



Designation: F3572 – 22

# Standard Practice for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation<sup>1</sup>

This standard is issued under the fixed designation F3572; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

The use of additive manufacturing (AM) technology allows designs that may not be achieved with traditional manufacturing methods. It is important to understand the risk associated with the AM usage by understanding the consequence of failure (including the loss of intended function) of the usage. Such information can be beneficial in establishing consistent manufacturing, inspection, or qualification processes relative to a defined risk scale, which can serve as supporting data when seeking regulatory approval of an AM part. A part classification scheme based on a part's consequence of failure can provide a consistent risk metric. Without carefully defined part classes, the ability to accurately gauge the consequence of failure associated with additively manufactured aviation parts within and across programs, projects, and suppliers becomes exceedingly difficult, resulting in mitigations that are either not commensurate or inconsistent. The part classification scheme documented here does not affect a part's functional requirements, but rather is used to group additive manufacturing aviation parts into categories which can be used in downstream standards. For example, this classification scheme can be used in material and process specifications to determine the appropriate levels of process control, thermal post processing, qualification, and inspection to ensure AM parts meet their application requirements. This classification scheme does not specify how the classification is used in any downstream processes. The use of the classification shall be left to the cognizant engineering or production entities, or downstream documents which reference this standard.

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### 1. Scope

1.1 This practice is intended to be used to assign part classifications across the aviation industries that use AM to produce parts.

1.2 This practice is applicable to all AM technologies defined in ISO/ASTM 52900 used in aviation.

1.3 This practice is intended to be used to establish a metric for AM parts in downstream documents.

1.4 This practice is not intended to establish criteria for any downstream processes, but rather to establish a metric that these processes can use.

1.5 The part classification metric could be utilized by the engineering, procurement, non-destructive inspection, testing, qualification, or certification processes used for AM aviation parts.

1.6 The classification scheme in this practice establishes a consistent methodology to define and communicate the consequence of failure associated with AM aviation parts.

1.7 This practice is not intended to supersede the requirements and definitions of the applicable regulations or policies, including but not limited to the ones listed in Annex A1.

1.8 Tables A1.1-A1.3 align the existing regulations and guidance with the four part classes established herein. However, this alignment should not be construed as an alignment of the existing regulations to each other.

1.9 The material or process, or both, in general does not affect the consequence of failure of a part, therefore the classification scheme defined in this document may be used outside AM.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.07 on Applications.

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**TABLE 1 Part Classifications**

| Classification | Consequence of Failure  | Non-exhaustive Examples  |
|----------------|-------------------------|--|
| A              | High                    | Part whose failure can directly affect continued safe flight and landing<br>Part whose failure can result in serious or fatal injury to passengers or cabin crews<br>Part whose failure requires exceptional piloting skill of flight crew to compensate   |
| B              | Medium                  | Part whose failure can indirectly affect continued safe flight and landing<br>Part whose failure can result in minor injury to flight crew, passengers, or cabin crews<br>Part whose failure can result in significant increase in workload of flight crew   |
| C              | Low                     | Part whose failure has no effect on continued safe flight and landing<br>Part whose failure has no effect on flight crew, passengers, or cabin crew<br>Part whose failure can result in slight reduction in operational/functional capabilities<br>Part whose failure can result in slight increase in workload of flight crew |
| D              | Negligible or No Effect | Part whose failure would pose no risk of damage to other equipment or injury to the ground personnel<br>Parts not affecting operational/functional capabilities  |

1.10 The user of this standard should not assume regulators' endorsement of this standard as accepted mean of compliance.

1.11 *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.*

1.12 *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 *ISO/ASTM Standards:*<sup>2</sup>

**52900 Additive Manufacturing – General principles – Fundamentals and vocabulary**

2.2 *United States Department of Defense Standards:*<sup>3</sup>

**MIL-STD-882 Standard Practice System Safety**  
**MIL-STD-1530 Aircraft Structural Integrity Program (ASIP)**

**MIL-STD-1798 Mechanical Equipment and Subsystems Integrity Program**

2.3 *NASA Standard:*<sup>4</sup>

**NASA-STD-6030 Additive Manufacturing Requirements for Spaceflight Systems**

2.4 *AWS Standard:*<sup>5</sup>

**AWS D20 Specification for Fabrication of Metal Components using Additive Manufacturing**

2.5 *AMS Standard:*<sup>6</sup>

**AMS2175 Castings, Classification and Inspection of**

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

<sup>3</sup> Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

<sup>4</sup> Available Online: <https://standards.nasa.gov/standard/nasa/nasa-std-6030>.

<sup>5</sup> Available from American Welding Society (AWS), 8669 NW 36 St., #130, Miami, FL 33166-6672, <http://www.aws.org>.

<sup>6</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

2.6 *FAA Regulations and Guidance Materials:*

**AC43-18 Fabrication of Aircraft Parts by Maintenance Personnel**<sup>7</sup>

**AC25.571 Damage Tolerance and Fatigue Evaluation of Structure**<sup>7</sup>

**AC25.1309 System Design and Analysis**<sup>7</sup>

**AC33.70-1 Guidance Material for Aircraft Engine Life-Limited Parts Requirements**<sup>7</sup>

**AC33-8 Guidance for Parts Manufacturer Approval of Turbine Engine and Auxiliary Power Unit Parts under Test and Computation**<sup>7</sup>

**14CFR27.602 Critical Part**<sup>8</sup>

**14CFR33.75 Safety Analysis**<sup>8</sup>

## 3. Terminology

3.1 *Definitions of Terms:*

3.1.1 Terminology in ISO/ASTM 52900 shall apply.

## 4. Part Classification Designations

4.1 *Classifications:*

4.1.1 All aviation parts produced using AM shall be classified in accordance with the four part classifications defined in **Table 1** and following the information found in **Annex A1**.

4.2 *Applicability:*

4.2.1 The cognizant engineering or production entity shall determine the part classification considering the consequence of the failure of the part and the functional or systems requirements. The applicant for a design or production approval must seek individual guidance from their respective regulatory body concerning the use of this specification as part of a design or production approval.

4.3 *Alignment with Regulations and Policies:*

4.3.1 In order to evaluate if the part classification scheme is practical, the scheme was compared with the regulations and the guidance materials which are currently used in the aviation industry. Reference documents from both military (**Table A1.1**)

<sup>7</sup> Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, [https://www.faa.gov/regulations\\_policies/advisory\\_circulars/](https://www.faa.gov/regulations_policies/advisory_circulars/).

<sup>8</sup> Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, [https://www.faa.gov/regulations\\_policies/faa-regulations](https://www.faa.gov/regulations_policies/faa-regulations)

and civilian (Table A1.2) domains covering both structural and non-structural aspects were reviewed. Other documents specific to spaceflight and broader non-aviation applications were also reviewed (Table A1.3) as reference. The four-classification

scheme works well with existing aviation regulatory documents. When establishing the specific methods of compliance, the user should refer to the original regulations (such as the ones listed in Annex A1).

## ANNEX

### (Mandatory Information)

#### A1. SUPPORTING DOCUMENTS

A1.1 This annex is included to support the AM part classification designation in Section 4. When establishing the spe-

cific methods of compliance, the user should refer to the original regulations.

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[ASTM F3572-22](https://standards.iteh.ai/catalog/standards/sist/d294294c-b4bd-4a96-8fc5-5bee96e5904f/astm-f3572-22)

<https://standards.iteh.ai/catalog/standards/sist/d294294c-b4bd-4a96-8fc5-5bee96e5904f/astm-f3572-22>

**TABLE A1.1 Alignment with Military Aviation Documents**

| F42 Classification | ARMY Policy 070-062  | MIL-STD-1530 (ASIP)   | NAVAIR Instruction 4790.41  | JAMA (Joint AM Acceptability)   | MIL-STD-1798   | MI-STD-882                                      |
|--------------------|--|---|---|---|--|---|
| Class A            | Category 6<br>Flight Parts/<br>Components that Pose a Safety Impact to Include Critical Safety Items (CSIs)  | Fracture Critical Traceable Part<br>A fracture-critical traceable part is a safety-of-flight structural component that is either single load path or judged to require serialization and traceability.<br>Fracture Critical Part<br>A fracture-critical part is a safety-of-flight structural component that is not single load path nor judged to require serialization and traceability | Class IV<br>Part consequence of failure: High<br>- Critical Safety Items (CSIs)   | Category 3<br>Items that pose a severe risk of damage to other equipment or personnel (for example, CSI)                | Safety Critical Component  | Category 1 (Catastrophic)                       |
| Class B            | Category 5<br>Flight Parts/<br>Components that Pose an Operational Impact but no Safety Impact<br>Category 4<br>Flight Parts/<br>Components with a Readiness Impact, but no Safety or Operational Impact | Durability Critical<br>A non-safety-of-flight structural component that is judged to require additional controls beyond those for normal-control parts.   | Class III<br>Part consequence of failure: Medium<br>- Critical Application Items (CAIs)<br>- Not fatigue critical<br>- Acceptable mission performance impact  | Category 2<br>Items that pose a risk of damage to other equipment or personnel (for example, CAI)                       | Mission Critical Component   | Category 2 (Critical)                           |
| Class C            | Category 3<br>Flight Parts/<br>Components with no Safety, Operation or Readiness Impact  | Normal Controls Part<br>A normal-controls part is a non-safety-of-flight structural component where standard aerospace practices are sufficient in the design, manufacturing, and maintenance of the part to ensure structural integrity.   | Class II<br>Part consequence of failure: Low<br>- No safety consequence<br>- Acceptable mission performance impact<br>- Not fatigue critical<br>- Not a CAI/CSI - Requires a flight clearance<br>- Airworthiness impact | Category 1<br>Items that pose little to no risk of damage to other equipment or personnel (for example, not CSI or CAI) | Durability Critical Component<br>Durability Non-Critical Component | Category 3 (Marginal) & Category 4 (Negligible) |
| Class D            | Category 2<br>Aviation Ground Support Equipment<br>Category 1<br>Fixtures, Jigs, Shop Aids and Tooling   | N/A   | Class I<br>Part consequence of failure: Negligible<br>- Non structural<br>- No airworthiness impact<br>- No risk of damage to other equipment or aircraft<br>- No risk of injury to personnel                           | Category 0<br>Items that pose no risk of damage to other equipment or personnel (for example, not CSI or CAI)           | Other/Expendable Component   | N/A   |

TABLE A1.2 Alignment with Civilian Aviation Documents

|                       |   |  |  |                                    |   |  |
|-----------------------|---|--|--|------------------------------------|---|--|
| F42<br>Classification | AC43-18 Fabrication of Aircraft Parts by Maintenance Personnel  | AC25.571 Damage Tolerance and Fatigue Evaluation of Structure  | AC25.1309 System Design and Analysis   | 14 CFR§27.602/29.602 Critical Part | AC33.70-1 Guidance Material for Aircraft Engine Life-Limited Parts Requirements   | AC33-9 Parts Manufacturer Approval of Turbine Engine and Auxiliary Power Unit Parts under Test and Computation   |
| Class A               | Category 1<br>A fabricated part, the failure of which could prevent continued safe flight and landing; resulting consequences could reduce safety margins, degrade performance, or cause loss of capability to conduct certain flight operations. | Principal Structural Element<br>(AC25.571-1D)<br>An element that contributes significantly to the carrying of flight, ground, or pressurization loads and whose integrity is essential in maintaining the overall structural integrity of the airplane | FHA = Hazardous or Catastrophic<br>Large reduction in functional capabilities or safety margins on airplane.<br>Serious or fatal injury to passengers or cabin crew.<br>Excessive workload of flight crew. | Critical Parts                     | Engine life-limited parts are rotor and major static structural parts whose primary failure is likely to result in a hazardous engine effect. Typically, engine life-limited parts include, but are not limited to disks, spacers, hubs, shafts, high-pressure casings, and non redundant mount components. For the purposes of this section, a hazardous engine effect is any of the conditions listed in § 33.75 of this part.  | Category 1. A product, i.e. engine, or part(s) thereof, whose failure could prevent continued safe flight and landing; resulting consequences could reduce safety margins, degrade performance, or cause loss of capability to conduct certain flight operations<br>A Category 1 part, for the purpose of this AC, meets the definition of a critical part defined in Order 8110.42. |
|                       |   |  |  |                                    | SA = Hazardous<br>Engine Effects:<br>(i) Non-containment of high-energy debris;<br>(ii) Concentration of toxic products in the engine bleed air intended for the cabin sufficient to incapacitate crew or passengers;<br>(iii) Significant thrust in the opposite direction to that commanded by the pilot;<br>(iv) Uncontrolled fire;<br>(v) Failure of the engine mount system leading to inadvertent engine separation;<br>(vi) Release of the propeller by the engine, if applicable; and<br>(vii) Complete inability to shut the engine down |  |