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Additive manufacturing — Process characteristics and performance — Practice for metal powder bed fusion process to meet critical applications

Fabrication additive — Caractéristiques et performances du procédé — Pratique du procédé de fusion sur lit de poudre métallique en vue de répondre aux applications critiques

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by ASTM Committee F42, *Additive Manufacturing Technologies* (as ASTM F3303-2018), and drafted in accordance with its editorial rules. It was assigned to Technical Committee ISO/TC 261, *Additive manufacturing*, and adopted under the "fast-track procedure".

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

ISO/ASTM 52904:2019(E)

Designation: F3303 – 2018

Standard for Additive Manufacturing – Process Characteristics and Performance: Practice for Metal Powder Bed Fusion Process to Meet Critical Applications[1]

This standard is issued under the fixed designation F3303; 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 practice describes the operation and production control of metal powder bed fusion (PBF) machines and processes to meet critical applications such as commercial aerospace components and medical implants. The requirements contained herein are applicable for production components and mechanical test specimens using powder bed fusion (PBF) with both laser and electron beams.

1.2 *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.*

1.3 *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. Normative References

2.1 The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.2 *ASTM Standards:*[2]

E8/E8M Test Methods for Tension Testing of Metallic Materials

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E2910 Guide for Preferred Methods for Acceptance of Product

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

2.3 *ISO/ASTM Standards:*[2]

52900 Standard Terminology for Additive Manufacturing – General Principles – Terminology

52921 Terminology for Additive Manufacturing – Coordinate Systems and Test Methodologies

2.4 *ISO Standards:*[3]

4497 Metallic powders – Determination of particle size by dry sieving

D6892–1 Metallic materials – Tensile testing at ambient temperature

D6892–2 Metallic materials – Tensile testing – Part 2: Method of test at elevated temperature

8573-1 Compressed air – Part 1: Contaminants and purity classes

9001 Quality management systems – Requirements

9044 Industrial Woven Wire Cloth – Technical Requirements and Testing

13320 Particle size analysis – Laser diffraction methods

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

2.5 *Other Standards:*

ANSI/ASQC C1-1996 Specification of General Requirements for a Quality Program[4]

AS9100 Quality Management Systems - Requirements for

[1] This practice 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, and is also under the jurisdiction of ISO/TC 261.

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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 International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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

Aviation, Space, and Defense Organizations[5]

3. Terms and Definitions

3.1 For the purposes of this document, the terms and definitions given in Specification F2924, ISO/ASTM 52900, ISO/ASTM 52921, Guide E2910, and the following apply.

3.2 ISO and IEC maintain terminological databases for use in standardization at the following addresses:

– IEC Electropedia available at http://www.electropedia.org/

– ISO Online browsing platform available at https://www.iso.org/obp

3.3 *Definitions:*

3.3.1 *build programmer*—person responsible for programming a build including part orientation, part(s) nesting, and the application of critical build parameters.

3.3.2 *machine operator*—person responsible for initiating builds and turning over machines, which includes, but is not limited to, loading feedstock powder, loading build platforms, removing completed builds and routine machine cleaning and filter changes.

3.3.3 *recoater blade*—portion of the machine that comes in contact with and spreads feedstock across the build area.

3.3.3.1 *Discussion*—The recoater blade may also be called a rake, recoater, roller, or brush.

4. PBF Material Identification

4.1 Material covered by this document (that is, powder and consolidated part/PBF machine input and output), shall be identified by specification callouts including, but not limited to, the following:

4.1.1 Alloy designation according to requirements; where no alloy designation exists, the chemical composition shall be listed.

4.1.2 *Powder type*—Virgin, used, blend or mix.

4.1.3 *Surface finish*—As built, media blasted, supports removed by machining or manual deburring, in accordance with specification callouts, or any combination of the latter finish types.

4.1.4 *Dimensional tolerances*—In accordance with specification callouts or PBF machine output capability.

NOTE 1—4.1.3 and 4.1.4 apply to consolidated parts only.

5. Feedstock and Powder Batches

5.1 The material supplier shall package the powder in containers capable of preventing moisture from penetrating the containers. No other materials including desiccant bags, labels, or tags shall be placed inside the containers in contact with the powder.

5.2 All feedstock shall have a certificate of conformance from the material supplier indicating that the feedstock meets the purchase specification requirements.

5.3 Metal powder shall be purchased from an approved material supplier on the QMS (Quality Management Systems (see 6.3)), an ASL (Approved Supplier List), or a customer-directed material supplier. Powder shall be verified for conformance to the material specification. Third-party certification of powder may be used. Guide F3049, ISO 4497, and ISO 13320 provide guidance on the measurement of particle size distribution.

5.4 The component manufacturer shall have a feedstock material specification against which feedstock can be ordered and tested. Feedstock used for qualification purposes may require a limited reused powder such that the powder utilized for one qualification build to another remains as consistent as practical (for example, by using virgin feedstock as the purpose of the qualification is to check the consistency of machine operation over time).

5.4.1 A feedstock material specification shall include, but not be limited to, chemical composition, particle size distribution, and manufacturing methodology.

5.5 Powder shall be stored in environmental containment to prevent contamination and moisture absorption.

5.6 Used powder is allowed (see 7.1.1.4.1 for requirement on used powder that is processed with ceramic recoater blade).The proportion of virgin to used powder shall be recorded and reported for each production run on the manufacturing plan (Section 10). Automated powder feed systems may not allow the proportion of virgin to used powder to be accurately measured and recorded on the manufacturing plan. In such systems the feedstock shall be considered used powder. The maximum number of times that used powder can be consumed as well as the number of times any portion of a powder lot can be processed in the build chamber shall be validated in accordance with 7.3. After a build cycle, any remaining used powder may be blended with virgin powder to maintain a powder quantity large enough for the next build cycle. The critical powder attributes impacting qualifications in accordance with 7.3 shall be analyzed regularly. All used powder shall be sieved with a sieve having a mesh size appropriate for removing any agglomerations. All powder sieves used to manufacture parts shall have a certificate of conformance that they were manufactured to ISO 9044 or Specification E11.

6. Personnel Requirements

6.1 Personnel competency requirements in ISO 13485 shall apply, including appropriate education, training, skills, and experience.

6.2 Manufacturing manager, machine operator, or build programmer (as defined in Section 3) shall be trained by the machine manufacturer or qualified agency for PBF machine hardware and software, where appropriate.

6.3 On machines that are qualified in accordance with 7.3, the machine manufacturer shall provide for continuing education as new hardware and software releases are purchased and implemented. Records of such training shall be maintained in employee training folders in accordance with a local Quality Management System (for example, ISO 9001, ISO 13485,

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