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Standard Specification for Metal Injection Molding (MIM) Ferrous Materials[1]

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1. Scope

1.1 This specification covers ferrous metal injection molded materials fabricated by mixing elemental or pre-alloyed metal powders with binders, injecting into a mold, debinding, and sintering, with or without subsequent heat treatment.

1.2 This specification covers the following injection molded materials.

1.2.1 *Compositions*:

~~1.2.1.1MIM-2200, low-alloy steel produced from admixtures of iron powder and other alloying elements such as nickel and molybdenum.~~

~~1.2.1.2MIM-2700, low-alloy steel produced from admixtures of iron powder, and other alloying elements such as nickel and molybdenum.~~

~~1.2.1.3MIM-4605, low-alloy steel produced from admixtures of iron powder and other alloying elements such as nickel, molybdenum, and carbon.~~

~~1.2.1.4MIM-316L, austenitic stainless steel produced from pre-alloyed powder or an admixture of powders.~~

~~1.2.1.5MIM-17-4 PH, precipitation hardening stainless steel produced from prealloyed powder or an admixture of powders.~~

~~1.2.1.6MIM-430L , ferritic stainless steel produced from pre-alloyed powder or an admixture of powders.~~

1.2.1.1 MIM-2200, low-alloy steel

1.2.1.2 MIM-2700, low-alloy steel

1.2.1.3 MIM-4605, low-alloy steel

1.2.1.4 MIM-4140, low-alloy steel

1.2.1.5 MIM-316L, austenitic stainless steel

1.2.1.6 MIM-17-4 PH, precipitation hardening stainless steel

1.2.1.7 MIM-420, ferritic stainless steel

1.2.1.8 MIM-430L, ferritic stainless steel

1.3 Chemical composition limits are specified in Table 1.

~~1.4Property values stated in inch-pound units are to be regarded as the standard. Conversions to SI units may be approximate.~~

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B243 Terminology of Powder Metallurgy

B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity

B328~~Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Metal Structural Parts and Oil-Impregnated Bearings~~

~~B~~933 Test Method for Microindentation Hardness of Powder Metallurgy (PM) Materials

B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

E8 Test Methods for Tension Testing of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

E415 Test Method for Atomic Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel

E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques

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[1] This specification is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of ~~Subcommittee~~ B09.11 on Near Full Density Powder Metallurgy ~~Metals.~~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.

E1086 Test Method for Atomic Emission Vacuum Spectrometric Analysis of Stainless Steel by Point-to-Plane Excitation Technique
E1621 Guide for X-Ray Emission Spectrometric Analysis
F1089 Test Method for Corrosion of Surgical Instruments

2.2 *MPIF Standards:*[3]

MPIF Standard 35~~Standard 35,~~ Material Standards for Metal Injection Molded Parts
~~MPIFStandard 50, Method for Preparing and Evaluating Metal Injection Molded Debound and Sintered Tension Test Specimens~~
~~MPIFStandard 51, Determination of Microhardness of Powder Metallurgy Materials~~
~~MPIFStandard 59, Determination of Charpy Impact Energy of Unnotched Metal Injection Molded Test Specimens~~ MPIF Standard 50 Method for Preparing and Evaluating Metal Injection Molded (MIM) Debound and Sintered/Heat Treated Tension Test Specimens
MPIF Standard 51 Method for Determination of Microindentation Hardness of Powder Metallurgy Materials
~~MPIFStandard 62, Determination of the Corrosion Resistance of MIM Grades of Stainless Steel Immersed in 2% Sulfuric Acid Solution~~ MPIF Standard 59 Method for Determination of Charpy Impact Energy of Unnotched Metal Injection Molded (MIM) Test Specimens
~~MPIFStandard 63, Density Determination of MIM Components (Gas Pycnometer)~~ MPIF Standard 62 Method for Determination of the Corrosion Resistance of MIM Grades of Stainless Steel Immersed in 2 % Sulfuric Acid Solution
MPIF Standard 63 Method for Density Determination of Metal Injection Molded (MIM) Components (Gas Pycnometer)

3. Terminology

3.1 *Definitions*:

3.1.1 Definitions of powder metallurgy terms can be found in Terminology B243. Additional descriptive information is available in the Related Material Section of Vol. 02.05 of the Annual Book of ASTM Standards.

4. Ordering Information

4.1 Orders for parts conforming to this specification may include the following:
4.1.1 ASTM designation,
4.1.2 Alloy composition including carbon content (see Table 1),
4.1.3 Heat treatment condition and hardness (see Tables 2-5),
4.1.4 Functional or mechanical property testing (see 7.3-7.7 and Tables 2-5),
4.1.5 Corrosion resistance testing (see 8.1-8.1.4 and Table 6),
4.1.6 Purchaser or purchaser's representative desire to witness the inspection and testing of material prior to shipment (see 10.2),
4.1.7 Requirement for certification of material and a report of test results (see 12.1),
4.1.8 Requirement for full or partial chemical analysis (see Section 6), and
4.1.9 Other special requirements as mutually agreed.

5. Materials and Manufacture

5.1 Parts shall be made by injection molding mixtures of metal powder with binders, debinding, and sintering, with or without subsequent heat treatment. The material shall conform to the designations in 1.2.1 and meet the chemical composition specified in Table 1.

6. Chemical Composition

6.1 Metal injection molded material shall conform to the chemical requirements prescribed in Table 1.

6.2 Chemical analysis for the elements copper, chromium, molybdenum, and nickel shall be determined in accordance with Test Methods E415 (preferred method), E350, E1086, E1621, Inductively Coupled Plasma–Atomic Emission Spectrometry (ICP-AES), Atomic Absorption (AA), or any such method as shall be agreed upon between buyer and seller. Analysis of the element carbon shall be determined in accordance with Test Methods E1019, via optical emission spectroscopy, or other method agreed upon between the purchaser and seller.

7. Mechanical and Physical Property Requirements

7.1 The preferred method of verifying the acceptable performance of a finished part is a qualification test to be performed on an actual part. The specific test should be determined following consideration of the function of the part, and should be agreed upon between manufacturer and purchaser.

7.2 Mandatory and typical mechanical properties of materials covered by this specification are shown in Tables 2-5.

7.3 *Tensile Properties*:

[3] Available from Metal Powder Industries Federation (MPIF), 105 College Road East, Princeton, NJ 08540–6692, USA.

7.3.1 The tensile properties of MIM materials shall be measured using test specimens prepared and evaluated in accordance with MPIF Standard 50.

7.3.2 *Tensile Test Method*—When requested in the purchase order, tensile specimens shall be prepared and processed along with production parts. Tensile specimens shall be tested in accordance with Test Methods E8. Yield strength shall be determined by the 0.2 % offset method. MPIF Standard 50 governs the manufacture of the test bars, while Test Methods E8governs the testing procedure.

7.4 *Impact Energy Properties*:

7.4.1 Typical impact energy properties of materials covered by this specification are shown in Tables 2-5.

7.4.2 The impact energy properties of MIM materials shall be measured using test specimens prepared and evaluated in accordance with MPIF Standard 59.

7.4.3 *Impact Energy Test Method*—When requested in the purchase order, impact energy specimens shall be prepared and processed along with production parts.

7.5 *Density*:

7.5.1 The density of MIM materials shall be measured in accordance with Test Method B311 or MPIF Standard 63. If a test specimen gains mass when immersed in water, it shall be tested in accordance with Test Method ~~B328~~B962.

7.6 *Apparent Hardness*—The apparent hardness of MIM materials shall be measured in accordance with Test Methods E18.

7.7 *Microindentation Hardness*—The microindentation hardness of MIM materials shall be measured in accordance with Test Method B933 or MPIF Standard 51B311.

8. Corrosion Resistance Requirements

8.1 *Corrosion Resistance*:

8.1.1 The preferred method of verifying the acceptable performance of a finished part is a qualification test to be performed on an actual part. The specific test should be determined following consideration of the function of the part, and should be agreed upon between manufacturer and purchaser.

8.1.2 Typical corrosion resistance of materials covered by this specification is shown in Table 6.

8.1.3 The corrosion resistance of MIM materials shall be measured using test specimens prepared in accordance with MPIF Standard 59.

8.1.4 *Corrosion Resistance Test Method*—When requested in the purchase order, corrosion resistance specimens shall be prepared and processed along with production parts. MPIF Standard 59 governs the manufacture of specimens, but Test Method F1089 governs corrosion resistance testing for copper sulfate and boiling water. MPIF Standard 62governs corrosion resistance testing for sulfuric acid.

9. Sampling

9.1 *Lot*—Unless otherwise specified, a lot is a quantity of product produced under similar conditions so that the product within the lot is expected to be homogeneous in all significant attributes and submitted for inspection at one time.

9.2 *Testing*—The manufacturer and purchaser shall mutually agree upon the number of specimens to represent the lot for qualification, chemical, mechanical, or corrosion resistance property testing.

10. Inspection

10.1 Inspection of the parts supplied under this specification shall be the responsibility of the manufacturer or a mutually agreed upon third party.

10.2 If the purchaser desires that a representative witness the inspection and testing of the material prior to shipment, such a requirement shall be part of the purchase order.

11. Rejection

11.1 Parts that fail to conform to the requirements of this specification may be rejected. Rejection should be reported to the manufacturer or supplier promptly and in writing.

12. Certification

12.1 When specified in the purchase order, a manufacturer's certification shall be furnished to the purchaser that the parts were manufactured, samples tested, and inspected in accordance with this specification and found to meet its requirements. When specified in the purchase order, a report of the test results shall be furnished.

13. Keywords

~~13.1corrosion resistance; low alloy steels; mechanical properties; metal injection molding (MIM); metal injection molded parts; metal injection molded steels; metal powders; MIM; PIM; powder injection molding; sintered steels; stainless steels; unnotched Charpy impact energy~~

13.1 corrosion resistance; low-alloy steels; mechanical properties; metal injection molded parts; metal injection molded steels; metal injection molding (MIM); metal powders; MIM; PIM; powder injection molding; sintered steels; stainless steels; unnotched Charpy impact energy