Designation: E2209 – 22

Standard Test Method for Analysis of High Manganese Steel by Spark Atomic Emission Spectrometry[1]

This standard is issued under the fixed designation E2209; 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 analysis of high manganese steel by spark atomic emission spectrometry for the following elements in the ranges shown:

Elements	Composition Range, %
Aluminum (Al)	0.02 to 0.15
Carbon (C)	0.3 to 1.4
Chromium (Cr)	0.25 to 2.00
Manganese (Mn)	8.0 to 16.2
Molybdenum (Mo)	0.03 to 2.0
Nickel (Ni)	0.05 to 4.0
Phosphorus (P)	0.025 to 0.06
Silicon (Si)	0.25 to 1.5

NOTE 1—The ranges represent the actual levels at which this method was tested.[2] These composition ranges can be extended by the use of suitable reference materials. Validation of these extensions may be conducted by following Practice E2587. Sulfur is not included because differences in results between laboratories exceeded acceptable limits at all sulfur levels.

1.2 *This test method may involve hazardous materials, operations, and equipment. 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.*

1.3 *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:*[3]

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

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

E305 Practice for Establishing and Controlling Spark Atomic Emission Spectrochemical Analytical Curves

E406 Practice for Using Controlled Atmospheres in Atomic Emission Spectrometry

E1059 Practice for Designating Shapes and Sizes of Non-graphite Counter Electrodes (Withdrawn 2013)[4]

E1329 Practice for Verification and Use of Control Charts in Spectrochemical Analysis (Withdrawn 2019)[4]

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

E1806 Practice for Sampling Steel and Iron for Determination of Chemical Composition

E2587 Practice for Use of Control Charts in Statistical Process Control

2.2 *Other Document:*

ASTM MNL 7 ASTM Manual on Presentation of Data and Control Chart Analysis, 8th Edition, 2010.

3. Terminology

3.1 For definition of terms used in this method, refer to Terminology E135.

4. Summary of Test Method

4.1 A controlled discharge is produced between the flat surface of the specimen and the counter electrode. The radiant energies of selected analytical lines are converted into electrical energies by photomultiplier tubes and stored on capacitors.

[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 E01.01 on Iron, Steel, and Ferroalloys.

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[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E01-1035. Contact ASTM Customer Service at service@astm.org

[3] 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.

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

This discharge is terminated after a fixed integration time. At the end of the integration period, the charge on each capacitor is measured and converted to mass fraction percent.

5. Significance and Use

5.1 The chemical composition of high manganese steel alloys must be determined accurately to ensure the desired metallurgical properties. This procedure is suitable for manufacturing control and inspection testing.

6. Interferences

6.1 Interferences may vary with spectrometer design and excitation characteristics. Direct spectral interferences may be present on one or more of the wavelengths listed in this method (Table 1). Frequently, these interferences may be determined and proper corrections made by the use of various reference materials. The composition of the sample being analyzed should match closely the composition of one or more of the reference materials used to prepare and control the calibration that is utilized. Alternatively, mathematical corrections may be used to solve for interelement effects. Various mathematical correction procedures are commonly utilized. Any of these are acceptable that will achieve analytical accuracy equivalent to that provided by this method.

7. Apparatus

7.1 *Sample Preparation Equipment:*

7.1.1 *Sample Mold,* to produce chilled cast samples approximately 38 mm (1½ in.) in diameter that are homogeneous, free of voids or porosity in the region to be excited, and representative of the material to be analyzed. Refer to Practice E1806 for steel sampling procedures.

7.1.2 *Immersion Sampler,* to take a sample from the bath or from the metal stream when pouring cannot be used. The sampler should produce a sample of the same dimensions as listed in 7.1.1.

7.1.3 *Surface Grinder or Sander With Abrasive Belts or Disk,* capable of providing a flat uniform surface on the reference materials and specimens. The following table shows the various methods of sample preparation used in the Inter-Laboratory Study (ILS):

Type of Grinding Preparation	Belt or Disk, or Both
Grinding Medium	Aluminum Oxide, Zirconium Oxide
Grit of Grinding Medium	36 to 180

NOTE 2—Silicon carbide grinding medium may be used but it was not utilized by the laboratories in the Inter-Laboratory Study (ILS).

7.2 *Excitation Source,* capable of providing a triggered capacitor discharge having the source parameters meeting the requirements of 11.1.

7.3 *Excitation Stand,* suitable for mounting in optical alignment, a flat surface for the specimen in opposition to a counter electrode. This stand shall provide an atmosphere of argon. The argon and electrode are described in 8.1 and 8.2.

7.4 *Spectrometer,* having sufficient resolving power and linear dispersion to separate clearly the analytical lines from other lines in the spectrum of a specimen in the spectral region 170.0 nm to 450.0 nm. The spectrometer shall have a dispersion of at least 2 nm/mm and a focal length of at least 0.5 m.

NOTE 3—Many current spectrometer manufacturers utilize CMOS/CCD array technology and this enables equivalent resolution with a shorter focal length than specified in 7.4.

7.5 *Measuring System,* spectrometer capable of converting light intensities to measurable electrical signals. The measuring system may consist of one of the following configurations:

7.5.1 A photomultiplier (PMT) array having individual voltage adjustments, capacitors in which the output of each PMT is stored, a voltage measuring system to register the voltages on the capacitors either directly or indirectly, and the necessary switching arrangements to provide the desired sequence of operation.

7.5.2 A semiconductor detector array (CCD or CMOS), pixel selection electronics to reset the pixels and to transport the voltage of an individual pixel to one or more output ports of the detector arrays, and a voltage measuring system to register the voltage of said output ports. However, this method was tested with spectrometers equipped with PMTs. If a spectrometer is utilized that is equipped with CCD or CMOS, the user should validate that the precision and bias equivalent to that specified in Section 16 can be obtained.

7.5.3 A hybrid design using both PMTs and semiconductor arrays.

7.6 *Vacuum Pump,* if required, capable of maintaining a vacuum of approximately 3 Pa. There are some equipment manufacturers that will purge the optical portion of the spectrometer with argon or other inert gas rather than apply a

TABLE 1 Wavelengths

Element	Wavelength (nm)	Line Classification	Possible Interferences[A]
Aluminum	394.4	I	V, Mn, Mo
	396.152	I	Mo
Carbon	193.09	I	Al
Chromium	298.92	II	Mn, V, Ni, Nb, Mo
	267.72	II	Mn, Mo, V
	425.435	I	
Iron (Internal Standard)	273.07	I	
	271.44	II	
Manganese	263.81	II	
	290.02	II	
	293.31	II	Cr
Molybdenum	202.03	II	
	263.876	II	
	281.61	II	Al, Mn
	386.41	I	V, Cr
Nickel	231.60	II	Co, Ti
	218.54	II	
	352.45	I	
	341.476	I	
Phosphorus	178.29	I	Mo
Silicon	212.41	I	
	288.16	I	Mo, Cr, W
	251.61	I	Fe, V
Sulfur	180.73	I	Mn

[A] Interferences are dependent upon instrument design, and excitation conditions, and those listed require confirmation based upon specimens designed to demonstrate interferences. This method does not purport to address all the interferences that these lines may have. Take care to address the interferences when calibrating the instrument.