



Designation: E278 – 21

Standard Test Method for Determination of Phosphorus in Iron Ores by Phosphomolybdate Coprecipitation and Nitric Acid Titrimetry¹

This standard is issued under the fixed designation E278; 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 phosphorus in iron ores, concentrates, and agglomerates.

1.2 This test method covers the determination of phosphorus in the range from 0.01 % to 1.00 %.

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, health, and environmental 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](#)

[E135 Terminology Relating to Analytical Chemistry for Metals, Ores, and Related Materials](#)

¹ This test method is under the jurisdiction of ASTM Committee [E01](#) on Analytical Chemistry for Metals, Ores, and Related Materials and is the direct responsibility of Subcommittee [E01.02](#) on Ores, Concentrates, and Related Metallurgical Materials.

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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.

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

[E877 Practice for Sampling and Sample Preparation of Iron Ores and Related Materials for Determination of Chemical Composition and Physical Properties](#)

[E882 Guide for Accountability and Quality Control in the Chemical Analysis Laboratory](#)

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology [E135](#).

4. Summary of Test Method

4.1 The sample is dissolved in HCl and HNO₃. After the addition of HClO₄, the solution is evaporated to strong fumes to dehydrate the silica. The insoluble residue is filtered off, ignited, and treated for the recovery of any contained phosphorus. Ammonium molybdate is added to precipitate phosphomolybdate. The precipitate is filtered off and washed free from acid. It is then dissolved in an excess of standard sodium hydroxide solution. The excess sodium hydroxide is titrated with a standard solution of HNO₃ using phenolphthalein as an indicator.

5. Significance and Use

5.1 This test method is intended to be used for compliance with compositional specifications for phosphorus content. It is assumed that all who use these procedures 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 and that proper waste disposal procedures will be followed. Appropriate quality control practices shall be followed, such as those described in Guide [E882](#).

6. Interferences

6.1 Vanadium and arsenic, elements commonly found in iron ores, coprecipitate with the phosphorus. Provisions for their removal or elimination of their interference are included in this test method.

6.2 Titanium tends to form an insoluble compound with phosphorus and thus may cause low values for phosphorus. Provision for its removal is included in this test method.

7. Reagents and Materials

7.1 *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.³ Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type I or Type II of Specification D1193. Type III or Type IV may be used if they effect no measurable change in the blank or sample.

7.3 *Ammonium Molybdate Solution (Acidic).*

7.3.1 *Solution No. 1*—Transfer 100 g of molybdic acid (85 % MoO₃) to a 600-mL beaker containing 240 mL of water and mix thoroughly. Add 140 mL of NH₄OH while stirring vigorously. When dissolution is complete, filter through a medium paper, add 60 mL of HNO₃, and cool.

7.3.2 *Solution No. 2*—Add 400 mL of HNO₃ to 960 mL of water in a 2-L beaker and cool.

7.3.3 Add Solution No. 1 to Solution No. 2 while stirring constantly. Add 0.1 g of ammonium phosphate, dibasic ((NH₄)₂HPO₄), and let stand at least 24 h before using. Use only the clear supernatant liquid.

7.4 *Ammonium Nitrate (NH₄NO₃).*

7.5 *Ferric Chloride Solution*—Dissolve 0.3 g of pure iron wire in 25 mL of HCl (1 + 1). Oxidize by adding HNO₃ dropwise to the hot solution. Cool, add 25 mL of HCl, dilute to 1 L and mix.

7.6 *Ferrous Sulfate Solution*—Dissolve 100 g of ferrous sulfate (FeSO₄·7H₂O) in 1 L of H₂SO₄ (5 + 95).

7.7 *Hydrobromic Acid (1 + 4)*—Mix 20 mL of concentrated hydrobromic acid (HBr, sp gr 1.49) with 80 mL of water.

7.8 *Hydrochloric Acid (1 + 1)*—Mix equal volumes of concentrated HCl (sp gr 1.19) and water.

7.9 *Hydrofluoric Acid (sp gr 1.15)*—Concentrated HF.

7.10 *Nitric Acid, Standard (0.15 N)*—Transfer 10 mL of clear and water white concentrated HNO₃ (sp gr 1.42) to a 1-L flask, dilute to the mark, and mix. Standardize this solution against the standard sodium hydroxide (NaOH) solution using phenolphthalein as indicator. If desired, this solution may be made equivalent to the standard sodium hydroxide solution by dilution with water.

7.11 *Nitric Acid, Wash Solution (1 + 99)*—Mix 10 mL of concentrated HNO₃ (sp gr 1.42) with 990 mL of water.

7.12 *Phenolphthalein Indicator Solution*—Dissolve 0.2 g of phenolphthalein in 100 mL of ethanol.

7.13 *Potassium Nitrate, Wash Solution (10 g/L)*—Dissolve 10 g of potassium nitrate (KNO₃) in water, dilute to 1 L, and mix.

7.14 *Potassium Permanganate Solution (25 g/L)*—Dissolve 25 g of potassium permanganate (KMnO₄) in water and dilute to 1 L.

7.15 *Sodium Carbonate (Na₂CO₃).*

7.16 *Sodium Hydroxide, Stock Solution*—Dissolve 300 g of NaOH in 1 L of water. Add a slight excess of barium hydroxide (Ba(OH)₂) to precipitate any carbon dioxide (CO₂). Allow any precipitate to settle out. Store the solution in a polyethylene container.

7.17 *Sodium Hydroxide, Standard Solution (0.15 N)*—Transfer 20 mL of the clear, supernatant stock solution to a 1-L flask. Dilute to the mark with freshly boiled and cooled water and mix thoroughly. Standardize this solution against potassium acid phthalate. It is convenient to adjust the normality of this standard solution to 0.148 N (1 mL = 0.0002 g P). Confirm the phosphorus value by analyzing a standard of a known phosphorus content, preferably an iron ore of similar composition. Protect the NaOH solution from CO₂ by means of a soda-lime or soda-asbestos tube.

7.18 *Sulfurous Acid (H₂SO₃).*

8. Hazards

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

9. Sampling and Sample Preparation

9.1 *Sampling*—The gross sample shall be collected and prepared in accordance with Practice E877.

9.2 *Sample Preparation*—The laboratory sample shall be pulverized to pass a No. 100 (150-μm) sieve.

NOTE 1—Some ores, such as specular hematites, may require finer grinding to pass a No. 200 (75-μm) sieve.

9.3 *Sample Weight*—Weigh approximately (within ± 25 mg) an amount of sample specified as follows:

Content of Phosphorus, %	Weight of Sample, g
0.01 to 0.10	2.0
0.11 to 0.50	1.0
0.51 to 1.00	0.5

10. Procedure

10.1 Transfer the test sample to a small dry weighing bottle and place in a drying oven. After drying at 105 °C to 110 °C for 1 h, cap the bottle, and cool to room temperature in a desiccator. Momentarily release the cap to equalize pressure and weigh the capped bottle to the nearest 0.1 mg. Repeat the drying and weighing until there is no further weight loss. Transfer the test sample to a 400-mL beaker and reweigh the

³ *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>.