AEROSPACE MATERIAL SPECIFICATION

AMS2649™	REV. E

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Superseding AMS2649D

Etch Inspection of High Strength Steel Parts

RATIONALE

AMS2649E results from a Five-Year Review and update of this specification with the addition of Ordering Information and changes to Preparation (see 3.1.1 and 3.1.2.1), Etching Solutions (see 3.2.1.4 and 3.2.1.5), Hydrogen-Embrittlement Relief (see 3.3.3.7), Type 3 Etch (see 3.3.4 and 3.3.4.4), Carburized Parts (see 3.4.5), Solution Qualification (see 3.5.1.1), Periodic Tests (see 4.2.2), and Notes (see 8.2).

NOTICE

ORDERING INFORMATION: The following information shall be provided to the processor by the purchaser.

The purchase order shall specify not less than the following:

- AMS2649E
- Quantity of parts to be etched
- Material type
- Any unique inspection requirements, such as the presence of carburization, if applicable
- Special packaging, if required

1. SCOPE

1.1 Purpose

This specification establishes the requirements for etch inspection of steel parts to detect overheating (rehardening or over-tempering) 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 µm) from the surface of the part.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS2649E/

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.

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 supplier 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 +1 724-776-4970 (outside USA), www.sae.org.

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

ARP1923 Qualification and Certification of Etch Inspectors

ARP4992 Periodic Test for Processing Solutions

AS7766 Terms Used in Aerospace Metals Specifications

2.2 U.S. Government Publications

Copies of these documents are available online at https://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)

2.3 Definitions

Terms used in AMS are defined in AS7766.

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. After cleaning and prior to etching, parts shall be able to maintain a minimum of 30 seconds water break free condition. 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, garnet, 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. Blast media size shall be 100 grit or finer.

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 the cognizant engineering organization.

3.2 Solutions

3.2.1 Etching Solutions

3.2.1.1 Type 1 etchant shall be a 3 to 5% by volume solution of 40° Bé 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).

3.2.1.1.1 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).

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

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

3.2.1.3 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).

3.2.1.4 Solutions may be made up and maintained with nitric acid at other than 40° Bé and hydrochloric acid at other than 22° to 23° Bé if the dilution factors are adjusted to result in the same processing solutions.

3.2.1.5 If different starting acid concentrations are used for solution makeup and maintenance, dilution factors shall be calculated and documented by qualified laboratory personnel, a chemist, or a chemical engineer.

3.2.2 Rinse Solution

3.2.2.1 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) (see 3.3.3.5.2).

3.2.2.2 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 (see 3.3.3.5.1).

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 as stated in 3.5.2.

3.3.1.2 Etching shall be performed under the supervision of personnel certified as stated in 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 as stated in 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 for the time determined for the sample part.

3.3.2.2 Without allowing any etched part to dry, each part shall be immediately rinsed in overflowing tap or hot (130 to 180 °F [54 to 82 °C]) water for not less than 1 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 3.2.1 for the time determined for the sample part.

3.3.3.2 Without allowing etched parts to dry, parts shall be immediately rinsed in overflowing tap water for not less than 1 minute.

3.3.3.3 Each part shall be immersed in the de-smut solution conforming to 3.2.1.2 for 15 to 120 seconds.

3.3.3.4 Without allowing de-smutted parts to dry, parts shall be immediately rinsed in overflowing tap water for not less than 1 minute.

3.3.3.5 Parts shall be rinsed with one of the solutions conforming to 3.2.2 for not less than 1 minute.

3.3.3.5.1 Parts that were immersed in the sodium hydroxide or alkaline cleaning solution shall be rinsed in tap or hot (130 to 180 °F [55 to 82 °C]) water for not less than 1 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 AMS2759/9. Such baking shall be performed after completion of the etch inspection and prior to subjecting the parts to any stress or mechanical operations.

3.3.4 Type 3 Etch

As stated in 1.3.2, Type 3 etch shall only be used when authorized by the cognizant engineering organization.

3.3.4.1 Etch solution conforming to 3.2.1.3 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 AMS2759/9 after the parts are etch inspected 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 a uniform light gray color over the entire area, indicating that the part is acceptable.

3.4.2 Over-Tempering

Areas of parts etching darker (light brown to black) in relation to the surrounding areas have an indication of over-tempering or localized carburization. Parts with this indication are not acceptable and shall be reinspected as stated in 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 as stated in 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 as stated in 3.4.6.

3.4.5 Carburized Parts

Inspection for carburization is applicable to only new manufactured parts and not required during overhaul of used components.

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 as stated in 3.4.6

3.4.5.2 Unauthorized Carburization

The presence of carburization in areas that are not specified is not acceptable and such parts shall be reinspected as stated in 3.4.6.

3.4.6 Reinspection

Parts with areas indicating over-tempering, rehardening, or absent or unauthorized carburize shall be cleaned as stated in 3.1, re-etched as stated in the applicable procedure in 3.3, and reexamined as stated in 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 each 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 (see 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 shall be trained and certified in accordance with ARP1923.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor (inspection source) shall be responsible for the performance of all required tests. The 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 (see 3.4) shall be performed to determine product acceptance.

4.2.2 Periodic Tests

Tests to maintain the cleaning and etching solutions (see 8.8 and 3.5.1) are periodic tests.

4.3 Sampling and Testing

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

4.4 Reports

The processor shall furnish with each shipment a report showing the type of inspection performed (see 1.2) and the results of the inspection. This report shall include the purchase order number, AMS2649E, part number, and quantity.

5. PREPARATION FOR DELIVERY

5.1 Identification

Parts that have been accepted by etch inspection described herein shall be identified as specified as follows:

5.1.1 The letters AE or NE (see 8.2) shall be legibly rubber-stamped on all parts or processing records, unless another method is specified.

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