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Standard Guide for Additive Manufacturing of Metals – Powder Bed Fusion – Guidelines for Feedstock Re-use and Sampling Strategies[1]

This standard is issued under the fixed designation F3592; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide:

1.1.1 Defines key powder re-use variables and factors affecting powder re-use strategies.

1.1.2 Outlines implications associated with implementation of powder re-use strategies based on selection of powder re-use variables and factors.

1.1.3 Provides guidance to AM users in selection of factors in powder re-use variables depending on considered material type, AM process type and end-use application.

1.1.4 Provides guidance on key process variables affecting powder properties, and considerations to mitigate their effects.

1.1.5 Identifies key powder properties that may be affected by powder re-use and provides AM users guidance on control measures that can be exploited to ensure quality of re-used powder.

1.1.6 Provides recommendations and guidance on factors to consider when implementing powder re-use strategies.

1.1.7 Provides information on how to design a powder re-use study to validate the selected re-use variables.

1.1.8 Summarizes sampling techniques and provides recommendations to AM users on sampling technique selection, and suitability of sampling techniques for powder re-use strategies.

1.1.9 Provides factors to consider when designing a powder sampling study to validate the selected sampling technique.

1.2 *Units*—The values stated in SI units are to be regarded as the standard units. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

F2924 Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with Powder Bed Fusion

F3001 Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) with Powder Bed Fusion

F3055 Specification for Additive Manufacturing Nickel Alloy (UNS N07718) with Powder Bed Fusion

F3184 Specification for Additive Manufacturing Stainless Steel Alloy (UNS S31603) with Powder Bed Fusion

F3318 for Additive Manufacturing – Finished Part Properties – Specification for AlSi10Mg with Powder Bed Fusion – Laser Beam

F3456 Guide for Powder Reuse Schema in Powder Bed Fusion Processes for Medical Applications for Additive Manufacturing Feedstock Materials

2.2 *ISO/ASTM Standards:*[2]

ISO/ASTM FDIS 52900 Additive manufacturing — General principles — Fundamentals and vocabulary

ISO/ASTM PWI 52928 Additive manufacturing of metals — Feedstock materials — Powder life cycle management

ISO/ASTM 52907 Additive manufacturing — Feedstock materials — Methods to characterize metal powders

3. Terminology

3.1 Powder metallurgy terms can be found in Terminology B243 and AM processes and terms can be found in ISO/ASTM 52900. Terms used frequently in this document are given below.

3.2 *Definitions:*

[1] This guide is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.05 on Materials and Processes.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

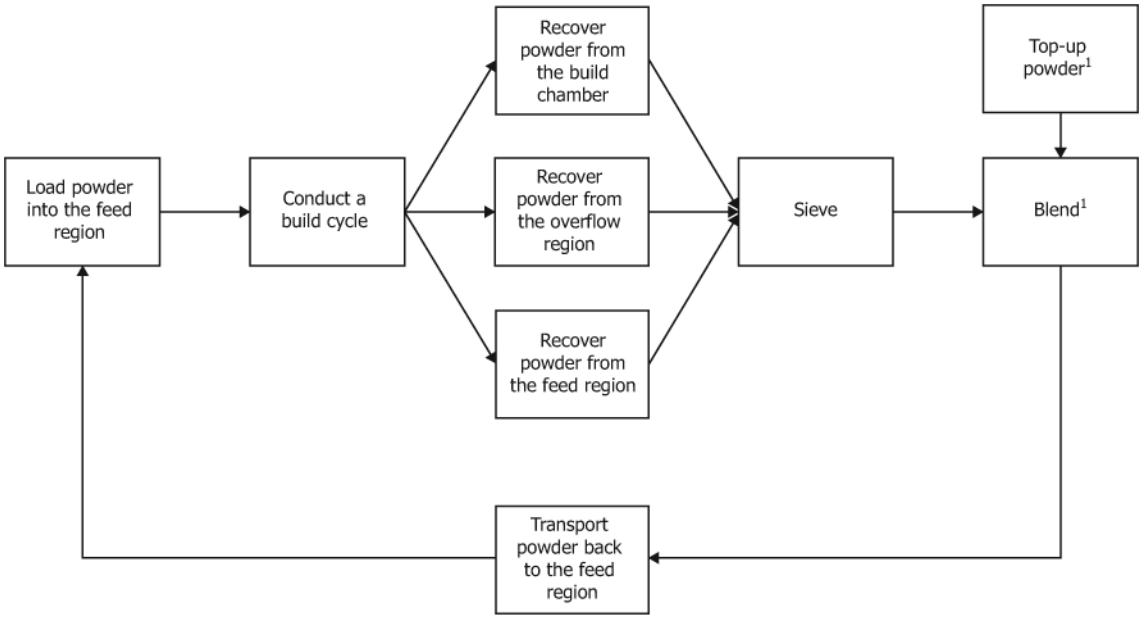

FIG. 1 Flow Diagram of Generalized Powder Handling Processes in PBF-LB

3.2.1 *batch, n*—description can be found in ISO/ASTM 52900.

3.2.2 *heat affected zone (HAZ), n*—unmelted powder affected by heating due to the proximity of the powder to melted powder.

3.2.3 *lot, n*—description can be found in ISO/ASTM 52900.

3.2.4 *powder re-use, n*—the process of returning used and virgin powder that is within specification, to be re-used in the PBF build process.

3.2.5 *refreshed powder batch, n*—description can be found in Guide F3456.

3.2.6 *used powder, n*—definition can be found in ISO/ASTM 52900.

3.2.7 *virgin powder, n*—same definition as 'virgin' feedstock found in ISO/ASTM 52900.

4. Significance and Use

4.1 The overall aim of this guide is to support AM users with the selection of the optimum re-use strategy for their AM process and end-use application, and provide guidance on how to implement re-use strategies in their organization.

4.2 This guide suggests possible control measures that AM users can use to maintain powder quality, and factors to consider when validating selected re-use strategies, including guidance on sampling techniques.

4.3 This guide is intended for metal powders used in Powder Bed Fusion processes.

5. Background

5.1 A relatively small fraction of powder feedstock used in Powder Bed Fusion (PBF) Additive Manufacturing (AM) machines is turned into the final part. In the majority of cases, the virgin powder remains within specification and can be re-used in the PBF process. Furthermore, the business case for PBF manufacturing will typically require the remaining powder to be re-used. Powder re-use strategies have been developed to account for factors such as the type of feedstock material, the design of the PBF machine and most importantly, the criticality of the end-use application. This guide aims to define common powder re-use variables upon which the powder re-use strategy is based, that can be commonly applied in PBF for metal powders.

5.2 Powder Bed Fusion (PBF) is one of seven AM process categories defined by ASTM/ISO 52900 and the process where powder re-use is most critical. Metal PBF processes use an energy source, either a laser beam or an electron beam, to melt metal particles together. The two main metal-based PBF processes: laser PBF (PBF-LB/M) and electron beam PBF (PBF-EB/M).[3] The generalized powder handling operations that occur during the PBF-LB and PBF-EB process chains are shown in Fig. 1 and Fig. 2, respectively. The main difference between the two process flow diagrams is the addition of the powder recovery step in the PBF-EB process chain, which is a designed to break-up the semi-sintered powder bed.

5.3 The powder handling operations shown in the figures above may not be required for all AM platforms, and partly depend on the implemented powder re-use strategy. The typical stages of powder re-use in PBF include the following stages.[3]

5.3.1 *Loading Powder into the Feed Region*—Regardless of machine platform, loading powder into the PBF machine requires some form of decanting, whether this is decanting into

[3] MTC. Metal Powder Bed Fusion Processes – Overview. Additive Manufacturing Knowledge Hub. [Online] 2021. http://knowledgehub.the-mtc.org/documents/#/folder/66.