



Designation: **E878—12 E878 – 20**

## Standard Test Method for Determination of Titanium in Iron Ores and Related Materials by Diantipyrylmethane Ultraviolet Spectrophotometry<sup>1</sup>

This standard is issued under the fixed designation E878; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the determination of titanium in iron ores, concentrates, and agglomerates in the compositional range from 0.01 % to 6.0 % titanium.

NOTE 1—As used in this test method (except as related to the term *relative standard deviation*), percent or “%” refers to mass fraction ( $\frac{wt}{wt}$ )( $\frac{mas}{mass}$ ) of the form  $\frac{g}{100g}$ ,  $\frac{g}{100g}$ .

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 This test method has been evaluated in accordance with Practice E1601 and Guide E1763. Unless otherwise noted in Section 13, the lower limit in the scope of each method specifies the lowest analyte content that may be analyzed with acceptable error (defined as a nominal 5 % risk of obtaining a 50 % or larger relative difference in results on the same test sample in two laboratories).

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:<sup>2</sup>

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

<sup>1</sup> 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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<sup>2</sup> 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.

**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

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

**E1763** Guide for Interpretation and Use of Results from Interlaboratory Testing of Chemical Analysis Methods (Withdrawn 2015)<sup>3</sup>

### 3. Terminology

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

#### 3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *Relative Standard Deviation (RSD), n*—the RSD tells you whether the “regular” standard deviation is a small or large quantity when compared to the mean for the data set.

### 4. Summary of Test Method

4.1 The sample is decomposed by treatment with hydrochloric, nitric, HCl, HNO<sub>3</sub>, and sulfuric H<sub>2</sub>SO<sub>4</sub> acids, or by sintering with sodium peroxide, or by fusion with sodium tetraborate and sodium carbonate. Iron is reduced in an acid medium with ascorbic acid, the color is developed with diantipyrylmethane, and the absorbance is measured at approximately 385 nm.

### 5. Significance and Use

5.1 This test method is intended to be used for compliance with compositional specifications for titanium 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 must be followed such as those described in Guide **E882**.

### 6. Interferences

6.1 None of the elements normally found in iron ores interfere.

### 7. Reagents and Materials

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<https://standards.iteh.ai/catalog/standards/sist/d347728-df5d-46a8-a5fa-20e7d65e567f/astm-e878-20>

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.<sup>4</sup> 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 II of Specification **D1193**. Type III or IV may be used if they effect no measurable change in the blank or sample.

7.3 *Ascorbic Acid Solution (10 g/100 mL) (CmL)*—Dissolve 10 g of ascorbic acid (C<sub>6</sub>H<sub>8</sub>O<sub>6</sub>) in water and dilute to 100 mL. Prepare fresh as needed.

7.4 *Diantipyrylmethane Solution (15 g/L) (C<sub>2233</sub>H<sub>224</sub>N<sub>4</sub>O<sub>2</sub>N<sub>4</sub> · H<sub>2</sub>O—Dissolve O)*—Dissolve 15 g of the reagent in about 300 mL of water and 30 mL of (H<sub>2</sub>SO<sub>4</sub>) (1 + 1) and dilute to 1 L with water. If a residue remains, filter and store the filtrate in a brown bottle.

7.5 *Ferric Ammonium Sulfate (100 g/L)*—Dissolve 100 g of ferric ammonium sulfate FeNH<sub>2</sub>(SO<sub>4</sub>)Fe(SO<sub>3</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> · 12H<sub>2</sub>O in 800 mL of water containing 5 mL of H<sub>2</sub>SO<sub>4</sub> (1 + 1) and dilute to 1 L with water.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC-DC, [www.chemistry.org](http://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. Pharmaceutical Convention, Inc. (USPC), Rockville, MD-MD, <http://www.usp.org>.

7.6 *Potassium Pyrosulfate* (~~K~~( $K_2S_2O_7$ )).

7.7 *Sodium Peroxide* ( $Na_2O_2$ ).

7.8 *Sodium Tetraborate (Anhydrous)* ( $Na_2B_4O_7$ )—Dry the commercial sodium tetraborate at 60 °C to 70 °C, then at 160 °C, and finally calcine at 400 °C.

7.9 *Sodium Tetraborate/Sodium Carbonate* ( $Na_2B_4O_7/Na_2CO_3$ ) *Fusion Mixture*—Mix 1 part of  $Na_2B_4O_7$  and 1 part of  $Na_2CO_3$  and store in an airtight container.

7.10 *Standard Titanium Calibration Solution:*

7.10.1 *Solution A (1 mL = 0.1 mg Ti)*—Transfer 0.1670 g of  $TiO_2$  (previously calcined at 900 °C) to a platinum crucible, add 3 g to 4 g of  $K_2S_2O_7$ , cover, and fuse at a temperature of 600 °C until a clear melt is obtained. Place the cooled crucible and cover into a 250-mL beaker, add 50 mL to 60 mL of  $H_2SO_4$  (1 + 9), and heat to dissolve the melt. Wash crucible and cover with  $H_2SO_4$  (1 + 9) and remove, adding the washings to the 250-mL beaker. Transfer the solution of a 1-L volumetric flask, dilute to volume with  $H_2SO_4$  (1 + 9), and mix.

7.10.2 *Solution B (1 mL = 0.02 mg Ti)*—Transfer 50.0 mL of ~~standard~~ titanium Solution A to a 250-mL volumetric flask, dilute to volume with  $H_2SO_4$  (1 + 9), and mix.

## 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*—Pulverize the laboratory sample to pass a ~~No. 100 (150- $\mu$ m)~~ 150- $\mu$ m (No. 100) sieve.

NOTE 2—To facilitate decomposition, some ores such as specular hematite require grinding to pass a ~~No. 200 (75- $\mu$ m)~~ 75- $\mu$ m (No. 200) sieve. ~~10.4.~~

## 10. Procedure

NOTE 3—If the procedure is based on acid decomposition, use steps in 10.1. If the procedure is based on alkaline sintering, use steps in 10.2. If the procedure is based on alkaline fusion, use steps in 10.3.

10.1 If the procedure is based on acid decomposition, use steps in 10.2. If the procedure is based on alkaline sintering, use steps in 10.3. If the procedure is based on alkaline fusion, use steps in 10.4.

10.2 *Acid Decomposition:*

10.2.1 Weigh approximately the amount of the test sample specified in the table below into a small weighing bottle previously dried at 150 °C.

Ti content, %	Mass of test portion, g	Amount of $H_2SO_4$ to be added in 10.1.3, mL	Aliquot, mL
0.01–0.1	1.0	20	20
0.1–0.3	1.0	20	10
0.3–1.0	0.5	10	5
1.0–6.0	0.1	10	5

Weigh approximately the amount of the test sample specified in the Table 1 below into a small weighing bottle previously dried at 150 °C. Dry the bottle and contents for 1 h at 105 °C to 110 °C. Cap the bottle and cool to room temperature in a desiccator.

TABLE 1 Amounts

Ti content, %	Mass of test sample, g	Amount of H <sub>2</sub> SO <sub>4</sub> to be added in 10.2.3, mL	Aliquot, mL
0.01–0.1	1.0	20	20
0.1–0.3	1.0	20	10
0.3–1.0	0.5	10	5
1.0–6.0	0.1	10	5

Momentarily release the cap to equalize the pressure and weigh the capped bottle and sample to the nearest 0.1 mg. Repeat the drying and weighing until there is no further loss of mass. Transfer the test sample to a 250-mL beaker and reweigh the capped bottle to the nearest 0.1 mg. The difference between the two masses is the mass of the test sample taken for analysis.

10.2.2 Carry a reagent blank through all steps of the procedure, starting with ~~10.1.3~~10.2.3.

10.2.3 *Decomposition of Sample*—Moisten the test sample with a few milliliters of water, add 30 mL of HCl, cover, and digest below the boiling point until no further attack is apparent. Add 5 mL of HNO<sub>3</sub> and 10 mL to 20 mL of H<sub>2</sub>SO<sub>4</sub> (see amounts specified in ~~10.1.1~~Table 1), evaporate slowly to fumes of H<sub>2</sub>SO<sub>4</sub>, then heat strongly for 10 min. Allow the solution to cool, add slowly 50 mL of water and 20 mL of HCl, and warm until soluble salts are in solution.

10.2.4 Filter on a fine-textured filter paper and collect the filtrate in a 250-mL beaker. Transfer the residue quantitatively to the filter paper and wash the filter paper two times or three times with hot dilute H<sub>2</sub>SO<sub>4</sub> (~~2(2 + 98)~~) and two times or three times with hot water. Reserve the filtrate.

10.2.5 *Treatment of Insoluble Matter*—Ignite the paper and residue in a platinum crucible. Cool, moisten with several drops of water, add 3 drops or 4 drops of dilute H<sub>2</sub>SO<sub>4</sub> (~~1(1 + 1)~~) and 10 mL of HF. Evaporate slowly to expel silica and excess of H<sub>2</sub>SO<sub>4</sub>. Cool, add to the residue about 2 g of potassium pyrosulfate, cover the crucible, and fuse over a burner (approximately 500 °C) until a clear melt is obtained.

10.2.6 Dissolve the cool melt in the reserved filtrate from ~~10.1.4~~10.2.4, remove, and wash the crucible and cover, adding the washings to the 250-mL beaker. Transfer the solution to a 200-mL volumetric flask, dilute to volume, and mix. Continue in accordance with as directed in ~~10.4~~10.5.

10.3 *Alkaline Sintering Decomposition:*

10.3.1 Transfer a sample weight in accordance with the table in ~~10.1.1~~ to a dried weighing bottle and dry the test sample as described in ~~10.1.1~~ small weighing bottle previously dried at 150 °C. Transfer the test ~~10.1.1~~. Finally transfer the test sample ~~sample~~ to a 40-mL nickel crucible.

10.3.2 Carry a reagent blank through all steps of the procedure starting with ~~10.2.3~~10.3.3.

TABLE 12 Grand Means and Precision of Titanium Content of the Test Samples as Determined by the Method Described Using Various Decomposition Methods

Sample No.	Decomposition Methods	Grand Mean X, %	Repeatability r, %	Permissible Tolerance P, %	Standard Deviation	
					Within-Laboratories σ <sub>w</sub> , %	Between-Laboratories σ <sub>b</sub> , %
76-3	Acid	3.7944	0.0788	0.1706	0.0285	0.0582
76-3	Sintering	3.8137	0.0848	0.2765	0.0306	0.0974
76-3	Fusion	3.8122	0.0785	0.1995	0.0283	0.0692
76-16	Acid	0.0399	0.0023	0.0042	0.0008	0.0014
76-16	Sintering	0.0402	0.0026	0.0051	0.0009	0.0017
76-16	Fusion	0.0402	0.0015	0.0034	0.0005	0.0012
76-17	Acid	0.1602	0.0032	0.0102	0.0012	0.0036
76-17	Sintering	0.1625	0.0049	0.0133	0.0018	0.0046
76-17	Fusion	0.1608	0.0055	0.0129	0.0020	0.0044
76-18	Acid	0.1796	0.0049	0.0081	0.0018	0.0027
76-18	Sintering	...	...	...	...	...
76-18	Fusion	0.1856	0.0090	0.0159	0.0032	0.0053