SAE The Engineering Society For Advancing Mobility Land Sea Air and Space

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 2649

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ETCH INSPECTION OF HIGH STRENGTH STEEL PARTS

1. SCOPE:

1.1 Purpose: This specification establishes the requirements for etch inspection of bare high-strength low-alloy steel parts having tensile strength of 180,000 psi (1240 MPa) and higher and of carburized parts to detect over-heating caused by abusive machining or grinding in the heat treated condition. This process may remove 0.0001 to 0.0005 in. (2.5 to 12.5 µm) from the surface of the part.

1.2 Classification: Etchants used in this specification are classified as follows:

Type I - Nitric acid in water with surfactant
Type II - Nitric acid in water
Type III - Sodium phosphate in water

1.2.1 Type I or Type II etchants may be used interchangeably.

1.2.2 Type III etchant, immersion or swab, shall be used only when specified.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Recommended Practices shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.1.2 Aerospace Recommended Practices:

ARP 1923 - Qualification and Certification of Etch Inspectors

2.2 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.2.1 Federal Specifications:

A-A-711 - Dry Cleaning Solvent
A-A-895 - Sodium Hydroxide, Technical
O-H-765 - Hydrochloric Acid, Technical
O-N-350 - Nitric Acid, Technical
O-S-642 - Sodium Phosphate, Tribasic, Anhydrous, Dodecahydrate, and Monohydrate, Technical
O-T-620 - Trichloroethane - 1,1,1, Technical, Inhibited

2.2.2 Military Specifications:

MIL-G-9954 - Glass Beads, for Cleaning and Peening
MIL-C-16173 - Corrosion Preventive Compound, Solvent Cutback, Cold-Application
MIL-A-21380 - Abrasive Material, for Blasting

3. TECHNICAL REQUIREMENTS:

3.1 Solutions:

3.1.1 Type I Etchant: Shall be a solution of technical grade nitric acid, such as O-N-350, in water with a concentration of 3 - 5% by volume mixed with a surfactant in accordance with manufacturer's recommendations. The etch solution shall be maintained at ambient temperature.

3.1.1.1 The surfactant shall be a solution of chemicals which, when mixed with the etchant, precludes the formation of smut on the surface of etched steel parts.

3.1.1.2 The cognizant engineering organization shall approve the surfactant used, based on its ability to retard smutting of etched steel parts.

3.1.2 Type II Etchant: Shall be a solution of technical grade nitric acid, such as O-N-350, in water with a concentration of 3 - 5% by volume. The etch solution shall be maintained at ambient temperature.

3.1.2.1 De-Smut: Shall be an aqueous solution containing 4 - 6% by volume technical grade hydrochloric acid, such as O-H-765. The solution shall be maintained at ambient temperature.

3.1.3 Type III Etch: Shall be a solution of 10% by weight of ammonium persulfate in water, maintained at ambient temperature. The solution shall be used within 72 hr of mixing.

3.1.4 Alkaline Rinse Solutions:

3.1.4.1 Sodium Phosphate: Shall be an aqueous solution containing 0.5 - 1.0 oz per gal (3.7 - 7.5 g/L) of technical grade sodium phosphate, such as O-S-642. The solution shall be maintained at 60° - 180°F (15° - 80°C).

3.1.4.2 Sodium Hydroxide: Shall be an aqueous solution containing 4 to 6% by weight of A-A-895 sodium hydroxide. The solution shall be maintained at 60° to 180°F (15° to 80°C).

3.2 Preparation:

3.2.1 Parts to be etch inspected shall be cleaned to remove all cutting oils and corrosion-preventive oils by wiping with A-A-711, Type I, or equivalent, solvent or by vapor degreasing using O-T-620, or equivalent.

3.2.2 The areas of the parts to be etched shall be blast cleaned using MIL-A-9954 glass beads, sizes 170 to 400 or using MIL-A-21380, Types I or III, aluminum oxide or silicon carbide, respectively, Grades B or C. Minimum blasting pressure to produce a matte finish shall be used. Parts that may be damaged by blasting or may trap the blasting media shall be abraded with 180 or finer bonded abrasive to achieve a matte finish.

3.2.3 Solvent wipe with A-A-711, Type I or equivalent solvent or degrease with O-T-620, or equivalent vapor degreasing solution to remove all fingerprints. Degreased parts shall not be touched with bare hands prior to inspection.

3.3 Procedure:

3.3.1 General:

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

3.3.1.2 Immersion 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 ft-candles (2150 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 alternate 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 permit even etching on all surfaces that are to be inspected.

3.3.2 Type I Etch:

3.3.2.1 Immerse the entire part in the etch solution (See 3.1.1) for the time determined on the sample part.

3.3.2.2 Without permitting the etched part to dry, immediately rinse in overflowing tap water for not less than one minute. Dry with a blast of oil-free air.

3.3.2.3 Examine the dried parts for evidence of overheating.

3.3.3 Type II Etch:

3.3.3.1 Immerse the entire part in the etch solution (See 3.1.2) for the time determined on the sample part.

3.3.3.2 Without permitting the etched part to dry, immediately rinse in overflowing tap water for not less than one minute.

3.3.3.3 Immerse the rinsed part in the de-smut solution (See 3.1.2.1) for 30 to 120 seconds.

3.3.3.4 Without permitting the de-smutted part to dry, immediately rinse in overflowing tap water for not less than one minute.

3.3.3.5 Immerse the part in one of the alkaline solutions (See 3.1.4) for not less than one minute.

3.3.3.6 Water rinse the parts immersed in sodium hydroxide for not less than 60 sec and dry with a blast of oil-free air. Parts that were immersed in sodium phosphate shall be dried only with oil-free air.

3.3.3.7 Examine the dried parts for evidence of overheating. Protect parts from corrosion during further processing.

3.3.3.8 Embrittlement relief bake the examined parts as soon as practicable after the parts are etched, but not over 24 hr after etching, and prior to subjecting the parts to any stress or mechanical operations. Embrittlement relief bake shall be accomplished by heating the parts at 375°F ± 25° (190°C ± 15°) for not less than four hours. Parts that were tempered below 400°F (205°C) shall be embrittlement-baked for not less than 8 hr at 275°F (135°C) or at 50 F (30 C) deg below the tempering temperature but not lower than 275°F (135°C).

3.3.4 Type III Etch (Immersion): (See 1.2)

3.3.4.1 Immerse the entire part in the etch solution (See 3.1.3) for the time determined on the sample part.

3.3.4.2 Without permitting the etched part to dry, immediately rinse in overflowing hot tap water for not less than one minute. After hot water rinse, parts may be dried with a blast of oil-free air or immediately dipped in alcohol followed by drying with a blast of oil-free air.

3.3.4.3 Examine the dried parts for evidence of overheating.