American National Standard

for Rolling Element Bearings – Aircraft Engine, Engine Gearbox, and Accessory Applications – Surface Temper Etch

ANSI B3.3-1992

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New York, New York
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B3.3-1992

American National Standard

for Rolling Element Bearings – Aircraft Engine, Engine Gearbox, and Accessory Applications – Surface Temper Etch

Secretariat

Anti-Friction Bearing Manufacturers Association, Inc.

Approved February 21, 1992

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Published by

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11 West 42nd Street, New York, New York 10036

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APS2C592/18

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Foreword (This foreword is not part of American National Standard B3.3-1992.)

This American National Standard was prepared by a task force consisting of representatives of companies which manufacture rolling element bearings and aircraft, or aircraft engines, or both, in the United States. This standard is issued by the Accredited Standards Committee B3 of the American National Standards Institute as an industrial standard that is intended to be used by aircraft manufacturers, or aircraft engine manufacturers, or both, for the procurement of rolling element bearings for aircraft engine and accessory applications. (This document parallels MIL-STD-867A (USAF), *Military standard temper etch inspection.*)

Suggestions for improvement of this standard will be welcome. They should be sent to the Anti-Friction Bearing Manufacturers Association, Inc., 1101 Connecticut Avenue, NW, Suite 700, Washington, DC 20036.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Ball and Roller Bearings, B3. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the B3 Committee had the following members:

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Robert H. Feest, Vice-Chairman
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American National Standard for Rolling Element Bearings – Aircraft Engine, Engine Gearbox, and Accessory Applications – Surface Temper Etch

1 Scope

During the manufacture of bearing components, there are many grinding processes which must be carefully controlled. These grinding processes can cause excessive localized heating of the metal being worked and result in altering the metallurgical structure of the alloy. An inspection method of etching the ground surface of these alloys with acids permits detection of those altered structures. This specification for temper etch inspection details the methods and controls for performing etching of ground surfaces for the detection, qualification, and control of altered metallurgical structures of various metallic alloys subjected to grinding.

This specification presents two basic methods of etch, one of alcohol base and another of water base, in addition to use of a photographic gray scale to control bath immersion times and part etching levels. This standard parallels MIL-STD-867A (USAF), *Military standard temper etch inspection*.[1)]

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI/SAE ARP 1923, *Qualification and certification of etch inspectors*

MIL-STD 867A-1979, *Military standard temper etch inspection*[1)]

3 Definitions

3.1 critical surfaces: Bearing critical surfaces are the surfaces of balls, rollers, and raceways.

3.2 tempering: Areas darker in color than the surrounding etched surfaces indicate lower surface hardness. The areas affected are recognized as dark gray to black in color. The burnt condition may be produced by abnormal tempering as a result of localized overheating due to abusive grinding.

3.3 rehardening: Areas white or very much lighter in color than the surrounding etched surfaces indicate higher surface hardness. The areas affected may be recognized as white islands surrounded by a border of tempered metal (black). The rehardened condition is produced by localized overheating that exceeds the critical temperature of the metal. The rehardening condition is the result of very severe abusive grinding.

3.4 decarburization: Areas lighter in color than the surrounding unburnt areas indicate a lower surface hardness. This discrepancy is unrelated to abusive grinding. These areas are deficient in carbon (*decarburization*) and are produced by certain heat treatment conditions.

3.5 false indications: Indications caused by smears, stains, certain wheel patterns, buffing wheel patterns, smutty finishes, fingerprints,

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and corrosion shall not be considered true temper indications.

3.6 Kodak paper gray scale: Photographic gray scale #906GS171 calibrated. Used to compare to etched parts for setting immersion times or to determine acceptable etching.

3.7 nital etch: A process that makes possible the study of steel grain structures, soft spots, and grinding damage by dipping the parts into nitric acid, alcohol, and water.

3.8 nicks, dents, or indentations: Depressions or hollows on a surface made by mechanical injuries to the surface, such as from pressure or blows by hard objects against the finished surface. These generally appear the same as the unmarred surface around, and are visible only by virtue of light reflection caused by the change in uniformity of the surface. Typically these defects are bright-bottomed.

3.9 wheel chatter: Recurring undulations or irregularities on the finished surface normally resulting from grinding wheel skips or external vibration.

3.10 scratch: A linear depression with a sharp bottom caused by movement of a sharp object or particle across the surface.

3.11 cracks: A separation, fissure, or rupture of material surface characterized by sharp edges or sharp changes in direction, or both, usually narrow and linear.

3.12 lap: Folding of metal onto itself during mechanical deformation, entrapping oxides or films.

3.13 seam: A linear imperfection caused by folding over of metal edges during rolling or forging operations, discontinuities in material (see also *lap*).

3.14 microshrinkage: Linear or nonlinear discontinuities of varying forms caused by decrease in volume during solidification.

3.15 porosity: A series of holes or pits caused by air or gas trapped in the metal during solidification.

3.16 cold shut: Intermittent or continuous lines caused by unfused material.

3.17 hot tears: Linear fractures in the form of ragged, wavy lines of variable width resulting from overstress of the material during solidification.

3.18 inclusion: An entrapped foreign material particle retained in the metal during solidification, irregular in shape and dark-colored in contrast to the normal metallic shiny surface.

3.19 tool marks: Recurring undulations or irregularities.

3.20 grinding tears: A deep narrow scratch, parallel to the lay of the surface, sometimes with a hole at one end, resulting from material being pulled during a grinding or honing operation. The scratch and the hole are commonly known as a comet tail and comet head, respectively.

4 Requirements

4.1 General requirements

Temper etch inspection is performed on ground surfaces of various steel alloys. All parts shall be 100% inspected. Alloys applicable to this inspection are from the following groups:

4.1.1 52100 type alloys

These alloys are as follows: SAE 52100; SAE 4140; SAE 4330; SAE 4340, 300M, D6AC; SAE 4620, 9310, AMS 6260, 8620, etc.

4.1.2 M-50 type alloys

These alloys are: through-hardened J-11, M-50, M-2, H-13, etc., and case-carburized M-50 NIL, etc.

4.1.3 Visual inspection areas

The visual inspection areas shall be illuminated by a minimum of 200 ft-candles (2000 lux) at inspection level. The white light intensity shall be checked at minimum on a semi-annual basis, and a calibration sticker placed on the fixture.

4.1.4 Surface temper inspection

Surface temper inspection shall be done before any plating, shot peening, sandblasting, or other surface process such as black oxide coating and manganese phosphate coating.

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4.1.5 Nonvisual inspection activity

The inspector shall have 15 min of nonvisual inspection activity after 2 hours of continuous high visual concentration.

4.1.6 Post-etch grinding

Post-etch grinding of faces and external ring corners of rolling element bearings is permitted without reinspection, provided each grinding pass is limited to 0.001 in (0.025 mm) maximum stock removal.

4.1.7 Magnetic particle inspection

Magnetic particle inspection, if specified, shall be done prior to temper etch inspection.

4.2 Inspection personnel requirements

4.2.1 All surface temper inspection personnel (operators and inspectors) shall be certified by the customer in accordance with the requirements outlined in ANSI/SAE ARP 1923. The recertification period may be altered to that permitted by MIL-STD-867A by agreement between customer and bearing manufacturer.

4.2.2 All applicants shall have a minimum of 4 hours of formal classroom training.

4.2.3 All applicants shall have at least one month of *on-the-job* training in the temper etch process prior to certification.

5 Test methods

The choice of method described below is left to the bearing manufacturer, with the exception of the material restrictions noted. All etchants are to be technical grade acids.

5.1 Etch method (52100 type)

5.1.1 Cleaning

Parts shall be cleaned preferably by immersion in a hot detergent solution. Alternative cleaning may be used as long as acceptably clean parts are obtained.

5.1.2 Rinse

One, preferably two, tanks of cold overflowing water 10 s minimum.

5.1.3 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.1.4 Nitric acid etch

Parts shall be immersed in a solution of nitric acid and water or alcohol for approximately 15 to 60 s, or until a uniform gray color is obtained. Immersion time can be adjusted to obtain a gray level equivalent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference. The total range of the etchant shall be 1.0 to 4.0% by volume and controlled to an operating range of 1.0% at room temperature, 60 to 90°F (15.5 to 32.2°C).

NOTE – Water-based solution will etch much more quickly; therefore, the gray color will be the time determining function.

5.1.5 Rinse

Use cold overflowing water, 10 s minimum.

5.1.6 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.1.7 Muriatic acid etch

Parts shall be immersed in a solution of concentrated muriatic acid and water or alcohol (five parts muriatic acid to 95 parts mix) for 1 to 1-1/2 min. The operating range of the etchant shall be 4 to 6% by volume at room temperature, 60 to 90°F (15.5 to 32.2°C).

5.1.8 Rinse

Use cold overflowing water, 10 s minimum.

5.1.9 Neutralize

Parts shall be immersed in a solution with a pH of 10 minimum for at least 15 s. A blue response on pH paper will meet this requirement.

5.1.10 Rinse

Use cold overflowing water, 10 s minimum.

5.1.11 Dry

Air blow to remove excess water, or place parts in a controlled, water-displacing, rust-preventative oil bath, agitate, and then allow

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to dwell 1 min minimum. The oil bath alternative satisfies the requirements of 5.1.12.

5.1.12 Corrosion protection

Parts shall be immersed in a light, rust-preventative oil to protect components during inspection.

5.2 Etch method (M-50 type)

5.2.1 Cleaning

Parts shall be cleaned preferably by immersion in a hot detergent solution. Alternative cleaning may be used as long as acceptably clean parts are obtained.

5.2.2 Rinse

One, preferably two, tanks of cold overflowing water, 10 s minimum.

5.2.3 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.2.4 First muriatic acid etch

Parts shall be immersed in a solution of concentrated muriatic acid and alcohol or water (5 parts muriatic acid to 95 parts mix) for 3 min ± 30 s. The operating range of the etchant shall be 4 to 6% by volume at room temperature, 60 to 90°F (15.5 to 32.2°C).

5.2.5 Rinse

Use cold overflowing water, 10 s minimum.

5.2.6 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.2.7 Nitric acid etch

Parts shall be immersed in a solution of nitric acid and water or alcohol for 3 min ± 30 s, or until a uniform gray color is obtained. Immersion time can be adjusted to obtain a gray level equivalent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference. The operating range of the etchant shall be 1.0 to 4.0% by volume and controlled to an operating range of 1.0% at room temperature, 60 to 90°F (15.5 to 32.2°C).

5.2.8 Rinse

Use cold overflowing water, 10 s minimum.

5.2.9 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.2.10 Second muriatic acid etch

Parts shall be immersed in a solution of concentrated muriatic acid and alcohol or water (5 parts concentrated, muriatic acid to 95 parts mix) for 2-1/2 to 3 min. The operating range of the etchant shall be 4 to 6% at room temperature, 60 to 90°F (15.5 to 32.2°C).

5.2.11 Rinse

Use cold overflowing water, 10 s minimum.

5.2.12 Neutralize

Parts shall be immersed in a solution with a pH of 10 minimum for at least 15 s. A blue response on pH paper will meet this requirement.

5.2.13 Rinse

Use cold overflowing water, 10 s minimum.

5.2.14 Dry

Air blow to remove excess water, or place parts in a controlled, water-displacing, rust-preventative oil bath, agitate, and then allow to dwell 1 min minimum. The oil bath alternative also satisfies the requirement of 5.2.15.

5.2.15 Corrosion protection

Parts shall be immersed in a light, rust-preventative oil to protect components during inspection.

5.3 Etch method (localized etch)

WARNING – Do not preclean too many parts at a time as dry parts are more prone to corrosion.

5.3.1 Cleaning

Parts shall be cleaned preferably by immersion in a hot detergent solution. Alternative

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cleaning may be used as long as acceptably clean parts are obtained.

5.3.2 Rinse

One, preferably two, tanks of cold overflowing water, 10 s minimum.

5.3.3 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.3.4 **First muriatic acid etch** (M-50 type only)

5.3.4.1 Internal surfaces

Dip felt pad cut to size in a 5% ± 1% solution of concentrated muriatic acid and alcohol or water (5 parts muriatic acid to 95 parts mix), and swab area to be etched for 2 to 3 min, occasionally redipping felt pad.

5.3.4.2 External surfaces

Place part in appropriately-sized shallow dish containing only enough, 5% ± 1%, solution of concentrated muriatic acid and alcohol or water to wet the surface to be etched, and slowly dip or rotate the part for 2 to 3 min.

5.3.5 Rinse

Use cold overflowing water, 10 s minimum.

5.3.6 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.3.7 **Nitric acid etch** (M-50 and 52100 types)

5.3.7.1 Internal surfaces

Dip a second felt pad cut to size in a 1 to 4% solution of nitric acid and water or alcohol, and swab area to be etched, for M-50 type 2 to 3 min, and for 52100 type 15 to 60 s or until uniform gray color is obtained. Swabbing time can be adjusted to obtain a gray level equivalent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference.

NOTE – Water-based solution will etch much more quickly; therefore, the gray color will be the time determining function.

5.3.7.2 External surfaces

Place part in second, appropriately-sized, shallow dish containing only enough, 1 to 4%, solution of nitric acid and water or alcohol to wet the surface to be etched, and slowly dip, rotate, or swab the part, for M-50 type 2 to 3 min, and for 52100 type 15 to 60 s, or until a uniform gray color is obtained. Immersion time can be adjusted to obtain a gray level equiva-lent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference.

NOTE – Water-based solution will etch much more quickly; therefore, the gray color will be the time determining function.

5.3.8 Rinse

Use cold overflowing water, 10 s minimum.

5.3.9 Dry

Air blow to remove excess water that may affect the concentration of the etch bath. (This applies if an alcohol acid solution is used for etching; alternatively, an alcohol rinse may be used.)

5.3.10 **Second muriatic acid etch** (M-50 and 52100 types)

5.3.10.1 Internal surfaces

Dip first felt pad in a 5% ± 1% solution of concentrated muriatic acid and alcohol or water, and swab area to be etched, for M-50 type 2 to 3 min, and for 52100 type 1 to 1-1/2 min, occasionally redipping felt pad.

5.3.10.2 External surfaces

Place part in first dish containing 5% ± 1% solution of concentrated muriatic acid and alcohol or water, and slowly dip or rotate the part, for M-50 type 2 to 3 min, and for 52100 type 15 to 60 s.

5.3.11 Rinse

Use cold overflowing water, 10 s minimum.

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5.3.12 Neutralize

Parts shall be immersed in a solution with a pH of 10 minimum for at least 15 s. A blue response on pH paper will meet this requirement.

5.3.13 Rinse

Use cold overflowing water, 10 s minimum.

5.3.14 Dry

Air blow to remove excess water, or place parts in a controlled, water-displacing, rust-preventative oil bath, agitate, and then allow to dwell 1 min minimum. The oil bath alternative also satisfies the requirements of 5.3.15.

5.3.15 Corrosion protection

Parts shall be immersed in a light, rust-preventative oil to protect components during inspection.

5.4 Water base short cycle etch

5.4.1 Cleaning

Parts shall be cleaned preferably by immersion in a hot detergent solution. Alternative or additional cleaning may be used as long as acceptably clean parts are obtained.

5.4.2 First rinse

Rinse in hot overflowing tap water, 90 to 120°F (32.2 to 48.9°C) 5 to 10 s.

5.4.3 Second rinse

5.4.3.1 52100 type steel

Rinse in ambient overflowing tap water, 60 to 90°F (15.5 to 32.2°C) 5 to 10 s.

5.4.3.2 M-50 type steel

Rinse in hot overflowing tap water, 100 to 140°F (37.8 to 60°C) 5 to 10 s.

5.4.4 Nitric acid etch

5.4.4.1 52100 type steel

Parts shall be immersed in a solution of nitric acid and water for 2 to 4 s or until a uniform gray color is obtained. The operating range of the etchant shall be 1 to 4% by volume at room temperature, 60 to 90°F (15.5 to 32.2°C). The vendor may select any concentration in that range, but must control the selected concentration ±1 and remain within the range. Immersion time can be adjusted to obtain a gray level equivalent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference.

NOTE – Water-based solution will etch much more quickly; therefore, the gray color will be the time determining function.

5.4.4.2 M-50 type steel

Parts shall be immersed in a solution of nitric acid and water for 15 to 60 s or until a uniform gray color is obtained. Immersion time can be adjusted to obtain a gray level equivalent to the range between 0.67 to 1.35 inclusive using a Kodak paper gray scale #906GS171, or equivalent, as a reference. The operating range of the etchant shall be 1 to 4% by volume at room temperature, 60 to 90°F (15.5 to 32.2°C). The vendor may select any concentration in that range, but must control the selected concentration ±1 and remain within the range.

NOTE – Water-based solution will etch much more quickly; therefore, the gray color will be the time determining function.

5.4.5 Post etch rinse

Rinse in warm overflowing tap water, 80 to 100°F (26.7 to 37.8°C) 5 to 10 s.

5.4.6 Corrosion protection

Parts shall be first sloshed then allowed to dwell 1 min minimum in a water-displacing, rust-preventative oil prior to inspection.

5.5 Maintenance and control of nital etch process baths

5.5.1 The solution (acid etchants and neutralizer) shall be checked and logged once per shift, when in use by the nital etch operator, for conformance to concentration limits. Defect samples shall be used each shift (daily), during the solution life, to verify effectiveness.

5.5.2 Proper additions shall be made to the solutions by the nital etch operator in order to maintain the required concentrations.

5.5.3 Solutions shall be discarded when analysis of tests indicate the need for change; however, more frequent changing may be required if experience indicates that this practice is nec-

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essary to control excessive contamination. In any event, all new solutions shall be checked for concentration limits before usage.

CAUTION – When mixing solutions, always add acid to alcohol or water, never alcohol or water to acid.

5.5.4 The etching solution tanks and neutralizer tank should be covered when not in use to retard evaporation losses and to prevent contamination.

5.5.5 Timer shall be calibrated, at minimum, on a yearly basis and have an unexpired sticker.

5.5.6 All cold water rinse tanks shall be equipped with constant overflow to prevent surface film build-up.

6 Acceptance limits

6.1 Any surface

Material defects such as cracks, laps, seams, microshrinkage, porosity, cold shuts, hot tears, inclusions, etc. shall be cause for rejection, and so noted by the inspector.

6.2 Critical surfaces

Raceways, sidewalls (also called guide flanges or ribs), balls, and rolls (also called rollers) shall not exhibit any overetching outside the gray scale limits, or overtempering, rehardening, or decarburization.

6.3 Noncritical surfaces (remaining surfaces)

6.3.1 Noncritical surfaces shall not exhibit any rehardened or decarburized areas.

6.3.2 Noncritical surfaces shall not exhibit discontinuous surface temper indications exceeding 20% of the total etched area.

6.3.3 Noncritical surfaces shall not exhibit continuous surface temper indications exceeding 10% of the total etched areas.

6.3.4 Noncritical areas with limited patterns of abnormal tempering are acceptable, only if the hardness tests in the pattern areas conform to purchaser's engineering print standards.

6.4 Questionable parts

6.4.1 Visible imperfections such as nicks, dents, wheel chatter, scratches, or tool marks shall be noted, tagged, or marked and evaluated to visual standards for acceptance or rejection.

6.4.2 After processing, should any areas appear unetched due to air entrapment, incomplete cleaning, etc. that interfere with acceptable inspection, parts exhibiting this condition shall have the etch removed, be cleaned, and reprocessed.

6.5 Nonconformances

Parts not meeting the requirements of this standard shall be rejected. If rework or repair is performed, reinspection is required.

7 Records

Records shall be kept of inspection and applicable test results. (The quality department shall be responsible for maintaining the records on file for 15 years.)

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