AEROSPACE
MATERIAL SPECIFICATIONS
SOCIETY OF AUTOMOTIVE ENGINEERS, Inc. 485 Lexington Ave., New York 17, N.Y.

AMS 7461

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Revised

BOLTS AND SCREWS, TITANIUM ALLOY
6Al - 4V
Upset Headed, Heat Treated, Roll Threaded

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

2. APPLICATION: Premium quality bolts and screws for use up to 600 F (315 C) where a high strength lightweight fastener is required.

3. MATERIAL: Shall be AMS 4928 titanium alloy.

4. FABRICATION:

4.1 Blanks: Heads shall be formed by hot upsetting.

4.2 Heat Treatment:

4.2.1 Heating Equipment: Furnaces may be any type ensuring uniform temperature control throughout the parts being heated and shall be equipped with, and operated by, automatic temperature controllers. The heating medium or atmosphere shall cause neither surface hardening nor embrittlement.

4.2.2 Solution Heat Treatment: Blanks shall be uniformly heated to a temperature approximately 50 F (28 C) below the beta transus as determined on the heat of material from which blanks are made, held at the selected temperature within ± 15 F (± 8.3 C) for 30 - 60 min., and quenched in water.

4.2.3 Precipitation Heat Treatment: Solution heat treated blanks shall be heated to a temperature within the range of 900 - 1100 F (482.2 - 593.3 C), held at the selected temperature within ± 10 F (± 5.6 C) for 4 - 8 hr, and cooled in air.

4.3 Contamination Removal: The solution and precipitation heat treated blanks, before rolling the threads, shall be free from all surface contamination and contamination penetration caused by prior heat treatment. The contamination removal process shall produce no intergranular attack, corrosion, or changes of structure of the blanks. The metal removed from the bearing surface of the head shall be as little as practicable to obtain a clean, smooth surface and in no case shall be greater than 0.010 inch.

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4.4 Cold Working of Fillet Radius: After removal of contamination as in 4.3, the head to shank fillet radius of parts shall be cold worked; the working operation shall be sufficient to remove all visual evidence of grinding or tool marks. Distortion due to cold working shall not raise metal more than 0.001 in. above the contour at "A" or depress metal more than 0.001 in. below the contour at "B" as shown in Fig. 1; distorted areas shall not extend beyond "C" as shown in Fig. 1. In configurations where an undercut is associated with the fillet radius, the cold working will be required only for 90 deg of fillet arc, starting at the point of tangency of the fillet radius and the washer face.

4.5 Thread Rolling: Threads shall be formed by a single rolling process after removal of contamination as in 4.3.

5. TECHNICAL REQUIREMENTS:

5.1 Flow Lines: Flow lines of upset heads shall conform to the general arrangement shown in Fig. 2A, 2B, or 2C. The intersection of the longitudinal axis of the part and the approximate transverse axis of the flow lines shall be not less than D/4 in. from the bearing surface for hexagonal, round, and square head parts and not less than D/6 in. from the bearing surface for 12 point head parts where D is the nominal diameter of the shank after heading.

5.2 Threads:

5.2.1 Flow lines at threads shall be continuous, shall follow the general thread contour, and shall be of maximum density at root of thread (See Fig. 3).

5.2.2 Root defects such as notches, slivers, folds, roughness, or oxide scale are not permissible (See Fig. 4).

5.2.3 Multiple laps on the sides of threads are not permissible regardless of location. Single laps on the sides of threads that extend toward the root are not permissible (See Figs. 5 and 6).

5.2.4 A single lap is permissible along the side of the thread below the pitch diameter on the non-pressure side provided the lap does not originate closer than 20% of the basic thread height from the root and extends toward the crest and generally parallel to the side (See Fig. 7). A single lap is permissible along the side of the thread above the pitch diameter on either the pressure or non-pressure side (one lap per thread) provided it extends toward the crest and generally parallel to the side (See Fig. 8). Basic thread height is defined as being equivalent to 0.650 times the pitch (See Table I).

5.2.5 Crest craters, crest laps, or a crest lap in combination with a crest crater are permissible, provided the imperfections do not extend deeper than 20% of the basic thread height (See Table I) as measured from the thread crest when the thread major diameter is at minimum size (See Fig. 9). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches maximum size, values for crest crater or crest lap imperfections listed in Table I may be increased by 1/2 the difference between the minimum major diameter and the actual major diameter as measured on the part.

5.2.6 Slight deviations from thread contour are permissible at the crest of the thread within the major diameter limits as shown in Fig. 10 and at the incomplete thread at each end of the threaded section.

5.2.7 Parts having holes for locking devices are permitted to have slight ovalization of the hole and the countersink and slight flattening of the crest of the thread at the countersink, provided the diameter of the hole is within specified tolerances.

5.2.8 Parts shall have a minimum thread run-out of one thread and a maximum of two threads. The run-out shall fair onto the shank eliminating any abrupt change in cross sectional area. Bottom and sides of threads contained in run-out shall be filleted, smooth, and devoid of abrupt tool stop marks.

5.2.9 All thread elements shall be within specified limits starting at a length 2 times the pitch from the end, including chamfer, and extending for the specified full thread length.

5.3 Straightness, Concentricity, and Squareness: For purposes of these inspections, shank and threads shall be included but shall be considered as separate elements of the part.

5.3.1 Straightness of Shank and Threads: Shank and threads shall be straight within the limits specified on the drawing for the total length (L) of the part under the head (See Fig. 11). Visibly abrupt changes in diameter or shape of the shank and threads which might cause stress concentrations are not permissible.

5.3.2 Concentricity of Thread Pitch Diameter: The concentricity of thread pitch diameter in relation to shank diameter shall be within the limits specified on the drawing for a distance of not less than 1.5 times the nominal part diameter away from the last full thread along the shank (See Fig. 12). For parts having a shank length less than 1.5 times the nominal part diameter, the concentricity of the shank diameter over its full length in relation to the thread pitch diameter shall be within the limits specified on the drawing.

5.3.3 Concentricity of Head: The concentricity of the head in relation to the shank diameter shall be within the limits specified on the drawing for a distance of not less than 1.5 times the nominal part diameter away from the washer face along the shank (See Fig. 13). For parts threaded to the head and for parts having shank length less than 1.5 times the nominal part diameter, concentricity of head shall be measured in relation to thread pitch diameter in lieu of shank diameter.

5.3.4 Squareness of Washer Face: The squareness of the washer face with the shank diameter shall be within the limits specified on the drawing for a distance of not less than 1.5 times the nominal part diameter away from the washer face along the shank (See Fig. 12). For parts threaded to the head and for parts having a shank length less than 1.5 times the nominal part diameter, squareness of washer face shall be measured in relation to thread pitch diameter in lieu of shank diameter.

5.4 Structure: Parts shall show microstructure free from indications of overheating resulting from heating above the beta transus without subsequent working in the alpha-beta temperature range. Slight overheating on and adjacent to the top of the head is permissible provided that the depth of overheating is not greater than 0.003 in.; measurements shall be made normal to the top of the head. A structure showing outlines of equiaxied beta grains and no primary alpha grains will be cause for rejection.

5.5 Surface Hardening: Parts shall have no surface hardening except as produced during cold working of the head to shank fillet radius and rolling of the threads. Determinations of surface hardening may be made by microscopic method or by a sensitive hardness testing instrument.

5.6 Properties: Parts shall conform to the requirements of 5.6.1 and 5.6.2, and shall be capable of meeting the requirements of 5.6.3.

5.6.1 Tensile Properties:

5.6.1.1 Finished Parts: Shall have breaking load not lower than specified in Table II when aligned in fixtures so that at least three full threads are exposed in the gage section. 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 reduced shank diameter or an undercut, parts shall conform to the requirements of 5.6.1.2.

5.6.1.2 Tensile Test Specimens: If the size or shape of the part is such that a tensile test cannot be made on the part, tensile test specimens machined from finished parts, or from specimens of the material heat treated with the parts, and having unnotched gage sections shall have the following properties. Tests shall be conducted at a strain rate of 0.003 - 0.007 in. per in. per min. through the yield strength, after which the rate shall be increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a test machine having a strain rate pacer, using a rate of 0.005 in. per in. per minute.

Tensile Strength, psi	160,000 min
Yield Strength at 0.2% Offset or at 0.0222 in. in 2 in. Extension Under Load (E = 16,500,000), psi	150,000 min
Elongation, % in 4D	8 min
Reduction of Area, %	20 min

5.6.2 Hardness: Shall be uniform and within the range of Rockwell C 36 - 42 or equivalent, but hardness of the threaded portion and the head to shank fillet area may be higher as a result of the cold working operations.

5.6.3 Fatigue Strength: Parts tested in tension-tension fatigue at room temperature with maximum load as specified in Table II and minimum load equal to 25% of maximum load shall have average life of 30,000 cycles with no part having life less than 15,000 cycles. Tests need not be run beyond 60,000 cycles. Life of parts which do not fail in less than 60,000 cycles shall be taken as 60,000 cycles for purposes of computing average life.

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

6.1 Parts subject to fluorescent penetrant inspection shall conform to the following standards.

6.1.1 Discontinuities transverse to grainflow, such as pipes, grinding checks, and quench cracks, shall be cause for rejection.

6.1.2 Longitudinal indications of surface seams and forming laps parallel to grainflow are acceptable within the following limits, provided the separation between indications is not less than 1/16 in. in all directions.

6.1.2.1 Sides of Head: A maximum of 3 surface indications per head is permitted and the length of each indication may be the full height of the surface. No indication shall break over either edge to a depth greater than 1/32 in. or the equivalent of the basic thread height (See Table I), whichever is less.

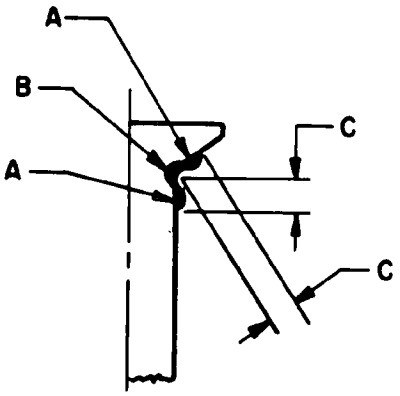
6.1.2.2 Top of Head and End of Stem: A maximum of 3 surface indications in each area is permitted provided the length or diameter of any individual indication does not exceed 1/32 in. or the equivalent of the basic thread height (See Table I), whichever is less.

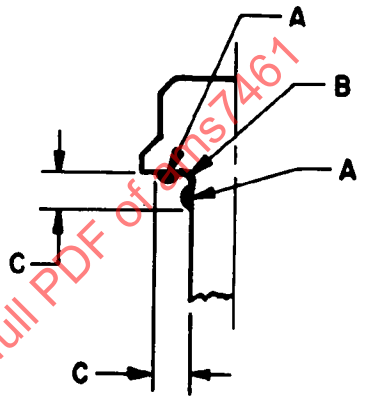
6.1.2.3 Shank or Stem: A maximum of 5 indications is permitted. The length of any one indication may be the full length of the surface but the total length of all indications shall not exceed twice the length of the surface. No indication shall break into a fillet or over an edge.

6.1.2.4 Threads: There shall be no indications of cracks, seams, pipes, or rolling laps in threads as shown by Figs. 4, 5, and 6 except that indications of slight laps as shown in Figs. 7, 8, and 9 will be permitted.

7. REPORTS: Unless otherwise specified, the vendor of parts shall furnish with each shipment three copies of a report stating that the chemical composition of the parts conforms to the requirements of the applicable material specification and showing the results of tests to determine conformance to the requirements of this specification. This report shall include the purchase order number, specification number, contractor or other direct supplier of material, part number, and quantity.

8. REJECTIONS: Parts not conforming to this specification or to authorized modifications will be subject to rejection.





Nominal Bolt Diameter	C, max
Under 0.3125	0.062
0.3125 and 0.375	0.094
0.4375 - 0.625, incl	0.125
0.750 - 1.000, incl	0.156
Over 1.000	0.188

PERMISSIBLE DISTORTION FROM FILLET WORKING
Figure 1

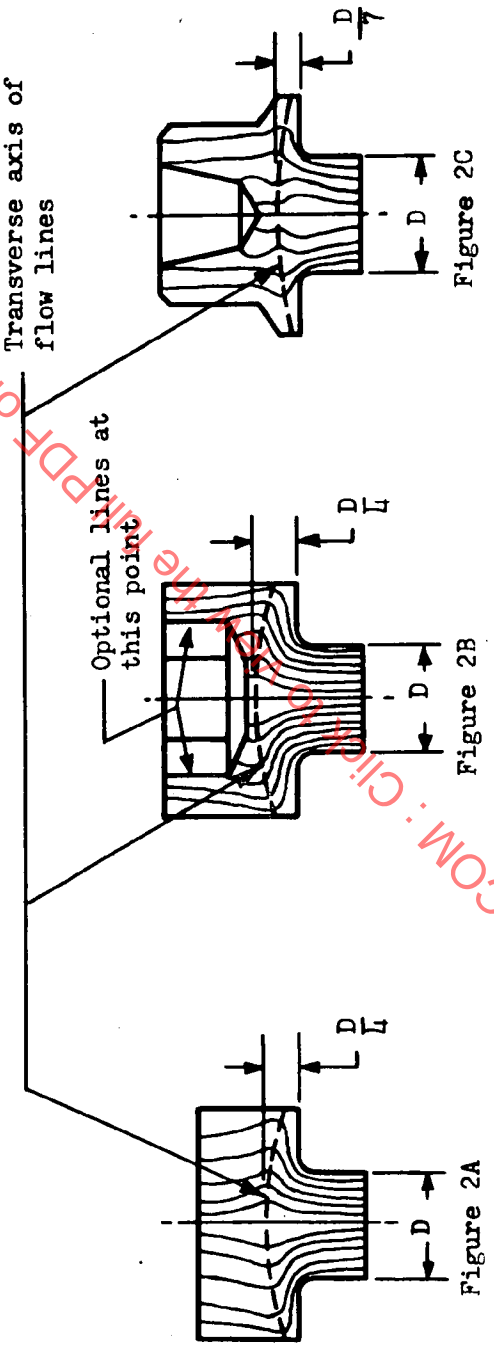
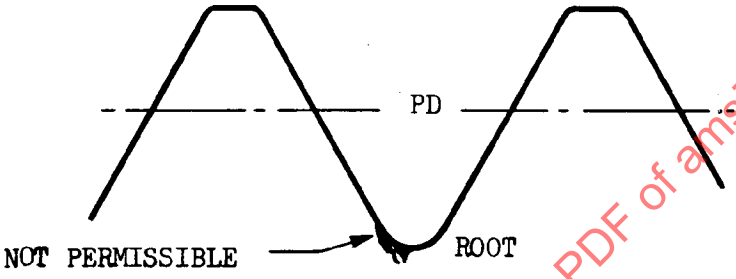


Figure 2C

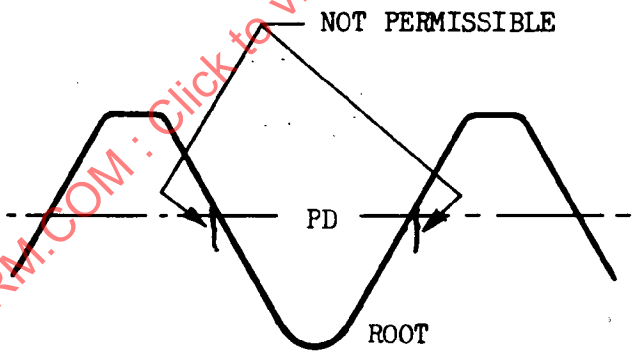
Figure 2B

Figure 2A

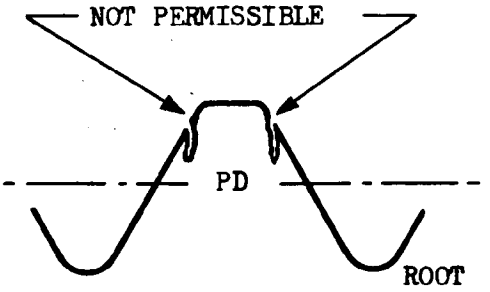
FLOW LINES - ROLLED THREAD
Figure 3



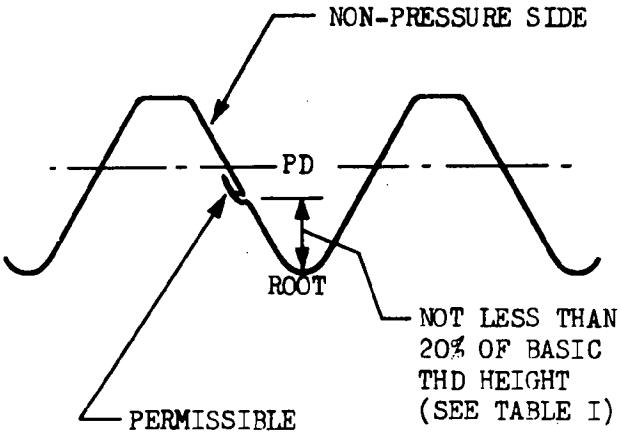
ROLLED THREAD
Figure 4



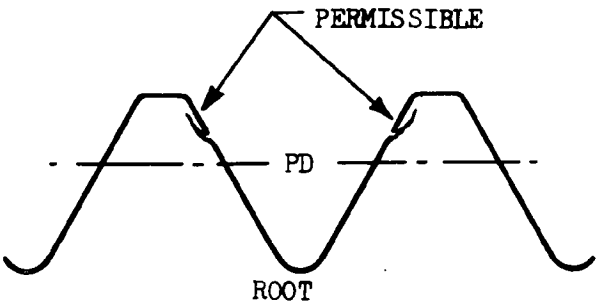
ROLLED THREAD
Figure 5



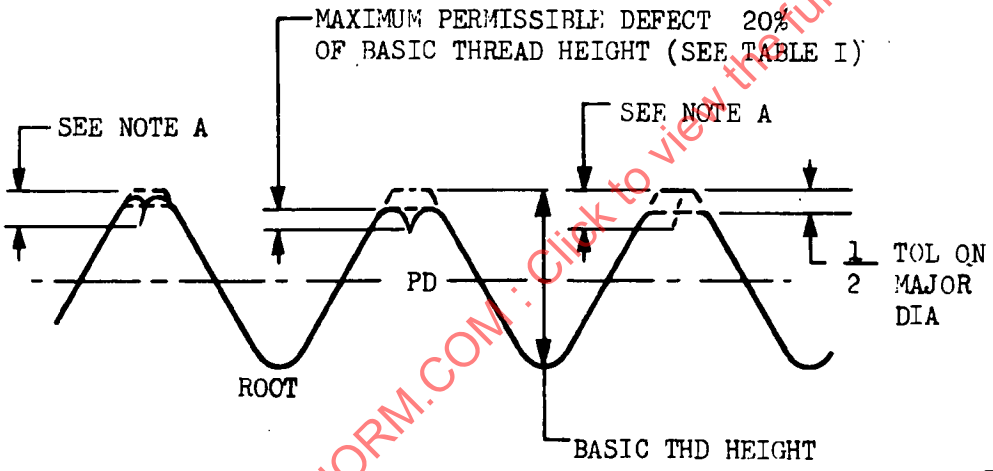
ROLLED THREAD
Figure 6



ROLLED THREAD
Figure 7

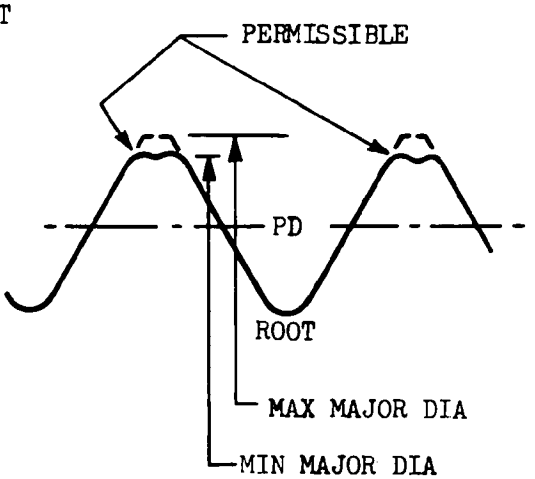


ROLLED THREAD
Figure 8



NOTE A. DEPTH OF DEFECT EQUALS 20% OF BASIC THREAD HEIGHT PLUS 1/2 THE DIFFERENCE OF THE ACTUAL MAJOR DIAMETER AND MINIMUM MAJOR DIAMETER.

ROLLED THREAD
Figure 9



ROLLED THREAD
Figure 10