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Additive manufacturing of metals — Qualification principles — Qualification of coordination personnel

Fabrication additive des métaux — Principes de qualification — Qualification du personnel de coordination

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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).

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 (AM) represents an interesting alternative to established manufacturing processes. The trend towards complex, customised or consolidated components, in addition to opportunities for reduced lead times and decentralised production allows an economically feasible use for a growing number of areas. This increasingly applies to many series applications, which add further demands on the efficiency and consistency of the processes. In particular, components used in regulated industries (e.g. automotive, rail, aerospace, process and industrial plants, medical) are subject to high demands in terms of quality and safety.

Where industrial components are produced using additive manufacturing processes, these shall satisfy the equivalent quality and safety requirements demanded of conventional processes. To this end, the production chain and environment are designed such that the process quality and resulting product quality are always consistent and reproducible. To achieve consistency and reproducibility, it is of utmost importance to ensure that the involved workforce is adequately qualified for all stages of production.

This document describes the activities and responsibilities of the personnel with coordination roles in the field of additive manufacturing for metallic parts.

Additive manufacturing of metals — Qualification principles — Qualification of coordination personnel

1 Scope

This document specifies qualification requirements for coordination personnel in industrial manufacturing sites responsible for additive manufacturing of metal parts.

This document is applicable to all metallic processes that are described by ISO 17296-2. In this context, the skills, tasks and responsibilities for different levels of AM coordination personnel are typically adapted according to the applicable regulations, depending on the process.

This document is intended to provide guidance and requirements for the qualification of coordination personnel in general-industrial applications. Additional requirements are typically needed for specific industries or applications (e.g. aerospace, medical) or to meet regulatory requirements.

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/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

ISO/ASTM 52920, *Additive manufacturing — Qualification principles — Quality requirements for industrial additive manufacturing sites*

ISO/ASTM/TS 52930, *Additive manufacturing — Qualification principles — Installation, operation and performance (IQ/OQ/PQ) of PBF-LB equipment*

3 Terms and definitions

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

3.1
AM coordination personnel
AM coordinator
person or group of people performing defined AM coordination tasks, designated by the company to be responsible for a specific process

Note 1 to entry: The designation can be valid for one specific AM process or covering several process categories as specified in ISO/ASTM 52900 and illustrated in ISO 17296-2.

Note 2 to entry: Different personnel may be appointed by the manufacturer for different AM related tasks.

3.2
examiner
person with knowledge and experience relevant to the qualification, and acceptable to the customer or examining body or engineering authority

Note 1 to entry: In certain cases, an external independent examining body can be required (ISO/IEC 17024).

4 Tasks and responsibilities

4.1 General

Coordination personnel can have multiple tasks and responsibilities for additive manufacturing of metals. These tasks and responsibilities can have varying levels depending on the companies' needs and the coordination personnel's education and experience. Coordination personnel can have tasks and responsibilities that are at their level of qualification or lower. The company specifies if these tasks, regardless of the level, are assigned to one single staff or to several staff members.

4.2 Specification of tasks and responsibilities

Each manufacturer is responsible for appointing their AM coordination personnel and specifying their levels of responsibility for coordination.

The tasks and responsibilities of AM coordination personnel should be selected from Annex B and/or as specified in applicable standards, contracts, and regulations. The level of competence of AM coordination personnel should be determined in accordance with the complexity of the AM and related activities, product type(s), criticality of the application and the quality requirements.

Where more than one person carries out AM coordination, the tasks and responsibilities should be clearly allocated, such that responsibility is clearly specified, and the persons are competent for each specific AM coordination task.

The manufacturer shall appoint at least one person to be responsible for AM coordination tasks.

If AM coordination is subcontracted, the tasks and responsibilities shall be specified and documented. However, compliance with this document remains the responsibility of the manufacturer.

4.3 Tasks and responsibilities

The tasks and responsibilities assigned to AM coordination personnel shall be identified in accordance with 4.1, 4.2 and Annex B, and documented per Annex A.

Persons other than the AM coordinator may be designated to perform specific tasks on their behalf. Delegations of this type shall be documented.

4.4 Responsibilities and extent of authorization

The responsibilities and extent of authorization assigned to the AM coordination personnel are identified as follows:

— their position in the manufacturer's organization and their responsibilities;

— the extent of authorization assigned to them to carry out the assigned tasks (see Annex B);

— the extent of authorization assigned to them to accept or validate, by signature, technical administrative documents or contracts, on behalf of the manufacturer, as needed to fulfil the assigned tasks, for example, for procedure specification and supervision reports.

5 Technical knowledge and competence

5.1 General

All AM coordination personnel shall be able to demonstrate

— competence in the AM-related tasks allocated to them, and

— technical knowledge in AM technologies relevant to the assigned tasks, defined in Annex B, obtained by a combination of education, training and/or experience.

Competence includes application of AM and related standards when relevant to the assigned tasks.

Competence shall be documented on the qualification test certificate given in Annex A for each task and responsibility based on:

— the level of qualification may be different for different categories;

— qualification in every category is not required, if not applicable.

NOTE For recommendations in terms of training, education and assessment minimum requirements, see References [6] and [7].

AM coordination personnel should be allocated to one of the levels described in 5.2, depending on the nature and/or complexity of the production.

5.2 Competence levels for AM coordination personnel

5.2.1 Level 1 - Basic

At Level 1, AM coordination personnel shall be competent to make decisions in basic work and supervise basic aspects of AM production related topics and activities, apply established procedures, apply variation within strict boundaries and supervise operators.

5.2.2 Level 2 - Standard

At Level 2, AM coordination personnel shall be competent to select and apply established procedures and implement variations in response to technical or economic requirements, select and supervise AM personnel.

Qualification for Level 2 shall include knowledge and skills of Level 1.

5.2.3 Level 3 – Advanced

At Level 3, AM coordination personnel shall be competent to evaluate application, develop, specify and apply procedures, select, instruct and supervise AM personnel and coordination personnel and implementing AM production, for a specific process and including coordination/supervision of the full manufacturing chain, and related topics and activities.

Qualification of Level 3 shall include the knowledge and skills of Level 2.

6 Qualification

6.1 Assessment of AM coordination personnel

The examination or assessment shall be conducted by personnel with a level of competence or responsibility equal or higher than the person under assessment.

The method applied for assessment shall be recorded in a specific document and contain the acceptance criteria to be applied in examination to assess the capabilities of the candidate against the expected responsibilities and performances described in Annex B.

The examiner or examining body shall certify that the AM coordination personnel have met the criteria specified.

Upon a passing result, the examiner completes the level assessment per task and responsibility on the qualification test certificate.

If the candidate fails to pass the test related to the tasks in Annex B of this standard, no qualification test certificate shall be issued.

6.2 Validity of qualification

The qualification remains valid whilst the AM coordination personnel maintains the appropriate level of knowledge relevant to the processes for which the AM coordination personnel is qualified.

Qualification can be maintained by periodic review to ensure the AM Coordination personnel still has the appropriate level of knowledge.

When the period of validity is not specified by the part manufacturer or by the specific industry sector or application, a maximum validity of 5 years from the last review shall apply.

The qualification can be revoked, and re-qualification required if there is evidence that the AM coordination personnel has not fulfilled the requirements of their qualification.

The qualification is not transferable to other manufacturers.

6.3 Re-qualification

The method applied for re-qualification shall be recorded in a specific document and contain the acceptance criteria to be applied in examination to assess the capabilities of the candidate against the expected responsibilities and performances described in Annex B.

The assessment may be adapted to the AM Coordination personnel's professional experience.

If a candidate wishes to raise the levels they are qualified to, then a new test shall be carried out.

Any practical element of the assessment may be undertaken during production.

The examiner or examining body shall certify that the AM coordination personnel have met the criteria specified.

7 Qualification test certificate

The certificate shall contain as a minimum the following:

a) name;

b) unique identifier;

c) scope of the application;

d) summary of aspects covered during assessment;

e) date of issue of the certificate;

f) name and signature of the examiner;

g) a reference to this document and its edition, i.e. ISO/ASTM 52935:2023;

h) level for each task/responsibility.

The certificate shall be issued under the responsibility of the examiner or examining body. A suggested certificate format is provided in Annex A.

The manufacturer may choose to keep a record of qualifications for the candidate or issue a certificate to the candidate.

Annex A
(informative)

Qualification test certificate of AM coordination personnel

Table A.1 — Contents of qualification test certificate

Qualification test certificate number:	
Examiner/examining body or company:	
Surname, first name:	
Employee number/unique identifier:	
Process categories (see ISO 17296-2):	
Manufacturer/company:	
Manufacturer/company location:	
Date of certification:	
Place of issue:	
Date of issue:	
Expiry date:	
Examiner/examining body signature:	

Table A.2 shows the scope of qualification of the additive manufacturing coordinator listed above in accordance with this document. For each qualification place an "X" in the appropriate level. N/A if the person does not possess any level for the qualification category.

Table A.2 — Scope of the AM coordination personnel qualification

Qualification category	**Level 1 Basic**	**Level 2 Standard**	**Level 3 Advanced**
AM process			
Equipment operations			
Process parameters			
Feedstock			
Build layouts			
Post processing			
Traceability			
Production floor layouts			
Safety			
Costing			
Process qualification			
Testing			
Documentation			
Risk assessment			
Manufacturing support			
Training			

NOTE Additional topics can be included in the scope of qualification.

Annex B
(normative)

AM coordination personnel tasks/responsibilities and levels

Table B.1 — Tasks and responsibilities of the qualification categories

Category	Level 1	Level 2	Level 3
AM process	— Differentiates the metallic AM processes and recognize their advantages and limitations for metal AM applications. — Supports AM production for a specific process. — Recognise the existing standards or in-house quality assurance requirements applicable to the industrial field. — Machine support including personnel, supporting tooling, utilities, calibration, inspection and maintenance. — Prepares the daily work and tasks distribution based on production plans. — Coordination of AM operators	— Differentiates the metallic AM processes and recognize their advantages and limitations for metal AM applications. — Understands the main advantages and limitations of metal AM over other processes. — Supports AM production for a specific process. — Recognise the existing standards or in-house quality assurance requirements applicable to the industrial field. — Machine support including personnel, supporting tooling, utilities, calibration, inspection and maintenance. — Prepares the daily work and tasks distribution based on production plans.	— Differentiates the metallic AM processes and recognize their advantages and limitations for metal AM applications. — Understands the main advantages and limitations of metal AM over other processes. — Supports AM production for a specific process. — Recognise the existing standards or in-house quality assurance requirements applicable to the industrial field. — Machine support including personnel, supporting tooling, utilities, calibration, inspection and maintenance. — Prepares the daily work and tasks distribution based on production plans.

Table B.1 *(continued)*

Category	Level 1	Level 2	Level 3
		— Coordination of AM operators	— Coordination of AM operators
		— Implements AM production, for a specific process and including coordination of the full manufacturing chain in accordance with ISO/ASTM 52920, and related topics and activities.	— Implements AM production, for a specific process and including coordination of the full manufacturing chain in accordance with ISO/ASTM 52920, and related topics and activities.
		— Ability to assess the AM process for a specific part taking into consideration the part requirements and customer requirements. (reference as an example: ISO/ASTM 52904, ISO/ASTM 52901).	— Ability to assess the AM process for a specific part taking into consideration the part requirements and customer requirements. (reference as an example: ISO/ASTM 52904, ISO/ASTM 52901).
		— Recognizes part selling cost in relation to choosing the correct AM process.	— Recognizes part selling cost in relation to choosing the correct AM process.
		— Knowledge of standards used for metal AM production.	— Knowledge of standards used for metal AM production.
		— AM process support including personnel, tooling, utilities, calibration, and maintenance.	— AM process support including personnel, tooling, utilities, calibration, and maintenance.
			— Specifies and implements AM production, for a specific process and including coordination of the full manufacturing chain, and related topics and activities.
			— Develops procedures for new equipment and processes.
			— Supports the continuous technical and commercial integration of metal AM in an industrial environment.
			— Analyses all the manufacturing processes existing in the company comparing AM with other manufacturing processes.
			— Recommends procedures for integration of AM processes within the company's manufacturing chain.

Table B.1 *(continued)*

Category	Level 1	Level 2	Level 3
Equipment operation	— Understands handling methods for feedstock, gases and auxiliary materials where applicable. — Responsible to ensure cycle time and through put is maximized and scrap rates are minimized. — Executes responses to process deviations (e.g. restart procedures).	— Understands handling methods for feedstock, gases and auxiliary materials where applicable — Responsible to ensure cycle time and through put is maximized and scrap rates are minimized. — Executes responses to process deviations (e.g. restart procedures). — Understanding of compatibility of feedstock, gases and auxiliary materials where applicable, for use in the equipment. — Develops instructions to ensure cycle time and through put is maximized and scrap rates are minimized. — Maintains the machine availability (hours available for AM manufacturing vs downtime) — Understands methods to address process deviations (e.g. restart procedures).	— Understands handling methods for feedstock, gases and auxiliary materials where applicable — Responsible to ensure cycle time and through put is maximized and scrap rates are minimized. — Executes responses to process deviations (e.g. restart procedures). — Understanding of for feedstock, gases and auxiliary materials where applicable, compatibility for use in the equipment. — Develops instructions to ensure cycle time and through put is maximized and scrap rates are minimized. — Maintains the machine availability (hours available for AM manufacturing vs downtime) — Understands methods to address process deviations (e.g. restart procedures). — Specifies the feedstock and atmosphere and equipment compatibility for a specific part. — Specifies cycle time/through put/scrap rates. — Assess the machine availability with respect to production requirements (hours available for AM manufacturing vs downtime). — Specifies methods to address process deviations (e.g. restart procedures) — Understands the possible negative effects of cross-contamination between powders of different alloy families (for facilities that handle multiple alloys within the same facility) Applies techniques to prevent cross-contamination between alloy families.

Table B.1 *(continued)*

Category	Level 1	Level 2	Level 3
Process parameters	— Ensures operators use the specified process parameters as specified.	— Ensures operators use the specified process parameters as specified. — Understands the influence of the process parameters, build platform, feedstock, and other consumables on the outcome of the finished part to prevent defects and process related issues (e.g. build interrupts and restarts).	— Ensures operators use the specified process parameters as specified. — Understands the influence of the process parameters, build platform, feedstock, and other consumables on the outcome of the finished part to prevent defects and process related issues (e.g. build interrupts and restarts). — Ensures the process parameters are specified and qualified
Feedstock	— Ensures operators follow the specified feedstock storage and handling instructions and maintain traceability.	— Ensures operators follow the specified feedstock storage and handling instructions and maintain traceability. — Knowledge of different types of feedstock for the applicable AM process. — Identifies the problems associated with inadequate handling and storage of feedstock and application of the gases used in production.	— Ensures operators follow the specified feedstock storage and handling instructions and maintain traceability. — Knowledge of different types of feedstock for the applicable AM process. — Identifies the problems associated with inadequate handling and storage of feedstock and application of the gases used in production. — Specifies the required feedstock for the applicable AM process and part. — Specifies the appropriate handling and storage of feedstock and application of gases and auxiliary materials where used in production. — Knowledge of the structure and properties of relevant metals and alloys and its impact on part requirements
Build layouts	— Ensures operators load the proper build layout. — Understands the basic principles of build layout, and the impact of part orientation, tool paths and thermal impact	— Ensures operators load the proper build layout. — Understands the basic principles of build layout, and the impact of part orientation, tool paths and thermal impact — Understands the part orientation and suitable toolpaths for a given part and identify the areas that will need thermal compensation. — Understands methods to reduce distortion or other flaws for a variety of part geometries and processes. — Capable to create build files ensuring data integrity and traceability.	— Ensures operators load the proper build layout. — Understands the basic principles of build layout, and the impact of part orientation, tool paths and thermal impact — Understands the part orientation and suitable toolpaths for a given part and identify the areas that will need thermal compensation. — Understands methods to reduce distortion or other flaws for a variety of part geometries and processes. — Capable to create build files ensuring data integrity and traceability. — Ensures the designer specifies part orientation, suitable toolpaths or scan strategy/support structures

Table B.1 *(continued)*

Category	Level 1	Level 2	Level 3
Post processing	— Ensures operators follows the specified post processing methods (e.g. removal from build space and cleaning). — Understand the specific requirements from various post-processing steps and how this might impact manufacturing	— Ensures operators follows the specified post processing methods (e.g. removal from build space and cleaning). — Understand the specific requirements from various post-processing steps and how this might impact manufacturing — Knowledge and support of the applicable post processing methods.	— Ensures operators follows the specified post processing methods (e.g. removal from build space and cleaning). — Understand the specific requirements from various post-processing steps and how this might impact manufacturing — Knowledge and support of the applicable post processing methods. — Recognizes and selects the applicable post processing methods.
Traceability	— Ensures operators collect and document the essential information during the AM manufacturing process.	— Ensures operators collect and document the essential information during the AM manufacturing process. — Ensures methods are in place to capture essential information during the AM manufacturing process. — Ensures AM personnel collect and document the essential information.	— Ensures operators collect and document the essential information during the AM manufacturing process. — Ensures methods are in place to capture essential information during the AM manufacturing process. — Ensures AM personnel collect and document the essential information. — Develops and specifies methods to capture essential information during the AM manufacturing process.
Production floor layouts	— Works with Level 2 and 3 in work cells set up or improvement.	— Understands the impact of the product flow through the AM cell. — Works with Level 1 and 3 in work cells set up or improvement.	— Understands the impact of the product flow through the AM cell. — Works with Level 2 and 3 in work cells set up or improvement. — Develops AM cells including selection of AM machine and methods to manipulate the part, fixturing, and sensing of the part, equipment for loading and unloading. — Applies techniques to prevent cross-contamination between alloy families (in accordance with ISO/ASTM 52920).

Table B.1 *(continued)*

Category	Level 1	Level 2	Level 3
Safety	— Understands the works cell and feedstock storage areas hazards. — Has familiarity with, and provides input to, the safety risk assessment for the work cell area including feedstock storage area. — Supports implementation of safety practices in the work area, including feedstock storage area — Provides the necessary resources for operators to follow the safety practices — Ensure AM personnel follows Environmental, Health and Safety (EHS) requirements and procedures.	— Understands the works cell and feedstock storage areas hazards. — Has familiarity with, and provides input to, the safety risk assessment for the work cell area including feedstock storage area. — Supports implementation of safety practices in the work area, including feedstock storage area — Provides the necessary resources for operators to follow the safety practices — Ensure AM personnel follows EHS requirements and procedures. — Provides inputs to establish or improve regulatory and EHS requirements and procedures.	— Understands the works cell and feedstock storage areas hazards. — Has familiarity with, and provides input to, the safety risk assessment for the work cell area including feedstock storage area. — Supports implementation of safety practices in the work area, including feedstock storage area — Provides the necessary resources for operators to follow the safety practices — Ensure AM personnel follows EHS requirements and procedures. — Provides inputs to establish or improve regulatory and EHS requirements and procedures. — Collects safety information from equipment manufacturers, feedstock providers and provides inputs to establish or improve regulatory and EHS requirements and procedures.
Costing	— N/A	— Provides inputs to quotations for repeat orders, calculating the cost of a product made by AM, including labour costs, overhead costs, and consumable costs.	— Provides inputs to quotations for new or repeat orders, calculating the cost of a product made by AM, including labour costs, overhead costs, and consumable costs. — Compares AM production costs to non-AM manufacturing costs determining the economic viability.