



AEROSPACE RECOMMENDED PRACTICE

ARP7064™

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Machine Requalification Considerations for Fusion-Based Metal Additive Manufacturing

RATIONALE

Metal additive manufacturing (AM) machine qualification requirements are process intensive. This document is intended to provide general guidance to supplement AMS7032 in reference to “High Impact” and “Low Impact” changes to an AM machine.

1. SCOPE

This document defines a recommended practice for addressing metal additive manufacturing (AM) machine requalification for all fusion-based metal AM machines. In general, this applies to powder bed fusion (PBF) and wire- or powder-fed directed energy deposition (DED) technologies. Plasma, electron beam, or lasers are applicable energy source(s).

1.1 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this standard may involve the use of hazardous materials, this standard does not address the hazards which may be involved in such use. It is the responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved, while ensuring any hazardous waste generated is handled and disposed of in accordance with local regulatory requirements.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS7003 Laser Powder Bed Fusion Process

AMS7007 Electron Beam Powder Bed Fusion Process

AMS7027 Electron Beam Directed Energy Deposition-Wire Additive Manufacturing Process (EB-DED-Wire)

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Documents

Standard, visit Sharing Hub

AMS7032 Machine Qualification for Fusion-Based Metal Additive Manufacturing

AS7766 Terms Used in Aerospace Metals Specifications

2.1.2 ISO/ASTM Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH 1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO/ASTM 52900 Standard Terminology for Additive Manufacturing – General Principles – Terminology

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report. This is not intended to be an all-inclusive list of publications that may be informative.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP5580 Recommended Failure Modes and Effects Analysis (FMEA) Practices for Non-Automobile Applications

AS13004 Process Failure Modes and Effects Analysis (PFMEA) and Control Plans

2.2.2 AIAG Publications

Available from Automotive Industry Action Group, 4400 Town Center, Southfield, MI 48075-1104, Tel: 248-799-7995, www.aiag.org.

AIAG MFMEA-2:2012 FMEA for Tooling & Equipment (Machinery FMEA)

2.3 Definitions

Unless otherwise specified herein, terms used in this document are clarified in AS7766 or are aligned with ISO/ASTM 52900.

AM MACHINE ARCHITECTURE: See *machine configuration* – the high-level design of an AM machine that determines the functionality of the machine (i.e., two versus four lasers, contact versus non-contact powder spreading, etc.), or the aspects of the machine that are (generally) fixed/unchangeable at purchase.

AM MACHINE CONFIGURATION: See *machine architecture* – the serialized parts that make up the AM machine (the parts that would be listed on a bill of materials) and may be swapped out of the machine.

AM PART PRODUCER: The organization responsible for the process engineering and for performing the additive manufacturing process to produce parts.

COGNIZANT ENGINEERING ORGANIZATION (CEO): In this case, refers to the organization that is procuring AM parts.

KEY PROCESS VARIABLE (KPV): Aspects of the manufacturing process that may impact the capability to meet the specified requirements. These include physical, chemical, metallurgical, mechanical property, or dimensional requirements.

MACHINE QUALIFICATION: Initial establishment that a serialized machine meets all of the performance requirements and that all of the documentation for operational qualification (OQ) is in place.

MACHINE REQUALIFICATION: Re-establishing that a serialized machine meets all of the performance requirements for OQ, either due to elapsing a periodic requirement or due to a change or event that occurred to or around the machine.

OPERATIONAL QUALIFICATION (OQ): Establishing sufficient process control to maintain stable material performance and demonstrating that the material specification requirements can be met; this is also tied to a specific machine serial number.

3. INTRODUCTION

When embarking on a machine qualification per AMS7032, preliminary considerations and planning for machine requalification should occur during the initial stages of OQ while preparing the Process Control Documents (PCDs) for machine qualification. The intent of machine requalification is to return an AM machine to its previously qualified state where OQ requirements are again met.

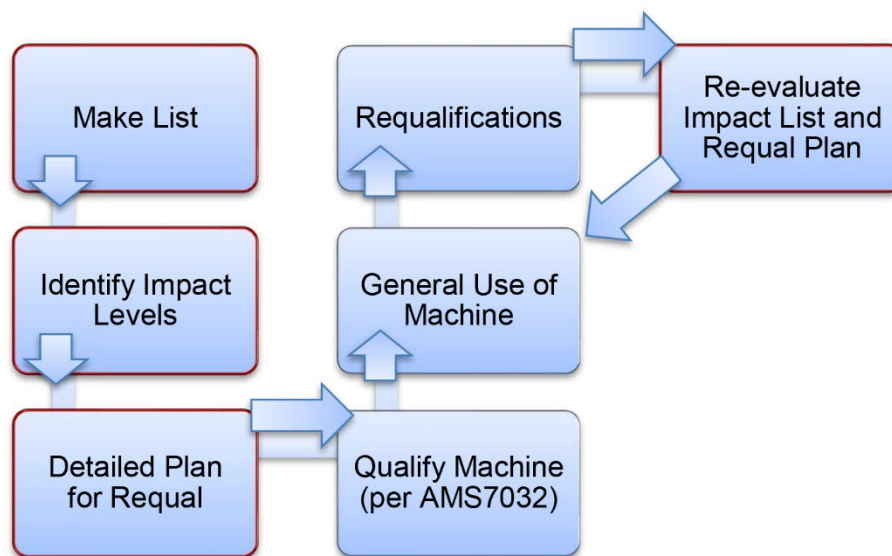
Who should be involved in developing the plan for machine requalification? The cognizant engineering organization (CEO) should, at a minimum, approve the plan. The AM Part Producer should involve their machine operators and/or subject-matter-experts (SMEs) for the specific machine, their quality organization, their maintenance organization, and their engineering organization in developing and approving the plan.

What should the planning entail? The result of planning for machine requalification should include a list of machine events/changes and their associated High, Low, or No Impact (per AMS7032) when examined in the context of a related AM process (e.g., AMS7003, AMS7007, AMS7027) and PCD, a description of what requalification testing will be done when each of these impact levels is triggered, and a detailed plan for how to evaluate unaccounted-for events or changes that may come up in the future. The scope of requalification testing should be appropriately tailored for both the kind and severity of the impact/change to avoid unnecessary burden on the AM Parts Producer by avoiding unrelated corrective actions or testing to substantiate return to a qualified state. It is important to keep in mind that the material test coupons typically used in a qualification build will only characterize the bulk material, not key characteristics such as surface finish, thin organic features, etc. Considerations should also be made for wear items – how the wear can affect part quality, and the wear limits will inform the necessary tailoring for these items.

It should be noted that this document is only intended to serve as guidance for the process; two different AM Part Producers could come up with requalification plans that look significantly different.

4. GENERAL GUIDANCE

It is important to develop a comprehensive list (or as inclusive as possible) of any machine changes or events that could occur during the machine's lifetime. It is also important to identify the impact level for each item in the list and its potential consequence to either part or process. General guidance for both of these aspects of the list is discussed here. It is recommended that this list be revisited periodically to re-evaluate the changes/events and their related impact level, as new experience and/or insight may have been gained since the previous iteration.



**Red outline indicates items that are part of this ARP*

Figure 1 - General process for machine qualification and requalification