



Designation: F3213 – 17

Standard for Additive Manufacturing – Finished Part Properties – Standard Specification for Cobalt-28 Chromium-6 Molybdenum via Powder Bed Fusion¹

This standard is issued under the fixed designation F3213; 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 additively manufactured cobalt-28 chromium-6 molybdenum alloy components with similar chemical composition to UNS R30075 by means of laser and electron beam-based full melt powder bed fusion processes. The components produced by these processes are used typically in applications that require mechanical properties similar to cast or wrought products. Components manufactured to this specification are often, but not necessarily, post processed via machining, grinding, electrical discharge machining (EDM), polishing, and so forth to achieve desired surface finish and critical dimensions.

1.2 This specification is intended for the use of purchasers or producers, or both, of additively manufactured cobalt-28 chromium-6 molybdenum alloy components for defining the requirements and ensuring component properties.

1.3 Users are advised to use this specification as a basis for obtaining components that will meet the minimum acceptance requirements established and revised by consensus of the members of the committee.

1.4 User requirements considered more stringent than requirements in Sections 1–22 may be met by the addition to the purchase order of one or more supplementary requirements, which may include, but are not limited to, those listed in Supplementary Requirements S1–S14.

1.5 The values stated in SI units are to be regarded as the standard. Other units are included only for informational purposes.

1.6 The chemical composition requirements in this specification for cobalt-28 chromium-6 molybdenum alloy components are similar to Specification F1537 Alloys 1 and 2 for wrought cobalt-28 chromium-6 molybdenum and Specification F75 for cast cobalt-28 chromium-6 molybdenum.

1.7 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

- A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
- B213 Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel
- B214 Test Method for Sieve Analysis of Metal Powders
- B243 Terminology of Powder Metallurgy
- B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity
- B822 Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering
- B855 Test Method for Volumetric Flow Rate of Metal Powders Using the Arnold Meter and Hall Flowmeter Funnel
- B964 Test Methods for Flow Rate of Metal Powders Using the Carney Funnel
- D3951 Practice for Commercial Packaging
- E3 Guide for Preparation of Metallographic Specimens
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E9 Test Methods of Compression Testing of Metallic Materials at Room Temperature
- E10 Test Method for Brinell Hardness of Metallic Materials
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

¹ This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.05 on Materials and Processes.

Current edition approved Nov. 1, 2017. Published January 2018. DOI: 10.1520/F2313M-17

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.

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

E238 Test Method for Pin-Type Bearing Test of Metallic Materials

E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

E384 Test Method for Microindentation Hardness of Materials

E399 Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

E407 Practice for Microetching Metals and Alloys

E466 Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

E606 Test Method for Strain-Controlled Fatigue Testing

E647 Test Method for Measurement of Fatigue Crack Growth Rates

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

E1417 Practice for Liquid Penetrant Testing

E1450 Test Method for Tension Testing of Structural Alloys in Liquid Helium

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt and High-Temperature Alloys

E1742/E1742M Practice for Radiographic Examination

E1820 Test Method for Measurement of Fracture Toughness

E1941 Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

E2368 Practice for Strain Controlled Thermomechanical Fatigue Testing

F75 Specification for Cobalt-28 Chromium-6 Molybdenum Alloy Castings and Casting Alloy for Surgical Implants (UNS R30075)

F1377 Specification for Cobalt-28Chromium-6Molybdenum Powder for Coating of Orthopedic Implants (UNS R30075)

F1537 Specification for Wrought Cobalt-28Chromium-6Molybdenum Alloys for Surgical Implants (UNS R31537, UNS R31538, and UNS R31539)

F2924 Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with Powder Bed Fusion

F2971 Practice for Reporting Data for Test Specimens Prepared by Additive Manufacturing

F3049 Guide for Characterizing Properties of Metal Powders Used for Additive Manufacturing Processes

F3122 Guide for Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes

2.2 ISO/ASTM Standards:²

52900 Terminology for Additive Manufacturing – General Principles – Terminology

52915 Specification for Additive Manufacturing File Format (AMF) Version 1.1

52921 Terminology for Additive Manufacturing – Coordinate Systems and Test Methodologies

2.3 ASQ Standard:³

ASQ C1 Specification of General Requirements for a Quality Program

2.4 ISO Standards⁴

ISO 148-1 Metallic materials – Charpy pendulum impact test – Part 1: Test method

ISO 1099 Metallic materials – Fatigue testing – Axial force-controlled method

ISO 4545 Metallic materials – Knoop hardness test – Part 2: Verification and calibration of testing machines

ISO 6506-1 Metallic materials – Brinell hardness test – Part 1: Test method

ISO 6507-1 Metallic materials – Vickers hardness test – Part 1: Test method

ISO 6508 Metallic materials – Rockwell hardness test – Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)

ISO 6892-1 Metallic materials – Tensile testing at ambient temperature

ISO 6892-2 Metallic materials – Tensile testing – Part 2: Method of test at elevated temperature

ISO 9001 Quality management system – Requirements

ISO 9044 Industrial woven wire cloth – Technical requirements and testing

ISO 12108 Metallic materials – Fatigue testing – Fatigue crack growth method

ISO 12111 Metallic materials – Fatigue testing – Strain-controlled thermomechanical fatigue testing method

ISO 12135 Metallic materials – Unified method of test for the determination of quasistatic fracture toughness

ISO 12737 Metallic materials – Determination of plane-strain fracture toughness (withdrawn)

ISO 13485 Medical devices – Quality management systems – Requirements for regulatory purposes

ISO 19819 Metallic materials – Tensile testing in liquid form

2.5 SAE Standards⁵

AMS 2248 Chemical Check Analysis Limits: Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

AMS 2269 Chemical Check Analysis Limits Nickel, Nickel Alloys, and Cobalt Alloys

AMS 2774 Heat Treatment Wrought Nickel Alloy and Cobalt Alloy Parts

AMS 5599 Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate 62Ni-21.5Cr-9.0Mo-3.7Cb (Nb) Solution Heat Treated

AMS 5894 Cobalt Alloys, Bars, Sheets, and Plate, 60Co-28Cr-4.5W-1.15C, Solution Heat Treated

AS 9100 Quality Management Systems – Requirements for Aviation, Space and Defense Organizations

³ Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203, <http://www.asq.org>.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.



2.6 *ASME Standard*.⁶

ASME B46.1 Surface Texture

2.7 *NIST Standard*.⁷

IR 7847 (March 2012) CODEN:NTNOEF

3. Terminology

3.1 Definitions:

3.1.1 Terminology relating to powder bed fusion in Specification **F2924** shall apply.

3.1.2 Terminology relating to additive manufacturing in ISO/ASTM 52900 shall apply.

3.1.3 Terminology relating to coordinate systems in ISO/ASTM 52921 shall apply.

3.1.4 Terminology relating to powder metallurgy in Terminology **B243** shall apply.

4. Conditon

4.1 Unless otherwise specified herein, all conditions shall meet the requirements in each system of this standard. Conditions are not listed sequentially.

4.1.1 Condition SR components shall be stress relieved or solution annealed in accordance with Section **12**.

4.1.2 Condition ANN components shall be solution annealed in accordance with Section **12**.

NOTE 1—Stress relieving in **4.1.1** refers to the thermal post-processing of dimensional stabilization to remove or reduce internal/residual stresses, and solution annealing in **4.1.1** and **4.1.2** refers to the thermal post-processing of heating the component to the maximum annealing temperature, holding for a sufficient time to gain boundary carbides to enter into solution, and cooling rapidly enough to prevent unacceptable grain boundary carbide precipitation.

4.1.3 Condition HIP components shall be hot isostatically pressed in accordance with Section **13**.

4.1.4 For Condition OPT components, all thermal post processing shall be optional.

4.1.5 The purchaser may specify multiple conditions on the purchase order such as Condition SR/HIP.

4.2 **Table 1** provides a guide on controls by condition.

5. Ordering Information

5.1 Orders for components compliant with this specification shall include the following to describe the requirements adequately:

⁶ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁷ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

5.1.1 This specification designation,

5.1.2 Description or part number of product desired,

5.1.3 Quantity of product desired,

5.1.4 Condition,

5.1.5 SI or SAE units,

5.1.5.1 *Discussion*—The STL file format used by many powder bed fusion machines does not contain units of measurement as metadata. When only STL files are provided by the purchaser, ordering information should specify the units of the component along with the electronic data file. More information about data files can be found in ISO/ASTM 52915.

5.1.6 Dimensions and tolerances (Section **14**),

5.1.7 Mechanical properties (Section **11**),

5.1.8 Methods for chemical analysis (Section **9**),

5.1.9 Sampling plans as agreed upon by the component supplier and purchaser, including any supplementary requirements (see **1.4**),

5.1.10 Post-processing sequence of operations,

5.1.11 Thermal post-processing condition,

5.1.12 Component marking such as labeling the serial or lot number in the CAD file prior to the build cycle, or product tagging,

5.1.13 Packaging and shipping requirements,

5.1.14 Certification,

5.1.15 Disposition of rejected material (Section **15**), and

5.1.16 Other supplementary requirements as agreed upon by the component supplier and purchaser such as allowable porosity (see **1.4**).

6. Manufacturing Information

6.1 Condition SR, ANN, HIP, and OPT components manufactured to this specification shall have a numbering plan that includes, but is not limited to, the following:

6.1.1 A machine, manufacturing control system, and qualification procedure as agreed between component supplier and purchaser;

NOTE 2—Qualification procedures typically require qualification build cycles in which mechanical property test specimens are prepared and measured in accordance with Section **11** or other applicable standards. Location, orientation on the build platform, number of test specimens for each machine qualification build cycle, and relationship between specimen test results and component quality shall be agreed upon by the component supplier and purchaser.

6.1.2 Feedstock that meets the requirements of Section **7**;

6.1.3 The machine identification, including machine software version, manufacturing control system version (if

TABLE 1 Controls by Condition

Condition	Thermal Post-Process	Manufacturing Plan Required	Powder Use Controlled	Powder Contamination Controlled	Post-Processing Controlled	Consolidated Material Chemistry Controlled	Microstructure Controlled	Mechanical Properties Controlled	Quality Program Required
SR	Stress Relief	yes	yes	yes	yes	yes	yes	yes	yes
ANN	Solution Annealed	yes	yes	yes	yes	yes	yes	yes	yes
HIP	Hot Isostatic Pressed	yes	yes	yes	yes	yes	yes	yes	yes
OPT	Optional	yes	no	no	no	no	no	no	no

