INTERNATIONAL STANDARD ISO/ASTM 52936-1

First edition
2023-01

Additive manufacturing of polymers — Qualification principles —

Part 1:
General principles and preparation of test specimens for PBF-LB

Fabrication additive de polymères — Principes de qualification —

Partie 1: Principes généraux et préparation des éprouvettes pour PBF-LB

Reference number
ISO/ASTM 52936-1:2023(E)

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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 ISO/TC 261, *Additive manufacturing*, and ISO/TC 61/SC 9, 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, and 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).

This first edition of ISO/ASTM 52936-1 cancels and replaces ISO 27547-1:2010, which has been technically revised.

The main changes are as follows:

— new standard number and title to make clear its status as additive manufacturing standard;

— requirements for conditions revised to allow use of state of the art machines;

— Annex B deleted because this procedure is not state of the art anymore.

Introduction

Many factors in an additive manufacturing test specimen-preparation process can influence the properties of the test specimens prepared and hence the measured values obtained when the test specimens are used in a test method. The mechanical properties of such test specimens are in fact strongly dependent on the conditions of the process used to prepare the test specimens. Exact definition of each of the main parameters of the process is a basic requirement for reproducible operating conditions.

It is important in defining test specimen-preparation conditions to consider any influence the conditions could have on the properties to be determined. Test specimens prepared by additive manufacturing techniques can show differences in molecular morphology (as with crystalline and semicrystalline polymers), differences in powder morphology (after undergoing a sintering process, for instance), differences in thermal history and differences in thickness of the layers, test specimen orientation or test specimen location, used to prepare the specimen. Only if each of these is controlled can differences in the values of the properties measured be avoided.

Additive manufacturing of polymers — Qualification principles —

Part 1: General principles and preparation of test specimens for PBF-LB

1 Scope

This document specifies the general principles to be followed when test specimens of thermoplastic materials are prepared by laser-based powder bed fusion (PBF-LB/P), which is commonly known as laser sintering. The (PBF-LB/P) process is used to prepare test specimens layer upon layer in which thermal energy selectively fuses regions of a powder bed. This document provides a basis for establishing reproducible and reportable sintering conditions. Its purpose is to promote uniformity in describing the main process parameters, build orientation of the sintering process and also to establish uniform practice in reporting sintering conditions.

This document does not specify the test procedure itself.

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 3167, *Plastics — Multipurpose test specimens*

ISO 20753, *Plastics — Test specimens*

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

ISO/ASTM 52921, *Standard terminology for additive manufacturing — Coordinate systems and test methodologies*

ISO/ASTM 52925, *Additive manufacturing of polymers — Feedstock materials — Qualification of materials for laser-based powder bed fusion of parts*

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 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
laser wavelength
wavelength at the peak intensity of the laser

Note 1 to entry: Laser wavelength is expressed in nanometres.

3.2
laser power
power of the laser beam at each defined process operation

Note 1 to entry: Laser power is expressed in watts.

Note 2 to entry: The laser power can be different when producing the contour (outline) of the test specimen and when hatching the part.

3.3
laser mode
parameter indicating which of the various electromagnetic standing waves that can be produced in the laser cavity is actually being used in a particular application

3.4
beam radius
radius of the laser beam at the point of interaction with the powder bed

Note 1 to entry: Beam radius is expressed in microns.

3.5
scan speed
speed of travel of the focal point of the laser beam across the surface of the parts being fabricated

Note 1 to entry: Scan speed is expressed in millimetres per second.

Note 2 to entry: A synonymous term is beam speed.

Note 3 to entry: The scan speed can be different when producing the contour (outline) of the test specimen and when hatching the part.

3.6
preheating temperature
temperature to which the build chamber is heated before the build cycle starts

Note 1 to entry: Preheating temperature expressed in degrees Celsius.

3.7
preheating time
length of time required for the powder bed to reach the *preheating temperature* (3.6)

Note 1 to entry: Preheating time is expressed in minutes.

Note 2 to entry: Since it is necessary to have a steady-state temperature throughout the whole build chamber, the preheating time can be rather long, often more than 30 min.

3.8
contour
track followed by the laser beam when producing the outline of each layer

3.9
hatching
closely spaced parallel laser paths used to fuse the bulk material in each layer

3.10
cool-down temperature
temperature of the powder bed when the parts are removed from the powder bed

Note 1 to entry: The cool-down temperature is measured at the centre of the surface of the powder bed.

4 Preparation of test specimen

4.1 General

Preparation of test specimens for the acquisition of data which are intended to be comparable with data obtained from other PBF-LB/P test specimens, as well as for use in the case of disputes, shall be according 4.2 to 4.5.

The particular conditions required for reproducible preparation of test specimens, which provides comparable results, vary for each material used. These conditions shall be agreed upon between the interested parties.

4.2 Dimensions of test specimen

The test specimen dimensions shall be in accordance with ISO 3167 or ISO 20753.

If agreed between the customer and the part provider, according with ISO 3167 or ISO 20753, a reduced-scale test specimen may be used (shorter length), for example in cases of samples manufactured in Z direction (see ISO/ASTM 52921) or when sample material exists in small quantities.

4.3 Conditioning and preparation of the material

Prior to processing, the powder batch of the thermoplastic material shall be conditioned, as required by the relevant material standard, or as recommended by the manufacturer if no standard covers this subject.

To avoid condensation of moisture onto the material, avoid exposing the material to the atmosphere while it is at a temperature significantly below the temperature of the location of the powder bed fusion equipment.

In case of using a refreshed blend of virgin and used powder, the virgin to re-use ratio shall be pre-determined via powder studies to specify the maximum number of cycles of used powder. Powder batch history shall be documented for each set of test specimens as appropriate in accordance with ISO/ASTM 52925, number of reuses, mass fraction of mixture with virgin material).

4.4 Test specimens manufacturing

4.4.1 Machine setting

The data file (AMF, STL, etc.) containing the sample geometry will be used to specify the processing route. The number of test specimens processed in one run should be as high as suitable to allow for an appropriate statistical analysis but similar to the actual build density as typically used in the given process. For example, if 15 test specimens can fit into the chamber, develop the bed geometry to have 5 test specimens on one level and repeated on each of 3 levels. Preparing test specimens together with other parts for other purposes is only allowed when testing the influence of these other parts on the test specimens. Set the machine to the conditions specified in the relevant material standard, or as agreed between the interested parties as applicable if no standard covers this subject.

Before starting the build cycle, the build chamber shall be preheated within tolerance to the desired operating temperature to assure a steady-state temperature throughout the chamber.

Any of the orthogonal orientations mentioned in ISO/ASTM 52921 may be used but, in cases of dispute, the specimen orientation shall be “XYZ” ISO/ASTM 52921.

The operational parameters such as type of hatching, distance between hatching lines, contour offset shall be reported. Also, the laser beam radius, the laser power and scan speed for hatching and the contour shall be reported.

4.4.2 Test specimens processing

For the purpose of qualification, the test specimen-preparation process shall be carried out in a single production run. It is not permissible to stop the build cycle and re-start it later. In the event of any interruption in the process, all the specimen in the chamber shall be rejected and not subsequently used for any qualification.

After the build cycle has been completed, the test specimens shall remain in the part cake until the cool-down temperature (see 3.10) has been reached. This cool-down process may take place inside the build-chamber or outside, but in order to maintain consistent process conditions it is recommended that this takes place inside the machine or use special equipment to ensure an inert gas atmosphere and a slow cooling rate. When the cool-down temperature has been reached, remove the test specimens from the part cake.

4.5 Cleaning, handling and storage of test specimens

As test specimens are being removed from the build, adherent powder shall be cleaned from the specimens being careful to recover acceptable powder from the build. Final cleaning of parts shall be done in the manner (e.g. blasting) that matches the parts being built. Tests specimens shall be stored according to the relevant test standard.

5 Report on test-specimen preparation

The report should include the following information:

a) a reference to this document, i.e. ISO/ASTM 52936-1:2023;

b) date, time and place the test specimens were produced;

c) full description of the material used (type, designation, manufacturer, powder batch);

d) in case of blend with used material, history of the powder batch as appropriate (see 4.3).

e) percentage of used material and virgin material in case of powder blend;

f) details of any conditioning of the material carried out prior to processing;

g) the type of test specimen produced and the relevant standard;

h) details of the laser-based powder bed fusion machine used (manufacturer, type, software release, etc.);

i) processing conditions:

   1) laser wavelength, in nanometres,

   2) laser mode,

   3) laser power(s) used when producing the contour(s), in watts,

   4) laser power(s) used when hatching(s), in watts,

   5) beam radius, in millimetres,

   6) contour offset, in millimetres,

   7) type of hatching,

   8) distance between the hatching lines, in millimetres,

   9) scan speed when producing the contour, in millimetres per second,