



AEROSPACE MATERIAL SPECIFICATION

AMS7100™

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Fused Filament Fabrication, Process Specification for

RATIONALE

This document defines the generic technical requirements, quality assurance provisions, and documentation needed for fused filament fabrication to produce parts capable of service in aerospace. Specifically, this standard will cover environmental controls, equipment configuration, software parameters, material controls, calibrations, and testing methodology. It will define and discuss critical requirements, which have substantial effects on the print quality and final print part properties. No such document currently exists, and such a document is needed to maintain high quality fused filament fabrication produced parts.

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1. SCOPE

This specification establishes the requirements for the production of reliable, repeatable, reproducible aerospace parts by fused filament fabrication but is not limited to such application. This specification establishes the requirements to approve new machines, processes, and materials. Specifically, this specification covers machine configuration, operating software, machine calibration, machine and build parameters, and testing methodology required to create aerospace parts. This specification also defines the user's responsibility for following the specified requirements.

1.1 Specification Structure and Order of Precedence

This specification contains generic requirements that apply to every fused filament fabrication system (machine/software/material combination). The slash sheets shall contain additional or superseding properties and requirements that apply to a specific fused filament fabrication system. This specification is in addition to and in no way limits, supersedes, or abrogates any contractual obligation as required by the applicable procurement documents. In the event of conflict in requirements, the order of precedence shall be:

- specifications referenced on the drawing,
- slash sheet associated with this specification,
- this specification, and
- all specifications referenced in this document.

1.2 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole 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.

1.3 Classification

The fused filament fabrication system is the combination of equipment, software, and material that is configured, calibrated, and maintained as outlined in accordance with this specification.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

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.

AMS7101 Material for Fused Filament Fabrication

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ISO/ASTM 52921 Standard Terminology for Additive Manufacturing-Coordinate Systems and Test Methodologies

2.3 Definitions and Acronyms

ADDITIVE MANUFACTURING (AM): Process of joining materials to make parts from 3D model data, usually layer upon layer.

BEAD: A single line of extruded material from a liquefier tip.

BREAKAWAY: A type of support material (indirect material) that represents the method of physical removal from the final part.

BUILD CYCLE: The single process cycle in which one or more parts are built by successive joining of material within the machine.

BUILD ENVELOPE: The volume within the fused filament fabrication system that can be utilized to produce a part or sets of parts.

BUILD SHEET: An expendable sheet or tray which is placed on and adhered to the machine platen, forming the surface on which the part is manufactured.

BUILD STYLE: Preset building parameters used to create parts within the pre-processing software.

CONTAINER: Packaging used to house filament that often aids in maintaining moisture and mitigating contamination. The packaging can include canisters and spools.

CONTOUR: The exterior bead, setting the perimeter of a given layer.

DIRECT MATERIAL: Material which forms a portion of the finished part.

DOUBLE DENSE RASTER: A type of Fill Pattern that has overlapping, 90 degree intersections of sparse layers.

FEEDSTOCK: Bulk raw material supplied to the additive manufacturing process.

FILAMENT: Feedstock characterized by extreme length relative to its uniform cross section.

FILL PATTERN: Preset methods of different ways or lattice structures used to complete the interior of a part.

FUSED FILAMENT FABRICATION (FFF): A type of extrusion based additive manufacturing technology that enables the construction of three-dimensional objects, prototypes and products through a computer-aided process.

INDIRECT MATERIAL: Material utilized in the production of a part which does not form any portion of the finished part.

LINKED CONTOUR: Two adjacent contours are joined as one continuous toolpath.

LOT: Quantity of parts produced under traceable controlled conditions from a single build cycle and a single lot of feedstock.

MACHINE: The computer guided apparatus that is used to create the extruded 3D part.

MACHINE CONTROLLING SOFTWARE: Software that controls motion and extrusion during the fused filament fabrication process workflow, manipulation of location, orientation, and enables machine scheduling.

MANUFACTURER: The organization who designed/built the fused filament fabrication system.

MATERIAL: The initial filament that is fed into the fused filament fabrication machine to be extruded.

MATERIAL SUPPLIER: The organization that manufactures the filament material.

MATERIAL EXTRUSION: An additive manufacturing process in which material is selectively dispensed through a nozzle or orifice. Common varieties include heated thermoplastic extrusion such as Fused Filament Fabrication.

PART: A physical extruded 3D object created through the fused filament fabrication system including but not limited to production articles, coupons, and specimens.

PRE-PROCESSING SOFTWARE: Software that converts part models from CAD or .STL files into machine processable files.

RASTER: The internal bead, used by the fill pattern between the perimeters created by a contour. Otherwise known as the hatch pattern.

SEAM: The start and stop location of a contour for each part layer.

SOFTWARE: The combination of pre-processing software and machine controlling software which is necessary to guide the fused filament fabrication machine.

SOLID FILL MODE: The manufacturer's approved software mode that will fill a single contour bead around the outside with rasters in a repeating, alternating pattern to fill as much space as possible.

SPARSE FILL MODE: Sparse fill is designed to expand the gap between rasters within the confines of the part to reduce the amount of material used. Raster width for sparse fill mode can be controlled exactly like in solid mode but the gap between rasters is controlled with the variable cell size.

SUPPORT: Structure separate from the part geometry that is created to provide a base and anchor for the part during the building process.

SUPPORT STYLE: Preset building parameters used to create parts within the manufacturer's approved pre-processing software.

SYSTEM: Refers to the combination of equipment, material, and software used to create the fused filament fabrication parts.

TOOLPATH: A plan of predetermined coordinates used to drive motion and control material deposition.

USER: The person or organization that is creating parts using the fused filament fabrication system.

3. TECHNICAL REQUIREMENTS

3.1 Process Control Document (PCD)

The user shall maintain a PCD documenting the means and methods of compliance with this specification and the appropriate slash sheet. The PCD shall be substantiated with respect to the specified requirements and shall be approved by the cognizant engineering organization. Once established, the PCD shall be under configuration control.

3.2 Facility

3.2.1 Fabrication Facility Conditions

The system shall be used indoors only and shall follow the requirements defined in the slash sheet for operating temperature and humidity. Facilities shall be monitored according to the user's quality management system.

3.2.2 Fabrication Facility Electrical

Unless deviation can be shown to have no detrimental effect, facility power shall meet the power quality and nominal voltage requirements defined in the slash sheet.