



AEROSPACE STANDARD	AS4726™	REV. A
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Nuts, Self-Locking, UNS S66286 Classification: 220 ksi/850 °F Procurement Specification FSC 5310		

RATIONALE

There are no known AS standards that currently reference this specification and currently no one is able to manufacture parts to this specification.

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1. SCOPE:

1.1 Type:

This specification establishes the requirements for self-locking nuts, wrenching type (i.e., hexagon, double hexagon, and spline drive), made of a corrosion and heat resistant steel of the type identified under the Unified Numbering System as UNS S66286.

1.1.1 Classification:

- a. 220 ksi minimum tensile strength at room temperature
- b. 850 °F maximum test temperature of parts.

1.2 Application:

Primarily for use in aerospace propulsion systems in temperatures up to approximately 850 °F where nuts are used with bolts capable of developing 220 ksi axial tensile strength at room temperature, and having UNJ thread form.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2403	Plating, Nickel, General Purpose
AMS 2418	Plating, Copper
AMS 2759/3	Heat Treatment of Precipitation Hardening, Corrosion Resistant and Maraging Steel Parts
AMS 5731	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.3Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1800 °F (980 °C) Solution Heat Treated
AMS 5732	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.2Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1800 °F (980 °C) Solution and Precipitation Heat Treated
AMS 5734	Steel Bars, Forgings, and Tubing, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.3Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1650 °F (900 °C) Solution Heat Treated
AMS 5737	Steel Bars, Forgings, and Tubing, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.3Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1650 °F (900 °C) Solution and Precipitation Heat Treated
AS954	Design Data and Standardization of Thin Wall 12-Point Sockets and Box Wrenches for Aerospace Engine Use
AS1310	Fastener Torque for Threaded Applications, Definitions of
AS1701	Lubricant, Solid Dry Film
AS7477	Bolts and Screws, Steel, Corrosion and Heat Resistant, Upset Headed, Heat Treated, Roll Threaded, 1800°F Solution and Precipitation Heat Treated

2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA, 19111-5094.

QQ-P-35	Passivation Treatments for Corrosion Resistant Steel
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-S-8879	Screw Threads, Controlled Radius Root With Increased Minor Diameter; General Specification For
MIL-W-8982	Wrenches, Splined, High Strength, Thin Wall, General Specification For
MIL-STD-1312-7	Fastener Test Methods, Method 7, Vibration
MIL-STD-1312-8	Fastener Test Methods, Method 8, Tensile Strength

2.1.3 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, Pa 19103-1187.

ASTM E 1417	Liquid Penetrant Examination
ASTM D 3951	Commercial Packaging

2.1.4 ANSI Publication: Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI/ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

2.2 Definitions:

Refer to AS1310 for definitions related to fastener torque.

DEFECTIVE: A unit of product which contains one or more defects.

BURR: A rough edge or ridge left on the metal due to a cutting, grinding, piercing or blanking operation.

TIGHT BURR: A burr closely compacted and binding in the periphery of a part without any loose ends and is within the dimensional limits of the part.

PRODUCTION LOT: Shall consist of finished nuts fabricated by the same process from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

INSPECTION LOT: Shall consist of nuts from a single production lot, of the same part number.

2.3 Unit Symbols:

°	degree, angular
°C	degree Celsius
°F	degree Fahrenheit
%	percent (1% = 1/100)
HRC	hardness, Rockwell C scale
lbf	pound-force
lbf-in	pound-force inch, torque
ksi	kips (1000 pounds) per square inch
cpm	cycles per minute
sq in	square inch
μin Ra	microinch, roughness average

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Shall be a corrosion and heat resistant steel, AMS 5731, AMS 5732, AMS 5734, or AMS 5737 bars or forgings. as specified on the part drawing.

3.2 Design:

Finished (completely manufactured) parts shall conform to the following requirements:

- 3.2.1 **Dimensions:** The dimensions of finished parts after all processing, shall conform to the part drawing, unless otherwise specified. Dimensions shall apply before coating with solid dry film lubricant.

- 3.2.1.1 **Bearing Surface Squareness:** The bearing surface shall be square with the thread pitch cylinder axis within the limits specified on the part drawing. Bearing surface shall not be convex. Bearing surface squareness shall be tested on an expanding type thread plug gage that positions on the nut thread pitch cylinder (thus, establishing the datum axis of nut thread) with a dial indicator stylus positioned on the nut bearing surface near the minimum bearing diameter. Indicator readings are taken during circular and radial stylus movements over the bearing surface. The squareness requirement shall apply to the complete bearing surface of the nut. The nuts to be inspected shall permit at least three full threads of engagement on the thread gage of the test fixture; coating shall be stripped to meet this requirement.
- 3.2.1.2 **Geometric Tolerances:** Part features shall be within the geometric tolerance specified on the part drawing when tested by conventional measuring methods, except for the measurement method for bearing surface perpendicularity as in 3.2.1.1.
- 3.2.2 **Surface Texture:** Surface texture of finished parts, prior to coating, shall conform to the requirements on the part drawing, determined in accordance with ANSI/ASME B46.1.
- 3.2.3 **Threads:** UNJ thread profile having dimensions and tolerances in accordance with MIL-S-8879.
- 3.2.3.1 **Thread Relief:** The entering end of the thread at the bearing surface shall be relieved by methods, such as, countersinking or counterboring to remove the thread feather edge, and the top of the nut shall be countersunk as specified on the part drawing.
- 3.2.3.2 **Coating Allowance:** Unless otherwise specified on the part drawing, internal thread coating allowance shall be as specified in MIL-S-8879 before forming the self-locking feature.
- 3.2.3.3 **Forming Self-Locking Feature:** The upper threaded portion shall be formed out-of-round in any manner which provides self-locking nuts meeting the locking torque requirements of this specification. The coated nut shall permit assembly of a test bolt, as in 3.8, freely with the fingers for a minimum of one turn.
- 3.2.4 **Construction:** Each nut shall be of the prevailing torque-type, self-contained, all metal unit, including the self-locking feature. The locking feature shall not operate by means of separate movement and shall not depend upon pressure on the bearing surface for the locking action. Tool marks resulting from producing the self-locking feature shall blend smoothly without abrupt change.
- 3.3 **Heat Treatment and Fabrication:**
- Parts shall be fabricated by forging or machining and heat treated in accordance with AMS 2759/3 for A286, aged after cold working to meet the tensile strength requirements of this specification and the part drawing.
- 3.3.1 **Passivation Treatment:** Finished parts that are not plated as in 3.5.1, shall before coating as in 3.5.2 be passivate treated and copper sulfate tested in accordance with QQ-P-35.

3.4 Product Marking:

Each part shall be marked for identification as specified on the part drawing. Depressed characters shall have a rounded root form, depressed 0.010 inch maximum.

3.5 Coating:

- 3.5.1 Plating: Before coating with solid dry film lubricant, nuts may be copper flash plated per AMS 2418-1 or nickel flash plated per AMS 2403, 0.0001 inch minimum thickness on thread and bearing surface; other surfaces are optional to plate.
- 3.5.2 Coating: After flash plating as in 3.5.1, parts shall be coated with MoS₂ dry film lubricant in accordance with AS1701, Type VI, unless otherwise specified on the part drawing.

3.6 Quality:

Parts shall be uniform in quality and condition, free from burrs (tight burrs may be acceptable if part performance is not affected), foreign materials, and from imperfections detrimental to the usage of the part.

- 3.6.1 Fluorescent Penetrant Inspection: Prior to coating as in 3.5, parts shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417, Type I, Sensitivity Level 2. Acceptance criteria of surface discontinuities shall be in accordance with Appendix F.

3.7 Product Performance Tests:

Refer to Tables 5 and 6 for details of sample sizes for Acceptance Test Plan and Qualification Approval Test Plan.

- 3.7.1 Axial Tensile Strength: Nuts shall withstand the minimum tensile load as specified in Table 1 without rupture, stripping or appearance of cracks when tested as follows:
 - 3.7.1.1 As Received Condition at Room Temperature: Nuts in as received condition tested in accordance with MIL-STD-1312-8, using alloy steel test bolts hardened and tempered to 46 HRC minimum, and having MIL-S-8879 threads, shall withstand the axial tensile load specified in Table 1.
 - 3.7.1.2 After Bake, at Room Temperature: Prior to testing, the nut shall be assembled on a test bolt as in 3.8 with at least two thread pitches protruding through the nut and baked for 6 hours + 0.25 hour at 850 °F ± 15 °F and then cooled to room temperature. The nut shall then be removed from the bolt and assembled onto a test bolt as in 3.7.1.1; a new test bolt shall be used for each axial tensile test. Nuts shall be tested, after baking, at room temperature in accordance with MIL-STD-1312-8 and shall withstand the axial tensile load in Table 1.

TABLE 1 - Axial Tensile Load

Nut Thread Size	Axial Tensile Load at Room Temperature lbf minimum
0.164 -32UNJC-3B	3410
0.164 -36UNJF-3B	3560
0.190 -32UNJF-3B	4820
0.250 -28UNJF-3B	8680
0.3125-24UNJF-3B	13790
0.375 -24UNJF-3B	20620
0.4375-20UNJF-3B	27930
0.500 -20UNJF-3B	37340
0.5625-18UNJF-3B	47360
0.625 -18UNJF-3B	59400

3.7.1.3 The axial tensile load for thread sizes not shown in Table 1 may be calculated from the following equation:

$$A = 0.7854 (d_3)^2 (2 - (d_3 / d_2)^2) \quad (\text{Eq. 1})$$

$$F = A \times 220 \times 10^3 \quad (\text{Eq. 2})$$

where:

- A = Tensile stress area in thread, square inch
- F = Axial tensile load, minimum, lbf
- d_2 = Pitch diameter, maximum, external thread, inch
- d_3 = Minor (root) diameter, maximum, external thread, inch
- 220 = ksi applied at area A

3.7.2 Wrench Torque: Nuts with hexagon, double hexagon or spline drive wrenching features shall be tested as specified in Appendix A and shall withstand the wrench torques specified in Table 2 applied through 12 engagement cycles without any permanent deformation which can interfere with the use of socket wrenches conforming to AS954 for hexagon and double hexagon drives, and MIL-W-8982 for spline drive wrenching feature. The dry film lubricant may be stripped from the nuts before performing the wrench torque test.

TABLE 2 - Wrench Torque

Nominal Thread Diameter Inch	Wrench Torque Minimum lbf-in
0.164	52
0.190	83
0.250	209
0.3125	428
0.375	817
0.4375	1284
0.500	2041
0.5625	2925
0.625	4187

- 3.7.3 Permanent Set: Nuts shall be tested as specified in Appendix B and shall not exceed the maximum permissible locking torque or be less than the minimum breakaway torque values specified in Table 3, Columns (3) and (1), respectively. The bolt or mandrel shall protrude through the top of the nut a minimum of three full thread pitches.
- 3.7.4 Reusability Test at Room Temperature, After Bake: Nuts shall be tested for five consecutive cycles as specified in Appendix C, loading initially to 110 ksi in accordance with 3.7.4.3. The assembly shall be heated in a furnace to 850 °F ± 15 °F for 6 hours ± 0.25 hour, removed from the furnace and cooled to room temperature.
- 3.7.4.1 Wrenching and Reference Recording: Nuts shall be wrenched by turning the nut relative to the fixture. The wrenchability of the tested nuts shall permit assembly using a standard wrench. For reference information, the assembly and breakloose torques shall be recorded for each heat cycle.
- 3.7.4.2 Locking Feature Torque Requirements: Nuts tested as in 3.7.4 shall conform to the minimum breakaway torque in Table 3, Column (1), for each cycle. The self-locking torque shall be measured on installation and removal, and shall not exceed the torque in Table 3, Column (4). The breakaway torque shall not be less than the torque in Table 3, Column (1).

TABLE 3 - Locking Feature Torques and Assembly Torque

Nominal Thread Size	Minimum Breakaway Torque lbf-in (1)	Minimum Breakaway Torque lbf-in (2a)	Minimum Breakaway Torque lbf-in (2b)	Maximum Self-Locking Torque lbf-in (3)	Maximum Self-Locking Torque lbf-in (4)	Assembly Torque lbf-in (5)
0.164 -32	1.5	3	1.8	11	22	32
0.164 -36	1.5	3	1.8	11	22	33
0.190 -32	2	4	2.4	15	30	50
0.250 -28	3.5	7	4.2	30	60	120
0.3125-24	6.5	13	7.8	60	120	230
0.375 -24	9.5	19	11	80	160	415
0.4375-20	14	28	17	100	200	655
0.500 -20	18	36	22	150	300	980
0.5625-18	24	48	29	200	400	1400
0.625 -18	32	64	38	300	600	1950

- (1) Minimum breakaway torque for 15-cycle, room temperature, as received test; 5-cycle, loaded and conditioned test; 3-cycle test; permanent set test.
- (2a) Minimum breakaway torque for first-cycle, of 3-cycle, loaded, room temperature test.
- (2b) Minimum breakaway torque for second and third cycles of 3-cycle, loaded, room temperature test.
- (3) Maximum self-locking torque for 15-cycle, room temperature, as received test; 3-cycle, loaded, room temperature test; permanent set test. At first installation, maximum self-locking torque values may be exceeded by 20% when bolt enters locking feature provided parts are within the specified limits after a minimum length of two pitches, including chamfer, protrudes through the nut.
- (4) Maximum self-locking torque for 5-cycle, loaded and conditioned test.
- (5) Assembly torque for 15-cycle and 3-cycle tests.

3.7.4.3 Loading by Elongation: Loading shall be determined by measurement of elongation of the bolt at room temperature using bolts having a shank diameter equal to the thread pitch diameter. The bolt elongation used to load the nut-bolt assembly to induce 110 ksi axial tensile stress in the bolted assembly is based on a modulus of elasticity of 29.5×10^3 ksi and Equation 3:

$$e = (s / E)(l_1((d_3 / d_2)^2) + (L - l_1)) \quad (\text{Eq. 3})$$

where:

- e = total bolt elongation, inch
s = 110 ksi bolt stress at area of max minor (root) dia
E = 29.5×10^6 psi modulus of elasticity
L = spacer length (see Appendix C) in loaded nut-bolt assembly
 l_1 = length of unthreaded shank, PD shank A286 bolt
 d_2 = max pitch dia of thd
 d_3 = max minor dia of thd

- 3.7.5 Reusability Test at Room Temperature, As Received Condition: Nuts shall be tested for 15 cycles as specified in Appendix D, loading to assembly torque specified in Table 3, Column (5). Nuts shall be wrenching by turning the nut relative to the fixture. Locking feature torque shall conform to the minimum breakaway torque and maximum self-locking torque in Table 3, Column (1) and (3), respectively, for each cycle. The self-locking torque shall be measured and recorded on installation and removal, and shall not exceed the torque in Table 3, Column (3). The breakaway torque shall not be less than the torque in Table 3, Column (1). After testing, the nut shall assemble freely, with the fingers, up to the self-locking feature. Bolt threads shall remain serviceable and permit assembly of a new nut freely, with the fingers, up to the self-locking feature.
- 3.7.6 3-Cycle Test at Room Temperature: Nuts shall be tested as specified in Appendix E, loading to assembly torque specified in Table 3, Column (5). Nuts shall be wrenching by turning the nut relative to the fixture. Nuts shall conform to the minimum breakaway torque in Table 3, Column (2a) for the first cycle, and Column (2b) for the subsequent 2nd and 3rd cycles. The self-locking torque shall be measured on installation and removal, and shall not exceed the torque in Table 3, Column (3). The breakaway torque shall not be less than the torque in Table 3, Column (2b).
- 3.7.7 Accelerated Vibration Test: Nuts shall be tested in accordance with MIL-STD-1312-7 and shall be loaded to assembly torques specified in Table 4. The loaded nut assembly shall withstand 15×10^3 cycles continuous vibration at a frequency of 1750 to 1800 cpm and amplitude (total travel) of 0.435 to 0.465 inch without relative rotation exceeding 360° , without cracking of the nut, and without being capable of turning by hand.
- 3.7.7.1 At Room Temperature, As Received Condition: Nut shall be loaded as specified in 3.7.7 on spacer then removed and reinstalled four additional times on the same bolt to the assembly torques in Table 4. The final assembly shall be with the block ready for the vibration test. The loaded nut assembly shall then be vibrated at room temperature in accordance with 3.7.7 requirements, and nuts shall conform to the requirements of 3.7.7 after the vibration test.

TABLE 4 - Assembly Torque for Vibration Test

Nominal Thread Size	Assembly Torque lbf-in
0.164 -32	22
0.164 -36	22
0.190 -32	30
0.250 -28	60
0.3125-24	120
0.375 -24	160
0.4375-20	200
0.500 -20	300
0.5625-18	400
0.625 -18	600