



International
Standard

ISO/ASTM 52904

**Additive manufacturing of
metals — Process characteristics
and performance — Metal powder
bed fusion process to meet critical
applications**

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

**Second edition
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (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 Technical Committee ISO/TC 261, *Additive manufacturing technologies*, based on a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on additive manufacturing, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 438, *Additive manufacturing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

This second edition cancels and replaces the first edition (ISO/ASTM 52904:2019), which has been technically revised.

The main changes are as follows:

- The structure of the document is modified to reflect the following workflow: Personnel – Digital data – PBF equipment – Feedstock – Qualification – Manufacturing plan;
- Original [Clauses 8](#) “Control of machine operating system software”, [Clauses 9](#) “Auxiliary tools and contamination” and [Clauses 11](#) “External environmental controls” have been merged to a new [Clause 6](#) “PBF equipment requirements”;
- New structure and examples for the manufacturing plan, consistent with the new workflow;
- [9.2](#) “Documentation” is added to the manufacturing plan;
- [Figure 1](#) was updated.

Introduction

Operation and production control of machines and processes for powder bed fusion (PBF) in critical applications are described in this document. Critical applications can be subject to regulation. This is one way of meeting quality requirements. The supplier/manufacturer can also ensure quality of components through validation and verification of the AM process, as per internal procedures and requirements, and inspection of the CTQs (critical to quality) of the AM components, as per customer agreement.

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Additive manufacturing of metals — Process characteristics and performance — Metal powder bed fusion process to meet critical applications

1 Scope

WARNING — This document 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 document to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

This document covers the operation and production control of metal powder bed fusion (PBF) machines and processes for areas of critical applications. A critical application is assumed once failing parts-functionality leads to immediate threats.

This document is applicable for production of parts and mechanical test specimens using powder bed fusion (PBF) with both laser and electron beams.

Specifications related to specific fields of application are provided in respective standards.

2 Normative references

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.

ISO 8573-1, *Compressed air — Part 1: Contaminants and purity classes*

ISO/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

ISO/ASTM 52907, *Additive manufacturing — Feedstock materials — Methods to characterize metal powders*

ISO 17295, *Additive manufacturing — General principles — Part positioning, coordinates and orientation*

ISO/ASTM 52926-1, *Additive manufacturing of metals — Qualification principles — Part 1: General qualification of operators*

ISO/ASTM/TS 52930:2021, *Additive manufacturing — Qualification principles — Installation, operation and performance (IQ/OQ/PQ) of PBF-LB equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and ISO/ASTM 52926-1 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 powder spreading device

recoater

portion of the machine that comes in contact with and spreads feedstock across the build area

Note 1 to entry: The actual component that is in direct contact with the powder during spreading of a new layer can typically be a blade, a rake, a roller, or a brush.

4 Personnel requirements

The personnel involved in operating the PBF-equipment shall be qualified in accordance with the part manufacturer or sector specific requirements (see ISO/ASTM 52926-1 and ISO/ASTM 52926-2 for PBF-LB operators or ISO/ASTM 52926-1 and ISO/ASTM 52926-3 for PBF-EB operators).

Records of qualification shall be maintained by the manufacturer in accordance with manufacturer or sector specific requirements (e.g. ISO 9001, ISO 13485, ANSI/ASQC C1, AS 9100).

5 Digital data

5.1 Digital data records

Unless otherwise agreed, the part manufacturer shall maintain records of all software, CAD, and part nesting layouts used in the production of parts, including:

- PBF machine operation software version, as recorded on the manufacturing plan (see [Clause 9](#));
- Customer supplied or customer approved CAD files;
- Modifications to the customer CAD files, which shall be in accordance with [Clause 8](#), and files such as AMF and STL that are converted from customer-supplied CAD files. The party that performs the translation from native CAD format to triangulated format (e.g. AMF, STL) is also responsible for performing a quality check of the translated file to ensure there are no unacceptable errors (e.g. bad/free edges, overlapping or intersecting triangles) and confirm that all required geometrical features are still present;
- Slice or layer files used by the PBF machines;
- Record of part nesting and build layout (e.g. data-preparation files; screenshots of isometric view);
- PBF machine build log file.

Any other customer-supplied electronic data, dimensional drawings, statement of work, PBF machine log file, or combination thereof, shall be maintained and saved. Multiple build cycles in a manufacturing lot shall be recorded with their unique manufacturing plan number.

The record retention period shall be as required for the relevant application/sector, or where not otherwise specified, shall be a minimum of 5 years.

5.2 Digital data processing

The part manufacturer shall have a manual or automated method for engineering file configuration control to ensure that the correct file designation on the purchase order is processed via PBF and, if necessary, final machining.

If the build model is modified from the original form received from the customer (e.g. to add machining allowance), the modification shall be performed in an engineering file format that allows for geometric inspection of the preform. The customer shall be informed and shall validate the modifications carried out. Support structures added to aid PBF processing shall not be considered as modifications to the original form. Modified CAD files shall be verified in the same manner as described in [8.1](#).

When engineering files, such as CAD files, are converted to triangulated surfaces for purposes of PBF processing, parameters used for the triangulation resolution of surfaces (e.g. chord height) shall be specified and recorded.

All CAD file translations necessary to support PBF processing, shall be configuration controlled.

6 PBF equipment requirements

6.1 General

Requirements for the following aspects are available in ISO/ASTM TS 52930:

- build consumables (build platform, recoater, gases, filters, etc.) see ISO/ASTM TS 52930:2021 6.4.2.1;
- auxiliary tools and equipment;
- machine operating software;
- environmental controls.

For PBF-LB, the part manufacturer shall specify shielding gases that, as a minimum, includes consideration of the gas composition and compatibility with the feedstock grade, build platform used and the PBF machine.

6.2 Build consumables

6.2.1 Build platform

The part manufacturer shall specify a build platform specification that, as a minimum, includes consideration of the following:

- compatibility of the substrate material grade with the feedstock grade and any shielding gases used;
- geometrical requirements, such as size, thickness and parallelism requirements;
- where the build platform is intended to be reused, sufficient additional thickness beyond the minimum specified by the machine manufacturer to allow for thinning during subsequent recovery of the build surface with each reuse;
- surface finish and cleanliness requirements.

6.2.2 Shielding gases

For PBF-LB, the part manufacturer shall specify shielding gases that, as a minimum, includes consideration of the following:

- gas composition and purity;
- compatibility with the feedstock and build platform used;
- PBF machine requirements.

6.2.3 Powder spreading device

The part manufacturer shall specify and select the type of powder spreading device that is used and its material with consideration of the material compatibility with feedstock and consolidated material.

6.2.4 Compressed air

Compressed air requirements for the PBF machine shall be in accordance with the machine manufacturer's recommendations, under consideration of ISO 8573-1.

6.3 Auxiliary tools and equipment

Auxiliary equipment (e.g. sieves, hand tools, power tools, powder storage containers, powder transport systems and delivery mechanism to machine) shall be cleaned and maintained in a manner to prevent cross contamination from different feedstock types, gases, dust, and foreign objects.

Particular care shall be taken with tools being used in the PBF machine build chamber to prevent contamination of the feedstock. Any tool or accessories used in the build chamber, such as spatulas, wrenches, vacuum attachments or similar, shall be non-contaminating to the feedstock.

Cooling systems chillers, where used, shall be operated in accordance with the cooling system manufacturer's recommendations.

6.4 Machine operating software

Refer to ISO/ASTM TS 52930 for software and data control requirements.

6.5 Environmental controls

Temperature and humidity controls in the workplace and storage areas shall be in accordance with the machine and feedstock manufacturers' specifications (see material safety datasheet provided with the feedstock) and any limits specified by the part manufacturer. Temperature and humidity shall be controlled and monitored to ensure the environment history is traceable to storage or build requirements.

7 Feedstock requirements

7.1 Purchasing feedstock

Feedstock shall be purchased in accordance with the specifications of the quality management system (QMS), for example included within an approved supplier list (ASL).

The part manufacturer shall provide a feedstock purchase specification against which feedstock may be ordered and accepted. The requirements stated in the feedstock purchase specification shall include, as a minimum, those specified by ISO/ASTM 52907, which covers: ²⁰²⁴

- product description (alloy designation);
- powder storage and handling;
- powder sampling;
- powder characterization;
- documentation and traceability.

Third-party certification of powder may be included as a requirement within the purchase specification, where required.

The feedstock supplier shall supply the powder in accordance with the requirements of the feedstock purchase specification (and hence, ISO/ASTM 52907). All feedstock shall be provided with a certificate of conformity from the feedstock supplier, declaring that the feedstock meets the feedstock purchase specification requirements.

7.2 Control of feedstock

All documentation received with the feedstock (e.g. certificate of conformity, safety datasheet) shall be referenced within the manufacturing plan (see [Clause 9](#)) and retained by the part manufacturer (see [5.1](#)).

Feedstock shall be stored in appropriate containers to prevent contamination and moisture absorption.