



Standard Specification for Metal Injection Molding (MIM), Ferrous Structural Parts¹

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1. Scope

1.1 This specification covers ferrous metal injection molded materials fabricated by mixing elemental or prealloyed 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 produced from admixtures of iron powder and other alloying elements such as nickel and molybdenum.

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

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

1.2.1.4 MIM-316L Austenitic stainless steel produced from prealloyed powder or an admixture of powders.

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

NOTE 1—Compositional limits and impurity elements may be different from AISI limits. Chemical composition limits are specified in 6.1 and Table 1.

1.3 Property values stated in English system units are the standard. Conversions to SI units may be approximate.

2. Referenced Documents

2.1 ASTM Standards:

B 243 Terminology of Powder Metallurgy²

B 311 Test Method for Density Determination for Powder Metallurgy (P/M) Materials Containing Less than Two Percent Porosity²

B 328 Test Method for Density, Oil Content and Interconnected Porosity of Sintered Metal Structural Parts and Oil Impregnated Bearings²

E 8 Test Methods for Tension Testing of Metallic Materials³

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials³

¹ This specification is under the jurisdiction of ASTM Committee B-9 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.11 on Near Full Density Powder Metallurgy Metals.

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² Annual Book of ASTM Standards, Vol 02.05.

³ Annual Book of ASTM Standards, Vol 03.01.

E 350 Test Method for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron⁴

E 415 Test Method for Optical Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel⁵

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, Oxygen, and Hydrogen in Steel and in Iron, Nickel, and Cobalt Alloys⁵

E 1479 Practice for Describing and Specifying Induction Coupled Plasma Optical Emission Spectrometers⁵

2.2 Other Test Methods and Standards:

MPIF Standard 35, Material Standards for Metal Injection Molded Parts⁶

MPIF Standard 50, Method for Preparing and Evaluating Metal Injection Molded Debound and Sintered Tension Test Specimens⁶

MPIF Standard 51, Determination of Microhardness of Powder Metallurgy Materials⁶

3. Terminology

3.1 Definitions:

3.1.1 Definitions of powder metallurgy terms can be found in Terminology B 243. 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 6.1 and Table 1),

4.1.3 Heat Treatment condition and hardness (see Tables 2-5),

4.1.4 Functional or mechanical property testing (see 7.1.1-7.1.3, 8.2, Tables 2-5),

4.1.5 Purchaser or purchaser's representative desire to witness the inspection and testing of material prior to shipment (see 9.2),

4.1.6 Requirement for certification of material and a report of test results (see 11.1),

⁴ Annual Book of ASTM Standards, Vol 03.05.

⁵ Annual Book of ASTM Standards, Vol 03.06.

⁶ Available from Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

TABLE 1 Chemical Requirements For Metal Injection Molded Parts

Material Designation		Fe	Ni	Cr	Mo	C	Cu	Nb + Ta	OTHER
MIM-2200	Min.	Bal.	1.5	-	0.0	0.0	-	-	0.0
	Max.	Bal.	2.5	-	0.5	0.1	-	-	2.0
MIM-2700	Min.	Bal.	6.5	-	0.0	0.0	-	-	0.0
	Max.	Bal.	8.5	-	0.5	0.1	-	-	2.0
MIM-4605	Min.	Bal.	1.5	-	0.2	0.4	-	-	0.0
	Max.	Bal.	2.5	-	0.5	0.6	-	-	2.0
MIM-316L	Min.	Bal.	10.0	16.0	2.0	0.00	-	-	0.0
	Max.	Bal.	14.0	18.0	3.0	0.03	-	-	2.0
MIM-17-4PH	Min.	Bal.	3.0	15.5	-	0.00	3.0	0.15	0.0
	Max.	Bal.	5.0	17.5	-	0.07	5.0	0.45	2.0

**TABLE 2 Mandatory and Typical Mechanical Properties of Metal Injection Molded Low-Alloy Steels^A
English Units**

Material Designation	Minimum Mandatory Values Tensile Properties			Typical Values Tensile Properties			Density g/cm ³	Typical Values Hardness	
	Ultimate Strength 10 ³ psi	Yield Strength 10 ³ psi	Elongation in 1 in. %	Ultimate Strength 10 ³ psi	Yield Strength 10 ³ psi	Elongation in 1 in. %		Apparent Rockwell	Matrix ^B Rockwell
MIM-2200	37	16	20	42	18	40	7.6	45 HRB	
MIM-2700	55	30	20	60	37	26	7.6	69 HRB	
MIM-4605	55	25	11	64	30	15	7.5	62 HRB	
MIM-4605-HT ^C	215	190	-	240	215	2	7.5	48 HRC	55 HRC

^AReprinted by permission from MPIF Standard 35, "Materials Standard for Metal Injection Molded Parts", 1993/1994, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

Density determined in accordance with Test Methods B 311 and B 328. Apparent hardness determined in accordance with Test Methods E 18. Tensile properties determined on test bars prepared in accordance with MPIF Standard 50 and tested in accordance with Test Method E 8.

^BConverted from HK₁₀₀ Microhardness, MPIF Standard 51, Appendix B.

^CThese data were measured on test bars tempered for 1 hour at 350°F.

**TABLE 3 Mandatory and Typical Mechanical Properties of Metal Injection Molded Low-Alloy Steels^A
SI Units**

Material Designation	Minimum Mandatory Values Tensile Properties			Typical Values Tensile Properties			Density g/cm ³	Typical Values Hardness	
	Ultimate Strength MPa	Yield Strength MPa	Elongation % in 25.4 mm	Ultimate Strength MPa	Yield Strength MPa	Elongation % in 25.4 mm		Apparent Rockwell	Matrix ^B Rockwell
MIM-2200	255	110	20	290	125	40	7.6	45 HRB	
MIM-2700	380	205	20	415	255	26	7.6	69 HRB	
MIM-4605	380	170	11	440	205	15	7.5	62 HRB	
MIM-4605-HT ^C	1480	1310	-	1650	1480	2	7.5	48 HRC	55 HRC

^AReprinted by permission from MPIF Standard 35, "Materials Standards for Metal Injection Molded Parts", 1993/1994, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692. S.I. values converted from English units in Table 2.

Density determined in accordance with Test Methods B 311 or B 328. Apparent hardness determined in accordance with Test Methods E 18. Tensile properties determined on test bars prepared in accordance with MPIF Standard 50 and tested in accordance with Test Methods E 8.

^BConverted from HK₁₀₀ Microhardness, MPIF Standard 51, Appendix B.

^CThese data were measured on test bars tempered for 1 hour at 177°C.

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

4.1.8 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 6.1 and 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 Method E 415 (preferred method), Test Method E 350, Test Method E 1479 or other such method as shall be agreed upon between buyer and seller. Analysis of the element carbon shall be determined in accordance with Test Method E 1019, via optical emission spectroscopy, or other method agreed upon between the purchaser and seller.

7. Mechanical Property Requirements

7.1 *Mechanical Properties:*

**TABLE 4 Mandatory and Typical Mechanical Properties of Metal Injection Molded Stainless Steels^A
English Units**

Material Designation	Minimum Mandatory Values			Typical Values			Typical Values	
	Tensile Properties			Tensile Properties			Density	Hardness
	Ultimate Strength 10 ³ psi	Yield Strength 10 ³ psi	Elongation % in 1 in. 10 ³ psi	Ultimate Strength 10 ³ psi	Yield Strength in.	Elongation % in 1 in. g/cm ³		Apparent Matrix. hard ^B Rockwell
MIM-316L	65	20	40	75	25	50	7.6	67 HRB
MIM-17-4 PH	115	94	4	130	106	6	7.5	27 HRC
MIM-17-4 PH-HT ^C	155	140	4	172	158	6	7.5	33 HRC 40 HRC

^AReprinted by permission from MPIF Standard 35, "Materials Standards for Metal Injection Molded Parts", 1993/1994, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

Density determined in accordance with Test Methods B 311 or B 328. Apparent hardness determined in accordance with Test Methods E 18. Tensile properties determined on test bars prepared in accordance with MPIF Standard 50 and tested in accordance with Test Methods E 8.

^BConverted from HK₁₀₀ Microhardness, MPIF Standard 51, Appendix B.

^CThese data were measured on test bars heat treated to H900.

**TABLE 5 Mandatory and Typical Mechanical Properties of Metal Injection Molded Stainless Steels^A
SI Units**

Material Designation	Minimum Mandatory Values			Typical Values			Typical Values	
	Tensile Properties			Tensile Properties			Density	Hardness
	Ultimate Strength MPa	Yield Strength MPa	Elongation % in 25.4 mm	Ultimate Strength MPa	Yield Strength MPa	Elongation % in 25.4 mm		Apparent Matrix. hard. ^B Rockwell
MIM-316L	450	140	40	515	170	50	7.6	67 HRB
MIM-17-4 PH	795	645	4	895	730	6	7.5	27 HRC
MIM-17-4 PH-HT ^C	1070	965	4	1185	1090	6	7.5	33 HRC 40 HRC

^AReprinted by permission from MPIF Standard 35, "Materials Standards for Metal Injection Molded Parts", 1993/1994 Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692. S.I. values converted from English units in Table 3.

Density determined in accordance with B 311 or B 328. Apparent hardness determined in accordance with ASTM E 18. Tensile properties determined on test bars prepared in accordance with MPIF Standard 50 and tested in accordance with ASTM E 8.

^BConverted from HK₁₀₀ Microhardness, MPIF Standard 51, Appendix B.

^CThese data were measured on test bars heat treated to H900.

7.1.1 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.

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

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

7.2 Mechanical Property Test Methods:

7.2.1 *Tensile Test Method*—When requested in the purchase order, tensile specimens shall be specially injection molded per MPIF Standard 50, sintered, and heat treated if necessary, along with production parts. Tensile specimens shall be tested in accordance with Test Method E 8. Yield strength shall be determined by the 0.2 % offset method. MPIF Standard 50 governs the manufacture of the test bars, but the testing procedure is governed by Test Method E 8.

8. Sampling

8.1 *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.

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

9. Inspection

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

9.2 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.

10. Rejection

10.1 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.

11. Certification

11.1 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.

12. Keywords

12.1 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

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