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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 7466B

Issued 15 APR 1978
Revised 1 OCT 1993

Submitted for recognition as an American National Standard

Superseding AMS 7466A

BOLTS AND SCREWS, CORROSION AND HEAT RESISTANT NICKEL ALLOY
Upset Headed, Roll Threaded, Fatigue Resistant

UNS N07718

This specification has been designated as "SUPERSEDED" by the Aerospace Materials Division, SAE, as of January 1991. The requirements of this specification are embodied in the latest issue of AS7466, Bolts and Screws, Corrosion and Heat Resistant Nickel Alloy, Upset Headed, Roll Threaded, Fatigue Resistant. The requirements of the latest issue of AS7466 shall be fulfilled whenever reference is made to AMS 7466.

By above action, jurisdiction of subject specification is transferred from AMS Committee "F" to SAE Committee E-25.

CAUTION: The applicable AS specification may present different technical requirements than the superseded AMS specification.

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "F".

1. SCOPE:

1.1 Type: This specification covers aircraft-quality bolts and screws made from a corrosion and heat resistant nickel alloy.

1.2 Application: Primarily for use where an optimum combination of impact resistance, fatigue resistance, and strength are required for use up to 800°F (425°C) and suitable for use at higher temperatures where degradation of mechanical properties is acceptable.

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 5662 - Alloy Bars, Forgings, and Rings, Corrosion and Heat Resistant, Nickel Base - 19Cr - 3.1Mo - 5.1(Cb+Ta) - 0.90Ti - 0.50Al - 19Fe, Consumable Electrode or Vacuum Induction Melted, 1750°F (954°C) Solution Heat Treated

2.1.2 Aerospace Standards:

AS 1132 - Design Parameters for Bolts and Screws, External Wrenching, Unified Threaded 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

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

2.3.2 Bureau of Standards Publications:

Handbook H28 - Screw-Thread Standards for Federal Services

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be AMS 5662 alloy heading stock.

3.2 Fabrication:

3.2.1 Blanks: Heads shall be formed by hot forging or cold forging; temperature for hot forging blanks shall be within the range 1650° - 2000°F (900° - 1095°C).

3.2.2 Heat Treatment: Headed blanks shall, before finishing the shank and the bearing surface of the head, be solution and precipitation heat treated 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 or atmosphere shall cause no surface hardening by carburizing or nitriding.

3.2.2.2 Solution Heat Treatment: Blanks shall be solution heat treated by heating to a temperature within the range 1700° - 1850°F (925° - 1010°C), holding at the selected temperature within ±25°F (±15°C) for 1 hr ± 0.1, and quenching in oil or water.

3.2.2.3 Precipitation Heat Treatment: After solution heat treatment as in 3.2.2.2, blanks shall be precipitation heat treated by heating to 1325°F ± 15 (718°C ± 8), holding at heat for 8 hr ± 0.25, furnace cooling at 100 F (56 C) deg per hr to 1150°F ± 15 (620°C ± 8), holding at 1150°F ± 15 (620°C ± 8) for 8 hr ± 0.25, and cooling in air. Instead of the 100 F (56 C) deg per hr cooling rate to 1150°F ± 15 (620°C ± 8), blanks may be furnace cooled at any rate provided the time at 1150°F ± 15 (620°C ± 8) is adjusted to give a total precipitation heat treatment time of approximately 18 hours.

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 and precipitation heat treated 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 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° - 70°C).

3.3 Properties: Parts shall conform to the requirements of 3.3.1, 3.3.2, and 3.3.3. Threaded members of gripping fixtures for tensile and fatigue 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 and fatigue 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
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 not lower than 185 000 psi (1276 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	185 000 psi (1276 MPa)
Yield Strength at 0.2% Offset, min	150 000 psi (1034 MPa)
Elongation in 4D, min	12%
Reduction of Area, min	15%

3.3.1.2 At 800°F (427°C):

3.3.1.2.1 Finished Parts: Parts, heated to 800°F ± 5 (427°C ± 3), held at heat for 30 min, before testing, and tested at 800°F ± 5 (427°C ± 3), 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 155,000 psi (1069 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 800°F ± 5 (427°C ± 3), held at heat for not less than 30 min. before testing, and tested in accordance with ASTM E21 at 800°F ± 5 (427°C ± 3):

Tensile Strength, min	155,000 psi (1069 MPa)
Yield Strength at 0.2% Offset, min	130,000 psi (896 MPa)
Elongation in 4D, min	12%
Reduction of Area, min	15%

3.3.2 Hardness: Shall be uniform and within the range 36 - 45 HRC 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.

3.3.3 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 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 105,000 psi (724 MPa) and a minimum stress of 10,500 psi (72 MPa). The above requirements apply only to parts 0.164 in. (4.6 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: 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 approximately 20X magnification 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 heads thinner-than-standard 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 in 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 nonpressure 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 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 mL of absolute ethyl alcohol, 100 mL of hydrochloric acid (sp gr 1.19), and 5 g of cupric chloride), Marble's reagent (20 mL of hydrochloric acid (sp gr 1.19), 20 mL 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 microstructure of completely recrystallized material except in the area of the threads and the head-to-shank fillet radius.

3.4.3.2 Grain Size: Shall be predominantly 3 or finer with occasional grains as large as 2 permissible, determined by comparison of the specimen with the chart in ASTM E112; grain size shall be substantially uniform without pronounced segregation of fine and coarse grain areas conforming to standards agreed upon by purchaser and vendor. In case of disagreement on grain size by the comparison method, the intercept (Heyn) procedure shall be used.

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, recarburization, 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 material (3.1), room-temperature tensile property (3.3.1.1), hardness (3.3.2), and fatigue (3.3.3) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to 800°F (427°C) tensile property (3.3.1.2) 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 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 heat of alloy processed with the parts. Specimens shall be machined from the center of parts 0.750 in. (19.05 mm) and under in nominal diameter, from the center of coupons 0.800 in. (20.32 mm) and under in nominal diameter or distance between parallel sides, and from mid-radius 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 chemical composition of the parts conform to the applicable material specification, showing the results of tests to determine conformance to the room-temperature tensile property, hardness, and fatigue requirements, and stating that the parts conform to the other technical requirements of this specification. This report shall include the purchase order number, AMS 7466, 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 not less than the following information:

FASTENERS, NICKEL ALLOY, CORROSION AND HEAT RESISTANT
AMS 7466
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 and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of these parts to ensure carrier acceptance and safe 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:

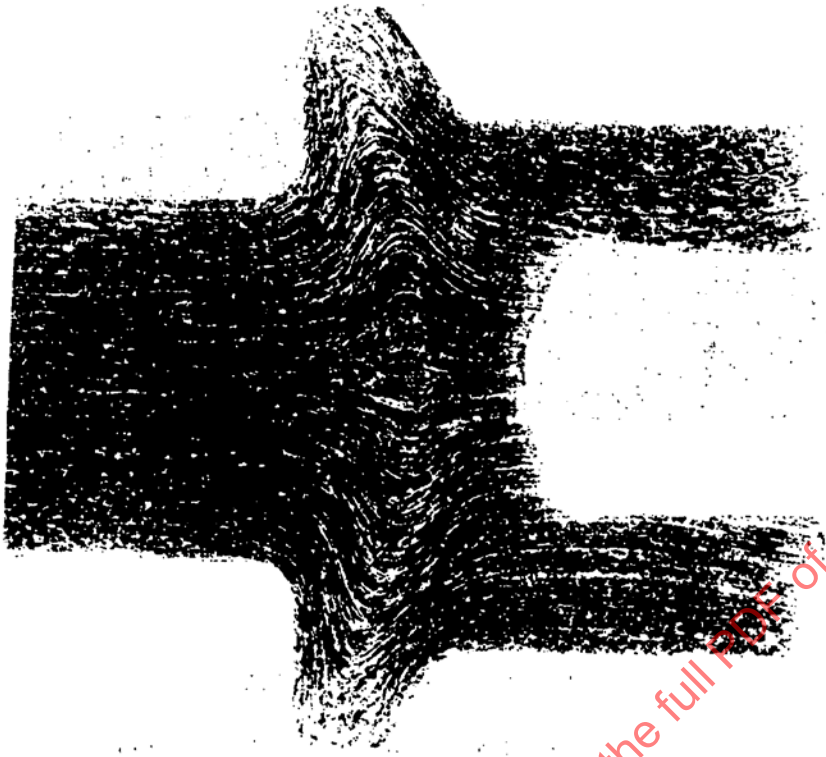
8.1 For direct U.S. Military procurement, purchase documents should specify not less than the following:

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).

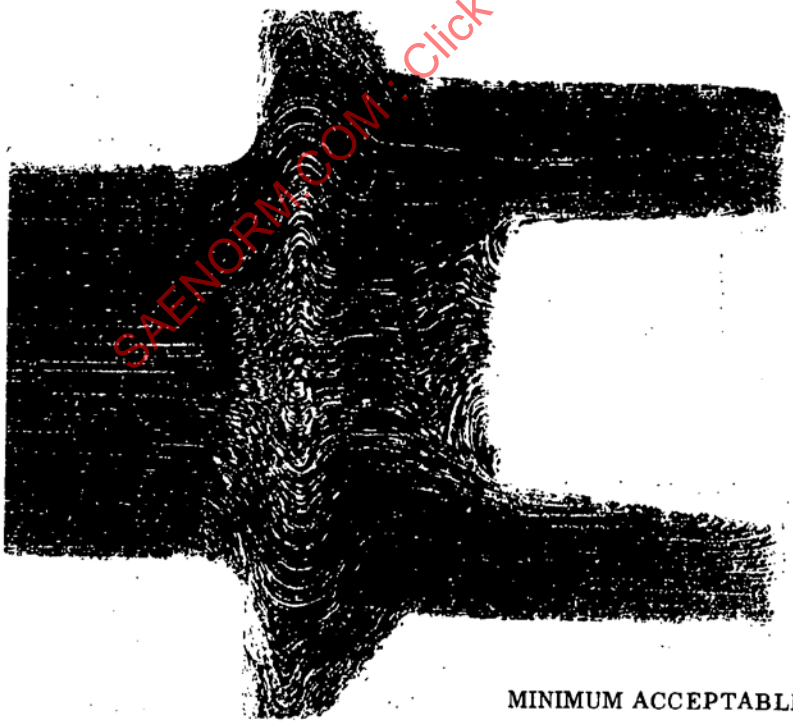
TABLE I

Threads Per Inch	Basic Thread Height Ref (See Note 1)		20% Basic Thread Height	
	Inch	(Millimeter)	Inch	(Millimeter)
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.



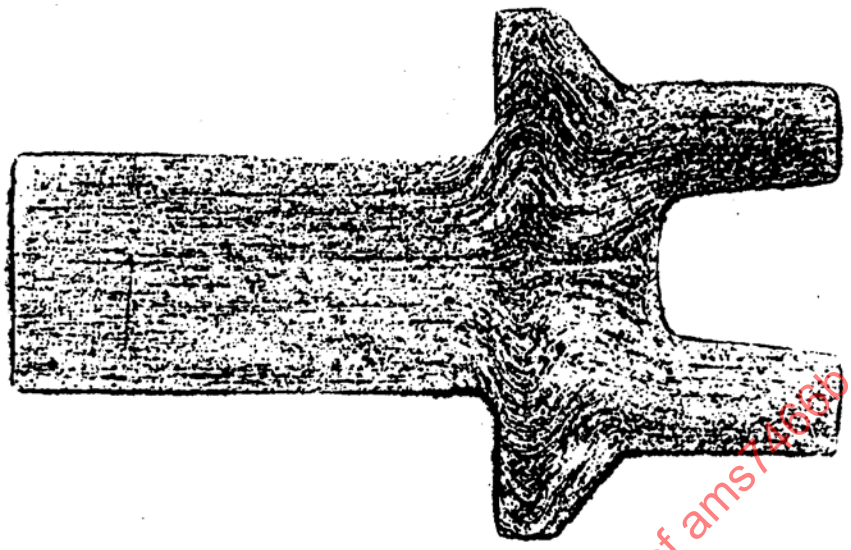
SATISFACTORY GRAIN FLOW
FIGURE 1A



MINIMUM ACCEPTABLE STANDARD

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

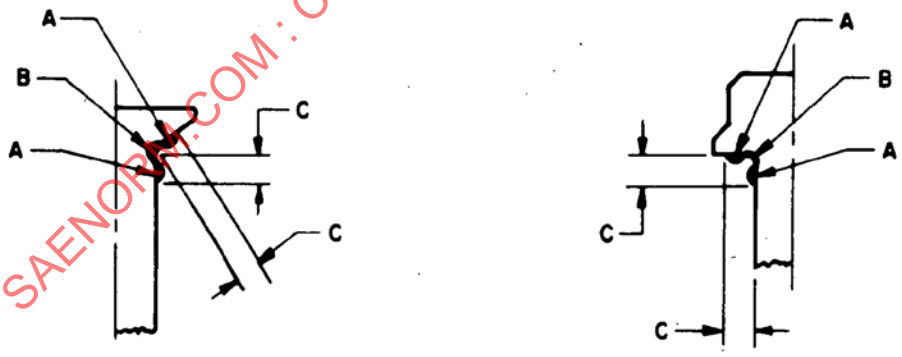
FIGURE 1B



UNACCEPTABLE GRAIN FLOW

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

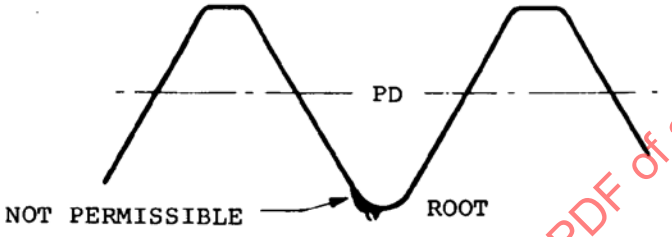
FIGURE 1C



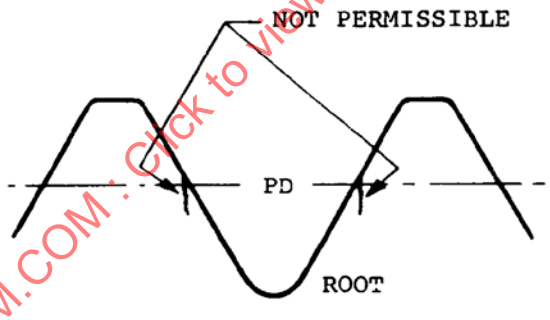
Nominal Bolt Diameter		C, max	
Inches	(Millimetres)	Inch	(Millimetres)
Up to 0.3125, excl	(Up to 7.94, excl)	0.062	(1.57)
0.3125 and 0.375	(7.94 and 9.52)	0.094	(2.39)
0.4375 - 0.625, incl	(11.11 -- 15.88, incl)	0.125	(3.18)
0.750 - 1.000, incl	(19.05 - 25.40, incl)	0.156	(3.96)
Over 1.000	(Over 25.40)	0.188	(4.78)

PERMISSIBLE DISTORTION FROM FILLET WORKING
FIGURE 2

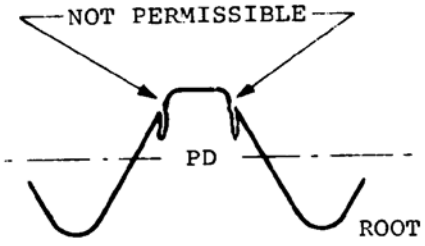
FLOW LINES, ROLLED THREAD
FIGURE 3



ROLLED THREAD
FIGURE 4



ROLLED THREAD
FIGURE 5



ROLLED THREAD
FIGURE 6