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SENSITIVE

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DEPARTMENT OF DEFENSE STANDARD PRACTICE

SELECTIVE, BRUSH PLATING, ELECTRO-DEPOSITION



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MIL-STD-865E
FOREWORD

1. This standard is approved for use by AF70, Hill AFB AFSC OO-ALC 309 CMXG/MXDEC, 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 for the process of electro-deposition (brush plating) for the Air Force repair, acquisition, and manufacture of parts or spare parts on the landing gear of all military aircraft.
3. Comments, suggestions, or questions on this document should be addressed to: OO-ALC AFSC 309 CMXG/MXDEC Maintenance, Hill AFB UT 84056-5228 or email to: 309.CMXG.Workflow@us.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

MIL-STD-865E
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<u>PAGE</u>	<u>MODIFICATIONS</u>
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Page ii Forward	Changed
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Page v – vi Table of contents	Changed

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MIL-STD-865E
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CONTENTS

<u>PARAGRAPH</u>	<u>PAGE</u>
<u>FORWARD</u>	ii
<u>SUMMARY OF CHANGES</u>	iii
<u>CONTENTS</u>	v
1. <u>SCOPE</u>	1
1.1 <u>Scope</u>	1
2. <u>APPLICABLE DOCUMENTS</u>	1
2.1 <u>General</u>	1
2.2 <u>Government Document</u>	1
2.2.1 <u>Specifications, standards, handbooks and commercial item descriptions</u>	1
2.2.2 <u>Other Government Documents, drawings, and publications</u>	1
2.3 <u>Non-Government Documents</u>	1
2.4 <u>Order of Precedence</u>	2
3. <u>DEFINITIONS</u>	2
3.1 <u>High strength steel</u>	2
4. <u>GENERAL REQUIREMENTS</u>	2
4.1 <u>General</u>	2
4.1.1 <u>Selective plating uses</u>	2
4.1.1 <u>Selective plating uses, steps a. through i.</u>	2
4.1.2 <u>Repair areas</u>	2
4.1.3 <u>Cleanliness</u>	2
4.1.4 <u>Scale, oxide, and grease</u>	3
4.1.5 <u>Selective plating characteristics</u>	3
4.1.6 <u>Activating</u>	3
4.1.7 <u>Film removal</u>	3
4.2 <u>Solutions</u>	3
4.2.1 <u>Types of solutions</u>	3
4.2.1.1 <u>Plating on high strength steel</u>	3
4.2.1.1 4.2.1.1.1 through 4.2.1.1.4	3
4.2.1.1 4.2.1.1.5 through 4.2.1.1.6	4
4.2.2 <u>Characteristics of selective plating solutions</u>	4
4.2.2.1 <u>Solution usage</u>	4
4.2.2.2 <u>Immersion deposits and pre-plates</u>	4
4.2.2.3 <u>Chrome plating solution</u>	4
4.2.2.4 <u>Build-up</u>	4
4.2.2.4 <u>Build-up, steps a. through b.</u>	5
4.3 <u>Anodes</u>	5
4.3.1 <u>Anode materials and shapes</u>	5
4.3.1 <u>Anode materials and shapes (a) through (d)</u>	5
4.3.1 <u>Anode materials and shapes, 4.3.1.1 through 4.3.1.4</u>	5
4.3.2 <u>Anode selection</u>	5
4.3.2.1 <u>Anode selection for preparatory steps</u>	5
4.3.2.2 <u>Anodes selection for plating steps</u>	6

MIL-STD-865E
CONTENTS (cont.)

<u>PARAGRAPH</u>		<u>PAGE</u>
4.3.2.2	<u>Anodes selection for plating, steps a. through e</u>	6
4.3.3	<u>Tool coverings</u>	6
4.3.3	<u>Tool coverings a. through d.</u>	6
4.4	<u>Equipment</u>	6
4.4.1	<u>Power unit</u>	6
4.4.1.1	<u>Ammeter</u>	6
4.4.1.2	<u>Voltmeter</u>	7
4.4.1.3	<u>Ampere-hour meter</u>	7
4.4.2	<u>Plating tool handles</u>	7
4.4.3	<u>Dishes, beaker, and flasks</u>	7
4.4.4	<u>Accessory equipment</u>	7
4.4.4.1	<u>Blasting equipment and abrasive</u>	7
4.4.4.2	<u>Motorized turning head</u>	7
4.4.4.3	<u>Rotary power anode</u>	7
4.4.4.4	<u>Additional equipment</u>	7
4.4.4.5	<u>Safety equipment</u>	7
5	<u>DETAILED REQUIREMENTS</u>	
5.1	<u>Calculation of required ampere-hours (amphr)</u>	8
5.2	<u>General plating procedure</u>	8
5.2	<u>General plating procedure, steps a. through e.</u>	8
5.2	<u>General plating procedure, steps f. through i.</u>	9
5.3	<u>Alternate activation method</u>	9
5.4	<u>Plating on dissimilar metals and changing base</u>	9
5.5	<u>Surface preparation</u>	9
5.5.1	<u>Inspection</u>	9
5.5.1	<u>Inspection, steps a. through d.</u>	9
5.5.1	<u>Inspection, step e.</u>	10
6	<u>NOTES</u>	10
6.1	<u>Intended use</u>	10
6.2	<u>Subject term (key word) listing</u>	11
6.3	<u>Changes from previous issue</u>	11
	<u>CONCLUDING MATERIAL</u>	12

1. SCOPE

1.1 Scope. This standard covers the process and materials for selective electro-deposition of various metals and alloys on ferrous alloys, aluminum alloys, copper alloys, nickel alloys and corrosion-resistant steel, etc.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Sections three (3), four (4), and five (5) of this standard, whether or not they are listed.

2.2 Government Documents.

2.2.1 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 SPECIFICATIONS

MIL-DTL-5002

Surface Treatments and Inorganic Coatings
for Metal Surfaces of Weapon Systems

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1504

Abrasive Blasting (Inactive)

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

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications 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.

COMMERCIAL ITEM DESCRIPTIONS

A-A-59460

Plating Units, Selective (Brush), Portable

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

2.3 Non-Government Publications.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) INTERNATIONAL

SAE J442

(R) Test Strip, Holder, and Gage for Shot Peening

SAE J443

(R) Procedures for Using Standard Shot Peening Almen
Test Strip

(Copies of these documents are available from www.sae.org or SAE World Headquarters, 1200 G St. NW, Suite 800, Washington DC 20005)

2.4 Order of Precedence. Unless otherwise noted herein or in the contract, in the 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

3.1 High Strength Steel. For the purpose of this standard, high strength steel is defined as steel heat treated to 180,000 pounds per square inch (psi) and above.

4. GENERAL REQUIREMENTS

4.1 General. The selective plating process (sometimes called “brush” plating) is the method of depositing metal from concentrated electrolyte solutions on selected areas without immersion tanks. In this process, metal is deposited from an electrolyte held in an absorbent material attached to an inert anode. Plating contact is made by brushing or swabbing the part (cathode) to be plated with electrolyte-bearing anode.

4.1.1 Selective plating uses.

- a. To prevent or minimize disassembly costs.
- b. To minimize machining costs (plate to size).
- c. To minimize masking costs.
- d. To develop field reliability.
- e. To plate small areas of extremely large parts.
- f. To supplement conventional plating
- g. To plate high strength steels.
- h. To plate onto difficult to plate metals, i.e., Aluminum, Molybdenum, Titanium, etc., either as a bonding agent or for subsequent finishing.
- i. To restore worn, corroded, or over-machined parts back to size.

4.1.2 Repair areas. The use of this process shall be governed by the expediency and economics of the individual case. The areas to be repaired shall normally be limited to reasonable small areas, but in some cases, it may be practical to plate large areas.

4.1.3 Cleanliness. All solutions shall be clean and free from contamination. Extra care shall be taken to ensure that the solutions are not contaminated by used anodes, other plating solutions, and/or grease and oil from surrounding area.

4.1.4 Scale, oxide, and grease. Selective plating solutions are not designed to remove large amount of scale, oxide, oil or grease. Use mechanical or chemical methods to remove large amounts of scale or oxide. Use solvents to remove large amounts of oil or grease.

4.1.5 Selective plating solutions. Selective plating solutions have significantly higher metal concentrations than tank solutions. The voltages and current densities listed on the Technical Data Sheets provide the operator with the flexibility to plate under a wide range of set ups and plating conditions to provide high quality adherent deposits. Insufficient current densities tend to produce stressed, low thickness deposits, while excessive current densities tend to produce burned, porous deposits. In either case the quality of the deposit will suffer. Selective plating operations are generally carried out within a temperature environment ranging from 60° F to 90° F. Consult the individual technical data sheets to ensure the plating solutions are maintained during the plating operation.

WARNING

Chemical breakdown of solutions may occur if advised maximum temperature is exceeded.

4.1.6 Activating. Materials that normally have passive surface (stainless steel, chromium, nickel, and aluminum) require an activating operation. The activating operation removes the passive surface.

4.1.7 Film removal. Etching operations sometimes results in the formations of an insoluble surface film, for example: carbon on carbon steel. These layers interfere with adhesions; therefore, it is important that these films are removed in the preparation procedure prior to plating.

4.2 Solutions.

4.2.1 Types of solutions. The solutions used in selective plating include solutions for cleaning, etching and activating the surface to be plated, plating solutions for depositing pure or alloy metals, stripping solutions, and special purpose solutions such as anodizing, chromate treatment, etc. Solutions of any manufacturers may be used provided they meet the applicable plating requirements and are qualified by procedure tests. Unless otherwise specified, plating and preparatory solutions of different manufacturers shall not inter-mix or be used in a plating procedures. Solutions used for repair of high strength steel surfaces shall meet requirements that prevent hydrogen embrittlement.

4.2.1.1 Plating on high strength steel. High strength steel parts must be hydrogen embrittlement relieved per AMS 2759/9 after brush plating, unless a non-embrittling solution is used for brush plating. In order to be considered non-embrittling, each batch of plating solution must be tested by performing the following testing:

4.2.1.1.1 Apply a 0.0003-0.0006 inch thick plating per this specification onto four (4) 1.a.1 or 1.a.2 specimens meeting ASTM F519. The plating shall be applied to the smooth cylindrical section of the specimen, including in the notch.

4.2.1.1.2 The notch shall be visually inspected for presence of plating. If there are visible areas where plating is not present, the specimen is unacceptable.

4.2.1.1.3 Do not bake the specimens.

4.2.1.1.4 Test the specimens per ASTM F519 at 75% UTS for 200 hours. If any one (1) of the four (4) specimens fails, the batch of solution shall be rejected.

4.2.1.1.5 If a processor makes their own plating solution, the hydrogen embrittlement test data shall be maintained for at least ten (10) years after the parts have been plated.

4.2.1.1.6 Hydrogen embrittlement testing is typically performed by the solution manufacturer. If the manufacturer has performed the testing, it is the responsibility of the processor to acquire either the testing documentation or a certificate of conformance from the manufacturer and maintain the documentation for at least ten (10) years after the parts have been plated. It is the responsibility of the solution manufacturer to maintain the testing documentation for at least ten (10) years.

4.2.2 Characteristics of selective plating solutions. The solution manufacturers have prepared and made available comprehensive literature on their solutions. This information shall be reviewed when selecting a solution and the instructions shall be followed when using the solution.

4.2.2.1 Solution usage.

- a. Alkaline and neutral solutions are preferred on porous base metals, white metals, high strength steel and for improved throwing power.
- b. Acid solutions are generally used for rapid build-up and as a laminating structure material in conjunction with alkaline type solutions.

4.2.2.2 Immersion deposits and pre-plates. Immersion deposits will form by certain solutions on certain base materials when pre-wetting a surface with no current flowing. Immersion deposits have poor adhesion to the base materials. Pre-plates are often used to prevent immersion deposits from forming and thereby improving adhesion. Common pre-plates are nickel, gold and palladium. When plating with solutions that form immersion deposits, care must be taken to avoid any solution contact with the part prior to plating. Solution literature generally is a good guideline on what solutions form immersion deposits.

4.2.2.3 Chrome plating solution. Chrome deposited from selective plating solutions is not recommended as a wear resistant coating. The hardness of selective brush plated chromium deposits is about 600 Brinell (BHN) as compares to 1000 BHN for hard chrome deposits from a tank. In addition, the limited thickness and difficulty of producing sound deposits from selective chrome plating solutions result in the use of other metals such as nickel or cobalt in applications where chromium would normally be used.

4.2.2.4 Build-up. Brush plating solutions are limited in the thickness that can be deposited since the deposited surface at some point becomes excessively rough. The thickness at which deposits become rough varies from 0.005 to 0.010 inches. At this point for higher build-up, the deposit must be smoothed by machining, grinding, or sanding. The deposit must then be cleaned, etched and reactivated before additional material can be applied. This can be easily and reliably done on more noble metals such as copper acid deposits, silver, gold, etc. The harder materials such as cobalt and nickel tend to form passive films and must be activated; an operation that requires speed and operator skill, which presents some element of risk. There are several techniques to circumvent this element of risk, they are:

a. Select metals and/or specific solutions with less tendency to become rough with thickness. The manufacturers of selective plating solutions have developed several solutions specifically for heavy build-up. By supplying these solutions at a constant flow rate and the use of abrasive type covers such as “Scotch-Brite™” it is possible to deposit thickness of metals such as copper or nickel up to 0.030 inch. The solution manufacturers list a normal maximum thickness build-up for each solution in their literature. Consult manufacturers’ solution manuals for specific instructions.

b. Use a lamination technique whereby layers of a harder more difficult to activate materials are laminated with a softer, more easily activated material. A typical example would be to plate 0.010 to 0.015 inch copper acid, polish and repeat until the desired thickness is obtained. Copper acid deposits are easy to activate and, therefore, a simple reliable procedure is being used. Grain growth is in horizontal layers for soft metals and vertical layers in hard metals. Thus, alternating layers of hard and soft deposits dissipate or eliminate stress much the same as the theory behind plywood.

4.3 Anodes.

4.3.1 Anode materials and shapes. The removable anodes are available in a wide range of standard sized and three (3) basic shapes. They are as follows:

- (a) Cylindrical – for plating inside diameters
- (b) Concave – for outside diameters
- (c) Flat or block shaped – for flat shapes
- (d) Bulk blocks of graphite material are available for manufacturing special shapes

4.3.1.1 Unless otherwise authorized by the responsible engineering organization, the anodes shall be of high purity dense – minimum bulk density of 1.74 g/cc and a maximum grain size of 0.008 inches – graphite, platinum, platinum plated titanium, of 90% (percent) platinum and 10% (percent) iridium, or other insoluble anode material approved by solution manufacturers.

4.3.1.2 Separate anodes shall be kept for use with each plating solution.

4.3.1.3 Each anode shall be dedicated to a solution and shall be identified with solution code and polarity.

4.3.1.4 Anodes that have been used for reverse current cleaning and etching operations shall be marked as such and shall not be used with forward current.

4.3.2 Anode selection.

4.3.2.1 Anode selection for preparatory steps. The cleaning, de-oxidizing, etching and activation steps usually require much less time than the plating steps. Therefore, close matching of the anode for preparatory steps is not as important as in the plating steps. To ensure that thorough and uniform preparatory operations have been carried out, it is desirable to use adequate size tools for those operations, recommend that the preparatory tools cover a minimum of 10% (percent) of the area to be plated.

4.3.2.2 Anode selection for plating steps. Metal is deposited essentially only in the area of the tool to work contact. As a result, the following shall be considered when selecting an anode:

- a. The anode shall have optimum contact area with the work piece, approximately 1/3 to 1/2 the total area to be plated when used in manual operation. Power pack size and the configuration of the area to be plated are of primary importance in automated or mechanized flow plating.
- b. The anode shall be selected which most nearly conforms to the configuration of the parts: i.e. flat anodes for flat parts, cylindrical anodes for internal diameters and concave anodes for outside diameters, etc.
- c. The anode shall cover the full length of a diameter or a flat area.
- d. When plating large areas, the maximum tool to work piece contact will depend on the plating solution and power pack used. The maximum contact area may be computed using the following formula:

$$\text{MCA} = \text{MAO}/\text{ACD}$$

NOTE: MCA = maximum contact area; MAO = Maximum amperage output of power pack;
ACD = average current density for the solution under optimum conditions.

- e. After the anode has been selected, it shall be drilled as necessary for flow plating where required and wrapped with the appropriate material selected in conjunction with solution manufacturer's recommendations.

4.3.3 Tool coverings. The tool covering is used to hold and distribute the solution uniformly. Solution manufacturers recommended tool coverings shall be used as they are essential for successful plating. Some of the most commonly used covering are:

- a. White and Red Scotch-Brite™
- b. Cotton batting
- c. Cotton and polyester sleeving
- d. Cotton and polyester jackets

NOTE: Use only solution manufacturer approved covers.

4.4 Equipment. (Reference: A-A-59460)

4.4.1 Power unit. A suitable power source is required and shall operate on 110, 220, or 440 volts alternating current (AC), 60 Hertz single phase or three (3) phase input. The unit shall be capable of producing direct current having smooth characteristics. The power unit shall be able to output a minimum of eight (8) amperes at ten (10) volts. Minimum instrumentation shall include a volt meter, ammeter, ampere-hour meter, variable DC output, and AC and DC circuit breakers.

4.4.1.1 Ammeter. The ammeter shall have sufficient capacity to provide a full-scale reading equal to the maximum capacity of the power source and an accuracy of $\pm$ five (5)% of the current being measured.

4.4.1.2 Voltmeter. The voltmeter shall have sufficient capacity to provide a full-scale reading equal to the maximum capacity of the power source and an accuracy of ± 1.0 volt.

4.4.1.3 Ampere-hour meter. The ampere-hour meter shall be readable to a division compatible with power unit and application; i.e. 15 to 30 amperes 0.001 ampere-hour (amphr), 60 to 200 amperes 0.01 amphr, over 200 amperes 0.1 amphr. Accuracy shall be $\pm$ one (1)% (percent).

4.4.1.4 (Optional) Programmable, software controlled power unit with process monitoring and data logging capability.

4.4.2 Plating tool handles. The handles shall be designed to hold anodes of various sizes and configurations. The handles shall be rated for specific maximum amperage. The handle shall be insulated for safety reasons.

4.4.3 Dishes, beakers, and flasks. The dishes, beakers, and flasks required to hold the plating solutions and catch the run-off shall be inert to the solutions and of the appropriate configuration.

4.4.4 Accessory equipment. Depending upon the type of work being done, other items may be required, such as:

4.4.4.1 Blasting equipment and abrasive. The size of the cabinet shall be adequate for the part to be plated. Air lines shall be suitably trapped and filtered to prevent in-process contamination of the parts to be cleaned. The blast material shall be aluminum oxide (AL_2O_3) or silica (SIO_2). The material shall be a particular size or grit that shall not affect the micro finish or dimension of the part.

NOTE: The blast material and blast procedure are subject to the approval of the responsible engineering organization.

4.4.4.2 Motorized turning head. The motorized turning head is used for rotating components such as shafts, bearings, etc., to assure concentric and uniform plating. The motorized turning head shall have a speed control from 0 to 500 revolution per minute (RPM) with input of 110 volts, single phase, 600 hertz AC. The turning head shall also have an on and off reverse control in either direction of rotation.

4.4.4.3 Rotary power anode. Rotary power anodes are used to rotate the anode for the plating of internal diameters or to reduce operator fatigue on large areas. The rotary power anode shall have an input of 110 volts, single phase, AC. A step-less speed control from 0 to 900 RPM and a reversing switch are also required.

4.4.4.4 Additional equipment. Additional equipment, such as: traversing arms which is a mechanical arm for holding anode during plating, a heater, pump, and filter package for solution maintenance and temperature control, and solution coolers, etc., are available through the solution manufacturer.

4.4.4.5 Safety requirement. To provide safe working conditions, ensure compliance with personal protective equipment standards (face shield, rubber gloves and apron) found in Title 29, Code of Federal Regulations (CFR), Occupational Safety and Health Standards (OSHA) Chapter 17, Subpart I Personal Protective Equipment.

5. DETAILED REQUIREMENTS

5.1 Calculation of required ampere-hours (amphr).

$$AH = F \times A \times T$$

Where “F” is the solution factor, “A” is the area to be plated, and “T” is the thickness to be plated.

NOTE: Each selective plating solution has a solution factor, which is equal to the ampere-hours required to deposit one (1) inch thickness on one (1) square inch of surface area.

Example: The amphr required to plate 0.001 inch thickness over a two (2) square inches of surface area using a solution that has a Factor of 200 is calculated as follows:

$$2 \text{ in}^2 \times 0.001 \text{ inch} \times 200 = 0.4 \text{ ampere-hours}$$

5.2 General plating procedure. This procedure is listed for general discussion. For specific applications see paragraph 5.3 and the solution manufacturer’s instructions.

- a. Prior preparation. Selective plating cleaning solutions are not designed to remove large amounts of grease, oil, oxide, and scale. Mechanical methods shall be used to remove large amounts of scale or oxides. Approved solvents or cleaning solutions shall be used to remove large amounts of grease or oil.
 - b. Electro-clean. Use electro-clean to remove residual amounts of grease, oil, and light oxide film. Forward current is normally used, but reverse current shall be used to prevent hydrogen embrittlement. Use electro-clean for areas larger than the area to be plated.
 - c. Rinse. The purpose of the rinse is to remove all of the previous solution, so that the following solution shall not be contaminated. Rinsing is a very important step, and usually but not always follows each step. Rinse a larger area than the area to be plated. Purified water is preferred. Where purified water is not available, water clean enough to drink is suitable for brush plating methods.
- NOTE: Some brush plating solution requires the use of deionized water (DI) water during processing; check manufacturer’s instructions prior to use.
- d. Etch. Etch the surface as required. Small amounts of oxides may still remain on the surface of many materials after electro cleaning. “Flowed” metal is often present on the surface from machining, grinding, and polishing operations or through usage of the part. The etching operation is used with reverse current and is continued until the oxide film, flowed metal, and contaminated surface material have been removed and a uniform “grainy” surface appearance is obtained.
 - e. De-smutting. The etching operation on some materials results in the formation of a loose layer carbon. This layer causes poor adhesion to the base material. This layer can be removed by an appropriate de-smutting operation. The de-smutting is completed when the surface is uniform in appearance, and continued de-smutting does not result in the surface becoming lighter in color.

f. Activating. Activate the surface as required for plating on aluminum alloys, high alloy steel, stainless steel, chromium, nickel, or nickel alloys. The purpose of the activation step is to remove the characteristically passive surface of these metals.

g. Pre-plate. Pre-plating is required. In many cases to obtain maximum adhesion, pre-plates of a suitable metal are deposited prior to deposition of the metal desired. Follow solution manufacturer's recommendations for bonding and pre-plate thickness.

h. Electro-plate. The final preparatory operation shall be followed as soon as possible by the plating operation. Electro-plate in accordance with the solution manufacturer's instructions.

i. Dry. Dry using a warm air blower, clean shop compressed air, clean paper towels, or clean dry rags.

5.3 Alternate activation method. An alternate method for activation of base metals is the abrasive blast method. Abrasive blast activation works well on all base metals and is especially useful in the activation of high strength steels, dissimilar metals and unknown metals. Refer to MIL-STD-1504 and the solution manufacturer's recommendation for the use of this method.

5.4 Plating on dissimilar metals and changing base. As a general rule, when you have two (2) dissimilar metals to plate on, follow the plating procedure for the one with the most steps of activation. Follow manufacturer's instructions for recommended activation requirements.

5.5 Surface preparation. The selective plating solution manufacturers have prepared and made available comprehensive literature on the use of their solutions. The literature shall be reviewed when planning a selective plating repair.

5.5.1 Inspection.

a. Quality control responsibility. The responsible Quality Control Department shall enforce the requirements of this standard. Testing to meet the requirements shall be performed with such frequency as deemed necessary by the Quality Control Department to assure compliance with this standard.

b. Qualification of operators. Operators performing work under this standard shall be certified as qualified operators by the Quality Control Department or solution manufacturer's certification. Certification shall be conferred on trained operators, who have successfully demonstrated knowledge of the process and their ability to produce satisfactory plating per this standard. Required re-certification of operators shall be completed annually, at a minimum.

c. Certification of equipment. All equipment shall satisfactorily demonstrate the ability to perform at a rated capacity and produce plating meeting the requirements of this standard annually. The Quality Control Department shall certify that the equipment conforms to this standard.

d. Inspection. The plating shall be smooth, fine grained, adherent, and free of visible blisters, pits, nodules, porosity, excessive edge build-up and other defects that would affect the functional use of the plated part.

e. Adhesion test. All plated surfaces shall be tested for adhesion of electro-deposits by performing any one (1) of the tests listed below. The tape test is the most common test in the selective plating industry. When areas plated are too small to apply tape (grooves or small IDs), visual inspection is sufficient.

1. Tape test.

(a) Apply a one (1) inch wide strip of Minnesota Mining and Manufacturing Tape, Code # 250 (3M™ 250 Flatback Masking Tape), or approved equivalent, with adhesive side to the freshly plated surface.

(b) Apply the tape with heavy hand pressure and remove the tape with one quick motion perpendicular to the plated surface.

(c) Any plating adhering to the tape shall be rejected.

2. Shot peen test.

(a) Shot peen using Minnesota Mining and Manufacturing© rotary peening tools.

(b) These tools consist of a rotary flap loaded with #330 Tungsten Carbide shot.

(c) The flap is used in a mandrel and rotated by an air or electric motor between 2000 and 3500 rpm.

(d) The intensities obtained by this method can be correlated to the Almen Strip Standard SAE J442 and SAE J443.

(e) If the peening caused the plating to flake, delaminate, or otherwise show poor adhesion, the plating shall be rejected.

3. Grinding or machining test.

(a) Grind or machine the plated surface IAW the customer requirements.

(b) During grinding or machining, if the plating flakes, delaminates, or otherwise shows poor adhesion, the plating shall be rejected.

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 for selective, brush plating, electro-deposition to be used during repair process and acquisition of spares for the landing gear of all military aircraft. It is a process and procedure unique to the Air Force and is used primarily by the Air Force at Hill Air Force Base.

6.2 Subject term (key word) listing.

Acid

Alkaline

Chrome

6.3 Changes form previous issue. Marginal notation are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes. A change summary page identifies where changes were made.

CONCLUDING MATERIALS

Custodian:
Air Force – 70

Preparing Activity:
Air Force – 70

(Project MFFP-2019-008)

NOTE: The activity listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using ASSIST Online database at <https://assist.dla.mil>.