AEROSPACE STANDARD

AS4506	REV. B

Issued 1992-12
Revised 2009-12
Reaffirmed 2015-04

Superseding AS4506A

Bolts and Screws, Steel, UNS S66286
Tensile Strength 160 ksi, Procurement Specification

FSC 5306

RATIONALE

AS4506B has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

This document covers bolts and screws made from a corrosion and heat resistant, precipitation hardenable iron base alloy of the type identified under the Unified Numbering System as UNS S66286.

1.1 Type

The following specification designations and their properties are covered:

AS4506 160 ksi minimum ultimate tensile strength at room temperature

AS4506-1 160 ksi minimum ultimate tensile strength at room temperature
95 ksi minimum ultimate shear strength at room temperature

1.1.1 Classification

160 ksi minimum tensile strength at room temperature.

1.2 Application

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

1.3 Safety - Hazardous Materials

While the materials, 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.

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SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AS4506B

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1.1 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.

AMS2750	Pyrometry
AMS5853	Steel, Corrosion and Heat-Resistant, Bars and Wire, 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V Consumable Electrode Melted 1800 °F (982 °C) Solution Treated and Work-Strengthened 160 ksi (1103 MPa) Tensile Strength
AS1132	Bolts, Screws and Nuts - External Wrenching UNJ Thread, Inch - Design Standard
AS3062	Bolts, Screws and Studs - Screw Thread Requirements
AS3063	Bolts, Screws and Studs, Geometric Control Requirements
AS8879	Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 140	Standard Hardness Conversion Tables for Metals
ASTM E 1417	Liquid Penetrant Examination
ASTM D 3951	Commercial Packaging

2.1.3 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

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

2.1.4 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM1312-6 Fastener Test Methods, Method 6, Hardness

NASM1312-8 Fastener Test Methods, Method 8, Tensile Strength

NASM1312-13 Fastener Test Methods, Method 13, Double Shear Test

2.2 Definitions

BURR: A rough edge or ridge left on the metal due to a cutting, grinding, piercing or blanking operation.

COLD ROLLING: Forming material below the recrystallation temperature.

CRACK: Rupture in the material which may extend in any direction and which may be intercrystalline or transcrystalline in character.

DISCONTINUITY: An interruption in the normal physical structure or configuration of a part; such as a lap, seam, inclusion, crack, machining tear, or stringer.

HEAT PATTERN: A discernible difference in the etched appearance between the head and shank caused by the plastic forming of the head.

INCLUSION: Nonmetallic particles originating from the making process. They may exist as discrete particles or strings of particles extending longitudinally.

INSPECTION LOT: Shall consist of nuts from a single production lot, of the same part number.

LAP: Surface imperfection caused by folding over metal fins or sharp corners and then rolling or forging them into the surface. The allowable lap depth shall not exceed the limit specified herein. The minimum condition that shall be rated as a lap is a fold having its length equal to or greater than three times its width with a depth of 0.0005 inch when viewed at 200X magnification.

MACHINING TEAR: A pattern of short, jagged individual cracks, generally at right angles to the direction of machining, frequently the result of improperly set cutting tools, or dull cutting tools.

NON-CONFORMANCE: A departure from a specified requirement for any characteristic.

NON-CONFORMING UNIT: A unit of the product that has one or more non-conformances.

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same 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 the manufacturer's inspection at the same time.

ROOM TEMPERATURE: Ambient temperature (68 °F approximately).

SEAM: Longitudinal surface imperfection in the form of an unwelded, open fold in the material.

STRINGER: A solid nonmetallic impurity in the metal bar, often the result of inclusions that have been extended during the rolling process.

TIGHT BURR: A burr closely compacted and binding in the periphery of a part without any loose ends and is within the dimensional limits of the part.

2.3 Unit Symbols

°C - degree Celsius

°F - degree Fahrenheit

% - percent (1% = 1/100)

lbf - pounds force

ksi - kips (1000 pounds) per square inch

sp gr - specific gravity

HRC - hardness, Rockwell C scale

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be AMS5853 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 solid 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 ASME B46.1.

3.2.3 Threads

Screw thread UNJ profile and dimensions shall be in accordance with AS8879, unless otherwise specified on the part drawing.

3.2.3.1 Incomplete Lead and Runout Threads

Incomplete threads are permissible at the entering end and at 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, in accordance with AS3063.

3.3 Fabrication

3.3.1 Blanks

Heads shall be formed by hot 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. Flash or chip clearance in machined recesses shall not cause dimensions to exceed the specified limits.

3.3.2 Heat Treatment

The following precipitation heat treatment shall be performed on the 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 AMS2750. The heating medium or atmosphere shall cause no surface hardening by carburizing or nitriding.

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 not less than 8 hours 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 and bearing surface of the head of the precipitation heat treated blanks prior to cold rolling the fillet radius 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.

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 1, unless otherwise specified on the part drawing. It shall not raise metal more than 0.002 inches above the contour at “A” or depress metal more than 0.002 inches below the contour at “B” as shown in Figure 1; distorted areas shall not extend beyond “C” shown in Figure 1. In configurations having an undercut connected with the fillet radius, the cold working will be required only for 90 degrees 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 connected with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold working will be required only for 90 degrees of the fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank. The shank diameter on full shank close tolerance bolts shall not exceed its maximum diameter limit after cold rolling the head to shank fillet radius.

3.3.5 Thread Rolling

Thread shall be formed on the finished blanks by a single cold rolling process after removal of oxide as in 3.3.3.

3.3.6 Cleaning

Parts, after finishing, shall be degreased and immersed in one of the following solutions for the time and temperature shown:

a. One volume of nitric acid (sp gr 1.42) and 9 volumes of water for not less than 20 minutes at room temperature.

b. One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 30 to 40 minutes at room temperature.

c. One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 to 15 minutes at 140 to 160 °F.

3.3.6.1 Immediately after removal from the cleaning solution, parts shall be thoroughly rinsed in clean water at 70 to 200 °F.

3.4 Product Marking

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

3.5 Plating or Coating

Where required, surfaces shall be plated as specified by the part drawing. Where coating with solid film lubricants is required, the under-head bearing surface, the unthreaded shank, and the threads shall be coated as specified on the part drawing; other surfaces are optional to coat, unless otherwise specified. Plating thickness shall be determined in accordance with the requirements in the applicable plating specification.

3.6 Mechanical Properties

Where AS4506B is specified, parts shall conform to the requirements of 3.6.1 and 3.6.2. Where AS4506-1 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, and 3.6.3. 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 two to three full threads from the thread runout exposed between the loading fixtures during tensile test.

AS4506B finished parts shall be tested in accordance with the following test methods:

a. Hardness: MIL-STD-1312-6 in accordance with NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: MIL-STD-1312-8 in accordance with NASM1312-8

AS4506-1 finished parts shall be tested in accordance with the following test methods:

a. Hardness: MIL-STD-1312-6 in accordance with NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: MIL-STD-1312-8 in accordance with NASM1312-8

c. Ultimate Double Shear at Room Temperature: MIL-STD-1312-13 in accordance with NASM1312-13

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 2 and shall be tested to failure in order to observe fracture location, first measuring and recording the maximum tensile load achieved. Screws, such as 100 degree flush head, pan head, and fillister head, shall have an ultimate tensile load not lower than that specified in Table 2; screws need not be tested to failure, however, the maximum tensile load achieved shall be measured and recorded. If size and shape of the part is such that failure would occur outside the threaded section but 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 have an ultimate tensile strength not lower than 160 ksi; for such parts, the diameter of the area on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with hexagon, double hexagon, or spline drive heads having a minimum metal condition in the head equal to the design parameters in AS1132, shall not fracture in the head-to-shank fillet radius except when this radius is connected with an undercut or with a shank diameter less than the minimum pitch diameter of the thread.

3.6.1.2 Machined Test Specimens

If the size and the 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 E8 on specimens prepared as in 4.4.6. Specimens may be required by the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 160 ksi

b. Yield Strength at 0.2% Offset, minimum: 120 ksi

c. Elongation in 2 inches 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 be uniform and 32 to 40 HRC (see 8.1), but hardness of the threaded section and of the head-to-shank fillet area may be higher as a result of the cold rolling operations. Parts shall not be rejected on the basis of hardness if the tensile strength properties specified in 3.6.1 are met.

3.6.3 Ultimate Shear Strength (Type AS4506-1 only)

Finished parts having a close toleranced full shank as in AS1132 shall have an ultimate double shear load no lower than that specified in Table 1. The double shear test may be discontinued without a complete shear failure after the ultimate double shear load has been reached, first measuring and recording the maximum double shear load achieved. Shear bolts having special shank diameters shall have the minimum ultimate double shear load based on 95 ksi minimum shear strength. Shear tests are not required for screws, such as 100 degree flush head, having a grip less than 2.5 times the nominal, or protruding head screws, such as pan head and fillister head, having a grip less than 2 times the nominal diameter. Shear test is not required for the following conditions:

a. Bolts having a grip less than 2 times the nominal diameter.

b. Bolts and screws having a coarse tolerance full shank.

c. Bolts and screws having a PD or relieved shank.

3.7 Quality

Parts shall be uniform in quality and condition, free from burrs (tight burrs may be acceptable if part performance is not affected), foreign materials, and from imperfections detrimental to the usage of the parts.

3.7.1 Macroscopic Examination

A specimen cut from headed blanks and from finished parts shall be etched in a suitable etchant and examined at a magnification of 20X to determine conformance to the requirements of 3.7.1.1 and 3.7.1.2. The head and shank section shall extend not less than D/2 from the bearing surface of the head, where “D” equals the nominal thread diameter, see Figure 4.

3.7.1.1 Flow Lines

After heading and prior to heat treatment, examination of an etched section taken longitudinally through the blank, as in 3.7.1, shall show lines or heat pattern in the shank, head- to-shank fillet, and the bearing surface which follows the contour of the blank as shown in Figure 2 or Figure 2A. Flow lines or heat pattern in the headed blanks 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.

3.7.1.2 Internal Imperfections

Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity.

3.7.2 Microscopic Examination, Finished Parts

Specimens cut from finished parts shall be polished, etched in Kalling’s Marble’s reagent, or other suitable etchant, and examined at 100X magnification to determine conformance to the requirements of 3.7.2.1, 3.7.2.2, 3.7.2.3 and 3.7.2.4, 3.7.2.5, and 3.7.2.6.

3.7.2.1 Flow Lines

Examination of a longitudinal section through the threaded portion of the shank shall show evidence that the threads were rolled, see Figure 3.

3.7.2.2 Internal Imperfections

Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity. Thread imperfections shall conform to the requirements of 3.7.2.6.

3.7.2.3 Microstructure

Parts shall have distorted grain structure indicative of cold worked material free from recrystallization in the areas other than the head.

3.7.2.4 Grain Size

The grain size shall be ASTM No. 5 or finer as determined by comparison with the chart in ASTM E112 of a polished and etched specimen, representing a plane transverse to the direction of working.

3.7.2.5 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 the threads. In the case of dispute over the results of the microscopic examination, microhardness testing shall be used as the referee method; a Vickers hardness reading of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance to this requirement.

3.7.2.6 Threads

3.7.2.6.1 Root imperfections such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 5).

3.7.2.6.2 Multiple laps on the flanks of threads are not permissible regardless of location.

3.7.2.6.3 Single Lap on Thread Profile

Shall conform to the following:

a. Thread Flank Above the Pitch Diameter: A single lap is permissible along the flank of the thread above the pitch diameter on either the pressure or the nonpressure flank (one lap at any cross-section through the thread) provided it extends towards the crest and is generally parallel to the flank (see Figure 6). The lap depth shall not exceed the limit specified in Table 1 for the applicable thread pitch. A lap extending towards the root is not permissible (see Figure 7).

b. Thread Flank Below the Pitch Diameter: A lap along the thread flank below the pitch diameter, regardless of direction it extends, is not permissible (see Figure 8).

c. 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 the limit specified in Table 1 as measured from the thread crest when the thread major diameter is at minimum size (see Figure 9). The major diameter of the thread shall be measured prior to sectioning. As the major diameter 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 actual major diameter as measured on the part.

3.7.3 Fluorescent Penetrant Inspection

Prior to any required coating, parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E1417, Type I, Sensitivity Level 2 minimum.

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 degrees to the axis of the shank), such as grinding checks and cracks.

3.7.3.1.2 Longitudinal indications (i.e., at an angle of 10 degrees 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 degrees or less to the axis of the shank) of seams and forming laps parallel to the grain flow that are 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 inches.

3.7.3.2.2 Sides of Head

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 inch or the equivalent of the 2H/3 thread depth (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 3.7.2.4. Rateable lap indications shall conform to 3.7.2.6.3.a.

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 inch 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 manufacturer 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 the random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1 Tests for all technical requirements are acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 4.

4.4 Acceptance Test Sampling

4.4.1 Material

Sampling for material composition on each heat shall be in accordance with AMS5853.

4.4.2 Nondestructive Test, Visual and Dimensional

A random sample shall be taken from each production inspection lot; the size of the sample to be as specified in Table 5. The classification of dimensional characteristics shall be as specified in Table 7. All dimensional characteristics are considered defective when out of tolerance.

4.4.3 Fluorescent Penetrant Inspection

A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 5 and as classified in Table 7. 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.

4.4.4 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 fluorescent penetrant inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.5 Acceptance Quality

Of random samples tested, acceptance quality shall be based on zero defectives.

4.4.6 Test Specimens

Specimens for tensile testing of machined specimens shall be of standard proportions in accordance with ASTM E8. 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.

4.5 Reports

The manufacturer 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 the tests to determine conformance to the room temperature ultimate tensile property, hardness, and double shear test (if required), and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS4506B, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.6 Rejected Lots

Failure of a destructive test requirement as specified in Table 4 shall constitute scrapping of the entire lot. Failure of a non-destructive test requirement as specified in Table 4 will require the manufacturer of parts to perform corrective action to screen out or rework the defective parts and resubmit for acceptance tests inspection as in Table 4. Resubmitted lots shall be clearly identified as reinspected lots.

5. PREPARATION FOR DELIVERY

5.1 Packaging and Identification

5.1.1 Packaging shall be in accordance with ASTM D3951.

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

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

BOLTS (SCREWS), STEEL, CORROSION AND HEAT RESISTANT
AS4506B (or AS4506-1B as applicable)
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

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

6. ACKNOWLEDGMENT

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

7. REJECTIONS

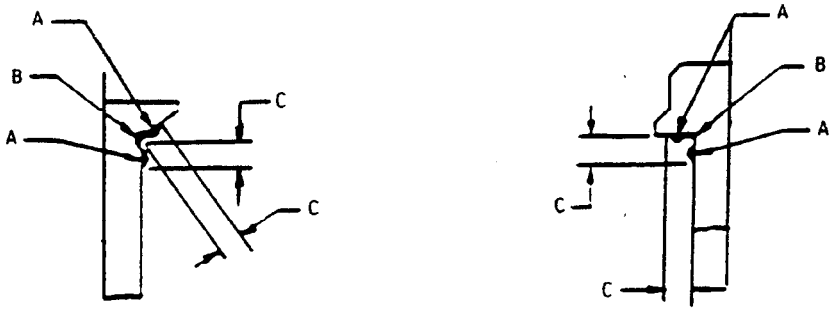
Parts not conforming to this specification shall be subject to rejection.

8. NOTES

8.1 Hardness Conversion Tables

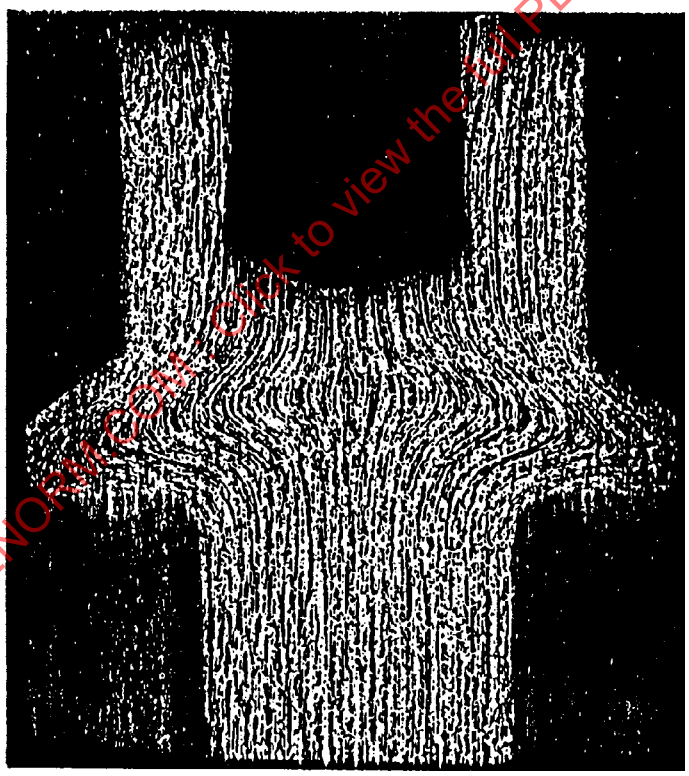
Hardness conversion tables for metals are presented in ASTM E140.

8.2 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.



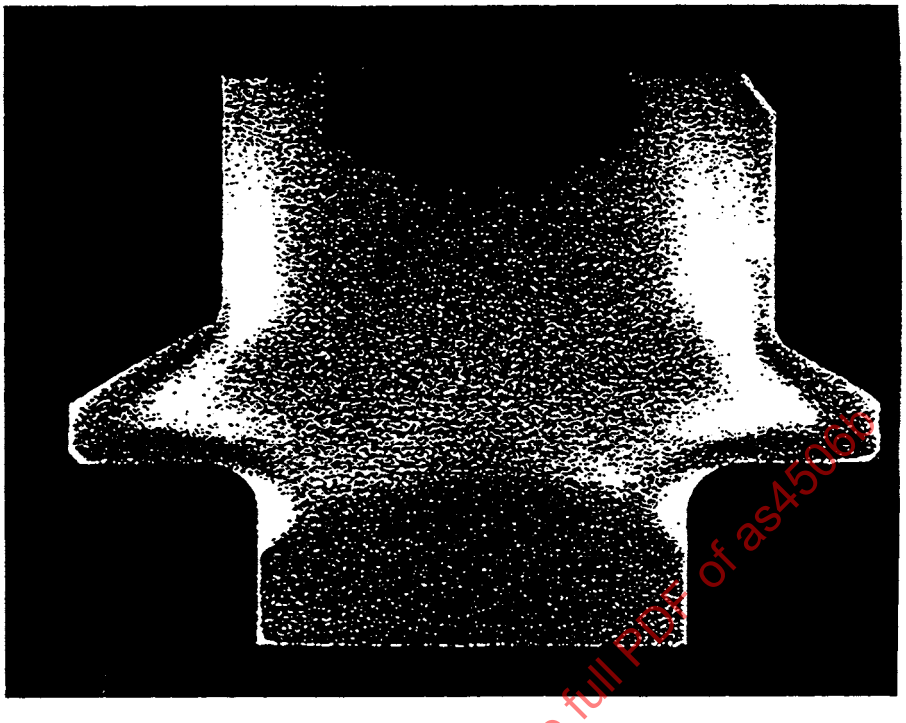
Nominal Bolt Diameter, inch	C max. inch
Less than 0.3125	0.062
0.3125 and 0.3750	0.094
0.4375 and 0.6250	0.125
0.7500 to 1.000	0.156
Greater than 1.000	0.188

FIGURE 1 - PERMISSIBLE DISTORTION FROM FILLET WORKING



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

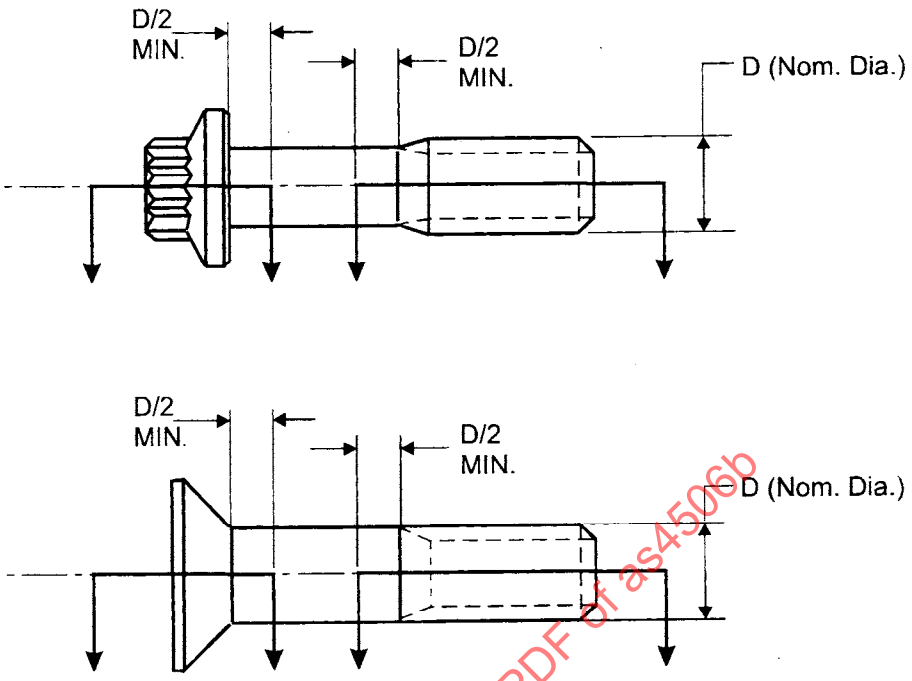
FIGURE 2 - SATISFACTORY GRAIN FLOW, COLD HEADED BLANK, BEFORE HEAT TREATMENT



Shows evidence that head was formed by forging.

FIGURE 2A - SATISFACTORY HEAT PATTERN, HOT HEADED BLANK, BEFORE HEAT TREATMENT

FIGURE 3 - FLOW LINES, ROLLED THREAD



Note: - Cut metallurgical specimens as indicated by arrows.

FIGURE 4 - METALLURGICAL SPECIMENS FOR MACROSCOPIC EXAMINATION

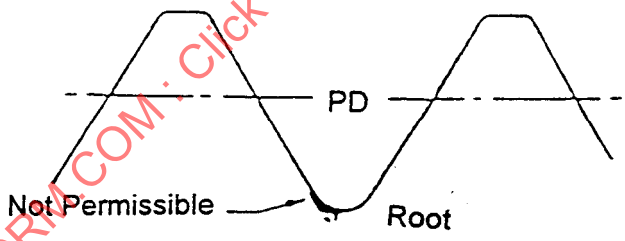


FIGURE 5 - ROOT IMPERFECTIONS, ROLLED THREAD

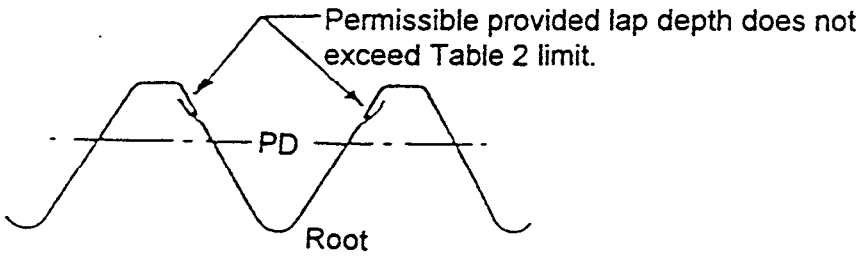


FIGURE 6 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS CREST, ROLLED THREAD

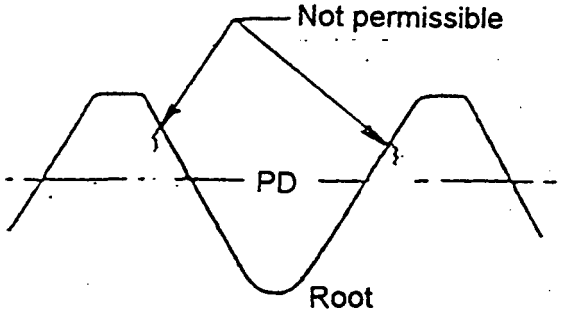


FIGURE 7 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS ROOT, ROLLED THREAD

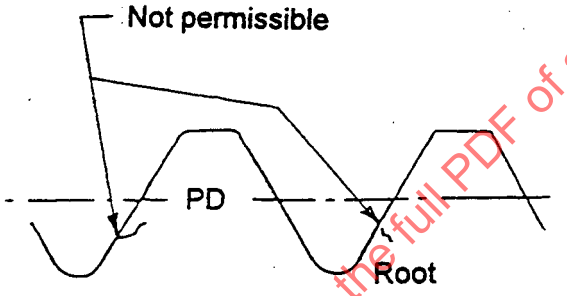
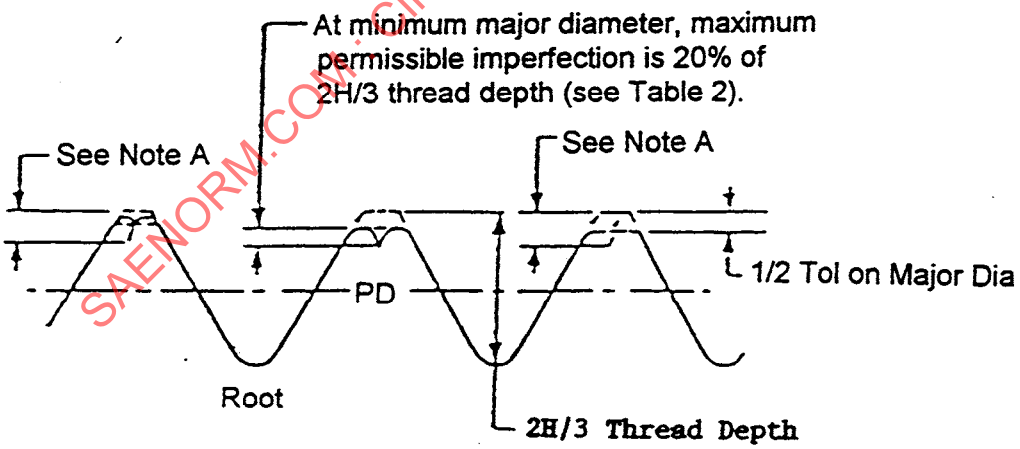


FIGURE 8 - LAPS BELOW PITCH DIAMETER EXTENDING IN ANY DIRECTION, ROLLED THREAD



Note A: Maximum depth of imperfection equals 20% of thread depth at 2H/3 plus half the difference of the actual major diameter and the minimum major diameter

FIGURE 9 - CREST CRATERS AND CREST LAPS, ROLLED THREAD

TABLE 1 - EXTERNAL THREAD DEPTH AT 2H/3 AND ALLOWABLE THREAD LAP DEPTH

Thread Pitches Per Inch n	External Thread Depth at 2H/3 Ref (See Note 1) inches	Allowable Thread Lap Depth inches
80	0.0072	0.0014
72	0.0080	0.0016
64	0.0090	0.0018
56	0.0100	0.0021
48	0.0120	0.0024
44	0.0131	0.0026
40	0.0144	0.0029
36	0.0160	0.0032
32	0.0180	0.0036
28	0.0206	0.0041
24	0.0241	0.0048
20	0.0289	0.0058
18	0.0321	0.0064
16	0.0361	0.0072
14	0.0412	0.0082
13	0.0444	0.0089
12	0.0481	0.0096
11	0.0525	0.0105
10	0.0577	0.0115
9	0.0642	0.0128
8	0.0722	0.0144

NOTE: Allowable lap depth is based on 20% of external thread depth at 2H/3 in accordance with AS8879, and is calculated as follows:

External thread depth = 2H/3 = (2/3) (cos 30°)/n = 0.57735/n
Lap depth = 0.2(2H/3) = 0.2(2/3) (cos 30°)/n = 0.11547/n