INCH - POUND

MIL-STD 869D (USAF)
01 March 2007
SUPERSEDING
MIL-STD-869C
20 October 1988

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

FLAME SPRAYING

This document is inactive for new design.

AMSC: N/A

AREA: MFFP

FOREWORD

1. This Military Standard is approved for use by 309MXSG/MXRL, Department of the Air Force, and is available for use by all departments and agencies of the Department of Defense.

2. This standard provides guidance on the process of flame spraying for the Air Force repair, acquisition, and manufacture of parts and/or spare parts on the landing gear of all military aircraft.

3. Beneficial comments, recommendations, additions, deletions, and any pertinent data, which may be of use in improving this document, should be addressed to 309MXSG/MXRL, Hill AFB, UT 84056-2609 or 309MXSG/MXRL@hill.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

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1. SCOPE

1.1 Scope. This standard covers the materials, procedures, and equipment for *flame* spraying of parts.

1.2 Process. Flame spraying is defined as the process of melting materials in a heating zone and propelling them in the molten state onto a part to form a coating. This process can be applied to build up worn areas on parts, for abrasion resistance and/or corrosion protection. It is not intended to rebuild damage by nicks, gouges, etc; without building an entire area.

1.3 Classification.

1.3.1 Types. The four types of flame spraying covered in this standard are as follows:

1.3.1.1 Type I. *Wire System:* Spraying materials in a wire form using oxygen-acetylene/hydrogen/propane, etc.

1.3.1.2 Type II. *Powder:* Thermo process, spraying materials in a powder Oxygen, acetylene or hydrogen.

1.3.1.3 Type III. *Powder:* Plasma process for spraying materials in a powder form utilizing a non-transferable electric arc with nitrogen. Argon and helium as a secondary gas with or without hydrogen.

1.3.1.4 Type IV. *Wire Arc Spraying Process:* Arc spraying system, simultaneously and continuously feeds two metalizing wires at a uniform rate of speed through electrically charged contact blocks.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are referenced throughout this standard. While every effort has been made to ensure the completeness of this list, standard users are cautioned that they must meet all referenced requirements of the documents cited, whether or not they are listed in this section.

2.2 Government Documents.

2.2.1 Government specifications, standards, handbooks, and commercial item descriptions. The following specifications, standards, handbooks, and commercial item descriptions form a part of this document to the extent specified herein. Unless otherwise specified the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE FEDERAL SPECIFICATIONS

BB-A-106	Acetylene, Technical, Dissolved
BB-H-886	Hydrogen
BB-O-925	Oxygen, Technical, Gas and Liquid

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-866 (Inactive)	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 PSI or over.

(Copies of these documents are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094 or http://assist.daps.dla.mil.online/start/.

2.3 Order of Precedence. In event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS: Not applicable.

4. GENERAL REQUIREMENTS

4.1 Materials and Equipment.

4.1.1 Wire/Flame Spray System. The wire system shall include either a compress air powder gun or an electronically controlled gun. Necessary air filtering shall be capable of delivering oil free and moisture free air. Gas and oxygen regulators shall be two stage regulators. Fuel gas flow meters and regulators must be equipped with flash back valves. Air pressure regulators shall be an OSHA approved type. Hoses, wire control and straightening units shall complete the system.

4.1.2 Thermo Spray System – Powder. The powder spray system shall include a spray gun that is capable of delivering flow rate. Regulators shall be of the two stage type. Fuel gas regulators and flow meters must be equipped with flash back valves. Air regulators shall be OSHA approved. Hoses and optional equipment shall complete the system.

4.1.3 Plasma Spray System – Powder. The plasma system shall include a plasma gun capable of operating on nitrogen. Argon or helium is primary gases with or without hydrogen as the secondary gas. The gun may be either a hand held or machine mounted type.

a. The plasma gun shall be capable of spraying coatings of powdered materials that have been heated to a plastic or molten state by a highly ionized gas stream passing through a non-transferable electric arc capable of reaching temperatures of 30,000˚F or higher producing coatings with bond strength of 4.000 to 12,000 psi or higher.

b. The power supply unit shall not be less than 40 (KW) capacities at 100% duty cycle.

c. The power feeder unit shall be capable of supplying a metered and constant flow of powdered material to the gun.

d. Extension equipment capable of spraying at a 90° angle for holes may be incorporated as a component part.

e. Control unit, heat exchanger, approved gauges, flow meters, hoses, power cables, and cooling devices shall complete the system.

4.1.4 Wire/Arc Spray System. The arc spray system shall consist of a gun capable of simultaneously feeding two wires at a controlled rate of speed, and delivering a fine atomized spray on a prepared surface. The gun shall be capable of producing coatings with bond strength of not less than 4,000 psi.

a. The gun shall be hand held or machine mounted and be capable of controlling wire feed rate. The gun shall also be capable of operating solely on compressed air and/or electrical current.

b. The power supply unit shall be capable of delivering amperage and voltage at 100% duty cycle.

c. The control unit shall be compatible with automatic traverse equipment, and include air, amperage and voltage controls and monitors.

d. Wire control units shall include wire straighteners.

e. Hoses, lines and cables will comprise the balance of the system.

4.1.5 Abrasive Blasting Equipment. Abrasive blasting equipment is required to roughen areas to be flame sprayed. Parts should be previously cleaned. Particular care should be taken to keep abrasive grit from contaminating surrounding area. Blasting equipment should be used solely for preparing parts for flame spray. Manufacturer's recommended procedures should be followed.

4.1.6 Flame Spray Wire. Only wires specifically manufactured for flame spray shall be used otherwise specified by the responsible engineering authority. The chemical composition of the material to be used shall be specified in the contract or purchase order for the materials. See manufacturer's handbook and current technical bulletins.

4.1.7 Flame Spray Powders. Powders used for flame spraying shall be designed specifically for flame spraying and the powder supplier shall so specify and certify that:

a. The material has been inspected for size and that the size is in accordance with the size range spelled out in the purchase order.

b. All material meets the chemical composition requirements as specified in the purchase order.

c. The material has been spray tested with oxygen-acetylene. Oxygen-acetylene combustion flame and plasma flame spray equipment, whichever is applicable. Insure that coatings can be produced that are smooth, uniform, and free from cracks and voids with required bond strength.

d. Material meets requirements of engineering and industry standards.

4.1.8 Gases. The following gases shall be used flame spraying:

GAS	SPECIFICATION	TYPE
Oxygen	BB-O-925	Commercial
Acetylene	BB-A-106	Commercial
Propane		Commercial
Hydrogen	BB-H-886	Commercial

4.1.8.1 Gases for plasma flame spraying. Gases for the plasma flame spraying process shall be as follows:

GAS	SPECIFICATIONS
Hydrogen	Pre-Purified 99.5% Max-Oxygen Content 0.05% Max-Dewpoint -76˚F (-60˚C)
Nitrogen	Pre-Purified Max-Oxygen Content 0.002% Max-Dewpoint -76˚F (-60˚C)
Argon	High Purity

4.2 Bond Strength. Flame sprayed coatings have bond strengths ranging from 3.000 to a maximum 12.000 psi. Coatings should only be used where the bond strength of the coating is approved for a specific application by engineering authority.

4.3 Coating Material. The coating material must be specified by the responsible authority. Metallurgical laboratory testing may be required where deemed necessary.

4.4 Spraying Parameters. Air, fuel gas, primary and secondary pressures and flow settings for the spraying of each material shall be in accordance with those recommended by the equipment manufacturer's instructions manuals for each process.

Gun to work distance shall be established from the instruction manuals or bulletins, or by testing and analysis.

4.5 Cooling While Spraying. Part and coating temperatures must be controlled to prevent warpage of the substrate and failure of the coating. The maximum substrate temperature is:

350˚F (176.6˚C) for Steel

225˚F (107.2˚C) for Aluminum

The time at this temperature is not to exceed one (1) hour.

4.6 Selected Areas. If selected areas are to be flame sprayed, the surrounding areas must be masked with available tapes or masking compounds. Keyways and oil holes may be masked with carbon plugs or polished metal inserts or silicone rubber.

4.7 Coating Thickness. Some coatings have thickness limitations. Coating thicknesses shall be specified by applicable documents, if thickness is not specified then the finish machine coating shall not exceed 0.030 inch.

a. A minimum of 0.010 inch over final dimension shall be allowed for grinding. Follow manufacturer's recommendations.

b. For corrosion protection, a minimum coating thickness of 0.003 to 0.005 inch is required.

5. DETAILED REQUIREMENTS

5.1 Procedure.

a. All parts must be machined and cleaned if required prior to flame spray.

b. High tensile steel and high strength aluminum part, which have been pre-machined must be stress relieved by shot peening areas to be flame sprayed.

c. Areas to be flame sprayed, which have been plated shall have these finishes removed from area to be sprayed by either chemical or mechanical means. Blasting is not acceptable method of removal.

5.1.1 Vapor Degreasing. All parts shall be vapor degreased prior to surface preparation unless otherwise specified by engineering.

5.1.2 Masking. Mask all areas not to be abrasive blasted or coated.

5.1.3 Abrasive Blast. Abrasive blast areas, to be coated for the removal of oxidation, follow the manufacturer's recommended procedure and bulletins unless otherwise specified by engineering.

5.1.4 Preheat. Preheat before spraying to remove all moisture and provide expansion. Manufacturer's bulletin should be followed regarding substances and material to be sprayed. Temperature control may be accomplished using temp stick or pyrometers.

5.1.5 Spraying. Spray the area to be coated using the gun to work distance recommended by the equipment manufacturer's for the material being sprayed. The direction of the metal spray should be as close to 90˚F as possible with the surface being coated and never less than 45˚F. The coating shall be allied in multiple passes. Complete area coverage must be made with each pass before the next pass is started. Spraying will continue until the coating thickness plus finishing allowance has been completed.

5.1.6 Remove Masking. Remove masking material.

5.1.7 Sealing Sprayed Coatings. All flame sprayed parts should be sealed unless intended as a bearing surface or as otherwise specified by engineering. Only, quality commercial sealers shall be used. Type of sealer used depends on the type of environment parts will be subjected to.

5.1.8 Finish Machining and Grinding. Remove the overspray and flash spray material build-up to prevent cracks form extending into the main coating immediately after spraying. Finish machine or grind in accordance with MIL-STD-866 and/or updated manufacturer's bulletins to the dimension specified or as shown on the blueprint.

5.2 Quality Control

5.2.1 Workmanship. The sprayed coating shall present a uniform appearance with a fine-to-medium granular finish. Surface defects of the coating shall be limited to nodules not exceed 0.045 inches in diameter and shall not exceed 0.025 inches above the surrounding sprayed surface. The following shall be cause for rejection:

a. Blisters

b. Cracks

c. Chips or loosely adhering particles

d. Oil or other internal contaminations that bleed out through the finished coating.

e. Fits that expose the undercoating or base metal.

f. Chips, cracks or tears of the coating after final machining

5.2.2 Testing. The most reliable test for any *flame-sprayed* coating is satisfactory performance in service and/or simulated service testing. Whenever service testing cannot be performed, the following tests shall be used as a method of controlling the quality of the *flame-spray* coatings.

5.2.2.1 Test for Bond Tensile Strength. From the same material as the production item was made; make the two (2) specimens shown in *Figure 1*. Drill and tap on one (1) end of each specimen approximately 1.2 inches deep and thread 3.8 inches, either 16 to 24 threads per inch. The tapped hole must be centered and parallel with the specimen axis; flat-faced ends must be surface ground perpendicular to the axis. Blast the flat-face and evenly apply 0.010 inch or more of the coating material to one specimen (See *Figure 1*). After surface grinding or handsanding the coated specimen flat within two (2) mils, cement the coated specimen to the plain specimen with epoxy adhesive and oven cure. Assemble the treaded pull rods and pull the specimens apart on an accurate tension tester. The minimum strength standard shall be established by the applicable engineering department for each application.

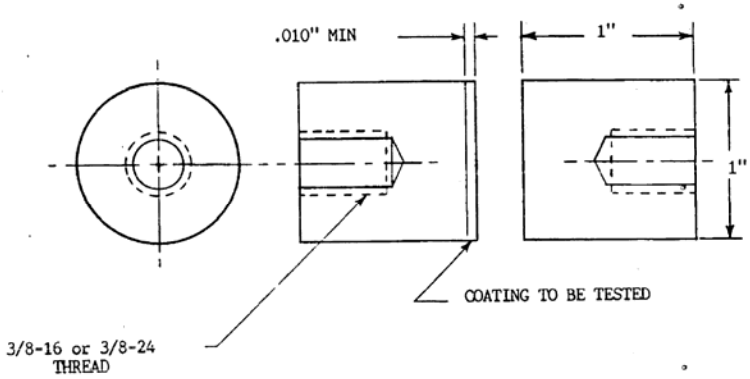

FIGURE 1. TENSILE BOND TEST SPECIMENS

5.2.2.2 Hardness Test. The hardness test is performed on a Rockwell hardness tester using the A, B, or D scales. The prepared test samples (2” x 3” x .005”) must have the following minimum coating thickness:

a. A Scale – 0.030 inch

b. B Scale – 0.050 inch

c. D Scale – 0.045 inch

Coating should have at least 100 micro-inch finishes when using the Rockwell A, B, or D scales. Hardness values of the coating materials shall be specified by applicable engineering department.

5.2.2.3 Metallographic Examination. Representative test panels approximately 3 x 2 x 0.050 inches shall be coated on one side to the same thickness as the production item. Metallographic examination of the coating shall show the constituents to be uniformly distributed and free from cracks, massive porosity, included material and excess oxides. The coating – substrate interface shall also be free from contamination. Frequency of this test shall be determined by the applicable engineering department. Porosity and oxide limits shall also be specified by the applicable engineering department.

5.2.3 Certification of Operators. Each operator must be trained and certified. A hardness test along with a bond strength test is required in accordance with local directives prior to being permitted to spray production parts.

5.2.4 Qualification of Operators. Operators performing work under this standard shall be certified as qualified operators by the Quality Control department. Certification shall be conferred on trained operators, who successfully demonstrate knowledge of the process and their ability to produce satisfactory coatings per this standard.

6. NOTES
(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard provides guidance on the processes and procedures for flame spraying for the verification of the Air Force repair process on the landing gear of all aircraft. It is an Air Force unique manufacturing, repair and re-procurement standard that will be used primarily by the Air Force at Hill AFB.

6.2 Subject term (key word) listing.

Flame Spray
Gases
Procedures
Spray System
Testing
Types

6.3 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

CONCLUDING MATERIAL

Custodian:
Air Force – 70

Preparing Activity:
Air Force – 70

(Project: MFFP-0726-000)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, verification of the currency of the information above using the ASSIST Online database at: http://assist.daps.dla.mil.