Designation: B848 – 15

Standard Specification for Powder Forged (PF) Ferrous Materials[1]

This standard is issued under the fixed designation B848; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers powder forged ferrous materials fabricated by hot densification of atomized prealloyed or iron powders and intended for use as structural parts.

1.2 This specification covers powder forged parts made from the following materials:

1.2.1 *Compositions:*

1.2.1.1 PF-10XX Carbon Steel (produced from atomized iron powder and graphite powder),

1.2.1.2 PF-10CXX Copper-Carbon Steel (produced from atomized iron powder, copper and graphite powders),

1.2.1.3 PF-11XX Carbon Steel with manganese sulfide for enhanced machinability (produced from atomized iron powder, manganese sulfide, and graphite powders),

1.2.1.4 PF-11CXX, PF-1130CXX, and PF-1135CXX Copper-Carbon Steels with manganese sulfide for enhanced machinability (produced from atomized iron powder, copper, manganese sulfide, and graphite powders),

1.2.1.5 PF-42XX Nickel-Molybdenum Steel (produced from prealloyed atomized iron-nickel-molybdenum powder and graphite powder),

1.2.1.6 PF-46XX Nickel-Molybdenum Steel (produced from prealloyed atomized iron-nickel-molybdenum powder and graphite powder),

1.2.1.7 PF-44XX Molybdenum Steel (produced from prealloyed atomized iron-molybdenum powder and graphite powder), and

1.2.1.8 PF-49XX Molybdenum Steel (produced from prealloyed atomized iron-molybdenum powder and graphite powder).

NOTE 1—Alloy composition designations are modifications of the AISI-SAE nomenclature. For example: 10CXX designates a plain carbon steel containing copper and XX amount of carbon. Compositional limits of alloy and impurity elements may be different from the AISI-SAE limits. Chemical composition limits are specified in Section 6.

NOTE 2—XX designates the forged carbon content, in hundredths of a percent, that is specified by the purchaser for the application. For a given specified carbon content, the permissible limits shall be as specified in 6.2.

NOTE 3—The old acronym for powder forging P/F has been replaced by PF throughout the document. The change in the prefix for the material designations is just to match the currently approved acronym for powder forging. No change has been made to the material specification and performance characteristics for the various powder forged materials.

1.2.2 *Grades:*

1.2.2.1 *Grade A*—Density equivalent to a maximum of 0.5 % porosity. The minimum density of those sections of the powder forged part so designated by the applicable part drawing shall not be less than the value specified in Table 1.

1.2.2.2 *Grade B*—Density equivalent to a maximum of 1.5 % porosity. The minimum density of those sections of the powder forged part so designated by the applicable part drawing shall not be less than the value specified in Table 1.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A255 Test Methods for Determining Hardenability of Steel

B243 Terminology of Powder Metallurgy

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

B795 Test Method for Determining the Percentage of Alloyed or Unalloyed Iron Contamination Present in Powder Forged (PF) Steel Materials

B796 Test Method for Nonmetallic Inclusion Content of Ferrous Powders Intended for Powder Forging (PF) Applications

B797 Test Method for Surface Finger-Oxide Penetration Depth and Presence of Interparticle Oxide Networks in Powder Forged (PF) Steel Parts

B934 Test Method for Effective Case Depth of Ferrous Powder Metallurgy (PM) Parts Using Microindentation Hardness Measurements

[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.

Current edition approved Nov. 1, 2015. Published December 2015. Originally approved in 1994. Last previous edition approved in 2010 as B848 – 10. DOI: 10.1520/B0848-15.

[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.

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

TABLE 1 Minimum Density for Selected Powder Forged Steel Compositions (Fully Annealed Heat Treatment Condition—Ferrite/Pearlite Microstructure)[A,B]

Chemical Composition	Density (g/cm ^{3})	
	Grade A (0.5 % porosity)[C]	Grade B (1.5 % porosity)[C]
PF-1040	7.81	7.74
PF-1060	7.81	7.73
PF-10C40	7.81[D]	7.74[D]
PF-10C60	7.81[D]	7.73[D]
PF-1140	7.79	7.71
PF-1160	7.78	7.70
PF-11C40	7.79[D]	7.71[D]
PF-11C60	7.79[D]	7.71[D]
PF-1130C50	7.82[D]	7.74[D]
PF-1130C60	7.82[D]	7.74[D]
PF-1135C60	7.82[D]	7.74[D]
PF-4220	7.82	7.74
PF-4240	7.81	7.73
PF-4260	7.80	7.72
PF-4420	7.82	7.74
PF-4440	7.81	7.73
PF-4460	7.81	7.73
PF-4620	7.82	7.74
PF-4640	7.81	7.73
PF-4660	7.81	7.73
PF-4680	7.80	7.72
PF-4920	7.83	7.75
PF-4940	7.82	7.74
PF-4960	7.81	7.74

[A] Quench-hardening and tempering will reduce the density values. Normalized samples may have lower density values then fully annealed materials.
[B] For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.
[C] Based on the method described in Smith, D. W., "Calculation of the Pore-Free Density of PM Steels: Role of Microstructure and Composition," *The International Journal of Powder Metallurgy,* Vol 28, No. 3, 1992, p. 259. Calculations based on 350 ppm max oxygen content and all oxygen combined as $3MnO \cdot Al_2O_3 \cdot 3SiO_2$.
[D] The method described by Smith is not considered applicable to steels with admixed copper additions. Pore-free densities for these materials were determined by experiment.

E3 Guide for Preparation of Metallographic Specimens
E8 Test Methods for Tension Testing of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
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
E562 Test Method for Determining Volume Fraction by Systematic Manual Point Count
E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
E1077 Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.2 *MPIF Standard:*[3]
MPIF 35 Materials Standards for PF Steel 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 Material Section of Vol. 02.05 of the *Annual Book of ASTM Standards.*

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core region*—a core region is one where there is either no decarburization as determined by the procedure in 9.3.4 or there is no hardened surface as determined by the procedure in S2.2.

3.2.2 *critical region*—a critical region of a part is one that requires a density level or a microstructural characteristic to be separately specified.

4. Ordering Information

4.1 Orders for parts conforming to this specification shall include the following:

4.1.1 Alloy composition, including carbon content (see 1.2.1, Section 6, and Table 2),

4.1.2 Grade (minimum density requirement—see 1.2.2 and Section 7),

4.1.3 Heat treatment condition and hardness (see 8.1.3, 8.1.4, and 8.2.3),

4.1.4 Location of critical regions (see 3.2.2),

4.1.5 Whether functional or mechanical property testing is required, what type of testing is required, and what performance level is required (see 8.1.1, 8.1.2, 8.2.1, and 8.2.2),

4.1.6 Whether the purchaser desires that his representative inspect or witness the inspection and testing of the material prior to shipment (see 11.1 and 11.2),

4.1.7 Whether there are special microstructural requirements (see Section 9 and S4),

4.1.8 Whether certification of the material is required (see Section 13),

4.1.9 Whether there is a maximum forged-oxygen content (see S1),

4.1.10 Whether case hardening is required (see S2),

4.1.11 Whether there is a maximum area percent porosity requirement for critical regions (see 3.2.2 and S3), and

4.1.12 ASTM designation and year of issue.

5. Materials and Manufacture

5.1 Make the structural parts by hot forging of powder metallurgy (PM) preforms in confined dies with or without subsequent heat treatment. Prepare PM preforms by pressing or by pressing and sintering material conforming to the designations in 1.2.1 and meeting the chemical compositions specified in Section 6 and Table 2.

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

TABLE 2 Chemical Composition Requirements for Powder Forged Parts (Weight %)[A]

Element	PF-10XX	PF-10CXX	PF-11XX	PF-11CXX	PF-1130CXX	PF-1135CXX
Nickel, max	0.10	0.10	0.10	0.10	0.10	0.10
Molybdenum, max	0.05	0.05	0.05	0.05	0.05	0.05
Manganese	0.10–0.25	0.10–0.25	0.30–0.60[B]	0.30–0.60[B]	0.30–0.60[B]	0.30–0.60[B]
Copper	0.30 max	1.8–2.2	0.30 max	1.8–2.2	2.7–3.3[F]	3.0–3.8[F]
Chromium, max	0.10	0.10	0.10	0.10	0.10	0.10
Sulfur, max	0.025	0.025	0.23[B]	0.23[B]	0.23	0.23
Silicon, max	0.03	0.03	0.03	0.03	0.03	0.03
Phosphorus, max	0.03	0.03	0.03	0.03	0.03	0.03
Carbon	[C]	[C]	[C]	[C]	[C]	[C]
Oxygen	[D]	[D]	[D]	[D]	[D]	[D]
Total Iron	Balance[E]	Balance[E]	Balance[E]	Balance[E]		

Element	PF-42XX	PF-46XX	PF-44XX	PF-49XX
Nickel	0.40–0.50	1.75–2.00	0.10 max	0.10 max
Molybdenum	0.55–0.65	0.50–0.60	0.80–0.95	1.4–1.6
Manganese	0.20–0.35	0.10–0.25	0.08–0.18	0.08–0.18
Copper, max	0.15	0.15	0.15	0.15
Chromium, max	0.10	0.10	0.10	0.10
Sulfur, max	0.03	0.03	0.03	0.03
Silicon, max	0.03	0.03	0.03	0.03
Phosphorus, max	0.03	0.03	0.03	0.03
Carbon	[C]	[C]	[C]	[C]
Oxygen	[D]	[D]	[D]	[D]
Total Iron	Balance[E]	Balance[E]	Balance[E]	Balance[E]

[A] For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.
[B] Covers manganese sulfide (MnS) additions of from 0.3 to 0.5 %. The manganese content in solution is similar to PF-10XX or PF-10CXX, that is, 0.10 to 0.25 %.
[C] Carbon content shall be as specified by the purchaser.
[D] When required, maximum oxygen content shall conform to the amount specified by purchaser. See S1.
[E] For information only. Quantitative determination of this element is not required.
[F] Some of the copper may be prealloyed.

6. Chemical Composition

6.1 The hot forged material shall conform to the requirements prescribed in Table 2.

6.2 Unless otherwise specified, the hot forged carbon content shall not deviate from that specified by the purchaser by more than ±0.05 weight percent.

6.3 Determine the concentration of the elements copper, chromium, manganese, molybdenum, nickel, phosphorus, and silicon in accordance with Test Method E415 or Test Method E350; X-ray fluorescence (XRF) or inductively coupled plasma, atomic emission spectrometry (ICP-AES) techniques may also be used for these analyses. Determine the concentration of the elements carbon and sulfur in accordance with Test Methods E1019.

7. Density Requirement

7.1 The minimum density of those sections of powder forged parts so designated by the applicable part drawing shall not be less than the values specified in Table 1.

7.2 Determine the density of complete parts or sections of parts in accordance with Test Method B311.

8. Mechanical Property Requirements

8.1 *Mechanical Properties:*

8.1.1 The preferred method for verifying the acceptable performance of a finished part is for the producer and the purchaser to agree upon a qualification test to be performed on an actual part. The specific test should be determined following consideration of the function of the part. An example would be measuring the force needed to break teeth off a gear, using a prescribed test fixture.

8.1.2 Where the part configuration permits, standard mechanical property test specimens may be machined from the part in the condition in which it is to be used. (Remove test specimens from parts to be used in the quenched and tempered condition after heat treatment of the part to ensure the microstructure is representative of the actual part.) The applicable part drawing or purchase order shall designate the location from which the mechanical property test specimens are to be removed and the type of specimen to be tested.

8.1.3 The core hardness range of parts shall be in accordance with the applicable part drawing or purchase order.

8.1.4 The surface hardness range of parts shall be in accordance with the applicable part drawing or purchase order.