Process Specification for Electrodeposited Chromium Plating

Engineering Directorate

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REVISIONS		
VERSION	**CHANGES**	**DATE**
--	Original version	5/96
A	Formatting; mandates 23 hour hydrogen bakeout for steel alloys.	7/26/99
B	Changed EM references to ES	9/2002
C	Updated specification reference to AMS-QQ-C-320	10/2004
D	Updated specification from AMS-QQ-C-320 to SAE AMS 2460, eliminated zinc and zinc alloys from scope and applicability, put a maximum final thickness class 2 dimension of 0.0050 inches, Does not cover thin dense chromium in the applicability section, Added information on anomalies and surface finishes, Added information and drawing callouts on hydrogen embrittlement and shot peening, Added references and definitions, added process requirements, process verification and process qualification, added appendix on shot peen media sizes and nominal diameters for shot selection.	6/2020
E	Periodic review. Minor updates in section 3. Edited table number of Table 3	3/2026

1.0 SCOPE

This process specification establishes technical requirements for the application of electrodeposited chromium plating on steels.

2.0 APPLICABILITY

This process specification applies to the electrodeposition of chromium plating on steel substrates or similar ferrous materials. This PRC does not cover chromium plating of alloys of copper and zinc. This PRC also does not cover thin dense chrome plating.

3.0 USAGE

This process specification shall be called out on the engineering drawing by using a drawing note that identifies the process specification, the class, the type and the thickness. Two examples are:

CHROMIUM PLATE TO A THICKNESS OF 0.0005-0.0015 INCHES [500 - 1500 µin] PER NASA/JSC PRC 5003, CLASS 1, TYPE II.

CHROMIUM PLATE TO A FINAL THICKNESS AFTER GRINDING OF 0.0020-0.0050 INCHES PER NASA/JSC PRC 5003, CLASS 2.

The two classes of electrodeposited chromium plating are:

Class 1 Corrosion protective chromium plating (>0.00001 in. [>10 µin] thick)

Class 2 Engineering chromium plating (>0.002 in. [>2 mils or 2000 µin] thick)

Class 1 chromium plating shall be one of the following types, as-specified on the engineering drawing:

Type I – Bright Finish

Type II – Satin Finish

Class 1 plating is used to protect steels against corrosive attack in rural, industrial, or marine environments, which varies depending on the thickness of the chromium deposit. It may also be used as an undercoat for a chromium plating or for aesthetic purposes.

Class 2 plating is used primarily for wear resistance, abrasion resistance, and incidental corrosion protection. Heavy deposits of Class 2 plating may be used for build-up of worn or undersized parts. Class 2 plating is typically used for final dimensional thicknesses (after grinding) of 0.0020 to 0.0050 inches [2 – 5 mils].

Drawing tolerances for as-plated thicknesses less than 0.0020 inches are commonly 0.0010 inches. Drawing tolerances for ground plating thicknesses of 0.0020 to 0.0050 inches thick [2 – 5 mils] are commonly 0.0005 inches [500 µin or 0.5 mil]. Closer tolerances can be achieved when required.

For chromium plating up to 0.002 inch thick, the surface finish will be similar to the original machined part. For chromium plating greater than 0.002 inch thick, the surface finish will become rougher with increasing plating thickness. Shot peening also typically increases surface finish roughness. Most class 2 applications utilize grinding after the post-hydrogen bakeout to achieve a finer surface finish.

If plating thickness measurement is required at critical locations of the part, it shall be specified on the drawing.

Most anomalies like pits and scratches prior to plating are amplified after plating. Removal of these anomalies prior to plating is required if the final surface finish is important.

3.1 SHOT PEENING

A common requirement for chromium plated items is shot peening prior to plating. Chromium plate often has cracks that run from the surface through the thickness to the substrate. The frequency of these cracks increases with increasing pre-grinding plate thickness. The use of shot peening prior to plating adds compressive residual stresses which prevents cracks from propagating into the substrate.

If shot peening is desired prior to plating, it shall be specified on the drawing. These four items shall be specified in the drawing note for shot peening:

- Shot Material Type
- Shot Size
- Intensity
- Coverage

3.1.1 Shot Material

There are 4 common types of shot material: 1) cast shot, 2) cut wire shot, 3) glass bead shot, and 4) ceramic shot.

1) Cast shot is the most common shot
2) Cut wire is made by cutting wire and rounding off the corners
3) Glass beads are typically used on aluminum or other soft non-ferrous alloys and are rarely used on steel
4) Ceramic shot is typically atomized powder with a hardness between 57-63 HRC

For steel parts over 200 ksi tensile strength, use hard steel shot (55-65 HRC) or

ceramic shot (57-63 HRC).

3.1.2 Shot Size and Selection

The nominal size of shot (see appendix A) used on fillet surfaces shall not be greater than one-half the smallest fillet radius. It is preferred that a fillet radius of 0.031 inches or greater be used when possible. Sharp corners should also be avoided and rounded when possible.

Selection of shot size based on intensity is listed in Table 1.

Table 1: Desired Minimum Shot Size for a Given Intensity

Intensity	Desired Minimum Size Peening Media
0.012 A	S-280 or CW-28 or Ceramic Bead Size 0.033
0.016 A	S-390 or CW-41 or Ceramic Bead Size 0.046
0.020 A	S-550 or CW-54

3.1.3 Intensity

Intensity can only be established during development by plotting a saturation curve, as shown in figure 1, and assuring that the required intensity (determined by the arc height of the test strip) falls on the right side of the knee of the curve. By doubling the time of exposure, the arc height of a test strip should not increase by more than 10%.

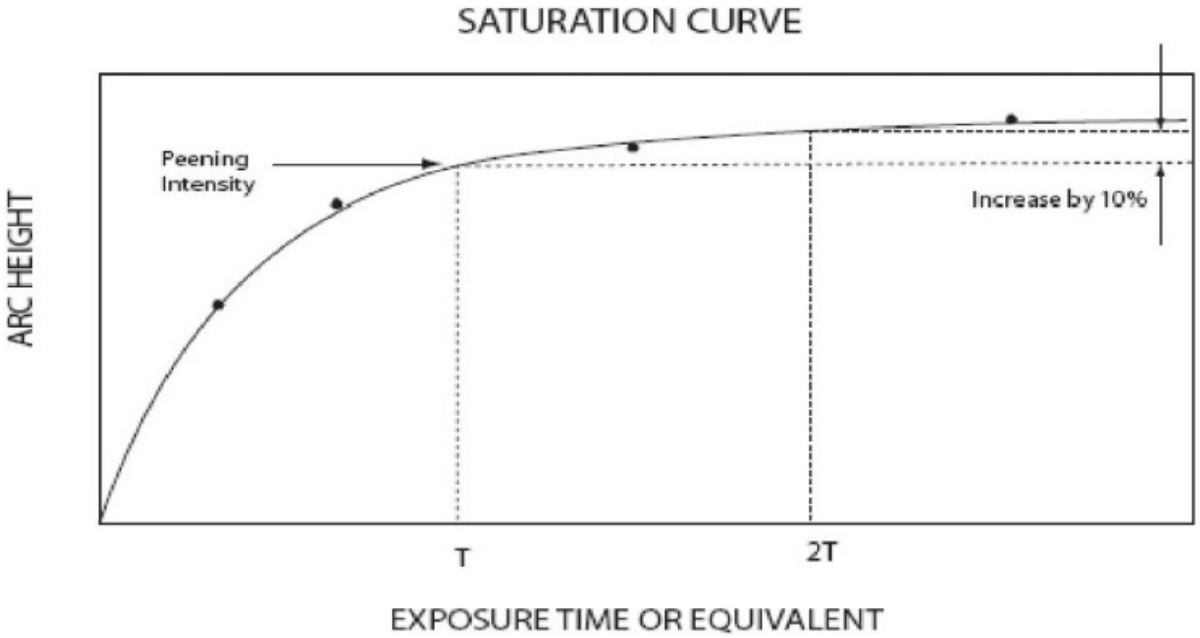


Figure 1: Saturation Curve to Verify Peening Intensity

For initial process development, a saturation curve shall be generated for each location where intensity is to be verified. A curve is produced by exposing individual

test strips for increasing time periods and plotting the results (exposure time vs. arc height). A minimum of four points other than zero shall be used to define the curve; one of the four points used to indicate saturation shall be at least double the time of the saturation point. Saturation is achieved when, as the exposure time for the test strips is doubled, the arc height does not increase by more than 10%. The reuse of test strips is not permitted.

Except for sections less than 0.090 inches, a test strip “A” conforming to SAE J442 utilizing procedure conforming to SAE J443 is typically used to determine arc height. The test strip “A” is used for arc heights between 0.004 and 0.024 inches. For sections less than 0.090 inches, consult the cognizant material and process (M &P) engineer.

Table 2: Recommended Arc Height Intensity Based on Thickness

Steel	**Under 200 ksi UTS**	**Over 200 ksi UTS***
Under 0.090 Inches Thick	Discuss with M & P	Discuss with M & P
0.090 – 0.375 Inches Thick	0.008 – 0.012 A	0.006 – 0.010 A
Over 0.090 Inches Thick	0.012 – 0.016 A	0.006 – 0.010 A

*For steel parts over 200 ksi tensile strength, use hard steel shot (55-65 HRC) or ceramic shot (57- 63 HRC).

3.1.4 Coverage

Complete visual coverage is a uniform and complete denting or obliterating of the original surface of the part or work piece as determined by either of the following methods.

Some vendors use a visual examination process using a 10X magnifying glass and other vendors use a liquid tracer system (typically fluorescent) using a 10X inspection. The liquid tracer system uses a pre-shot peen coating and typically fluorescent lighting to inspect post-shot peening.

Typically 100% coverage (T Exposure Time in Figure 1) is specified; however, 200% coverage (2T Exposure Time in Figure 1) is desired on low margin, fracture critical parts.

3.1.5 Drawing Note Examples for Shot Peening

For a steel under 200 ksi:

SHOT PEEN PER SAE AMS 2430 WITH S-230 OR EQUIVALENT SIZE

SHOT PRIOR TO CHROMIUM PLATING. AN INTENSITY OF 0.008-0.012 A IS REQUIRED WITH 100% COVERAGE.

For a steel over 200 ksi:

SHOT PEEN PER SAE AMS 2430 WITH CERAMIC BEAD 0.024 BEAD SIZE PRIOR TO CHROMIUM PLATING. AN INTENSITY OF 0.006-0.010 A IS REQUIRED WITH 100% COVERAGE.

3.2 POST-PLATING HYDROGEN BAKEOUT

If the base material is a high strength ferrous alloy or case hardened, and has a hardness/temper or strength as defined in Table 3, a hydrogen bakeout shall be required within four hours after the completion of the plating operation.

Table 3: Steels That Require a Hydrogen Bakeout after Chromium Plate

Alloys	Type	Hardness / Temper	Ultimate Tensile Strength
Carbon Steel, Low Alloy Steel, & Martensitic Stainless Steels**	Fasteners	≥ 36 HRC	≥ 160 ksi
Carbon Steel, Low Alloy Steel, & Martensitic Stainless Steels**	All Parts Other Than Fasteners	≥ 40 HRC	≥ 180 ksi
High Strength Precipitation Hardening Stainless Steels***	All Parts	See Tempers Listed in Table 1 Located in AMS 2759/9	≥ 150 ksi
Case-hardened Steel Parts***	All Parts	See Table 2 Located in AMS 2759/9	≥ 255 ksi in the Case
Music Wire, 52100, 440C, or Any Other Alloy Tempered Below 375 °F***	All Parts	See Table 2 Located in AMS 2759/9	≥ 255 ksi

**Require a post-plating hydrogen baking procedure of 375 F for 23 hours.
*** Require a post-plating hydrogen baking procedure listed in AMS 2759/9. An example for an alloy steel with a hardness greater than 40 HRC:

3.3 WORK INSTRUCTIONS

Work instructions shall be generated for implementing this process specification. The work instructions shall contain sufficient detail to ensure that the manufacturing process produces consistent, repeatable products that comply with this specification. For work performed at JSC facilities, these work procedures consist of Detailed Process Instructions (DPIs). For contracted work, the contractor shall be responsible for preparing, maintaining, and certifying written work procedures that meet the requirements of this specification.

A HYDROGEN BAKEOUT SHALL BE PERFORMED AT 375 F FOR 23 HOURS WITHIN 4 HOURS AFTER THE COMPLETION OF THE PLATING OPERATION.

4.0 REFERENCES

The following references were used in developing this process specification:

ASTM B571	Qualitative Adhesion Testing of Metallic Coatings
JPR 8500.4	Engineering Drawing System Requirements
SAE AMS 2460	Plating, Chromium
SAE AMS 2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
SAE AMS-S-13165A	Shot Peening of Metal Parts
SAE AMS 2430	Shot Peening, Automatic
SAE J442	Test Strip, Holder, and Gage for Shot Peening
SAE J443	Procedures for Using Standard Shot Peening Almen Test Strip
SAE J444	Cast Shot and Grit Size Specifications for Peening and Cleaning
SOP-007.1	Preparation and Revision of Process Specifications

5.0 MATERIALS REQUIREMENTS

The materials used shall meet the requirements of SAE AMS 2460.

Prior to shot peening, parts shall be within dimensional and surface finish requirements. All heat treatment shall be completed before shot peening. All fillets shall be formed, all burrs shall be removed, and all sharp edges and corners to be peened shall be provided with sufficient radii to result in complete **plating** coverage.

Thin sections shall not distort after shot peening prior to plating.

6.0 PROCESS REQUIREMENTS

All electrodeposited chromium plating shall be applied according to the technical requirements of SAE AMS 2460. In addition to the control factors in SAE AMS 2460, these additional control factors are required:

- Organic contamination, metallic contamination and pH levels and plating bath composition parameters shall be sampled and checked at the same time.
- Proper bath temperature and temperature uniformity shall be checked and maintained
- Composition, organic contamination, metallic contamination and pH levels shall be checked monthly (or more frequently)

Tanks used for cleaning, pickling (or other activation methods) and rinsing are critical for proper surface preparation for plating. These tanks shall be controlled and maintained for proper chemistry, pH and low contamination levels using documented procedures.

Fluoride levels often deplete in nitric/hydrofluoric pickling tanks over time and the typical titration test for “total acids” analysis is not adequate to check the nitric-to-hydrofluoric ratio. Periodic removal of the old pickling solution, cleaning out the drained tank, and creating a new pickling tank solution is often the easiest method to insure the proper nitric-to- hydrofluoric ratio.

In addition to the control factors in SAE AMS 2460, these additional control factors are required:

- Abrasive blasting media shall be removed prior to plating.
- The cleaning procedure shall not produce pitting or intergranular attack of the basis metal and shall preserve dimensional requirements.
- The plating shall be applied over a surface free from water breaks per AMS 2460.

7.0 PROCESS QUALIFICATION

Adhesion tests, if required, shall meet the requirements of ASTM B571 bend test 180 degrees with 4T mandrel to insure good plating deposit adhesion. Class 2 plating that will be ground to final dimensions typically does not require an adhesion test.

Tribology and microhardness tests (ASTM E384) on test specimens may be required to insure proper wear resistance.

Corrosion test panels shall be periodically tested by exposure for 48 hours to continuous salt spray corrosion test conducted in accordance with ASTM B117.

8.0 PROCESS VERIFICATION

The process verification shall include visual examination, adhesion tests, and thickness measurements, as-specified by AMS 2460.

The chromium deposits shall be visually examined (after grinding for class 2) for the following general problems:

- Pits, pores and/or cracking
- Regions with missing or insufficient plating thickness
- Poor coverage
- Edge pullback
- Roughness in the deposits
- Discoloration in the deposits
- Step plating

If the drawing requires plating thickness measurements at specific locations of the part, then these measurements shall be performed and recorded by the vendor.

If a hydrogen bakeout is performed, a quality record documenting the time and temperature shall be supplied. A simple strip chart on the oven is adequate to document the process. A digital file of the bakeout run is also adequate. In addition, a recent record certifying the accuracy of the oven temperature and uniformity is needed.

A laboratory verification test (compared to known standards) of the ppm hydrogen on a simulation coupon (same material and mill lot as the parts being processed) can also be used to verify that hydrogen bakeout procedure was performed.

For shot peening, documentation for the measurements on the Almen Test Strip is required.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

This chromium plating process shall be performed by personnel qualified to conduct the process through training or experience. If this process is performed by an outside vendor, the development of an appropriate training program shall be the responsibility of the vendor.

10.0 DEFINITIONS

Abrasive Blasting: A process for cleaning or finishing by means of an abrasive directed at high velocity against a work piece.

Activation: Elimination of a passive condition on a surface, usually by chemical removal of oxides.

Almen Test Strip: A thin strip of SAE 1070 steel used to quantify the intensity of a shot peening process. Developed and patented by John O. Almen, the strip was originally supported by 2 knife edges; later improvements see it being supported on 4 small balls.

Arc Height: A measurement of the amount of deflection or bow in an Almen strip, after it has been shot peened. The measurement is taken at the center of the concave side of the peened Almen strip using an Almen gauge.

Blister: A dome-shaped imperfection or defect, resulting from loss of adhesion between a metallic deposit and the substrate.

Electroless Plating: Deposition of a metallic coating by a controlled chemical reduction that is catalyzed by the metal or alloy being deposited.

Electrodeposit: An electrolytic plating deposit.

Electrolytic Plating: Deposition of a metallic coating by putting a conductive material from a plating solution onto a substrate by the application of an electric current.

Liquid tracer system: A tracer system that employs liquid coating material which removes at a rate proportioned to peening coverage. A fluorescent tracer system has, in addition, a pigment which fluoresces under ultraviolet light.

Pickling: The removal of oxides or other compounds from a metal surface by means of a chemical solution.

Pit: A small depression or cavity produced in a metal surface during deposition or by corrosion.

Substrate: The material, component, or work piece to which the chromium plating is deposited. The substrate may also be called “base metal.”

Water Break: The appearance of a discontinuous film of water on a surface, signifying non-uniform wetting and usually associated with a surface contamination.

Appendix A: Nominal Diameters for Common Shot Peen Media (See SAE J444) Sizes

Cast Shot Sizes	Cut Wire Sizes	Glass Bead Sizes (Max)	Ceramic Bead Sizes (Max)	Nominal Diameter
S-780				0.095 Inches
S-660				0.080 Inches
S-550	CW-62	0.079 Inches		0.062 Inches
S-460	CW-54	0.066 Inches		0.054 Inches
S-390	CW-47	0.056 Inches		0.047 Inches
S-330	CW-41	0.047 Inches	0.046 Inches	0.041 Inches
	CW-35			0.035 Inches
S-280	CW-32	0.039 Inches		0.032 Inches
S-230	CW-28	0.0331 Inches	0.033 Inches	0.028 Inches
S-190	CW-23	0.0278 Inches		0.023 Inches
S-170	CW-20	0.0234 Inches	0.024 Inches	0.020 Inches
S-110		0.0165 Inches	0.017 Inches	0.016 Inches
S-70		0.0139 Inches		0.011 Inches