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Standard Specification for Metal Injection Molded (MIM) 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:*

1.2.1.1 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, martensitic stainless steel

1.2.1.8 MIM-430L, ferritic stainless steel

1.2.1.9 MIM-440, martensitic stainless steel

1.2.1.10 MIM-Cu, copper

1.3 Chemical composition limits are specified in Table 1.

1.4 With the exception of the values for density and the mass used to determine density, for which the use of the gram per cubic centimetre (g/cm^3) and gram (g) units is the longstanding industry practice, the values in inch-pound units are to be regarded as

[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 Materials.

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***A Summary of Changes section appears at the end of this standard**

standard. The values given in parentheses or in separate tables are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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.*

1.6 *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]

B243 Terminology of Powder Metallurgy
B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity
B933 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 [Metric] E0008_E0008M
E18 Test Methods for Rockwell Hardness of Metallic Materials
E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
E350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
E415 Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry
E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Inert Gas Fusion Techniques
E1086 Test Method for Analysis of Austenitic Stainless Steel by Spark Atomic Emission Spectrometry
E1461 Test Method for Thermal Diffusivity by the Flash Method
E1621 Guide for Elemental Analysis by Wavelength Dispersive X-Ray Fluorescence Spectrometry
F1089 Test Method for Corrosion of Surgical Instruments

2.2 *MPIF Standards:*[3]

MPIF Standard 35-MIM Materials Standards for Metal Injection Molded Parts
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
MPIF Standard 59 Method for Determination of Charpy Impact Energy of Unnotched Metal Injection Molded (MIM) Test Specimens
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),

[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] Available from Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540-6692, http://www.mpif.org.

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 Thermal conductivity testing (see 9.1–9.2 and Table 7 and Table 8),

4.1.7 Thermal expansion testing (see 10.1–10.2 and Table 9 and Table 10),

4.1.8 Purchaser or purchaser's representative desire to witness the inspection and testing of material prior to shipment (see 12.2),

4.1.9 Requirement for certification of material and a report of test results (see 14.1),

4.1.10 Requirement for full or partial chemical analysis (see Section 6), and

4.1.11 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, Guide 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 2-10.

7.3 *Tensile Properties:*

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 E8 governs 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 Methods 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 51.

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 62 governs corrosion resistance testing for sulfuric acid.

9. Thermal Conductivity Requirements

9.1 Mandatory and typical thermal conductivity values for MIM-Cu are shown in Table 7 and Table 8.

9.2 The thermal conductivity of MIM materials shall be measured in accordance with Test Method E1461.

10. Thermal Expansion Coefficient

10.1 The typical coefficients of thermal expansion for MIM-Cu material are shown in Table 9 and Table 10.

10.2 The coefficient of thermal expansion for MIM-Cu was determined in accordance with Test Method E228. A push-rod dilatometer was used for the tests, using a 1.8 °F/min (1 °C/min) heating rate in air atmosphere. The average coefficient of thermal expansion was determined at room temperature [68 °F (20 °C)] up to a series of temperatures.

11. Sampling

11.1 *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.