Designation: F3318 – 18

Standard for Additive Manufacturing – Finished Part Properties – Specification for AlSi10Mg with Powder Bed Fusion – Laser Beam[1]

This standard is issued under the fixed designation F3318; 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 AlSi10Mg (similar to DIN EN 1706:2013-12 EN AC-43000) parts using powder bed fusion such as laser melting. The parts produced by these processes are used typically in applications that require mechanical properties similar to or exceeding those of cast aluminum products of equivalent alloys. Parts 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 AlSi10Mg parts for defining the requirements and ensuring part properties.

1.3 Users are advised to use this specification as a basis for obtaining parts 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 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–S16.

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 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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]

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
B769 Test Method for Shear Testing of Aluminum Alloys
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
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

[1] This test method 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.

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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.

E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys (Withdrawn 2017)[3]
E155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings
E238 Test Method for Pin-Type Bearing Test of Metallic Materials
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
E607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere (Withdrawn 2011)[3]
E647 Test Method for Measurement of Fatigue Crack Growth Rates
E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry
E1417 Practice for Liquid Penetrant Testing
E1450 Test Method for Tension Testing of Structural Alloys in Liquid Helium
E1479 Practice for Describing and Specifying Inductively Coupled Plasma Atomic Emission Spectrometers
E1742 Practice for Radiographic Examination
E1820 Test Method for Measurement of Fracture Toughness
E2368 Practice for Strain Controlled Thermomechanical Fatigue Testing
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

2.2 *ISO/ASTM Standards:*[2]
52900 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*[4]
ASQ 1 Specification of General Requirements for a Quality Program

2.4 *ISO Standards:*[5]
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-contolled 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 19819 Metallic materials – Tensile testing in liquid helium

2.5 *SAE Standards:*[6]
AMS 2175 Castings, Classification and Inspection of
AMS 2771 Heat Treatment of Aluminum Alloy Castings
AMS 9100 Quality Systems – Aerospace – Model for Quality Assurance in Design, Development, Production, Installation and Servicing

2.6 *ASME Standards:*[7]
ASME B46.1 Surface Texture

2.7 *NIST Standard:*[8]
IR 7847 CODEN:NTNOEF

2.8 *VDI:*[9]
VDI 3405 Part 2.1 Additive Manufacturing Processes, Rapid Manufacturing Laser Beam Melting of Metallic Parts, Material Data Sheet for Aluminium Alloy AlSi10Mg

2.9 *DIN:*[10]
DIN EN 1706:2013-12 Aluminum and Aluminum Alloys – Castings – Chemical Composition and Mechanical Properties

3. Terminology

3.1 *Definitions:*

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

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

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203, http://www.asq.org.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.
[7] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.
[8] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.
[9] Available from The Association of German Engineers (VDI), Beuth Verlag GmbH, 10772 Berlin, https://www.din.de/en.
[10] Available from Deutsches Institut für Normung e.V.(DIN), Am DIN-Platz, Burggrafenstrasse 6, 10787 Berlin, Germany, http://www.din.de.

3.1.3 Terminology relating to powder metallurgy in Terminology B243 shall apply.

4.1 Unless otherwise specified herein, the material condition shall meet the requirements in each section of this standard.

NOTE 1—Refer to Section 8 for build platform temperature requirement.

4.1.1 Condition SR1, parts shall be stress relieved or partially annealed in accordance with 12.1.

4.1.2 Condition SR2, parts shall be stress relieved or partially annealed in accordance with 12.2.

4.1.3 Condition T6, parts shall be solution heat treated and artificially aged in accordance with 12.3.

4.1.4 Condition HIP+T6, parts shall be hot isostatic pressed, solution heat treated and artificially aged in accordance with 12.4.

4.1.5 Condition NHT, parts are supplied in the as built condition in accordance with 12.5.

4.1.6 Thermal post processing, and the corresponding lot acceptance values, to other conditions not listed herein shall be defined by the purchaser.

5. Ordering Information

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

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 Material condition,

5.1.5 Units of measurement (SI or US Customary),

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 part along with the electronic data file. More information about data files can be found in ISO/ASTM 52915.

5.1.6 Dimensions an 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 part supplier and purchaser, including any supplementary requirements (see 1.4).

5.1.10 Post-processing sequence of operations,

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

5.1.12 Packaging,

5.1.13 Certification,

5.1.14 Disposition of rejected material (Section 15), and

5.1.15 Other supplementary requirements as agreed upon by the part supplier and purchaser such as allowable porosity (See 1.4).

6. Manufacturing Plan

6.1 All parts manufactured to this specification shall have a manufacturing plan that includes, but is not limited to, the following:

6.1.1 A machine, manufacturing control system, and qualification procedure as agreed upon by the part 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, build parameters/exposure strategies, number of test specimens for each machine qualification build cycle, and relationship between specimen test results and part quality shall be agreed upon by the part supplier and purchaser.

6.1.2 Feedstock that meets the requirements of Section 7;

6.1.3 The machine identification, including machine software version, build parameters/exposure strategies, manufacturing control system version (if automated), build chamber environment, machine conditioning, and calibration information of the qualified machine;

6.1.4 Predetermined process as substantiated by the qualification procedure;

6.1.5 Safeguards to ensure traceability of the digital files, including design history and source of the parts;

6.1.6 All of the steps necessary to start the build process, including build platform selection, machine cleaning, and powder handling;

6.1.7 The requirements for approving/qualifying machine operators;

6.1.8 Logging of machine build data files, upper and lower limits of the parameters affecting part quality and other process validation controls;

6.1.9 The number of parts per build cycle, their orientation and location on the build platform, and support structures, if required;

6.1.10 Process steps including, but not limited to, Section 8;

6.1.11 Post-processing procedure, including sequence of the post-processing steps and the specifications for each step;

6.1.12 Thermal processing including platform temperature during build process, and post build stress relief, hot isostatic pressing, or other heat treatment specified by the purchaser; and

6.1.13 Inspection requirements as agreed upon by the part supplier and purchaser, including any supplementary requirements.

7. Feedstock

7.1 The feedstock for this specification shall be pre-alloyed metal powder, as defined in Terminology B243, that has the particle size distribution, shape, density, and flow rate acceptable for the process as determined by the part supplier.

7.2 The metal powder shall be free from detrimental amounts of inclusions and impurities, and its chemical composition shall be adequate to yield, after processing, the final chemical composition listed in Table 1.

7.3 Powder blends are allowed unless otherwise specified between the part supplier and purchaser, as long as all powder used to create the powder blend has a flow rate acceptable for the process, meets the chemical composition requirements in Table 1 and lot numbers are documented and maintained.

7.4 Used powder is allowed unless otherwise specified between the part supplier and purchaser. The proportion of