AVOIDANCE OF HYDROGEN EMBRITTLEMENT OF STEEL FASTENERS AND OTHER HARDENED OR SPRING STEEL PARTS FROM SURFACE COATING PROCESSES

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AVOIDANCE OF HYDROGEN EMBRITTLEMENT OF STEEL FASTENERS AND OTHER HARDENED OR SPRING STEEL PARTS FROM SURFACE COATING PROCESSES

1. SCOPE:

This standard outlines the conditions that enhance the risk of hydrogen embrittlement of steel and define the relief procedures required to minimize the risk of hydrogen embrittlement. It is intended to control the process.

1.1 Hydrogen embrittlement of steel, which can cause brittle fractures under stress, occurs as a result of the absorption of hydrogen during cleaning, phosphate coating and plating processes. The susceptibility to hydrogen embrittlement increases with increasing stress (internal or externally applied stress) and increasing material strength (hardness).

1.2 Residual phosphate on the steel surface prior to heat treating can lead the formation of delta ferrite microstructure – a white phosphorus enriched layer. This brittle surface layer may lower the fatigue life of the component.

1.3 Exposing parts to temperatures near the melting point of the metal causes the diffusion of the metal into the substrate resulting in a loss of ductility commonly referred to as liquid metal embrittlement.

1.4 Hardness values in this specification are in Rockwell C (HRc) hardness scale. SAE J417 or ISO 18265 shall be referred to for conversion to other scales.

1.5 Deviations or non-compliance with any part of this standard shall be agreed upon by the OEM.

1.6 Oven controls and verification shall be conducted in accordance with CQI-11.

2. REFERENCES:

2.1 SAE Publications:

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J417 - Hardness Tests and Hardness Number Conversions.

ISO 18265

2.2 AIAG Publications:

Available through www.aiag.org

CQI-11 Special Processes – Coating Assessment

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3. REQUIREMENTS:

The parts shall be processed in accordance with this specification as applicable to minimize the risk of hydrogen embrittlement. Specific applications or customer requirements may require processing that goes beyond the requirements of this specification. Baking shall be performed continuously and without interruption for the temperatures and durations specified.

NOTE: All references to temperatures relate to part core temperature and not the indicated oven air temperature. The effectiveness of stress relief increases with increasing temperature and time, however, the maximum temperature shall not detrimentally affect the coating or substrate.

3.1 Cleaning Prior to Heat Treatment:

All parts to be heat treated to a specified hardness (core or surface) greater than HRc 32 must be cleaned prior to heat treatment to remove phosphate associated lubricant residues and detrimental contaminants from the surface including the avoidance of delta ferrite formation.
Examples: Phosphorus coating, Copper layer (except when intended as heat treat masking)

3.1.1 Acid Cleaning:

Heat treated and/or cold worked parts with core or surface hardness greater than 32 HRc are highly susceptible to hydrogen embrittlement when exposed to acidic solutions.

Acid cleaning/pickling shall be limited to a maximum exposure time of 10 minutes. Acid strength shall not exceed 50% by volume (6.0 Molar) concentration at maximum temperature of 35 °C for Hydrochloric Acid, or 30% by volume (5.4 Molar) concentration at maximum temperature of 70 °C for Sulfuric Acid. Use of an inhibited acid is recommended.

All parts that are acid cleaned or pickled shall not be used for 48 hours or alternately these parts shall be baked for at least 1 hour at 110 °C minimum.

3.2 Electroplating:

The electroplated parts shall be baked at the specified temperature and duration listed in Table 1. All parts shall reach the specified temperature within 2 hours after exiting the plating bath. The minimum temperature shall be continuously maintained for the specified duration.

3.2.1 Parts tempered or stress relieved above 200 °C

Baking times shall comply with table 1. Longer times at heat than those given may be necessary if verification testing detailed in the Control Plan (see para 3.6) indicates a failure risk.

Table 1: Embrittlement Relief

Specified core or surface hardness	Part core temperature	Minimum bake time
Less than 32 HRc	Not applicable	Bake not required
32 to 39 HRc	200 °C minimum	4 hours
Greater than 39 HRc	200 °C minimum	8 hours
NOTE: Baking time temperature may be adjusted based on compatibility with the finish. Consult the OEM standards for details.		

3.2.2 Parts at risk for softening if exposed to temperatures at or above 200 °C

Hardened parts which have been tempered or stress relieved at less than 200 °C may be at risk for softening. These parts shall be baked for 8 hours minimum at 110 °C minimum after electroplating. Longer baking times or higher baking temperature may be necessary as determined by verification testing.

3.2.3 Tin or Tin Alloy Electroplated Coatings.

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