1 SCOPE

NOTE: Incorporated PSDs: None
Cancelled PSDs: None

a. This specification covers the requirements for the electrodeposition of hard chromium (chrome) plating. This specification also covers thin dense chrome plating (formerly BMS10–70, Type I and II).

b. Hard chrome plating in accordance with this specification will meet the requirements of QQ–C–320 Class 2 for steel parts heat treated below 220 ksi, and MIL–STD–1501 for steel parts heat treated to 220 ksi and above.

c. Chrome plating baths other than those listed in Section 9.2 that will produce parts meeting the requirements of Section 11 of this specification may be used if approved by Boeing Quality Assurance.

d. This specification requires Qualified Processors for Class 4 chrome plating. Processors shall be qualified in accordance with Section 12, and shall be listed in the QPL.

2 CLASSIFICATION

Chromium plating in accordance with this specification is classified as follows:

a. Class 1 Decorative plating.

b. Class 2 Hard chrome plating (or plating and grinding) to specified dimensions.

c. Class 3 Special pretreatment followed by hard chrome plating (or plating and grinding) with narrower processing parameters for improved adhesion to specified dimensions.

d. Class 4 Plating deposited by processes that produce a precisely controlled thin, hard chromium coating having a minimum hardness equivalent to Rockwell C67.

e. Where Class is not specified, use Class 2.

f. Where drawings call out BMS10–70 (Type I or Type II), use Class 4.

3 REFERENCES

The current issue of the following documents shall be considered a part of this specification to the extent herein indicated.

ASTM E 140 – Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, Knoop Hardness, and Sclerscope Hardness E1–1999; E2–2000

ASTM B 374 – Definitions of Terms Relating to Electroplating

3 REFERENCES (Continued)

ASTM E 384	–	Test Method of Microhardness of Materials
ASTM F 519	–	Method for Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Materials
ASTM B 578	–	Standard Test for Microhardness of Electroplated Coatings
BAC5032	–	Grinding of Chromium Plate
BAC5408	–	Vapor Degreasing
BAC5436	–	Etch Inspection of Ground or Machined Steel Parts
BAC5440	–	Hole Preparation, Machining, and Grinding of Steels
BAC5617	–	Heat Treatment of Alloy Steels
BAC5618	–	Carburizing and Nitriding of Steels
BAC5619	–	Heat Treatment of Corrosion Resistant Steel
BAC5621	–	Temperature Control for Processing of Materials
BAC5625	–	Surface Treatments for Ferrous Alloys
BAC5650	–	Hardness Testing
BAC5714	–	Electroplating of Aluminum Alloys
BAC5730	–	Shot Peening
BAC5744	–	Manual Cleaning (Cold Alkaline, Solvent Emulsion, and Foam Cleaners)
BAC5748	–	Abrasive Cleaning, Deburring and Finishing
BAC5749	–	Alkaline Cleaning
BAC5750	–	Solvent Cleaning
BAC5751	–	Cleaning, Descaling and Surface Preparation of Ferrous Alloys
BAC5763	–	Emulsion Cleaning (Immersion and Spray)
BAC5770	–	Cleaning, Descaling and Surface Preparation of Copper and Copper Alloys
BAC5771	–	Stripping Inorganic Finishes
BACD2097	–	Surface Roughness
BSS7035	–	Electric/Electronic Glossary
BSS7217	–	Air Cleanliness, Shop Compressed Air
D6–4307	–	Fabrication and Standardization of Notched Tensile Specimens
MIL–STD–105	–	Sampling Procedures and Tables for Inspection by Attributes
MIL–STD–1501	–	Chromium Plating, Low Embrittlement, Electrodeposition
QQ–C–320	–	Chromium Plating (Electrodeposited)

4 **CONTENTS**

4 **CONTENTS** (Continued)

4 **CONTENTS** (Continued)

LIST OF FIGURES

LIST OF TABLES

5 MATERIALS CONTROL

a. Abrasives for Scouring

(1) Wyandotte F–1013, or equivalent pumice detergent

(2) Pumice

(3) Tripoli Powder

(4) Silicon Carbide Abrasive Paper

(5) Scotch Brite Pads, No. 7448, Silicon Carbide, 3M Company, St. Paul, Minn.

(6) Restoro Polish, Restoro Polish Company, Mars, PA

b. Acetone, 0–A–51

c. Ammonium Bifluoride, Technical

d. Anodes

(1) Lead – containing 4 to 7 percent Tin

(2) Lead – containing 4 to 7 percent Antimony

(3) Chemical Lead

(4) Platinum Wire, Lead or Lead–Tin Plated Steel Wire

(5) Carbon **FL 1**

(6) Nickel Anodes, 99 percent nickel: rolled, depolarized; electrolytic grade nickel; or carbon–nickel cast and rolled.

OPTION: Sulfur depolarized (SD) nickel chips. **FL 1**

FL 1 Not for use in chrome plating solutions.

e. BMS11–7 Solvent Blend, QPL

f. Chromic Acid (Chromium Trioxide), Technical

g. Chromic Acid, Liquid Concentrate, Technical, Concentration 12.0 to 12.3 lbs. per gallon

h. Copper Sulfate, Technical

i. Hydrochloric Acid, 20 Degree Be′, Technical

j. Hydrofluoric Acid, 70 percent, Technical

5 **MATERIALS CONTROL** (Continued)

k. Maskants

Any maskant or masking tape that production tests indicate to be satisfactory may be used. Some satisfactory materials are:

(1) Thermocote, Type N–455, Thermo–cote, Inc.

(2) Tape, Unichrome 705, M & T Chemicals, Inc.

(3) Tape, Lead, #420, 3M Co., or similar

(4) Microshield Stop–Off Lacquer, Pyramid Plastics, Inc.

l. Methyl Ethyl Ketone, TT–M–261

m. Nickel Chloride, Hexahydrate, Technical

n. Plating Compound, Econochrome S, McGean Rohco, Rohco Incorporated

o. Plating Compound, Econochrome 40, McGean Rohco, Rohco Incorporated

p. Plating Compound, Econochrome 66, McGean Rohco, Rohco Incorporated

q. Plating Compound, Unichrome CR–110, M&T Chemicals, Inc.

r. Plating Compound, Unichrome CR–204, M&T Chemicals, inc.

s. Potassium Ferricyanide, Technical

t. Rochelle Salt (Potassium Sodium Tartrate), Technical Grade

u. Sodium Chloride, Technical

v. Sodium Gluconate, Technical

w. Sodium Hydroxide, Flake or Granulated, Technical

x. Sulfamic Acid, Reagent Grade – any source

y. Sulfuric Acid, O–S–809, Type I, Class 1, or equivalent

z. Test Materials, Chisel Test

(1) Hammer, plastic–faced No–bounce, 1 lb. (0.45 kg)
(Boeing Perishable Tool No. B3–1766–3590)

(2) Chisel bit, A1S1 M34 Tool Steel, or equivalent,
HRC 62 minimum, 1/2 $\times$ 1/2 $\times$ 4 inches (Figure 3)
(Boeing Perishable Tool No. B1–1161–1000)

aa. Thickener: Agar or Corn Starch

6 FACILITIES CONTROL

a. The plating tank and associated plumbing that contacts the solution shall be lined with lead–antimony or lead–tin or with acid–resistant plastic, or shall be fabricated from similar materials sufficiently resistant to the solution to permit consistent application of acceptable coatings.

b. The plating solutions shall be agitated to minimize all temperature and concentration gradients. The maximum temperature gradient measured from the hottest to the coldest points in the bath shall not exceed 10 F.

c. Air used for solution agitation or for drying parts shall be free of oil, water, or solid particles when tested in accordance with BSS7217.

d. All tanks to be operated at temperatures other than room or ambient temperature shall be equipped with automatic temperature indicating and regulating devices sufficient to maintain the desired temperature within $\pm$ 5 F. Cooling capability is required for power inputs greater than 10 amperes per gallon.

e. The required current range for plating is obtained by multiplying the number of square inches of unmasked surface to be plated by the current density stated in the flowchart from Section 8.2.

f. Power supplies shall have sufficient capacity to deliver the required current at the minimum and the maximum anticipated plating tank loads without current interruption during a striking and/or plating operation. Power supplies shall be equipped to automatically turn off all the current to the tank in the event of any current interruption if unattended Class 2 or 3 plating is performed. Power supplies shall produce DC current having less than 5 percent ripple (100 $\times$ AC voltage divided by DC voltage) over the entire approved plating range; three–phase full–wave rectification with stepless control is preferred.

g. The power supply shall be equipped with an ammeter that is readily visible to the plater. The power supply shall be equipped with either digital or analog meters. All current and voltage meters shall be certified to $\pm$ 5 percent of the indicated current or voltage. Power supplies shall be certified as producing DC current having less than 5 percent ripple over the entire approved plating range.

h. Furnaces used for stress relieving or baking shall be instrumented and periodically tested for accuracy and uniformity in accordance with BAC5621, Class IV Type D, or better, except an indicating high limit instrument is not required.

i. Temperature controllers, ammeters and voltmeters shall be periodically calibrated or tested within the time limits specified by the applicable document.

7 DEFINITIONS

The following definitions apply to terms that are uncommon and or have special meaning as used in this specification. Electrical/electronic terms are defined in BSS7035.

Acceptance Number – The maximum allowable number of test samples failing to meet any one test.

Arc Damage – The permanent damage of the metal substrate due to the high intensity arcing or jumping of current from a charged surface to the part. Resulting damage may be either incipient melting or intergranular oxidation. Arcing usually occurs at two places: at the contact point between the part and part holder, and any section of the part which may have been too close to an anode. Visual evidence of arcing may be similar to burning but brownish in color.

Burning – The damaging of a chrome deposit by plating under excessively high current density. Frequently, visual evidence of burning is apparent as either a darkened, rough, non–adherent (powdery or flaky) chrome plate, or a milky deposit of chrome plate.

Chicken Wire Cracks – Cracks that occur when stresses created in the chrome deposit during plating are relieved. The cracks are evident in the deposited chrome when viewed from a perpendicular plane as a pattern similar to chicken wire. Crack size can vary with plating conditions.

Cracks – Fractures or rifts that occur in a surface due to relief of a load or stress within the surface.

Cracked Plating – Both macro and/or micro fissures that occur when stresses relieved in the chrome deposit during plating are relieved. All hard chrome plating has cracks due to the volume contraction that occurs when the as–deposited chromium hydrides decompose to molecular hydrogen and chromium metal during post–plating bakeout. Cracks can be either non–penetrating or penetrating to basis metal depending on the conditions of plating and the extent of bakeout.

Hydrogen Embrittlement – Embrittlement of a metal or alloy caused by absorption of hydrogen which may occur, for example, during pickling, cathodic cleaning, electroplating, and auto–catalytic plating processing (ASTM B 374).

Hydrogen Embrittlement Relief Bake – A heating process that reduces the amount of hydrogen in high strength steels, thereby decreasing the chance for embrittlement. Sometimes called post–plate bake.

Lot – Any group of parts of approximately the same size, shape, and basis metal which have been processed under the same conditions and submitted for inspection at the same time.

Micropits – Micropits are partial or complete voids of plate. They are typically attributed to retention of hydrogen bubbles on the surface of the part, organic contaminants, or poor basis metal preparation. Generally, the results are either a partial void or a complete absence of plate. The resultant micropits will generally be removed during the grinding of Class 2 and 3 plating, provided the depth of the pit is not in excess of the plate thickness removed.

7 DEFINITIONS (Continued)

Non–functional Surface – A surface on which the presence of a plating imperfection will not affect the proper operation of the part.

Purchaser – That agency (either a Boeing Division or a Boeing Subcontractor) which receives plated material from the supplier.

Proof Loading – The application of a load to a new part or assembly which is significantly greater than the expected service load, in order to test for gross manufacturing or process defects.

Run–out – That area on the edge of a chrome plated surface where the coating is allowed to taper from the drawing–required thickness to zero. The plating border shall be gradual as defined by the appropriate drawing dimensions. A run–out is required to provide a tolerance on the location of a robber device or stop–off (maskant), applied prior to plating to limit the plating to designated areas. Run–out also provides grinding relief.

Supplier – That organization that accomplishes the chrome plating.

Water–Break–Free – A water–break–free surface is a surface that maintains a continuous water film for a period of at least 30 seconds after having been spray or immersion rinsed in clean water at a temperature below 100 F.

See ASTM B 374 for standard definitions of plating terms.

8 MANUFACTURING CONTROL

WARNING

This specification involves the use of chemical substances which are hazardous. Boeing personnel shall refer to the work area Hazard Communication Handbook for health effect and control measure information contained in the HazCom Info Sheets and Material Safety Data Sheets. For disposition of hazardous waste materials, consult site environmental engineers for proper disposal methods.

Non–Boeing personnel should refer to manufacturer's Material Safety Data Sheet(s) and their employer's safety instructions.

8.1 GENERAL NOTES

a. Unless otherwise specified, the chrome plating shall be applied after all basis metal heat treatments and mechanical operations (such as machining, brazing, welding, forming, and perforating) have been completed.

b. Unless otherwise noted on the drawing, the maximum surface roughness of parts to be Class 2 or 3 plated shall not exceed R_a 63.

NOTE: Unless post–plate finishing is conducted, surface finish of any Class plating will be no smoother than the unplated surface.

8.1 GENERAL NOTES (Continued)

c. Unless otherwise specified by the drawing, the surfaces of parts to be Class 4 plated shall be smooth and free from blemishes, pits, tool marks, and other irregularities that will be detrimental to the appearance of the coating and/or function of the finished part. All functional surfaces to be Class 4 plated shall have a finish of R_a 32 or better.

d. Surfaces shall be water–break–free following immersion in any processing solution or rinse except following vapor degreasing, solvent cleaning or emulsion cleaning. Reclean parts that develop water–breaks.

e. Mechanical finishing (polishing, buffing, lapping, honing, grinding) of parts may be used prior to and/or after chrome plating to obtain the required surface finishes and dimensions specified in applicable Engineering drawings. Parts ground in accordance with BAC5032 shall be cleaned in accordance with that specification. Parts that have been mechanically finished by other processes shall be cleaned in accordance with BAC5408, BAC5744, BAC5749, BAC5750, or BAC5763 to remove surface contamination. Steels heat treated to 180 ksi and above are subject to the following special restrictions:

NOTE: Correct mechanical finishing is critical for good chrome plate adhesion.

(1) Any polishing or buffing shall be performed with soft polishing or buffing wheels, No. 150 or finer abrasives, and a light contact pressure between the part and the wheel. Overgrinding may cause cracks in the plated chrome. The wheel speed and contact pressure shall be low enough to avoid locally heating Class 2 or 3 parts above the Section 8.3.1 stress–relief temperature, and to avoid heating Class 4 parts above the temperature where they can be handled with bare hands.

(2) Any grinding before plating shall be accomplished in accordance with BAC5440. PH steels do not require processing in accordance with BAC5440.

(3) Any grinding after plating shall be accomplished in accordance with BAC5032 (grinding after plating is not permitted for Class 4).

f. Runout should be produced during the plating operation, utilizing conforming anodes, thieves, metal tape, and shields as necessary. Materials used for current “robbing” (that is, thieves) shall be free from all soils, including oils, waxes and greases, or any other material that will react with any of the pretreatment (etch) or chrome plating solutions. Use only the approved maskant materials from Section 5.

g. Place all contacts and electrode connections in a non–functional area. When in doubt, consult the applicable Design Engineering department.

h. Maximum Total Dissolved Solids (TDS) for final rinse tanks shall not exceed 1000 ppm. Use of common rinse tanks for acid and alkaline solutions is not recommended.

i. Do not permit the drying of parts between process steps, except where noted.

j. Parts requiring Class 1 decorative plating may be processed using the process specified in Section 8.2 or an alternate method which matches required appearance standards specified on the Engineering drawing. Any alternative method shall be approved by Materials Technology.

NOTE: Processing is applicable to all Classes unless otherwise stated.

8.2 FLOW CHART

Ferrous Alloys, Nickel **FL 1** and Other Heat–Resistant Alloys

Aluminum and Copper Alloys

a. Verify that all required stress relief has been performed in accordance with Section 11.1.

b. Shot peen according to BAC5730 when required by the drawing. See Sections 8.1b. or 8.1c. for subsequent surface finish requirements.

c. Vapor degrease according to BAC5408, manual solvent clean in accordance with BAC5750, or emulsion clean according to BAC5763.

d. Mask and rack parts as required. Mask or plug all holes, recesses, or similar areas subject to low cathodic current densities that do not require plating. Plug all closed hollow structures and other parts having surfaces from which drainage cannot be assured. Utilize proper parts placement, special anodes, and current robbers as required to obtain a uniform plating thickness and to avoid thin areas, excessive corner buildup, and burning. Use lead–backed tape to define the edges of stop–off areas; work the tape as required to ensure that electrical contact and current robbing produce a proper chromium runout without bead formation.

OPTION: Masking and/or racking may be delayed until after steps e., f., or g.(1) if desired.

Optional for Class 1, 2 and 4 parts heat treated below 180 ksi

Class 1, 2 and 4 parts

Parts where drawings specify “Class 3” (optional for Class 2) and steel parts with partially nickel–plated areas **FL 1**

e. Alkaline clean and rinse in accordance with BAC5749 and scour using abrasive material (5a.); or dry abrasive blast in accordance with BAC5748.

Ferrous Alloys, Nickel **FL 1** and other Heat–Resistant Alloys

8.2 FLOW CHART (Continued)

f. (1)
- (a) Parts heat treated below 180 ksi clean in accordance with BAC5625, Solution 1 or abrasive clean in accordance with BAC5748; or periodic reverse electroclean in accordance with BAC5749, Method 3, Endox 214 solution.
- (b) Parts heat treated above 180 ksi: abrasive clean in accordance with BAC5748; or grind in accordance with BAC5440; or polish (Section 8.1e.(1)), or periodic reverse electroclean according to BAC5749, Method 3, using Endox 214 solution. If parts are ground, they shall be restressed relieved in accordance with Section 11.1 and re–shot peened, if applicable.
- (c) CRES steels that have contacted lead–containing tools or equipment: Clean in accordance with BAC5625, Method II, or periodic reverse clean with BAC5749, Method 3, using Endox 214 solution.
- (d) For low alloy steel parts requiring Class 4 chrome plating and an R_a 16 finish, or finer, clean in accordance with BAC5625 using Solution 1. The maximum immersion time is 60 seconds.

f. (2) Dry abrasive blast clean parts in accordance with BAC5748, Type I, using 80 to 120 grit aluminum oxide only with an air pressure 45 psi minimum. Threaded parts shall be protected prior to abrasive blast cleaning.

OPTION: Parts requiring a plating less than 0.0007 inch thick and an R_a 32 or finer finish may be lightly sanded in accordance with BAC5748, or polished (see Section 8.1e.(1)).

Aluminum and Copper Alloys

Wet processed parts

Abrasive cleaned and polished parts

g. (1) If required, removed smut by scouring using abrasive materials (5a.), or by immersion in sulfamic acid solution (Section 9.7) for 30 to 90 seconds. Rinse thoroughly. **FL 2**

g. (2)
- (a) Prepare aluminum alloys for plating in accordance with BAC5714. **FL 4**
- (b) Prepare copper alloys for plating in accordance with BAC5770. **FL 4**

More than 2 hours delay for abrasive cleaned and more than 16 hours for polished parts

In case of delay in plating (more than 10 minutes for wet processed parts)

No delay in plating **FL 4**

8.2 FLOW CHART (Continued)

h. Immerse in Solution 11 cyanide holding bath, of BAC5625 or Solution 11 of BAC5751. Maximum immersion time 4 hours.

Aluminum and Copper Alloys

Optional step for abrasive cleaned parts

i. If further masking is required manual solvent clean, after masking, all unmasked areas in accordance with BAC5750 using MEK (5l.), acetone (5b.) or BMS11–7 (5e.)

j. Cold water rinse (100 F maximum). **FL 2**

PH and other corrosion resistant steels, nickel and cobalt–based alloys, and heat–resistant alloys (other than Class 3) **FL 1 FL 3**

Low alloy steels where Class 2 or Class 4 is permitted

Low alloy and PH steels:
(1) Where drawing specify "Class 3" (Optional for Class 2)
(2) Parts with partially nickel–plated areas

k. (1)

Nickel strike: anodically etch in nickel strike solution (Section 9.6) for up to 2 minutes at 30 to 35 ASF (0.21 to 0.24 ASI):
Instantly follow with cathodic current for 3 to 4 minutes at 10 to 15 ASF (0.07 to 0.10 ASI).
or
Anodic etch in plating bath (Section 9.2) at 1 to 2 ASI for 1/2 to 5 minutes.
or
Cathodically treat in sulfuric acid bath (Section 9.4) at 5 to 6 volts and room temperature for 2 to 3 minutes.
or
Periodic reverse teat in Endox 214 (BAC5625, Solution 21) at 4 to 7 volts. Start anodic for 15 to 25 seconds always keeping the anodic time longer than the cathodic time. Continue periodic reverse treatment for 2 to 10 minutes or until water–break–free surface is obtained. Always end anodic. Electro–less nickel surface shall be hand scoured with Scotch–Brite dry or wet with Endox 214. Hand scouring is optional on other surfaces. Rinse at least 2 minutes before immersion in the chrome plating solution.

k. (2)

Anodic etch in chromic acid bath (Section 9.3) or in plating bath (Section 9.2). Etch at 1 to 2 ASI for 1/2 to 5 minutes. Exception: Etch high molybdenum (for example, 0.5 percent) steel 1 to 15 min.

NOTE: Etching in the plating bath will increase the iron contamination in the bath.

or

Periodic reverse treat in Endox 214 (BAC5625, Solution 21) for 3 to 5 minutes at 2.5 to 5 volts. End the cycle with a 15 to 25 seconds anodic polarity cycle. Rinse 2 to 15 minutes before immersion in the chromium plating bath. (Long rinse times may result in oxide formation which may adversely affect plating adhesion.)

k. (3)

Immerse in sulfuric–HF solution (Section 9.5) with current off. Activate anodically for 60 to 70 seconds at 3 to 4 ASI (3 to 6 ASI for PH steels).

8.2 FLOW CHART (Continued)

l. (1) Cold water rinse (100 F maximum) **FL 2**. Use 2 minute minimum rinse time if Endox 214 activation was used

NOTE: Cold water rinse is not required after anodic etch in plating bath.

l. (2) Cold water rinse (100 F maximum) **FL 2** and examine surfaces; verify that a uniform brown to black smut forms on low alloy steel. No change in appearance will occur for nickel plate, nickel alloys and PH steels. Keep surfaces wet and transfer to plating bath within 7 minutes.

NOTE: The smut formation on low alloy steel is critical to good adhesion.

m. Dummy plate as required to maintain clean anodes. Immerse part in plating solution (Section 9.2) with current off, for 1 to 10 minutes as required to heat part to solution temperature if parts were not activated in the plating bath (Section 8.2k). A strike at 3 to 5 ASI for 30 to 90 seconds is optional. Reduce current to desired range and plate parts to the thickness specified.

Establish the required plating current, time, and any supplemental anoding requirements based on the production experience, or by using test specimens with a configuration representative of the production parts.

(1) Class 2: Plate at a current density specified in Section 9.2.1, 9.2.2, or 9.2.3 as applicable. Plate at a current density compatible with tank temperature, that is, lower temperature requires lower current density. Extension of plating current density limits is allowed for the Econochrome baths (Section 9.2.3), except for Class 3 plating. Refer to Section 8.3.2 and 8.3.3 on current interruptions during plating.

(2) Class 3: Reduce current to 2 to 3 ASI and plate to thickness specified.

(3) Class 4: Plate at the current density and temperature which produces the required hardness (see Section 11.7), generally at high current density and lower temperatures.

NOTE: To improve plating adhesion and minimize chicken wire cracks for Class 2 and 4, use low cathode current density (that is, 2 to 3 ASI) during plating. Excessive plating thickness will reduce plate adhesion and promote chicken wire cracks.

n. Rinse using cold or hot water.

o. Remove maskant.

p. Final rinse as necessary to remove any residual plating solution under maskant. **FL 2**

q. Dry parts.

8.2 FLOW CHART (Continued)

r. Bake parts as soon as possible after plating within 10 hours) in accordance with Section 8.3.1, unless otherwise specified on the drawing.

s. Grind Class 2 or 3 chrome plate in accordance with BAC5032, when required. Polish Class 4 chrome plate, if required (See Section 8.1e.).

t. Inspect to the requirements of Sections 10 and 11.

FL 1 Class 2 parts that have been nickel or electroless nickel plated and have not been allowed to dry after final rinsing may be chrome overplated directly, starting with step m.

FL 2 Maximum Total Dissolved Solids (TDS) for rinse tanks shall not exceed 1000 ppm.

FL 3 Some of the CRES and heat–resist alloys (such as Inconel 625, containing 9 percent molybdenum) have alloying constituents which are difficult to activate. Use separate specimens to establish that the selected activation procedure will permit formation of an adherant plating on these alloys before plating production parts. Cases where an adherant plate cannot be produced by any of the approved processes shall be referred to the Liaison Engineer.

FL 4 Reclean starting at Section 8.2e. if water breaks develop, or if there is evidence of corrosion.

8.3 PROCESS NOTES

8.3.1 HYDROGEN EMBRITTLEMENT RELIEF BAKE (POST–PLATING BAKE)

a. Bake parts within 10 hours after plating, according to the baking schedule shown in Table I, unless otherwise noted on the drawing. A single bake may be used for multiple chrome plating operations provided the time from the initial application of plating current to the part until the start of baking is less than 24 hours.

TABLE I POST–PLATE BAKING SCHEDULE FL 1

BASIS METAL	HEAT TREATMENT	BAKING REQUIREMENTS **FL 2**
Ferrous Alloys, Except Threaded Parts	Below 180 ksi	Not required
Externally Threaded Ferrous Alloy Parts	160 to 220 ksi	3 hours (minimum) at 375 ± 25 F
Ferrous Alloys **FL 3**	180 to 220 ksi	3 hours (minimum) at 375 ± 25 F
Ferrous Alloys **FL 3**	Above 220 ksi	12 hours (minimum) at 375 ± 25 F

8.3.1 HYDROGEN EMBRITTLEMENT RELIEF BAKE (POST–PLATING BAKE) (Continued)

TABLE I POST–PLATE BAKING SCHEDULE FL 1 (Continued)

BASIS METAL	HEAT TREATMENT	BAKING REQUIREMENTS **FL 2**
Ferrous Alloys	Carburized or 440A, B, or C Steels	5 to 8 hours at 275 ± 25 F
300 Series and A–286 CRES	Any condition	Not required
17–7 PH	CH–900	Not required
Nickel Alloy 625 and 718	Any condition	Not required
Aluminum Alloys	Any Condition	1 hour at 200 ± 25 F or 1 hour in boiling water
Beryllium/Copper Alloys	Any Condition	3 hours at 375 ± 25 F
All Other Copper Alloys	Any Condition	Not required

FL 1 Post–plate baking schedule given in Table I applies to parts whose thickest part section is 1 inch or less. For parts with section thicknesses greater than 1 inch, the minimum baking time shall be increased by 1/4 hour for each additional half inch of part thickness.

FL 2 Baking Time is the total cumulative time when the coldest work zone recorder thermocouple is above the minimum of the specified baking temperature range.

FL 3 Including all PH steels except 17–7PH.

b. When the parts are to be subsequently plated with cadmium or cadmium–titanium, the above bake cycles may be:

(1) Interrupted after 6 hours to permit grinding and subsequent plating operation. A minimum of 6 hour bake between each plating cycle is required, followed by a bake cycle that meets the baking requirements for the last plating deposited, or a bake that will complete the required minimum bake for chromium plating, whichever is longer.

(2) Delayed until the completion of cadmium or cadmium–titanium plating operation provided that the time from the initial application of chromium plating current to the part until the start of baking is less than 24 hours. Baking and application of post chromate treatment and primer (as appropriate for drawing–specified finishes) shall be completed before any grind is started.

8.3.2 CURRENT INTERRUPTION TO MEASURE DIMENSIONS (CLASS 2 AND 3 PLATING)

Use either method below.

a. Alternate Method No. 1

(1) Reduce power to zero amps.

(2) Remove part and measure plating thickness or dimensions; keep the part wet with the chrome plating solution during the entire operation.

8.3.2 CURRENT INTERRUPTION TO MEASURE DIMENSIONS (CLASS 2 AND 3 PLATING) (Continued)

(3) Return part to the plating bath within 5 minutes.

(4) Allow to soak in plating bath with current off for 10 minutes.

(5) Anodic etch in plating bath at 1 to 2 ASI for 30 to 60 seconds.

(6) Apply cathodic current at 5 to 60 ASF (0.03 to 0.42 ASI) for 10 minutes.

(7) Increase the current to the normal current density over 5 to 10 minutes and continue plating in accordance with Section 8.2m.

b. Alternate Method No. 2

(1) Reduce power to zero amps; do not turn power off.

(2) Remove part from bath to check plating. If part is contacted in any manner or rinsed, it shall be kept wet at all times by frequent immersion in water or the chrome plating solution. If the part is not contacted, for example, removed to check treeing, the chrome solution may be allowed to dry on the part.

(3) Return the part to plating bath at zero amps within 5 minutes.

(4) Soak parts for 2 to 5 minutes at zero amps; power shall be on.

(5) Increase the power to the normal current density over 5 to 10 minutes and continue plating in accordance with Section 8.2m.

8.3.3 OTHER CURRENT INTERRUPTION (CLASS 2 AND 3 PLATING)

a. Preferred Procedure to Reactivate and Resume Plating

Clean and rinse according to BAC5408, BAC5749, BAC5750, or BAC5763 as necessary and process in accordance with Section 8.3.2a., starting at step (4), or Section 8.3.2b., starting at step (5).

b. Alternate Procedure to Reactivate and Resume Plating

(1) Clean and rinse in accordance with BAC5408, BAC5744, BAC5749, BAC5750, or BAC5763 as necessary.

(2) Electrolytically clean using Endox 214 BAC5625, (Solution 21) as follows:

(a) Immerse hardware in Endox 214. Set voltage at 4 to 6 volts DC and periodic reverse clean, 15 seconds anodic and 5 seconds cathodic, for 3 minutes. End with an anodic cycle for 10 to 20 seconds.

(b) Remove hardware from the solution and visually examine the surface. Remove obvious contamination by hand sanding with fine silicon carbide abrasive paper and/or scour with a gray Scotch–Brite pad wetted with Endox.

8.3.3 OTHER CURRENT INTERRUPTION (CLASS 2 AND 3 PLATING) (Continued)

(3) Activate the chrome plate in Endox 214 using the same periodic reverse cycle as defined in step (2)(a) above.

(4) Water rinse for 5 to 7 minutes. Do not allow parts to dry.

(5) Make electrical connections. Set rectifier at “0” volts and immerse hardware in the chrome plate solution. Soak for 5 to 7 minutes.

(6) Increase the current to the normal current density over 5 to 10 minutes and continue plating in accordance with Section 8.2, step m.

8.3.4 UNATTENDED PLATING

Class 2 and 3 plating may be done without anyone in attendance. If desired plating thickness has been attained, continue processing at Section 8.2p. If current has been interrupted without reaching the desired plating thickness, parts shall be reactivated in accordance with Section 8.3.2a., beginning at step (4), or Section 8.3.2b., beginning at step (5), before plating is continued.

8.4 REWORK

The following rework shall be documented as required by the applicable quality assurance provisions.

a. Parts with insufficient Class 2 or 3 plating thickness may receive additional chrome plating. Remask as required and process in accordance with Section 8.3.4.

b. Parts that have blisters or show other evidence of non–adhesion or poor quality plating, including cracks in the as–deposited plating, shall be stripped to the basis metal and baked in accordance with BAC5771, and replated.

c. Plated parts ground in accordance with BAC5032 shall be reworked, if required, in accordance with the rework provisions of that specification.

d. Parts used for plating thickness and coverage checks to establish plating conditions (that is, anode configuration, plating time, and current density) may be stripped of plating and baked in accordance with BAC5771, and replated.

9 MAINTENANCE CONTROL

9.1 GENERAL REQUIREMENTS

a. Agitate the solutions to prevent temperature stratification and to ensure complete mixing at least once each shift, and always before reuse after standing idle longer than 4 hours. The SRHS bath (Section 9.2.2) requires more agitation than other baths to assure proper catalyst distribution throughout.

b. The general procedure for makeup of solutions is as follows:

(1) Clean the makeup tank.

(2) Unless otherwise specified, fill the tank two–thirds full of water.

9.1 GENERAL REQUIREMENTS (Continued)

(3) Adjust bath temperature, if required.

(4) Add the required amount of solid chemicals by spreading uniformly over the tank surface, and mix until dissolved.

Alternate: Chemicals which tend to cake on the bottom of the tank should be placed in a fine–mesh basket, hung in the tank, and the solution agitated until the chemicals are dissolved.

(5) Add concentrated liquid acids slowly to water or aqueous solutions when diluting them and mix thoroughly. Add the principle acid (especially sulfuric acid) first, and allow the solution to cool down before adding other acids.

(6) Add water to the operating level and mix thoroughly.

(7) Adjust the bath temperature to be within the required temperature range.

c. Keep anodes free of encrusted deposits, and maintain bus bars and contacts in a clean condition to assure proper electrical conductivity. To remove deposits on lead anodes, scrub with Scotch–Brite and wipe clean with moist rags. Do not allow deposits on the lead anodes to go into the process solution. Rinse lead anodes before and after immersing anodes in Solution 9.8.

d. Do not allow parts to contact settled sludge in the bottom of plating tanks.

(1) Desludge the SRHS solution (Section 9.2.2) by the following procedure:

(a) Heat the bath to 150 F and stir up sludge vigorously.

(b) Allow the bath to settle for at least 30 minutes.

(c) Siphon off all but a few inches of plating solution into a clean (heated if possible) storage tank.

(d) Remove and discard the sludge and remaining solution.

(e) Clean the plating tank and return the previously siphoned–off plating solution.

(f) Restore the plating solution to correct concentration by the addition of Unichrome CR–110 compound as indicated in Section 9.2.2.

(g) Heat the bath to 135 to 145 F and add 5 pounds of Unichrome CR–204 compound for each 100 gallons of solution, stirring bath thoroughly. If the Unichrome CR–204 dissolves completely, repeat the addition. An excess will not harm the proper function of the bath.

(h) Reduce the temperature of the plating bath to proper operating limits.

9.1 GENERAL REQUIREMENTS (Continued)

(2) Desludge the standard chrome (Section 9.2.1) and Econochrome (Section 9.2.3) plating solutions by filtering with the aid of an acid–proof filter pump, or by siphoning off liquid into a clean holding tank and removing the sludge manually.

(3) Use a 5–micron filter maximum for removing fine particulate matter when siphoning off the solution and when returning it to the plating bath.

e. Table II may be used as a guide in estimating the time necessary to deposit the required chrome plate thickness. Actual plating rates may vary ± 50 percent or more from these values, depending on anode condition, anode configuration, and the condition of the plating solution.

TABLE II NOMINAL PLATING RATE (INCH/HOUR AT 130 F)

CURRENT DENSITY (ASI)	DILUTE STANDARD BATH	CONCENTRATED STANDARD BATH	SRHS AND ECONOCHROME BATHS
1	0.0003	0.0002	0.0004
2	0.0009	0.0007	0.0012
3	0.0015	0.0012	0.0020
4	0.0021	0.0018	0.0028
5	0.0029	0.0023	0.0036

9.2 CHROME PLATING BATHS

9.2.1 STANDARD CHROME PLATING BATHS

Plating solution tank makeup and operating conditions shall be as shown below:

MATERIAL/ CONDITION	DILUTE STANDARD BATH		CONCENTRATED STANDARD BATH	
	MAKEUP/ 100 GALLONS	CONTROL	MAKEUP/ 100 GALLONS	CONTROL
Chromic Acid (5f.) CrO_3 **FL 4**	200 lb	30 to 35 oz/gal.	330 lb	50 to 55 oz/gal.
CrO_3/SO_4 Ratio				
Class 1, 2 or 4	– – –	100 ± 15 **FL 1** **FL 5**	– – –	100 ± 15 **FL 1** **FL 5**
Class 3		95 ± 10 **FL 6**		95 ± 10 **FL 6**
Trivalent Chromium	– – –	0.53 oz/gal. max.	– – –	0.53 oz/gal. max.
Iron	– – –	1.0 oz/gal. max.	– – –	1.0 oz/gal. max.
Water	– – –	**FL 2**	– – –	**FL 2**
Temperature	– – –	110 to 140 F	– – –	110 to 140 F
Class 1		120 to 140 F		

9.2.1 STANDARD CHROME PLATING BATHS (Continued)

MATERIAL/ CONDITION	DILUTE STANDARD BATH		CONCENTRATED STANDARD BATH	
	MAKEUP/ 100 GALLONS	CONTROL	MAKEUP/ 100 GALLONS	CONTROL
Class 2		(130 to 140 F Preferred)		
Class 3		130 to 140 F		130 to 140 F
Class 4		120 to 130 F		
Anodes	– – –	In accordance with Section 5d.	– – –	In accordance with Section 5d.
Current Density Range	– – –			
Class 1, 2 or 4		1 to 5 ASI **FL 3**		1 to 5 ASI **FL 3**
Class 3		2 to 3 ASI		2 to 3 ASI

FL 1 Do not add sulfuric acid on makeup. Dissolve the chromic acid in water, dilute to volume, analyze for SO_4, and add sulfuric acid (Section 5y.) as required to achieve the CrO_3/SO_4 ratio of 100 to 1.

FL 2 Use distilled or deionized water if the total dissolved solids in water exceeds 450 ppm, or if the total dissolved chlorides exceeds 50 ppm.

FL 3 For ferrous alloys, current density range is 1 to 4 ASI. For aluminum and copper alloys, current density range is 1 to 5 ASI.

FL 4 When chromic acid liquid concentrate is used for bath makeup, use 16.5 gallons of liquid concentrate to make 100 gallons of dilute standard bath (33 oz/gal) and use 27.25 gallons of liquid concentrate to make 100 gallons of concentrated standard bath (55 oz/gal). To add 1 ounce of chromic acid/100 gallons of solution, add 0.52 gallons of liquid concentrate.

FL 5 To improve plating adhesion and minimize chicken wire cracking, it is recommended to keep this ratio between 95 to 1 and 100 to 1.

FL 6 To improve plating adhesion, it is recommended to keep this ratio between 90 to 1 and 95 to 1.

9.2.2 SELF–REGULATING HIGH–SPEED UNICHROME CR–110 BATH (SRHS)

Plating solution tank makeup and operating conditions shall be as shown below:

MATERIAL/ CONDITION	MAKEUP/ 100 GALLONS	CONTROL	REMARKS
Water (Initial)	2/3 of final volume	**FL 1**	Adjust temperature to 120 F.
Unichrome Compound CR–110 (Section 5q.)	230 lb **FL 2**	33.6 to 40.0 oz/gal	Add CR–204 (Section 5r.) or CR–110 (Section 5q.) in accordance with manufacturer's instructions to maintain concentration. Agitate 2 to 3 hours after makeup or additions.
Trivalent Chromium		0.53 oz/gal max.	
Iron		1.0 oz/gal max.	
Water (Final)	Balance required	**FL 1**	Add balance of water to operating level and mix solution thoroughly.
Temperature			
Class 1, 2 or 4	– – –	120 to 140 F	– – –
Class 3	– – –	130 to 140 F	
Anodes		In accordance with Section 5d.	Clean anodes frequently. **FL 3**
Current Density Range			
Class 1, 2 or 4	– – –	1 to 5 ASI **FL 4**	– – –
Class 3	– – –	2 to 3 ASI	

FL 1 Use distilled or deionized water if the total dissolved solids in water exceeds 450 ppm, or if the total dissolved chlorides exceeds 50 ppm.

FL 2 When removing a small amount of CR–110 compound from a large container, mix thoroughly before withdrawal to ensure uniform catalyst distribution.

FL 3 Arrange anodes in tank to prevent etching in low current density areas.

FL 4 For ferrous alloys, current density range is 1 to 4 ASI. For aluminum and copper alloys, current density range is 1 to 5 ASI.

9.2.3 ECONOCHROME PLATING BATHS

Plating solution tank makeup and operating conditions shall be as shown below:

MATERIAL/ CONDITION	ECONOCHROME 40 BATH		ECONOCHROME S BATH		
	MAKEUP/ 100 GALLONS	CONTROL	MAKEUP/ 100 GALLONS	CONTROL	REMARKS
Water (Initial)	2/3 of final volume	**FL 1**	2/3 of final volume	**FL 1**	Adjust temperature to 125 F.
Chromic Acid CrO_3	205 lb Econochrome 40 (Section 5o.)	18 to 40 oz/ gal. (28 to 32 oz/gal. optimum)	125 lb Econochrome S (Section 5n.)	18 to 21 oz/gal.	Agitate until completely dissolved. Maintain with Econochrome (Sections 5n. or 5o.) or chromic acid (Section 5f.).
Trivalent Chromium		0.53 oz/gal. max.		0.53 oz/gal. max.	
Iron		1.0 oz/gal. max.		1.0 oz/gal. max.	
CrO_3/66 Ratio	As required **FL 2**	25 to 50 **FL 2**	As required	5.0 to 6.7	Maintain with Econochrome 66 (Section 5p.).
CrO_3/SO_4					
Ratio Class 2, 4	As required	75 to 200 (75 to 125 optimum) **FL 2 FL 4**	As required	105 to 200 (125 to 155 optimum) **FL 2 FL 4**	Maintain with sulfuric acid (Section 5y.)
Class 3	– – –	95 ± 10 **FL 2 FL 5**	– – –	95 ± 10 **FL 2 FL 5**	– – –
Water (Final)	Balance required	**FL 1**	Balance required	**FL 1**	Mix solution thoroughly.
Electrolyze (Dummy)	Electrolyze 1 to 2 hours at 100 to 130 ASF. Use a dummy cathode area of 2.7 to 3.3 square feet/100 gallons. Repeat as required to remove metallic impurities.				

9.2.3 ECONOCHROME PLATING BATHS (Continued)

MATERIAL/ CONDITION	ECONOCHROME 40 BATH		ECONOCHROME S BATH		
	MAKEUP/ 100 GALLONS	CONTROL	MAKEUP/ 100 GALLONS	CONTROL	REMARKS
Temperature					
Class 1		115 to 150 F		115 to 150 F	
Class 2		120 to 140 F (130 to 140 F preferred)		120 to 140 F (130 to 140 F preferred)	
Class 3	– – –	130 to 140 F	– – –	130 to 140 F	– – –
Class 4		120 to 130 F		120 to 130 F	
Anodes		In accordance with Section 5d.		In accordance with Section 5d.(1) or 5d.(2)	Clean anodes frequently.
Current Density					
Class 1, 2 or 4		0.7 to 4.0 ASI		1.0 to 4.5 ASI	**FL 3**
Class 3	– – –	2 to 3 ASI		2 to 3 ASI	

FL 1 Use distilled or deionized water if the total dissolved solids in water exceeds 450 ppm, or if the total dissolved chlorides exceeds 50 ppm.

FL 2 Ratio of CrO_3/SO_4 is unitless. Ratio of CrO_3/66 is oz/gal CrO_3 to units/gal Econochrome 66. 1 unit = 1.28 fl. oz. of Econochrome 66.

FL 3 Etching of parts may occur below the lower current density limit. Each plating setup should be such that the lowest current density areas are above this limit.

FL 4 To improve plating adhesion and minimize chicken wire cracking, it is recommended to keep this ratio between 95 to 1 and 100 to 1.

FL 5 To improve plating adhesion, it is recommended to keep this ratio between 90 to 1 and 95 to 1.

9.3 CHROMIC ACID ETCH BATH

Make up and maintain bath at 30 to 50 ounces chromic acid (Section 5f.) per gallon of solution.

9.4 SULFURIC ACID ETCH BATH

Make up and maintain bath as indicated below:

MATERIAL/CONDITION	MAKEUP/100 GALLONS	CONTROL
Sulfuric Acid (Section 5y.)	10 gallons	20 to 24 oz/gal. as H_2SO_4
Temperature		86 F maximum

9.5 SULFURIC–HF ETCH BATH

Make up and maintain bath as indicated below.

MATERIAL/CONDITION	MAKEUP/100 GALLONS	CONTROL
Sulfuric Acid (5y.)	25 gallons	50 to 70 oz/gal. as H_2SO_4
Hydrofluoric Acid (5j.)	4 gallons	3 to 6 oz/gal. as F^-
or	or	
Ammonium Bifluoride (5c.)	46 pounds	
Dissolved Iron		1.5 oz/gal. maximum
Temperature		60 to 100 F
Electrodes		In accordance with Sections 5d.(1), 5d.(2), or 5d.(5)

9.6 NICKEL STRIKE BATH

Make up and maintain bath as indicated below.

MATERIAL/CONDITION	MAKEUP/100 GALLONS	CONTROL
Nickel Chloride (5m.)	200 lb	30 to 35 oz/gal. as $NiCl_2$ $6H_2O$
Hydrochloric Acid (5i.)	8.6 gallons	3.7 to 4.3 oz/gal. as HCl
Dissolved Iron		1 oz/gal. maximum **FL 1**
Temperature		60 to 100 F
Anodes **FL 2**		In accordance with Sections 5d.(5) and 5d.(6) **FL 3**
Anode/Cathode Ratio		1:1 minimum

FL 1 Make up a new tank when this level is reached.

FL 2 Use anode bags with all anodes.

a. Boil unbleached muslin in a solution of 1 ounce of sodium hydroxide per gallon of water for 30 minutes followed by soak in dilute (1 percent) hydrochloric or sulfuric acid, or

b. Use Dacron bags. Soak in alkaline cleaning solution and rinse thoroughly.

FL 3 Use nickel and/or carbon anodes as required to maintain the required dissolved nickel concentration. Remove nickel anodes when the bath is not in use for prolonged periods of time.

9.7 SULFAMIC ACID

Make up sulfamic acid at 13 to 15 ounces/gallon with tap water. Operate at room temperature.

9.8 LEAD ANODE CLEANER

Make up and maintain baths as indicated below.

MATERIAL/ CONDITION	MAKEUP/ 100 GALLONS	CONTROL	REMARKS
Sodium Hydroxide	150 lbs	Discard when no longer effective	Agitation before use is not required.
Sodium Gluconate	150 lbs		
Water	Balance		
Temperature		Room	

MATERIAL/ CONDITION	MAKEUP/ 100 GALLONS	CONTROL	REMARKS
Sodium Hydroxide	100 lbs	Discard when no longer effective	Agitation before use is not required.
Rochelle Salts	100 lbs		
Water	Balance		
Temperature		Room	

10 QUALITY CONTROL

10.1 GENERAL

a. Accept parts only when both Section 10.2 (Process acceptance criteria) and Section 10.3 (plated parts acceptance criteria) are met.

b. Ensure compliance with the plated parts acceptance criteria of Section 10.3. Acceptance of parts for the requirements of Sections 11.2, 11.3, 11.4, 11.6 and 11.9 may be on the basis of sampling with an AQL of 1.5 in accordance with MIL–STD–105 or with an equivalent sampling procedure. When experience warrants, a skip–lot plan based on MIL–STD–1235 may be used for successive lots of similar parts.

c. A laboratory approved by The Boeing Company will analyze the process tank solutions at regular intervals adequate to ensure that each remains within specified limits (see Section 9). For Class 3, chromic acid and sulfate concentrations shall be analyzed at least weekly that the plating bath is in use. A record shall be kept of any additions, purifications or withdrawals required to keep solutions within these limits.

d. Sulfate analysis by the centrifugation method is not allowed. The centrifugation method gives high values for the barium sulfate precipitate produced during the analysis. This leads to apparent CrO_3/SO_4 ratios lower than actually present in the solution. The gravimetric method for determination of sulfate ion is preferred for the highest accuracies, however instrumental methods may be used if their accuracies can be documented against suitable certified standards.

10.2 PROCESS ACCEPTANCE CRITERIA

a. Adhesion and plating hardness shall be tested on a periodic basis and shall meet the requirements of Section 11.5, and 11.7, respectively. Begin testing frequency in accordance with Table III. Begin sampling at frequency levels shown in Figure 1.

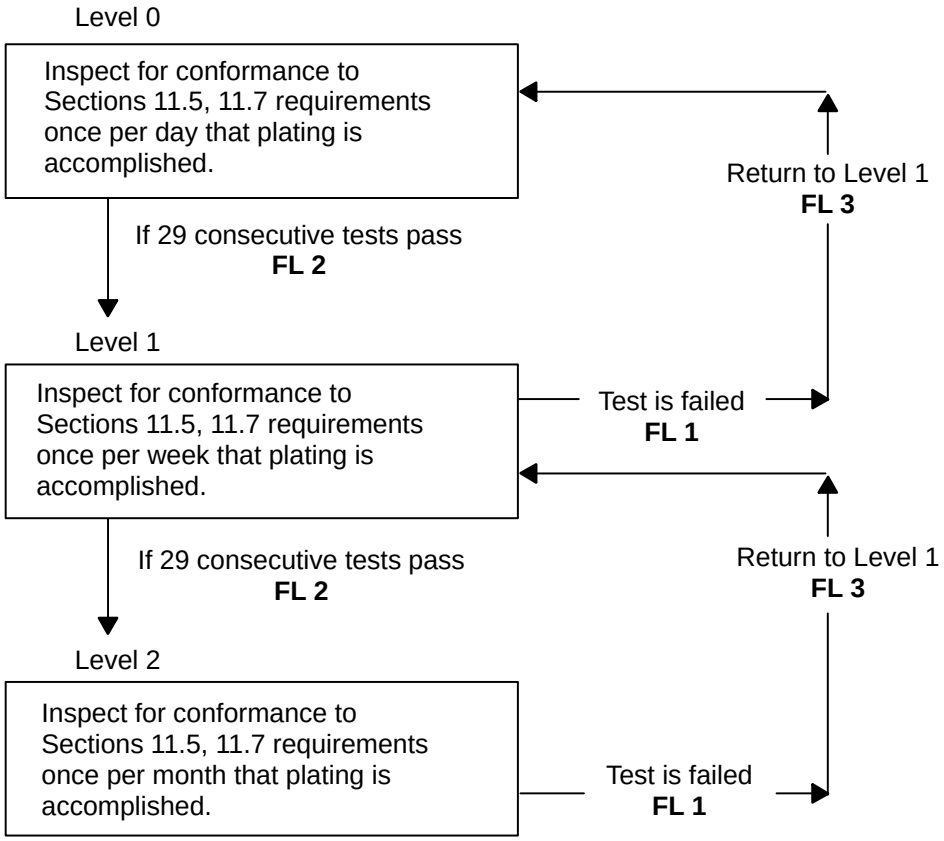
b. Process control requirements for hydrogen embrittlement (Section 11.8) shall be required for initial approval to this specification, for approval of chromium baths alternate to those listed in Section 9.2, and for any change from the originally approved process. Boeing Quality Assurance reserves the right to run periodic tests as deemed necessary to ensure that production parts are not hydrogen embrittled.

c. The process is acceptable if the requirements of Section 11 have been met.

TABLE III STARTING SAMPLING FREQUENCIES

PLATING CLASS	ADHESION	HARDNESS
Class 2	Level 2	Level 2
Class 3	Level 0	Level 2
Class 4	Level 0	Level 0

10.2 PROCESS ACCEPTANCE CRITERIA (Continued)



FL 1 All production parts plated since the most recent testing shall be rejected.

FL 2 This condition applies to each requirement separately, and each tank separately.

FL 3 Corrective action is to be taken and recorded and evidence of subsequent successful test given before plating is resumed.

FIGURE 1 INSPECTION LEVELS/SAMPLING FREQUENCIES

10.3 PLATED PARTS ACCEPTANCE CRITERIA

a. Ensure that all parts have been processed to meet the requirements of process acceptance criteria, Section 10.2.

b. Ensure that all plated parts have met requirements, Sections 11.1 through 11.10, as applicable.

10.4 PURCHASER QUALITY CONTROL FOR CLASS 4

a. Quality Assurance shall obtain copies of the Class 4 certifications and tests reports from each lot of production parts. These shall be used to ascertain that plating was performed in accordance with Section 11.

b. All certificates covering Class 4 plating on parts which become integrated into assemblies or subassemblies shall be retained by the purchaser for examination by The Boeing Company for 3 years.

11 REQUIREMENTS

11.1 STRESS RELIEF

a. The plater shall receive written verification from the parts fabricator that all stress relieving has been accomplished as specified below. The parts fabricator is responsible for the stress relief.

b. All ferrous parts heat treated to 180 ksi (160 ksi for externally threaded parts) or higher shall be stress relieved prior to plating if any of the following operations have been performed after heat treatment: grinding, machining, straightening, forming or proof loading (exceptions: honing, lapping, shot peening, cold working of holes, or thread rolling). In addition, stress relief is required if the part has been in service. When stress relief is required, it shall be performed in accordance with BAC5617, BAC5618 or BAC5619 as applicable. Stress relief after grinding, machining, straightening, forming, or proof loading shall be performed prior to shot peening.

EXCEPTIONS: If grinding, machining, straightening, forming or proof loading are required in localized area after shot peening, cold working of holes and/or cadmium–titanium plating, stress relieve at 375 ± 25 F (or at 275 ± 25 F for carburized parts and 440A, B, or C corrosion resistant steel parts for 3 hours minimum).

11.1 STRESS RELIEF (Continued)

c. Unless otherwise specified, the following alloys do not require a stress relief prior to processing.

(1) 300 series and A286 corrosion resistant steels

(2) 17–7PH (CH–900 condition)

(3) Nickel Alloy 625 and 718

d. If more than one plating operation (including different platings and replating) is required, stress relief shall be accomplished only once.

11.2 WORKMANSHIP

a. When examined with the unaided eye, the chrome plate shall be smooth, fine–grained, adherent, and visibly free from blisters, pits, nodules, porosity, excessive edge build up, and indications of burning or arcing. Slight discolorations resulting from baking or superficial staining from rinsing shall not be be cause for rejection.

b. Plating on functional areas will be smooth and free from frosty areas. Edges of plating that cover only a portion of the surface will, after finishing in accordance with the drawing, be free of beads, nodules, and jagged edges. See Section 8.1f.

c. Micropits in Class 2 or 3 plate which are due to incomplete removal of as plated surface during grinding shall not be cause for rejection provided other requirements of this specification are met.

11.3 PLATING THICKNESS

a. The chrome plate thickness shall be as specified on the applicable drawing. The thickness requirement applies to plating after all required metal finishing operations have been completed. Where no definite plating thickness requirement is specified, it shall be 0.003 inch minimum for Class 2 and 3, and 0.0003 to 0.0005 inch for Class 4.

NOTE: Operator is responsible for correcting readings to take into account thermal expansion.

b. Part surfaces designated on the drawing shall be completely covered with visible chrome plating, within the capability of the throwing power of the plating solution. Unless otherwise specified by the drawing, measurements for plating thickness apply only to those surfaces that can be touched by a metal ball 0.75 inch in diameter, but shall not apply to the runout area.

11.4 CRACKED PLATING

The chrome plating shall not show any evidence of cracking, when examined with the unaided eye.

11.5 PLATING ADHESION

The chrome plate and any electrodeposited undercoat shall be firmly adherent and will show no delamination or separation from the base metal or from each other at their common interface, when tested in accordance with Section 12.3. Cracks found in the basis metal or plating attributable to the test procedure specified in Section 12.3, but not resulting in flaking, peeling or blistering of the plating, will not be considered cause for rejection to the adhesion requirements.

When the chisel test is used, plating adhesion is considered acceptable if the fracture region after the test contains over 60 percent of electrodeposited chromium. Local exposure of basis metal at the point of chisel impact is required.

11.6 SURFACE ROUGHNESS

When tested in accordance with Section 12.4 the plating shall meet the following requirements.

a. The surface roughness of plating shall meet the requirements stated on the drawing.

b. For Class 4 parts the as plated surface shall have a surface finish equal to the unplated surface without having to be ground, honed, lapped or otherwise treated.

EXCEPTION: Parts requiring an R_a 16 or finer finish may be lightly polished in accordance with Section 8.1e.(1) after plating. Where no surface finish is specified on the drawing, the surface shall be no rougher than R_a 32.

11.7 PLATING HARDNESS

When tested in accordance with Section 12.5, the plating shall meet the following requirements.

a. Class 2 and 3 plating will have a minimum hardness equivalent to R_c 55 (630 Knoop or 595 Vickers).

b. Class 4 plating will have a minimum microhardness equivalent to R_c 67 (895 Knoop).

11.8 HYDROGEN EMBRITTLEMENT

When tested in accordance with Section 12.6 the plating shall meet the following requirements.

a. Notched tensile specimens for hydrogen embrittlement testing shall sustain 200 hours of continuous tensile loading at 75 percent of the ultimate tensile stress without failure.

b. Inspection required for initial approval to specification.

11.9 APPEARANCE, CLASS 1 PLATING

Parts requiring Class 1 decorative plating shall match required appearance standards as specified by the Engineering drawing.

11.10 HYDROGEN EMBRITTLEMENT RELIEF BAKE

All parts shall be baked for the correct time and temperature as required in Section 8.3.1.

12 TEST METHODS

Test specimens may be tested in lieu of parts provided the specimens were processed in the same manner as the parts they represent.

12.1 THICKNESS

a. Select samples as specified in Section 10.1b. and perform thickness measurements of chrome plating by any method that provides accuracy within ± 10 percent of the specified thickness requirement.

b. Thickness measurement will be performed on the plating after baking, supplemental treatments and any grinding, if required, are completed.

12.2 CRACKED PLATING

Select samples as specified in Section 10.1b. and view the chrome plated surface with the unaided eye using oblique light. Change the viewing angle and direction several times to ensure crack detection.

12.3 PLATING ADHESION

a. Evaluate a production part (destructive test) or test specimen in accordance with the frequency specified in Section 10.2a.

b. Test specimens are recommended when production parts are too expensive for destructive testing or are produced in small lot sizes. The test specimens shall be processed using the same procedures, solutions and facilities (except rectifiers) as the parts represented. See Figure 2 for recommended adhesion specimen configuration.

c. The test specimens shall be of the same alloy, heat treatment, and surface finish of the parts represented with the exceptions noted in Table IV.

d. Refer to Table IV for test specimen configuration and plating thickness.

e. Chisel Test

When the heat treated chisel test specimen of Figure 2 is used, it is to be tested with a chisel (Section 5z.(2)) configured as shown in Figure 4. The chisel tip shall be held tightly against the plating/basis metal interface and struck using a one pound (0.45 kg) no–bounce plastic–tipped hammer (Section 5z.(1)) in the direction shown in Figure 3 to chip the chrome plate. The fracture zone shall be visually examined for evidence of plating separation from the basis metal according to the fracture patterns of Figure 3. Exposed basis metal shall be verified on low alloy steels by swabbing with a solution containing 16 grams/liter copper sulfate and 5 milliliter/liter sulfuric acid. A copper color indicates exposed basis metal. PH and other corrosion resistant steels cannot be tested for exposed basis metal by the copper sulfate test, but shall be tested by other methods that detect presence of chromium at levels above those present in the basis metal.

12.3 PLATING ADHESION (Continued)

f. Bend Test

Bend the specimen repeatedly through an angle of 180 degrees until fracture of the basis metal occurs. Use a knife and attempt to pry or lift the plating from the edge of the fracture. Examine the chipped area under 10× or higher magnification for evidence of delamination or separation of the plating from the basis metal at the interface by determining whether removal has been caused by chipping or cutting away of an adherent plate, or by lifting of an non–adherent plate.

TABLE IV PLATING ADHESION TEST SPECIMEN CHARACTERISTICS FL 1

BASIS METAL	TEST SPECIMEN	CONFIGURATION	MINIMUM PLATING THICKNESS, INCH
Low Carbon Steels	Low Carbon Steels	Figure 2(a) or Figure 2(b)	0.006 **FL 2** 0.003 **FL 2** 0.0003 to 0.0005 **FL 3**
Low Carbon Steels, Low Alloy Steels (Below 220 ksi Ultimate Tensile Strength)	AISI 4130	Figure 2(a) or Figure 2(b)	0.006 **FL 2** 0.003 **FL 2** 0.0003 to 0.0005 **FL 3**
High Strength Low Alloy Steels (Above 220 ksi Ultimate Tensile Strength): AISI 4330 AISI 4330M AISI 4340 AISI 4340M (300M) D6AC AMS 6407 Low Carbon Steels, Low Alloy Steels (Below 220 ksi Ultimate Tensile Strength)	AISI 4340M (300M)	Figure 2(a)	0.006 **FL 2 FL 4**
15–5PH CRES 17–4PH CRES	15–5PH CRES 17–4PH CRES	Figure 2(a) or Figure 2(b)	0.006 **FL 2** 0.003 **FL 2** 0.0003 to 0.0005 **FL 3**

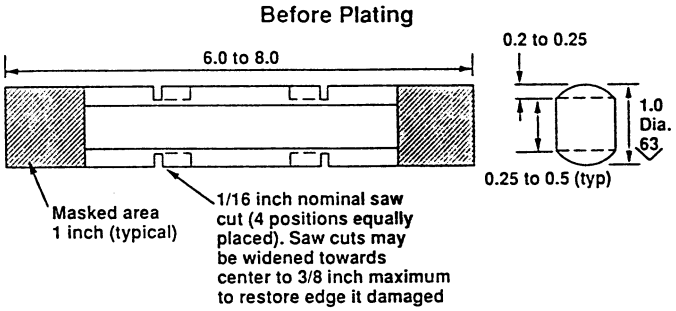
FL 1 For other basis metals, consult Boeing Materials Technology.

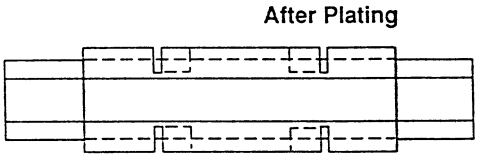
FL 2 For Class 1, 2 and 3.

FL 3 For Class 4.

FL 4 Bend test specimen not allowed for Class 3.

12.3 PLATING ADHESION (Continued)





All dimensions are in inches

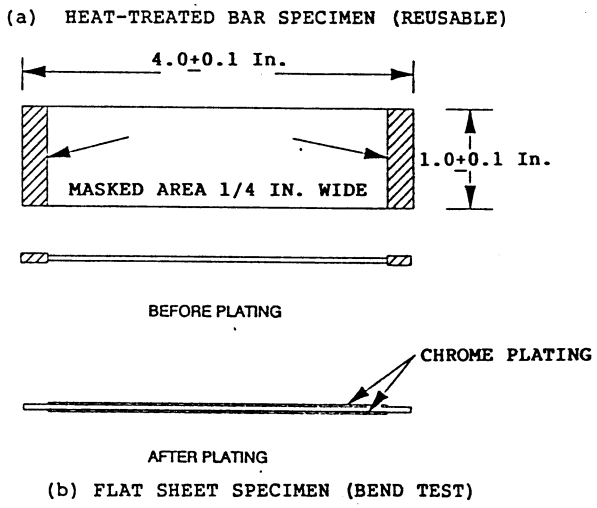


FIGURE 2 SPECIMENS FOR ADHESION TESTING CHROME PLATE

12.3 PLATING ADHESION (Continued)

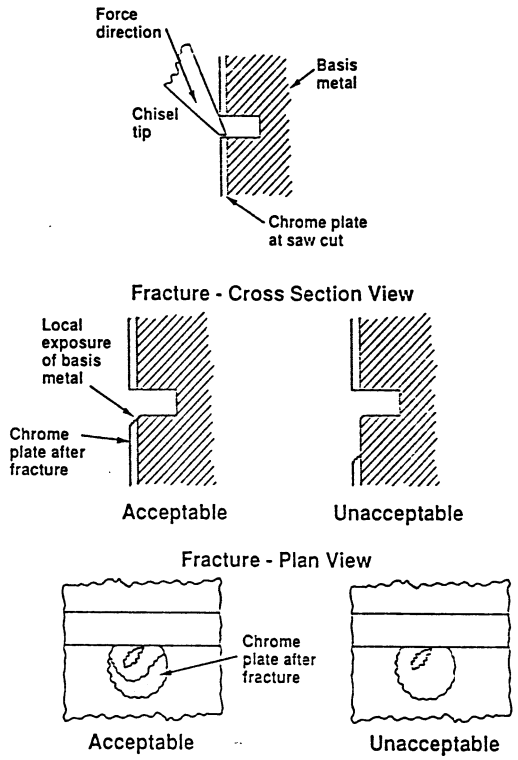
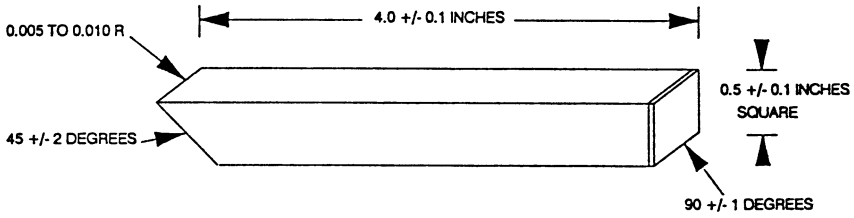


FIGURE 3 CHISEL TEST/FRACTURE PATTERNS



MATERIAL: AISI M34 OR EQUIVALENT TOOL STEEL

NOTE: BAR MAY BE REGROUND AS SHOWN TO RESTORE CHISEL EDGE

FIGURE 4 CHISEL FOR CHISEL TEST

12.4 SURFACE ROUGHNESS

Select production parts as specified in Section 10.1b. and evaluate the surface roughness of the chrome plate by visual/tactile comparison with suitable roughness standards, or by direct instrumental measurement in accordance with BACD2097, as applicable.

12.5 PLATING HARDNESS

a. Use a production part (destructive test) or test specimens as specified in Section 10.2a. and Figure 5. The hardness of Class 2 and 3 plating shall be determined by a microhardness traverse on a metallographic cross–section of the plating deposit in accordance with ASTM B 578 except that a 100 gram load only shall be used.

b. Inspection of Class 2 and 3 plating hardness is required for initial approval to this specification, for approval of chromium baths alternate to those listed in Section 9.2 and for any change from the originally approved process.

c. Class 4 plating shall be microhardness tested in accordance with ASTM E 384 using a Knoop indenter.

(1) The recommended test specimen is shown in Figure 5. The surface to be tested will have an R_a 16 or finer surface finish. The test specimen may be polished to provide an adequate surface for microhardness testing provided the final plating thickness is a least 0.0004 inch.

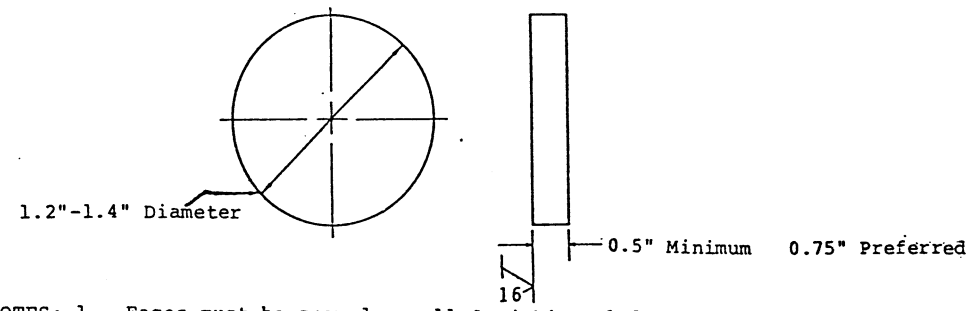
(2) Alternate Method

Hardness may be determined by microsectioning and mounting a part or specimen with a 0.003 inch or thicker chrome plate. Measurement may be made using the Knoop or Vickers indenters.

d. The back and sides of the hardness test specimen or mount shall be clamped during testing to maintain the flat surface normal to the axis of the indenter within $\pm$ 1 degree, and to prevent rocking or rolling under load.

e. The test load will be 100 grams applied normal to the plate, and hardness readings shall be approximated to Rockwell C values using the conversion table for Knoop 500g, in accordance with, Table labeled: “Approximate Hardness Conversion Numbers for Non–Austenitic Steels (Rockwell C Hardness Range) of ASTM E 140”. The average of at least 5 readings shall be used to determine hardness acceptability.

12.5 PLATING HARDNESS (Continued)



NOTES: 1. Faces must be ground parallel within ± 1 degree.

2. Material: Steel Heat Treated above 220 KSI (Rockwell C 46).

3. Plating thickness to be 0.0005 ± 0.0001 inch on flat surfaces.

FIGURE 5 SPECIMENS FOR CLASS 4 HARDNESS TESTING

12.6 HYDROGEN EMBRITTLEMENT

Two hydrogen embrittlement test specimens are required for each Class. These shall be made from longitudinal grain 4340 steel, heat treated to 260 to 280 ksi in accordance with ASTM F 519, Type 1a.2. D6–4307 may be used as the manufacturing process. The notch shall be completely covered with plating, but the plating thickness need not be uniform on all areas of the notch.

a. Class 2 and 3

The shank shall have a minimum plating thickness of 0.003 inch. The button ends of the specimen and 0.5 to 0.6 inch of adjacent shank shall be left unplated to facilitate testing. After plating, bake specimens 6 ± 0.5 hours at 375 ± 25 F.

b. Class 4

The entire specimen (except contact areas on the ends) shall be plated to a thickness of 0.0003 to 0.0005 inch. After plating, bake specimens 12.5 ± 0.5 hours at 375 ± 25 F.

13 QUALIFICATION

This specification requires qualified suppliers (processors) for Class 4 thin, dense chrome plating.

a. All requests for Class 4 qualification shall be directed to a Materiel Department of The Boeing Company. Requests shall include a facilities report of the plating line (solutions, tank size, sequence), control equipment, baking ovens, and a dated copy of any alternate process specification (or special proprietary control specification) to be used on qualification specimens and production parts.

b. Requests that are acceptable to the Materiel Department shall be forwarded to the Engineering staff, Boeing Materials Technology Unit (for review and technical approval of the facilities report) and to Source Quality Assurance.

13 QUALIFICATION (Continued)

c. Following the above, Source Quality shall survey the processor. The processor shall demonstrate his ability to meet Class 4 requirements by plating test specimens in accordance with Table V.

d. Qualification shall be based on results of the survey and the plating tests. Testing is to be conducted by Boeing Quality Assurance, by Boeing Materials Technology, or by a laboratory approved by Boeing Quality Assurance. Approval is granted by the Boeing Engineering Staff. Qualified suppliers shall be notified in writing by the Materiel Department and shall be listed in the QPL.

e. No changes in raw materials, methods of manufacture or plant location shall be made without notification and prior approval in writing. Requalification of the revised material may be required and a revised supplier designation may be requested.

TABLE V SPECIMEN AND TEST REQUIREMENTS FOR CLASS 4 QUALIFICATION

BASIS MATERIAL	SPECIMEN DESCRIPTION	SPECIMENS FOR TEST BY BOEING	REQUIRED TESTS PARAGRAPH NO.	THICKNESS INCHES	BAKING REQUIREMENTS	
					TEMP (F)	TIME (HR)
17–7 PH Steel	Panels 1 by 4 by 0.02 to 0.040 inch, R_a 32, Plate One Side Only	2	11.2 to 11.6	0.0003 to 0.0005	375 ± 25 F	3 hours minimum
AISI 4130 Steel	Panels 1 by 4 by 0.02 to 0.040 inch, R_a 32, Plate One Side Only	2	11.2 to 11.6	0.0003 to 0.0005	375 ± 25 F	3 hours minimum
AISI 4340 **FL 1** Steel 260–280 KSI UTS	ASTM F 519, Type 1a.2 or D6–4307	2	11.2, 11.3 (micrometer) and 11.8	0.0003 to 0.0005	375 ± 25 F	12.5 ± 0.5 hours
Steel 180 KSI (Rockwell C–40) or Higher	Figure 5	2	11.6 and 11.7	0.0005 ± 0.0001	375 ± 25 F	3 hours minimum

FL 1 Specimens to be furnished by Boeing.