AEROSPACE STANDARD

AS4506™	REV. C

Issued 1992-12
Reaffirmed 2015-04
Revised 2021-09

Superseding AS4506B

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

FSC 5306

RATIONALE

AS6416 added to references, many paragraphs updated or deleted, specs updated, photo of bolt head deleted, figures redrawn, and notes updated.

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 bolt 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.

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

For more information on this standard, visit
https://www.sae.org/standards/content/AS4506C/

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 +1 724-776-4970 (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, Capable of 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
AS6416	Bolts, Screws, Studs, and Nuts, Definitions for Design, Testing and Procurement
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 A380	Practice for Cleaning and Descaling of Stainless Steel Parts
ASTM A967	Chemical Passivation Treatment for Stainless Steel
ASTM D3951	Standard Practice for Commercial Packaging
ASTM E8	Tension Testing of Metallic Materials
ASTM E112	Determining Average Grain Size
ASTM E140	Standard Hardness Conversion Tables for Metals
ASTM E1417/E1417M	Liquid Penetrant Examination

2.1.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), 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

Refer to AS6416.

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 shall conform to the part drawing. Dimensions apply after plating but before lubrication or 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

Threads shall be in accordance with AS8879, unless otherwise specified on the part drawing.

3.2.3.1 Incomplete Lead and Runout Threads

Incomplete threads and runouts are permissible as specified in AS3062.

3.2.3.2 Chamfer

Bolts 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 resulting from prior heat treatment shall be removed from the full body diameter, thread roll 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 headed parts having the radius shall be cold worked, if called for on the product standard 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 inch above the contour at “A” or depress metal more than 0.002 inch below the contour at “B” as shown in Figure 1; distorted areas shall not extend beyond “C” as shown in Figure 1 unless otherwise specified on the part drawing.

3.3.4.1 Undercut Bolt Heads

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.

3.3.4.2 Shouldered Bolts

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.

3.3.4.3 Close Tolerance Bolts

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

Bolts after finishing, shall be cleaned in one of the following solutions for the time and temperature shown and then thouroughly rinsed:

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

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

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

d. ASTM A967, ASTM A380 or AMS2700 for cleaning parts only, excluding any additional verification requirements (such as salt spray).

3.4 Plating or Coating

Where required, bolts 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.

3.5 Mechanical Properties

Bolts for tensile tests shall be of sufficient size and strength to develop the full strength of the bolt 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.

AS4506 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

3.5.1 Ultimate Tensile Strength at Room Temperature

3.5.1.1 Finished Parts

Tension fasteners with either standard double hexagon or spline drive 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 connected with an undercut or with a shank diameter less than the minimum pitch diameter of the thread. Parts shall have an ultimate tensile load not lower than that specified in Table 2.

3.5.1.2 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/E8M on specimens prepared as in 4.3.6. 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%

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

3.5.2 Hardness

Shall be 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. Bolts shall not be rejected on the basis of hardness if the tensile strength properties of the part are met.

3.5.3 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 2. The double shear test may be discontinued without a complete shear failure after the ultimate double shear load has been reached, and recording the load achieved. Shear bolts having special diameters shall have the double shear load based on 95 ksi minimum shear strength. Shear test is not required for the following conditions:

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

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

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

3.6 Quality

Parts shall be uniform in quality and condition, free from burrs, foreign materials, and from imperfections detrimental to the usage of the parts.

3.6.1 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 or greater to determine conformance to the requirements of 3.6.1.1 and 3.6.1.2. 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).

3.6.1.1 Flow Lines

After heading and prior to heat treatment, examination of an etched section taken longitudinally through the sample shall show lines or heat pattern in the shank, head- to-shank fillet, and the bearing surface which are representative of a forging process and shall follow the head contour.

3.6.1.2 Internal Imperfections

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

3.6.2 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 3.6.2.1, 3.6.2.2, 3.6.2.3, and 200X magnification to determine conformance to the requirements of 3.6.2.4.

3.6.2.1 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).

3.6.2.2 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 3.6.2.6.

3.6.2.3 Microstructure

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

3.6.2.4 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.

3.6.2.5 Threads

3.6.2.5.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 4).

3.6.2.5.2 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 4 and 5).

3.6.2.5.3 Single lap on thread profile shall conform to the following: a rateable lap shall have its length equal to or greater than three times its width. The minimum interpretable lap size is 0.0005 inch length or depth when viewed at 200X magnification.

3.6.2.5.4 There shall be no laps along the flank of the thread below the pitch diameter (see Figure 4). A single lap is permissible along the flank of the thread above the pitch diameter on either the pressure or non-pressure flank (one lap at any cross-section through the thread), provided it extends towards the crest and generally parallel to the flank (see Figure 4).

3.6.2.5.5 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 7). 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 1/2 of the difference between the minimum major diameter and the actual major diameter as measured on the part.

3.6.3 Fluorescent Penetrant Inspection

Prior to any required coating, parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E1417/E1417M, Type I, Sensitivity Level 2 minimum.

3.6.3.1 The following conditions shall be considered acceptable on parts inspected:

3.6.3.1.1 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.

3.6.3.2 Shank

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.

3.6.3.3 Threads

There shall be no indications, except as permitted in 3.6.2.4. Rateable lap indications shall conform to 3.6.5.2.3.

3.6.3.4 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 shall break over an edge.

4. QUALITY ASSURANCE PROVISIONS

4.1 Acceptance Test Sampling

4.1.1 Material

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

4.1.2 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.

4.1.3 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.

4.1.4 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.

4.1.5 Acceptance Quality

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

4.1.6 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.

4.2 Reports

The manufacturer of parts shall furnish a repot for all tests. This report shall include the purchase order number, AS4506C, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.3 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
AS4506C (or AS4506-1B as applicable)
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.4 Threaded fasteners shall be protected 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.

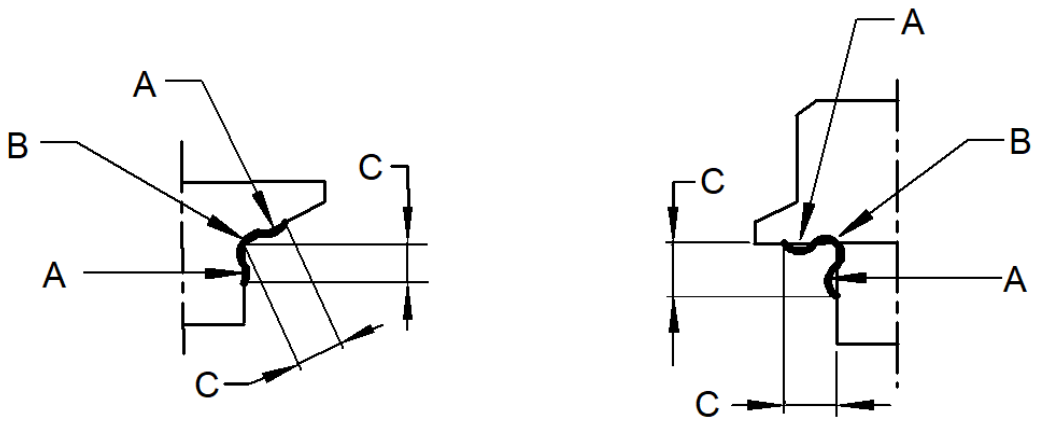
8. NOTES

8.1 Hardness Conversion Tables

Hardness conversion tables for metals are presented in ASTM E140.

8.2 Revision Indicator

A change bar (I) 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	C Max Inches
Up to 0.3125	0.062
0.3125 and 0.375	0.094
0.4375 to 0.625	0.125
0.750 to 1.000	0.156
Over 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.

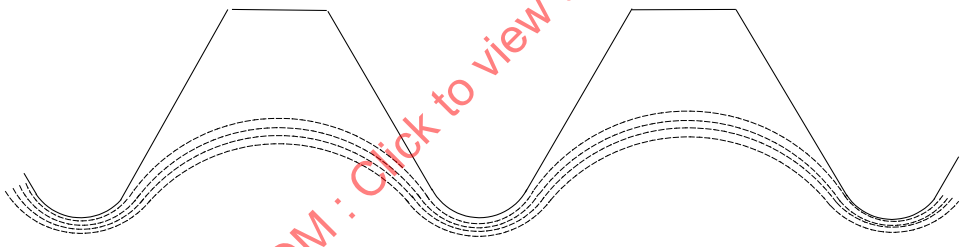
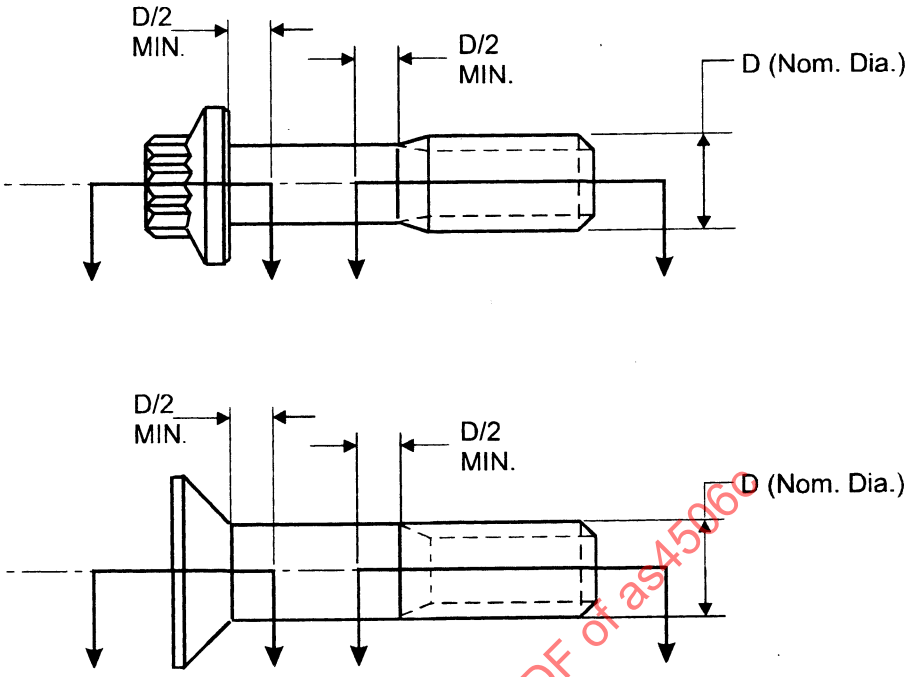


Figure 2 - Flow lines, rolled thread



Note: - Cut metallurgical specimens as indicated by arrows.

Figure 3 - Metallurgical specimens for macroscopic examination

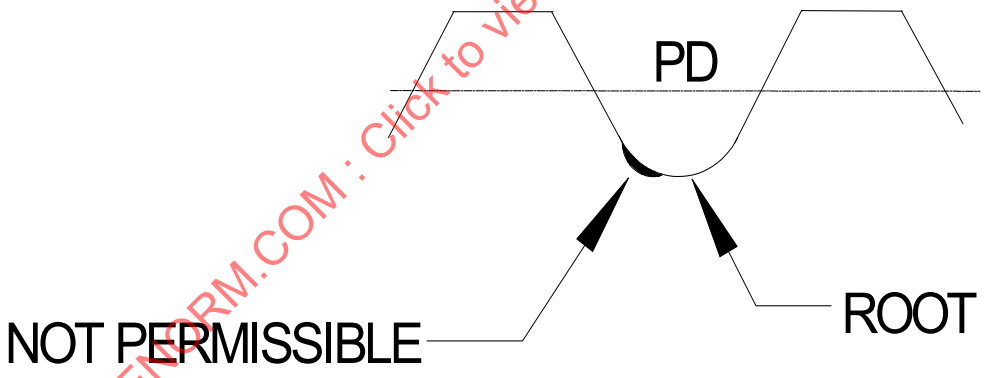


Figure 4 - Root imperfections, rolled thread

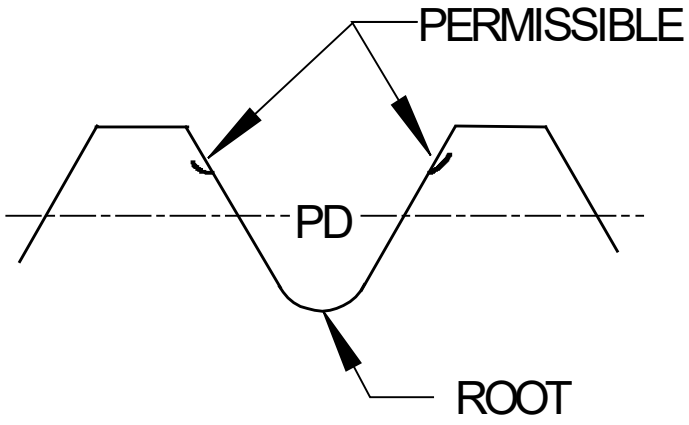


Figure 5 - Laps above pitch diameter extending towards crest, rolled thread

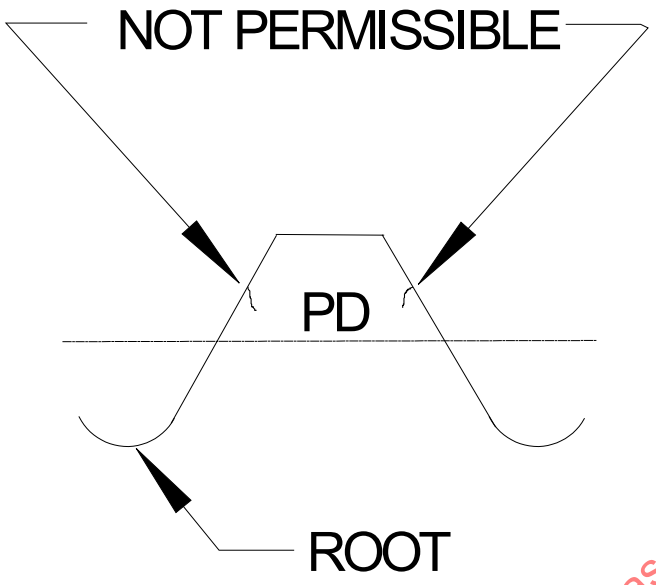


Figure 6 - Laps above pitch diameter extending towards root, rolled thread

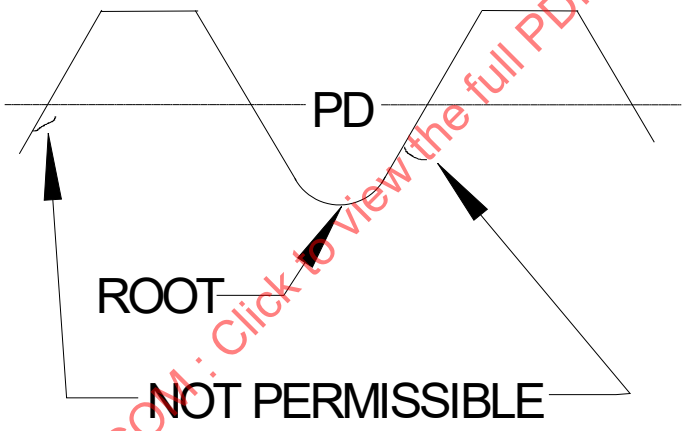
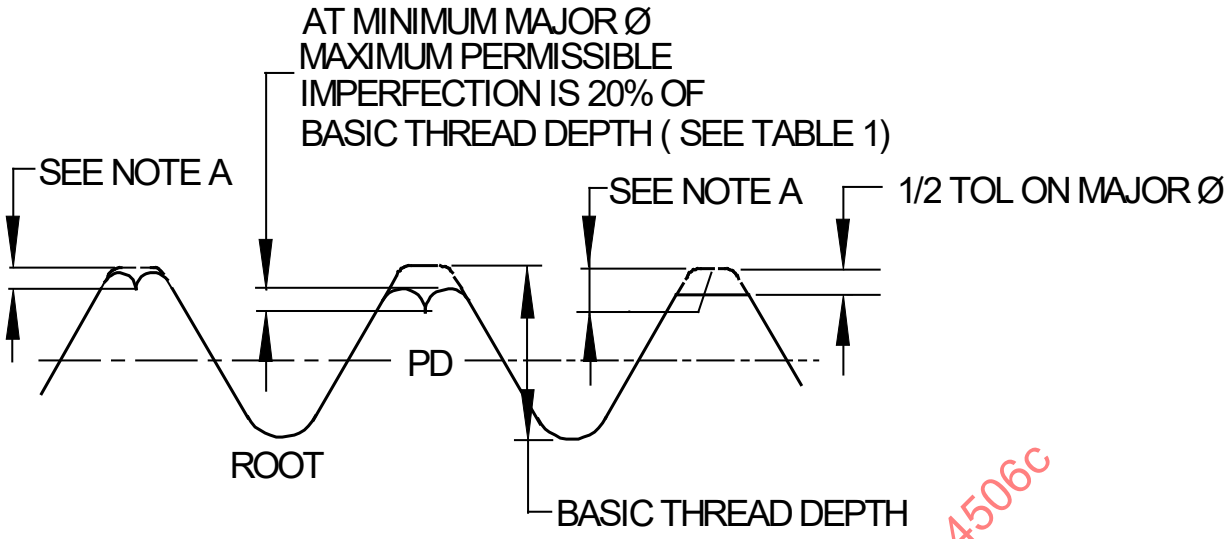


Figure 7 - Laps below pitch diameter extending in any direction, rolled thread



NOTE A
MAXIMUM DEPTH OF IMPERFECTION EQUALS 20% OF 2H/3 BASIC THREAD DEPTH PLUS 1/2 THE DIFFERENCE OF THE ACTUAL MAJOR DIAMETER AND MINIMUM MAJOR DIAMETER

Figure 8 - 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

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