SIST

SLOVENSKI STANDARD
oSIST prEN ISO/ASTM 52911-3:2022

01-februar-2022

[Not translated]

Additive Manufacturing - Design - Part 3: Electron beam powder bed fusion of metals (ISO/ASTM 52911-3:2021)

Additive Manufacturing - Konstruktion - Teil 3: Standardrichtlinie für das pulverbettbasierte Elektronenstrahlschmelzen von Metallen (ISO/ASTM 52911-3:2021)

Fabrication additive - Conception - Partie 3: Fusion par faisceau d'électrons sur lit de poudre métallique (ISO/ASTM 52911-3:2021)

Ta slovenski standard je istoveten z: prEN ISO/ASTM 52911-3

ICS:

25.030	3D-tiskanje	Additive manufacturing

oSIST prEN ISO/ASTM 52911-3:2022 en,fr,de

DRAFT INTERNATIONAL STANDARD
ISO/ASTM DIS 52911-3

ISO/TC **261** Secretariat: **DIN**

Voting begins on: **2021-12-13** Voting terminates on: **2022-03-07**

Additive Manufacturing — Design —

Part 3:
Electron beam powder bed fusion of metals

Fabrication additive - Conception —

Partie 3: Fusion par faisceau d'électrons sur lit de poudre métallique

ICS: 25.030

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/ASTM DIS 52911-3:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11

Email: copyright@iso.org
Website: www.iso.org

ASTM International
100 Barr Harbor Drive, PO Box C700
West Conshohocken, PA 19428-2959, USA
Phone: +610 832 9634
Fax: +610 832 9635
Email: khooper@astm.org
Website: www.astm.org

Published in Switzerland

Contents

Page

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 documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*, in cooperation with ASTM Committee F42, *Additive Manufacturing Technologies*, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on Additive Manufacturing.

A list of all parts in the ISO 52911 series can be found on the ISO website.

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.

Introduction

Powder bed fusion of metals (PBF/M) is an additive manufacturing (AM) process that offers additional manufacturing options alongside other established AM processes. PBF/M has the potential to reduce manufacturing time and costs, and increase part functionality. Practitioners are aware of the strengths and weaknesses of conventional, long-established manufacturing processes, such as cutting, joining and shaping processes (e.g. by machining, welding or injection moulding), and of giving them appropriate consideration at the design stage and when selecting the manufacturing process. In the case of PBF/M and AM in general, design and manufacturing engineers only have a limited pool of experience. Without the limitations associated with conventional processes, the use of PBF/M offers designers and manufacturers a high degree of freedom and this requires an understanding about the possibilities and limitations of the process.

The ISO 52911 series provides guidance for different powder bed fusion (PBF) technologies. In addition to this document on PBF-EB/M, the series is made up of ISO 52911-1 on laser-based powder bed fusion of metals (PBF-LB/M) and ISO 52911-2 on laser-based powder bed fusion of polymers (PBF-LB/P). Each document in the series shares Clauses 1 to 5, where general information including terminology and the PBF process is provided. The subsequent clauses focus on the specific technology.

This document provides support to technology users, such as design and production engineers, when designing parts that need to be manufactured by means of PBF-EB/M. It will help practitioners to explore the benefits of PBF-EB/M and to recognize the process-related limitations when designing parts. It also builds on ISO/ASTM 52910 to extend the requirements, guidelines and recommendations for AM design to include the PBF process.

Additive Manufacturing — Design —

Part 3:
Electron beam powder bed fusion of metals

1 Scope

This document specifies the features of electron beam powder bed fusion of metals (PBF-EB/M) and provides detailed design recommendations.

Some of the fundamental principles are also applicable to other additive manufacturing (AM) processes, provided that due consideration is given to process-specific features.

This document also provides a state of the art review of design guidelines associated with the use of powder bed fusion (PBF) by bringing together relevant knowledge about this process and by extending the scope of ISO/ASTM 52910.

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

ISO 17296-2, *Additive manufacturing — General principles — Part 2: Overview of process categories and feedstock*

ISO/ASTM 52915, *Specification for additive manufacturing file format (AMF) Version 1.2*

3 Terms and definitions

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

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

— IEC Electropedia: available at https://www.electropedia.org/

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

3.1
curl effect
thermal and residual stress effect
<aspect of heat-induced warping> dimensional distortion as the melted material cools and solidifies after being built or by poorly evacuated heat input

3.2
downskin area
D
(sub-)area where the normal vector $\vec{n}$ projection on the *z*-axis is negative

Note 1 to entry: See Figure 1.

3.3
downskin angle
δ
angle between the plane of the build platform and the *downskin area* (3.2) where the value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform)

Note 1 to entry: See Figure 1.

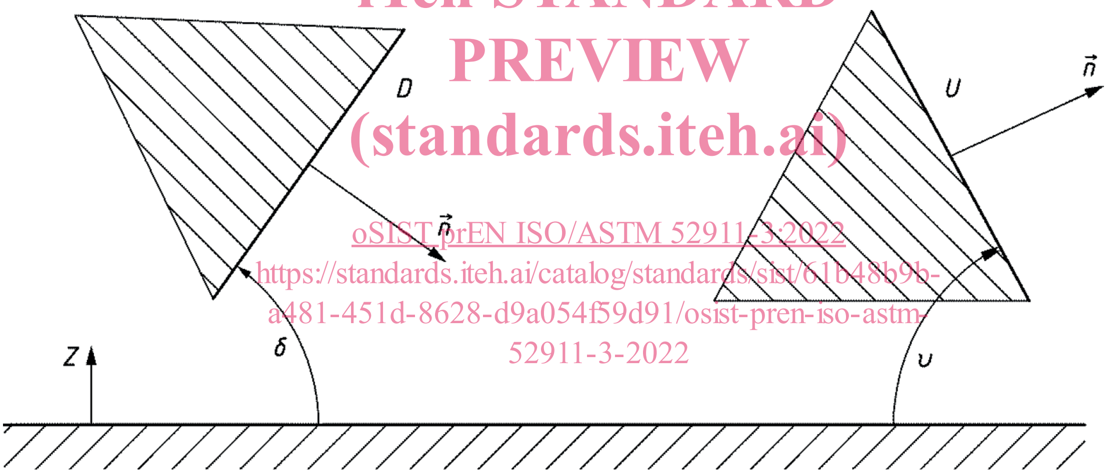
3.4
upskin area
U
(sub-)area where the normal vector $\vec{n}$ in relation to *z*-axis is positive

Note 1 to entry: See Figure 1.

3.5
upskin angle
υ
angle between the plane of the build platform and the *upskin area* (3.4) where the value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform)

Note 1 to entry: See Figure 1.

Note 2 to entry: Source: VDI 3405 Part 3:2015[1].



Key

δ	downskin angles	***U***	Upskin (right) areas
$\vec{n}$	normal vector	***υ***	Upskin angles
D	downskin (left) areas	***Z***	build direction

Note 1 to entry Source: VDI 3405 Part 3:2015[1].

Figure 1 — Orientation of the part surfaces relating to the build platform

4 Symbols and abbreviated terms

4.1 Symbols

The symbols given in Table 1 are used in this document.

Table 1 — Symbols

Symbol	Designation	Unit
a	overhang	mm
D	downskin area	mm^2
I	island	mm^2
$\vec{n}$	normal vector	—
U	upskin area	mm^2
δ	downskin angle	°
υ	upskin angle	°

4.2 Abbreviated terms

The following abbreviated terms are used in this document.

CT computed tomography

DICOM digital imaging and communications in medicine

PBF-EB/M electron beam powder bed fusion of metals

HIP hot isostatic pressing

PBF-LB laser-based powder bed fusion

PBF-LB/M laser-based powder bed fusion of metals (also known as, for example, laser beam melting, selective laser melting)

PBF-LB/P laser-based powder bed fusion of polymers (also known as, for example, laser beam melting, selective laser melting)

MRI magnetic resonance imaging

5 Characteristics of powder bed fusion (PBF) processes

5.1 General

Consideration should be given to the specific characteristics of the manufacturing process used in order to optimize the design of a part. Examples of the features of AM processes which need to be taken into consideration during the design and process planning stages are listed in 5.2 to 5.8. With regards to metal processing, a distinction can be made between, for example, laser-based PBF (applied for metals and polymers) and electron beam-based PBF (applied for metals only).

Polymers PBF uses, in almost every case, low power lasers to sinter polymer powders together. Electron beam powder bed fusion for polymers is not usually considered because the negative charge from the electron beam will accumulate in non-conductive polymer powder and cause repulsive events that will ruin powder layer continuity and make any controlled sintering or melting impossible. As with polymer powders PBF, metals PBF includes varying processing techniques. Like polymers, metals PBF often requires the addition of support structures (see 6.3.3). Metals PBF processes may use low-power lasers to bind powder particles by only melting the surface of the powder particles or high-power (approximately 200 W to 1 kW) energy beams to fully melt and fuse the powder particles together.

PBF-EB/M and PBF-LB/M have similar capabilities, although differences between these processes leads, in general, to PBF-EB/M supporting faster build rates at lower feature resolution compared to PBF-LB/M. The beam energy from the electron beam is of a higher intensity (due to a high energy source 3 to 6 kW), and the mechanism to raster the beam (i.e. electromagnetics for PBF-EB/M, optics for PBF-LB/M) differs between the two types of PBF processes. PBF-EB/M also tends to utilize a larger beam spot size, larger powder size distribution, and larger layer thickness. In general, PBF-EB/M subjects parts to less thermal stresses (as powder layers are preheated before melting) and have faster build rates, but the trade-off often comes with general greater minimum feature sizes and greater surface roughness compared to PBF-LB/M.

5.2 Size of the parts

The size of the parts is not only limited by the working area/working volume of the PBF-machine. Also, the occurrence of cracks and deformation due to residual stresses can limit the maximal part size. Another important practical factor that can limit the maximal part size is the cost of production having a direct relation to the size and volume of the part. Cost of production can be minimized by choosing part location and build orientation in a way that allows nesting of as many parts as possible. Also, the volume of powder needed to fill the bed to required volume (part depth x bed area) may be a consideration. Powder reuse protocols impact this cost significantly. If no reuse is allowed then all powder is scrapped regardless of volume solidified.

5.3 Benefits to be considered in regard to the PBF process

PBF processes can be advantageous for manufacturing parts where the following points are relevant.

- Integration of multiple functions in the same part
- Parts can be manufactured to near-net shape (i.e. close to the finished shape and size).
- Degrees of design freedom for parts are typically higher. Limitations of conventional manufacturing processes do not usually exist, e.g. for
  - tool accessibility, and
  - machining undercuts.
- A wide range of complex geometries can be produced, such as
  - free-form geometries, e.g. organic structures,
  - topologically optimised structures, in order to reduce mass and optimize mechanical properties,
  - infill structures, e.g. honeycomb, and
  - porous lattice structure on surface of otherwise solid component, e.g. osteosynthesis structures in medical device industry.
- The degree of part complexity is largely unrelated to production costs, unlike most conventional manufacturing.
- Assembly and joining processes can be reduced through part consolidation, potentially achieving en bloc construction.
- Overall part characteristics can be selectively configured by adjusting process parameters locally.
- Reduction in lead times from design to part production.

5.4 Limitations to be considered in regard to the PBF process

Certain disadvantages typically associated with AM processes should be taken into consideration during product design.

- Shrinkage, residual stress and deformation can occur due to temperature differences. Preheating of the powder bed (which is the normal procedure in PBF-EB/M) can be used to minimize these effects.

