NOTE: MIL-STD-2197 has been redesignated as a Design Criteria Standard. The cover page has been changed for Administrative reasons. There are no other changes to this Document.

INCH-POUND

MIL-STD-2197 (SH)
28 MARCH 1989
SUPERSEDING
NAVSEA 0900-LP-038-6010
SEPTEMBER 1972

DEPARTMENT OF DEFENSE DESIGN CRITERIA

BRUSH ELECTROPLATING ON MARINE MACHINERY

AMSC N/A AREA MFFP

CONTENTS

CONTENTS - Continued

CONTENTS - Continued

1. SCOPE

1.1 Purpose. The information contained herein is intended for guidance to activities in developing a contact plating capability, and to aid in choosing applications for the process which will save time and money without sacrificing the reliability of the plated part or system in which it is used.

1.2 Scope. This standard describes the requirements for the equipment, materials, personnel, quality control and safety precautions for the electrodeposition of metals by brush electroplating.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 8.2).

SPECIFICATION

MILITARY
MIL-P-80249 - Plating Units, Selective (Brush), Portable.

STANDARDS

MILITARY
MIL-STD-271 - Requirements for Nondestructive Testing Methods.
MIL-STD-865 - Selective (Brush Plating), Electrodeposition.

(Unless otherwise indicated, copies of federal and military specifications and standards are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government document. The following other Government document forms a part of this standard to the extent specified herein. Unless otherwise specified, the issue is that cited in the solicitation.

DEPARTMENT OF LABOR (DOL)
Code of Federal Regulations, Title 29
Part 1910 - Occupational Safety and Health Standards

(The Code of Federal Regulations (CFR) and the Federal Register (FR) are for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. When indicated, reprints of certain regulations may be obtained from the Federal agency responsible for issuance thereof.)

2.2 Non-Government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of

the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 8.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
B 374 - Standard Definitions of Terms Relating to Electroplating.

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. 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 applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Quality assurance function. Quality assurance function is that portion of the organization separate and discrete from the production function that is responsible for assuring desired quality is met.

3.2 Plating activity. Plating activity is that organization responsible for and actually performing electroplating.

3.3 Other definitions. Other definitions relating to this standard and electroplating in general should be in accordance with ASTM B 374.

4. GENERAL REQUIREMENTS

4.1 Equipment.

4.1.1 Power packs. Power packs shall be in accordance with MIL-P-80249.

4.1.2 Plating tool handles. Handles shall be insulated for safety reasons. Where corrosion is a problem, handles with stainless steel or aluminum cooling fins shall be used. Handles shall be covered with a corrosion-resistant material.

4.1.3 Automatic processing equipment. Commercially available automatic equipment listed below may be considered for process improvement:

(a) Microprocessor for automatic coating thickness display and automatic calculation of ampere-hours. This unit may be attached to existing power packs or as an extra unit when new equipment is purchased.
(b) Microcomputer which prints out complete procedure for process control.
(c) Internal diameter plating devices.
(d) Plating solution tanks with built-in pumps, filters, heaters and temperature control systems.

4.2 Materials.

4.2.1 Solutions. The solutions used in brush electroplating are generally available only as proprietary products from brush electroplating supply manufacturers. Solutions from any manufacturer which meet all requirements of this standard may be used provided the user is qualified for brush electroplating with those solutions. Solutions from different manufacturers shall not be mixed and shall not be used with the same graphite anodes. The various commercially available solutions and their characteristics are specified in MIL-STD-865. A complete listing of solutions may be obtained from the contractors.

4.2.1.1 Solution acquisition. Acquisition of solutions shall be based on the following considerations:

(a) The reliability of the products and service of the manufacturer based on past experience.
(b) Availability of qualified plating procedures and operators.
(c) Availability of training programs and technical documents.
(d) Availability of technical representatives for consultation and technical assistance for resolution of plating problems which may occur.

4.2.2 Anodes. Anodes shall be made from graphite, 90-10 platinum-iridium or platinum, tantalum, columbium or titanium clad. All anode materials except graphite may be used with different solutions provided they are thoroughly washed when changing to a new solution. Anodes used for reverse current shall be marked as such and shall not be used with forward current.

4.2.2.1 Graphite anodes. For most applications, graphite anodes are most practical and least costly. They are available in a variety of shapes or in bulk blocks for machining special shapes. Graphite shall be acquired only from brush electroplating equipment manufacturers or their authorized agents because commercially available graphite may contain contaminants which are detrimental to electroplating. Graphite anodes shall be used with only one solution and shall be marked accordingly.

4.2.3 Tool coverings. Tool coverings shall be in accordance with MIL-STD-865. Other coverings may be used provided the plating produced meets requirements and they are approved by the plating activity's quality assurance office.

4.3 Plating procedures.

4.3.1 Requirements for plating procedures. Brush electroplating shall be performed to an approved written procedure. The procedure shall contain as a minimum the following:

(a) A unique identifying number.
(b) Date of approval.
(c) Authorizing signature.
(d) Applicable plating thickness.
(e) Preplating treatments; such as, stress relief or peening, if required.

(f) Required operators qualification.
(g) Preliminary cleaning.
(h) Electrocleaning and etching.
(i) Rinsing.
(j) Activating.
(k) Plating solutions, preplate (if needed), current density, anode to cathode speed, and so forth.
(l) Drying.
(m) Post plate treatments, such as blasting or grinding, if required.
(n) Records.
(o) Inspection requirements and acceptance criteria.

4.3.2 Sources of information for procedures. In addition to this document and MIL-STD-865, commercial manuals provided by brush electroplating solution and equipment contractors form the basis for information pertaining to brush electroplating. Current editions of commercial manuals should replace older ones. Activities performing plating shall contact their supplier to assure they are on the distribution list for new or revised manuals.

4.4 Qualification requirements.

4.4.1 Procedures. Procedures shall be qualified by performing plating in accordance with the procedure and inspecting for the attributes of 4.4.1.3 and any other requirements as necessary for the end use application of the plating such as hardness, corrosion resistance or hydrogen embrittlement. The qualification shall consist of using one specific plating solution on one base metal as designated in generic groups below.

(a) Aluminum and its alloys.
(b) Chromium plated parts.
(c) Copper and its alloys except aluminum bronze.
(d) Low carbon steel.
(e) Medium carbon or high strength steels.
(f) Cast iron.
(g) Nickel and its alloys.
(h) Zinc.
(i) Aluminum bronze.
(j) Martensitic stainless steel.
(k) Austenitic stainless steel.

Regardless of base metal used for qualification, it will qualify all base metals in that specific generic group for the type of plating applied (see 4.3.2). Revisions to procedures other than editorial or administrative shall require requalification in accordance with this standard prior to use.

4.4.1.1 Specimens needed to qualify.

4.4.1.1.1 Manual application procedure. Specimens for qualification of procedures where the plated layer is applied manually shall be strips of metal approximately 5 inches long by 1 inch wide by 0.050 inch thick. When the procedure is used to fill defects, the strip shall contain a groove 0.0625 inch wide by 0.010 inch deep by 1 inch long. The length dimension of the groove shall coincide with the length direction of the strip and be centered on it.

4.4.1.1.2 Machine assisted application procedure. Specimen for qualification of procedures where the plated layer is applied with the assistance of a rotating head shall be a bar or pipe of sufficient wall thickness about 5 inches long by 0.75 inch outside diameter (od) minimum. When the applicable procedure is used to fill pits or grooves, a groove 0.0625 inch wide by 0.010 inch deep by 1 inch long shall be cut into the specimen. The length dimension of the groove shall be parallel to the axis of the bar or pipe and at mid length.

4.4.1.2 Plating of qualification specimens. Plate to repair defects, if necessary, and plate a thickness equivalent to the maximum plating thickness to which the procedure is to be qualified on one side of strip or od of bar or tube in accordance with the procedure.

4.4.1.3 Inspection requirements. After plating, the specimens shall be inspected to the requirements of 7.2.1, 7.2.3 and 7.2.4 and tested for adhesion as follows. Specimens need not be inspected until after grinding if it is specified.

4.4.1.3.1 Manual application procedure. Bend the center of the strip around a radius equal to four times the thickness of the test strip with the plating on the outside of the bend. The bent surface when examined at up to 5X magnification shall be acceptable if no separation or flaking occurs between the base metal and plating or the layers of plating or if the plating cannot be peeled back with a sharp edged tool.

4.4.1.3.2 Machine assisted application procedure. Grind 0.003 inch off the diameter using standard grinding practice for the plating material. The plating shall be acceptable if no flashing or separation of plating occurs between the base metal and the plating or layers of plating.

4.4.1.4 Valve seat and disc repair procedures. To qualify procedures for repair of steam cuts and other damages in valve seats, discs, and stems, the following procedures are required (see 5.5.2).

(a)	Specimen	- Mock-up to simulate production material, configuration and restriction. The surface to be plated shall contain two grooves, 180 degrees apart, of about 0.125 inch wide by 0.010 inch deep.
(b)	Plating	- Fill in grooves and provide a top coat of about 0.006 inch thick.
(c)	Grinding	- Grind to remove about 0.002 inch of top coat plating.
(d)	Inspection	- The ground surface shall meet the acceptance criteria as specified in 7.2.1 and 7.2.4.
(e)	Micrographic examination	- The specimens shall be sectioned through and perpendicular to each grooved area. The polished and etched cross sections shall be examined at 50X magnification minimum. Linear or rounded defects shall not be acceptable. Evidence of porosity, lack of adhesion or cohesion shall not be acceptable.

(f) Hardness test - Three micro-hardnesses shall be made on the top coat of each specimen, and the average equivalent hardness shall be not less than hardness, Rockwell C (HRC) 40.

4.4.2 Operators. Operators shall be qualified by the quality assurance function of the plating activity prior to being permitted to perform contact electroplating.

4.4.2.1 Training. Prior to examination for qualification each prospective operator shall successfully complete a manufacturer sponsored training course or one provided by the plating activity. The course shall be approved by the quality assurance function of the plating activity and shall as a minimum prepare the prospective operator to demonstrate a knowledge of:

(a) The technical aspects of brush electroplating.
(b) Job safety for hazardous chemicals and electrical work.
(c) The calculation of plating amperage, plating time, quantity of solution required, and surface area and ampere-hours.
(d) The meaning of the terms; current density, activation, anode, cathode, adhesion, burned deposits, modules, porosity stripping, etch, waterbreak, matte finish, and volts and amperes.
(e) Set up and operation of a power supply.
(f) Preparation of metal surface for brush electroplating.
(g) Selection, preparation of, and post use care of the plating tools (anodes) and covers.
(h) The attributes used to control plating thickness time and quality.
(i) Prevention of contamination of plating solutions.
(j) Proper masking technique.
(k) Proper plating technique.
(l) Proper surface finishing technique.
(m) Evaluation of deposit's adhesion, thickness, and visual appearance.
(n) Preparation of job records.

4.4.2.2 Qualification examinations.

4.4.2.2.1 Written examination. An operator shall have passed a written examination covering the subjects specified in 4.4.2.1, administered either by the training activity or the plating activity, and approved by the quality assurance function of the plating activity.

4.4.2.2.2 Practical examination. The prospective operator shall demonstrate to the quality assurance function of the plating activity that he or she is capable of performing brush electroplating by successfully plating one of the test specimens (see 4.4.2.1) using the applicable procedure. To be qualified to fill defects, the grooved specimen shall be used. One set of specimens may be used to qualify a procedure and an operator.

4.4.2.3 Operator qualification. An operator is qualified for classes 1 and 2 (see 5.3) when they have successfully completed training and testing as specified (see 4.4.2.1). Qualification for classes 3 and 3A require plating a

mockup that simulates the production plating in shape, size and position of the item being plated. Successfully plating one mockup qualifies the operator for all similar work.

4.4.3 Requalification. Requalification is required when the operator has not performed any production work for which he is qualified for a period of 12 months or more, or when the quality assurance function of the plating activity has reason to question the ability of the operator to produce quality plating.

4.4.4 On-the-job-training. Prospective operators may be employed for on-the-job-training under the direct, on-site supervision of a qualified operator.

4.5 Restrictions and limitations.

4.5.1 Structural reinforcement. Brush electroplating shall not be used to restore strength to structural parts which have been unacceptably weakened by loss of metal.

4.5.2 Cracks. Plating shall not be made over areas containing cracks. Cracks shall be completely removed by grinding or other mechanical means. Shallow grooves may be filled by copper plating and then the area plated with the specified material. Deep grooves shall be repaired by welding.

4.5.3 Hydrogen embrittlement. Steel and nickel alloys having a tensile strength of 150,000 pounds per square inch or greater, or a hardness equal to or greater than HRC 35 or Brinell (BHN) 327, shall be given a hydrogen baking treatment as follows.

(a) Steels shall be baked at 375 ± 25 degrees Fahrenheit (°F) (191 ± 14 degrees Celsius (°C)) for 3 hours or more within 2 hours after plating.
(b) The nickel alloys, nickel-chromium-iron-titanium-columbium (Inconel X750) and nickel-copper aluminum (Monel K500) shall be baked at 600-650°F and 500-550°F respectively for 3 hours or more.
(c) When baking in an oven is not feasible, thermostatically controlled induction or resistance heaters shall be used to accomplish the baking treatment.
(d) Solutions and procedures specifically designed to deposit plating free of hydrogen shall be exempt from this requirement.

4.5.4 Case-hardened steel parts. Parts which have been nitrided, carburized or otherwise hardened to HRC 45 (421) or greater, shall not be restored to plan dimensions in the case-hardened area by brush electroplating.

4.5.5 Spray metallized parts. Previously spray metallized parts shall not be repaired by brush electroplating unless the metallized coating is completely removed.

4.5.6 Substitution of solutions. Substitution of solutions specified by the applicable procedure shall be prohibited. This prohibition shall apply to substitution of one proprietary solution for another even though both solutions have the same generic description. However, more than one proprietor's plating

solutions (vice preparatory solutions) may be used in any one procedure provided the procedure is qualified separately in accordance with 4.4.1 for each combination of solutions.

4.5.7 Mixing of solutions. Mixing of solutions which do not have identical labels shall be prohibited unless specifically authorized by a manufacturer's procedure or other certified procedure.

4.5.8 Aged solutions. Solutions which have passed the manufacturer's expiration date or which have exhibited poor quality plating shall not be used on Naval ship hardware.

4.5.9 Recovered solutions. Recovered solutions may be reused if they have not been chemically contaminated or mixed with other solutions. Recovered solutions may be stored if they have been filtered, are kept in separate non-contaminating containers from fresh solutions, and the remaining usable ampere-hours are indicated on the container. Expiration dates on stored recovered solutions shall not be exceeded. Solutions that have been pumped over dirty or oily surfaces of the workpiece shall not be reused.

4.5.10 Restrictions on electrodeposited metals.

4.5.10.1 Cadmium. Electroplating cadmium shall be prohibited. Cadmium shall be routinely replaced with zinc wherever specified.

4.5.10.2 Chromium. Brush electroplating of chromium shall be permitted only for decorative applications in thickness 0.0001 inch and less. For applications where high hardness and wear resistance are required, such as in shaft journals, nickel and its alloys with hardness in excess of HRC 35 and which produce dense adherent plates shall be used. For shafts with existing chromium plating, the chromium shall be completely stripped prior to applying other plating material. For areas requiring extensive build-up, soft nickel may be deposited to within about 0.004 inch of the final dimension followed by a deposit of an outer layer of nickel, or its alloys which are dense, adherent, and have hardnesses not less than HRC 35.

4.5.10.3 Lead and lead alloys. Brush electroplating of lead and lead alloys shall be restricted. It shall be used only on repair of plating on battery terminals and busing where its use has been previously authorized.

4.5.10.4 Cobalt and cobalt alloys. Cobalt and cobalt base alloy plating shall not be used on rotating shaft journals which are seated in babbitted bearings.

4.5.10.5 Tin, indium and tin-indium alloys. Tin, indium and tin-indium alloys provide excellent resistance to sea water and are ideal for repairing corrosion pits because of their fast deposition rate. However, because of the low melting points of these materials, their use shall be restricted to sea water and other ambient temperature applications.

4.6 Safety requirements. The general requirements for personal protective equipment shall be in accordance with the Code of Federal Regulations, Title 29, chapter XVII, subpart I. The following safety requirements apply.

4.6.1 Eye protection. Chemical goggles, face shields, or safety glasses with side shields shall be worn during brush electroplating operations. If overhead work is being performed, face shields shall be used.

4.6.2 Respiratory protection. For shipboard operations, portable exhaust ducts with a capture velocity of 100 feet per minute shall be placed within 12 inches of the work surface, or other equivalent ventilation provided. Shop work shall be in a well ventilated area. Plating with silver, gold, or other solutions containing cyanide shall be under conditions reviewed by safety engineers and found adequate. Respirators are not required for use with other brush electroplating solutions.

4.6.3 Skin protection. Shoulder length solution-repellent sleeves or whole body solution-repellent garments shall be worn where required to prevent solutions from contacting the skin. An example is overhead plating. Acid and alkaline-resistant gloves shall be worn. Gloves shall be taped where they connect with other solution-repellent apparel to prevent leakage.

4.6.4 Recovery of solutions. Plastic troughs or catch basins shall be used to collect any plating solutions which may drip from the workpiece.

4.6.5 Mixing of solutions. Solutions containing cyanide shall be prevented from mixing with acid solutions. Cyanides and acid solutions react to make hydrogen cyanide gas, a deadly poison. This restriction includes control of waste solutions or solutions which have dripped off the workpiece.

4.6.6 Waste solution disposal. Waste solutions shall be disposed of in conformance with applicable local, state and federal regulations.

5. DETAILED REQUIREMENTS

5.1 Types of damage which can be repaired. Brush electroplating may be used to repair any type of damage which does not result in structural weakening such as cracks or substantial loss of material. Examples of repairable damage include wear, scoring, corrosion and mismachining. Examples of damage which cannot be repaired are particle pull-out from gears, cracks, very deep or very large pits which compromise pressure boundary integrity, and damage to case hardened surfaces with hardness greater than HRC 45.

5.2 Repair of pits and scores. Pits and scores shall be filed, honed, ground or electrochemically machined dish shape to remove steep walls and sharp corners. On shafting with scored or smeared metal at the journal, all smeared metal shall be removed so that brush electroplating is on undisturbed base metal.

5.3 Classification of repairs. Applications shall be classified as follows:

Class 1 - Plating used to perform decorative or corrosion-prevention functions only.
Class 2 - Plating on parts to restore dimensions on surfaces which remain in static contact with gaskets, O-rings, or other metal surfaces.

Class 3 - Plating on parts which make rubbing or intermittent contact with other plated or unplated parts including electrical contacts except those in class 3A.
Class 3A - Plating on rubbing contact surfaces of turbines, reduction gears, electric power generating units, and main propulsion shaft seals, steam valves, and other sliding contact areas when specified.
Class 4 - Plating on parts under the cognizance of the Nuclear Propulsion Directorate.

5.4 Class 1 (corrosion-resistant) coatings. Allowable thickness shall be governed by practical and economical use of the metal or metals deposited and shall be restricted to the qualification limit of the procedure. Three types of corrosion resistant coatings may be repaired by brush electroplating: sacrificial coatings (zinc or aluminum), noble or semi-noble metal (gold, silver, chromium, or nickel) coatings, and anodized coatings. Sacrificial coatings may be repaired with electroplated zinc. Noble or semi-noble metal coatings may be repaired by applying the same metal as was present before being damaged. An exception is chromium which shall be repaired with nickel or cobalt patches; when appearances are all-important, a thin coating of chromium may be used. Anodized aluminum may be repaired using an anodizing solution (refer to contractor's instruction manual).

5.5 Class 2 (static contact) coatings. Allowable thickness shall be not greater than 0.030 inch exclusive of filling pits, scores, dents, and so forth, when the total surface area of the defects comprises not greater than 10 percent of the area to be plated. The maximum allowable plating thickness shall not exceed the qualification limit of the procedure. Class 2 coatings are generally for surface restorations for purposes of sealing or fit, or to electrical conductors such as silver or lead on bus bars. The following paragraphs show the type or types of repairs and repair procedures to which this class is applicable.

5.5.1 Seawater static sealing surfaces. The application for seawater static sealing surfaces shall be as follows:

(a) Type of damage - Corrosion pits, scratches, gouges, mismachining.
(b) Typical workpieces - Flanges, valve and pump mating surfaces, all types of static sealing surfaces including O-ring grooves, submarine main shaft seal static sealing surfaces, and so forth.
(c) Typical base metals - Nickel-copper, copper-nickel, bronzes, stainless steels or chrome plated steel.
(d) Allowed build-up thickness - Not greater than 0.030 inch over wide surfaces, no limit on filling pits provided pits do not compromise pressure boundary strength. Thickness limitations imposed by the qualified procedure shall be observed.
(e) Typical fillers - Soft metals such as tin, indium, copper for heavy build-ups which can be hand worked to size.

(f) Typical top coat - Nickel for white base metal (tin or indium) application. (An alkaline or neutral pH solution is required to plate over tin filler to prevent dissolution of the tin.) When copper filler is used, acidic pH solutions of nickel or nickel-tungsten should be used.

(g) Authorization - All applications authorized.

5.5.2 Steam static sealing surfaces. The application for steam sealing surfaces shall be as follows:

(a) Type of damage - Scratches, corrosion, steam cuts, mismachining.
(b) Typical work-pieces - Flanges, valve turbine mating surfaces, and so forth.
(c) Typical base metals - Carbon steel, alloy steel, and chromium stainless steel.
(d) Allowed build-up thickness - Not greater than 0.050 inch over wide surface. No limit on filling pits provided that pits do not compromise pressure boundary strength. Thickness limitation imposed by the qualified procedure shall be observed.
(e) Typical filler metals - Silver, copper.
(f) Typical top coat metals - None required.
(g) Authorization - All applications authorized.

5.5.3 Machinery static mating surfaces. The procedure for machinery static mating surfaces shall be as follows:

(a) Type of damage - Fretting, mismachining, misalignment, and corrosion.
(b) Typical work-pieces - Motor or generator bell housings, motor or generator shafts at rolling element bearing fit area, keyways, cylinder heads, and so forth.
(c) Typical base metals - Steels, bronze, copper-nickel, nickel-copper, and so forth.
(d) Allowed build-up thickness - Not greater than 0.030 inch.
(e) Typical filler metals - Nickel, copper, silver.
(f) Typical topcoat - Nickel, nickel-tungsten, or nickel-cobalt (when damage is caused by fretting, 0.0003 to 0.0005 inch of tin or tin-indium may be applied over the hard topcoat to prevent further fretting).
(g) Authorization - All applications authorized.

5.5.4 Printed circuit repairs. Printed circuit repairs are authorized using approved procedures.

5.6 Class 3 (sliding contact surface) coatings. Allowable thicknesses shall be limited to not more than 0.025 inch exclusive of filling pits, scores, and so forth, when the total surface area of the defects comprises not more than 10 percent of the area to be plated. The maximum allowable plating thickness shall not exceed the qualification limit of the procedure. Class 3 brush plated surfaces are generally for wear resistance such as shaft journals, hydraulic cylinders, pistons, rams, valve stems, electrical contacts and commutators. The following is a typical application of this class.

5.6.1 Shaft journals and other cylindrical parts with sliding contact. The procedure for repair of shaft journals and other cylindrical parts with sliding contact shall be as follows:

(a)	Type of damage	- Wear, scoring, corrosion or mismachining.
(b)	Typical work-pieces	- Straight shafts and crankshafts, valve stems in packing area and so forth.
(c)	Typical base metals	- Steels, stainless steels, bronze, nickel-copper and chromium.
(d)	Allowed build-up thickness	- Not greater than 0.025 inch, except filling pits and scoring is limited to a depth of 0.020 inch.
(e)	Typical hard top coat	- Nickel, or nickel-tungsten alloy, not less than 0.002 inch over copper filled pits.
(f)	Authorization	- Sliding surfaces except classes 3A and 4 shafts which require NAVSEA approval.

5.6.2 Class 3A (sliding contact surfaces requiring NAVSEA approval) coatings. Class 3A coatings are the same as class 3 coatings except they are applied in areas where the applications require that NAVSEA approval be obtained before applying them. Surfaces which are in this class are in turbines, reduction gears, electric power generating equipment, main propulsion shaft seals, steam valve seats, discs and stems, and other sliding contact areas when specified.

5.7 Class 4 (nuclear power) coatings. Plating on parts under the cognizance of the Nuclear Propulsion Directorate shall be performed only upon their approval. Approval of procedures by NAVSEA or the prime contractor is required.

6. JOB PLANNING REQUIREMENTS

6.1 Selection of metals to be electroplated. The selection of a metal or metals for deposition in a repair job shall be based on the desired properties for the application. Among the factors to be considered are hardness, corrosion resistance, ease of electroplating, wear, and so forth. Section 5 and vendor's handbooks provide selection guidance.

6.2 Identification of base metal material. Base metal material shall be identified as to type (copper alloy, low carbon steel, nickel alloy, and so forth) and whether there is existing plating. When drawings are available, these

may suffice to identify material. Some commercial brush electroplating procedures have sub-procedures included which provide a method for identification using conventional chemical spot tests.

6.3 Job records. A job record shall be kept for each plating job so that this information can be retrieved and re-used when appropriate. The job record generally will include most or all of the information provided below. Figure 1 (or a commercial procedure form) may be used to record the essential job data.

6.3.1 Essential job data. Essential job data shall include the following:

(a) Identification of workpiece. Name, drawing number, piece number, system and plating procedure used, and ship name or number.
(b) Workpiece deficiency, or type and location of repair required. (For example; pit filling in O-ring groove, build-up of shaft bearing seating area, build-up of motor bell housing outer fit area.) A sketch shall be made on the back side of the form to identify the location of the repair.
(c) Workpiece material.
(d) Operating conditions including pressure, temperature range, corrosive environment, static or sliding contact and wear.
(e) Type of plating applied.
(f) Procedure number.

6.4 Design of anode. Requirements for conforming anode and size of anode shall be based on cost reduction by increasing plating contact area whenever advantageous. Flow-through pump-fed anodes shall be used whenever possible to reduce labor cost and to improve deposit quality.

6.5 Deposition time. On large or long jobs, deposition time shall be calculated using a standard commercial procedure and associated solution data. Very long jobs which are impractical may be identified in this way before the jobs are started.

6.6 Amount of solution required. The amount of solution required to accomplish the necessary build-up shall be calculated to ensure adequate stock of solutions is on hand.

7. QUALITY ASSURANCE

7.1 Quality assurance test requirements. The quality assurance function of the plating activity shall enforce the requirements of this standard. Testing to meet the requirements shall be performed with the frequency determined to be necessary by the quality assurance function to ensure compliance with this standard.

7.2 Quality assurance tests for brush electroplating deposits. The tests listed below shall be performed by the quality assurance office of the activity performing production plating to ensure adequate quality.

7.2.1 Visual inspection. Color matching shall not be required. The plating shall be smooth, fine-grained, adherent, and free of visible blisters, pits, nodules, porosity, and excessive edge build-up when examined with normal

corrected vision without magnification. Burned deposits are not acceptable. Magnification may be used to determine the significance of a condition which has been found with the unaided eye. Stains on unplated areas from rinse water or solution run-off shall not be cause for rejection.

7.2.2 Adhesion tests. Contact plated surfaces shall be tested for adhesion of the electrodeposit. The tape test is the generally accepted test in the selective plating industry. Subsequent machining or grinding of class 3 jobs shall be considered an adhesion test, since improperly bonded coatings fail during grinding. The solution manufacturer's instructions for machining or grinding parameters shall be adhered to prevent overheating and cracking. The tape test shall consist of applying a 1 inch wide strip of Minnesota Mining and Manufacturing Tape code number 250, or equal, across the freshly plated but thoroughly dried surface and on a location where the plating meets the unplated surface, whenever feasible. 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.

7.2.3 Thickness of deposit. Deposit thickness on the workpiece shall be determined by before and after dimensional measurements whenever possible. When measurement cannot be made, the thickness shall be estimated from area and ampere-hour data.

7.2.4 Dye penetrant inspection. Group I penetrant shall be used in accordance with MIL-STD-271. Any defect greater than 0.0625 inch in length shall be cause for rejection. This test shall be required for classes 3 and 3A applications only.

8. NOTES

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

8.1 Intended use. This standard is intended for guidance to activities in developing a contact plating capability.

8.2 Issue of DoDISS. When this standard is used in acquisition, the issue of the DoDISS to be applicable to this solicitation must be cited in this solicitation (see 2.1.1 and 2.2).

8.3 Documentation. Documentation should be required for classes 2, 3 and 3A plating jobs. Sample job record form as shown on figure 1, should be used. NAVSEA approval should be required for class 3A application.

8.4 Subject term (key word) listing.

Anodes
Contact plating
Electrodeposition of metals
Hydrogen embrittlement

Preparing activity:
Navy - SH
(Project MFFP-N298)

BRUSH PLATING JOB RECORD

Date:

Part/Component:

Ship/project: Job order:

Base metal: Plating procedure:

Location: ☐ Shop ☐ Ship Operator:

Application class: NAVSEA approval: ☐ Yes ☐ Not req.
NAVSEA ltr no:

Reason for plating 1/

Action required (itemize) 2/

QA check list

- ☐ Pre-plating inspection
- ☐ Operator certification
- ☐ Plate thickness/dimension
- ☐ Yes ☐ Not req. Hydrogen bake
- ☐ Visual inspection
- ☐ PT inspection
- ☐ Tape test
- ☐
- ☐

Inspector name and signature Date

1/ Provide a brief description of the type, location and extent of damage. Use "remark" section for sketch, if feasible.
2/ Provide sequential instruction (Example: (1) Remove corroded area to sound metal; (2) Inspect ground area for defects; (3) Nickel plate to plan dimension plus 0.010 inch; (4) Machine to plan dimension; (5) Inspect plated and adjacent surface.)
3/ Record actual operational data.

FIGURE 1. Sample job record.

Step number	Operation 1/	Solution number	Voltage	Anode plus or minus	Ampere hours required	Ampere hours drawn	Remarks

Remarks:

FIGURE 1. Sample job record - Continued.

☆U.S. GOVERNMENT PRINTING OFFICE: 1989 - 604-033/12404