METRIC

MIL-STD-867B (USAF)
w/CHANGE 1
17 July 2008
SUPERSEDES
MIL-STD-867B
01 March 2007

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

TEMPER ETCH INSPECTION

This document is inactive for new design.

AMSC: N/A

AREA: NDTI

FOREWORD

1. This military standard is approved for use by 309MXSG/MXRL, Department of the Air Force, and is available for use by all departments and agencies of the Department of Defense.

2. This standard provides guidance on the processes for the grinding of chrome plated steel and steel parts for the Air Force repair, acquisition, and manufacture of parts and/or spare parts on the landing gear of all military aircraft.

3. Beneficial comments, recommendations, additions, deletions, and any pertinent data, which may be of use in improving this document, should be addressed to 309MXSG/MXRIL, Hill AFB, UT 84056-2609 or 309MXSG/MXRL@hill.af.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

CONTENTS

CONTENTS

SUMMARY OF CHANGE 1 MODIFICATIONS

1. Paragraph 4.5.1.1 was “Physical test” (delete) and moved “Re-examine for qualification” to paragraph 4.5.1.1, deleting paragraph numbering 4.5.1.4.

2. Paragraph 4.5.1.2 was “Written test” (delete) and move “Re-certification” to paragraph 4.5.1.2 and deleting paragraph numbering 4.5.1.5.

3. Paragraph 4.5.1.3 “Practical test” has been deleted in its entirety with no replacement.

PARAGRAPHS	MODIFICATION
4.5.1.1	Changed
4.5.1.2	Changed
4.5.1.3	Deleted

1. SCOPE

1.1 Scope. This standard establishes requirements and test for performing temper etch inspection of carburized steels and tool and low alloy steels, which are heat treated above 1.24×10^9 Pascal (PA) (1.26×10^2 kilogram – force/square millimeter (Kgf/mm^2) or 1.8×10^5 pound – force/square inch (psi). This standard applies to aircraft and missiles structural and propulsion system components when MIL-HDBK-6870 (for guidance only) and/or MIL-STD-866 are reference documents in the solicitation or contract.

1.2 Groups. Temper-etch inspection is typically performed on steels from the following groups:

a. Group A: Low alloy steels:

SAE 52100	SAE 4140	SAE 4330
SAE 4340	300 M	D6AC
440C		

Carburizing Steels:

SAE 4620	9310	AMS 6260

b. Group B: Tool Steels:

H-11	M-50	M-2
H-13		

1.2.1 Case hardened steels. The standard is not applicable to surface hardened steels produced by nitriding or carbonitriding.

1.3 Purpose. This inspection is to be conducted to determine if heat has been induced in a component, subsequent to final heat treat, by machining, grinding, or other means, which will adversely affect the required properties of that component.

1.3.1 Localized discontinuous carburization. To detect localized discontinuous carburization due to an inadvertent carburize stop-off and to determine the presence of or lack of total carburization in specified locations.

1.3.2 De-carburized surface layer. To detect a de-carburized surface layer.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, and 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, handbooks, and commercial item descriptions. The following specifications, standards, handbooks, and commercial item descriptions form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

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

(Copies of these documents are available online at http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

COMMERICAL ITEM DESCRIPTIONS

A-A-59105	Nitric Acid, Technical
A-A-59281	Cleaning Compound, Solvent Mixtures

(Copies of these documents are available online at http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5091.)

CODE OF FEDERAL REGULATIONS (CFR)

27CFR 21.35	Formula 3-A

(Copies of this document are available online at www.access.gpo.gov/nara/cfr or from the Superintendent of Documents, U.S. Printing Office, North Capitol & “H” Streets, N.W., Washington D.C. 20402-0002.)

2.3 Non-Government standards and publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE-AMS-H-6875 Heat Treatment of Steels, Raw Materials

(Copies of these documents are available online at www.sae.org or from the Society of Automotive Engineers International, 400 Commonwealth Drive, Warrendale, PA 15096-1001.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM – D329 Acetone

ASTM – D456 Sodium (Anhydrous), Caustic

ASTM – E1146 Acid, Muriatic, (Technical Grade) Hydrochloric Acid

ASTM – E1444 Particle Testing, Magnetic

(Copies of these documents are available at www.astm.org or ASTM International, 100 Barr Harbor Drive, P.O. Box C700, Wes Conshohocken, PA 19428-2959.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS (Not applicable.)

4. GENERAL REQUIREMENTS

4.1 Materials and equipment.

4.1.1 Materials. The use of reclaimed materials shall be encouraged to the maximum extent possible. Materials required are as follows:

a. Methyl or ethyl alcohol (CH_3OH – C_2H_5OH), (27CFR 21.35, Formula 3-A)

b. Hydrochloric Acid (HCL), (ASTM – E1146)

c. Nitric Acid (HNO_3), (A-A-59105)

d. Sodium Hydroxide (NaOH), (ASTM – D456)

e. In lieu of (d) above, any common alkali solution with a pH greater than or equal to 10 may be used.

f. Ammonium Peroxydisulfate (Ammonium Persulfate) $(NH_4)_2S_20_8$ commercial.

4.1.2 Equipment.

a. A commercial industrial vapor degreaser or a hot alkaline cleaning system.

b. Containers used for acid solutions shall be non-reactive to acid and alkali solutions, preferably made of polyethylene or polyvinyl chloride material.

c. Water rinse tanks shall be equipped with a constant overflow or skimming device.

d. The following auxiliary equipment shall be provided:

(1) Clock or timer with sweep second hand.

(2) Light capable of insuring 2152.8 Lux. (200 foot candles) at inspection level.

(3) Burette for titrating solutions for acid concentrations.

4.1.3 Company process specifications. Company process specifications may be prepared incorporating the applicable requirements of this standard and in addition supplying the detailed information necessary to meet or exceed this standard using the particular equipment, process, personnel and test facilities required to meet the reliability requirements of the product. Personnel training, qualification and certification procedures shall be documented.

4.1.3.1 Standardization. The company process specification shall reflect procedures and records to assure adequate Quality Assurance measures are being enforced to keep the NDT process in control. Applicable drawings or other documents shall specify the allowable severity and concentration of allowable temper etch conditions through use of photographs or wording as to allowable grinding burn severities by color, size and/or hardness differential. The component or applicable document shall also show:

a. Process name.

b. Process step number and operation name.

c. Processing time for each step.

d. Processing temperature for each step.

e. Materials used in each processing tank.

4.2 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection

requirements as specified herein. The supplier may utilize his own facilities or any other commercial laboratory acceptable to the customer.

4.3 Manufacturing process cycle. The temper etch process shall be used after final grinding or machining operations but prior to any processing, which may interfere with this inspection, such as plating or shot peening. Parts finished to close tolerances shall be dimensionally inspected after etch inspection as the etch process may remove from 0.0013 to 0.0051 millimeters (0.00005 to 0.0002 inch) of material from the surface of the part.

4.4 Record of inspection. The results of the etch inspection shall be appropriately recorded and filed.

4.5 Qualification and certification. Before performing temper etch inspection on production parts inspection personnel shall be qualified and certified in accordance with this standard.

4.5.1 Initial qualification. At qualification inspection personnel shall pass physical, written and practical tests.

4.5.1.1 Re-examine for qualification. Personnel examined and not meeting qualification standards must wait 30 days and show evidence of having taken suitable corrective action, additional training or self-study before re-examination.

4.5.1.2 Re-certification. Personnel performing temper etch inspection shall be re-qualified and re-certified as specified in paragraphs 4.5.1.2 and 4.5.1.3 at intervals not to exceed three (3) years.

4.5.2 Certification. Records for all qualified personnel shall be maintained and include: Date of qualification, results of physical, written and practical test, and experience as a temper etch inspector.

5. DETAILED REQUIREMENTS

5.1 Process. Temper etch inspection may be accomplished utilizing a process procedure as listed in Tables I, II, III or IV for the type of steel to be inspected. The entire surface of the feature in question shall be etched and inspected.

5.2 Cleaning. Parts shall be cleaned to a water break free condition just prior to the etch process by vapor degreasing, hot ultrasonic cleaning or nitric acid etch. To obtain a uniform surface for optimum temper etch on rough surfaces, grit blasting or liquid honing is recommended.

TABLE I

Table I may be used to etch low alloy steels (Group A)

	PROCESS	SOLUTION	TIME	TEMPERATURE	REMARKS
1.	Nitric Acid Etch	Nitric Acid 3% - 5% (by volume) in alcohol Nitric Acid 3% - 5% (by volume) in water	15 – 60 seconds 5 – 15 seconds	Ambient	Agitate parts when immersed. Exact time may vary to produce desired black oxide film.
2.	Rinse	Circulating water	Rinse only	Ambient	To remove acid. Total immersion required.
3.	Hydrochloric Acid Dip	Hydrochloric Acid 4% - 6% (by volume) in alcohol or water Hydrochloric Acid 1% - 3% (by volume) in alcohol	30 – 60 seconds 5 – 15 seconds	Ambient Part immersed in hot directly from a 82.2˚C (180˚F) min vapor degreaser	Agitate parts when immersed to remove black oxide film and provide uniform brownish grey surface.
4.	Rinse	Running water	Rinse only	Ambient	Agitate parts when immersed.
5.	Neutralize	Any alkali solution with pH of 10 minimum	15 seconds minimum	15.5 – 82.2˚C (60 - 180˚F)	Agitate parts when immersed.
6.	Rinse	Circulating water	Rinse only	Ambient	To remove caustic.
*7.	Rinse	Alcohol	Rinse only	Ambient	To remove water.
8.	Oil	Rust preventative oil		Ambient	To remove corrosion & aid to color contrast of burns.
9.	Inspect and evaluate per appropriate criteria.				
* Operational procedure: Hot water rinse (65.5˚C minimum {150˚F}), followed by a dry air blast may be used in lieu of this rinse.					
Pre-cleaning, water rinse and Steps 1 thru 8 shall be one continuous operation.					

TABLE II

Table II may be used to acid etch tool steels (Group B)

STEP	PROCESS	SOLUTION	TIME	TEMPERATURE	REMARKS
1.	Hydrochloric acid clean	Hydrochloric acid 4.0% - 6.0% (by volume) in alcohol or water	1 ½ to 3 ½ minutes	Ambient	To de-oxidize part. Agitate part during entire immersion time
2.	Rinse	Circulating water	Rinse only	Ambient	To remove acid. Total immersion required.
3.	Nitric acid	Nitric acid 2.5% to 3.5% (by volume) in alcohol or water	1 ½ to 2 ½ minutes	Ambient	Agitate parts during entire immersion time. Exact time may vary to produce desired black oxide film.
4.	Rinse	Circulating water	Rinse only	Ambient	To remove acid. Total immersion required.
5.	Hydrochloric acid. Acid dip.	Hydrochloric acid 4.0% - 6.0% (by volume) in alcohol or water	1 ½ to 3 ½ minutes	Ambient	Agitate parts during entire immersion time. To remove black oxide film and produce a uniform brownish/gray surface.
6.	Rinse	Circulating water	Rinse only	Ambient	Agitate parts when immersed
7.	Neutralize	Any alkali solution with pH of 10 minutes	15 seconds minimum	Ambient	Agitate parts when immersed
8.	Rinse	Running water	Rinse only	Ambient	To remove caustic
*9.	Rinse	Alcohol	Rinse only	Ambient	To remove water
10.	Oil	Rust preventative oil	Dip only	Ambient	To prevent corrosion and aid in color contrast of burns.
11.	Inspect and evaluate per appropriate criteria.				
* Optional procedure: Hot water rinse (65.5˚C minimum {150˚F}), followed by a dry air blast may be used in lieu of this rinse.					
Pre-cleaning, water rinse and Steps 1 thru 10 shall be one continuous operation.					

TABLE III

(Limited Access or Swab Etch Techniques)

STEP	PROCESS	SOLUTION	TIME	TEMPERATURE	REMARKS
1.	Solvent clean	Cleaner A-A-59281 or ASTM-D329	As necessary	Ambient	Wipe surface with commercial cheese cloth saturated with solvent. Wipe dry with cheese cloth.
2.	Nitric acid etch	Nitric acid (A-A-59105) 4% to 10% (by volume) in alcohol (27CFR 21.35, Formula 3-A)	Until a black smutty etch is produced.	Ambient	Swab the surface with commercial grade cheese cloth saturated with Nitric solution. The more concentrate solution reduces time.
3.	Rinse	Acetone (ASTM-D329)	To remove nital	Ambient	Rinse immediately
4.	Acid clean	Hydrochloric acid (ASTM-E1146) 6% to 10% (by volume) in water	To remove black smut.	Ambient	Swab with commercial cheese cloth saturated with HCL solution.
5.	Rinse	Clean water	To remove HCL	Ambient	Swab with commercial cheese cloth saturated with water.
6.	Neutralize	Any alkali solution with pH of 10 minimum	To neutralize HCL	Ambient	Swab with commercial cheese cloth saturated with alkali solution.
7.	Rinse	Clean water	To remove caustic	Ambient	Swab with commercial cheese cloth saturated with water.
8.	Rinse	Alcohol (27CFR 21.35, Formula 3-A)	To remove water	Ambient	Swab with commercial cheese cloth saturated with alcohol and wipe dry.
9.	Oil	Rust preventative MIL-PRF-16173	Swab only	Ambient	To prevent corrosion.
10. Inspect and evaluate per appropriate criteria.					
Steps 1 thru 10 should be completed without interruption.					

TABLE IV

Ammonium Peroxydisculfate (Ammonium Persulfate) swab etch technique

STEP	PROCESS	SOLUTION	TIME	TEMPATURE	REMARKS
1.	Solvent clean	Acetone (ASTM-D329) or cleaner (A-A-59281)	As necessary	Ambient	Wipe surface with commercial cheese cloth saturated with solvent. Wipe dry with cheese cloth.
2.	Etch	Ammonium Peroxydisulfate 10% by weight in water.	15 – 60 seconds	Ambient	Make solution just before using swab with commercial cheese cloth saturated with solution.
3.	Rinse	Clear water	As required to remove alkali solution	Ambient	Swab area with commercial cheese cloth saturated with water.
4.	Neutralization	Any alkali solution with a pH of 10 minimum	As required to neutralize etchant	Ambient	Swab area with commercial cheese cloth saturated with alkali solution.
5.	Rinse	Clear water	As required to remove alkali solution	Ambient	Swab with commercial cheese cloth saturated with water.
6.	Rinse	Alcohol (27CFR 21.35, Formula 3-A)	To remove water	Ambient	Swab with commercial cheese cloth saturated with alcohol. Wipe dry.
7.	Oil	Rust preventative (MIL-PRF-16173)	Swab only	Ambient	To prevent corrosion.
8.	Inspect and evaluate per appropriate criteria.				
* This process may also be used as an immersion technique, provided pre-cleaning is in accordance with para 5.2.					
Steps 1 thru 8 should be completed without interruption.					

5.3 Acid etches visual inspection. Inspection of etched surfaces shall be performed under light resulting in a minimum of 2152.8 Lux (200 foot candles) at part surface.

5.3.1 Rejection criterion. The presence of the following indications shall be cause for rejection.

a. Un-tempered martensite as evidenced by light gray or white areas surrounded by a light brown to black border.

b. Over-tempered areas as evidenced by light brown to black indications darker than surrounding areas.

c. Acceptance/rejection standards. The presence of the following indications shall be cause for review to established acceptance/rejection standards (See: 4.1.3.1).

(1) Non-carburized/de-carburized areas. Non-grinding related: These areas will appear unusually lighter in color than adjacent carburized areas.

(2) Improper carburization. Non-grinding related: These areas are isolated or complete areas of carburization not required by blueprint.

5.3.2 Acceptable color. If no damage was produced by the pre-production operations, the surface will be a uniform gray. This discoloration is not detrimental to part usage.

5.4 Baking. After the final etch, accepted parts processed by etch methods: Table I, II and III shall be baked at 191 ± 14˚C (375 ± 25˚F) or 10 ± 13.88˚C (50 ± 25˚F) below the final tempering temperature of the part for four (4) hours. Parts with tempering temperature exceeding 398.88˚C (750˚F) may be baked at 371.11 ± 13.89˚C (700 ± 25˚F) for four (4) hours. Such baking should to be initiated within eight (8) hours of the final visual inspection and before any plating operations. Parts processed by etch methods in Table IV will not require a bake. All furnaces used shall be certified to SAE-AMS-H-6875.

5.5 In-service quality checks.

5.5.1 Acid concentrations. Acid solutions shall be analyzed at a frequency determined to assure concentration limits.

5.5.2 Sensitivity. A standard test piece, which contains representative grinding burns will be processed each day that the etch is operated by production inspection personnel to verify that the etching solutions and techniques are adequate to detect grinding burns.

5.5.3 Magnetic particle inspection. All parts shall be magnetic particle inspected in accordance with ASTM – E1444 after baking and prior to other processing, which might hinder detection of a discontinuity.

5.5.4 Records. Historical records shall be maintained on all chemical tests and on additions made to the solution.

5.6 Re-etching. A part may be etched two or more times, if dimensions and surface finishes allows, in order distinguishing burn indications from irrelevant indications; such as, smear or smutty finishes. Aluminum oxide grit – blast between re-etch is recommended.

5.7 Seeking competent advice. A metallurgist shall be consulted in instances where the results of the etching appear inconclusive and where further interpretation is required. When results of etching are inconclusive or interpretation is questionable, as representative part may be sectioned and prepared for metallographic examination. Micro-hardness and structural characteristics should be determined.

5.8 Hardness testing. If part size and configuration permits, hardness testing in accordance with ASTM – E18 using 15/N Rockwell test equipment may be used as an evaluation of hardness in moderate to heavy over-tempered areas. A reduction of two (2) Rockwell 15/N points or more from the areas directly adjacent to the burn is indicative of an over-stressed and crack susceptive condition and should **not** be accepted in high stress areas. In lieu of Rockwell 15/N hardness testing, 1000 gram maximum load micro-hardness testing may be employed.

5.9 Rework/salvage. If sufficient stock remains for rework within the specified dimensions, the parts may be reworked to remove indications of over-tempering or re-hardening. Parts subjected to this rework shall be re-acid etch inspected.

5.10 Acid etch removal. Discoloration from the acid etch inspection process shall be acceptable unless otherwise specified by the drawing or customer requirements. The discoloration may be removed by polishing, honing, vapor grit blasting, or electrolytic alkaline cleaning methods providing dimensional changes do not exceed drawing requirements and customer approval is obtained.

5.11 Marking. Parts which have met the etch inspection requirements shall be marked in accordance with the applicable drawing, specification, purchase order or contract. Marking, as specified, shall be applied in such manner and location as to be harmless to the part and which will preclude removal smearing or obliterating by subsequent handling. A symbol N or NE may be used.

5.12 Toxic and hazardous substances. This document specifies use of certain materials, which have been listed in subpart Z, 29 CFR 1910 (OSHA Standards), “Toxic and Hazardous Substances.” Personnel exposure to these materials must be limited to the values specified in applicable portions of 29 CFR 1910.1000.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard provides the step by step process and procedures for temper etch to be used during repair process and acquisition of spares

for the landing gear of all military aircraft. It is a process and procedure unique to the Air Force and is used primarily by the Air Force at Hill Air Force Base.

6.2 Subject term (key word) listing.

Equipment
Materials
Process

6.3 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate modifications generated by this change. This was done as a convenience only and the Government assumes no liability whatsoever for an inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

CONCLUDING MATERIAL

Custodian:
Air Force – 70

Preparing Activity:
Air Force – 70

(Project: NDTI-2008-006)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using ASSIST Online database at http://assist.daps.dla.mil.