
Aditivna proizvodnja - Kvalifikacijska načela - Usposobljenost upravljavcev strojev in opreme za fuzijo plasti kovinskih prašnih delcev za uporabo v aeronavtiki (ISO/ASTM/DIS 52942:2019)

Additive manufacturing - Qualification principles - Qualifying machine operators of metal powder bed fusion machines and equipment used in aerospace applications (ISO/ASTM/DIS 52942:2019)

Additive Fertigung - Grundsätze der Qualifizierung - Standard Richtlinie zur Prüfung von Anlagenbedienern für pulverbettbasierte Laserstrahlanlagen zur additiven Fertigung für Luft- und Raumfahrtanwendungen (ISO/ASTM/DIS 52942:2019)

Fabrication additive - Principes de qualification - Lignes directrices normalisées pour la qualification des opérateurs des machines à fusion sur lit de poudre et équipements utilisés dans les applications aérospatiales (ISO/ASTM/DIS 52942:2019)

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Additive manufacturing — Qualification principles — Qualifying machine operators of metal powder bed fusion machines and equipment used in aerospace applications

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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).

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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*.

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Additive manufacturing — Qualification principles — Qualifying machine operators of metal powder bed fusion machines and equipment used in aerospace applications

1 Scope

This document specifies requirements for the qualification of operators of metal powder bed fusion machines and equipment for additive manufacturing.

This document is applicable if the operator qualification testing is required by contract or by application standards.

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 14732:2013, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO/ASTM 52900, *Additive manufacturing — General principles — Part 1: Terminology*

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

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

examiner

person who has been appointed to verify compliance with the applicable standard

Note 1 to entry: In certain cases, an external independent examiner can be required.

[SOURCE: ISO 14732:2013, 3.12]

3.2

examining body

organization that has been appointed to verify compliance with the applicable standard

Note 1 to entry: In certain cases, an external independent examining body can be required.

[SOURCE: ISO 14732:2013, 3.13]

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3.3 operator

person who operates metal powder bed fusion machines and equipment for additive manufacturing

Note 1 to entry: This definition is valid for this ISO/ASTM standard, only.

3.4 additive manufacturing procedure specification APS

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

3.5 preliminary additive manufacturing procedure specification pAPS

document containing the required variables of the additive manufacturing procedure which has to be qualified

4 Qualification

4.1 General

The qualification test for operators shall follow an additive manufacturing procedure specification. An example of an additive manufacturing procedure specification (APS) is given in [Annex D](#).

Qualification of operators shall include the following aspects:

- a) theoretical test;
- b) practical test;
- c) evidence of vision acuity.

4.2 Essential variables and the range of qualification

4.2.1 General

The qualification of operators of metal powder bed fusion machines for additive manufacturing is based on essential variables. For each essential variable, a range of qualification is defined. If the operator has to work outside the range of qualification, a new qualification test is required. The essential variables are:

- a) powder material groups;
- b) machine model.

NOTE For machine model see [4.2.3](#).

4.2.2 Powder material group

The theoretical test in the framework of the qualification scope shall be adapted according to the powder material group in use for production.

Material group A: Unalloyed steel, low-alloyed steels, high-alloyed ferritic steels.

Material group B: Austenitic, martensitic and precipitation hardening steels.

Material group C: Titanium and titanium alloys, niobium, zirconium and other reactive metals.

Material group D: Aluminium and magnesium alloys.

Material group E: Materials that do not conform to other material groups (e.g. molybdenum, tungsten, copper alloys, titanium aluminide).

Material group F: Nickel alloys, cobalt alloys.

A qualification made in a material group only qualifies for the specific material group.

4.2.3 Machine model

The machine model is related to the machine manufacturer and the specific machine type.

4.3 Evidence of vision acuity

The candidate shall provide documented evidence of satisfactory vision in accordance with the following requirements. Any limitations (e.g. visual aids when required to pass the eye sight test), shall be documented on the operator test certificate. Any limitations in colour perception shall be evaluated prior to qualification and must be approved in writing.

Eye sight requirements shall be achieved by using one eye or both eyes. The candidate shall successfully achieve the near vision acuity and colour perception specified herein.

Eye sight tests shall be administered by competent personnel.

The method for testing near vision acuity shall be chosen from one of the following:

- a) Jaeger No. 2 eye chart at approximately 400 mm;
- b) Visus 0,8 at approximately 400 mm;
- c) Eye sight requirements of EN 4179/NAS 410 or ISO 18490.

NOTE The results of the 3 near vision testing methods are not fully comparable.

Colour perception shall be examined by a suitable method, e.g. the Ishihara test.

Near vision shall be tested to these requirements at least every 2 years. Colour perception shall be tested to these requirements at least every 5 years.

4.4 Theoretical test

The theoretical test shall include the content given in [Annex A](#).

The theoretical knowledge shall be as a minimum proofed in a multiple choice test. The test shall contain a minimum of 20 questions. At least 80 % of the questions shall be answered correctly.

4.5 Practical test

The practical test shall include the content given in [Annex B](#).

For proving the practical skills, the operator shall demonstrate the necessary process steps on a metal powder bed based fusion machine and shall set up the machine according to a (preliminary) additive manufacturing procedure specification (pAPS or APS).

NOTE See [Annex D](#) for an example of an APS.

The advanced skills listed in [Annex B](#) shall be given on the qualification test certificate when trained and successfully tested.

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5 Qualification test certificate

The examiner or examining body shall certify that the operator for metal powder bed fusion machine has successfully passed all tests.

If the operator for a metal powder bed fusion machine failed to pass one of the tests according to [4.3](#), [4.4](#) and/or [4.5](#), no qualification test certificate shall be issued.

The certificate shall contain as a minimum the following:

- a) name
- b) date of birth or unique identifier, e.g. employee number;
- c) machine model (machine manufacturer and the specific machine type) of the machine(s) used for the practical assessment;
- d) material group(s) addressed in the theoretical test;
- e) if applicable, the trained and tested advanced skills (according to [Annex B](#));
- f) corrective lenses, if required to pass the vision acuity test according to [4.3](#);
- g) date of issue of the certificate;
- h) expiration date for period of validity;
- i) name and signature of the examiner.

The certificate shall be issued under the responsibility of the examiner or examining body. A suggested certificate format is provided in [Annex C](#).

6 Validity of testing

6.1 General

The qualification test certificate is valid only for the machine model, powder material(s) and skills which had been assessed.

6.2 Period of validity

The qualification test certificate is valid for a period of 2 years. The operator qualification test certificate shall be renewed every two years, according to [clause 6.3](#).

The certificate expires by the end of the respective month when the practical test was taken.

Re-qualification shall be carried out during the period of validity at any time when:

- a) there is reason to assume, that the operator doesn't fulfil the requirements of his/her qualification;
- b) the operator has not been working for more than 6 months on the machine model of his/her qualification;
- c) unsatisfactory results occur on representative parts, which are related to the setup of the machine according to a procedure specification.

6.3 Re-qualification test

For the re-qualification test, the same requirements as for the initial qualification tests apply.

The theoretical assessment may be adapted to the operator's professional experience.