Process Specification for Electrodeposited Nickel Plating

Engineering Directorate

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REVISIONS		
VERSION	**CHANGES**	**DATE**
Baseline	Original version	5/14/96
A	Typo on p. 3, formatting, and increased bakeout for steel alloys	7/14/98
B	Changed EM2 references to ES4, reviewed for accuracy	6/2004
C	Updated specification reference to AMS-QQ-N-290	10/2004
D	Updated signatures and date. Changed applicability. Added types, changed thickness requirements added hydrogen bakeout section, changed work instructions to Usage. Updated references. Added surface roughness to material requirements. Added process requirements and process qualification items. Added visual exam, adhesion test and thickness measurements, plus hydrogen bakeout documentation to process verification. Added definitions.	6/2020

1.0 SCOPE

This process specification establishes technical requirements for the application of electrodeposited nickel plating on steel, copper and copper alloys, and zinc and zinc alloys.

2.0 APPLICABILITY

This process specification applies to the electrodeposition of nickel plating on substrates of steel, copper, zinc, and their alloys. These electrodeposits are typically used for corrosion resistance, for joining applications involving soldering, brazing & welding, and for wear resistance.

3.0 USAGE

3.1 CLASS, GRADE, AND TYPE

This process specification shall be called out on the engineering drawing by using a drawing note that identifies the process specification, the class, the grade, and the type. For example:

NICKEL PLATE PER NASA/JSC PRC 5004, CLASS 1, GRADE D, TYPE I.

The two classes of electrodeposited nickel plating are:

Class 1 Corrosion protective nickel plating (0.0002-0.0016 in. thick)

Class 2 Engineering nickel plating (>0.002 in. thick)

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

Class 1 nickel plating shall be one of the following grades, as specified on the engineering drawing:

Grade	Thickness	Grade	Thickness
Grade A	0.0016 in. thick	Grade E	0.0006 in. thick
Grade B	0.0012 in. thick	Grade F	0.0004 in. thick
Grade C	0.0010 in. thick	Grade G	0.0002 in. thick
Grade D	0.0008 in. thick		

Please note that grade F and G thicknesses for Class 1 nickel plating may be marginal for corrosion protection.

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.

The default thickness for a Class 2 nickel plating is 0.0020 to 0.0030 inches. If a different thickness range is desired, it must be a minimum of 0.0020 inches and must be specified on the engineering drawing.

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

Type IDull (or Unbrighted) nickel plate

Type I is the preferred choice for joining applications including soldering, brazing and welding. It is commonly produced using the *Nickel Sulfamate Bath* (see Nickel Plating Handbook) method.

Type II Bright nickel plate

Type II is used to enhance luster using organic additives (brighteners) that refine the grain structure of the nickel. Type II is a more tensile stressed deposit with reduced ductility compared to Type I deposits. It is commonly produced using the *Watts Bath* (see Nickel Plating Handbook) method. Type II is not recommended for joining processes, such as soldering, brazing, and welding.

3.2 POST-PLATING HYDROGEN BAKEOUT

If the base material is a high strength ferrous alloy or case hardened, a hydrogen bakeout may be required (See Table 1).

All steel parts having a hardness of Rockwell C40 or higher shall be baked out within 4 hours of the plating process at a minimum of 375 +/- 25 F for a duration of 23 hours or longer for hydrogen embrittlement relief.

Table 1: 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.

The following is an example of the call out on an engineering drawing for an alloy steel with a hardness greater than 40 HRC:

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

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 (DPI's). For contracted work, the contractor shall be responsible for preparing and maintaining, and certifying written work procedures that meet the requirements of this specification.

4.0 REFERENCES

ASTM B571	Qualitative Adhesion Testing of Metallic Coatings
ASTM B117	Standard Practice for Operating Salt Spray (Fog)
Apparatus JPR 8500.4	Engineering Drawing System Requirements
Nickel Plating Handbook	https://www.nickelinstitute.org/media/2323/nph_141015.pdf
SAE AMS 2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
SAE AMS-QQ-N-290	Aerospace Material Specification/Nickel Plating (Electrodeposited)
SOP-007.1	Preparation and Revision of Process Specifications

5.0 MATERIALS REQUIREMENTS

The materials used shall meet the requirements of SAE AMS-QQ-N-290.

Smoothness and integrity of the original substrate surface are critical factors in final results of the electroplated surface. Typically, the smoother the original surface, the better the electrolytic nickel coating. Since surface finish can become rougher with thicker coating layers, post-machining (pre-coating) surface finish requirements need to be adjusted to achieve the post-coating default drawing surface finish of 32 RMS. In addition, poor surface integrity that might entrap fluids (EDM oxide layer, porous casting surfaces, as-made additive manufactured parts, etc.) or very poorly machined surfaces (rough & work-hardened material) can make it difficult-to-impossible to produce a high-quality electrolytic nickel coating.

6.0 PROCESS REQUIREMENTS

All electrodeposited nickel plating shall be applied according to the technical requirements of SAE AMS-QQ-N-290.

In addition to the requirements in SAE AMS-QQ-N-290, these additional production controls are required:

- Organic contamination, metallic contamination and pH levels shall be checked at the same time periods and the plating bath composition.
- 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.

The below additional control factors are also 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 SAE AMS- QQ-N-290.

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.

Periodic corrosion test panel shall be periodically tested 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 SAE AMS-QQ-N-290.

The nickel deposits shall be visually examined for the following general problems:

- Regions with missing plating
- Poor coverage
- Edge pullback
- Frosted deposits or edges
- Roughness in the deposits
- Streaks in the deposits
- Pitting

- Dull or matte deposit
- Step plating
- Laminar plating
- Dark or black deposits
- Blistering
- Porosity

The finished thickness of the nickel plating shall be measured in critical locations if noted on the drawing. These measurements, if required on the drawing, 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 shall be provided. 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.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

This nickel 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.

Autocatalytic: Deposition of a metal coating by controlled chemical reduction, catalyzed by the metal or alloy being deposited.

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.

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.

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 nickel 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.