

NOTICE OF
ADOPTIONADOPTION NOTICE 1
09 August 1993
AS4506
29 December 1992

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400 Commonwealth Drive
Warrendale, PA 15096-0001

Title of Document: BOLTS AND SCREWS, STEEL, CORROSION
AND HEAT RESISTANT, PRECIPITATION
HEAT TREATED BEFORE ROLL THREADED
160 000 PSI MINIMUM TENSILE STRENGTH

Date of Specific Issue Adopted: 29 DECEMBER 1992

Releasing Non-Government Standards Body: Society of Automotive
Engineers, Inc.

Custodians:

Army - AR
Air Force - 99
Navy - AS

Military Coordinating Activity:
DLA - IS
(Project 5306-1681)

Review Activities:

Army - AV
Air Force - 82

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FSC 5306

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AEROSPACE STANDARD

SAE AS4506

Issued 1992-12-29

Submitted for recognition as an American National Standard

BOLTS AND SCREWS, STEEL, CORROSION AND HEAT RESISTANT
Precipitation Heat Treated Before Roll Threaded
160 000 psi Minimum Tensile Strength

FSC 5306

1. SCOPE:

1.1 Type:

This procurement specification covers bolts and screws made from a corrosion and heat resistant age hardenable iron base alloy of the type identified under the Unified Numbering System as UNS S66286, and of 160 000 psi minimum ultimate tensile strength at room temperature, with maximum test temperature of parts at 1000 °F.

1.2 Application:

Primarily for aerospace propulsion system applications where a good combination of strength and corrosion resistance is required.

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 which 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. REFERENCES:

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 documents shall be the issue in effect on the date of the purchase order.

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2.1 Applicable Documents:

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

AMS 2645 Fluorescent Penetrant Inspection
 AMS 2750 Pyrometry
 AMS 5853 Steel Bars, Corrosion and Heat Resistant, 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V, 1800 °F (980 °C) Solution Heat Treated and Work Strengthened 160 000 psi (1105 MPa) Tensile Strength (Consumable Electrode Melted)

AS1132 Design Parameters for Bolts and Screws, External Wrenching, Unified Thread Inch Series

AS3062 Bolts, Screws, and Studs, Screw Thread Requirements

AS3063 Bolts, Screws, and Studs, Geometric Control Requirements

- 2.1.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 8 Tension Testing of Metallic Materials

ASTM E 112 Estimating the Average Grain Size of Metals

- 2.1.3 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-1312 Fasteners, Test Methods

MIL-STD-2073-1 Parts and Equipment, Procedures for Packaging and Packing of

MIL-S-8879 Screw Threads, Controlled Radius Root With Increased Minor Diameter; General Specification For

- 2.1.4 ANSI Publication:

Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

ANSI/ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

2.2 Definitions:

- 2.2.1 PRODUCTION INSPECTION LOT: A production inspection lot shall be all finished parts of the same basic part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

- 2.2.2 ACCEPTANCE TESTS: The acceptance tests shall be performed on each production inspection lot. The acceptance tests consist of all the tests specified in Table 3.

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3. TECHNICAL REQUIREMENTS:**3.1 Material:**

Shall be AMS 5853 steel heading stock.

3.2 Design:

Finished (completely manufactured) parts shall conform to the following requirements:

3.2.1 Dimensions: The dimensions of finished parts, after all processing, including plating, shall conform to the part drawing. Dimensions apply after plating but before coating with dry film lubricants.

3.2.2 Surface Texture: Surface texture of finished parts, prior to plating or coating, shall conform to the requirements as specified on the part drawing, determined in accordance with ANSI/ASME B46.1.

3.2.3 Threads: Screw thread UNJ profile and dimensions shall be in accordance with MIL-S-8879, unless otherwise specified on the part drawing.

3.2.3.1 Incomplete Threads: Incomplete threads are permissible at the chamfered end and the juncture of the unthreaded portion of the shank or adjacent to the head as specified in AS3062.

3.2.3.2 Chamfer: The entering end of the thread shall be chamfered as specified on the part drawing.

3.2.4 Geometric Tolerances: Part features shall be within the geometric tolerances specified on the part drawing and, where applicable, controlled in accordance with AS3063.

3.3 Fabrication:

3.3.1 Blanks: Heads shall be formed by hot-cold forging at a temperature not higher than 1950 °F, or by cold forging. Lightening holes may be produced by any suitable method. Wrenching recesses may be forged or machined.

3.3.2 Heat Treatment: The following precipitation heat treatment shall be performed on headed blanks before finishing the shank and bearing surface of the head, cold working the head-to-shank fillet radius or rolling the threads:

3.3.2.1 Heating Equipment: Furnaces may be any type ensuring uniform temperature throughout the parts being heated and shall be equipped with, and operated by, automatic temperature controllers and data recorders conforming to AMS 2750. The heating medium or atmosphere shall cause no surface hardening by carburizing or nitriding.

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- 3.3.2.2 Precipitation Heat Treatment: Blanks shall be precipitation heat treated by heating to a temperature within the range 1200 to 1300 °F, holding at the selected temperature within ± 25 °F for not less than 8 h and cooling in air.
- 3.3.3 Oxide Removal: Surface oxide and oxide penetration, resulting from prior heat treatment shall be removed from the full body diameter, thread diameter and bearing surface of the head of the precipitation heat treated blanks prior to cold working the fillet radius when specified and rolling the threads. The oxide removal process shall produce no intergranular attack or corrosion of the blanks. The metal removed from the bearing surface of the head and the full body diameter of the shank shall be as little as practicable to obtain a clean, smooth surface and in no case shall be so great as to produce more cutting of flow lines in the head-to-shank junction than shown in Figure 1B.
- 3.3.4 Cold Working of Fillet Radius: After removal of oxide as in 3.3.3, the head-to-shank fillet radius of parts having the radius complete throughout the circumference of the part shall be cold worked sufficiently to remove all visual evidence of grinding or tool marks. Distortion due to cold working shall conform to Figure 2, unless otherwise specified on the part drawing. It shall not raise metal more than 0.002 in above the contour at "A" or depress metal more than 0.002 in below the contour at "B" as shown in Figure 2; distorted areas shall not extend beyond "C" shown in Figure 2. In configurations having an undercut associated with the fillet radius, the cold working will be required only for 90° of fillet arc, starting at the point of tangency of the fillet radius and the bearing surface of the head. For shouldered bolts, having an unthreaded shank diameter larger than the thread major diameter and having an undercut associated with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold working will be required only for 90° of fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank. For parts with compound fillet radii between head and shank, cold work only the radius that blends with the head.
- 3.3.5 Thread Rolling: Threads shall be formed on the heat treated and finished blanks by a single rolling process after removal of oxide as in 3.3.3.
- 3.3.6 Cleaning: Except when other finishes are specified, finished parts shall be degreased and then immersed in one of the following solutions for the time and at the temperature shown:
- One volume of nitric acid (sp gr 1.42) and 9 volumes of water for not less than 20 min at room temperature.
 - One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 30 to 40 min at room temperature.
 - One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 to 15 min at 140 to 160 °F.

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3.4 Product Marking:

Each part shall be identification marked as specified on the part drawing. Unless otherwise specified, the markings may be formed by forging or stamping, raised or depressed 0.010 in maximum, with rounded root form on depressed characters.

3.5 Coating:

Where required, all surfaces shall be coated as specified on the part drawing.

3.6 Mechanical Properties:

Parts shall conform to the requirements of 3.6.1 and 3.6.2. Threaded members of gripping fixtures for tensile tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. The loaded portion of the shank shall have a minimum of three full thread turns from the thread runout exposed between the loading fixtures during tensile tests. Finished parts shall be tested in accordance with the applicable test methods of MIL-STD-1312 shown:

- a. Hardness: MIL-STD-1312-6
- b. Room Temperature Ultimate Tensile Strength: MIL-STD-1312-8

3.6.1 Ultimate Tensile Strength at Room Temperature:

- 3.6.1.1 Finished Parts: Parts shall have an ultimate tensile load not lower than that specified in Table 3 and shall be tested to failure after measuring and recording the maximum tensile load achieved. If the size or shape of the part is such that failure would occur outside the threaded section but the part can be tested satisfactorily, such as parts having a shank diameter equal to or less than the thread root diameter or having an undercut, parts shall conform to only the ultimate tensile strength requirements of 3.6.1.2; for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with either standard double hexagon drive or hexagon-type heads having a minimum metal condition in the head equal to the design parameters specified in AS1132 shall not fracture in the head-to-shank fillet radius except when this radius is associated with an undercut or with a shank diameter less than the minimum pitch diameter of the thread.

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3.6.1.2 Machined Test Specimens: If the size or shape of the part is such that a tensile test cannot be made on the part, tensile tests shall be conducted in accordance with ASTM E 8 on specimens prepared as in 4.3.3. Such specimens shall meet the following requirements:

- | | |
|---|-------------|
| a. Ultimate tensile strength, minimum | 160 000 psi |
| b. Yield strength at 0.2% offset, minimum | 120 000 psi |
| c. Elongation in 2 in or 4D, minimum | 12% |
| d. Reduction of area, minimum | 18% |

3.6.1.2.1 When permitted by purchaser, hardness tests on the end of parts may be substituted for tensile tests of machined specimens.

3.6.2 Hardness: Shall conform to 32 HRC minimum, but hardness of the threaded section and of the head-to-shank fillet area when cold working of this area is specified, may be higher as a result of the cold working operations.

3.7 Quality:

Parts shall be uniform in quality and condition, clean, sound, smooth, and free from burrs and foreign materials and from imperfections detrimental to their performance.

3.7.1 Macroscopic Examination: Parts or sections of parts, as applicable, shall be etched in a solution consisting of approximately 40% hydrochloric acid (sp gr 1.19) 10% of a 30% solution of hydrogen peroxide, and 50% water, or other suitable etchant, for sufficient time to reveal flow lines but not longer than 30 min, shall be examined at a magnification of approximately 20X to determine conformance to the following requirements, except that examination for the thread imperfections as specified in 3.7.1.3 should be made by microscopic examination of specimens polished and etched as in 3.7.2.

3.7.1.1 Flow Lines:

3.7.1.1.1 Head-to-Shank: Examination of a longitudinal section through the part shall show flow lines in the shank, head-to-shank fillet, and bearing surface which follow the contour of the part as shown in Figure 1A, except that slight cutting of flow lines by the oxide removal process of 3.3.3 is permissible, as shown in Figure 1B; excessive cutting of flow lines in the shank, head-to-shank fillet, and bearing surface, as shown in Figure 1C, is not permissible except when an undercut is associated with the fillet radius. The head style shown in Figures 1A through 1C is for illustrative purposes only but other symmetrical head styles shall conform to the above requirements. Flow lines in heads on parts having special heads, such as Dee- or Tee-shaped heads or thinner than AS1132 standard heads, shall be as agreed upon by purchaser and vendor.

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- 3.7.1.1.2 Threads: Flow lines in threads shall be continuous, shall follow the general thread contour, and shall be of maximum density at root of thread (see Figure 3).
- 3.7.1.2 Internal Imperfections: Examination of longitudinal sections of the head and shank and of the threads shall reveal no cracks, laps, or porosity except laps in threads as permitted in 3.7.2.4.3 and 3.7.2.4.4. The head and shank section shall extend not less than $D/2$ from the bearing surface of the head and the threaded section shall extend not less than $D/2$ beyond the thread runout where "D" is the nominal diameter of the shank after heading. If the two sections would overlap, the entire length of the part shall be sectioned and examined as a whole.
- 3.7.2 Microscopic Examination: Specimens cut from parts shall be polished, etched in Kalling's reagent [100 cm³ of absolute ethyl alcohol, 100 cm³ of hydrochloric acid (sp gr 1.19), and 5 g of cupric chloride], Marble's reagent [20 cm³ of hydrochloric acid (sp gr 1.19), 20 cm³ of water, and 4 g of cupric sulfate pentahydrate], or other suitable etchant, and examined at a magnification not lower than 100X to determine conformance to the requirements of 3.7.2.1, 3.7.2.2, 3.7.2.3, and 3.7.2.4.
- 3.7.2.1 Microstructure: Parts shall have microstructure of completely recrystallized material except in the area of the threads and the head-to-shank fillet radius.
- 3.7.2.2 Grain Size: Grain size shall be 5 or finer as determined by comparison of the specimen with the chart in ASTM E 112. Up to 25% by area of grains 3 ASTM numbers coarser than the general grain size are permitted in any specific area of 100 adjacent grains. Bands of fine or coarse grains are not permitted.
- 3.7.2.3 Surface Hardening: Parts shall have no change in hardness from core to surface except as produced during cold working of the head-to-shank fillet radius and during rolling of threads. There shall be no evidence of carburization or nitriding. In case of dispute over results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading within 0.003 in of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance to this requirement.
- 3.7.2.4 Threads:
- 3.7.2.4.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 4).
- 3.7.2.4.2 Multiple laps on the flanks of threads are not permissible regardless of location. Single laps on the flanks of threads that extend toward the root are not permissible (see Figures 5 and 6).
- 3.7.2.4.3 There shall be no laps along the flank of the thread below the pitch diameter (see Figure 7). A single lap is permissible along the flank of the thread above the pitch diameter on either the pressure or nonpressure flank (one lap at any cross-section through the thread) provided it extends toward the crest and is generally parallel to the flank (see Figure 7).

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- 3.7.2.4.4 Crest craters, crest laps, or a crest lap in combination with a crest crater are permissible, provided that the imperfections do not extend deeper than 20% of the basic thread height (see Table 1) as measured from the thread crest when the thread major diameter is at minimum size (see Figure 8). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches maximum size, values for depth of crest crater and crest lap imperfections listed in Table 1 may be increased by one-half of the difference between the minimum major diameter and the actual major diameter as measured on the part.
- 3.7.3 Fluorescent Penetrant Inspection: Uncoated parts shall be subject to fluorescent penetrant inspection in accordance with AMS 2645; coated parts shall have coating removed for this inspection.
- 3.7.3.1 The following conditions shall be cause for rejection of parts inspected.
- 3.7.3.1.1 Discontinuities transverse to grain flow (i.e., at an angle of more than 10° to the axis of the shank), such as grinding checks and quench cracks.
- 3.7.3.1.2 Longitudinal indications (i.e., at an angle of 10° or less to the axis of the shank) due to imperfections other than seams, forming laps, and nonmetallic inclusions.
- 3.7.3.2 The following conditions shall be considered acceptable on parts inspected.
- 3.7.3.2.1 Parts having longitudinal indications (i.e., at an angle of 10° or less to the axis of the shank) of seams and forming laps parallel to the grain flow within the limits specified in 3.7.3.2.2 through 3.7.3.2.5 provided the separation between indications in all directions is not less than 0.062 in.
- 3.7.3.2.2 Sides of Heads: There shall be not more than three indications per head. The length of each indication may be the full height of the surface but no indication shall break over either edge to a depth greater than 0.031 in or the equivalent of the basic thread height (see Table 1), whichever is less.
- 3.7.3.2.3 Shank or Stem: There shall be not more than five indications. The length of any indication may be the full length of the surface but the total length of all indications shall not exceed twice the length of the surface. No indication shall break into a fillet or over an edge.
- 3.7.3.2.4 Threads: There shall be no indications, except as permitted in 3.7.1.2.

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3.7.3.2.5 Top of Head and End of Stem: The number of indications is not restricted but the depth of any individual indication shall not exceed 0.010 in as shown by sectioning representative samples. No indication, except those of 3.7.3.2.2, shall break over an edge.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of parts shall supply all samples and shall be responsible for performing all required tests. Purchaser reserves the right to perform such confirmatory testing as deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance:

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during production of parts.

4.3 Production Acceptance Tests:

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.4 Classification of Tests:

The inspection of parts are classified as follows:

- a. Acceptance tests that are to be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.
- b. Periodic tests which are to be performed periodically on production lots at the discretion of the vendor or purchaser. Ultimate tensile strength test at room temperature (3.6.1) and hardness test (3.6.2) are classified as periodic tests and shall be performed at a frequency selected by the vendor, unless frequency of testing is specified by purchaser.

4.5 Acceptance Test Sampling:

4.5.1 Material: In accordance with AMS 5853.

4.5.2 Nondestructive Test - Visual and Dimensional: A random sample of parts shall be taken from each production inspection lot; the size of the sample to be as specified in Table 4. The classification of dimensional characteristics shall be as specified in Table 5. All dimensional characteristics are considered defective when out of tolerance.

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- 4.5.3 Magnetic Particle Inspection: A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 4 and classified as in Table 5. The sample units may be selected from those that have been subjected to and passed the visual and dimensional inspection, with additional units selected at random from the production inspection lot as necessary.
- 4.5.4 Destructive Tests: A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 6. The sample units may be selected from those that have been subjected to and passed the nondestructive tests and the magnetic particle inspection, with additional units selected at random from the production inspection lot as necessary.
- 4.5.5 Acceptance Quality: Of random samples tested, acceptance quality shall be based on zero defectives.
- 4.5.6 Test Specimens: Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E 8 with either 0.250 in diameter at the reduced parallel gage section or smaller specimens proportional to the standard when required. Specimens shall be machined from finished parts or coupons of the same lot of alloy and be processed together with the parts they represent. Specimens shall be machined from the center of parts 0.750 in and under in nominal diameter, from the center of coupons 0.800 in and under in nominal diameter or distance between parallel sides, and from mid-radius of larger size parts or coupons.
- 4.6 Periodic Test Sampling:
As agreed upon by purchaser and vendor.
- 4.7 Reports:
The vendor of parts shall furnish with each shipment a report stating that the chemical composition of the parts conforms to the applicable material specification, showing the results of tests to determine conformance to the room temperature ultimate tensile strength requirements, hardness, and stress embrittlement test when required, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS4506, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.
- 4.8 Rejected Lots:
If a production inspection lot is rejected, the vendor of parts may perform corrective action to screen out or rework the defective parts, and resubmit for acceptance tests inspection as in Table 3. Resubmitted lots shall be clearly identified as reinspected lots.

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5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Parts having different part numbers shall be packed in separate containers.

5.1.2 Each container of parts shall be marked to show not less than the following information:

FASTENERS, LOW ALLOY, HEAT RESISTANT STEEL
AS4506
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.3 Threaded fasteners shall be suitably protected from abrasion and chafing during handling, transportation, and storage.

5.1.4 Containers of parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery.

5.1.5 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-2073-1, industrial packaging, unless Level A is specified in the request for procurement.

6. ACKNOWLEDGMENT:

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Parts not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Direct U.S. Military Procurement:

Purchase documents should specify the following:

Title, number, and date of this specification
Part number of parts desired
Quantity of parts desired
Level A packaging, if required (see 5.1.5)

8.2 Key Words:

Bolts, screws, procurement specification

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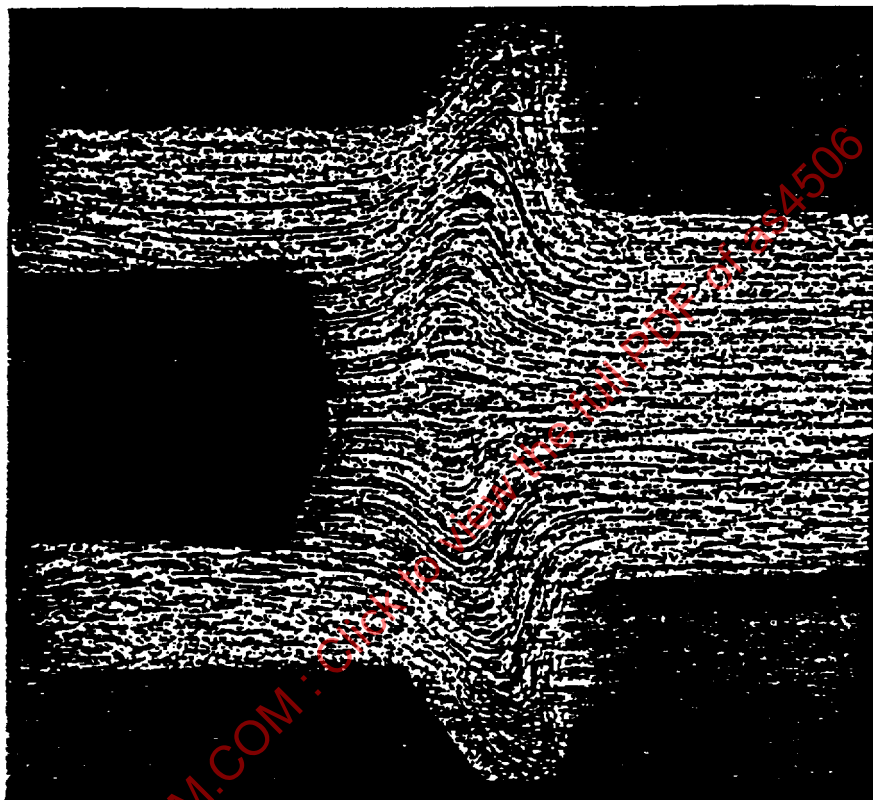


FIGURE 1A - Satisfactory Grain Flow

Showing a smooth, well formed grain flow following the contour of the under head fillet radius.

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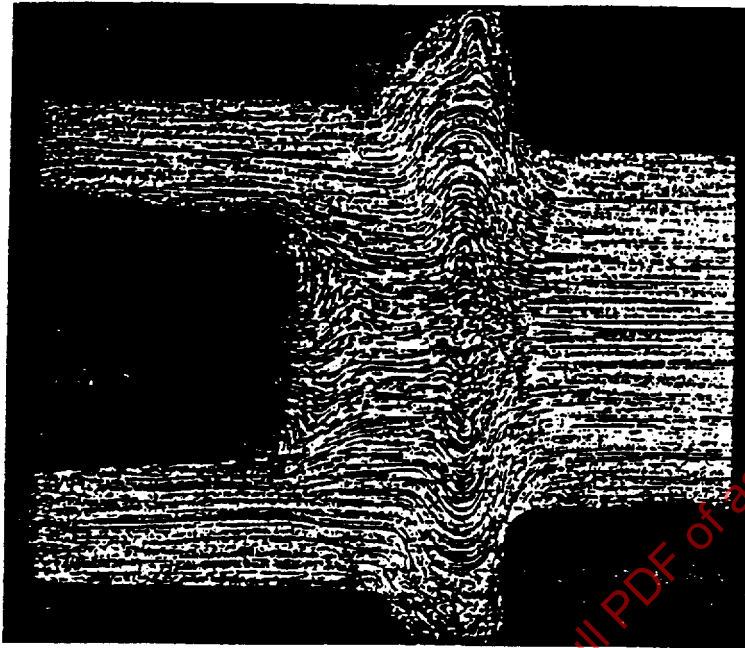


FIGURE 1B - Minimum Acceptable Standard

Showing maximum permissible cutting of grain flow after machining to remove contamination oxide.

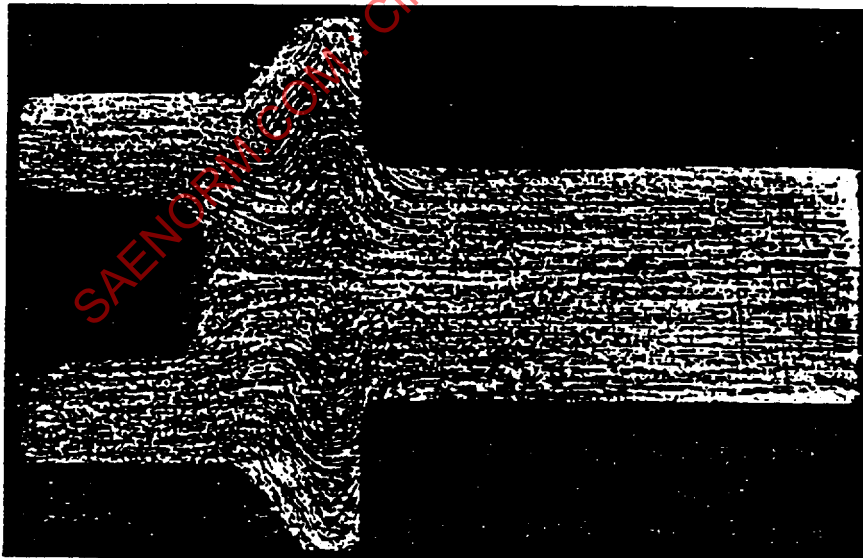
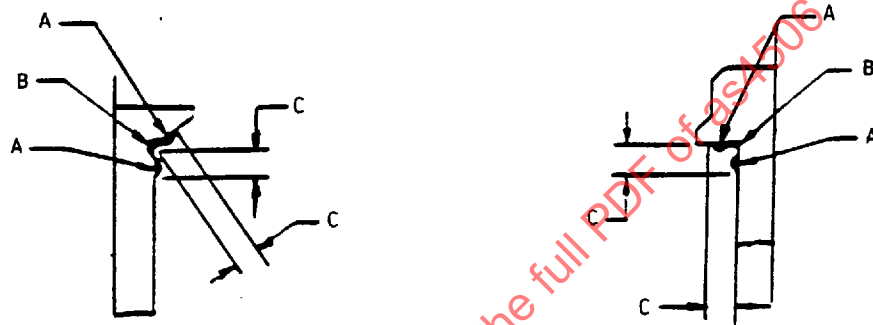


FIGURE 1C - Unacceptable Grain Flow

Showing excessive cutting of grain flow in the shank, fillet, and bearing surface which is not permissible.

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Nominal Bolt Diameter, inch	C max inch
Up to 0.3125, excl	0.062
0.3125 and 0.375	0.094
0.4375 to 0.625, incl	0.125
0.750 to 1.000, incl	0.156
Over 1.000	0.188

FIGURE 2 - Permissible Distortion From Fillet Working

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FIGURE 3 - Flow Lines, Rolled Thread

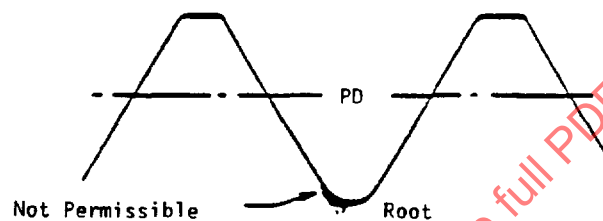


FIGURE 4 - Root Imperfections, Rolled Thread

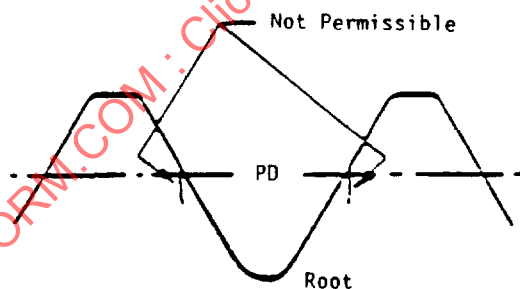


FIGURE 5 - Laps Below PD Extending Toward Root, Rolled Thread

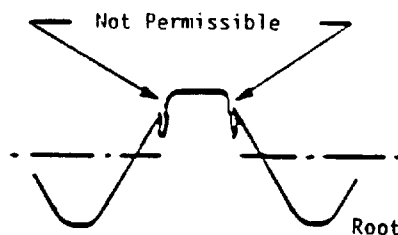


FIGURE 6 - Laps Above PD Extending Toward Root, Rolled Thread

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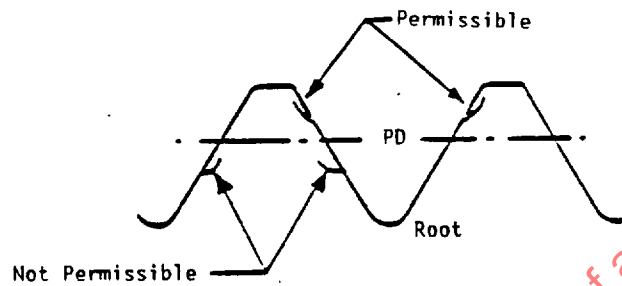
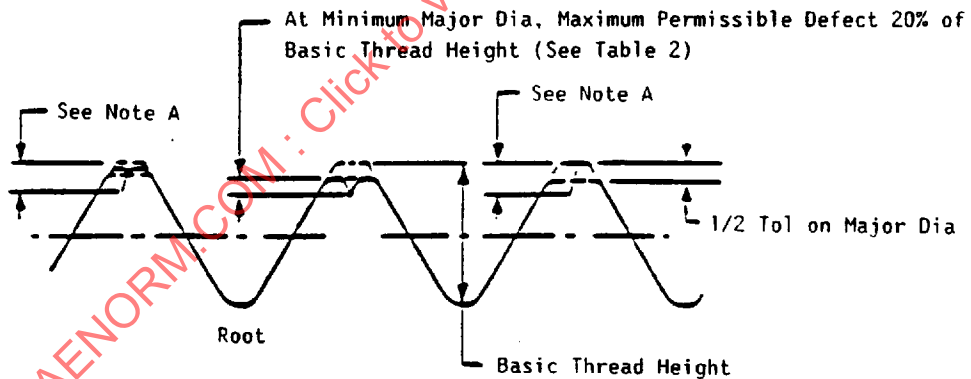


FIGURE 7 - Laps Extending Towards Crest, Rolled Thread



NOTE A: Depth of imperfection equals 20% of basic thread height plus 1/2 the difference of the actual major diameter and minimum major diameter.

FIGURE 8 - Crest Craters and Crest Laps, Rolled Thread

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TABLE 1 - Thread Height

Thread Pitches Per Inch n	Basic Thread Height Ref (See Note 1) in	20% Basic Thread Height in
80	0.0081	0.0016
72	0.0090	0.0018
64	0.0102	0.0020
56	0.0116	0.0023
48	0.0135	0.0027
44	0.0148	0.0030
40	0.0163	0.0033
36	0.0181	0.0036
32	0.0203	0.0041
28	0.0232	0.0046
24	0.0271	0.0054
20	0.0325	0.0065
18	0.0361	0.0072
16	0.0406	0.0081
14	0.0464	0.0093
13	0.0500	0.0100
12	0.0542	0.0108
11	0.0591	0.0118
10	0.0650	0.0130
9	0.0722	0.0144
8	0.0813	0.0163

Note 1: Basic thread height is defined as being equivalent to 0.650 times the pitch, where pitch equals $1/n$.