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Additive manufacturing of metals - Feedstock materials - Powder life cycle management (ISO/ASTM DIS 52928:2022)

Additive Fertigung von Metallen - Ausgangsmaterialien - Steuerung des Lebenszyklus von Pulvern (ISO/ASTM DIS 52928:2022)

Fabrication additive de métaux - Matières premières - Gestion du cycle de vie de la poudre (ISO/ASTM DIS 52928:2022)

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Additive manufacturing of metal — Feedstock materials — Powder life cycle management

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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.

Introduction

Metal powders represent the feedstock for numerous additive manufacturing processes. Specifications and quality of metal powder feedstock are directly related to the quality and performance of components fabricated by additive manufacturing (AM).

During their usage in additive manufacturing processes as well as during storage and handling, powders can be subject to various quality-relevant influencing factors.

These may include:

— cross-contamination and impurities;

— changes in particle size distribution;

— reactions with ambient gases;

— changes in moisture content of powder;

— changes in flow properties;

— changes of particle morphology;

— absorption of welding fumes and spatters;

— changes in chemical composition due to selective evaporation of individual alloying elements.

Quality assurance of the powder materials over the entire service life from receiving, over storage and handling to reuse and disposal is therefore decisive for qualified additive manufacturing processes in any relevant industry.

This standard aims to raise awareness of powder quality issues and to describe measures and procedures for quality assurance, batch identification and traceability of powder materials. The proposed measures are derived from best practices in the processing industry with a main emphasis on how frequently and at which stages of the process chain to document certain properties.

Additive manufacturing of metal — Feedstock materials — Powder life cycle management

1 Scope

This document specifies requirements and describes aspects for the lifecycle management of metal feedstock materials for powder based additive manufacturing processes. Those aspects include:

— Powder properties;

— Powder lifecycle;

— Test methods;

— Powder quality assurance.

NOTE This document can be used by manufacturers of metal powders, purchasers of powder feedstock for additive manufacturing, those responsible for the quality assurance of additively manufactured parts and suppliers of measurement and testing equipment for characterizing metal powders for use in powder-based additive manufacturing processes.

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 3953, *Metallic powders — Determination of tap density*

ISO 9277, *Determination of the specific surface area of solids by gas adsorption — BET method*

ISO 12154, *Determination of density by volumetric displacement — Skeleton density by gas pycnometry*

EN 10204, *Metallic products — Types of inspection documents*

ASTM B 527, *Standard Test Method for Tap Density of Metal Powders and Compounds*

ASTM B 923, *Standard Test Method for Metal Powder Skeletal Density by Helium or Nitrogen Pycnometry*

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
split
action of physically or systematically splitting a batch into one or more smaller volumes of powder

Note 1 to entry: It is possible that such action is taken in order to differentiate between volumes of powder used for individual machines but which originate from a single large batch.

3.2
sub-batch
quantity of powder which has been split from a larger batch

Note 1 to entry: A sub-batch can also designated as a new single batch.

3.3
combine
two or more powder batches of the same nominal specification are brought together in the same container or AM system without blending

EXAMPLE An AM machine feedstock hopper is topped up with powder whilst an existing volume of powder remains in the hopper.

3.4
reuse metric
quantitative measure of the exposure or use of a powder batch in an AM process

Note 1 to entry: This may be expressed iteratively, for example a number of builds or exposures, or with a continuous scale such as total laser exposure time (laser-on time) or total incident energy.

4 Symbols and abbreviations

The following symbols are used throughout this standard:

Symbol	Designation	Unit
D_{v10}	10 % quantile of particle size based on the sample volume	µm
D_{v50}	50 % quantile of particle size based on the sample volume	µm
D_{v90}	90 % quantile of particle size based on the sample volume	µm
H_R	Hausner ratio	—
V_∞	bulk volume	ml
V_0	tapped volume	ml
ρ_∞	bulk density	g/ml
ρ_0	tapped density	g/ml

5 Powder properties

5.1 General

Powder properties are critical to the manufacturing process and the quality of the formed material in the final product. To help with the repeatability of the process and the quality and consistency of the products produced, certain powder properties require measurement and monitoring on receipt and re-use of the feedstock.

The following sub-clauses provide further information on these properties and the effects they have on the AM process and final product. Measurement techniques for each property are provided in each sub-clause.

For all parameters discussed in the following sub-clauses, properties shall be determined by examining a representative sample of the powder, ensuring homogeneity when split. Refer to 7.2 for detailed information on sampling methods.

Procedures should be included for equipment cleanliness prior to sampling to prevent cross contamination of powder.

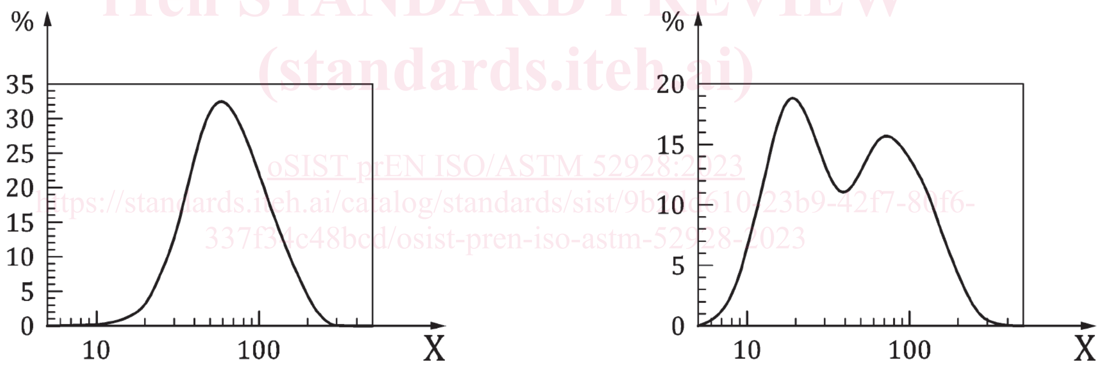
5.2 Particle size distribution

5.2.1 General

The particle size distribution of a powder is a set of characteristic values or a mathematical function that describes the relative amount of particles (typically by mass or number) of a certain size class or category.

During processing in additive manufacturing machines, the particle size distribution typically shifts to higher (coarser) values as small particles tend to be carried away by the inert gas flow and collected in ultra-fine filters, particles melt together to form larger particles, and reactions with ambient gases lead to surface layers on the particles, which increases their volume and mass.

The processing behaviour (e.g. flowability, packing behaviour) of a certain powder is influenced by the width, the median and the lower and upper limits of the particle size distribution. Engineered powder lots can contain bi-modal or multi-modal distributions (see Figure 1) with significant changes based on deviations from as-designed particle size distributions.



a) bi-modal **b) multi-modal**

Key

x particle size / µm

Figure 1 — Particle size distribution charts

Particle size distribution has a direct effect on the processability of the powder. A shift in distribution which increases the proportion of fine or coarse particles has an impact on the flow characteristics and coating capacity of powder in the beam melting machine. Particle size distribution also affects the density of the powder bed and thus its energy absorption and distribution behavior.

The following methods may be used to determine the particle size distribution of particles in the metal powder. The latter methods mostly require greater analytical effort.

NOTE The results obtained from the different methods are in general not directly comparable.

5.2.2 Dynamic image analysis

Dynamic image analysis in accordance with ISO 13322-2 is a method of characterizing particles by optically analyzing their shadow projections. By capturing an image of the particle, it is possible to calculate various particle size and shape parameters such as diameter, maximum length, circularity, or minimum width. During analysis, each separate measurement is assigned to a measuring class according to its size. The upper and lower limit of the measuring range are determined by the camera resolution and magnification.

NOTE 1 The results of dynamic image analysis largely depend on the measurement parameters and settings of the evaluation algorithms. Consequently, significantly different results can be obtained from measurement systems made by different manufacturers.

It shall be observed that the results may be presented by volume or number.

NOTE 2 With these types of analytical systems, it is often possible to analyze particle size distribution and particle morphology simultaneously, allowing correlations to be made between morphology and particle size.

5.2.3 Laser diffraction

Laser diffraction in accordance with ISO 13320 or ASTM B 822 calculates the particle size by measuring the light scatter produced (angle, intensity) as a laser beam passes through a dispersed powder sample. With laser diffraction, it shall be observed that the particle size distribution can be reported as volume- or number-based data. This method is used for particle sizes ranging from 0,1 µm to 3 mm and is highly suitable for comparative measurements. With irregularly shaped powder particles, for example, the particle size distribution obtained corresponds to the light scattering behavior of a volume of spherical powder. Consequently, the results can differ from those obtained by dry sieving or sedimentation.

NOTE The results of laser diffraction largely depend on the measurement parameters and settings of the evaluation algorithms. Consequently, significantly different results can be obtained from measurement systems made by different manufacturers.

It shall be observed that the results may be reported by volume or number.

5.2.4 Dry sieving

Dry sieving in accordance with ISO 4497 and ASTM B214 is only suitable for dry powders that contain no binders or auxiliary materials. ISO 4497 does not recommend the use of dry sieving for irregular powder particles or powders in which all or most of the particles have a grain size less than 45 µm.

5.2.5 Light or scanning electron microscopy (SEM) images

This method is already used in industry and research and can be applied synergistically to particle morphology analysis (see 5.7).

NOTE The number of particles captured and subsequently analyzed by image processing software is limited and it is possible that it is not representative of the entire powder sample.

5.3 Chemical composition

5.3.1 General

The chemical composition relates to the relative amount of elements that constitute a powder or bulk material. Values are given either in atomic percent (at%) or weight percent (wt%). Material properties are directly related to the chemical composition.

In manufacturing practice, the chemical composition of metal powder feedstock is subject to variation due to process-related phenomena, such as selective evaporation of individual alloying elements, reactions with ambient gases (e.g. oxygen, nitrogen) and/or absorption of welding fumes and spatters (see Figure 2).

