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Standard Specification for Materials for Ferrous Powder Metallurgy (PM) Structural Parts[1]

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1. Scope

1.1 This specification covers a variety of ferrous PM structural materials and includes a classification system or material designation code. The classification system used in this specification includes chemical composition, minimum tensile; 0.2 % offset yield strength for as-sintered materials and minimum ultimate tensile strength for heat-treated materials (sinter hardened or quenched and tempered). It also contains minimum density and maximum coercive field strength requirements for iron-phosphorus materials.

1.2 Material classification is governed by the designation code which is explained in Appendix X1. The data provided display typical mechanical properties achieved under commercial manufacturing procedures. Physical and mechanical property performance characteristics can change as a result of subsequent processing steps beyond the steps designated in this standard.

1.3 With the exception of density values for which the g/cm^3 unit is the industry standard, property values stated in inch-pound units are the standard. Values in SI units result from conversion. They may be approximate and are only for information.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A839 Specification for Iron-Phosphorus Powder Metallurgy Parts for Soft Magnetic Applications

B243 Terminology of Powder Metallurgy

B528 Test Method for Transverse Rupture Strength of Powder Metallurgy (PM) Specimens

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

B963 Test Methods for Oil Content, Oil-Impregnation Efficiency, and Surface-Connected Porosity of Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

E8 Test Methods for Tension Testing of Metallic Materials

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

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

2.2 *MPIF Standard:*[3]

MPIF Standard 35 Materials Standards for PM Structural Parts

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy terms can be found in Terminology B243. Additional descriptive information is available in the Related Materials section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Ordering Information

4.1 Materials for parts conforming to this specification shall be ordered by material designation code.

4.2 Orders for parts under this specification may include the following information:

4.2.1 Certification and test reports, if required (see Section 11),

4.2.2 Test methods and mechanical properties other than strength (see 8.2 and 8.3),

4.2.3 Density (see 7.1),

4.2.4 Porosity or oil content (see 7.2), and

4.2.5 Special packaging if required.

5. Materials and Manufacture

5.1 Structural parts shall be made by compacting and sintering metal powders with or without subsequent heat -treating. Parts may also be made by repressing or repressing and resintering sintered parts, if necessary, with or without

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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 MPIF, 105 College Road East, Princeton, NJ 08540.

subsequent heat treatment to produce finished parts conforming to the requirements of this specification.

6. Chemical Composition

6.1 The material shall conform to the requirements of Table 1.

6.2 Chemical analysis, if required, shall be performed by methods agreed upon by the producer and the user.

6.3 Various analytical test methods are used to determine the chemical composition (see ASTM standards for the appropriate test methods) of PM materials. Combustion-infra-red absorption and inert gas fusion methods (Test Methods E1019) are used for the specific elements carbon, nitrogen, oxygen, and sulfur.

6.4 The Chemical Composition Requirements Table (Table 1) designates the limits of metallurgically combined carbon for each alloy. The combined carbon level can be estimated metallographically for sintered PM steels. When a clear pearlite to ferrite ratio cannot be estimated metallographically, total carbon can be determined using analytical methods (Test Methods E1019). This would include very low carbon levels (<0.08 %), heat treated steels and materials made from prealloyed base powders or diffusion alloyed powders. When reporting carbon levels, the report should identify whether the carbon is metallurgically combined carbon or total carbon and the test method should be identified. While total carbon will approximate the combined carbon in many materials, free graphite and other carbonaceous material will raise the total carbon level above the level of combined carbon, possibly causing the total carbon content to exceed the combined carbon level specified for the material.

7. Physical Properties

7.1 *Density:*

7.1.1 The user and producer may agree upon a minimum average density for the part or minimum densities for specific regions of the part, or both, except soft magnetic materials, which require a minimum average density as part of the material specification.

7.1.2 Density shall be determined in accordance with Test Method B962.

7.2 *Porosity:*

7.2.1 The producer and the user may also agree upon a minimum volume oil content for parts that are to be self-lubricating.

7.2.2 Porosity or oil content, or both, shall be determined in accordance with Test Method B963.

7.2.3 The producer and the user may agree upon a functional test for porosity in parts that are to be self-lubricating, or for permeability where fluid flow must be restricted.

8. Mechanical Properties

8.1 The guaranteed properties shown in Tables 2-12 are included in the suffix of the material designation code. The code is adopted from MPIF Standard 35. All tensile strengths are read as 10^3 psi, and are defined as the 0.2 % offset yield strength for as-sintered materials and the ultimate tensile strength for heat-treated materials (sinter hardened or quenched and tempered). Iron-phosphorus materials (Table 3) contain an alphanumeric suffix and are an exception to this rule. The iron-phosphorus suffix is related to the minimum density and maximum coercive field strength and not the tensile yield strength (see X1.3 and X1.4 for details).

8.1.1 Materials that are heat treated (sinter-hardened or quenched and tempered) have the numeric value followed by HT in the suffix.

8.2 The producer and the user should agree upon the method to be used to verify the minimum strength characteristics of the finished parts. Since it is usually impossible to machine tensile test specimens from these parts, alternative strength tests are advisable. An example would be measuring the force needed to break teeth off a gear with the gear properly fixtured.

8.3 If the tensile properties of the materials are required, standard test bars shall be compacted from the same mixed powder lot, at the density of a critical region in the part, and processed along with the parts. When a PM part has a larger ruling section than the test bar being used, the test bar may not be representative of the part. The following procedures are listed with the preferred method first.

8.3.1 Transverse rupture strength (see Test Method B528) can be related to the minimum tensile strength by the ratio of typical transverse rupture strength to typical tensile strength at the same density as the part, as shown in, or interpolated from the tables contained in Appendix X1.

8.3.2 For as-sintered material, flat unmachined tension test specimens (see Test Methods E8) should be used for determination of 0.2 % offset yield strength.

8.3.3 For determining the tensile strength of heat-treated (sinter-hardened or quenched and tempered) material, round test bars should be machined from specially compacted, as-sintered bars because heat-treated, unmachined specimens yield lower values. The machined tension test specimens (see Test Methods E8) shall be heat-treated with the production parts.

9. Sampling

9.1 *Chemical Analysis*—When requested on the purchase order, at least one sample for chemical analysis shall be taken from each lot. The analysis shall be performed by a mutually agreed upon method.

9.2 *Mechanical Tests*—The producer and the user shall agree on the number of specimens for mechanical tests.

10. Rejection and Rehearing

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

11. Certification and Test Reports

11.1 When specified in the purchase order or contract, a producer's certification shall be furnished to the user that the parts were manufactured, sampled, tested, and inspected in accordance with this specification and have been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

TABLE 1 Chemical Composition Requirements[A]

NOTE 1—For the Stainless Steels: N1—Nitrogen alloyed. Good strength, low elongation. N2—Nitrogen alloyed. High strength, medium elongation. L—Low carbon. Lower strength, highest elongation. HT—Martensitic grade, heat treated. Highest strength.

Material Designation		Chemical Composition, Mass %													
		Iron	Copper	Carbon	Nickel	Molybdenum	Chromium	Manganese	Silicon	Sulfur	Phosphorus	Nitrogen	Columbium	Oxygen	Other
F-0000	Min	Bal.	...	0.0	...	...	...	...	...	...	...	...	...	...	...
F-0000	Max	Bal.	...	0.3	...	...	...	...	...	...	...	...	...	...	2.0
F-0005	Min	Bal.	...	0.3	...	...	...	...	...	...	...	...	...	...	...
F-0005	Max	Bal.	...	0.6	...	...	...	...	...	...	...	...	...	...	2.0
F-0008	Min	Bal.	...	0.6	...	...	...	...	...	...	...	...	...	...	...
F-0008	Max	Bal.	...	0.9	...	...	...	...	...	...	...	...	...	...	2.0
FY-4500	Min	Bal.	...	0.00	...	...	...	...	...	...	0.40	0.00	...	0.00	...
FY-4500	Max	Bal.	...	0.03	...	...	...	...	...	...	0.50	0.01	...	0.10	0.5
FY-8000	Min	Bal.	...	0.00	...	...	...	...	...	...	0.75	0.00	...	0.00	...
FY-8000	Max	Bal.	...	0.03	...	...	...	...	...	...	0.85	0.01	...	0.10	0.5
FX-1000	Min	Bal.	8.0	0.0	...	...	...	...	...	...	...	...	...	...	...
FX-1000	Max	Bal.	14.9	0.3[B]	...	...	...	...	...	...	...	...	...	...	2.0
FX-1005	Min	Bal.	8.0	0.3[B]	...	...	...	...	...	...	...	...	...	...	...
FX-1005	Max	Bal.	14.9	0.6[B]	...	...	...	...	...	...	...	...	...	...	2.0
FX-1008	Min	Bal.	8.0	0.6[B]	...	...	...	...	...	...	...	...	...	...	...
FX-1008	Max	Bal.	14.9	0.9	...	...	...	...	...	...	...	...	...	...	2.0
FX-2000	Min	Bal.	15.0	0.0	...	...	...	...	...	...	...	...	...	...	...
FX-2000	Max	Bal.	25.0	0.3[B]	...	...	...	...	...	...	...	...	...	...	2.0
FX-2005	Min	Bal.	15.0	0.3[B]	...	...	...	...	...	...	...	...	...	...	...
FX-2005	Max	Bal.	25.0	0.6[B]	...	...	...	...	...	...	...	...	...	...	2.0
FX-2008	Min	Bal.	15.0	0.6[B]	...	...	...	...	...	...	...	...	...	...	...
FX-2008	Max	Bal.	25.0	0.9[B]	...	...	...	...	...	...	...	...	...	...	2.0
FC-0200	Min	Bal.	1.5	0.0	...	...	...	...	...	...	...	...	...	...	...
FC-0200	Max	Bal.	3.9	0.3	...	...	...	...	...	...	...	...	...	...	2.0
FC-0205	Min	Bal.	1.5	0.3	...	...	...	...	...	...	...	...	...	...	...
FC-0205	Max	Bal.	3.9	0.6	...	...	...	...	...	...	...	...	...	...	2.0
FC-0208	Min	Bal.	1.5	0.6	...	...	...	...	...	...	...	...	...	...	...
FC-0208	Max	Bal.	3.9	0.9	...	...	...	...	...	...	...	...	...	...	2.0
FC-0505	Min	Bal.	4.0	0.3	...	...	...	...	...	...	...	...	...	...	...
FC-0505	Max	Bal.	6.0	0.6	...	...	...	...	...	...	...	...	...	...	2.0
FC-0508	Min	Bal.	4.0	0.6	...	...	...	...	...	...	...	...	...	...	...
FC-0508	Max	Bal.	6.0	0.9	...	...	...	...	...	...	...	...	...	...	2.0
FC-0808	Min	Bal.	7.0	0.6	...	...	...	...	...	...	...	...	...	...	...
FC-0808	Max	Bal.	9.0	0.9	...	...	...	...	...	...	...	...	...	...	2.0