



# AEROSPACE MATERIAL SPECIFICATION

AMS7057™

Issued

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## Cold Spray Additive Manufacturing (CSAM) Process

### RATIONALE

Initial release. This Aerospace Material Specification provides technical requirements and quality assurance provisions and references additional required specifications for precursor materials, process, and all secondary operations for cold spray additive manufacturing (CSAM).

#### 1. SCOPE

##### 1.1 Purpose

This specification establishes process controls for the repeatable implementation of the CSAM process for the manufacturing of metallic and metal-nonmetal blend components.

##### 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 that 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.

#### 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](http://www.sae.org).

AS7766 Terms Used in Aerospace Metals Specifications

AS13100 AESQ Quality Management System Requirements for Aero Engine Design and Production Organizations

RM13006 Process Control Methods

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## 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](http://www.astm.org).

ASTM E3      Standard Guide for Preparation of Metallographic Specimens

ASTM E2281   Process Capability and Performance Measurement

ASTM E2587   Use of Control Charts in Statistical Process Control

## 2.3 ISO 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](http://www.iso.org).

ISO/ASTM 52900   Additive manufacturing

## 2.4 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

### 2.4.1 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](http://www.sae.org).

AMS7002      Process Requirements for Production of Metal Powder Feedstock for Use in Additive Manufacturing of Aerospace Parts

AMS7025      Metal Powder Feedstock Size Classifications

AMS7031      Batch Processing Requirements for the Reuse of Used Powder in Additive Manufacturing of Aerospace Parts

### 2.4.2 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-DTL-32495   Powders for Cold Spray Deposition

MIL-STD-3021   Department of Defense Manufacturing Process Standard: Materials Deposition, Cold Spray

## 2.5 Definitions

Terms used in AMS are defined in AS7766, ISO/ASTM 52900, and as follows:

ACCEPTANCE: The process conducted by the CEO that the deliverable complies with the product specification.

AUTHORIZED BY CEO: Requires prior written approval from the CEO.

BEAD: The material that is deposited by cold spray with a single pass of a powder plume.

BEAD WIDTH: The measurement of the bead width as taken perpendicular to the direction of deposition movement.

BUILD ENVELOPE: Largest external dimensions of the x-, y-, and z-axes within the build space where parts will be fabricated.

CEO: Cognizant engineering organization.

COLD SPRAY (CS): Also known as supersonic particle deposition (SPD), kinetic metallization, and kinetic fusion. No such standard for CSAM currently exists.

CSAM MACHINE: CSAM machine is any fixed configuration of cold spray gas/powder control system in combination with the automation for part and nozzle control.

DATA FILE: Three-dimensional model of designed preform.

DEPOSITION EFFICIENCY (DE): The percentage of feedstock material that is deposited onto the preform during a cold spray operation versus the total amount of feedstock material consumed (the difference being the quantity of powder that is rejected/non-adhered to the preform).

DEPOSITION FILE: The electronic file that is supplied to the CSAM machine for manufacturing one or more parts. This includes but is not limited to part geometry, location, orientation, and process parameters.

FEEDSTOCK: Powder that is sprayed during the CSAM process to become a deposited bead and constitute the deposit.

FLAT/FLATWISE/LINEAR SPRAY: A preform that is produced in a conventional X-Y-Z build wherein the cold spray gun traverses a build bed and deposits material to build up a three-dimensional structure.

INTERRUPTIONS: To break the continuity of the deposition process.

KEY PROCESS VARIABLES: Aspects of the manufacturing process that may impact the capability to meet the specified requirements. These include physical, chemical, metallurgical, mechanical, and dimensional properties (see 3.1.1).

LAYER: The contiguous coating generated by a series of adjacent and generally nested beads.

LAYER THICKNESS (OR HEIGHT): The thickness may be measured and expressed as either maximum or average.

METAL-NONMETAL BLENDS: These blends are a mixture of metals and nonmetals (i.e., ceramics) to enhance the deposition performance for specific build characteristics.

NOZZLE: A key component of the gun system to deliver accelerated particles in a defined spray plume. The nozzle is normally optimized via material selection and internal geometry. Nozzles are normally subject to erosion, which can adversely affect deposition performance and characteristics.

OVER-TRAVEL: The region of deposition beyond the net shape of the part, usually nonfunctional manufacturing excess in regions of spray reversal.

PREFORM: The product that results from the deposition of powder feedstock onto a substrate. Preform can also be known as “near net” and “net shape.” Preform excludes additional potential post-deposition/build processes such as heat treatment, hot isostatic pressing, final machining, etc., that may be required and, as such, are not specifically addressed herein.

POWDER INJECTION POSITION: This defines the position of the powder injection into the gun, which is the device that generates the carrier plume and particle momentum. This position is defined as axial or radial and before, at, or after the nozzle divergent throat.

PROCESS CONTROL DOCUMENT (PCD): A collection of procedures and requirements that are used to document and to control variation of a product.

PRODUCER: The entity using the CSAM process to produce a preform.

PURCHASER: The organization that issues the purchase order to the producer.

STAND-OFF DISTANCE (SOD): The distance between the exit of the cold spray nozzle to the surface of the preform.

**STEP-OVER:** The distance between adjacent passes in a given direction as measured from the centerline of the bead. Often referred to as offset.

**SUBSTRATE:** Alternatively referred to as a mandrel or deposition tool, it represents the base material utilized to initiate the deposition of CSAM material. This material may remain a portion of the preform or may be removed (demolded) following the build process.

## 2.6 Acronyms

|      |                                    |
|------|------------------------------------|
| AM   | additive manufacturing             |
| CAD  | computer-aided design              |
| CEO  | cognizant engineering organization |
| CSAM | cold spray additive manufacturing  |
| DE   | deposition efficiency              |
| OEM  | original equipment manufacturer    |
| PCD  | process control document           |
| PSD  | particle size distribution         |
| SOD  | stand-off distance                 |

## 3. TECHNICAL REQUIREMENTS

### 3.1 Process Control Document (PCD)

The PCD shall be established by the producer, substantiated with respect to the specified requirements, and authorized by the cognizant engineering organization (CEO). Once substantiated, all aspects of the PCD are a fixed process, and any changes to the PCD shall require substantiation prior to the change being implemented into production. Changes to the PCD that can affect a key process variable must be authorized by the CEO. All other changes to the PCD must be acceptable to the CEO. The PCD shall address the following aspects of the CSAM process:

#### 3.1.1 Key Process Variables (KPVs)

- 3.1.1.1 The producer shall establish values, tolerances, and measurement frequency for all KPVs of the CSAM process including, but not limited to, the variables defined in Appendix A. These values, tolerances, and statistical process control (SPC) requirements shall be substantiated by the producer with respect to the specified requirements and be authorized by the CEO. Any change to a KPV shall be substantiated by the producer and authorized by the CEO.
- 3.1.1.2 Process parameters may be omitted from the PCD when substantiated by the producer and authorized by the CEO.
- 3.1.1.3 The values of any KPV considered proprietary by the producer may be assigned a code designation and recorded by the producer in an internal document. Each variation in such value shall be assigned a modified code designation.

#### 3.1.2 Process Interruption

- 3.1.2.1 Process interruptions are permitted when previously substantiated by the producer, incorporated in the KPVs of the PCD, and authorized by the CEO.

3.1.2.2 To substantiate an allowable process interruption, the producer shall provide documentation, demonstrated through testing or other suitable means, that such process interruptions do not affect the quality and performance of the preform. This documentation shall be provided to the purchaser prior to acceptance.

### 3.1.3 Digital File and Software Configuration Control

The producer shall establish a configuration control system to ensure the correct software and files are used in the production of components using CSAM. This system shall include internal procedures to control electronic files, conversion settings, and machine parameters. All files shall be traceable through revision control and have access control.

### 3.1.4 Calibration and Verification Plan

3.1.4.1 Procedures for calibration and verification shall be established and substantiated to measure and adjust, at a minimum, all variables required by the CSAM machine OEM as well as those identified as required in Appendix B. The plan shall include procedures, values, tolerances, and frequency of verification of each variable specific to the application.

3.1.4.2 All procedures performed shall be recorded via manual or electronic means and maintained for a period compliant with requirements of the ordering documents.

3.1.4.3 When authorized by the CEO, calibration and verification variables may be omitted when substantiated to have no impact on the ability of the part produced to meet the specified requirements.

### 3.1.5 Maintenance Plan

3.1.5.1 Procedures for maintenance shall be established and substantiated, including a checklist of activities, instructions to perform each activity, and the frequency by which that activity shall be completed.

3.1.5.2 At a minimum, maintenance plans shall include all activities and instructions that are required by the CSAM machine OEM.

3.1.5.3 Additional maintenance items unique to the installation, facility, or specific application shall also be documented and included in the maintenance plan.

3.1.5.4 The maintenance plan shall include all auxiliary equipment required to meet the specified requirements.

3.1.5.5 All maintenance performed shall be recorded via manual or electronic means and maintained for a period compliant with the requirements of the ordering documents.

### 3.1.6 Substrate and Feedstock Handling and Storage Plan

Procedures for handling and storage of substrate and feedstock materials shall be established, substantiated, and authorized by the CEO to meet the requirements defined by the finished part material. At a minimum, the substrate and feedstock handling plan shall include:

- The procedure to substantiate that the substrate and feedstock used in the CSAM machine complies with the specified requirements, including the inspection procedures.
- Storage conditions for the substrate and feedstock.
- Substrate and feedstock lot traceability and tracking to maintain traceability compliant with the requirements of the CEO.
- Substrate preparation requirements, such as surface condition, roughness, and cleaning requirements.