SLOVENSKI STANDARD
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Additive manufacturing - Finished part properties - Orientation and location dependence of mechanical properties for metal powder bed fusion (ISO/ASTM DIS 52909:2021)

Additive Fertigung - Eigenschaften von Fertigteilen - Orientierung und Lage in Abhängigkeit der mechanischen Eigenschaften für pulverbettbasierte metallische Bauteile (ISO/ASTM DIS 52909:2021)

Fabrication additive - Propriétés des pièces finies - Dépendance de l'orientation et de l'emplacement des propriétés mécaniques pour la fusion sur lit de poudre métallique (ISO/ASTM DIS 52909:2021)

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Additive manufacturing — Finished part properties — Orientation and location dependence of mechanical properties for metal powder bed fusion

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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 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.

The committee responsible for this document is 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.

Introduction

AM produced metallic parts are being intensively developed and used more widely nowadays with expected even a faster growth in near future. This document aims to support customers' needs to address specifics of the AM deposited parts – location and orientation dependent local properties and their variations over the part or deposition chamber.

This document provides a list of accurate terminologies and existing standards dedicated to mechanical testing of metallic material's, guidance on designation of coordinate systems and their application to AM deposited specimens/parts designation, and recommendations on possibilities for local properties measurement.

Additive manufacturing — Finished part properties — Orientation and location dependence of mechanical properties for metal powder bed fusion

1 Scope

This document covers supplementary guidelines for evaluation of mechanical properties including static/quasi-static and dynamic testing of metals made by additive manufacturing (AM) to provide guidance toward the reporting when results from testing of as build specimen or those excised from printed parts made by this technique or both.

This document is provided to leverage already existing standards. Guidelines are provided for mechanical properties measurements and reporting for additively manufactured metallic specimen as well as those excised from parts.

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 standard to establish appropriate safety, health and environemental practices and determine the applicability of regulatory limitations prior to use.

This document expands upon the nomenclature of ISO/ASTM 52900 and principles of ISO/ASTM 52921 and extends them specifically to metal additive manufacturing. The application of this document is primarily intended to provide guidance on orientation designations in cases where meaningful orientation/direction for AM cannot be obtained from available test methods.

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 1099, *Metallic materials — Fatigue testing — Axial force-controlled method*

ISO 4506, *Hardmetals — Compression test*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 12106, *Metallic materials — Fatigue testing — Axial-strain-controlled method*

ISO 12108, *Metallic materials — Fatigue testing — Fatigue crack growth method*

ISO 12135, *Metallic materials — Unified method of test for the determination of quasistatic fracture toughness*

ISO/ASTM 52900, *Additive manufacturing — General principles — Terminology*

ISO/ASTM 52921, *Standard Terminology for Additive Manufacturing—Coordinate Systems and Test Methodologies*

ASTM E8/E8M, *Standard test methods for tension testing of metallic materials*

ASTM E9, *Standard test methods of compression testing of metallic materials at room temperature*

ASTM E23, *Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E399, *Standard test method for linear-elastic plane-strain fracture toughness kic of metallic materials*

ASTM E466, *Standard practice for conducting force-controlled constant amplitude axial fatigue tests of metallic materials*

ASTM E561, *Standard test method for k-r curve determination*

ASTM E606/E606M, *Standard test method for strain-controlled fatigue testing*

ASTM E647, *Standard test method for measurement of fatigue crack growth rates*

ASTM E1221, *Standard test method for determining plane-strain crack-arrest fracture toughness, k_{ia}, of ferritic steels*

ASTM E1820, *Standard test method for measurement of fracture toughness*

ASTM E1823, *Terminology Relating to Fatigue and Fracture Testing*

ASTM E1921, *Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range*

ASTM E2248, *Standard Test Method for Impact Testing of Miniaturized Charpy V-Notch Specimens*

ASTM E2472, *Standard test method for determination of resistance to stable crack extension under low-constraint conditions*

ASTM E2899, *Standard test method for measurement of initiation toughness in surface cracks under tension and bending*

ASTM F2971, *Practice for Reporting Data for Test Specimens Prepared by Additive Manufacturing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and ISO/ASTM 52921 apply.

ISO and IEC maintain terminological 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 Definition

3.1.1
Part location
location of the part/samplespecimen location within the build volume. The part location is normally specified by the X,Y, Z coordinates for the position of the geometric centre of the part´s bounding box with respect to the build volume origin

3.2 Abbreviations

The abbreviations used in this document and in particular in Figure A.1 are listed in Table 1.

Table 1 — Abbreviations

Abbreviation	Signification	Comment
S	Start	any base of the specimen or part that provides a surface upon which deposition starts (see annex A).
E	End	any area of a specimenor part that provides a surface upon which the the specimen or part deposition ends. (see annex A)
M	Middle	mid-plane of a specimen or part between start and end. (see annex A)

Table 1 *(continued)*

Abbreviation	Signification	Comment
B	Both	crack growth captures both start and end of build. (see Annex A)
RD	Raster direction	this may or may not be the same throughout the build. (see Annex A)

3.3 Acronyms

The acronyms used in this document are listed in Table 2. They are illustrated in Figure A.4.

Table 2 — Acronyms

Acronym	Signification
XY, YX, XZ, ZX, YZ, ZY	the first letter represents the direction normal to the crack plane and the second letter represents the expected direction of crack extension
XYB	indicates that crack growth captures both the start and end of the build in XY direction
XZE	indicates that the crack growth occurs from the end to the start of build in the XZ direction
XZS	indicates that the crack growth occurs from the start to the end of build in the XZ direction
YXB	indicates that crack growth captures both the start and end of the build in YX direction
YZE	indicates that the crack growth occurs from the end to the start of build in the YZ direction
YZS	indicates that the crack growth occurs from the start to the end of build in the YZ direction
ZXM (or ZX1/2)	indicates that crack growth occurs at the middle plane in ZX direction

In situations in which a test specimen is created from other locations with respect to the start of the build (for example ¼, ¾, etc. distance from the start of the build) in the ZX direction, the notation used should indicate this location. For example, ZX1/4 indicates that testing was conducted in the ZX direction at a location one quarter of the way from the start of the build.

In situations where a test specimen (i.e. either a standard size or miniaturized specimen) is excised from a portion of the build volume (e.g. from an actual part) this should be noted. The terminology provided above should still be used to indicate the location of the excised sample with respect to the original build volume.

4 Summary of guide

4.1 The purpose of this document is to provide guidelines for test methods referenced in Clause 2 and also use some of the terminologies defined in ISO/ASTM 52900 for use with metal additive manufacturing test specimens. Test specimens may be built directly to net-shape, or near net-shape, or excised from a part.

4.2 Standard geometries can be used based on the reference standards indicated in Clause 2, however, direct testing of a part is a highly recommended practice for metal AM (See Annex A.6).

4.3 In order to investigate and document orientation and location-specific mechanical properties, cut small-scale specimen from the relevant locations of the parts should be achieved . This document describes some principles to applyfor the testing of various properties.

5 Significance and use

5.1 Although evaluation of mechanical properties of many additively manufactured materials can be conducted using the guidelines developed for conventional materials within existing testing standards, the coordinate systems and nomenclature specific to conventional materials testing (for example in ASTM E399, ISO 12135 and ASTM E647) are not sufficient to be applicable across the full spectrum

