Designation: E581 – 17

Standard Test Methods for Chemical Analysis of Manganese-Copper Alloys[1]

This standard is issued under the fixed designation E581; 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 These test methods cover the chemical analysis of manganese-copper alloys having chemical compositions within the following limits:

Element	Range, %
Copper	68.0 to 72.0
Manganese	28.0 to 32.0
Carbon	0.03 max
Iron	0.01 max
Phosphorus	0.01 max
Silicon	0.05 max
Sulfur	0.01 max

1.2 The test methods appear in the following order:

	Sections
Iron by the 1,10-Phenanthroline Spectrophotometric Method [0.003 % to 0.02 %]	11 – 20
Manganese by the (Ethylenedinitrilo) Tetraacetic Acid (EDTA)—Back-Titrimetric Method [28 % to 32 %]	21 – 27
Phosphorus by the Molybdivanadophosphoric Acid Extraction Spectrophotometric Method [0.002 % to 0.014 %]	28 – 38

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.*

1.5 *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]

D1193 Specification for Reagent Water

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E50 Practices for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials

E55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition

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

E88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition

E135 Terminology Relating to Analytical Chemistry for Metals, Ores, and Related Materials

E173 Practice for Conducting Interlaboratory Studies of Methods for Chemical Analysis of Metals (Withdrawn 1998)[3]

E1601 Practice for Conducting an Interlaboratory Study to Evaluate the Performance of an Analytical Method

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology E135.

4. Significance and Use

4.1 These test methods for the chemical analysis of metals and alloys are primarily intended to test such materials for compliance with compositional specifications. It is assumed that all who use these test methods will be trained analysts capable of performing common laboratory procedures skillfully and safely. It is expected that work will be performed in a properly equipped laboratory.

5. Apparatus

5.1 Spectrophotometers shall conform to the requirements prescribed in Practice E60.

[1] These methods are under the jurisdiction of ASTM Committee E01 on Analytical Chemistry for Metals, Ores, and Related Materials and are the direct responsibility of Subcommittee E01.05 on Cu, Pb, Zn, Cd, Sn, Be, Precious Metals, their Alloys, and Related Metals.

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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.

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

6. Reagents and Materials

6.1 Reagents required for each determination are listed in separate sections of each test method. The standard solutions and certain other reagents used in more than one procedure shall conform to the requirements prescribed in Practices E50.

6.2 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents 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.

6.3 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type I of Specification D1193.

7. Hazards

7.1 For precautions to be observed in this method, refer to Practices E50.

7.2 A warning statement is given in 24.7.

8. Sampling

8.1 For procedures for sampling the material, refer to Practices E55 and E88.

9. Rounding Calculated Values

9.1 Rounding of test results obtained using this test method shall be performed as directed in Practice E29, Rounding Method, unless an alternative rounding method is specified by the customer or applicable material specification.

10. Interlaboratory Studies

10.1 These test methods have been evaluated in accordance with Practice E173, unless otherwise noted in the precision section. The Reproducibility R_2 of Practice E173 corresponds to the Reproducibility Index R of Practice E1601. The Repeatability R_1 of Practice E173 corresponds to the Repeatability Index r of Practice E1601.

IRON BY THE 1,10-PHENANTHROLINE SPECTROPHOTOMETRIC METHOD

11. Scope

11.1 This test method covers the determination of iron from 0.003 % to 0.02 %.

[4] *Reagent Chemicals, American Chemical Society Specifications,* American Chemical Society, Washington, DC, www.chemistry.org. For suggestions on the testing of reagents not listed by the American Chemical Society, see the *United States Pharmacopeia and National Formulary,* U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD, http://www.usp.org.

TABLE 1 Statistical Information

Test Sample	Labs	Iron Found, %	Repeatability (r, Practice E1601)	Reproducibility (R, Practice E1601)
Manganese Copper	7	0.0137	0.0013	0.0028

12. Summary of Test Method

12.1 The sample is dissolved in HCl and hydrogen peroxide, and the excess oxidant removed by evaporation. The iron is extracted with methyl isobutyl ketone-benzene mixture. The iron is extracted from the organic phase into a hydroxylamine hydrochloride solution and the red-colored 1,10-phenanthroline complex is formed. Spectrophotometric absorbance measurement is made at 510 nm.

13. Iron Range

13.1 The recommended range is from 0.005 mg to 0.125 mg of iron per 50 mL of solution using a 2-cm cell.

NOTE 1—This test method has been written for cells having a 2-cm light path. Cells having other dimensions may be used, provided suitable adjustments can be made in the amounts of sample and reagents used.

14. Stability of Color

14.1 The color develops within 5 min and is stable for at least 4 h.

15. Interferences

15.1 Elements ordinarily present do not interfere if their percentages are under the maximum limits shown in 1.1.

16. Reagents

16.1 *Hydroxylamine Hydrochloride Solution* (10 g/L)—Dissolve 5.0 g of hydroxylamine hydrochloride ($NH_2OH·HCl$) in 500 mL of water. Prepare fresh as needed.

16.2 *Iron, Standard Solution A* (1 mL = 0.125 mg Fe)—Transfer 0.1250 g of iron (purity: 99.9 % min) to a 100-mL beaker. Add 10 mL of HCl (1 + 1) and 1 mL of bromine water. Boil gently until the excess bromine is removed. Add 20 mL of HCl, cool, transfer to a 1-L volumetric flask, dilute to volume, and mix.

16.3 *Iron, Standard Solution B* (1 mL = 0.00625 mg Fe)—Using a pipet, transfer 50 mL of iron solution A (1 mL = 0.125 mg Fe) to a 1-L volumetric flask, dilute to volume with HCl (1 + 49), and mix.

16.4 *Methyl Isobutyl Ketone-Benzene Mixture*—Mix 200 mL of methyl isobutyl ketone (MIBK) and 100 mL of benzene.

16.5 *1,10-Phenanthroline-Ammonium Acetate Buffer Solution*—Dissolve 1.0 g of 1,10-phenanthroline monohydrate in 5 mL of HCl in a 600-mL beaker. Add 215 mL of acetic acid, and, while cooling, carefully add 265 mL of NH_4OH. Cool to room temperature. Using a pH meter, check the pH; if it is not between 6.0 and 6.5, adjust it to that range by adding acetic acid or NH_4OH as required. Dilute to 500 mL.

17. Preparation of Calibration Curve

17.1 *Calibration Solutions:*

17.1.1 Using pipet, transfer (1, 2, 5, 10, 15, and 20) mL of iron solution B (1 mL = 0.00625 mg Fe) to 50-mL volumetric flasks. Dilute to 20 mL.

17.1.2 Add 20 mL of $NH_2OH·HCl$ solution, mix, and allow to stand 1 min. Proceed as directed in 17.3.

17.2 *Reference Solution*—Transfer 20 mL of water to a 50-mL volumetric flask and proceed as directed in 17.1.2.

17.3 *Color Development*—Add 5 mL of 1,10-phenanthroline-ammonium acetate buffer solution, dilute to volume, and mix. Allow to stand at least 5 min but not more than 4 h.

17.4 *Spectrophotometry:*

17.4.1 *Multiple-Cell Spectrophotometer*—Measure the cell correction using absorption cells with a 2-cm light path and a light band centered at 510 nm. Using the test cell, take the spectrophotometric absorbance readings of the calibration solutions.

17.4.2 *Single-Cell Spectrophotometer*—Transfer a suitable portion of the reference solution to an absorption cell with a 2-cm light path and adjust the spectrophotometer to the initial setting, using a light band centered at 510 nm. While maintaining this adjustment, take the spectrophotometric absorbance readings of the calibration solutions.

17.5 *Calibration Curve*—Plot the net spectrophotometric readings of the calibration solutions against milligrams of iron per 50 mL of solution.

18. Procedure

18.1 *Test Solution:*

18.1.1 Transfer a 2.0-g sample, weighed to the nearest 10 mg, to a 400-mL beaker.

18.1.2 Process a reagent blank through the entire procedure, using the same amounts of all reagents but with the sample omitted.

18.1.3 Add 25 mL of HCl (7 + 3) and then H_2O_2 as needed to dissolve the alloy completely. When dissolution is complete, add 20 mL of HCl and heat carefully to decompose excess H_2O_2. Cool to room temperature, transfer to a 125-mL conical separatory funnel. Add HCl (1 + 1), as required, to adjust the volume to 50 mL.

18.1.4 Add 20 mL of MIBK – benzene mixture to the separatory funnel and shake 1 min. Allow the phases to separate, discard the aqueous phase, wash the organic phase three times with 3-mL to 5-mL portions of HCl (1 + 1) to remove copper, and discard the washings. Extract the iron from the organic phase by shaking vigorously 30 s with 10 mL of $NH_2OH{\cdot}HCl$ solution. Transfer the aqueous phase to a 50-mL volumetric flask. Repeat the extraction with a second 10-mL portion of $NH_2OH{\cdot}HCl$ solution, and transfer the extract to the 50-mL flask. Dilute to 40 mL and proceed as directed in 18.3.

18.2 *Reference Solution*—Use the reagent blank solution prepared as directed in 18.1.2.

18.3 *Color Development*—Proceed as directed in 17.3.

18.4 *Spectrophotometry*—Proceed as directed in 17.4.

19. Calculation

19.1 Convert the net spectrophotometric absorbance reading of the test solution to milligrams of iron by means of the calibration curve. Calculate the percentage of iron as follows:

$$\text{Iron, \%} = A/(B \times 10) \quad (1)$$

where:

A = milligrams of iron found in 50 mL of the final test solution, and

B = grams of sample represented in 50 mL of the final test solution.

20. Precision and Bias

20.1 *Precision*—Seven laboratories cooperated in testing this test method and obtained the precision data shown in Table 1, which were calculated in accordance with Practice E1601. Although samples covered by this test method with iron percentages near the lower limit of the scope were not available for testing, the precision data obtained should apply.

20.2 *Bias*—The accuracy of this test method could not be evaluated because adequate certified standard reference materials were unavailable at the time of testing. The user is encouraged to verify by the use of certified reference materials, if available, that the accuracy of this test method is adequate for the contemplated use.

MANGANESE BY THE (ETHYLENEDINITRILO)TETRAACETIC ACID (EDTA)—BACK-TITRIMETRIC METHOD

21. Scope

21.1 This test method covers the determination of manganese from 28.0 % to 32.0 %.

22. Summary of Test Method

22.1 The sample is dissolved in HNO_3. Manganese is chelated with disodium (ethylenedinitrilo) tetraacetate (EDTA), which is added in excess. The pH of the solution is adjusted to 10 and sodium cyanide is added to complex copper. The manganese is then determined by back-titration with standard manganese solution.

23. Interferences

23.1 The elements ordinarily present do not interfere if their percentages are under the maximum limits shown in 1.1.

24. Reagents

24.1 *Buffer Solution* (pH 10)—Transfer 54 g of ammonium chloride (NH_4Cl) to a 1-L beaker, dissolve in 500 mL of water, add 350 mL of NH_4OH, dilute to 1 L, and mix. Store in a polyethylene bottle.

24.2 *Copper Solution* (25 g/L)—Transfer 2.50 g of copper (purity: 99.9 % min) to a 250-mL beaker. Add 20 mL of HNO_3 (1 + 1). When dissolution is complete, boil to expel oxides of nitrogen. Cool, dilute to 100 mL, and mix.

24.3 *Disodium (Ethylenedinitrilo)tetraacetic Acid Dihydrate (EDTA), Standard Solution* (0.05 *M*)—Dissolve 18.6127 g of disodium (ethylenedinitrilo) tetraacetate dihydrate in water, transfer to a 1-L volumetric flask, dilute to volume, and mix. The solution is stable for several months when stored in plastic or borosilicate glass bottles.

24.3.1 Standardize the solution as follows: Using a pipet, transfer 25 mL of zinc solution (0.050 *M*) to a 400-mL beaker.

Add 25 mL of buffer solution and dilute to about 250 mL. Add four drops to six drops of eriochrome black-T indicator solution and titrate with EDTA standard solution to the color change from magenta to blue. Calculate the molarity of the EDTA solution as follows:

$$\text{Molarity of } EDTA \text{ solution, } A = \frac{1.25}{B} \quad (2)$$

where:

A = molarity of EDTA solution, and
B = milliliters of EDTA solution required to titrate 25 mL of zinc standard solution (0.050 *M*).

24.4 *Eriochrome Black-T Indicator Solution* (8 g/L)—Dissolve 0.4 g of the sodium salt of eriochrome black-T in a mixture of 20 mL of ethanol and 30 mL of triethanolamine. This solution is stable for at least three months when kept in a tightly closed plastic dropping bottle.

24.5 *Hydroxylamine Hydrochloride Solution* (100 g/L)—Dissolve 5.0 g of hydroxylamine hydrochloride ($NH_2OH{\cdot}HCl$) in 50 mL of water. Prepare fresh as needed.

24.6 *Manganese, Standard Solution* (0.05 *M*)—Pretreat manganese metal (purity, 99.8% min) (Note 2) as follows: Wash in H_2SO_3, rinse with water, and dry. Store in a covered glass beaker in a desiccator. Transfer 2.7470 g, weighed to the nearest 0.1 mg (do not use small particles of metal) to a 150-mL beaker, and cover. Add 10 mL of HNO_3 (1 + 1). Heat gently until dissolution is complete and brown fumes are expelled. Cool, transfer to a 1-L volumetric flask, dilute to volume, and mix.

NOTE 2—For the analysis of high-manganese materials, the manganese metal must be assayed. This would include the determination of oxygen as well as all metallics.

24.6.1 Standardize as follows: Using a pipet, transfer 25 mL of the manganese solution to a 400-mL beaker. Add 10 mL of copper solution. Proceed as directed in 25.2. Calculate the EDTA equivalent of the solution as follows:

$$EDTA \text{ equivalent, mL } EDTA/\text{mL Mn} = 30.00/(25.00 \times C) \quad (3)$$

where:

C = milliliters of manganese solution required for titration of excess EDTA solution.

24.7 *Sodium Cyanide Solution* (200 g/L)—Dissolve 200 g of sodium cyanide (NaCN) in water, and dilute to 1 L. Store in a plastic bottle. (**Warning**—The preparation, storage, and use of NaCN solutions require care and attention. Avoid inhalation of fumes and exposure of the skin to the chemical or its solutions. Work in a well-ventilated hood. Refer to Practices E50.)

24.8 *Sodium Tartrate Solution* (250 g/L)—Dissolve 250 g of sodium tartrate in water, and dilute to 1 L. Store in a plastic bottle.

24.9 *Zinc, Standard Solution* (0.050 *M*)—Transfer 3.2690 g of zinc (purity: 99.9 % min) to a 400-mL beaker, and cover. Add 25 mL of HNO_3 (1 + 1) and warm gently until the zinc is dissolved. Boil to expel oxides of nitrogen. Cool, transfer to a 1-L volumetric flask, dilute to volume, and mix.

25. Procedure

25.1 Transfer a 5.0-g sample, weighed to the nearest 1 mg, to a 400-mL beaker, and cover. Cautiously, add 40 mL of HNO_3 (1 + 1) and warm gently until dissolution is complete. Boil to expel oxides of nitrogen. Cool, transfer to a 500-mL volumetric flask, dilute to volume, and mix. Using a pipet, transfer 25 mL of the test solution to a 400-mL beaker.

25.2 Add 10 mL of $NH_2OH{\cdot}HCl$ solution. Using a pipet, add 30 mL of EDTA solution, and mix. Add 5 mL of sodium tartrate solution, 25 mL of buffer solution, and 10 mL of NaCN solution, mixing after each addition. Adjust the volume to about 200 mL. Add four drops to six drops of eriochrome black-T indicator solution. Using a 10-mL buret, titrate the excess EDTA with manganese standard solution to the first permanent pink end point, and record the buret reading to the nearest 0.01 mL.

26. Calculation

26.1 Calculate the percentage of manganese as follows:

$$\text{Manganese, \%} = [30.00 - (D \times E)] \times F \times 21.98 \quad (4)$$

where:

D = milliliters of manganese standard solution required for back-titration of the test solution,
E = milliliters of EDTA standard solution equivalent to 1 mL of manganese standard solution (refer to 24.6), and
F = molarity of EDTA standard solution (refer to 24.3).

27. Precision and Bias

27.1 *Precision*—Eight laboratories cooperated in testing this test method and obtained the precision data summarized in Table 2.

27.2 *Bias*—The accuracy of this test method could not be evaluated because adequate certified standard reference materials were unavailable at the time of testing. The user is encouraged to verify by the use of certified reference materials, if available, that the accuracy of this test method is adequate for the contemplated use.

PHOSPHORUS BY THE MOLYBDIVANADOPHOSPHORIC ACID—EXTRACTION SPECTROPHOTOMETRIC METHOD

28. Scope

28.1 This test method covers the determination of phosphorus from 0.002 % to 0.014 %.

TABLE 2 Statistical Information

Test Sample	Labs	Manganese Found, %	Repeatability (R_1, Practice E173)	Reproducibility (R_2, Practice E173)
1. Manganese copper	7	30.44	0.20	0.32

TABLE 3 Statistical Information

Test Sample	Labs	Phosphorus Found, %	Repeatability (R_1, Practice E173)	Reproducibility (R_2, Practice E173)
1. Manganese copper	7	0.0021	0.0005	0.0015

29. Summary of Test Method

29.1 The sample is dissolved in HNO_3 and HCl. The quinquevalent phosphorus reacts with an excess of molybdate solution in the presence of vanadate to form the yellow molybdivanadophosphoric acid complex which is extracted into methyl isobutyl ketone. Spectrophotometric absorbance measurement is made at 400 nm.

30. Phosphorus Range

30.1 The recommended range is from 0.0035 mg to 0.07 mg of phosphorus per 15 mL of solution, using a 2-cm cell.

NOTE 3—This test method has been written for cells having a 2-cm light path. Cells having other dimensions may be used, provided suitable adjustments can be made in the amounts of sample and reagents used.

31. Stability of Color

31.1 Full color develops in the aqueous solution within 7 min. The extracted color is stable for at least 1 h.

32. Interferences

32.1 Elements ordinarily present in manganese copper alloys do not interfere if their percentages are under the maximum limits shown in 1.1.

33. Apparatus

33.1 Glassware must be phosphorus- and arsenic-free. Boil the glassware with HCl and rinse with water before use. It is recommended that the glassware used for this determination be reserved for this use only. Many detergents contain phosphorus and must not be used for cleaning purposes.

34. Reagents

34.1 *Ammonium Molybdate Solution* (100 g/L)—Dissolve 100 g of ammonium molybdate tetrahydrate ($(NH_4)_6Mo_7O_{24}\cdot 4H_2O$) in 600 mL of hot water, and dilute the solution to about 950 mL. Cool and dilute to 1 L. Store in a polyethylene bottle.

34.2 *Ammonium Vanadate Solution* (2.4 g/L)—Dissolve 2.4 g of ammonium vanadate (NH_4VO_3) in 500 mL of hot water. When dissolution is complete, add 20 mL of HNO_3 (1 + 1), cool, and dilute to 1 L. Store in a polyethylene bottle.

34.3 *Citric Acid Solution* (500 g/L) —Dissolve 500 g of citric acid monohydrate in 800 mL of water and dilute to 1 L. Store in a polyethylene bottle.

34.4 *Methyl Isobutyl Ketone (MIBK).*

34.5 *Phosphorus, Standard Solution A* (1 mL = 0.5 mg P)—Dissolve 0.9285 g of ammonium dihydrogen phosphate ($NH_4H_2PO_4$) in 200 mL of water in a 500-mL volumetric flask, dilute to volume, and mix.

34.6 *Phosphorus, Standard Solution B* (1 mL = 0.01 mg P)—Using a pipet, transfer 10 mL of phosphorus Solution A (1 mL = 0.5 mg P) to a 500-mL volumetric flask, dilute to volume, and mix.

35. Preparation of Calibration Curve

35.1 *Calibration Solutions:*

35.1.1 Using pipets, transfer (1, 2, 4, and 6) mL of Solution B (1 mL = 0.01 mg P) to 150-mL beakers.

35.1.2 Add 50 mL of water and 10 mL of $HClO_4$. Cool. Proceed as directed in 35.3.

35.2 *Reference Solution*—Transfer 50 mL of water and 10 mL of $HClO_4$ to a 150-mL beaker. Cool. Proceed as directed in 35.3.

35.3 *Color Development:*

35.3.1 Add 10 mL of NH_4VO_3 solution and mix. Add 15 mL of ammonium molybdate solution, mix, and transfer into a 125-mL conical separatory funnel. Drain the beaker well but do not rinse. Let stand for 7 min. Add 10 mL of citric acid solution, stopper the funnel, and shake for 5 s.

35.3.2 Using a pipet, transfer 15 mL of MIBK to the solution and shake again, vigorously, for 30 s. Allow the phases to separate. Drain and discard the aqueous phase. Rinse the stem of the separatory funnel with about 1 mL of the MIBK phase. Filter, using a dry, triple-folded, 9-cm, hardened paper, into a dry absorption cell.

35.4 *Spectrophotometry:*

35.4.1 *Multiple-Cell Spectrophotometer*—Measure the cell correction using absorption cells with a 2-cm light path and a light band centered at 400 nm. Using the test cell, take the spectrophotometric absorbance readings of the calibration solutions.

35.4.2 *Single-Cell Spectrophotometer*—Transfer a suitable portion of the reference solution to an absorption cell with a 2-cm light path and adjust the spectrophotometer to the initial setting, using a light band centered at 400 nm. While maintaining this adjustment, take the spectrophotometric absorbance readings of the calibration solutions.

35.5 *Calibration Curve*—Plot the net spectrophotometric absorbance readings of the calibration solutions against milligrams of phosphorus per 15 mL of MIBK.

36. Procedure

36.1 *Test Solution:*

36.1.1 Transfer a 0.50-g sample, weighed to the nearest 5 mg, to a 150-mL beaker (Note 3).

36.1.2 Carry a reagent blank through the entire procedure, using the same amounts of all reagents but with the sample omitted.

36.1.3 Add a mixture of 5 mL of HNO_3 and 5 mL of HCl and warm gently. When dissolution is complete, heat to boiling and evaporate to 6 mL to 7 mL. Add 50 mL of water and 10 mL of $HClO_4$. Cool. Proceed as directed in 36.3.

36.2 *Reference Solution*—Use the reagent blank solution prepared as directed in 36.1.2.

36.3 *Color Development*—Proceed as directed in 35.3.

36.4 *Spectrophotometry*—Proceed as directed in 35.4.

37. Calculation

37.1 Convert the net spectrophotometric absorbance reading of the test solution to milligrams of phosphorus by means of the calibration curve. Calculate the percentage of phosphorus as follows:

$$\text{Phosphorus, } \% = A/(B \times 10) \quad (5)$$

where:

A = milligrams of phosphorus found in 15 mL of the final test solution, and

B = grams of sample represented in 15 mL of the final test solution.

38. Precision and Bias

38.1 *Precision*—Eight laboratories cooperated in testing this test method and obtained the precision data summarized in Table 3. Although samples covered by this test method with phosphorus near the lower and upper limits of the scope were not available for testing, the precision data obtained should apply.

38.2 *Bias*—The accuracy of this test method could not be evaluated because adequate certified standard reference materials were unavailable at the time of testing. The user is encouraged to verify by the use of certified reference materials, if available, that the accuracy of this test method is adequate for the contemplated use.

39. Keywords

39.1 EDTA titration; iron; manganese; phosphorus; spectrophotometry