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Additive manufacturing of metals — Qualification principles —

Part 2: Qualification of operators for PBF-LB

Fabrication additive de métaux — Principes de qualification —
Partie 2: Qualification des opérateurs pour PBF-LB

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Foreword

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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 document 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*, 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, 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).

A list of all parts of the ISO/ASTM 52926 series can be found on the ISO website.

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.

Introduction

For many companies, additive manufacturing represents an alternative to more conventional manufacturing processes such as casting, forging or milling. The trend towards complex components, decentralised production and customer specific products allows an economically feasible use for more and more areas. This also applies to many series applications, which comprise completely different demands on the efficiency of the processes. In particular, components used in different fields (e.g., automotive industry, mechanical engineering, railway sector, aerospace, process and industrial plants, medical technology, etc.) are subject to high demands in terms of quality and safety. This creates a need for norms and standards that provide a transparent baseline for the production of components for a great variety of application areas.

The manufacturing of products intended for applications subjected to specific requirements relies on that the products' compliance to these requirements can be assured. Additive manufacturing is no exception to this. To this end, the production chain and environment should be designed in such a way that the process quality and the resulting product quality are always consistent and reproducible. To assure this consistency and reproducibility, it is of utmost importance to assure that the involved workforce is adequately qualified for all stages in the production.

ISO/ASTM 52926 series describes the activities and responsibilities of the operators in the field of the additive manufacturing technology. Its aim is to specify the qualification tests to be employed in the assessment of AM operators' skills when operating AM machines, especially in regulated industries, such as automotive industry, mechanical engineering, the railway sector, the aerospace industry, process and industrial plants or medical technology, consideration of the criteria specified within the framework of this document create a basis for fulfilling the requirements for specific products.

NOTE This document gives the constraints and requirements for an operator to be qualified for powder bed fusion – laser beam (PBF-LB).

Additive manufacturing of metals — Qualification principles —

Part 2: Qualification of operators for PBF-LB

1 Scope

This document identifies the capabilities and responsibilities required for the qualification of the AM operators on the field of the additive manufacturing technologies dealing with metallic parts production, specifically for the employment of powder bed fusion – laser beam with metals (PBF-LB/M).

This document identifies criteria for the theoretical and practical assessment of personnel operating PBF-LB/M machines. The activities and procedures foreseen to be performed by the PBF-LB/M operator are also part of this document.

This document is intended to provide an outline for qualification of AM machine operators in general industrial applications. Where industry-specific requirements exist for the qualification of AM operators, such as ISO/ASTM 52942 for aerospace applications, those industry-specific standards are used instead of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

ISO/ASTM 52926-1, *Additive Manufacturing of metals — Qualification principles — Part 1: General qualification of operators*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and ISO/ASTM 52926-1 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/

4 Operator qualification

4.1 General

The qualification test for AM operators should follow a suitable documented procedure or manufacturing plan.

Prior to the assessment, the AM operator should have received the necessary amount of theoretical and practical training (example of 24 h of training) or prior equivalent experience in a PBF-LB/M operator role.

Qualifications of AM operators in PBF-LB/M should follow the assessment for this technology identified in 4.2.

NOTE For recommendations in terms of training, education and assessment minimum requirements, see Reference [8].

4.2 Assessment procedures

4.2.1 General

The assessment principles are described in ISO/ASTM 52926-1.

The theoretical test should have at least twenty questions covering the topics selected from 4.2.2 to 4.2.7. Each question should have four possible answers where only one is correct. The candidate should achieve a minimum score of 60 % to pass the theoretical test (ISO/ASTM 52926-1).

The practical test shows that the AM operator demonstrates the practical skills to conduct all the necessary process steps for a specific AM process and machine in accordance with a manufacturing plan.

The topics cover general characteristics of PBF-LB/M systems and additional specific skills that should be considered/evaluated in accordance with the relevant activities expected to be the responsibility of the operator in their actual work environment. These can include the items listed in 4.2.2 to 4.2.7.

4.2.2 Aspects of PBF-LB/M

— Recognise different AM Metal processes (where applicable).

— Recognise the advantages and limitations of PBF-LB/M processes.

— Describe the PBF-LB/M systems, including the components and their functions.

— Recognise the characteristics of the PBF-LB build platform, feedstock and other consumables.

— Recognise the PBF-LB/M parameters and the influence of their adjustment on the as built part.

— Recognise the interaction of the main process energy source (laser beam) with the feedstock.

— Recognise the interaction of the process heat source (build chamber/platform heating system) with the feedstock.

— Identify the problems associated with inadequate preparation and setup of the build. (i.e. build platform installation, installation of spreading device system, handling and storage of feedstock, application of the shielding and process gases used in PBF-LB/M).

— Follow work instructions created by, for example, AM coordination personnel.

— Recognise how post build - cycle activities performed by the operator can influence part quality.

— Recognise the factors or events that can affect the qualification status of the PBF-LB equipment.

— Follow environmental, health & safety (EHS) procedures in all manufacturing steps.

NOTE Guidance for EHS considerations and requirements is provided in ISO/ASTM 52931 and ISO/ASTM 52938-1.

4.2.3 Feedstock activities

— Recognize and follow procedures for identification, loading, removal, and life cycle management of feedstock, ensuring cleanliness of canisters and transfer equipment used and demonstrate awareness of the risk of cross-contamination.

NOTE Guidance for feedstock life cycle management considerations and requirements is provided in ISO/ASTM 52928.

— Prepare and verify the feedstock and its conditions in accordance with manufacturing plan.

— Record feedstock related data in the work documentation.

— Perform powder sampling in accordance with the established procedure.

— Perform powder reconditioning (e.g. sieving) where applicable.

Additional specific skills:

— Analyse powder in accordance with the manufacturing plan.

4.2.4 System set-up activities

— Prepare the build platform and verify its condition in accordance with the manufacturing plan.

— Perform the build platform installation in accordance with the manufacturing plan.

— Perform build file loading.

— Prepare the machine for operation in accordance with the manufacturing plan.

4.2.5 Manufacturing/Build activities

— Record manufacturing process related data in the work documentation.

— Identify the main procedures, equipment, and their role.

— Perform the starting procedure to (re-)initiate the build cycle, according to the manufacturing plan.

— Verify that the PBF-LB machines are working in accordance with the job specification, in terms of process parameters.

— Check the PBF-LB system set-up according to the procedure determined by the machine manufacturer and required operational conditions.

— Perform and record process observation, in-build corrections, malfunction detection and reaction.

Additional specific skills:

— Carry out preventive maintenance tasks as designated by the PBF-LB system manufacturer, AM coordination personnel and/or the quality assurance organization procedures.

4.2.6 Post-processing activities

— Execute the bulk powder removal.

— Execute the build platform removal.

— Execute part cleaning steps.

— Complete data records (e.g. process protocols, monitoring data and photographs) of the build.