SLOVENSKI STANDARD
oSIST prEN ISO/ASTM 52943-2:2023

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Aditivna proizvodnja za letalsko in vesoljsko industrijo - Karakteristike in zmogljivost procesa - 2. del: Nanašanje materiala z usmerjenim vnosom energije z žico in oblokom (ISO/ASTM DIS 52943-2:2023)

Additive manufacturing for aerospace - Process characteristics and performance - Part 2: Directed energy deposition using wire and arc (ISO/ASTM DIS 52943-2:2023)

Additive Fertigung für Luft- und Raumfahrt - Prozessanforderungen und Qualifizierung - Teil 2: Materialauftrag mit gerichteter Energieeinbringung unter Verwendung von Draht und Lichtbogen (ISO/ASTM DIS 52943-2:2023)

Fabrication additive pour l'aérospatiale - Caractéristiques et performances du procédé - Partie 2: Dépôt d'énergie dirigée utilisant du fil et un arc (ISO/ASTM DIS 52943-2:2023)

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25.030	3D-tiskanje	Additive manufacturing
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Additive manufacturing for aerospace — Process characteristics and performance —

Part 2:
Directed energy deposition using wire and arc

Fabrication additive pour l'aérospatiale — Caractéristiques et performances du procédé —

Partie 2: Dépôt d'énergie dirigée utilisant du fil et un arc

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Member bodies are requested to consult relevant national interests in ISO/TC 44/SC 14 before casting their ballot to the e-Balloting application.

This document is circulated as received from the committee secretariat.

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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 is the first edition of this document.

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.

Additive manufacturing for aerospace — Process characteristics and performance —

Part 2: Directed energy deposition using wire and arc

1 Scope

This document specifies requirements for the additive manufacturing of metallic parts with directed energy deposition in the aerospace industry. These can be additively built parts or additively built additions to existing parts. Within the application scope of this document, wire is used as feedstock, and arc processes (gas-shielded metal arc processes, tungsten inert gas processes, plasma arc processes) are used as the main energy source.

This document is to be used in conjunction with the engineering documents, if required by the engineering authority.

This document does not apply to national or international safety and health regulations.

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 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO/ASTM/DIS 52926-5, *Additive Manufacturing of metals — Qualification principles — Part 5: Qualification of operators for DED-Arc*

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:

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

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

3.1
preliminary additive procedure specification
pAPS
document containing the required variables of the additive manufacturing process which shall be qualified

3.2
additive procedure specification
APS
document that has been qualified and provides the required variables of the additive manufacturing process to ensure repeatability during production

Note 1 to entry: Further information on the qualification of processes can be found in the ISO 15614 series.

3.3
key process variable
KPV
aspects of the manufacturing process that may impact the capability to meet the specified requirements that include physical, chemical, metallurgical, mechanical and dimensional properties

[SOURCE: SAE AMS 7005]

3.4
engineering authority
organization that has the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

[SOURCE: ISO 24394:2018, 3.8]

3.5
build platform
base which provides a surface upon which the building of the part/s, is started and supported throughout the build process

[SOURCE: ISO/ASTM 52900, 2.3.5]

3.6
substrate
base metal utilized to initiate the deposition of material thatmay remain a portion of the preform

[SOURCE: SAE AMS 7005]

4 Requirements for the feedstock

The properties of the feedstock to be used shall be specified. In order to guarantee a constant delivery quality ISO 544, ISO 15792 (all parts) and ISO 14344 can be used. Typical properties include:

— feedstock diameter;

— chemical composition;

— surface condition;

— storage conditions;

— traceability (e.g. heat lot, batch).

5 Qualification of the machine operator

The qualification of the machine operator shall be carried out in accordance to ISO/ASTM DIS 52926-5. Alternative qualification of machine operator may be carried out, if approved by the engineering authority. Example of such are included in SAE AMS 7005:2019, 4.8 and Appendix C and ISO 24394 but

with the following restrictions and additions. The operator checks subdivide into DED processes and type of DED machine user interface.

NOTE DED processes within the scope of this document share many of the key characteristics with established welding processes such as MIG/MAG (GMAW), TIG (GTAW) and plasma (PAW) as well as mixed variants. The user interface is standardized or manufacturer-specific.

The machine operator sets up the machine for the process and prepares it for the product to be manufactured. This is done on the basis of an APS and a prepared product-specific programme as well as internal specifications.

Machine set-up can include the following:

— wire change;

— change of protective gas supply;

— replacement of wearing parts;

— cleaning of the machine;

— loading the production programme;

— inspection of the overall condition of the machine;

— maintenance.

A theoretical examination is required. The content of the theoretical examination shall be adapted to the DED process and the DED machine type of user interface. Testing and evaluation are the responsibility of the welding or additive manufacturing coordinator, examiner or examining body and shall be documented. For the theoretical examination, the guidelines for the theoretical part of the examination from ISO 24394 can be applied, if applicable. A company defined training program per SAE AMS 7005:2019, Clause C.2 may be used if approved by the engineering authority.

In the practical part of the test, the machine operator shall prove their ability to operate the DED machine according to an existing APS. Defined test pieces or production parts can be used for practical testing.

An example for a certificate for a machine operator test can be found in Annex A, and the examination shall be taken every 2 years to ensure certification to the process

6 Qualification of the DED machine

6.1 Machine Qualification

Each individual DED machine shall be qualified by a qualification test programme within its working range, (see ISO 17662 or SAE AMS 7032 for information) as specified by the machine user and approved by the engineering authority.

The machine qualification test programme shall include the main activities of calibration/verification, deposition of test specimens and established maintenance plan.

Within the scope of this document, a DED machine can consist of the following components. Depending on the type of machine, the following can be verified, if applicable:

— power source (see IEC 60974-14);

— moving axes (see ISO 14744-4, ISO 14744-5 and ISO 15616-2 for general guidance, although the application is formally limited to beam welding, or for industrial robots see ISO 9283);

— wire feed rate according to the wire diameter and the wire feedstock;

— wire straightening;

— wire alignment to melt pool feed point;

— machine environment;

— enclosure of the machine or the work area, if needed;

— machine controller;

— control systems (e.g. temperature, weld pool size, process height);

— process gases;

— hot wire system;

— appropriate build of test samples to evaluate the machine functionality;

— machine and auxiliary equipment software version(s);

— maintenance plan and maintenance is up to date;

— calibration plan and calibration is up to date;

— safety features for proper operation;

— floor layout for proper spacing to other equipment and room to perform maintenance.

The results of the qualification testing shall be documented.

6.2 Machine Requalification

Relevant qualification testing shall be repeated for the following cases:

— operational conditions have changed substantially;

— modification of the machine;

— process deterioration;

— repair or replacement of key parts;

— relocation of the machine.

To ensure that when there is deterioration of the directed energy deposition process (using wire and arc), as identified by a decrease in the equipment performance or quality of the parts, there shall be a documented procedure that controls how this is tracked and resolved.

Key parts of the machine include, but are not limited to:

— heat source;

— type of torch;

— motion control system;

— hot wire system.

7 Build platform/substrate requirements

The build platform is subject to the following requirements:

— the appropriate platform/substrate material shall be specified;

— it shall be defined geometrically and positioned such that the substrate should not pose a collision hazard during the build that prevents the required geometry being deposited;

— the surface shall be free of grease or other impurities which have a negative influence on the DED process and product quality;

— the required clamping force and positions are defined.

The requirements listed here also apply to wire and arc additions to existing parts.

8 Environment requirements

8.1 General

A facility and process environment control plan shall be established before production. Materials with a high affinity for the absorption of atmospheric gases shall be protected during the process by the use of inert gases according to ISO 14175. For this purpose, auxiliary equipment (e.g. drag nozzles or protective gas chambers) can be used.

8.2 Facility environment

The following can be addressed in the facility environment control plan:

— feedstock handling and storage;

— build platform handling and storage;

— process gases (e.g. shielding gas, chamber gas, plasma gas) and auxiliary equipment (e.g. drag nozzles or protective gas chambers), where used;

— cleaning routines;

— gas distribution;

— temperature/humidity control;

— process fumes (filtering system).

8.3 Process environment

The following can be addressed in the process environment control plan:

— contamination, moisture, oxygen level or draughts;

— location of feedstock (avoidance of cross contamination);

— process gases (e.g. shielding gas, chamber gas, plasma gas);

— process fumes (local extraction ventilation).

9 Procedure qualification

9.1 General

Procedure qualification is required before the start of production. For this purpose, a procedure qualification plan shall be prepared on the basis of the requirements provided by the responsible engineering authority.