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Aditivna proizvodnja - Preskusna telesa - Geometrijske zmogljivosti aditivnih proizvodnih sistemov (ISO/ASTM DIS 52902:2021)

Additive manufacturing - Test artifacts - Geometric capability assessment of additive manufacturing systems (ISO/ASTM DIS 52902:2021)

Additive Fertigung - Testkörper - Geometrische Leistungsbewertung additiver Fertigungssysteme (ISO/ASTM DIS 52902:2021)

Fabrication additive - Pièces types d'essais - Évaluation de la capacité géométrique des systèmes de fabrication additive (ISO/ASTM DIS 52902:2021)

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Additive manufacturing — Test artifacts — Geometric capability assessment of additive manufacturing systems

Fabrication additive — Pièces types d'essai — Évaluation de la capacité géométrique des systèmes de fabrication additive

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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.

This second edition cancels and replaces the first edition (ISO/ASTM 52902:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Addition of a test artefact for testing the performance of the Z-axis in an AM system.

— Changed dimensions in text and in drawing (Figure 3) of medium circular artefact such that the description in the text matches the dimensions in the downloadable STEP file; Figure 3 was also re-drawn to better depict the circular artefact geometry.

Additive manufacturing — Test artifacts — Geometric capability assessment of additive manufacturing systems

1 Scope

This document covers the general description of benchmarking test piece geometries along with quantitative and qualitative measurements to be taken on the benchmarking test piece(s) to assess the performance of additive manufacturing (AM) systems.

This performance assessment can serve the following two purposes:

— AM system capability evaluation;

— AM system calibration.

The benchmarking test piece(s) is (are) primarily used to quantitatively assess the geometric performance of an AM system. This document describes a suite of test geometries, each designed to investigate one or more specific performance metrics and several example configurations of these geometries into test piece(s). It prescribes quantities and qualities of the test geometries to be measured but does not dictate specific measurement methods. Various user applications can require various grades of performance. This document discusses examples of feature configurations, as well as measurement uncertainty requirements, to demonstrate low- and high-grade examination and performance. This document does not discuss a specific procedure or machine settings for manufacturing a test piece.

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.

ASME B46.1, *Surface Texture (Surface Roughness, Waviness and Lay)*

3 Terms and definitions

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

4 Significance and use

4.1 General

Measurements and observations described in this document are used to assess the performance of an AM system with a given system set-up and process parameters, in combination with a specific feedstock material.

The primary characterization of the AM system obtained by this document is via geometric accuracy, surface finish and minimum feature sizes of the benchmarking test piece(s).

4.2 Comparing results from one machine

The test piece(s) can be built and measured for example when the new machine is installed. The test piece(s) may be used to periodically evaluate the performance or diagnose a fault in one AM system, for example, after system maintenance or as defined by the requirements of a quality system.

The test piece(s) described in this test method may be used as a demonstration of capabilities for a contract between a buyer and seller of AM parts or AM systems.

Data from the measurements described in this document can be used to gauge the impact of new process parameters or material on the AM system performance.

Certain test geometries may be included with every build on a particular AM system to help establish performance traceability. Depending on the needs of the end user, not all test artefacts need to be built, and individual test artefacts can be built separately if required.

5 General principles for producing test artefacts

5.1 General

This clause outlines principles applicable for producing all of the test artefact geometries in this document. Reporting requirements are previewed in connection with the production steps in this clause, but more details about recording and reporting can be found with the individual artefact descriptions given in Clause 7.

5.2 Need to use feedstock conforming to a material specification

In order to ensure repeatable results, the use of a quality feedstock material is needed. A feedstock material specification should be selected or determined by the end user and the feedstock used for test artefact trials should match said specification. For example, the specification may include the particulate properties (particle size, size distribution, morphology) for powder feedstock, bulk properties (such as flow) and chemical properties (such as chemical composition and level of contamination). Although the details of the material specification shall not be disclosed (unless otherwise agreed between supplier and purchaser), it should be documented by the producer and reported with a unique alphanumeric designation as specified by ASTM F2971:2013, Annex A1, element “B”. For powder-based processes, the material specification should specifically address limitations of powder re-use and percent of virgin/re-used powder.

5.3 Need to undertake artefact building according to a documented process specification

The processing of the material in the AM system should be undertaken according to a documented process specification/manufacturing plan, as specified by ASTM F2971:2013, Annex A1, element “C”. This may be a proprietary internal standard or external standard (subject to buyer/seller negotiations), but the producer should document user-definable settings and conditions surrounding the building of parts. For example, it should document the layer thickness, build strategies (e.g. scan path, tool path, and/or scan parameters), temperatures, etc. used during the build. This process should be consistent for all test artefacts produced within one build. These recommendations can be different for each use, so the parameters in the process specification should be agreed between the vendor and end user.

5.4 File formats and preparation

The file formats used and steps of the digital file preparation including slice parameters should be included in the process specification. Care shall be taken during the creation and transfer of data files to avoid degradation of the model. Any discrepancy between these affects the outcome of tests on the artefacts and for this reason, best practice for the control of the file formats and preparation is discussed here.

5.5 Download files

The 3D digital models for standard test artefact geometries can be downloaded in *.step format at https://standards.iso.org/iso/52902/ed-1/en. For a complete list of available files, please see Annex D.

5.6 Discussion of file conversion

When a CAD model is converted to AMF, STL (or any intermediate file format), sufficient fidelity shall be maintained to ensure that the test artefact produced from it fairly reflects the capabilities of the AM system under assessment. The file conversion tolerance selected should ensure that the maximum deviation of the data from the nominal CAD model is less than one quarter and, based on good measurement practice, ideally less than one tenth of the expected accuracy of the AM system being assessed. Currently, most additive manufacturing equipment cannot produce features with a resolution better than 10 µm, therefore CAD models are saved to STL/AMF ensuring at least a 2,5 µm accuracy or better. This is only general guidance and should be confirmed for the specific output system. It is recommended that users check the maximum deviation and record the conversion parameters used, as well as any maximum deviation (chord height and angular tolerance).

Files should not be scaled up or down either during conversion or afterward. Machine correction factors (e.g. offsets, axis scaling, etc.) may be used and should be documented as part of the process specification.

5.7 AMF preferred (with conversion instructions/ resolutions)

The AMF file format as defined by ISO/ASTM 52915 is the preferred model format for test artefact geometry representation due to its ability to store high fidelity geometry with embedded units in an intermediate file format.

5.8 Need for test specification and test process

This document forms the basis for the general *Test Plan/Specification* described in ASTM F2971:2013, Annex A1, element "D", but specifics about its implementation need recording to accurately document the *Test Process* (element "E" in Annex A1) used for producing the parts as discussed in Clause 6.

5.9 Quantity of test artefacts

For a complete test of machine performance, two things dictate the quantity of the test artefacts produced. First, the Test Specification / Test Process shall ensure a quantity of samples, typically no less than five, so that statistically significant measurements can be made. Second, sufficient coverage (see 5.13) of the build platform needs to be made to account for variations in performance between build locations. Fewer test artefacts with less complete coverage may be used for spot checks or limited demonstrations, such as the example detailed in Annex A. The number of artefacts shall be agreed upon between the buyer and seller and shall permit to perform at least 5 mesurements.

5.10 Position and orientation of test artefacts

As per ASTM F2971:2013, Annex A1, element "F", it is recommended to report results in combination with the test artefacts' build position and orientations according to the convention set forth in ISO/ASTM 52921.

5.11 Considerations for orientation

Since these test artefacts are intended to reveal the strengths and weaknesses of additive building techniques, there will be failed build geometries. It is worth considering which features are likely to fail and place them in a position that minimizes the risk that this leads to an outright failure of the features/parts/artefacts in the rest of the build. For example, in a powder bed process, it can be advisable to position parts that are more likely to fail at a higher level in the overall build to reduce the risk that failed parts or sections of parts impinge on other components in the build or the AM machine mechanism.

5.12 Labelling

It can be useful to add labels to parts to identify respective artefact orientations and positions in the build. Labelling is summarized in 7.5.

5.13 Coverage

It is important that test artefacts be made with sufficient coverage of the build volume to get representative data for where real parts are made. Coverage evaluates variability throughout the build volume. This is best practice for all AM processes and is especially critical for processes that have a “sweet spot” (for example, some galvanometric laser beam steering systems give more repeatable results in the centre of the platform). The artefact distribution should span at least 80 % of the machine’s build platform area. If build location effects are known or deemed irrelevant for the trial being performed, then a single build location may be selected and used, as agreed between vendor and user.

Long artefacts, which reach across the extents of the build volume, can be necessary to detect corrections that are not linear or are periodic in nature.

5.14 Arrays

Geometry should not be scaled (since this affects the measurement outputs) but may be patterned in an array to give larger coverage areas. See an example in Figure 2.

5.15 Part consolidation

When arrays of parts are needed for better coverage, it can be most practical to build a single combined part instead of trying to build arrays of adjacent individual parts. This can be achieved by consolidating adjacent AMF or STL files prior to slicing and other file preparation steps.

As AM most commonly is a layered process (in Z-direction) and often based on pixels (in X/Y-direction), the exact position of the part in the build can affect the test significantly. This is especially true of artefacts testing machine resolution. A minor translation of the part can influence rounding off issues influencing whether a specific layer or pixel will build or not. This can be caused during preparation of the slice file and during orienting the slice file ino the working area in the machine. Results should be reported in combination with the test artefacts’ build orientations according to the convention set forth in ISO/ASTM 52921.

With certain AM processes (especially with metals), heat build-up from processing large cross-sectional areas near the test artefacts can affect their geometrical accuracy. Therefore, it is advised that the manufacturer ensure compliance with specified distances.

5.16 Supports and post processing

Where possible, supports should be avoided or supports which do not impede or affect in any way the intended measurement should be employed. Supporting strategy, including, but not limited to material, geometry, removal technique, etc., shall be fully documented in the process specification.

Data reported from this document shall be in the as-built condition prior to any surface or downstream processing. In the case of unavoidable post-processing undertaken prior to measurement (e.g. removal of necessary support material), details of the process shall be reported as part of the process specification. The reporting should include a description of any used abrasive media and how it was applied to the surface of the artefacts. In addition, data after additional post-processing treatments (such as sand blasting of metal parts for example) may be obtained but only if clearly noted and presented together with as-built measurements.

6 General principles for measuring artefacts

6.1 General

This clause outlines principles applicable for measuring all the test artefact geometries in this document. The specific measurements are specified in Clause 7 describing the individual artefact geometries. This document does not prescribe any specific measurement methods; the measurements described below can be accomplished by a variety of techniques and devices (e.g. coordinate measuring machine, optical scanner, dial indicators with calibrated motion devices, surface profilometers, etc.). ISO 17296-3 can be used to improve communication between stakeholders concerning test methods. Reporting requirements are previewed in connection with the measurement steps in this clause but more details about recording and reporting can be found in Annexes B and C.

6.2 Measure parts as built

The test artefact should be allowed to cool to room temperature and then measured directly after it is removed from the system used to build it, before any post-processing is performed. The end user may require that parts be held at a set temperature and humidity prior to measurement. If the parts are built by a powder bed-based process, the parts should be completely separated from the surrounding powder before measurement. If the parts are built on a build platform, perform the measurements without removing the part from the platform. (Removal from a build platform can affect the shapes of the artefacts, thereby influencing the results. If measurement is not possible on the platform, this shall be explicitly stated in the report.) If post-processing is desired, report all details of each post-processing step and measure the part before and after each post-processing steps (reporting all measurement results).

6.3 Measurement strategy

It is well known that measurement strategy affects the overall measurement uncertainty; this is true for dimensional measurements and surface measurements alike. Measurement strategy, here, involves the device chosen to perform the measurement along with the number of points selected to represent the feature or surface, and the distribution of points along the feature or surface. For roughness measurements, the measurement strategy includes any applied filters (e.g. the cut-off length). Measurement strategy is a complicated subject and is often very specific to the part or feature being measured. As such, there is no general "best practice" for performing these measurements. However, some tips are provided in Annexes B and C. The measurement uncertainty is ultimately the important concept, and, with consideration given to the available measurement devices, using a measurement strategy that minimizes the measurement uncertainty within any given constraints should be the primary focus.

Nominally "flat" surfaces may be very uneven or rough. Multiple points sometimes need to be measured to obtain a mean result.

6.4 Measurement uncertainty

The standard uncertainty of each measurement should be reported along with the measurement. Guidance on determining measurement uncertainty can be found in the following references:

— ASME B89.7.3.2 for uncertainty in dimensional measurements;

— ASME B46.1 for surface texture measurements;

— JCGM 100 and JCGM 101 for measurement uncertainty in general;

— ISO/IEC Guide 98-1 and related documents.

Users should document any calibration and/or quality maintenance system for the measurement processes and equipment used. Measurement device and resolution shall be disclosed in the report.

