



Standard Specification for Metal Injection Molding (MIM) Ferrous Materials¹

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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 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 pre-alloyed 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.

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

1.3 Chemical composition limits are specified in **Table 1**.

1.4 Property 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

B 243 Terminology of Powder Metallurgy

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

B 328 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 (P/M) Materials

E 8 Test Methods for Tension Testing of Metallic Materials

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

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

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

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

E 1086 Test Method for Optical Emission Vacuum Spectrometric Analysis of Stainless Steel by the Point-to-Plane Excitation Technique

E 1621 Guide for X-Ray Emission Spectrometric Analysis

F 1089 Test Method for Corrosion of Surgical Instruments

2.2 MPIF Standards:³

MPIF Standard 35, Material Standards for Metal Injection Molded Parts

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

MPIF Standard 51, Determination of Microhardness of Powder Metallurgy Materials

MPIF Standard 59, Determination of Charpy Impact Energy of Unnotched Metal Injection Molded Test Specimens

MPIF Standard 62, Determination of the Corrosion Resistance of MIM Grades of Stainless Steel Immersed in 2 % Sulfuric Acid Solution

MPIF Standard 63, Density Determination of MIM Components (Gas Pycnometer)

3. Terminology

3.1 Definitions:

3.1.1 Definitions of powder metallurgy terms can be found in Terminology **B 243**. Additional descriptive information is

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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.

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

TABLE 1 Chemical Composition Requirements For Metal Injection Molded Materials

Material Designation		Fe	Ni	Cr	Co	Mo	C	Cu	Si	Mn	Nb + Ta	V	Other
MIM-2200	Min.	Bal.	1.5	-	-	-	-	-	-	-	-	-	-
	Max.	Bal.	2.5	-	-	0.5	0.1	-	1.0	-	-	-	1.0
MIM-2700	Min.	Bal.	6.5	-	-	-	-	-	-	-	-	-	-
	Max.	Bal.	8.5	-	-	0.5	0.1	-	1.0	-	-	-	1.0
MIM-4605	Min.	Bal.	1.5	-	-	0.2	0.4	-	-	-	-	-	-
	Max.	Bal.	2.5	-	-	0.5	0.6	-	1.0	-	-	-	1.0
MIM-316L	Min.	Bal.	10	16	-	2	-	-	-	-	-	-	-
	Max.	Bal.	14	18	-	3	0.03	-	1.0	2.0	-	-	1.0
MIM-430L	Min.	Bal.	-	16	-	-	-	-	-	-	-	-	-
	Max.	Bal.	-	18	-	-	0.05	-	1.0	1.5	-	-	1.0
MIM-17-4PH	Min.	Bal.	3	15.5	-	-	-	3	-	-	0.15	-	-
	Max.	Bal.	5	17.5	-	-	0.07	5	1.0	1.0	0.45	-	1.0

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

TABLE 2 Mandatory and Typical Mechanical and Physical Properties of Metal Injection Molded Low-Alloy Steels^A
Inch-Pound Units

Material Designation	Minimum Mandatory Values			Typical Values			Density	Typical Values		Unnotched Charpy Impact Energy ^B
	Tensile Properties			Tensile Properties				Hardness		
	Ultimate Strength	Yield Strength	Elongation in 1 in.	Ultimate Strength	Yield Strength	Elongation in 1 in.		Macro (apparent)	Micro (converted)	
	10 ³ psi	10 ³ psi	%	10 ³ psi	10 ³ psi	%		g/cm ³	Rockwell	
MIM-2200 (as-sintered)	37	16	20.0	42	18	40.0	7.6	45 HRB	...	100
MIM-2700 (as-sintered)	55	30	20.0	60	37	26.0	7.6	69 HRB	...	130
MIM-4605 (as-sintered)	55	25	11.0	64	30	15.0	7.5	62 HRB	...	50
MIM-4605 ^C (quenched and tempered)	215	190	≤1.0	240	215	2.0	7.5	48 HRC	55 HRC	40

^A Reprinted by permission from [MPIF Standard 35](#), "Materials Standard for Metal Injection Molded Parts", 2000, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

^B [MPIF Standard 59](#) specimens are 0.197 × 0.394 × 2.155 in. The results were not normalized to 0.394 × 0.394 × 2.165 in. since this would have resulted in higher impact energy values.

^C These data were measured on test bars tempered for 1 h at 350°F.

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

Material Designation	Minimum Mandatory Values			Typical Values			Typical Values			Unnotched Charpy Impact Energy ^B
	Tensile Properties			Tensile Properties			Density	Hardness		
	Ultimate Strength	Yield Strength	Elongation in 25.4 mm	Ultimate Strength	Yield Strength	Elongation in 25.4 mm		Macro (apparent)	Micro (converted)	
	MPa	MPa	%	MPa	MPa	%	g/cm ³	Rockwell		
MIM-2200 (as-sintered)	255	110	20.0	290	125	40.0	7.6	45 HRB	...	135
MIM-2700 (as-sintered)	380	205	20.0	415	255	26.0	7.6	69 HRB	...	175
MIM-4605 (as-sintered)	380	170	11.0	440	205	15.0	7.5	62 HRB	...	70
MIM-4605 ^C (quenched and tempered)	1480	1310	<1.0	1655	1480	2.0	7.5	48 HRC	55 HRC	55

^A Reprinted by permission from **MPIF Standard 35**, "Materials Standards for Metal Injection Molded Parts", 2000, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692. SI values converted from inch-pound units in Table 2.

^B **MPIF Standard 59** specimens are 5 × 10 × 55 mm. The results were not normalized to 10 × 10 × 55 mm since this would have resulted in higher impact energy values.

^C This data was measured on test bars tempered for 1 h at 177°C.

TABLE 4 Mandatory and Typical Mechanical and Physical Properties of Metal Injection Molded Stainless Steels^A
Inch-Pound Units

Material Designation	Minimum Mandatory Values			Typical Values			Density	Typical Values		Unnotched Charpy Impact Energy ^B
	Tensile Properties			Tensile Properties				Hardness		
	Ultimate Strength	Yield Strength	Elongation in 1 in.	Ultimate Strength	Yield Strength	Elongation in 1 in.		Macro (apparent)	Micro (converted)	
	10 ³ psi	10 ³ psi	%	10 ³ psi	10 ³ psi	%	g/cm ³	Rockwell		
MIM-316L (as-sintered)	65	20	40.0	75	25	50.0	7.6	67 HRB	...	140
MIMI-430L (as-sintered)	50	30	20.0	60	35	25.0	7.5	65 HRB	...	^C
MIM-17-4 PH (as-sintered)	115	94	4.0	130	106	6.0	7.5	27 HRC	...	50
MIM-17-4 PH ^D (heat treated)	155	140	4.0	172	158	6.0	7.5	33 HRC	40 HRC	^C

^A Reprinted by permission from **MPIF Standard 35**, "Materials Standards for Metal Injection Molded Parts", 2000, Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

^B **MPIF Standard 59** specimens are 0.197 × 0.394 × 2.165 in. The results were not normalized to 0.394 × 0.394 × 2.165 in. since this would have resulted in higher impact energy values.

^C Additional data in preparation will appear in subsequent editions of this specification.

^D This data was measured on test bars aged at 900°F (heat treated to H900).

with Test Methods **E 415** (preferred method), **E 350**, **E 1086**, **E 1621**, 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 **E 1019**, 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:

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 **E 8**. Yield strength shall be determined by the 0.2 % offset method. **MPIF Standard 50** governs the manufacture of the test bars, while Test Methods **E 8** 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**.

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

Material Designation	Minimum Mandatory Values			Typical Values			Density	Typical Values		Unnotched Charpy Impact Energy ^B	
	Tensile Properties			Tensile Properties				Hardness			
	Ultimate Strength	Yield Strength	Elongation in 25.4 mm	Ultimate Strength	Yield Strength	Elongation in 25.4 mm		Macro (apparent)	Micro (converted)		J
	MPa	MPa	%	MPa	MPa	%		g/cm ³	Rockwell		
MIM-316L	450	140	40.0	520	175	50.0	7.6	67 HRB	...	190 ^C	
MIM-430L	345	205	20.0	415	240	25.0	7.5	65 HRB	...		
MIM-17-4 PH	795	650	4.0	900	730	6.0	7.5	27 HRC	...	70 ^C	
MIM-17-4 PH ^D (heat treated)	1070	965	4.0	1185	1090	6.0	7.5	33 HRC	40 HRC		

^A Reprinted by permission from **MPiF Standard 35**, "Materials Standards for Metal Injection Molded Parts", 2000 Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692. SI values converted from inch-pound units in Table 4.

^B **MPiF Standard 59** specimens are 5 × 10 × 55 mm. The results were not normalized to 10 × 10 × 55 mm since this would have resulted in higher impact energy values.

^C Additional data in preparation will appear in subsequent editions of this specification.

^D This data was measured on test bars aged at 482°C (heat treated to H900).

TABLE 6 Typical Corrosion Resistance Properties of Metal Injection Molded Stainless Steels^A
SI Units

Material Designation	H ₂ SO ₄ ^B	Typical Values	Boil Test in H ₂ O
	g/dm ² /day	CUSO ₄	
MIM-316L (as-sintered)	<0.005	Pass	Pass
MIM-430L (as-sintered)	_C	_C	_C
MIM-17-4 PH (as-sintered)	<0.005	Pass	Pass
MIM-17-4 PH ^D (heat treated)	<0.005	Pass	Pass

^A Reprinted by permission from **MPiF Standard 35**, "Materials Standards for Metal Injection Molded Parts", 2000 Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692.

^B **MPiF Standard 59** test specimens were tested in 2 % H₂SO₄ for 1000 h at 22°C ± 2°C. These test specimens were tested in accordance with **MPiF Standard 62**.

^C Additional data will appear in subsequent editions of this specification.

^D This data was measured on test bars aged at 482°C (heat treated to H900).

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 **B 311** or **MPiF Standard 63**. If a test specimen gains mass when immersed in water, it shall be tested in accordance with Test Method **B 328**.

7.6 *Apparent Hardness*—The apparent hardness of MIM materials shall be measured in accordance with Test Methods **E 18**.

7.7 *Microindentation Hardness*—The microindentation hardness of MIM materials shall be measured in accordance with Test Method **B 933** 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 **F 1089** governs corrosion resistance testing for copper sulfate and boiling water. **MPiF Standard 62** governs 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 accor-

dance 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

13.1 corrosion 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

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