SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2649C

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Superseding AMS 2649B

Etch Inspection of High Strength Steel Parts

RATIONALE

This revision was issued to add requirements for examination of carburized surfaces and to remove requirements for (1) blasting or abrading to prepare the parts and (2) approval of the anti-smut chemical. Other changes were deemed necessary as part of the SAE Five Year Review process.

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, and to detect localized discontinuous carburization. This process is not applicable to surface hardened steels produced by nitriding or carbonitriding. This process may remove 0.0001 to 0.0005 inch (2.5 to 12.7 micrometers) from the surface of the part.

1.2 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

1.2.1 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.

1.2.2 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.

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.

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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.

AMS 2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
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 or www.dsp.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, 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 ambient temperature.

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).

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 ambient temperature.

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 ambient temperature.

3.2.3 Type 3 Etchant shall be a 10 ± 1% by weight solution of ammonium persulfate in water maintained at ambient temperature. 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).

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.

3.3.3.5 Parts shall be rinsed with one of the solutions conforming to 3.2.4 for not less than one minute.

3.3.3.5.1 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. Parts shall be dried or immersed in water-displacing oil (MIL-PRF-32033) immediately.

3.3.3.5.2 Parts that were immersed in sodium phosphate solution do not require a water rinse but shall be dried or immersed in water-displacing oil (MIL-PRF-32033).

3.3.3.6 Dried or oiled parts shall be visually examined.

3.3.3.7 Hydrogen Embrittlement Relief

Parts that are desmutted with hydrochloric or other reducing acids shall be treated in accordance with AMS 2759/9. Such baking shall be performed prior to subjecting the parts to any stress or mechanical operations.

3.3.4 Type 3 Etch

(See 1.2).

3.3.4.1 Etch solution conforming to 3.1.3 shall be applied by swabbing or immersing for the time determined for the sample part.

3.3.4.2 Parts shall be rinsed by swabbing with or immersing in clean water followed by swabbing with or immersing in alcohol. Parts shall be dried or immersed in water-displacing oil (MIL-PRF-32033 or equivalent) immediately after rinsing.

3.3.4.3 Dried or oiled parts shall be visually examined.

3.3.4.4 Hydrogen Embrittlement Relief

Parts that were immersed in etch solution shall be treated in accordance with AMS 2759/9 after the parts are etched and prior to subjecting the parts to any stress or mechanical operations.

3.4 Visual Examination

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

3.4.1 If no overheating or discontinuous carburization, as applicable, 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 or localized carburization. Parts with this indication are not acceptable and shall be reinspected in accordance with 3.4.6.

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 3.4.6.

3.4.4 Extraneous Indications

Etched surfaces with fingerprints, spots, smeared metal, or any other extraneous indications after etching are not acceptable and shall be cleaned, re-etched, and reinspected in accordance with 3.4.6.

3.4.5 Carburized Parts

3.4.5.1 Absence of Carburization

The absence of carburization in any local area where carburization is required (localized discontinuous carburization) is not acceptable and such parts shall be reinspected in accordance with 3.4.6

3.4.5.2 Unauthorized Carburization

The presence of carburization in areas that are not specified are not acceptable and such parts shall be reinspected in accordance with 3.4.6.

3.4.6 Reinspection

Parts with areas indicating overtempering,rehardening, or absent or unauthorized carburize shall be cleaned in accordance with 3.1, re-etched in accordance with the applicable procedure in 3.3, and re-examined in accordance with 3.4 one time only. 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 unacceptable condition such as from overheating, carburization, or decarburization.

3.5.1.2 The etched part shall be examined to confirm that the unacceptable condition (3.5.1.1) can be detected with the solution and the selected etching time.

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

4.1 Responsibility for Inspection

The inspection source shall be responsible for the performance of all required tests. Purchaser reserves the right to perform any confirmatory testing deemed necessary to ensure that etch inspection results conform to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Visual examination (3.4) shall be performed to determine product acceptance.

4.2.2 Periodic Tests

Tests to maintain the solutions (3.5.1) are periodic tests.

4.3 Sampling and Testing

Etch inspection shall be performed on all parts or as agreed upon by purchaser and processing .