Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 7460B
Superseding AMS 7460A

Issued 6-30-60
Revised 11-1-70

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

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

2. APPLICATION: High quality bolts and screws for use up to 600 F (316 C) where a high strength lightweight fastener is required.

ø 3. MATERIAL: Shall be AMS 4967 titanium alloy.

4. FABRICATION:

4.1 Blanks: Heads shall be formed by hot forging or by machining.

4.2 ø Heat Treatment: Headed and machined blanks shall, before finishing the shank and the bearing surface of the head, cold working the head-to-shank fillet radius when specified, and rolling the threads, be heat treated as follows:

4.2.1 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. The heating medium or atmosphere shall cause neither surface hardening nor embrittlement unless blanks are machined, after heat treatment, to remove surface hardening.

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 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 ø Contamination Removal: The solution and precipitation heat treated blanks, before cold working the fillet radius when specified and rolling the threads, shall have all surfaces free from surface contamination and contamination penetration caused by prior heat treatment. The 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 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 of upset headed parts than shown in Fig. 1B.

4.4 ø Cold Working of Fillet Radius: After removal of contamination as in 4.3, the head-to-shank fillet radius of parts having the radius complete throughout the circumference of the part shall, when specified, be cold worked sufficiently to remove all visual evidence of grinding or tool marks. Distortion due to cold working shall not raise metal more than 0.002 in. above the contour at "A" or depress metal more than 0.002 in. below the contour at "B" as shown in Fig. 2; distorted areas shall not extend beyond "C" as shown in Fig. 2. In configurations having an undercut 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 bearing surface of the head.

4.5 Thread Rolling: Threads shall be formed on the heat treated and finished blanks by a single rolling process after removal of contamination as in 4.3.

5. TECHNICAL REQUIREMENTS: Parts shall conform to the metallurgical and mechanical requirements specified below, determined in accordance with MIL-STD-1312 except as otherwise specified herein; ø when ASTM methods are specified for determining conformance, tests shall be conducted in accordance with the issue of the ASTM method listed in the latest issue of AMS 2350. Parts shall also conform to the latest issue of the following:

AS 1177 - Nondestructive Inspection Standards for Bolts and Screws
AS 3062 - Bolts, Screws, and Studs, Screw Thread Requirements
AS 3063 - Bolts, Screws, and Studs, Straightness, Concentricity, and Squareness Requirements

5.1 Macroscopic Examination: Parts or sections of parts, as applicable, shall be etched in a solution of approximately 5% hydrofluoric acid (sp gr 1.15) and 95% water for sufficient time to reveal flow lines ø but not longer than 1 hr and shall then be examined at approximately 20X magnification to determine conformance to the following requirements, except that examination for the thread imperfections of 5.1.3 may be made by microscopic examination of specimens polished and etched as in 5.2.

5.1.1 Flow Lines:

5.1.1.1 If parts have upset heads, examination of a longitudinal section through the part shall show flow lines in the shank, head-to-shank fillet, and bearing surface which follow the contour of the part ø as shown in Fig. 1A, except that slight cutting of flow lines by the contamination removal process of 4.3 is permissible, as shown in Fig. 1B; excessive cutting of flow lines in the shank, head-to-shank fillet, and bearing surface, as shown in Fig. 1C, is not permissible except when an undercut is associated with the fillet radius. The head style shown in Figs. 1A through 1C is for illustrative purposes only but other symmetrical head styles shall conform to the above requirements. Flow lines in upset heads on parts having special heads, such as Dee- or Tee-shaped heads or thinner-than-standard heads, shall be as agreed upon by purchaser and vendor.

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

5.1.2 Internal Defects: Examination of longitudinal sections of the head and shank and of the threads shall reveal no cracks, laps, or porosity. The head and shank section shall extend not less than D/2 in. ø from the bearing surface of the head and the threaded section shall extend not less than D/2 in. 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.

5.1.3 Threads:

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

5.1.3.2 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 Figs. 5 and 6).

5.1.3.3 There shall be no laps along the flank of the thread below the pitch diameter (See Fig. 7). 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 generally parallel to the flank (See Fig. 7).

5.1.3.4 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. 8). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches maximum size, values for depth of crest crater and crest lap imperfections listed in Table I may be increased by 1/2 of the difference between the minimum major diameter and the actual major diameter as measured on the part.

5.2 Microscopic Examination: Specimens cut from parts shall be polished, etched in a solution of approximately 1% hydrofluoric acid (sp gr 1.15), 12% nitric acid (sp gr 1.42), and 87% water, and then examined at not lower than 100X magnification to determine conformance to the following requirements:

5.2.1 Microstructure: 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 if 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 equiaxed beta grains and no primary alpha grains will be cause for rejection.

5.2.2 Surface Hardening: Parts shall have no surface hardening except as produced during cold working of the head-to-shank fillet radius when specified and during rolling of threads. Evidence of alpha case will not be permitted. In case of dispute over results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading within 0.003 in. of the surface more than 30 points higher than the reading in the core will be evidence of nonconformance to this requirement.

5.3 Properties: Parts shall conform to the requirements of 5.3.1.1 or 5.3.1.2, as applicable. 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. For tensile tests on finished parts, the parts shall be aligned in fixtures so that three full turns of thread are exposed in the gage section.

5.3.1 Tensile Properties:

5.3.1.1 Finished Parts: Parts shall have breaking load not lower than that specified in Table II. 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 minor diameter or having an undercut, parts shall conform to only the tensile strength requirement of 5.3.1.2; for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part and parts shall fracture only in the unthreaded shank section or the undercut, not in the area of the head-to-shank fillet radius except when this radius is associated with an undercut.

5.3.1.2 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 A370 on specimens machined from finished parts or from coupons of the same heat of material heat treated with the parts. Tests shall be conducted at a strain rate of 0.003 - 0.007 in. per in. per min. through the 0.2% offset after which the rate shall be increased so as to produce failure in approximately one additional minute. Specimens shall conform to the following requirements:

Tensile Strength, psi	160,000 min
Elongation, % in 2 in. or 4D	8 min
Reduction of Area, %	20 min

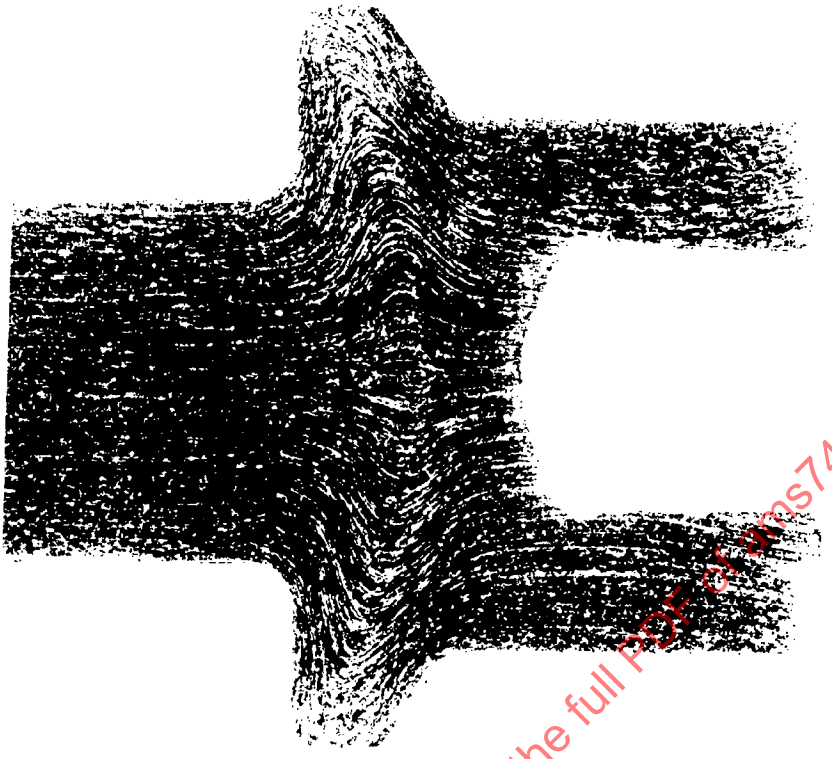
5.4 Resampling and Retesting: If any part or specimen used in the above tests fails to meet the specified requirements, acceptance of the parts may be based on the testing of three additional parts or specimens for each original nonconforming part or specimen, all of which additional parts or specimens shall conform to specified requirements. Failure of any retest part or specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. Results of all tests shall be reported.

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.

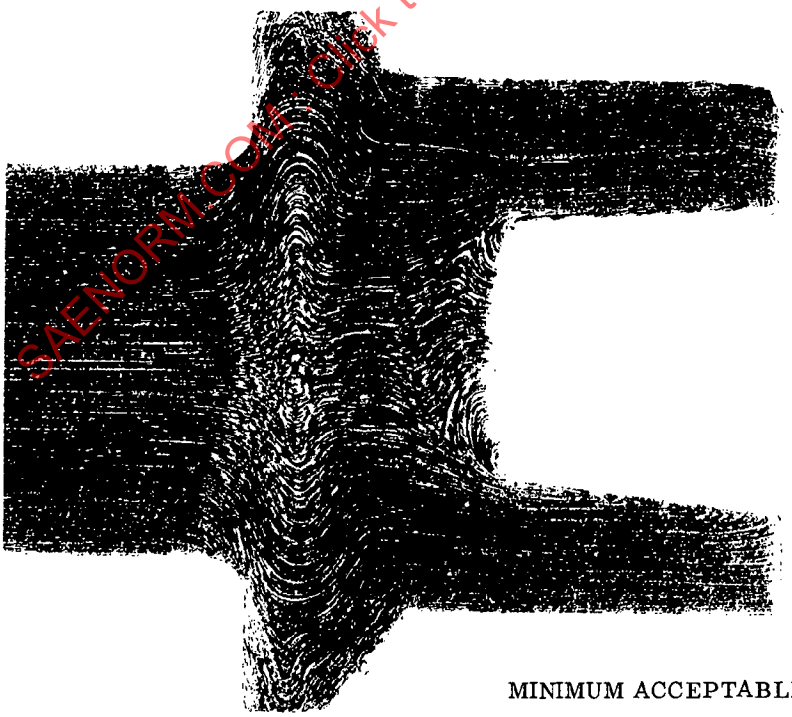
7. SAMPLING: Shall be in accordance with the latest issue of AMS 2373.

8. 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 tensile property requirements of this specification. This report shall include the purchase order number, AMS 7460B, contractor or other direct supplier of material, part number, and quantity.

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



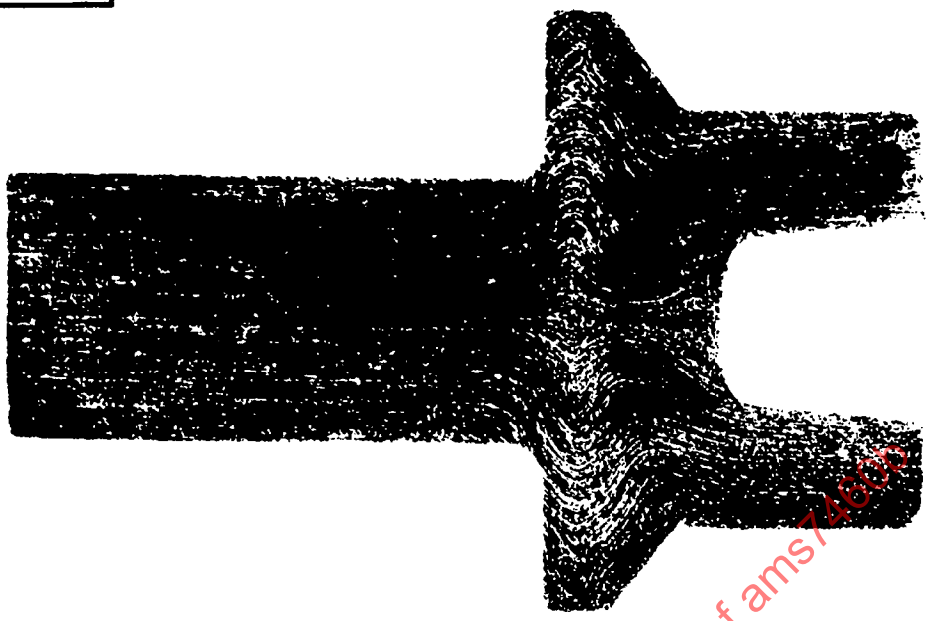
SATISFACTORY GRAIN FLOW
FIGURE 1A



MINIMUM ACCEPTABLE STANDARD

Showing maximum permissible cutting of flow lines after machining to remove oxide and decarburization as in 4.3.

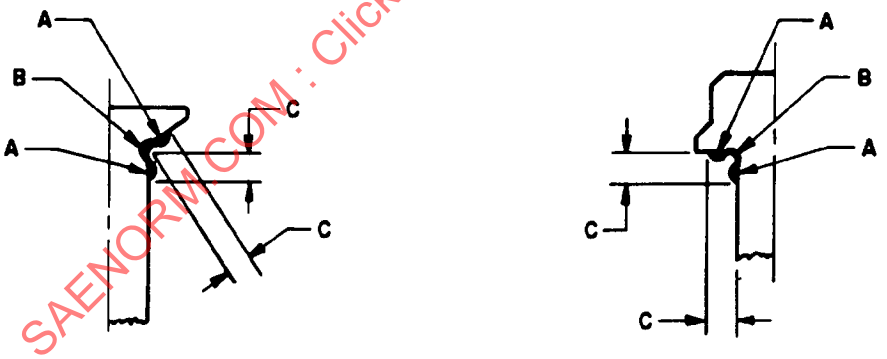
FIGURE 1B



UNACCEPTABLE GRAIN FLOW

Excessive cutting of flow lines in the shank, head to shank fillet, and bearing surface is not permissible.

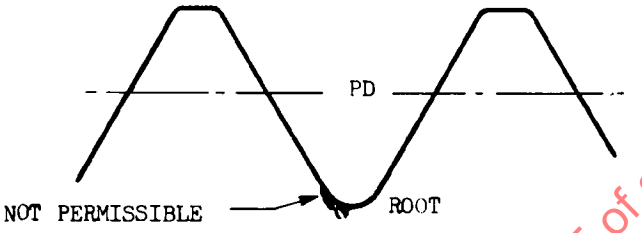
FIGURE 1C



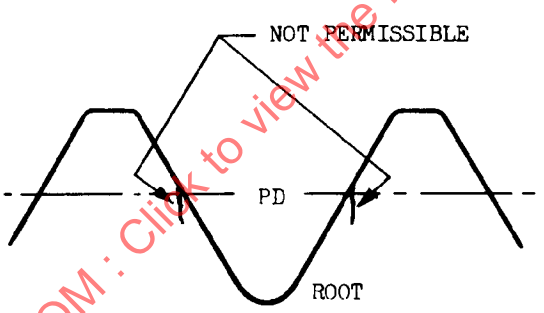
Nominal Bolt Diameter	C, max
Up to 0.3125, excl	0.062
0.3125 and 0.375	0.094
0.4375 - 0.625, incl	0.125
0.750 - 1.000, incl	0.156
Over 1.000	0.188

PERMISSIBLE DISTORTION FROM FILLET WORKING
FIGURE 2

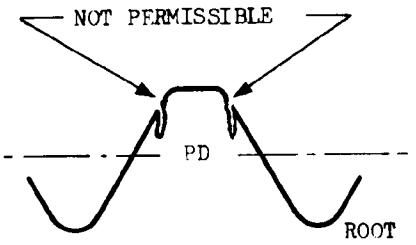
FLOW LINES, ROLLED THREAD
FIGURE 3



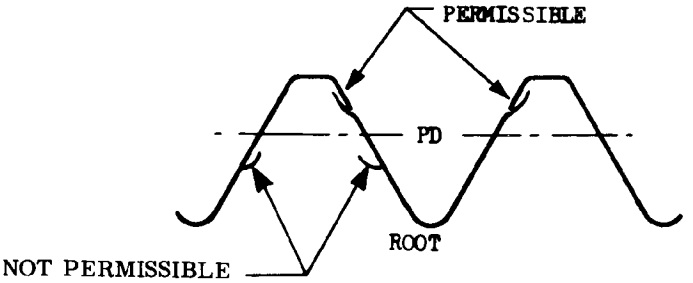
ROLLED THREAD
FIGURE 4



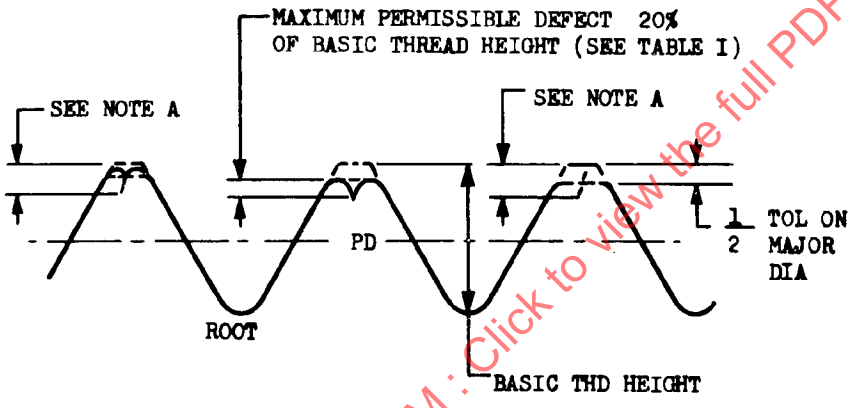
ROLLED THREAD
FIGURE 5



ROLLED THREAD
FIGURE 6



ROLLED THREAD
FIGURE 7



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 8