SAE The Engineering Society For Advancing Mobility Land Sea Air and Space
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

# AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE AMS 2649A

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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 ksi (1241 MPa) and higher and of carburized parts to detect overheating caused by abusive machining or grinding in the heat treated condition. This process may remove 0.0001 to 0.0005 inch (2.5 to 12.7 µm) from the surface of the part.

1.2 Classification:

Etchants used in this specification are classified as follows:

Type 1 - Nitric acid in water with an anti-smut additive
Type 2 - Nitric acid in water
Type 3 - Ammonium persulfate in water

1.2.1 Type 1 and Type 2 etchants may be used interchangeably. Type 1 or 3 should be used when the part cannot be stress relieved.

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

1.3 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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1923 Qualification and Certification of Etch Inspectors

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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|---|---|
| MIL-G-9954 | Glass Beads, for Cleaning and Peening |
| MIL-C-16173 | Corrosion Preventive Compound, Solvent Cutback, Cold-Application |
| MIL-A-21380 | Abrasive Materials, for Blasting |
| MIL-STD-2073-1 | DOD Materiel, Procedures for Development and Application of Packaging Requirements |
| A-A-711 | Dry Cleaning Solvent |
| A-A-895 | Sodium Hydroxide, Technical |
| O-N-350 | Nitric Acid, Technical |
| O-S-642 | Sodium Phosphate, Tribasic, Anhydrous, Dodecahydrate, and Monohydrate, Technical |
| VV-L-800 | Lubricating Oil, General Purpose, Preservative (Water Displacing, Low Temperature) |

3. TECHNICAL REQUIREMENTS:

3.1 Solutions:

3.1.1 Type 1 Etchant: Shall be a 3 to 5% by volume solution of nitric acid, such as O-N-350, in water mixed with an anti-smut additive in accordance with manufacturer's recommendations. The etch solution shall be maintained at ambient temperature.

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

3.1.1.2 The cognizant engineering organization shall approve the anti-smut additive used based on its ability to retard smutting of etched steel parts.

3.1.2 Type 2 Etchant:

3.1.2.1 Shall be a 3 to 5% by volume solution of nitric acid, such as O-N-350, in water. The solution shall be maintained at ambient temperature.

3.1.2.2 (R) De-Smut: Shall be 4 to 6% by volume of technical grade hydrochloric acid in alcohol (methanol/IPA) or water. The solution shall be maintained at ambient temperature.

3.1.3 Type 3 Etchant: Shall be a 10% by weight solution of ammonium persulfate in water maintained at ambient temperature. The solution shall be used within 72 hours of mixing.

3.1.4 Alkaline Rinse Solution:

3.1.4.1 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, such as O-S-642. The solution shall be maintained at 60 to 180 °F (16 to 82 °C).

3.1.4.2 (R) Sodium Hydroxide: Shall be an aqueous solution containing 2 to 6% by weight of A-A-895 sodium hydroxide. The solution shall be maintained at 60 to 180 °F (16 to 82 °C).

3.2 Preparation:

3.2.1 (R) Parts to be etch inspected shall be cleaned with A-A-711, Type 1, or equivalent, wipe solvent or with an immersion-type degreaser solution to remove cutting oils, corrosion protective oils, fingerprints, or other 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. Degreased parts shall not be touched with bare hands prior to inspection.

3.2.2 (R) The areas of the parts to be etched shall be blast or abrasion cleaned. Parts that may be damaged by blasting or may trap the blasting media shall be abrasion cleaned.

3.2.2.1 (R) Blasting shall be performed using MIL-G-9954, glass beads, sizes 170 to 400, or using MIL-A-21380, Type 1 or Type 3, aluminum oxide or silicon carbide, respectively, Grade B or C. Minimum blasting pressure to produce a matte finish shall be used.

3.2.2.2 Sanding or abrading shall be performed using 180 grit or finer bonded abrasive to achieve a matte finish.

3.2.2.3 (R) Alternate methods of surface activation may be used when acceptable to purchaser.

3.3 Procedure:

3.3.1 General:

3.3.1.1 Determine the immersion etch time for the solution 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 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 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 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 to ensure uniform etching on all surfaces that are to be inspected.

3.3.2 Type 1 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 or hot (130 to 180 °F [55 to 82 °C]) water for not less than one minute. Dry with a blast of oil-free air.

3.3.2.3 (R) Parts may be oiled before inspection.

3.3.2.4 Examine the dried parts for evidence of overheating.

3.3.3 Type 2 Etch:

3.3.3.1 Immerse the entire part in the etch solution (See 3.1.2.1) 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 (R) Immerse the rinsed part in the de-smut solution (See 3.1.2.2) for 15 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.

3.3.3.5.1 (R) Parts that were immersed in the sodium hydroxide solution shall be rinsed, in tap or hot (130 to 180 °F [55 to 82 °C]) water, for not less than one minute and dried with a blast of oil-free air.

3.3.3.5.2 (R) For parts that were immersed in sodium phosphate, there is no water rinse necessary. Dry the parts using oil-free air.

3.3.3.6 (R) Parts may be oiled before inspection.

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

3.3.3.8 (R) Embrittlement relief bake the examined parts as soon as practicable after the parts are etched, but not over 24 hours after etching, and prior to subjecting the parts to any stress or mechanical operations. Embrittlement relief bake by heating the parts at 375 °F ± 25 (191 °C ± 14) for not less than four hours. Parts that were tempered below 400 °F (204 °C) shall be embrittlement-baked for not less than 8 hours at 275 °F ± 25 (135 °C ± 14).

3.3.4 Type 3 Etch: (See 1.2)

3.3.4.1 (R) Apply the etch solution (See 3.1.3) by swabbing or by immersing the entire part for the time determined on the sample part.

3.3.4.2 (R) Swab or immersion rinse with clean water followed by swab or immersion rinse with denatured ethyl alcohol, or equivalent. Dry with a blast of oil-free air.

3.3.4.3 Parts may be oiled before inspection.

3.3.4.4 Examine the dried surface for evidence of overheating.

3.4 Acceptance Criteria:

Unless other acceptance standards are specified by the cognizant engineering organization, acceptance criteria shall be as follows:

3.4.1 If no overheating has occurred, the etched surface will be uniform light gray color over the entire area, and the part is acceptable.

3.4.2 Overtempering: Areas of parts etching darker, light brown to black, in relation to the surrounding areas have an indication of overtempering. Parts with this indication are not acceptable and shall be reinspected in accordance with 3.4.5.

3.4.3 Rehardening: Areas of parts etching light gray to white surrounded by a light brown or black border have an indication of rehardening. Parts with this indication are not acceptable and shall be reinspected in accordance with 3.4.5.

3.4.4 Extraneous Indications: Etched surfaces with fingerprints, spots, smeared metal, or any extraneous indications after etching are not acceptable and shall be cleaned, re-etched, and reinspected in accordance with 3.4.5.

3.4.5 Reinspection: Parts with areas indicating overtempering or rehardening may be cleaned, re-etched, and reinspected in accordance with 3.2 and 3.3 one time. Recurrence of initial indications shall be cause for rejection.

3.5 Qualification:

3.5.1 Solution Qualification:

3.5.1.1 The etch solution shall be qualified daily or prior to use by etching a sample part with a known overheating condition.

3.5.1.2 (R) The etched part shall be examined to confirm that the overheating condition can be detected with the solution and the selected etching.

3.5.2 Inspector Qualification: All personnel performing etch inspection in accordance with this specification shall be trained and certified in accordance with ARP1923.

4. QUALITY ASSURANCE PROVISIONS:

Not applicable.

5. PREPARATION FOR DELIVERY:

5.1 (R) Identification:

Parts that have been accepted by etch inspection described herein shall be identified as specified in 5.1.1 and 5.1.2.

5.1.1 (R) The letters AE or NE (See 8.2) shall be legibly rubber-stamped on all parts or processing records.

5.1.2 (R) The marking shall have no deleterious effect on the parts and shall be sufficiently stable to withstand normal handling.

5.2 Packaging:

5.2.1 (R) Parts shall be protected from corrosion during subsequent storage, handling, and shipping, as applicable. Some acceptable methods include either coating with VV-L-800 or MIL-C-16173 corrosion-preventive compound or packaging in volatile-corrosion-inhibiting wrapping.