AEROSPACE STANDARD

AS7461™	REV. E

Issued 1992-05
Reaffirmed 2001-10
Revised 2022-05

Superseding AS7461D

Bolts and Screws, Titanium Alloy 6Al - 4V, UNS R56400 Fatigue-Rated, Procurement Specification for

FSC 55306

RATIONALE

AS6416 added, many paragraphs updated or deleted, specs updated, figures redrawn, notes updated, and load tables values rounded up or down to make more realistic.

1. SCOPE

1.1 Type

This procurement specification covers aircraft-quality bolts and screws made from 6Al - 4V titanium alloy of the type identified under the Unified Numbering System as UNS R56400. The following specification designation and its properties are covered:

AS7461 160 ksi minimum ultimate tensile strength at room temperature.

77 ksi tension to 19.2 ksi tension fatigue at room temperature.

1.2 Application

Primarily for aerospace propulsion system bolt applications where high strength, light weight, fatigue rated fasteners are required for use up to approximately 600 °F.

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

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

AMS4967 Titanium Alloy, Bars, Wire, Forgings, and Rings, 6.0Al - 4.0V, Annealed, Heat Treatable

AS1132 Bolts, Screws, and Nuts - External Wrenching, UNJ Thread, Inch - Design Standard

AS1814 Terminology for Titanium Microstructures

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 AIA/NAS 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, Tensile Strength

NASM1312-11 Fastener Test Methods, Tension Fatigue

2.1.3 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-STD-2073-1 Standard Practice for Military Packaging

2.1.4 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 B600 Descaling and Cleaning Titanium and Titanium Alloy Surfaces

ASTM E8/E8M Standard Test Methods for Tension Testing of Metallic Materials.

ASTM E340 Standard Test Method for Macroetching Metals and Alloys

ASTM E407 Standard Test Practice for Microetching Metals and Alloys

ASTM E1417/E1417M Standard Practice for Liquid Penetrant Testing

ASTM E1447 Standard Test Method for Determination of Hydrogen in Titanium and Titanium Alloys, by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

2.1.5 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)

2.2 Definitions

Refer to AS6416.

Refer to AS1814 for titanium microstructure terms and definitions.

2.3 Unit Symbols

° Baume’	hydrometer scale unit for measuring specific gravity of liquids
°F	degree Fahrenheit
%	percent (1% = 1/100)
lbf	pound-force
ksi	kips (1000 pounds) per square inch
sp gr	specific gravity

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be AMS4967 titanium alloy.

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 before any required coating with dry film lubricants.

3.2.2 Surface Texture

Surface texture of finished parts, prior to any required coating, shall conform to the requirements as specified on the part drawing, determined in accordance with ASME B46.1.

3.2.3 Threads

Thread UNJ profile and dimensions shall be in accordance with AS8879, 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

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, controlled in accordance with AS3063.

3.3 Fabrication

3.3.1 Blanks

Heads shall be formed by hot forging.

3.3.1.1 Cleaning

Blanks shall be cleaned prior to heat treatment in accordance with ASTM B600, or other methods approved by the purchaser. Blank surfaces shall be free of halogen compounds, such as residue from halogenated solvents and coolants, and salt from sweaty hands. Surfaces of parts, fixtures, racks, etc., shall be clean and free of dirt, water, oil, grease, paint, ink, crayon markings, dye pickup, finger prints, and other foreign materials. After cleaning and prior to heat treatment, personnel handling blanks shall wear clean white cotton gloves or equivalent.

3.3.2 Heat Treatment

Headed blanks after cleaning as in 3.3.1.1 shall, before finishing the shank and the bearing surface of the head, cold working the head-to-shank fillet radius, and rolling the threads, be heat treated as follows:

3.3.2.1 Heating Equipment

Furnaces may be any type ensuring uniform temperature throughout the blanks 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 neither surface hardening nor embrittlement.

3.3.2.2 Solution Heat Treatment

Blanks shall be uniformly heated to a temperature within the range 1650 to 1750 °F, held at the selected temperature within ±25 °F for 30 to 60 minutes, and quenched in water.

3.3.2.3 Precipitation Heat Treatment

Solution heat treated blanks shall be heated to a temperature within the range 900 to 1100 °F, held at the selected temperature within ±10 °F for 4 to 8 hours, and cooled in air.

3.3.3 Contamination Removal

The solution and precipitation heat treated blanks, before cold working the fillet radius and rolling the threads, shall have the full body, head-to-shank fillet, and bearing surface of the head free from surface contamination and contamination penetration caused by prior heat treatment. The removal process shall produce no intergranular attack or corrosion, or changes of structure 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.

3.3.4 Cold Rolling of Fillet Radius

After removal of contamination as in 3.3.3, the head-to-shank fillet radius of headed parts having the radius complete throughout the circumference of the part shall be cold worked. The fillet shall be cold worked sufficiently to remove all visual evidence of grinding or tool marks. If there is no visual evidence of grinding or tool marks prior to cold working, the fillet shall still be cold worked. Distortion due to cold rolling 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. In configurations having an undercut associated with the fillet radius, the cold rolling 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 associated with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold rolling will be required only for 90 degrees 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 roll only the radius that blends with the head. The shank diameter on close tolerance full shank bolts shall not exceed its maximum diameter limit after cold rolling the head-to-hank fillet radius. The shank diameter on close tolerance full shank parts shall not exceed its maximum diameter limit after cold rolling the head-to-shank fillet radius.

3.3.5 Thread Rolling

Threads shall be formed on the heat treated and finished blanks by a single rolling process after removal of contamination as in 3.3.3.

3.4 Mechanical Properties

Parts shall conform to the requirements of 3.4.1 and 3.4.2. Threaded members of gripping fixtures for tensile and fatigue 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 the tensile and fatigue tests. Finished parts shall be tested in accordance with the following applicable test methods:

a. Room temperature ultimate tensile strength: MIL-STD-1312-8 in accordance with NASM1312-8.

b. Fatigue strength: MIL-STD-1312-11 in accordance with NASM1312-11.

3.4.1 Ultimate Tensile Strength at Room Temperature

3.4.1.1 Finished Parts

Tension bolts, such as hexagon, double hexagon, and spline drive head, shall have an ultimate tensile load not lower than that specified in Table 2A 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 2B, screws need not be tested to failure, however the maximum tensile load achieved shall be measured and recorded. 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 3.4.1.2; 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 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.

3.4.1.2 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 E8/E8M on specimens prepared as in 4.5.6. Tests on such specimens shall be conducted at a strain rate of 0.003 to 0.007 in/in/min through the 0.2% offset after which the rate shall be increased so as to produce failure in approximately 1 minute. Specimens may be required by the purchaser to perform confirmatory tests. Specimens shall meet the following requirements:

a. Ultimate tensile strength, minimum: 160 ksi.

b. Elongation in 2 inches or 4D, minimum: 8%.

c. Reduction of area, minimum: 20%.

3.4.2 Fatigue Strength

Finished parts tested in tension-tension fatigue at room temperature with maximum load as specified in Table 2 and minimum load equal to 25% of maximum load shall have average life of not less than 30000 cycles with no part having life less than 15000 cycles. Tests need not be run beyond 60000 cycles for purposes of computing average life. If the shank diameter of the part is less than the minimum pitch diameter of the thread, parts shall withstand fatigue testing as above using loads sufficient to produce a maximum stress of 77 ksi and a minimum stress of 19.2 ksi. The above requirements apply only to parts 0.138 inch and larger in nominal thread size with round, square, hexagonal, or double hexagonal heads designed for tension applications and not having an undercut and having a head-to-shank fillet radius equal to or larger than that specified in AS1132; for all parts to which the above requirements do not apply, fatigue test requirements shall be as specified on the part drawing.

3.5 Quality

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

3.5.1 Macroscopic Examination

Parts or sections of parts as applicable, shall be etched in a solution consisting of:

a. 15% ± 2% by volume, technical grade nitric acid, 42° Baume'.

b. 10% ± 1.5% by volume, hydrofluoric acid (48%).

c. Balance water

(Or other suitable etchant) for sufficient time to reveal flow lines but not longer than 5 minutes, and then be examined at a magnification of approximately 20X to determine conformance to the requirements of 3.6.1.1 and 3.6.1.2.

3.5.1.1 Flow Lines

3.5.1.1.1 Head-to-Shank

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

3.5.1.1.2 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 2).

3.5.1.2 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 3.6.2.3.3 and 3.6.2.3.4. 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.

3.5.2 Microscopic Examination

Specimens cut from parts shall be polished, etched in accordance with ASTM E340 and ASTM E407 and examined at a magnification not lower than 100X to determine conformance to the requirements of 3.6.2.1, 3.6.2.2, and 3.6.2.3.

3.5.2.1 Microstructure

Parts shall have microstructure free from indications of overheating resulting from heating above the beta transus without subsequent working in the alpha-beta temperature range. Alpha case or evidence of slight overheating on nonbearing surfaces of the head is permissible if the depth of overheating or case in not greater than 0.003 inch. Measurements shall be made normal to the surface. A structure showing outlines of equiaxed beta grains and no primary alpha grains will be cause for rejection.

3.5.2.2 Grinding Damage

Altered microstructure consisting of continuous or intermittent disturbed material or heat affected zone is considered grinding damage and is rejectable. None is permitted on the shank or head-to-shank fillet. Grinding burns are allowed on the head of the fastener and head bearing surface to a maximum depth of 0.003 inch.

3.5.2.3 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. In case of dispute over results of the microscopic examination, microhardness testing in accordance with MIL-STD-1312-6 in accordance with NASM1312-6 shall be used as a referee method; a Vickers hardness reading within 0.003 inch of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance to this requirement.

3.5.2.4 Threads

3.5.2.4.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 3).

3.5.2.4.2 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 4 and 5).

3.5.2.4.3 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.

3.5.2.4.4 There shall be no laps along the flank of the thread below the pitch diameter (see Figure 6). 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 toward the crest and is generally parallel to the flank (see Figure 6).

3.5.2.4.5 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 one-half of the difference between the minimum major diameter and the actual major diameter as measured on the part.

3.5.3 Fluorescent Penetrant Inspection

Parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E1417; Type 1, Sensitivity Level 2 minimum use of higher sensitivity penetrant is permissible. Any required coating shall be removed for this inspection.

3.5.3.1 The following conditions shall be cause for rejection of parts inspected.

3.5.3.1.1 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 quench cracks.

3.5.3.1.2 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.

3.5.3.2 The following conditions shall be considered acceptable on parts inspected.

3.5.3.3 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 3.6.3.2.2 through 3.6.3.2.5 provided the separation between indications is not less than 0.062 inch in all directions.

3.5.3.3.1 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 basic thread height (see Table 1), whichever is less.

3.5.3.3.2 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.

3.5.3.3.3 Threads

There shall be no indications, except as permitted in 3.6.2.4.

3.5.3.3.4 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, except those of 3.6.3.2.2, shall break over an edge.

3.6 Hydrogen Content Determination

When tested in accordance with ASTM E1447 the hydrogen content shall not exceed 0.0125% (125 ppm).

4. QUALITY ASSURANCE PROVISIONS

4.1 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. Acceptance tests are to be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.

4.2 Acceptance Test Sampling

4.2.1 Material

In accordance with AMS4967.

4.2.2 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.

4.2.3 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 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.

4.2.4 Macroscopic Examination

A random sample shall be selected from each production inspection lot, the size of the sample shall be as specified in Table 6.

4.2.4.1 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.

4.2.4.2 Hydrogen Determination

Determine the hydrogen content per ASTM E1447 from material removed from the head-to-shank fillet section of the fastener. Any plating or lubricants must be removed prior to chip removal. Care should also be taken to prevent overheating during removal of the test sample.

Check two random finished fasteners for lot sizes less than 500 parts and five random parts from larger lots. All samples from the inspection shall not exceed 0.0125% (125 ppm) defined in 3.7. If any sample exceeds 125 ppm, a second drilling is permissible from same part as previously tested and the average of the two readings must comply with the 125 ppm maximum requirement. If any second sample fails, the lot is not accepted.

4.2.5 Acceptance Quality

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

4.2.6 Test Specimens

Specimens for tensile testing of machined test specimens shall be of standard proportions in accordance with ASTM E8 with either 0.250 inch 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 inch and under in nominal diameter, from the center of coupons 0.800 inch and under in nominal diameter or distance between parallel sides, and from mid-radius of larger size parts or coupons.

4.3 Reports

The vendor of parts shall furnish with each shipment a report of all tests. This report shall include the purchase order number, AS7461E, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.4 Rejected Lots

Failure of a non-destructive test requirement as specified in Table 3 will require vendor of parts to perform corrective action to screen out or rework the non-conforming parts and resubmit for acceptance tests inspection as in Table 3. Resubmitted lots shall be clearly identified as reinspected lots.

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:

a. FASTENERS, TITANIUM ALLOY, 6Al - 4V

b. AS7461 (Current Revision Letter)

c. PART NUMBER

d. LOT NUMBER

e. PURCHASE ORDER NUMBER

f. QUANTITY

g. MANUFACTURER'S IDENTIFICATION

5.1.3 Threaded fasteners shall be suitably protected from damage 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:

a. Title, number, and date of this specification

b. Part number of parts desired

c. Quantity of parts desired

d. Level A packaging, if required (see 5.1.5)

8.2 Equipment

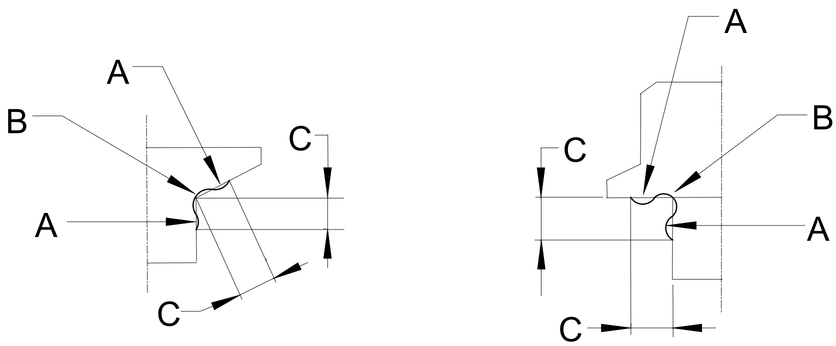
8.2.1 The tank for the solution of 3.6.1 must be lined with polyvinyl chloride or comparable lining material.

8.2.2 Adequate ventilation is necessary because of the production of gaseous fumes due to vigorous reaction.

8.2.3 Fixtures, racks, and baskets shall be coated with acid resistant material that will not react with the nitric-hydrofluoric acid solution.

8.3 Revision Indicator

A change bar (l) 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 Inch
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

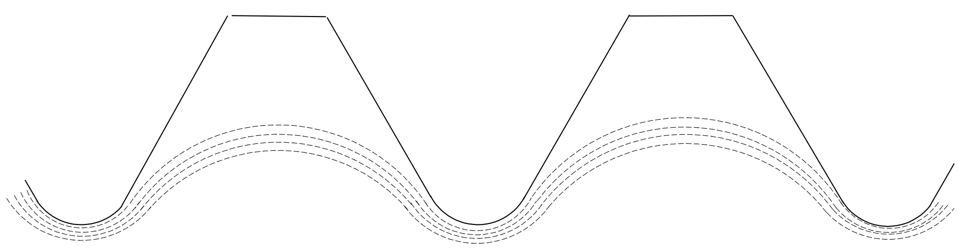


Figure 2 - Flow lines, rolled thread

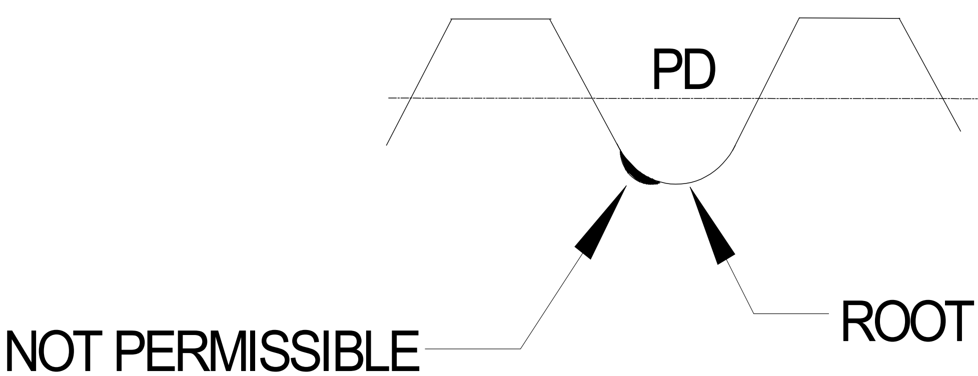


Figure 3 - Root defects, rolled thread

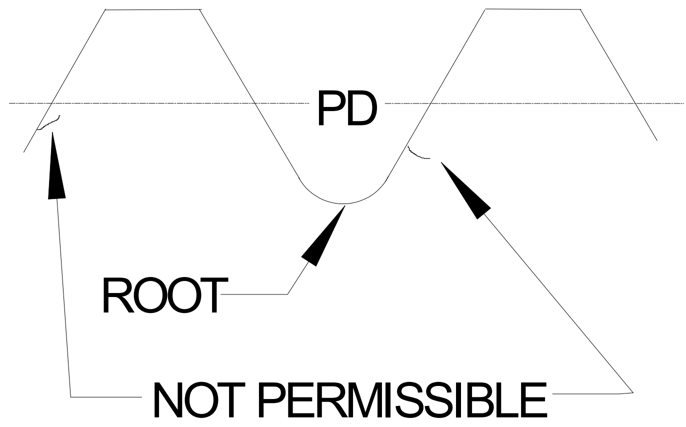


Figure 4 - Laps below PD extending toward root, rolled thread

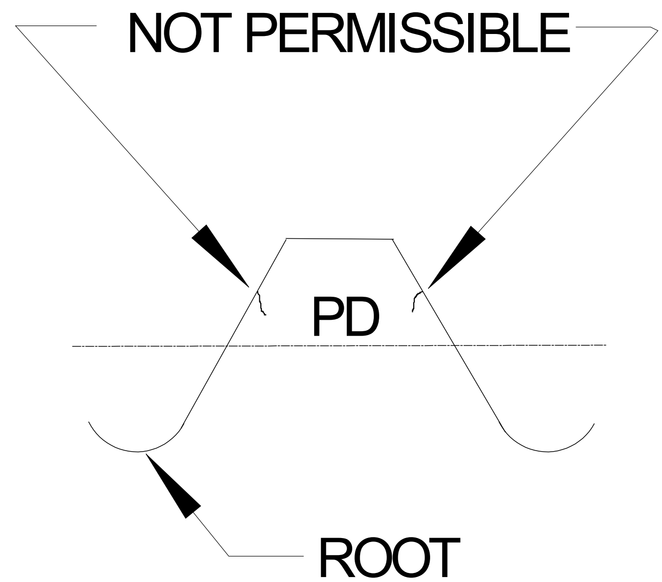


Figure 5 - Laps above PD extending toward root, rolled thread

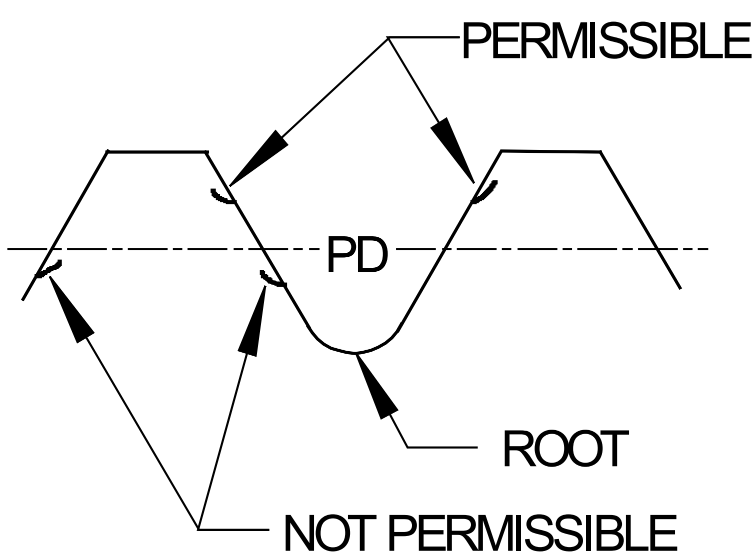
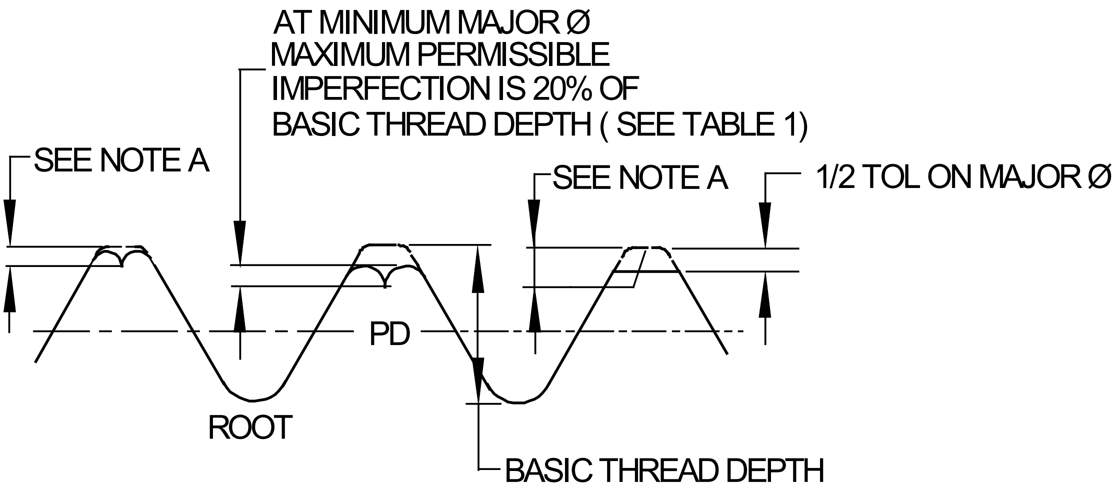


Figure 6 - Laps extending towards crest, rolled thread



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 7 - Crest craters and crest laps, rolled thread

Table 1 - Thread height

Thread Pitches per Inch n	Basic Thread Height Ref (see Note 1) Inch	20% Basic Thread Height Inch
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.

Table 2A - Test loads for bolts

Thread Size	Ultimate Tensile Strength Test Load, lbf, Minimum Standard Pitch Dia UN and UNJ Threads	Ultimate Tensile Strength Test Load, lbf, Minimum Reduced Pitch Dia UN Threads Only	Fatigue Strength Test Load lbf, Maximum Standard Pitch Dia UN and UNJ Threads	Fatigue Strength Test Load lbf, Maximum Reduced Pitch Dia UN Threads Only
0.1120 - 40	1020	950	--	--
0.1120 - 48	1110	1040	--	--
0.1380 - 32	1530	1450	600	560
0.1380 - 40	1700	1610	700	660
0.1640 - 32	2350	2250	950	900
0.1640 - 36	2470	2360	1020	970
0.1900 - 32	3350	3220	1390	1340
0.2500 - 28	6070	5910	2570	2500
0.3125 - 24	9690	9480	4130	4040
0.3750 - 24	14600	14400	6340	6230
0.4375 - 20	19800	19500	8560	8420
0.5000 - 20	25800	25500	11600	11500
0.5625 - 18	32700	32300	14800	14600
0.6250 - 18	41200	40800	18800	18600
0.7500 - 16	60100	59500	27400	27200
0.8750 - 14	82000	81400	37500	37200
1.0000 - 12	107000	106000	48700	48400

NOTE 1: Requirements above apply to parts with UNC, UNF, UNJC, or UNJF threads, as applicable to the sizes shown, to class 3A tolerances; requirements for reduced pitch diameter threads are based on 0.003 inch reduction below standard major, pitch and minor (root) diameters. Area upon which stress for ultimate tensile strength test load is based is one-half of the sum of the maximum pitch diameter and the maximum minor (root) diameter for UN threads, calculated from the equation:

$$\text{Std PD } A = 0.7854\,[d - ((3H/4) + (17H/12))/2]^2 = 0.7854\,[d - (0.9282/n)]^2 = 0.7854\,[d - (0.9282p)]^2 \quad \text{(Eq. 1)}$$

where:

A = area at [PD maximum + minor (root) diameter maximum]/2
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch
p = pitch (1/n)

Area upon which stress for fatigue strength test load requirements is based is the area at the maximum minor (root) diameter for UN threads at 17H/24 thread depth, calculated from equation:

$$A = 0.7854\,[d - (17H/12)]^2 = 0.7854\,[d - (1.2269/n)]^2 = 0.7854\,[d - (1.2269p)]^2 \quad \text{(Eq. 2)}$$

where:

A = area at 17H/24 thread depth
H = height of sharp V-threads = (cos 30°)/n
d = maximum major diameter
n = number of thread pitches per inch
p = pitch (1/n)

Load requirements are based on:

165 ksi for ultimate tensile strength test load for thread sizes below 0.500 inch nominal diameter

160 ksi for ultimate tensile strength test load for thread sizes 0.500 inch nominal diameter and larger

77 ksi for maximum fatigue strength test load

19.2 ksi for minimum fatigue strength test load (25% of maximum load)

NOTE 2: For sizes not shown and for parts having other than Class 3A thread tolerances, ultimate tensile strength test loads and fatigue test loads for parts tested as parts, not as specimens machined from parts or from coupons of the stock, shall be based upon the area and stresses given in Note 1.

Table 2B - Test loads for screws

Thread Size	Pan Head and Fillister Head: Ultimate Tensile Strength Test Load, lbf, Minimum Standard Pitch Dia UN and UNJ Threads	Pan Head and Fillister Head: Ultimate Tensile Strength Test Load, lbf, Minimum Reduced Pitch Dia UN Threads Only	Normal 100 Degree Countersunk Heads: Ultimate Tensile Strength Test Load, lbf, Minimum Standard Pitch Dia UN and UNJ Threads	Normal 100 Degree Countersunk Heads: Ultimate Tensile Strength Test Load, lbf, Minimum Reduced Pitch Dia UN Threads Only	Reduced 100 Degree Countersunk Head without Drive Recess in Head: Ultimate Tensile Strength Test Load, lbf, Minimum Standard Pitch Dia UN and UNJ Threads	Reduced 100 Degree Countersunk Head without Drive Recess in Head: Ultimate Tensile Strength Test Load, lbf, Minimum Reduced Pitch Dia UN Threads Only	Reduced 100 Degree Countersunk Head with Drive Recess in Head: Ultimate Tensile Strength Test Load, lbf, Minimum Standard Pitch Dia UN and UNJ Threads	Reduced 100 Degree Countersunk Head with Drive Recess in Head: Ultimate Tensile Strength Test Load, lbf, Minimum Reduced Pitch Dia UN Threads Only
0.1120 - 40	990	930	800	740	500	460	400	370
0.1120 - 48	1090	1020	870	820	540	510	440	410
0.1380 - 32	1500	1420	1200	1130	750	710	600	570
0.1380 - 40	1670	1590	1340	1270	840	790	670	630
0.1640 - 32	2310	2300	1850	1770	1160	1100	920	890
0.1640 - 36	2430	2320	1940	1860	1210	1160	970	930
0.1900 - 32	3300	3180	2640	2540	1650	1590	1320	1270
0.2500 - 28	6000	5840	4800	4700	3000	2920	2400	2330
0.3125 - 24	9580	9370	1660	7500	4790	4690	3830	3750
0.3750 - 24	14490	14230	11600	11390	7250	7120	5800	5690

NOTE 1: Requirements above apply to screws with UNC, UNF, UNJC, or UNJF threads, as applicable to the sizes shown, to class 3A tolerances; requirements for reduced pitch diameter parts are based on 0.003 inch reduction below standard. Area upon which stress for ultimate tensile strength test load for standard PD threads is based is UN basic minor diameter at 0.5625H thread depth, calculated from the equation:

$$\text{Std PD } A_3 = 0.7854\,[d - 1.125H]^2 = 0.7854\,[d - (0.9743/n)]^2 = 0.7854\,[d - (0.9743p]^2 \quad \text{(Eq. 3)}$$

Area upon which stress for ultimate tensile strength test load for reduced PD threads is based is UN reduced basic pitch diameter at 0.5625H thread depth, calculated from the equation:

$$\text{Reduced PD } A_4 = 0.7854\,[d - 0.003 - 1.125H]^2 = 0.7854\,[d - 0.003 - (0.9743/n)]^2 = 0.7854\,[d - 0.003 - (0.9743p]^2 \quad \text{(Eq. 4)}$$

where:

A_3 = area at the UN basic minor diameter at 0.5625H thread depth, in^2
A_4 = area at the UN reduced basic minor diameter at 0.5625H thread depth, in^2
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch
p = pitch (1/n)

Test load requirements are based 165 ksi ultimate tensile strength and are derived as shown in Table 2C for parts having Class 3A thread tolerances.

NOTE 2: For sizes not shown and for parts having other than Class 3A thread tolerances, ultimate tensile strength test loads and fatigue test loads for parts tested as parts, not as specimens machined from parts or from coupons of the stock, shall be based upon the area and stresses given in Note 1.

Table 2C - Load requirements for screws

Screw Type	Standard PD	Reduced PD
Pan Head and Fillister Head	165000 x A_3	165000 x A_4
Normal 100 Degree Countersunk Head	165000 x A_3 x 0.8	165000 x A_4 x 0.8
Reduced 100 Degree Countersunk Head without Drive Recess in Head	165000 x A_3 x 0.5	165000 x A_4 x 0.5
Reduced 100 Degree Countersunk Head with Drive Recess in Head	165000 x A_3 x 0.4	165000 x A_4 x 0.4

NOTE: A_3 and A_4 are tensile stress areas calculated by Equation 3 and 4, respectively.

Table 3 - Summary of acceptance tests

Table 3A - Nondestructive tests

Characteristic	Req Para	Sample Size	Test Method
Packaging and Identification	5.1	None	Visual
Dimensions	3.2.1	Tables 4 and 5	Conventional measuring methods
Surface Texture	3.2.2	Tables 4 and 5	Per ASME B46.1M by visual or fingernail comparison with standard texture specimens. In case of conflict, stylus instrument may be used if surface is accessible.
Thread Size	3.2.3	Tables 4 and 5	Inspection per AS8879
Geometric Tolerances	3.2.4	Tables 4 and 5	Conventional measuring methods
Fluorescent Penetrant Inspection	3.6.3	Tables 4 and 5	Inspection per ASTM E1417
Quality	3.6	Tables 4 and 5	Visual

Table 3B - Destructive tests

Characteristic	Req Para	Sample Size	Test Method
Material	3.1	4.4.1	Per AMS4967
Ultimate Tensile Strength	3.5.1	Table 6	NASM1312-8
Fatigue Strength	3.5.2	Table 6	NASM1312-11
Flow Lines	3.6.1.1	Table 6	Macroscopic exam. per 3.6.1
Internal Imperfections	3.6.1.2	Table 6	Macroscopic exam. per 3.6.1
Grinding Burns	3.6.2.2	Table 6	Microscopic exam. per 3.6.2
Threads (Laps, Seams, etc.)	3.6.2.3	Table 6	Microscopic exam. per 3.6.2
Microstructure	3.6.2.1	Table 6	Microscopic exam. per 3.6.2
Surface Hardening	3.6.2.2	Table 6	Microscopic exam. per 3.6.2 or Vickers hardness reading
Hydrogen Determination	3.7	4.4.4.2	ASTM E1447

Table 4 - Sampling data

Nondestructive tests
Visual and dimensional characteristics
For Classes Major A, Major B, Minor A, and Minor B

Production Inspection Lot	Major A Sample Size	Major B Sample Size	Minor A Sample Size	Minor B Sample Size
25 and under	All	13	5	3
26 to 50	All	13	8	5
51 to 90	80	20	13	8
91 to 150	80	32	20	13
151 to 280	80	50	32	20
281 to 500	80	50	32	20
501 to 1200	125	80	50	32
1201 to 3200	200	125	80	50
3201 to 10000	200	125	80	50
10001 to 35000	315	200	125	80
35001 to 150000	500	315	200	125
150001 to 500000	800	500	315	200
500001 and over	1250	800	500	315

Table 5 - Classification of visual and dimensional characteristics

Class	Characteristic
Major A	
101	Surface discontinuities revealed by fluorescent penetrant inspection
Major B	
201	Thread size
202	Shank diameter
203	Grip length
204	Fillet radius - distortion and dimensions
205	Drilled holes missing, when required
206	Surface texture (visual)
207	Burrs and tool marks
208	Overall length
209	Head bearing, surface diameter
210	Depth of lightening hole in head, when required
211	Thread form
212	Incomplete threads
213	Perpendicularity - head bearing surface to shank
214	Straightness of shank
Minor A	
301	Coating, when required
303	Lightening hole diameter, when required
304	Drilled hole location & diameter, when required
305	Wrenching element configuration
306	Runout - head OD to shank
307	Runout - thread pitch diameter to shank
Minor B	
401	Chamfer on thread end
402	Head flange thickness
403	Head height
404	Other dimensional characteristics

Table 6 - Sampling data - destructive tests

Mechanical and metallurgical characteristics

Production Inspection Lot	Sample Size
Up to 500	3
501 to 3200	5
3201 to 35000	8
35001 and over	13

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