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

AEROSPACE MATERIAL SPECIFICATION

AMS 7464A
Superseding AMS 7464

Issued 2-15-65
Revised 11-1-70

BOLTS AND SCREWS, STEEL, LOW ALLOY HEAT RESISTANT
220,000 psi Tensile Strength
Hardened and Tempered, 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: Premium quality bolts and screws having controlled root radius of 0.15011 - 0.18042p where p is the pitch, for use between -100 F (-73 C) and 1000 F (538 C) in highly stressed locations.

3. MATERIAL: Shall be AMS 6485 steel, unless otherwise specified.

4. FABRICATION:

4.1 Blanks: Heads shall be formed by hot forging or cold forging, machined heads will not be permitted.

4.2 Heat Treatment: Headed blanks 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 threated 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 decarburization other than that permitted by 5.2.2 and 5.2.3.

4.2.2 Annealing: Blanks shall be annealed by heating to a temperature within the range 1500 - 1650 F (815.6 - 898.9 C), holding at the selected temperature within +25 F (±14 C) for 2 hr, and cooling at a rate not greater than 50 F (28 C) degrees per hr to 1000 F (538 C) or below, and then cooling as desired.

4.2.3 Hardening: Annealed blanks shall be uniformly heated to 1850 F ± 25 (1010 C ± 14), held at heat for 15 - 45 min., and cooled in air; preheating of blanks to 1450 F (788 C) before transferring to the austenitizing furnace at 1850 F (1010 C) is permissible.

4.2.4 Tempering: Hardened blanks shall be tempered three times by heating uniformly to the respective tempering temperature, holding at heat for 2 - 3 hr, and cooling in air; the temperature for the first and second tempering operations shall be not lower than 1060 F (571 C) and the temperature for the third tempering operation shall be not more than 25 F (14 C) degrees below that of the second tempering operation.

4.2.5 Stress-Relief: After removal of oxide and decarburization but before cold working the fillet radius and rolling the threads, blanks shall be stress relieved by heating to a temperature not more than 25 F (14 C) degrees below that of the final tempering temperature, holding at heat for 2 - 3 hr, and cooling in air.

4.3 Oxide and Decarburization Removal: The heat treated blanks, before cold working the fillet radius and rolling the threads, shall have all surfaces free from surface oxide, oxide penetration, and decarburization except as permitted in 5.2.3 caused by prior heat treatment. The 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 and in no case shall be so great as to produce more cutting of flow lines in the head-to-shank junction than shown in Fig. 1B.

4.4 Cold Working of Fillet Radius: After removal of oxide and decarburization as in 4.3, the head-to-shank fillet radius of parts having the radius complete throughout the circumference of the part shall be
ø cold worked sufficiently to remove all visual evidence of grinding or tool marks and to produce the fatigue strength specified in 5.3.5. 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 oxide 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 50% hydrochloric acid (sp gr 1.19) and 50% water for sufficient time to reveal flow lines
ø but not longer than 15 min. 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 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 as shown in Fig. 1A, except
ø that slight cutting of flow lines by the oxide and decarburization 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 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 2% Nital, and then examined at not lower than 100X magnification to determine conformance to the following requirements:

5.2.1 Microstructure: Parts shall have microstructure of tempered martensite.

5.2.2 Surface Hardening: Parts shall have no surface hardening except as produced during cold working of the head-to-shank fillet radius and during rolling of threads. Evidence of carburization, recarburization, or nitriding 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.

5.2.3 Decarburization:

5.2.3.1 The bearing surface of the head, the head-to-shank fillet radius, the shank, and the threads shall be free from decarburization.

5.2.3.2 Depth of decarburization on those surfaces of the head which are the original surfaces of the bar shall be not greater than that permitted by the applicable material specification.

5.2.3.3 Depth of decarburization on the OD of the head of cylindrical head parts is not restricted.

5.2.3.4 Depth of decarburization at any point on any surface not covered by 5.2.3.1, 5.2.3.2, or 5.2.3.3, shall not exceed 0.002 inch.

5.3 Properties: Parts shall conform to the requirements of 5.3.1.1 or 5.3.1.2, as applicable, and to the requirements of 5.3.3 and shall be capable of meeting the requirements of 5.3.2.1 or 5.3.2.2, as applicable, 5.3.4.1 or 5.3.4.2, as applicable, and 5.3.5. Threaded members of gripping fixtures for tensile, stress-rupture, and fatigue tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. For tensile, stress-rupture, and fatigue 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 at Room Temperature:

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 ø 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. Specimens shall conform to the following requirements:

Tensile Strength, psi	220,000 min
Elongation, % in 2 in. or 4D	12 min
Reduction of Area, %	43 min

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

5.3.2 Tensile Properties at 900 F (482.2 C):

5.3.2.1 Finished Parts: Parts heated to 900 F ± 3 (482.2 C ± 1.7), held at heat for 30 min. before testing, and tested at 900 F ± 3 (482.2 C ± 1.7) shall have breaking load not lower than that specified in ø 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 5.3.2.2; for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part.

5.3.2.2 Machined Test Specimens: If the size or shape of the part is such that a tensile test cannot be made ø on the part, tensile test specimens prepared as in 5.3.1.2, heated to 900 F ± 3 (482.2 C ± 1.7), held at heat for 30 min. before testing, and tested at 900 F ± 3 (482.2 C ± 1.7) in accordance with 5.3.1.2 shall conform to the following requirements:

Tensile Strength, psi	170,000 min
Elongation, % in 2 in. or 4D	15 min
Reduction of Area, %	50 min

5.3.3 Hardness: Shall be uniform and within the range Rockwell C 46 - 50 or equivalent but hardness of the threaded section and of the head-to-shank fillet area may be higher as a result of the cold working operations.

5.3.4 Stress-Rupture Test at 900 F (482.2 C):

5.3.4.1 Finished Parts: Parts, maintained at 900 F ± 3 (482.2 C ± 1.7) while the load specified in Table II ø is applied continuously, shall not rupture in less than 100 hours. If the shank diameter of the part is less than the maximum minor (nominal minor) diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 5.3.4.1.1.

5.3.4.1.1 Parts having a shank diameter less than the maximum minor (nominal minor) diameter of the part ø shall be tested as in 5.3.4.1 except that the load shall be as specified in 5.3.4.2. The diameter on which stress is based shall be the actual measured minimum diameter of the part.

5.3.4.2 Machined Test Specimens: If the size or shape of the part is such that a stress-rupture test cannot be made on the part, a test specimen, maintained at 900 F ± 3 (482.2 C ± 1.7) while a load sufficient ø to produce an initial axial stress of 130,000 psi is applied continuously, shall not rupture in less than 100 hours. Specimens shall be machined from finished parts, or from coupons of the same heat of material heat treated with the parts, to the dimensions shown in ASTM A370. Tests shall be conducted in accordance with ASTM E139.

5.3.5 Fatigue Strength: Parts tested in tension-tension fatigue at room temperature with maximum load as specified in Table II and minimum load equal to 10% of maximum load shall have average life of not
Ø less than 65,000 cycles with no part having life less than 45,000 cycles. Tests need not be run beyond 130,000 cycles. Life of parts which do not fail in less than 130,000 cycles shall be taken as 130,000 cycles for purposes of computing average life. If the shank diameter of the part is less than the minimum pitch diameter of the part, parts shall withstand fatigue testing as above using loads sufficient to produce a maximum stress of 115,000 psi and a minimum stress of 11,500 psi. The above requirements apply only to parts 0.138 in. and larger in nominal thread size with round, square, hexagonal, or double hexagonal heads designed for tension applications and not having an undercut; for all parts to which the above requirements do not apply, fatigue test requirements shall be as specified on the drawing.

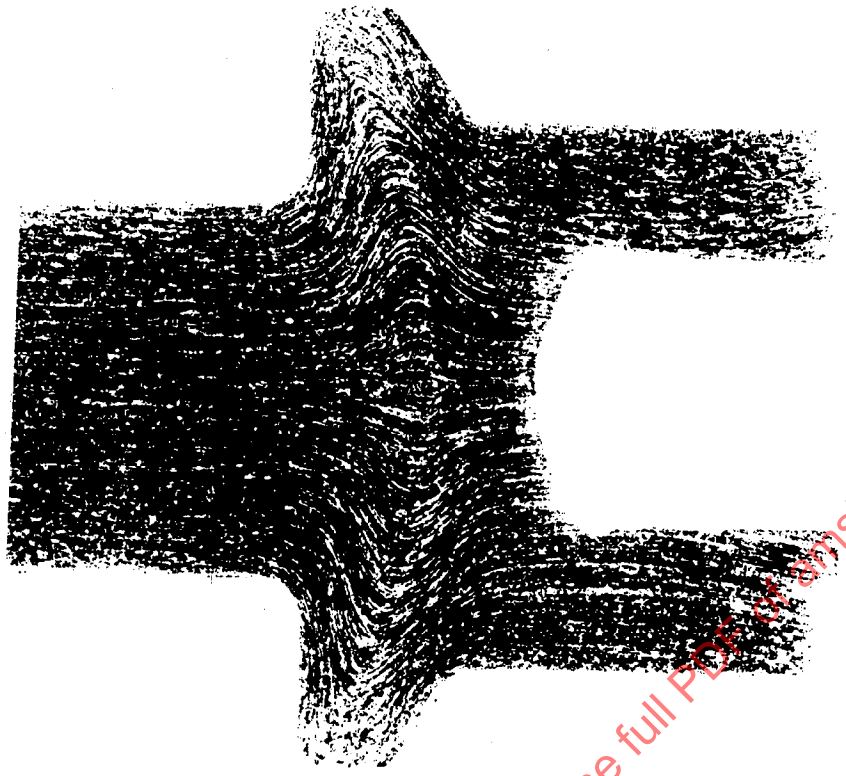
5.4 Resampling and Retesting: If any part or specimen used in the above tests fails to meet the specified requirements, acceptance of the parts may be based on the testing of three additional parts or specimens
Ø for each original nonconforming part or specimen, all of which additional parts or specimens 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.

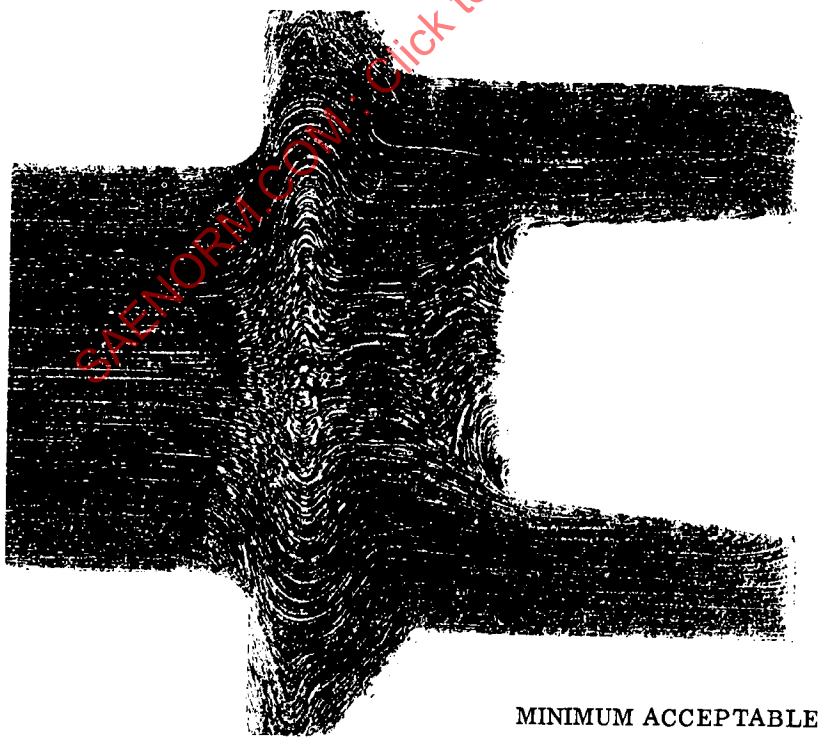
Ø 7. SAMPLING: Shall be in accordance with the latest issue of AMS 2373.

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 room temperature tensile property and hardness requirements of this specification and a statement that the parts conform to all other requirements of this specification. This report shall include the purchase order number, AMS 7464A, 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.



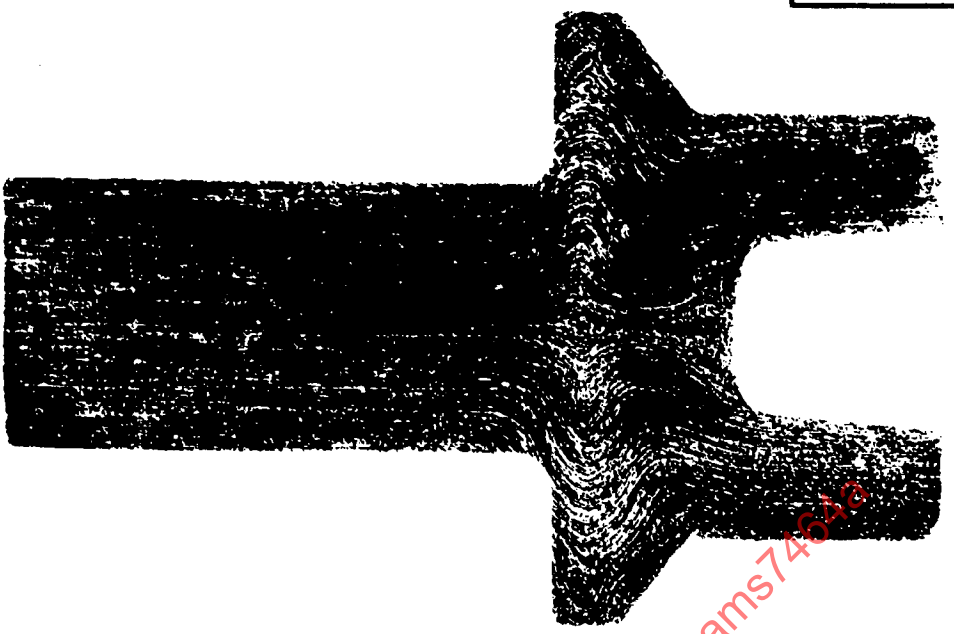
SATISFACTORY GRAIN FLOW
FIGURE 1A



MINIMUM ACCEPTABLE STANDARD

Showing maximum permissible cutting of flow lines after machining to remove oxide and decarburization as in 4. 3.

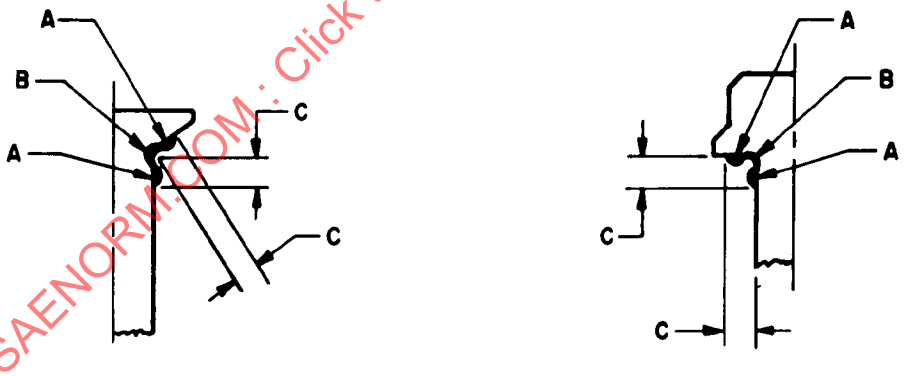
FIGURE 1B



UNACCEPTABLE GRAIN FLOW

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

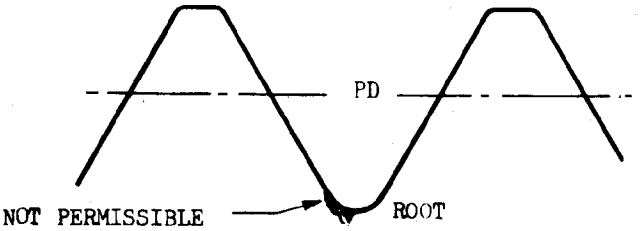
FIGURE 1C



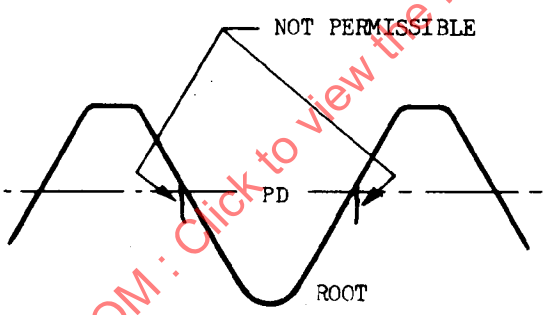
Nominal Bolt Diameter	C, max
Up to 0.3125, excl	0.062
0.3125 and 0.375	0.094
0.4375 - 0.625, incl	0.125
0.750 - 1.000, incl	0.156
Over 1.000	0.188

PERMISSIBLE DISTORTION FROM FILLET WORKING
FIGURE 2

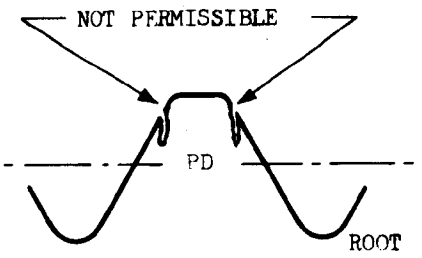
FLOW LINES, ROLLED THREAD
FIGURE 3



ROLLED THREAD
FIGURE 4



ROLLED THREAD
FIGURE 5



ROLLED THREAD
FIGURE 6