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AEROSPACE MATERIAL SPECIFICATION

AMS2649™ REV. D

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Superseding AMS2649C

Etch Inspection of High Strength Steel Parts

RATIONALE

This revision results from a Five Year Review. Glass bead is added as acceptable media for use in surface activation, and alkaline clean solution is added as a rinse solution in lieu of sodium hydroxide solution.

1. SCOPE

1.1 Purpose

This specification establishes the requirements for etch inspection of steel parts to detect overheating (rehardening or overtempering) caused by abusive machining or grinding, or to detect localized discontinuous carburization.

1.2 Application

This process has been used typically for carburized parts and for bare low-alloy steel parts having tensile strength of 180 ksi (1241 MPa) and higher, but usage is not limited to those applications. The process can also be used to detect abusive grinding or machining in heat treatable steels of lower core hardness. This process may remove 0.0001 to 0.0005 inch (2.5 to 12.7 micrometers) from the surface of the part.

1.3 Classification

Etchants used in this specification are classified as follows:

Type 1 - Nitric acid in water or alcohol with an anti-smut additive

Type 2 - Nitric acid in water or alcohol

Type 3 - Ammonium persulfate in water

1.3.1 Type 1 and Type 2 etchants may be used interchangeably. Type 1 immersion or Type 3 swabbing method shall be used when the part cannot be hydrogen embrittlement relieved.

1.3.2 Type 3 etchant shall be applied by swabbing and only used when authorized by the cognizant engineering organization. Type 3 is not as sensitive for detecting grinding burns as Type 1 or Type 2.

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1.4 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The processor may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

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

AMS2759/9 Hydrogen Embrittlement Relief (Baking) of Steel Parts

ARP1923 Qualification and Certification of Etch Inspectors

2.2 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, http://quicksearch.dla.mil/.

MIL-PRF-16173 Corrosion Preventive Compound, Solvent Cutback, Cold-Application

MIL-PRF-32033 Lubrication Oil, General Purpose, Preservative (Water-Displacing, Low Temperature)

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Parts to be etch inspected shall be cleaned to remove contaminants that will prevent wetting of the etching solution. The part to be etched shall have a water-break-free surface when held vertically for 30 seconds. Cleaned parts shall not be touched with bare hands prior to inspection.

3.1.2 Surface activation shall be performed as follows:

3.1.2.1 When blasting is performed, glass bead, aluminum oxide or silicon carbide media shall be used to produce a matte appearance. Parts that can be damaged by blasting or may trap the blasting media shall not be cleaned by blasting.

3.1.2.2 When sanding or abrading is performed, 180 grit or finer bonded abrasive shall be used to produce a matte appearance.

3.1.2.3 Alternative methods of surface activation may be used when acceptable to purchaser.

3.2 Solutions

3.2.1 Type 1 Etchant shall be a 3 to 5% by volume solution of 40° Be nitric acid in water or alcohol mixed with an anti-smut additive. The etch solution shall be maintained at 60 to 80 °F (16 to 27 °C).

3.2.1.1 The anti-smut additive shall be chemicals that, when mixed with the etchant, prevent the formation of smut on the surface of etched steel parts (See 8.3).

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3.2.2 Type 2 Etchant shall be a 3 to 5% by volume solution of 40° Be nitric acid in water or alcohol. The solution shall be maintained at 60 to 80 °F (16 to 27 °C).

3.2.2.1 De-Smut shall be 4 to 6% by volume solution of 22° to 23° Be hydrochloric acid in alcohol or water. The solution shall be maintained at 60 to 80 °F (16 to 27 °C).

3.2.3 Type 3 Etchant shall be a 10% ± 1 by weight solution of ammonium persulfate in water maintained at 60 to 80 °F (16 to 27 °C). The solution shall be applied within 72 hours of mixing. See 8.4.

3.2.4 Rinse Solution

3.2.4.1 Sodium phosphate shall be an aqueous solution containing 0.5 to 1.0 ounce per gallon (3.7 to 7.5 g/L) of sodium phosphate. The solution shall be maintained at 60 to 180 °F (16 to 82 °C).

3.2.4.2 Sodium hydroxide shall be an aqueous solution containing 2 to 6% by weight sodium hydroxide. The solution shall be maintained at 60 to 120 °F (16 to 49 °C). Alkaline cleaning solutions designed for use with low alloy and carburized steels may be used in lieu of the sodium hydroxide solution.

3.3 Procedure

3.3.1 General

3.3.1.1 Etch time for the solution shall be determined using a sample part of the same alloy with a known overheated condition and in the same heat treat condition as the production parts to be processed. Etch time shall be that time required to start turning the part a uniform gray, determined by personnel certified in accordance with 3.5.2.

3.3.1.2 Etching shall be performed under the supervision of personnel certified in accordance with 3.5.2.

3.3.1.3 All examinations shall be performed under a light of not less than 200 foot-candles (2153 lx) by personnel certified in accordance with 3.5.2.

3.3.1.4 Parts having areas that cannot be adequately etch inspected due to geometric restrictions shall be inspected by alternative methods or techniques that have been approved by the cognizant engineering organization.

3.3.1.5 Parts shall be racked for immersion etching to prevent contact with each other and to ensure uniform etching on all surfaces that are to be inspected.

3.3.2 Type 1 Etch

3.3.2.1 Each part shall be immersed in etch solution conforming to 3.2.1 the time determined for the sample part.

3.3.2.2 Without permitting any etched part to dry, each part shall be immediately rinsed in overflowing tap or hot (130 to 180 °F [55 to 82 °C]) water for not less than one minute. Parts shall be dried or immersed in water-displacing oil (MIL-PRF-32033) immediately.

3.3.2.3 Dried or oiled parts shall be visually examined.

3.3.3 Type 2 Etch

3.3.3.1 Each part shall be entirely immersed in etch solution conforming to 3.2.2 for the time determined for the sample part.

3.3.3.2 Without permitting etched parts to dry, parts shall be immediately rinsed in overflowing tap water for not less than one minute.

3.3.3.3 Each part shall be immersed in the de-smut solution conforming to 3.2.2.1 for 15 to 120 seconds.

3.3.3.4 Without permitting de-smutted parts to dry, parts shall be immediately rinsed in overflowing tap water for not less than one minute.