl) in milligrams per litre as follows:

13.1.1 *Slope and Intercept of Standard Curve:*

$$m = \frac{n \sum ca - \sum c \sum a}{n \sum a^2 - (\sum a)^2} \quad (1)$$

$$b = \frac{\sum a^2 \sum c - \sum a \sum ac}{n \sum a^2 - (\sum a)^2} \quad (2)$$

where:

a = absorbance of standard solution,
 c = concentration of CN in standard, mg/L,
 n = number of standard solutions,
 m = slope of standard curve, and
 b = intercept on c axis.

13.1.1.1 In **Eq 1** and **Eq 2**, the blank concentration, 0.0 mg/L, and the absorbance of the blank must be included.

13.1.2 *Concentration:*

$$\text{Cyanogen Chloride, as CN}^-, \text{ mg/L} \quad (3)$$

$$= (ma_1 + b) \times \frac{50}{\text{sample, mL}}$$

where:

a_1 = absorbance of sample solution.

14. Precision and Bias⁵

14.1 The instability of cyanogen chloride precludes round-robin testing procedures (see **Fig. 1**), so only single operator precision is provided.

14.2 Six operators have conducted duplicate analyses on different samples of various concentrations within the applicable range of the test method. From this study, the overall single operator precision of this test method within its designated range may be expressed as follows:

$$\log S_o = [0.5308 \log c] - 1.9842$$

$$\log R = [0.5292 \log c] - 1.8436$$

where:

S_o = single-operator precision in the range of this test method (mg/L). The precision is dependent on concentration (c , mg/L), and

R = range (mg/L) between duplicate determinations.

14.2.1 **Fig. 2** provides a plot of the precision of this test method.

14.3 These collaborative test data were obtained on reagent grade water. For other matrices, these data may not apply.

15. Quality Assurance/Quality Control

15.1 Before this test method is applied to the analysis of samples of unknown cyanogen chloride concentration, the analyst must establish quality control by procedures recommended in Practice **D4210** and Guide **D3856**.

15.2 A known standard must be run each day that the analysis is performed.

15.3 All analyses must be performed in duplicate since the instability of cyanogen chloride precludes spiking. The results

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D19-1100.

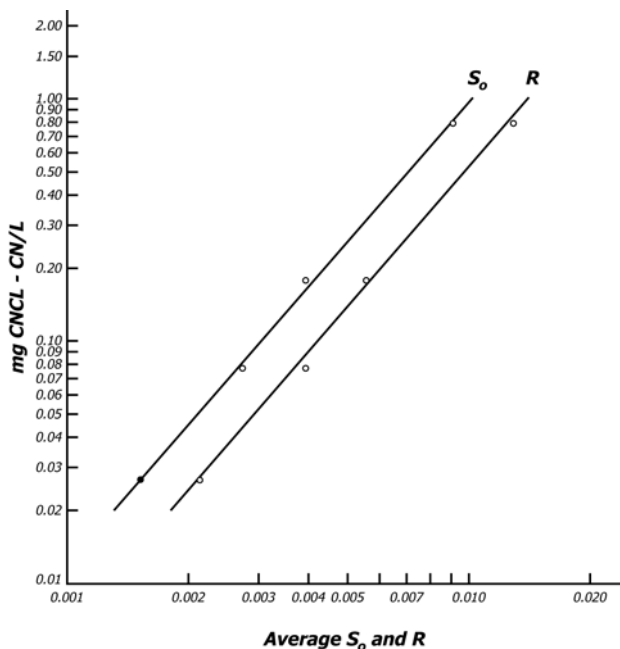


FIG. 2 Precision

must meet the limits established in Section 14 of this test method before the data are acceptable.

15.4 Analysts performing this test method will be required to measure their performance against the performance level achieved by interlaboratory (single-operator precision) study of the test method.

15.5 *Verification of Colorimetric Procedure:*

15.5.1 Prepare a series of cyanide standards including zero (blank), based on the expected concentration range of the samples, and follow the standardization (Section 11) each time new reagents are prepared or every six months.

15.5.2 The slope (m) of the standard curve should check the theoretical value. (1.0-cm cell, 0.22–0.24 mg CN/L/a; 5.0-cm cell, 0.044–0.048 mg CN/L/a; 10.0-cm cell, 0.022–0.024 mg CN/L/a).

15.5.3 At least one standard solution and one blank should be checked each time the procedure is used.

16. Keywords

16.1 cyanide; cyanogen chloride; pyridine-barbituric acid; spectrophotometer

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