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

AEROSPACE MATERIAL SPECIFICATION

AMS 7482

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Revised

STUDS, STEEL, CORROSION AND HEAT RESISTANT
Roll Threaded After Heat Treatment
1800° F (982.2° C) Solution Heat Treatment

1. SCOPE:

1.1 Type: This specification covers high-quality studs made of a corrosion and heat resistant steel.

1.2 Application: Primarily for joining parts where a good combination of strength and resistance to relaxation at temperatures up to 1200° F (649° C) is required.

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., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2373 - Quality Assurance Sampling of Bolts and Screws
AMS 5731 - Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr - 26Ni - 1.3Mo - 2.1Ti - 0.30V, Consumable Electrode Melted, 1800° F (982.2° C) Solution Treated
AMS 5732 - Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr - 26Ni - 1.3Mo - 2.1Ti - 0.30V, Consumable Electrode Melted, 1800° F (982.2° C) Solution and Precipitation Treated

2.1.2 Aerospace Standards:

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

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

ASTM A370 - Mechanical Testing of Steel Products
ASTM E112 - Estimating 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, Pennsylvania 19120.

2.3.1 Military Standards:

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 5731 steel heading stock or AMS 5732 steel.

3.1.1 Stock: Stock for upsetting shall be reduced 15 - 25% in cross-sectional area during the final drawing or rolling at a temperature not higher than 1600° F (871° C) unless stock is so reduced or is otherwise processed, during manufacture of parts, to prevent grain growth during heat treatment. Stock reduced as above shall have hardness of 201 - 285 HB or equivalent, determined in accordance with ASTM A370.

3.2 Fabrication:

3.2.1 Blanks: Shall be machined sufficiently to remove surface defects. The smaller diameter or nut end of blanks for stepped studs may be reduced as necessary by extruding or machining or both but the larger diameter or stud end shall not be upset. Upsetting to produce a shoulder or shoulders between the threaded ends is permissible provided grain flow in the stud end is not distorted. Heading stock to be hot upset shall not be heated to a temperature higher than 2100° F (1149° C).

3.2.1.1 The metal removed from the bearing surface of the shoulder or shoulders shall be as little as practicable to obtain clean, smooth surfaces.

3.2.2 Heat Treatment: Blanks, unless machined from solution heat treated stock or AMS 5732 material, shall, before finishing the shank and rolling the threads, be heat treated as follows:

3.2.2.1 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 not cause surface hardening by carburizing or nitriding.

3.2.2.2 Solution Heat Treatment: Blanks shall be solution heat treated by heating to 1800° F ± 25 (982.2° C ± 14), holding at heat for approximately 1 hr, and quenching in oil or water.

3.2.2.3 Precipitation Heat Treatment: All blanks, except those of AMS 5732, shall be precipitation heat treated by heating to a temperature within the range 1300° - 1400° F (704.4° - 760° C), holding at the selected temperature within ± 15° F (±8.3° C) for approximately 16 hr, and cooling in air.

3.2.3 Oxide Removal: The solution and precipitation heat treated blanks, before rolling the threads, shall have the full body and bearing surfaces of shoulders, as applicable, free from surface oxide and oxide penetration caused by prior heat treatment. The removal process shall produce no intergranular attack or corrosion of the blanks.

3.2.4 Thread Rolling: Threads shall be formed on the heat treated and finished blanks by a single rolling process for each end after removal of oxide as in 3.2.3.

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

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

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

(c) One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 - 15 min. at 140° - 160° F (60° - 71.1° 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 stress-rupture tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. Tests shall be conducted in accordance with the following procedures:

Test	Finished Parts	Machined Test Specimens
Tensile Strength	MIL-STD-1312, Test 8	ASTM A370
Hardness	MIL-STD-1312, Test 6	---
Stress-Rupture	MIL-STD-1312, Test 10	ASTM E139

3.3.1 Tensile Properties:

3.3.1.1 Finished Parts: Parts shall have breaking load not lower than that specified in Table II for the applicable thread size. Unless the part is of such size and shape that failure would occur outside the threaded section, such as parts having a shank diameter equal to or less than the thread minor diameter (smaller thread minor diameter for parts with unequal size threads) or having an undercut, parts shall fail in one of the threaded sections as specified in 3.3.1.1.1 through 3.3.1.1.3. If the size or shape of the part is such that failure would occur outside the threaded section, as specified above, parts shall conform to only the tensile strength requirement of 3.3.1.2; for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part.

3.3.1.1.1 Parts having both ends threaded with the same diameter/pitch series may fail in either threaded section.

3.3.1.1.2 Parts having both ends threaded to the same diameter but different pitches shall fail in the coarser threaded section.

3.3.1.1.3 Parts having threads of unequal diameter, whether of the same pitch or not, shall fail in the smaller diameter threaded section.

3.3.1.2 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. Specimens shall conform to the following requirements:

Tensile Strength, min	130,000 psi (896 MPa)
Yield Strength at 0.2% Offset, min	85,000 psi (586 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	15%
Reduction of Area, min	20%

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

3.3.2 Hardness: Shall be uniform and within the range 24 - 37 HRC or equivalent but hardness of the threaded sections may be higher as a result of the cold working operations.

3.3.3 Stress-Rupture Test at 1200° F (649.9° C):

3.3.3.1 Finished Parts: Parts, maintained at 1200° F ± 3 (648.9° C ± 1.7) while the load specified in Table II is applied continuously, shall not rupture in less than 23 hours. For parts having ends threaded to different diameter/pitch series, the lower load shall be used. 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 3.3.3.1.1.

3.3.3.1.1 Parts having a shank diameter less than the maximum minor (nominal minor) 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 as in 3.3.3.1 cannot be made on the part, a tensile test specimen shall be machined from a finished part, or from coupons of the same heat of material heat treated with the parts, to the dimensions shown in ASTM A370. A tensile test specimen, maintained at 1200° F ± 3 (648.9° C ± 1.7) while a load sufficient to produce an initial axial stress of 70,000 psi (483 MPa) is applied continuously, shall not rupture in less than 23 hours.

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 meet the requirements of the drawing and 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 the requirements of AS 3062.

3.4.2 Macroscopic Examination: Parts or sections of parts, as applicable, shall be etched in a solution 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. and 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: Flow lines in threads shall be continuous; shall follow the general contour and shall be of maximum density at the root of the thread (See Fig. 1). Below the thread roots, flow lines not affected by forming shall be parallel to the axis except that on the nut end of parts formed by extruding the flow lines may be oblique to the axis for a distance from the end equal to 1.5 times the B dimension of Table II of AS 3062.

3.4.2.2 Internal Imperfections: Examination of longitudinal sections of parts shall reveal no cracks or other injurious imperfections.

3.4.2.3 Threads:

3.4.2.3.1 Root defects such as notches, slivers, folds, roughness, and oxide are not permissible (See Fig. 2).

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. 3 and 4).

3.4.2.3.3 There shall be no laps along the flanks of the threads below the pitch diameter (See Fig. 5). 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. 6).

3.4.2.3.4 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. 7). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches the 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 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 following requirements:

3.4.3.1 Microstructure: Parts shall have microstructure of completely recrystallized material except in the area of the threads.

3.4.3.2 Grain Size: Shall be 5 or finer as determined by comparison of the specimen with the chart in ASTM E112. Up to 25%, by area, of abnormally large grains will be permitted in any specific area of 100 or more adjacent grains; abnormally large grains are defined as grains more than 3 ASTM numbers coarser than the average grain size of the part.

3.4.3.3 Surface Hardening: Parts shall have no surface hardening except that produced by rolling of threads. Parts shall show no evidence of carburization or nitriding. In case of dispute over results of microscopic examination, microhardness testing in accordance with MIL-STD-1312, Test 6 using loads not higher than 1 kg shall be used as a referee method; hardness readings taken within 0.003 in. (0.08 mm) of an unrolled surface which are more than 30 points on the Vickers scale higher than the reading in the core shall 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 assure that the parts conform to the requirements of this specification.

4.2 Classification of Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine control tests.

4.3 Sampling: Shall be in accordance with AMS 2373.

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 conforms to the applicable material specification and showing the results of tests to determine conformance to the tensile strength, hardness, and stress-rupture requirements of this specification. This report shall include the purchase order number, this specification number, contractor or other direct supplier of material, part number, 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 Identification: Each different part number shall be packed in a separate container. Each container shall be marked to show the following information:

STUDS, STEEL, CORROSION AND HEAT RESISTANT
AMS 7482
PART NUMBER_____
PURCHASE ORDER NUMBER_____
QUANTITY_____
MANUFACTURER'S IDENTIFICATION_____

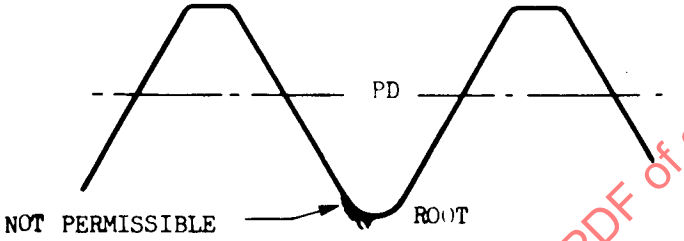
5.2 Packaging: Containers of parts shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

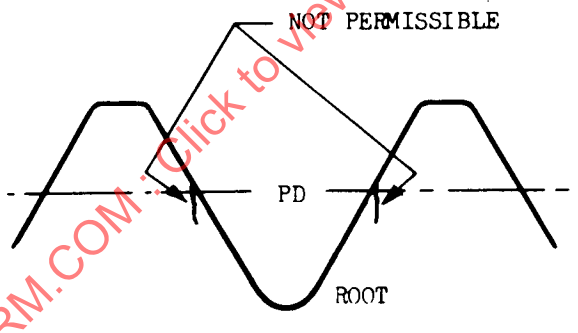
7. REJECTIONS: Parts not conforming to this specification or to authorized modifications will be subject to rejection.

8. NOTES: None.

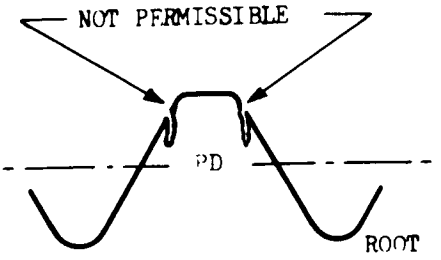
FLOW LINES, ROLLED THREAD
FIGURE 1



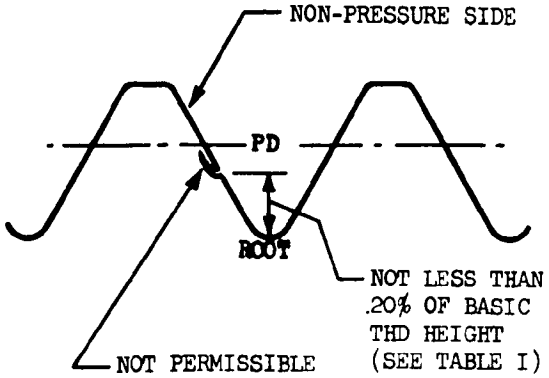
ROLLED THREAD
FIGURE 2



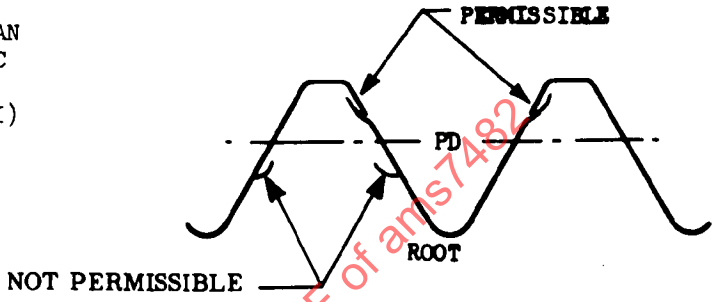
ROLLED THREAD
FIGURE 3



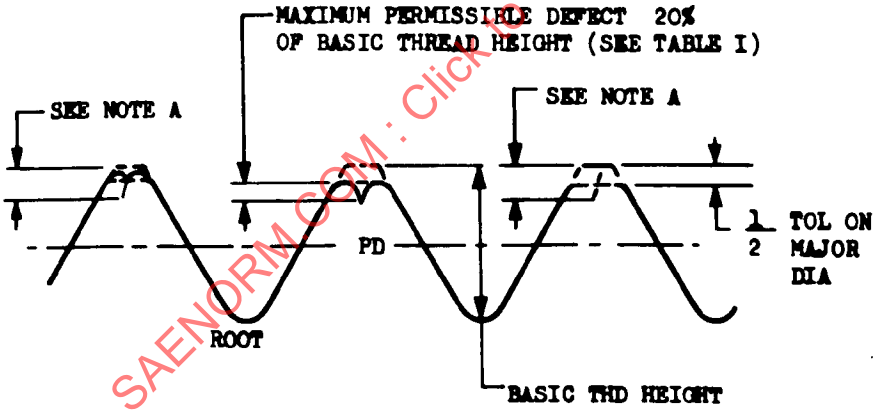
ROLLED THREAD
FIGURE 4



ROLLED THREAD
FIGURE 5



ROLLED THREAD
FIGURE 6



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 7