AEROSPACE
MATERIAL SPECIFICATIONS

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AMS 7464

Issued 2-15-65
Revised

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 in all quotations and when acknowledging purchase orders.

2. APPLICATION: Premium quality bolts and screws having controlled root radius of 0.15011 - 0.18042 p where p is the pitch, for use between -100 F (-73 C) and 1000 F (538 C) in highly stressed locations. Parts require plating to prevent corrosion.

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

4. FABRICATION:

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

4.2 Heat Treatment: Headed blanks shall, before finishing the shank and the bearing surface of the head and rolling the head to shank fillet radius and 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 decarburization other than that permitted by 5.7.

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

4.2.3 Hardening: 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) below that of the second tempering operation.

4.2.5 Stress-Relief: After removal of oxide and decarburization but before cold working, blanks shall be stress relieved by heating to a temperature not more than 25 F (14 C) 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 rolling the threads, shall be free from all surface oxide, oxide penetration, and decarburization 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 head and the full body diameter of the blank shall be as little as practicable to obtain a clean, smooth surface and in no case shall be greater than shown below.

Nominal Bolt Diameter Inches	Maximum Depth of Metal Removed Inch
Up to 0.138, incl (No. 6)	0.006
Over 0.138 to 0.3125, incl	0.008
Over 0.3125 to 0.375, incl	0.010
Over 0.375 to 0.500, incl	0.013
Over 0.500	0.015

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 shall be cold worked sufficiently to remove all visual evidence of grinding or tool marks and to produce the fatigue strength specified in 5.5.3. 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 on the heat treated and finished blanks by a single rolling process after removal of oxide as in 4.3.

5. TECHNICAL REQUIREMENTS:

5.1 Flow Lines: Shall conform to the general arrangement shown in Fig. 2A, 2B, or 2C, shall be continuous, and shall follow the contour of the head to shank fillet. Except when an undercut is associated with the fillet radius, cutting of flow lines in excess of that permitted by 4.3 will be cause for rejection. 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 standard hexagonal and square head parts and for standard round head parts not having an internal wrenching recess, and shall be not less than D/6 in. for round head parts having an internal wrenching recess and for double hexagon head parts, where D is the nominal diameter of the shank after heading. Flow line requirements for parts having special heads, such as Dee heads or thinner-than-standard heads, shall be as agreed upon by purchaser and vendor.

5.1.1 Examination for Internal Defects: Visual examination of a longitudinal section of a head and 1/4 in. or more of the shank, after etching in approximately equal volumes of hydrochloric acid (sp gr 1.19) and water at 160 - 180 F (71.1 - 82.2 C) for 10 - 15 min., shall reveal no cracks, laps, or porosity.

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 There shall be no laps along the sides of the thread below the pitch diameter. 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. 7).

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. 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 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. 9 and 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. Root 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.

5.2.10 Unless otherwise specified, threads may be 0.0012 in. under the specified limits before plating but shall conform to the gage requirements after plating.

5.3 Straightness, Concentricity, and Squareness: For purposes of these inspections, shank and threads 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. 10). 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. 11). 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. 12). 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 have microstructure of tempered martensite. Structure of the head to shank fillet area shall show evidence of cold work.

5.5 Properties: Parts shall conform to the room temperature requirements of 5.5.1.1 or 5.5.1.2, as applicable, and to the requirements of 5.5.2; parts shall be capable of meeting the elevated temperature requirements of 5.5.1.1 or 5.5.1.2, as applicable, and the requirements of 5.5.3, 5.5.4, and 5.5.5. Threaded members of gripping fixtures shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. For tensile and stress-rupture tests, parts shall be aligned in fixtures so that 3 - 5 full threads are exposed in the gage section. For tensile tests at 900 F (482.2 C), parts or specimens shall be 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).

5.5.1 Tensile Properties:

5.5.1.1 Finished Parts: Shall have breaking load not lower than 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 reduced shank diameter or an undercut, parts shall conform to the requirements of 5.5.1.2.

5.5.1.2 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 coupons of the material heat treated with the parts, and having unnotched gage sections shall conform to the following requirements; the diameter of the area on which stress is based shall be the actual measured minimum diameter of the specimen.

Test Temperature	Tensile Strength psi, min	Elongation % in 4D, min	Reduction of Area %, min
Room	220,000	12	43
900 F (482.2 C)	170,000	15	50

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

5.5.2 Hardness: Shall be uniform and within the range of Rockwell C 46 - 50 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.

5.5.3 Fatigue Strength: Parts tested in tension-tension fatigue at room temperature with maximum load as specified in Table II and minimum load equal to 10% of maximum load shall have average life of 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.

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

5.5.4.1 Finished Parts: A part, maintained at 900 F ± 3 (482.2 C ± 1.7) while the axial load specified in Table II is applied continuously, shall not rupture in less than 100 hours. 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 5.5.4.2.

5.5.4.2 Test Specimens: If the size or shape of the part is such that a stress-rupture test cannot be made on the part, tensile test specimens machined from the part, or from coupons of the material heat treated with the parts, and having un-notched gage sections, maintained at 900 F ± 3 (482.2 C ± 1.7) while an axial stress of 130,000 psi is applied continuously, shall not rupture in less than 100 hours. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.

5.5.5 Stability: Parts or specimens, after being heated to 900 F ± 15 (482.2 C ± 8.3), held at heat for 100 hr, and cooled to room temperature, shall conform to the requirements of 5.5.1.1 or 5.5.1.2 as applicable.

5.6 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. Determination of surface hardening may be made by microscopic method or by a sensitive hardness testing instrument.

5.6.1 This requirement prevents heat treating procedures such as uncontrolled atmosphere for heating, bath heating medium, carbon restoration, and other similar processes.

5.7 Decarburization:

5.7.1 The bearing surface of the head, the fillet between head and shank, the shank, and threads shall be free from decarburization.

5.7.2 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, except as noted in 5.7.1.

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

5.7.4 Depth of decarburization at any point on any surface not covered in 5.7.1, 5.7.2, or 5.7.3 shall not exceed 0.002 inch.

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 magnetic particle 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 seams, forming laps, and non-metallic inclusions parallel to grain flow 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 6 surface or subsurface indications per head is permissible 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 6 surface or subsurface indications in each area is permissible provided the length or diameter of any individual indication does not exceed 1/32 in. or the equivalent of the basic thread height, whichever is less.

6.1.2.3 Shank or Stem: A maximum of 10 subsurface and hairline surface indications is permissible. 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.

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 by Figs. 7 and 8 will be permissible.

6.2 Any method of magnetic particle inspection may be used to determine conformance of the parts to the above requirements, but resolution of disputed rejections shall be based upon the wet, residual, black oxide suspension method using amperages shown in 6.2.1 and 6.2.2.

6.2.1 Circular Magnetization: 800 - 1000 amp per sq in. of smallest contact area passed through the part longitudinally.

6.2.2 Longitudinal Magnetization: Sufficient to produce 5000 amp-turns per inch of shank diameter with the part placed in a standard solenoid of appropriate size.

7. REPORTS: Unless otherwise specified, the vendor of parts shall furnish with each shipment three copies of 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 hardness and room temperature tensile strength 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.

TABLE I

THREADS PER INCH	BASIC THD HEIGHT REF	20% BASIC THD HEIGHT
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	0.0162	0.0032
36	0.0180	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	0.0541	0.0108
11	0.0590	0.0118
10	0.0650	0.0130
9	0.0722	0.0144
8	0.0812	0.0163

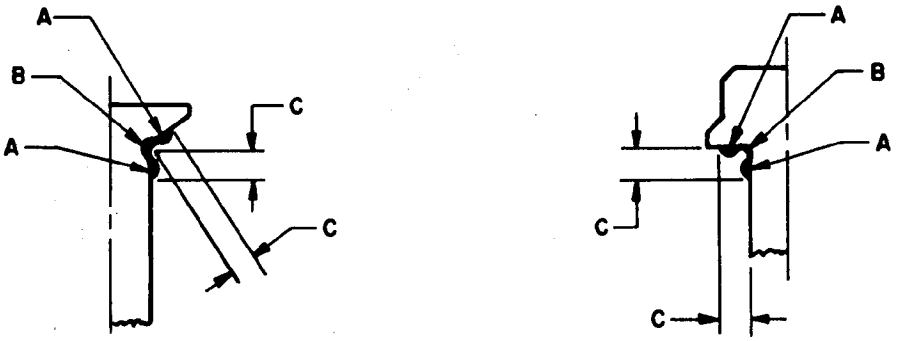
TABLE II

Nominal Bolt Diameter Inch	Threads per Inch	Tensile Breaking Load lb, min		Maximum Fatigue Test Load, lb	Stress-Rupture Test Load lb
		Room Temperature	900 F (482.2 C)		
0.112	48	1,680	1,300	651	991
0.138	40	2,560	1,980	1,010	1,510
0.164	36	3,680	2,850	1,480	2,190
0.190	32	4,980	3,850	2,020	2,940
0.250	28	8,890	6,870	3,750	5,250
0.3125	24	14,100	10,900	6,000	8,320
0.375	24	20,900	16,200	9,300	12,400
0.4375	20	28,300	21,900	12,500	16,700
0.500	20	37,800	29,200	17,100	22,300
0.5625	18	47,900	37,000	21,700	28,300
0.625	18	59,900	46,300	27,600	35,400
0.750	16	87,000	67,200	40,400	51,400
0.875	14	119,000	91,700	55,300	70,100
1.000	12	155,000	119,000	71,800	91,400

Note 1. Areas upon which stresses are based are those at the basic pitch diameter for tensile and stress-rupture tests and at the basic minor diameter for fatigue tests.

Note 2. For sizes not shown, tensile breaking load for parts tested as parts, not as specimens machined from parts or from coupons of the stock, shall be based upon a stress of 220,000 psi for tests at room temperature and a stress of 170,000 psi for tests at 900 F (482.2 C).

Note 3. For sizes not shown, maximum fatigue test load shall be based on a stress of 115,000 psi.



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

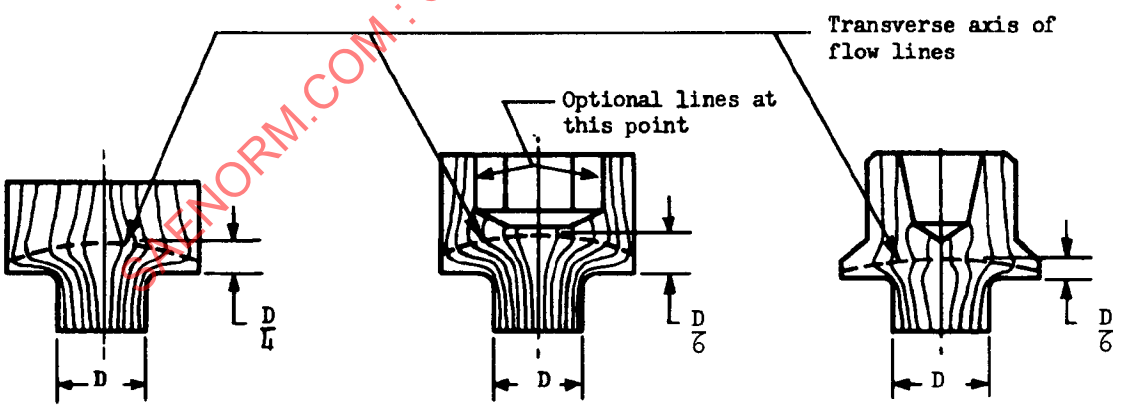


Figure 2A

Figure 2B

Figure 2C