Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 7475

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Revised

BOLTS AND SCREWS, WORK-STRENGTHENED ALLOY, CORROSION AND HEAT RESISTANT
Forged Head, Roll Threaded After Aging

1. SCOPE:

1.1 Type: This specification covers aircraft-quality bolts and screws made from a corrosion and heat resistant, work-strengthened cobalt-chromium-nickel alloy and aged to develop the specified properties.

1.2 Application: Primarily for use where fasteners having an excellent combination of strength, creep, fatigue, and relaxation resistance are required for use up to 1100°F (595°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Standards (AS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2373 - Quality Assurance Sampling of Bolts and Screws
AMS 5842 - Alloy Bars, Work Strengthened, Corrosion and Heat Resistant, 19Cr - 36Co - 25Ni - 7.0Mo - 0.50Cb - 2.9Ti - 0.20Al - 9.0Fe, Solution Heat Treated and Cold Drawn

2.1.2 Aerospace Standards:

AS 1132 - Design Parameters for Bolts and Screws, External Wrenching, Unified Thread Inch Series
AS 1177 - Nondestructive Inspection Standards for Bolts and Screws
AS 3062 - Bolts, Screws, and Studs, Screw Thread Requirements
AS 3063 - Bolts, Screws, and Studs, Geometric Control Requirements

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E21 - Elevated Temperature Tension Tests of Metallic Materials
ASTM E112 - Estimating the Average Grain Size of Metals
ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-1312 - Fasteners, Test Methods

Printed in U.S.A.

2.3.2 Bureau of Standards Publications:

Handbook H28 - Screw-Thread Standards for Federal Services

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be AMS 5842 alloy heading stock.

3.2 Fabrication:

3.2.1 Blanks: Heads shall be formed by forging. Forged or machined lightening holes are acceptable.

3.2.2 Heat Treatment: Headed blanks, before cold working the fillet radius and rolling the threads, shall be aged as follows:

3.2.2.1 Heating Equipment: Furnaces may be any type ensuring uniform temperature throughout the parts and shall be equipped with, and operated by, automatic temperature controllers. The heating medium shall not cause surface hardening by carburizing or nitriding.

3.2.2.2 Aging Heat Treatment: Blanks shall be aged by heating to a temperature within the range 1200° - 1250°F (650° - 675°C), holding at the selected temperature within ±25°F (±15°C) for 4 - 4-1/2 hr, and cooling at a rate equivalent to an air cool.

3.2.3 Oxide Removal: Surface oxide and oxide penetration resulting from prior heat treatment shall be removed from the full body diameter and the bearing surface of the head of the solution heat treated, work strengthened, and aged blanks prior to cold working the fillet radius and rolling the threads. The oxide 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.

3.2.4 Cold Working of Fillet Radius: After removal of oxide as in 3.2.3, the head-to-shank fillet radius of headed parts having the radius complete throughout the circumference of the part shall 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. (0.05 mm) above the contour at "A" or depress metal more than 0.002 in. (0.05 mm) 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 (1.57 rad) of fillet arc, starting at the point of tangency of the fillet radius and the bearing surface of the head.

3.2.5 Thread Rolling: Threads shall be formed on the finished blanks by a single rolling process after removal of oxide as in 3.2.3.

3.2.6 Cleaning: Parts, after finishing, shall be degreased and then immersed in one of the following solutions for the time and at the temperature shown:

3.2.6.1 One volume of nitric acid (sp gr 1.42) and 9 volumes of water for not less than 20 min. at room temperature.

3.2.6.2 One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 30 - 40 min. at room temperature.

3.2.6.3 One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 - 15 min. at 140° - 160°F (60° - 71°C).

3.3 Properties: Parts shall conform to the requirements of 3.3.1, 3.3.2, 3.3.3, and 3.3.4. Threaded members of gripping fixtures for tensile, fatigue, and stress-rupture 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 two full thread turns from thread runout exposed between the loading fixtures during tensile, fatigue, and stress-rupture tests. Finished parts shall be tested in accordance with the following applicable test methods of MIL-STD-1312:

Requirement	Test Method
Hardness	No. 6
Room Temperature Tensile Strength	No. 8
Stress-Rupture	No. 10
Fatigue Strength	No. 11
Elevated Temperature Tensile Strength	No. 18

3.3.1 Tensile Properties:

3.3.1.1 At Room Temperature:

3.3.1.1.1 Finished Parts: Parts shall have breaking load not lower than the value 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 minimum pitch diameter or having an undercut, parts shall have tensile strength nor lower than 260,000 psi (1793 MPa); for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with either standard double-hexagon or hexagon-type heads having a minimum metal condition in the head equal to the design parameters specified in AS 1132 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.

3.3.1.1.2 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 on specimens prepared as in 4.3.3. Such specimens shall meet the following requirements:

Tensile Strength, min	260,000 psi (1793 MPa)
Yield Strength at 0.2% Offset, min	250,000 psi (1724 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	6%
Reduction of Area, min	22%

3.3.1.2 At 1100°F (593°C):

3.3.1.2.1 Finished Parts: Parts, heated to 1100°F ± 10 (593°C ± 6), held at heat for 30 min. before testing, and tested at 1100°F ± 10 (593°C ± 6), shall have breaking load not lower than the value 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 minimum pitch diameter or having an undercut, parts shall have tensile strength not lower than 205,000 psi (1413 MPa); for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with either standard double-hexagon or hexagon-type heads having a minimum metal condition in the head equal to the design parameters specified in AS 1132 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.

3.3.1.2.2 Machined Test Specimens: If the size or shape of the part is such that a tensile test cannot be made on the part, specimens prepared as in 4.3.3 shall meet the following requirements when heated to 1100°F ± 10 (593°C ± 6), held at heat for 30 min. before testing, and tested in accordance with ASTM E21 at 1100°F ± 10 (593°C ± 6):

Tensile Strength, min	205,000 psi (1413 MPa)
Yield Strength at 0.2% Offset, min	190,000 psi (1310 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	5%
Reduction of Area, min	15%

3.3.2 Hardness: Shall be uniform and not lower than 44 HRC or equivalent; hardness of the threaded section and of the head-to-shank fillet area may be higher than that of other areas as a result of the cold working operations.

3.3.3 Stress-Rupture Properties at 1200°F (649°C): Shall be as follows; tests shall be conducted in accordance with ASTM E139:

3.3.3.1 Finished Parts: Parts, maintained at 1200°F ± 3 (649°C ± 2) while the load specified in Table II is applied continuously, shall not rupture in less than 23 hours. If the shank diameter of the part is less than the minimum pitch diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 3.3.3.1.1.

3.3.3.1.1 Parts having a shank diameter less than the minimum pitch diameter of the part shall be tested as in 3.3.3.1 except that the load shall be as specified in 3.3.3.2. The diameter on which stress is based shall be the actual measured minimum diameter of the part.

3.3.3.2 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 prepared as in 4.3.3, maintained at 1200°F ± 3 (649°C ± 2) while a load sufficient to produce an initial axial stress of 140,000 psi (965 MPa) is applied continuously, shall not rupture in less than 23 hours.

3.3.4 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 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 135,000 psi (931 MPa) and a minimum stress of 13,500 psi (93 MPa). The above requirements apply only to parts 0.190 in. (4.83 mm) and larger in nominal thread size with round, square, hexagonal, or double-hexagon 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 AS 1132; for all parts to which the above requirements do not apply, fatigue test requirements shall be as specified on the part drawing.

3.4 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. Parts shall conform to AS 1177.

3.4.1 Dimensional Examination: Parts shall conform to the following:

3.4.1.1 Straightness, Concentricity, and Squareness: Parts shall be within the limits of the drawing, determined in accordance with AS 3063.

3.4.1.2 Threads: Shall be as specified on the drawing and shall conform to AS 3062.

3.4.2 Macroscopic Examination: Parts or sections of parts as applicable, etched in a solution consisting of approximately 40% hydrochloric acid (sp gr 1.19), 10% of a 30% solution of hydrogen peroxide, and 50% water, or other suitable etchant, for sufficient time to reveal flow lines but not longer than 30 min., shall be examined at a magnification of approximately 20X to determine conformance to the following requirements, except that examination for the thread imperfections of 3.4.2.3 may be made by microscopic examination of specimens polished and etched as in 3.4.3.

3.4.2.1 Flow Lines:

3.4.2.1.1 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 that slight cutting of flow lines by the oxide removal process of 3.2.3 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 as in AS 1132, shall be as agreed upon by purchaser and vendor.

3.4.2.1.2 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).

3.4.2.2 Internal Defects: 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 by 3.4.2.3.3 and 3.4.2.3.4. 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.

3.4.2.3 Threads:

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

3.4.2.3.2 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).

3.4.2.3.3 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).

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

3.4.3 Microscopic Examination: Specimens cut from parts shall be polished, etched in Kalling's reagent (100 cm^3 of absolute ethyl alcohol, 100 cm^3 of hydrochloric acid (sp gr 1.19), and 5 g of cupric chloride), Marble's reagent (20 cm^3 of hydrochloric acid (sp gr 1.19), 20 cm^3 of water, and 4 g of cupric sulfate pentahydrate), or other suitable etchant, and examined at not lower than 100X magnification to determine conformance to the requirements of 3.4.3.1, 3.4.3.2, and 3.4.3.3.

3.4.3.1 Microstructure: Parts shall have distorted grain structure indicative of cold-worked material free from recrystallization in areas other than the head.

3.4.3.2 Grain Size: Shall be predominantly 4 or finer with occasional grains as large as 2 permissible, determined by comparison of a polished and etched specimen with the chart in ASTM E112.

3.4.3.3 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. There shall be no evidence of carburization or nitriding. 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. (0.08 mm) of the surface more than 30 points higher than the reading in the core will be evidence of nonconformance to this requirement.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of parts shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.4. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the parts conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to room-temperature tensile property (3.3.1.1), hardness (3.3.2), stress-rupture property (3.3.3), and quality (3.4) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to elevated-temperature tensile property (3.3.1.2) and fatigue (3.3.4) requirements are classified as periodic tests.

4.3 Sampling: Shall be in accordance with the following; a lot shall be all parts of one size and configuration made from a single heat of alloy processed in one continuous run and submitted for vendor's inspection at one time.

4.3.1 Acceptance Tests: AMS 2373.

4.3.2 Periodic Tests: As agreed upon by purchaser and vendor.

4.3.3 Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E8 with either 0.250 in. (6.35 mm) diameter at the reduced parallel gage section or smaller specimens proportional to the standard when required. Specimens shall be machined from finished parts or from coupons of the same lot of alloy processed with the parts. Specimens shall be machined from the center of parts 0.750 in. (19.05 mm) and under in diameter, from the center of coupons 0.800 in (20.32 mm) and under in nominal diameter or distance between parallel sides, and from midradius of larger size parts or coupons.

4.4 Reports: The vendor of parts shall furnish with each shipment three copies of a report stating that the the chemical composition of the parts conforms to the applicable material specification, showing the results of tests to determine conformance to the room-temperature tensile property, hardness, and stress-rupture requirements, and stating that the parts conform to the other technical requirements of this specification. This report shall include the purchase order number, this specification number, contractor or other direct supplier of material, part number, nominal size, and quantity.

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

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 the following information:

FASTENERS, WORK-STRENGTHENED ALLOY, CORROSION AND HEAT RESISTANT
AMS 7475
PART NUMBER_____
PURCHASE ORDER NUMBER_____
QUANTITY_____
MANUFACTURER'S IDENTIFICATION_____

5.1.3 Containers of parts shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.1.4 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1.3 will be acceptable if it meets the requirements of Level C.

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 authorized modifications will be subject to rejection.

8. NOTES:

8.1 For direct U.S. Military procurement, purchase documents should specify the following:

Title, number, and date of this specification
Part number or size of parts desired
Quantity of parts desired
Applicable level of packaging (See 5.1.4).

TABLE I

Threads Per Inch	Basic Thread Height Ref (See Note 1)		20% Basic Thread Height	
	Inch	(Millimetres)	Inch	(Millimetres)
80	0.0081	(0.206)	0.0016	(0.041)
72	0.0090	(0.229)	0.0018	(0.046)
64	0.0102	(0.259)	0.0020	(0.051)
56	0.0116	(0.295)	0.0023	(0.058)
48	0.0135	(0.343)	0.0027	(0.069)
44	0.0148	(0.376)	0.0030	(0.076)
40	0.0162	(0.411)	0.0032	(0.081)
36	0.0180	(0.457)	0.0036	(0.091)
32	0.0203	(0.516)	0.0041	(0.104)
28	0.0232	(0.589)	0.0046	(0.117)
24	0.0271	(0.688)	0.0054	(0.137)
20	0.0325	(0.826)	0.0065	(0.165)
18	0.0361	(0.917)	0.0072	(0.183)
16	0.0406	(1.031)	0.0081	(0.206)
14	0.0464	(1.179)	0.0093	(0.236)
13	0.0500	(1.270)	0.0100	(0.254)
12	0.0541	(1.374)	0.0108	(0.274)
11	0.0590	(1.499)	0.0118	(0.300)
10	0.0650	(1.651)	0.0130	(0.330)
9	0.0722	(1.834)	0.0144	(0.366)
8	0.0812	(2.062)	0.0163	(0.414)

Note 1. Basic thread height is defined as being equivalent to 0.650 times the pitch.

TABLE II

Thread Size	Tensile Breaking Load lb, min: Room Temperature	Tensile Breaking Load lb, min: at 1100°F	Stress Rupture Test Load lb	Fatigue Test Max Load lb
0.190 -32	5,640	4,450	3,050	2,930
0.250 -28	10,100	7,950	5,450	5,250
0.3125 -24	16,000	12,600	8,640	8,300
0.375 -24	24,700	19,500	13,300	12,800
0.4375 -20	33,500	26,400	18,100	17,400
0.500 -20	44,600	35,200	24,000	23,200
0.5625 -18	56,600	44,600	30,600	29,400
0.625 -18	70,800	55,800	38,200	36,800
0.750 -16	103,000	81,000	55,600	53,400
0.875 -14	140,000	110,500	--	72,900
1.000 -12	183,000	144,000	--	95,000

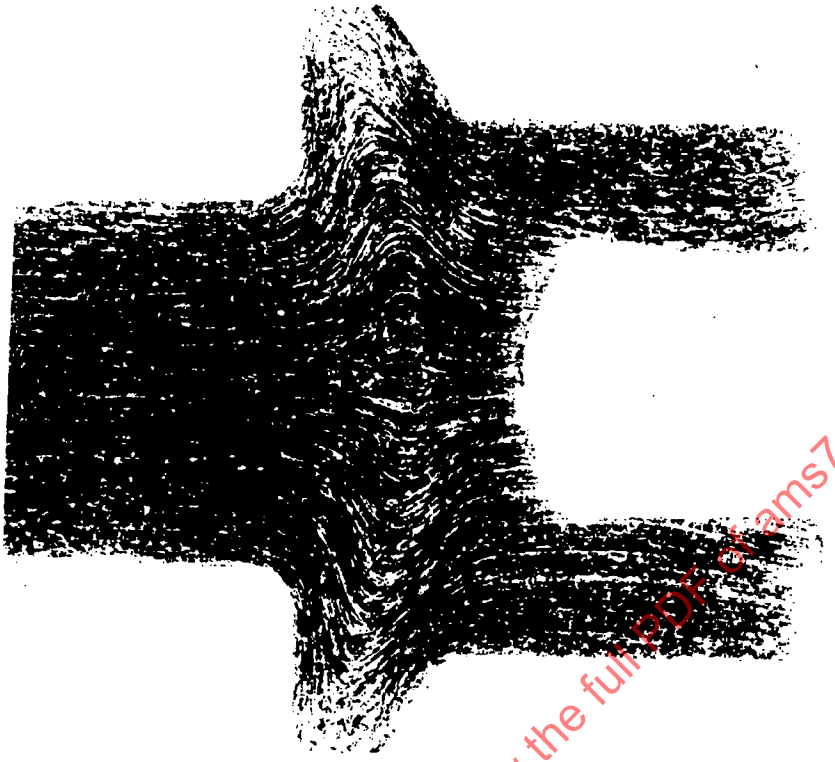
TABLE II (SI)

Thread Size	Tensile Breaking Load N, min: Room Temperature	Tensile Breaking Load N, min: at 1100°F	Stress Rupture Test Load N	Fatigue Test Max Load N
0.190 -32	25,100	19,800	13,600	13,000
0.250 -28	44,900	35,400	24,200	23,400
0.3125 -24	71,200	56,000	38,400	36,900
0.375 -24	109,900	86,700	59,200	56,900
0.4375 -20	149,000	117,400	80,500	77,400
0.500 -20	198,400	156,600	106,800	103,200
0.5625 -18	251,800	198,400	136,100	130,800
0.625 -18	314,900	248,200	169,900	163,700
0.750 -16	458,100	360,300	247,300	237,500
0.875 -14	622,700	491,500	--	324,300
1.000 -12	814,000	640,500	--	422,600

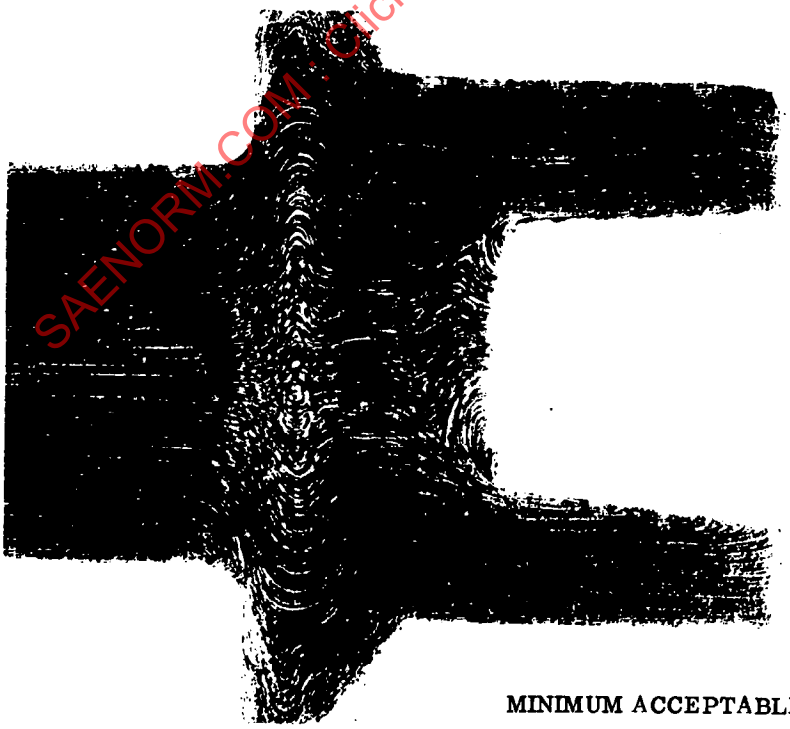
Note 1. Requirements of Table II apply to parts with UNJF threads and having hardness not lower than 44 HRC. Area upon which stress is based is 98% of the basic pitch diameter for nominal thread major diameters up to 0.3125 in. (7.938 mm), incl, and the basic pitch diameter for larger sizes.

Load requirements are based on:

260,000 psi (1793 MPa) for tensile breaking load at room temperature
205,000 psi (1413 MPa) for tensile breaking load at 1100°F (593°C)
140,000 psi (965 MPa) for stress-rupture test load
135,000 psi (931 MPa) for fatigue test load



SATISFACTORY GRAIN FLOW
FIGURE 1A



MINIMUM ACCEPTABLE STANDARD

Showing maximum permissible cutting of flow lines after machining to remove oxide as in 3.2.3.

FIGURE 1B