

NOT MEASUREMENT
SENSITIVE

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MILITARY STANDARD
SELECTIVE (BRUSH PLATING), ELECTRODEPOSITION

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DEPARTMENT OF DEFENSE

Selective (Brush Plating), Electrodeposition MIL-STD-865C

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MILITARY STANDARD
SELECTIVE (BRUSH PLATING), ELECTRODEPOSITION

1. SCOPE

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

1.2 Process description. The selective plating process (sometimes called "brush" plating) is a 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 the electrolyte-bearing anode.

1.3 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 capability.
- 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 overmachined parts back to size.

1.4 Printed circuit repairs. Because of the growing demand and limited availability of electronic components, there has been a significant increase in the need for an approved repair process for salvage of damaged or defective printed circuit boards. Techniques have been developed utilizing selective plating for repair of these boards. These techniques are available through the manufacturer of the selective plating solutions. The specific types of repairs that can be accomplished are:

- a. Repair of defective plating.

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- b. Repair of damaged contacts (fingers) due to peeling.
- c. Repair of lifted, damaged, or missing pads and traces.
- d. Adding new circuitry or rerouting traces on existing circuit boards.
- e. Repairing breaks in continuity.
- f. Repairs of damaged plating in through holes.

2. REFERENCED DOCUMENTS

2.1 Specifications. The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein.

SPECIFICATIONS

Military

MIL-S-5002 Surface Treatments and Inorganic Coating for Metal Surfaces of Weapon Systems

MIL-P-60247 Plating Units, Selective (Brush), Portable

MIL-STD-1504 Abrasive Blasting

(Copies of specifications, standards, handbooks, drawings and publications required by contractor in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

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 data.

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

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

4.1.3 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 grease or oil.

4.1.4 Selective plating characteristics. Selective plating solutions are 5 to 50 times as concentrated as tank solutions. The current densities used range from 500 to 10,000 amps/FT². The voltages listed on the solution containers have been precalculated to give proper current densities. Too high a current density burns the plating and too low a current density produces stressed deposits and low efficiencies. Agitation is provided by anode to cathode motion. Too slow a motion causes burning and too fast a motion results in low efficiencies and stressed deposits. If the tool is too dry it will result in burned plate, coarse grain structure and unsound deposits. The minimum operating temperature should be 70 degrees. Consult the technical data sheet or technical representative for maximum operating temperature of plating solutions.

WARNING

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

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

4.1.6 Film removal. Etching operations sometimes result in the formations of an insoluble surface film, for example: carbon on carbon steels. These layers can interfere with adhesion; 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. However, plating and preparatory solutions of different manufacturers should not be intermixed or substituted into a plating procedure.

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

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are labeled as to range of voltage for various anodes and solution factor. This information should be used during plating operations. The selective plating solution characteristics listed in the Appendix are presented as a guide for solution selection and use.

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 preplates. Immersion deposits will form with no current flowing from certain solutions on certain base materials. Immersion deposits have poor adhesion to the base material. Preplates are often used to prevent immersion deposits from forming thereby improving adhesion. Common preplates are nickel, gold and palladium.

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 as compared to 1000 Brinell for hard chrome deposited 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 which chromium would normally be used.

4.2.2.4 Build-up. Brush plating solutions are limited in the thickness that can be deposited in one operation since the deposit surface at some point becomes excessively rough. The thickness at which deposits become rough varies from 0.001 to 0.030 inches but as a general rule the average is 0.005 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. This 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 of a 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 as a constant flow rate and the use of abrasive type covers such as "Scotch Brite" it is possible to deposit layers of metals such as nickel in excess of 0.030 inch without layering or sandwiching. The solution manufacturers list a normal maximum thickness build-up for each solution in their literature.

b. Use a lamination technique whereby layers of a harder more difficult to activate material are laminated with a softer, more easily

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activated material. A typical example would be to plate 0.002" nickel then 0.002" 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 metal and vertical layers in hard metal. 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 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.

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, or 90 percent platinum and 10 percent iridium unless otherwise authorized by the responsible engineering organization. Separate anodes should be kept for use with each plating solution. Each anode should be dedicated to a solution and should be identified with solution code and polarity. Anodes that have been used for reverse current cleaning and etching operations should be marked as such and should not be used with forward current.

4.3.2 Anode selection.

4.3.2.1 Anode selection for preparatory steps. The cleaning, deoxidizing, etching and activation steps usually require much less time than the plating steps. Therefore, close matching of the anode for the preparatory steps is not as important as in the plating steps. To insure 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 should be considered when selecting an anode:

- a. The anode should 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 should be selected which most nearly conforms to the

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configuration of the parts: For example flat anodes for flat parts, cylindrical anodes for internal diameters and concave anodes for outside diameters, etc.

c. The anode should cover the full length of a diameter or a flat area.

d. When plating large areas, the maximum tool to work contact will depend on the plating solution and power pack used. The maximum contact area may be computed using the following formula:

$$C.A. = \frac{A}{C}$$

In the above, C.A. = maximum contact area (In); A = amperage output of power pack; C = 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 manufacturers recommendations.

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

- a. Surgical grade U.S.F long fiber sterile cotton
- b. Dacron batting
- c. Felon
- d. Scotch-Bright
- e. Dacron felt

Cotton, dacron or cotton dacron sleeving can be used to extend the tool covering life of the cotton or dacron batting.

4.4 Equipment. (Reference MIL-P-80249A)

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 phase input. The unit shall be capable of producing direct current having smooth characteristics. The power unit must be able to output a minimum of 8 amperes at 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) percent of the current being measured.

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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 amp-hr, 60 to 200 amperes 0.01 amp-hr, over 200 amperes 0.1 amp-hr.) Accuracy shall be ± 1 percent.

4.4.1.4 Microprocessor. Optionally replaces the single digital ampere-hour meter, with five (5) programmable memories. The Microprocessor will monitor up to a five (5) step procedure and notify the operator by audible alarm when required ampere-hours is reached in each step. It performs as a calculator, automatically inputs the results of the calculations into the power supply control mechanisms, and monitors selective plating operations as follows: performs surface area calculations and incorporates them with ampere-hour factor and thickness build-up requirements to determine pre-set ampere-hour values for the job. It then automatically programs the alarm system. The Microprocessor is capable of monitoring coating thickness in inches or ampere-hours. In run mode, ampere-hour usage is monitored so that operator can record solution usage to avoid over-depletion. Ampere-hour monitor retains data from repetitive operations in its cumulative memory.

4.4.2 Plating tool handles. The handles shall be designed to hold anodes of various sizes and configurations. The handles should be designed for rapid cooling. 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 should 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 of particular size or grit that will not affect the micro finish or dimension of the part. (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 0-600 RPM with an input of 110V, single phase, 600 hertz AC. The turning head shall also have an on-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,

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areas. The rotary power anode shall have an input of 110 volts, single phase, 600 hertz AC current. A stepless speed control from 0-900 RPM and a reversing switch are also required.

4.4.4.4 Additional equipment. Additional equipment such as transversing arms - mechanized arm for holding anode during plating, heater, pump, filter package - for solution maintenance and temperature control, solution coolers, etc., are available through the solution manufacturers.

4.4.4.5 Safety requirement. To provide safe and healthful working conditions, insure compliance with personal protective equipment standards (face shield, rubber gloves and apron) found in the CFP, Title 29, Labor, Chapter XVII, Subpart I (Occupational Safety and Health Regulations).

5. DETAILED REQUIREMENTS

5.1 Calculation of required ampere-hours.

a. Each selective plating solution has a solution factor which is equal to the ampere-hours required to deposit 0.001 inch on one square inch of surface.

NOTE: "Selectrons" has multiplied this figure by 10^4 and is now showing the ampere-hour figure as the ampere-hours required to deposit one inch on one square inch of surface. This allows the operator to utilize the actual required thickness in lieu of a whole number representing how many tenths of thousands he is dealing with.

b. Multiply this figure by the number of square inches (sq in) involved. This gives 0.0001 inch of deposit on the number of square inches involved or using the new "selectrons" figure the number of ampere-hours required to deposit one inch of deposit on the number of square inches involved.

c. Multiply the figure calculated in paragraph "b" by the thickness to be deposited in inches times 10^4 or if the new "selectrons" figure is used by the thickness in inches. The result is the required ampere-hours; i.e., plate two square inches to a thickness of 0.001 with a solution factor or 0.020 or a new "selectrons" solution factor of 200.

$$(OLD) \quad 2in^2 \times 0.001 \text{ inch} \times 10^4 \times 0.020 = .4 \text{ ampere-hours}$$

$$(NEW) \quad 2in^2 \times 0.001 \text{ inch} \times 200 = .4 \text{ ampere-hours}$$

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 oxides and scale. Mechanical methods should be used to remove large amounts of scale or oxides. Solvents should be used to remove large amounts of grease or oil.

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b. Electroclean. Electroclean to remove residual amounts of oil, grease, and light oxide films. Forward current is normally used but reverse current can be used to prevent hydrogen embrittlement. Electroclean an area 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 will 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. Use clean tap water.

d. Etch. Etch the surface as required. Small amounts of oxides may still remain on the surface of many materials after electrocleaning. "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. Desmutting. The etching operation on some materials results in the formation of a loose layer of insoluble material. This layer causes poor adhesion to the base material. This layer can be removed by an appropriate desmutting operation. The desmutting is completed when the surface is uniform in appearance, and continued desmutting 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. Preplate. Preplate as required. In many cases to obtain maximum adhesion, preplates of a suitable metal are deposited prior to deposition of the metal desired. Follow solution manufacturer's recommendations for bonding and preplate thickness.

h. Electroplate. The final preparatory operation should be followed as soon as possible by the plating operation. Electroplate in accordance with the solution manufacturer's instructions.

i. Dry. Dry using a warm air blower, paper toweling, or clean dry rags.

5.3 Alternate activation method. An alternate method for activation of base metals is the abrasive blast method. There are distinct advantages to this type of activation procedure, such as speed and consistency. 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 recommendations for the use of this method.

5.4 Plating on dissimilar metals and changing base. As a general rule when you have two dissimilar metals to plate on, follow the plating procedure for

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the one with the most steps of activation. If activation steps have to be mixed, use reverse current activation steps prior to forward current activation steps. Example: Fill pit in chrome plated aluminum.

- a. Electroclean using forward current until water does not break on surface.
- b. Rinse thoroughly with clean tap water.
- c. Activate the aluminum surfaces using reverse current and the appropriate solution until a uniform gray to black surface is obtained.
- d. Rinse thoroughly.
- e. Activate the chrome surface using forward current and the appropriate solution.
- f. Do not rinse.
- g. Immediately nickel flash the surface to a thickness of 0.0001 inch. Nickel flash with one of the preplate nickels.
- h. Rinse thoroughly.
- i. Continue plating with the desired metal to the proper thickness.
- j. Rinse and dry.

5.5 Surface preparation. The selective plating solution manufacturers have prepared and made available comprehensive literature on the use of their solutions. This literature should be reviewed when planning a selective plating repair. The following selective plating procedures for plating on some of the more common basis are presented as a guide.

5.5.1 Plating on aluminum and aluminum base alloys.

- a. Electroclean with chemical solutions using forward current.
- b. Rinse thoroughly with clean tap water.
- c. Activate with reverse current until a uniform gray to black surface is obtained. "Do Not" over activate.
- d. Rinse thoroughly.
- e. Immediately electroplate to color with a preplate of nickel or copper.
- f. Rinse thoroughly.
- g. Continue plating with the desired metal to the proper thickness.

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h. Rinse and dry.

NOTE: Certain aluminum alloys will exhibit improved adhesion if the following steps are inserted between steps "d" and "e".

(1) Activate with forward current until a uniform, light surface is obtained.

(2) Rinse thoroughly.

5.5.2 Plating on copper and copper base alloys.

a. Electroclean using forward current until water does not break on the surface.

b. Rinse thoroughly in clean tap water.

c. Etch with reverse current until a clean, copper colored surface is obtained.

d. Rinse thoroughly.

e. Electroplate the part with any of the plating solutions except silver (see immersion deposit instructions).

NOTE: Alloys of Beryllium Copper may form a smut during etching operation. This can be avoided by substituting a nickel acid bonding layer for the etching operation.

5.5.3 Plating on 300 series and 400 series stainless steels, nickel base alloys, chromium base alloys, high nickel ferrous alloys, cobalt base alloys, nickel plate and chromium plate.

a. Electroclean using forward current until water does not break on surface.

b. Rinse thoroughly in clean tap water.

c. Reverse current etch with the appropriate solution for the base material until a uniformly etched surface is obtained.

d. Rinse thoroughly in clean tap water.

e. Activate the surface using forward current and the appropriate solution for the base material.

f. DO NOT RINSE.

g. Immediately nickel plate the surface to a thickness of 0.00005 to 0.0001. Nickel flash with one of the preplate nickels.

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- h. Rinse thoroughly.
- i. Continue plating with the desired metal to the proper thickness.
- j. Rinse and dry.

5.5.4 Plating on iron and carbon steels (for steel heat treated above 180,000 psi see 5.5.5).

- a. Electroclean using forward current until water does not break on the surface.
- b. Rinse thoroughly in cold tap water.
- c. Reverse current etch with the appropriate activating solution until a uniform gray smut is obtained.
- d. Rinse thoroughly.
- e. Reverse current desmut with the appropriate desmutting solution until smut is removed.
- f. Rinse thoroughly.
- g. Electroplate the part with the desired metal. If copper or silver is the desired metal, an undercoat is required.
- h. Rinse and dry.

5.5.5 Plating on ultra high strength steels. (steels heat treated to 180,000 psi and above).

- a. Electroclean using reverse current until water does not break on the surface.
- b. Rinse thoroughly in clean tap water.
- c. Electroplate the part with the desired metal. If copper or silver is the desired metal, an undercoat is required. Plate initially at the highest voltage recommended for the solution so as to develop an initial barrier layer. Then reduce to the standard voltage.
- d. Rinse and dry.
- e. Bake the parts for four hours at 375 ± 25 degrees F within four hours of plating. Parts including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating to 375° F (190° C) shall be heated to 275 ± 15 degrees F (135 ± 8 ° C) and held at heat for not less than 5 hours.

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NOTE:

1. The activity with the engineering responsibility for the items to be plated should determine which selective plating solutions can be used on their high strength steel parts without a post plate bake.

2. Parts plated with Dalic Cadmium Code 2023, Liquid Development Company Cadmium LDC 4803, and Selectron Cadmium LHE (SPS 5070) have been tested in accordance with MIL-S-5002 and have satisfied the Air Force requirements for use without a post plate bake.

6. INSPECTION:

6.1 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.

6.2 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 successfully demonstrate a knowledge of the process and their ability to produce satisfactory plating per this standard. Re-certification of operators is required at least annually.

6.3 Certification of equipment. All equipment shall satisfactorily demonstrate its ability to perform at its rated capacity and to produce plating meeting the requirements of this standard every six months. The Quality Control Department shall certify that the equipment conforms to this standard.

6.4 Inspection. The plating should be smooth, fine grained, adherent and free of visible blisters, pits, nodules, porosity, excessive edge buildup and other defects that would affect the functional use of the plated part.

6.5 Adhesion test. All contact plated surfaces shall be tested for adhesion of the electrodeposit. The tape test is the generally accepted test in the selective plating industry. Shot peening or machining is a more severe test.

6.5.1 Tape test. Apply a one inch wide strip of Minnesota Mining and Manufacturing Tape, Code No 250, or approved equal, with the adhesive side to the freshly plated surface. Apply the tape with heavy hand pressure and remove the tape with one quick motion perpendicular to the plated surface. Any plating adhering to the tape shall be cause for rejection.

6.5.2 Shot peen test. Shot peen using Minnesota Mining and Manufacturing rotary peening tools. These tools consist of a rotary flap loaded with #330

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Tungsten Carbide shot. The flap is used in a mandrel and rotated by an air or electric motor between 2000 and 3500 RPM. The intensities obtained by this method can be correlated to the Almen Standards.

Custodian:
Air Force - 99

Preparing Activity:
Air Force - 70

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A P P E N D I X

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TABLE I. BROOKTRON PLATING SOLUTIONS

BROOKSTONICS ENGINEERING CORPORATION
 13165 Sherman Way
 North Hollywood CA 91605
 (213) 875-2553

<u>PLATING SOLUTION</u>	<u>MFRS CODE</u>	<u>SOLUTION FACTOR</u> <u>AMP HRS/.001 in/1 in²</u>
CADMIUM ACID	BEC 300	.050
CADMIUM ALKALINE	BEC 301	.040
CADMIUM SPECIAL	BEC 303	.046
CADMIUM LOW HYDROGEN EMBRITTLE.	BEC 305B	.033
CHROMIUM	BEC 310	.300
COBALT ACID	BEC 320	.300
COBALT ALKALINE	BEC 321	.120
COPPER ACID	BEC 330	.120
COPPER ALKALINE	BEC 331	.142
COPPER HIGH SPEED	BEC 333	.087
COPPER ACID, SOFT	BEC 335	.120
IRON	BEC 340	.180
LEAD	BEC 350	.060
NICKEL ACID	BEC 360	.236
NICKEL A	BEC 363	.120
NICKEL M FOR MAGNESIUM	BEC 364	.220
NICKEL B HIGH SPEED	BEC 367	.096
NICKEL C ACID HIGH BUILD	BEC 368	.186
TIN ACID	BEC 370	.071
TIN ALKALINE	BEC 371	.070
TIN HIGH SPEED	BEC 373	.068
ZINC ACID	BEC 380	.078
ZINC ALKALINE	BEC 381	.089
ZINC HIGH SPEED	BEC 383	.087
GOLD ACID	BEC 20	.065
GOLD ALKALINE	BEC 21	.065
GOLD NEUTRAL	BEC 22	.065
GOLD 23K	BEC 23	.070
GOLD 24K	BEC 24	.065
INDIUM	BEC 30	.090
IRIDIUM	BEC 40	.300
PALLADIUM	BEC 50	.220
PLATINUM	BEC 60	.400
RHODIUM A	BEC 70	.145
RHODIUM B	BEC 71	.165
RHENIUM	BEC 80	.300
SILVER	BEC 90	.065
SILVER CYANIDE FREE	BEC 95	.065
COBALT-NICKEL	BEC 420	.200
NICKEL-TUNGSDEN	BEC 470	.290

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TIN-LEAD 60%-40%
TIN-LEAD 10%-90%

BEC 490
BEC 491

.060
.060

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TABLE II. BRUSHTRON PLATING SOLUTIONS

BRUSHTRONICS ENGINEERING SALES AND TECHNOLOGY
 405 Main Street
 Laurel, MD 20707
 (301) 953-7373
 (800) PLATE-IT

<u>PLATING SOLUTION</u>	<u>MFRS CODE</u>	<u>AMPERE-HOUR ENERGY FACTOR FOR 0.0001 INCH CUBE</u>
CADMIUM ACID	BEST 1300	0.007
CADMIUM ALKALINE	BEST 1301	0.007
CADMIUM NEUTRAL	BEST 1302	0.007
CADMIUM "M"	BEST 1303	0.007
CADMIUM "SPECIAL"	BEST 1304	0.007
CADMIUM LOW HYDROGEN EMBRITTLEMENT	BEST 1305B	0.007
CHROMIUM	BEST 1310	0.137
CHROMIUM	BEST 1311	0.120
COBALT ACID	BEST 1320	0.014
COBALT ALKALINE	BEST 1321	0.013
COPPER ACID	BEST 1330	0.013
COPPER ALKALINE	BEST 1331	0.012
COPPER, NEUTRAL	BEST 1332	0.013
COPPER, "HIGH SPEED"	BEST 1333	0.012
IRON, ACID	BEST 1340	0.025
IRON, ALKALINE	BEST 1341	0.018
IRON, "HIGH SPEED"	BEST 1341	0.015
LEAD	BEST 1350	0.006
LEAD, SHIELD "HIGH SPEED"	BEST 1351	0.007
MERCURY	BEST 1355	0.009
MERCURY, "SUPER WET"	BEST 1356	0.010
NICKEL, ACID	BEST 1360	0.047
NICKEL, ALKALINE	BEST 1361	0.017
NICKEL, NEUTRAL	BEST 1362	0.025
NICKEL, SOLUTION "A"	BEST 1363	0.018
NICKEL, SOLUTION "M", FOR MAGNESIUM	BEST 1364	0.038
NICKEL, BLACK	BEST 1365	0.025
NICKEL, SOLUTION "B"	BEST 1367	0.025
NICKEL, SOLUTION "C"	BEST 1368	0.037
NICKEL, SOLUTION "D"	BEST 1369	0.019
TIN, ACID	BEST 1370	0.004
TIN, ALKALINE	BEST 1371	0.004
TIN, NEUTRAL	BEST 1372	0.003
TIN, TYPE "A" HIGH SPEED	BEST 1373	0.005
ZINC, ACID	BEST 1380	0.007
ZINC, ALKALINE	BEST 1381	0.006
ZINC, NEUTRAL	BEST 1382	0.008
ZINC, HIGH SPEED"	BEST 1383	0.008
GALLIUM	BEST 1010	0.014

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GOLD, 12K	BEST 1012	0.006
GOLD, 14K	BEST 1014	0.006
GOLD, 18K	BEST 1018	0.007
GOLD, ACID (24K)	BEST 1020	0.006
GOLD, ALKALINE	BEST 1021	0.008
GOLD, NEUTRAL	BEST 1022	0.007
GOLD, 23K	BEST 1023 (TYPE II)	0.007
GOLD, 24K	BEST 1024 (TYPE I)	0.007
INDIUM	BEST 1030	0.009
IRIDIUM	BEST 1040	0.069
PALADIUM	BEST 1050	0.019
PLATIUM	BEST 1060	0.015
RHODIUM, "A"	BEST 1070	0.030
RHODIUM, "B"	BEST 1071	0.030
SILVER, "PURE NO BRIGHTNERS"	BEST 1090	0.004
SILVER, "NO" (NO CYANIDE)	BEST 1091	0.006
COBALT-NICKEL	BEST 1420	0.019
BRASS	BEST 1430	0.017
BRONZE SPECIAL	BEST 1435	0.017
COBALT-TUNGSTEN	BEST 1460	0.015
NICKEL-TUNGSTEN	BEST 1470	0.020
TIN-INDIUM	BEST 1480	0.008
TIN-LEAD (60%-40%)	BEST 1490	0.007
TIN-LEAD (10%-90%)	BEST 1491	0.006
ALLOY SPECIAL	BEST 1500	0.007

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TABLE III. DALIC PLATING SOLUTIONS

SIFCO SELECTIVE PLATING
5708 Schaaf Road
Independence OH 44131
(216) 524-0099

SIFCO SELECTIVE PLATING
1301 South Shamrock
Monrovia CA 91016
(818) 357-7976

<u>PLATING SOLUTION</u>	<u>MFRS CODE</u>	<u>AMPHERE-HOUR FACTOR</u>
AERO NIKL 250	7280	0.020
AERO NIKL 400	7281	0.020
AERO NIKL 575	7282	0.020
CADMIUM	2020	0.007
CADMIUM	2021	0.007
CADMIUM	2022	0.007
CADMIUM	2023	0.007
CHROMIUM	2030	0.137
CHROMIUM	2031	0.120
COBALT	2043	0.020
COPPER	2050	0.013
COPPER	2052	0.013
COPPER	2055	0.013
COPPER	2056	0.015
IRON	2061	0.018
LEAD	2070	0.006
LEAD	2071	0.006
NICKEL	2080	0.021
NICKEL	2085	0.015
NICKEL	2086	0.025
NICKEL	2088	0.021
TIN	2090	0.007
TIN	2092	0.007
ZINC	2100	0.011
ZINC	2101	0.011
ZINC	2102	0.011
ZINC	2103	0.011
GALLIUM	3011	0.015
GOLD	3020	0.006
GOLD	3021	0.006
GOLD	3022	0.006
GOLD	3023	0.007
INDIUM	3030	0.009
PLADIUM	3040	0.017
PLATINUM	3052	0.150
RHENIUM	3060	0.750

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RHODIUM	3072	0.030
RHODIUM	3074	0.030
SILVER	3080	0.005
SILVER	3081	0.005
SILVER	3082	0.005
SILVER	3083	0.050
NICKEL-COBALT	4002	0.030
TIN-INDIUM	4003	0.008
TIN-LEAD NICKEL	4005	0.006
COBALT TUNGSTEN	4007	0.020
NICKEL-TUNGSTEN	4008	0.025
BABBITT-SAE II	4009	0.006
BABBITT	4010	0.006
BABBITT-NAVY 2	4011	0.006
TIN-CADMIUM	4013	0.007
ANODIZING	5001	
ANODIZING TYPE I	5010	
ANODIZING TYPE II	5011	
ANODIZING TYPE III	5012	

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TABLE IV. LIQUID DEVELOPMENT COMPANY SOLUTIONS

LIQUID DEVELOPMENT COMPANY INC
 3748 E 91st Street
 Cleveland OH 44105
 (216) 641-9366
 (216) 641-9262
 (800) 321-9194

<u>PLATING SOLUTION</u>	<u>MFRS CODE</u>	<u>AMPERE-HOUR FACTOR</u>
CADMIUM ACID	LDC 4801	.007
CADMIUM ALKALINE	LDC 4802	.007
CADMIUM S (NO BAKE)	LDC 4803	.007
CHROMIUM (T)	LDC 2400	.120
CHROMIUM (H)	LDC 2401	.130
COBALT	LDC 2701	.020
COBALT M	LDC 2702	.020
COPPER ACID D	LDC 2901	.013
COPPER ALKALINE	LDC 2902	.013
COPPER ACID HI-SPEED	LDC 2903	.013
COPPER ALKALINE HI-SPEED	LDC 2904	.013
IRON	LDC 2601	.018
LEAD ACID	LDC 8201	.005
LEAD ALKALINE	LDC 8202	.005
NICKEL	LDC 2801	.030
NICKEL ALKALINE	LDC 2802	.018
NICKEL HI-SPEED	LDC 2803	.015
NICKEL SOFT	LDC 2805	.025
NICKEL BRIGHT	LDC 2806	.030
NICKEL SULFAMATE (SOFT)	LDC 2820	.020
NICKEL SULFAMATE (MEDIUM)	LDC 2840	.020
NICKEL SULFAMATE (HARD)	LDC 2854	.020
TIN ALKALINE	LDC 5001	.005
TIN ACID	LDC 5002	.005
ZINC ALKALINE	LDC 3001	.011
ZINC S (ACID)	LDC 3002	.011
ZINC BRIGHT	LDC 3003	.011
ZINC ACID	LDC 3004	.011
GOLD 100	LDC 7900	.006
GOLD 50	LDC 7901	.006
GOLD 25	LDC 7905	.006
GOLD 10	LDC 7910	.007
INDIUM	LDC 4901	.009
PALLADIUM	LDC 4601	.017
PLATINUM	LDC 7801	.150
RHENIUM	LDC 7501	.750
RHODIUM	LDC 4501	.080
RHODIUM	LDC 4502	.080
SILVER	LDC 4701	.005
SILVER	LDC 4703	.006

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SILVER	LDC 4704	.005
BABBITT NAVY GRADE II	LDC 5029	.006
BRONZE	LDC 2950	.013
NICKEL-COBALT	LDC 2827	.030
TIN-INDIUM	LDC 5049	.007
TIN-LEAD	LDC 5082	.005
TIN-CADMIUM	LDC 5048	.005
COBALT TUNGSTEN	LDC 2774	.020
NICKEL TUNGSTEN	LDC 2874	.030
TIN NICKEL	LDC 5028	.010

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TABLE V. SELECTRON PLATING SOLUTIONS

SELECTRON LTD
137 Mattatuck Heights Road
WATERBURY CT 06725-0115
(203) 754-3103

INTERNATIONAL SALES OFFICE
SELECTRON LTD
116 East 16th Street
New York NY 10003
(212) 228-6800

SELECTRONS PACIFIC INC
1655 Ninth Street
Santa Monica CA 90404
(213) 450-7149

PLATING SOLUTION	MFRS CODE	SOLUTION FACTOR AMPERE-HOURS FOR 0.0001 INCH ON A SQUARE INCH	
		OLD STYLE	NEW STYLE
CADMIUM ACID	SPS 5050	0.006	60
CADMIUM LHE	SPS 5070	0.006	60
CADMIUM (ALK)	SPS 5100	0.006	60
CHROMIUM	SPS 5150	0.137	1370
CHROMIUM (ACID)	SPS 5155	0.120	1000
COBALT MACHINABLE	SPS 5200	0.025	250
COBALT (SEMI BRIGHT H.B.)	SPS 5204	0.014	140
COPPER (ACID)	SPS 5250	0.012	120
COPPER (H.S. ACID)	SPS 5260	0.012	130
COPPER (NAUTRAL)	SPS 5290	0.013	130
COPPER (HEAVY BUILD ALKALINE)	SPS 5280	0.013	130
COPPER (ALKALINE)	SPS 5300	0.013	130
IRON	SPS 5500	0.130	1500
IRON (SEMI BRT)	SPS 5502	0.030	300
LEAD	SPS 5550	0.006	60
LEAD (FOR ALLOYING)	SPS 5551	0.006	60
NICKEL (ACID H.B.)	SPS 5640	0.045	450
NICKEL (ACID)	SPS 5600	0.025	250
NICKEL (H.T.)	SPS 5610	0.025	250
NICKEL (LOW STRESS)	SPS 5621	0.038	380
NICKEL (SPECIAL)	SPS 5630	0.038	380
NICKEL (SEMI BRT)	SPS 5642	0.020	200
NICKEL (H.S.)	SPS 5644	0.017	170
NICKEL (NEUTRAL)	SPS 5650	0.025	250
NICKEL "M"	SPS 5647	0.050	500
NICKEL XHS	SPS 5646	0.017	170
NICKEL SHD	SPS 5720	0.025	250
NICKEL MACHINABLE	SPS 5715	0.014	140

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TIN (ACID)	SPS 5900	0.003	30
TIN (ALKALINE B)	SPS 5951	0.005	50
ZINC (ALKALINE B)	SPS 5981	0.011	110
ZINC (ACID)	SPS 5985	0.010	100
GOLD	SPS 5350	0.007	65
GOLD (HARD ALLOY)	SPS 5370	0.007	65
GOLD (NEUTRAL)	SPS 5380	0.007	65
GOLD (ACID)	SPS 5400	0.007	65
INDIUM	SPS 5450	0.009	90
PALLADIUM	SPS 5730	0.020	200
PLATINUM	SPS 5730	0.070	700
RHODIUM	SPS 5800	0.080	800
RHODIUM (LOW STRESS)	SPS 5810	0.060	600
SILVER	SPS 5850	0.004	40
SILVER (HEAVY BUILD)	SPS 5860	0.004	40
COBALT-TUNGSTEN	SAS 5230	0.025	250
NICKEL-TUNGSTEN "D"	SAS 5710	0.038	380
NICKEL-COBALT	SAS 5705	0.025	250
CHROMIC ANODIZING	SBA 3100	-----	-----
SULPHURIC ANODIZING	SBA 3250	-----	-----
SILVER NO NON-CYANIDE	SPS 5870	-----	-----
ALORODE	SBA 4750	-----	-----
ZINC NICKEL NEUTRAL	SAS 5937	-----	-----
ZINC NICKEL ACID	SAS 5938	-----	-----
NICKEL MACHINABLE 40	SPS 5716	-----	-----
NICKEL MACHINABLE 50	SPS 5717	-----	-----