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Additive manufacturing — General principles — Requirements for purchased AM parts

Fabrication additive — Principes généraux — Exigences pour l'achat de pièces

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 261, *Additive manufacturing* in cooperation with ASTM 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.

Introduction

This document covers the definition and communication of requirements for purchased parts made by additive manufacturing. It is intended to enable efficient and unambiguous communication between the part providers and the customers of parts made by additive manufacturing to ensure that the resulting part meets the customer's requirements. It is intended that the document is used by the part providers and/or the customers of parts made by additive manufacturing.

This document is a top-level standard in the hierarchy of additive manufacturing standards in that it is intended to apply to parts made by any additive manufacturing process and any material type. The document allows for different requirements based on the classification of the criticality and expected end use of the parts made by additive manufacturing.

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Additive manufacturing — General principles — Requirements for purchased AM parts

1 Scope

This document defines and specifies requirements for purchased parts made by additive manufacturing.

It gives guidelines for the elements to be exchanged between the customer and the part provider at the time of the order, including the customer order information, part definition data, feedstock requirements, final part characteristics and properties, inspection requirements and part acceptance methods.

It is applicable for use as a basis to obtain parts made by additive manufacturing that meet minimum acceptance requirements. More stringent part requirements can be specified through the addition of one or more supplementary requirements at the time of the order.

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 17296-3, *Additive manufacturing — General principles — Part 3: Main characteristics and corresponding test methods*

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

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

ASTM F 3122, *Standard Guide for Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes*

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:

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

3.1

pre-shipment inspection

inspection carried out by the part producer on the parts to be supplied according to the part definition or on the test units in order to verify that these parts are in compliance with the order requirements

3.2

qualification part

part fabricated prior to commencing production which is used to qualify specific aspects of the manufacturing process or part characteristics in order to use as a basis to initiate production

3.3

first production part

part with the same geometry (and with the same tolerances), same material and same properties as the one requested by the order that allows verification by the *customer* (3.8) that the production processes are capable of producing parts that meet the requirements

3.4

reference part

part with characteristics similar to the desired final parts but with different geometry or scale or features that can be easily measured or characterized

Note 1 to entry: Reference parts are typically sacrificial parts with simple geometries that are used to verify build properties and reduce measurement effort.

3.5

acceptance

agreement between the *customer* (3.8) and the *part provider* (3.7) that the delivered part(s) meet the purchase order requirements

3.6

inspection plan

set of instructions specifying the process of verification including appropriate resources and sequence of inspections to be referenced by the manufacturing plan

3.7

part provider

manufacturer or distributor of parts produced by an additive manufacturing process

3.8

customer

person or group ordering and receiving parts manufactured by additive manufacturing equipment

4 Requirements

4.1 General

The elements described in 4.2 to 4.5 shall be included in the purchase order subject to agreement between the customer and the part provider. Annex A provides a typical content of a purchase order.

4.2 Part ordering information

The part order shall include the following elements:

- a) customer organization and contact information (preferably with points of contact for ordering, payment and delivery);
- b) definition of the part(s) to be manufactured;
- c) associated conditions of delivery to the customer;
- d) other purchase requirements;
- e) a reference identification of this document, i.e. ISO/ASTM 52901 and other relevant national/international regulations;
- f) customer part order identification (requisition number, requisition date, etc.);
- g) designation or description of the part(s) desired (part number/identification, revision index, etc.);
- h) quantity of parts desired;

- i) required delivery date, if single order;
- j) required delivery quantity, frequency and time duration of the order, if ongoing or multiple orders;
- k) required marking or tagging of the parts, including, for example, labels, serial number, lot number, feedstock type, part provider's reference, inspection identifier, traceability reference, etc.;
- l) part packaging requirements for delivery to customer;
- m) customer shipping address;

The specific values of the elements are subject to agreement between the customer and the part provider.

4.3 Definition of the part to be manufactured

4.3.1 General

The part definition shall include the following elements:

- part geometry;
- tolerances;
- surface texture;
- build orientation, if necessary to meet the customer requirements;
- feedstock for the part to be manufactured, if necessary to meet the customer requirements;
- repair methods (taking into account the testing categories defined in ISO 17296-3);
- acceptable imperfections or deviations;
- process control information.

NOTE Disclosure of proprietary information is subject to agreement between the customer and the part provider.

4.3.2 Part geometry

The part definition shall include the following elements:

- a) the engineering drawing reference (number, index and version), if applicable;
- b) the digital file reference (name, format, version), if applicable;
- c) the geometry description by
 - 1) an engineering drawing that fully defines the part, or
 - 2) a digital file containing the 3D model or the part geometry information; for electronic data exchanges, the customer and the part provider shall ensure that the systems used are compatible, and define
 - i) the method for supplying digital files, including level of confidentiality and methods for data protection,
 - ii) the format of the electronic data, and
 - iii) the procedures for creating the digital file (including source of the electronic data and conversion requirements necessary to produce the digital file).

The part geometry description documents may be supplied by the customer or by the part provider.

NOTE The STL file format used by many additive manufacturing machines does not contain units of measurement as metadata. When only STL files are provided by the customer, ordering information specifies the units of measurements of the part along with the digital file. More information about digital files can be found in ISO/ASTM 52915.

4.3.3 Tolerances

The tolerances shall be specified (e.g. general tolerances, see ISO 2768-1 and ISO 2768-2, and/or specific, ISO 1101), including the definition of functional (e.g. machining allowance for finishing or rework) and aesthetic or cosmetic zones, so that the part provider can orient the part according to the requirements, and decide on the location and type of part support structures if needed.

4.3.4 Surface texture

The surface texture (also known as surface finish) of the part should be specified, if possible by reference to existing standards (e.g. by using ISO 1302 and/or ISO 25178-1).

The surface texture requirement may be specified by a maximum value of roughness/waviness for the whole part or by a specific roughness/waviness for one or more critical surfaces.

NOTE The surface texture typically depends on several process parameters, including part orientation and layer thickness.

4.3.5 Part manufacturing process

The desired manufacturing process for building the part shall be identified, including necessary post-processing steps (e.g. heat treatment, surface finishing).

The build orientation shall follow the rules given in ISO/ASTM 52921.

NOTE The build orientation is usually chosen by the part provider to meet the requirements; however, the customer can specify the build orientation of the part if needed to achieve specific mechanical properties.

4.3.6 Feedstock for the part to be manufactured

The type and/or limits of the chemical composition of the feedstock for the part to be manufactured shall be specified by reference to existing standards and/or material specifications.

The purchase order shall mention or reference appropriate specifications for

- characteristics of the feedstock for the part to be manufactured,
- storage, handling, and processing requirements for proper use of feedstock and to control its properties, and
- if necessary to meet the customer requirements, information about the allowed use of recycled (reused) feedstock.

NOTE If the customer is concerned about the country of origin of the feedstock or the producer of the feedstock, the desired source of feedstock can be specified.

4.3.7 Repair methods

Any repair shall be communicated to the customer and authorized prior to being performed. The authorized repair methods (such as repair by material deposition, welding, gluing, or bonding) and corresponding repair conditions shall be specified if needed and shall be approved by the customer.

4.3.8 Acceptable imperfection(s) or non-conformance

Allowances for cracks, defects, discontinuities, foreign material, inclusions, acceptable imperfection(s) or deviation(s), discolorations, and porosity shall be agreed upon between the part provider and the customer.

4.3.9 Process control information

Requirements for manufacturing process repeatability shall be identified, including reference to relevant standards or measurement methods for assessing repeatability, particularly for orders of multiple parts or expected multiple orders of the same part.

Requirements for documenting process control information during manufacturing shall be identified. Required information as agreed upon between the part provider and the customer shall be documented during the manufacturing and included in the quality record for the AM part as retained by the part provider. The retention period for the quality record and the process control information to be transmitted to the customer shall be agreed upon between the customer and the provider.

4.3.10 Authorized outside service providers

If authorized outside service providers are required (e.g. for post treatment, inspection, etc.), they shall be agreed upon between the part provider and the customer and shall be documented.

4.4 Part characteristics, functionality and performance

4.4.1 General

The most important part characteristics from the customer view shall be identified, particularly those related to dimensional accuracy, defects, mechanical properties, residual stress, or chemical composition. Required part characteristics may be stated relative to a suitable reference, such as in relation to the mechanical properties of cast or wrought materials.

4.4.2 Part characteristics

Part characteristics, including those found in ISO 17296-3 or ASTM F 3122, shall meet the requirements of applicable standards or shall be agreed upon between the part provider and the customer. Since standards specific to additive manufacturing are still under development, relevant part characteristics that are not described in the current standards shall be agreed upon between the part provider and the customer. Part characteristic information shall be included in the quality record for the purchased AM part.

4.4.3 Functionality

The desired functionality of the part, as well as its performance requirements, shall be described from the customer view to communicate the purpose and intended use of the part. This description shall include a listing of part functions and functional requirements, identification of the intended working environment and related environmental parameters, definition of specific performance requirements for each part function, and (if applicable) identification of the performance test methods to be used to evaluate the conformance of the part to the performance requirements. The high-level purpose for the part (e.g. prototype vs. pre-production sample vs. end-use part) may dictate different levels of detail needed to specify the functional and performance requirements of the part, and the level of detail shall be agreed upon between the part provider and the customer to ensure sufficient communication.

4.4.4 Inspection

Test methods and inspection criteria to measure, evaluate, or visually inspect part characteristics shall meet applicable standards and shall be agreed upon between the part provider and the customer. Requirements for specific inspection methods, such as computed tomography (CT) scanning, laser

surface scanning, touch probe measurement, or surface profile measurement, and the corresponding acceptance criteria shall be identified. Any test methods that require building of a separate test artefact for quality control shall define the size, number, orientation, and location(s) of the test artefact within the part build process.

4.4.5 Post-processing

Post-processing of as-built parts may be necessary to meet customer requirements. Post-processing may include subtractive manufacturing, surface finishing, thermal processing, or other operations. Post-processes shall be performed in accordance with applicable standards or as agreed upon between the part provider and the customer. When post-processing of as-built parts is necessary, the customer may provide a set of samples to the part provider to demonstrate the required post-processing characteristics, or any unacceptable post-processing characteristics. When subsequent processing requires a modification to the digital design file, this modification shall be agreed upon between the part provider and the customer.

4.4.6 Other requirements

By agreement with the part provider, the customer may impose more stringent requirements for part characteristics and post-processing by including these requirements on the purchase order and/or paper drawing/digital file. In the event of requirements that are more stringent than specified in applicable standards, the test methods, inspection criteria, and measurement techniques shall be agreed upon between the part provider and the customer.

4.5 Acceptance

4.5.1 General

The parts as received by the customer shall meet the requirements of the purchase order as described above.

The customer may specify acceptance requirements of purchased AM parts using one or more acceptance stages depending on the type of part and level of manufacturing process development.

The acceptance stages are defined as

- a) acceptance of qualification parts for manufacturing process development,
- b) acceptance of first production part to launch production, and
- c) acceptance of final or reference parts for ongoing process control.

The type of acceptance shall be agreed and shall include either the three stages (a, b, and c), or the last two stages (b and c), or the last stage (c). The agreement shall be specified in the purchase order according to the descriptions in [4.5.2](#) to [4.5.4](#).

If relevant quality assurance standards exist for the target application, their use shall be agreed upon between the part provider and the customer. For example, if a certification agency requires specific quality standards for maintenance, calibration and/or traceability, then these need to be included and planned in advance.

If the parts do not comply with the requirements specified in the purchase order after acceptance testing, the agreements made as described in [4.3.8](#) shall apply.

NOTE In demanding applications, parts definition and acceptance are typically addressed only after the successful completion of the process qualification phase.

4.5.2 Acceptance of qualification parts

According to the testing category selected, qualification parts should be produced in advance of full delivery quantity production.

In this case, the purchase order shall mention the number of qualification parts to be produced (e.g. for geometry qualification or for metallurgy qualification). The verification of the conformance and the acceptability threshold for these parts shall be agreed upon by the customer and the part provider.

Any manufacturing defect on these qualification parts shall be reported to the part provider so that required modifications can be made to the manufacturing process and retesting performed, if necessary.

If the results of the retest conform to the requirements, then the retest values shall become the test values for acceptance.

If any of the results for the retests fail to conform to the requirements, the part shall be rejected.

The manufacturing of the first production part can only be launched if the qualification parts meet the acceptance requirements.

4.5.3 Acceptance of first production part

When agreed upon between the part provider and the customer, a first production part inspection shall be performed on one part for each production run. Multiple copies of the same parts may be built during the first production part run.

The corresponding process parameters used during the first production part run shall be documented.

The first production part inspection shall include verification of the requirements of the engineering drawing/digital file and all test results agreed upon between the customer and the part provider.

The manufacturing of final or reference part can only be launched if the first production part meets the acceptance requirements.

4.5.4 Acceptance of final or reference part

The purchase order shall specify whether the inspection shall be performed on one or more final or reference parts (e.g. on a complete production run, on samples from the production runs, or on reference parts having similar characteristics but different geometry or scale).

If the results of the test specified in the purchase order comply with the acceptance criteria, then the part shall be accepted.

If the results of the tests do not comply with the values defined in the purchase order, additional samples from the same production run shall be subject to additional tests for acceptance.

Any part that does not comply with the requirements but meets the rework conditions stipulated in the purchase order may be repaired or accepted.

Any remaining non-conformance with the requirements of the purchase order, whether rework is performed or not, shall be reviewed by the customer to determine if a specific deviation from the requirements can be accepted. If not, the parts shall be rejected.

4.5.5 Documentation of acceptance

The inspection documents to be provided shall address all sections from the purchase order and shall specify the values obtained for each part characteristic corresponding to the purchase order requirements.

All test results, including the original results and any retest results, shall be reported and shall reference the part ordering information.

Acceptance documentation shall include the following:

- a) person who performed the inspection (part provider or third party);
- b) acceptance site, if different from the part provider's premises, and if applicable, organization which performed the tests;
- c) inspection plan;
- d) machine type, model, software version and, if necessary, serial number;
- e) inspection report based on a pre-shipment inspection;
- f) acceptance results.

The acceptance results shall constitute either the authorization of shipment and delivery of the parts, or the rejection.

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