METRIC AEROSPACE STANDARD

MA1943™	REV. C

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Stabilized 2024-05

Superseding MA1943B

Nuts, Self-Locking, UNS N07001
730 °C, 1100 MPa, and 1210 MPa
Procurement Specification for, Metric

FSC 5310

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

This document has been declared “STABILIZED” by SAE E-25 General Standards for Aerospace and Propulsion Systems Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

This procurement specification covers aircraft quality self-locking nuts for wrenching (hex, spline) and anchor (plate, gang channel, shank) types of nuts made from a corrosion and heat-resistant nickel-base alloy of the type identified under the Unified Numbering System as UNS N07001. Tension height nuts having overall length of threaded portion not less than 1.2 times the nominal thread diameter have 1210 MPa minimum tensile strength at room temperature. Shear height nuts having shorter threaded portion have 1100 MPa minimum tensile strength at room temperature. Maximum test temperature of parts is 730 °C.

1.1 Safety-Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document 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 document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

2.1.1.1 Aerospace Material Specifications

AMS2411	Plating, Silver, for High Temperature Applications
AMS5544	Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate, 57Ni - 19.5Cr - 13.5Co - 4.2Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode or Vacuum Induction Melted, Annealed
AMS5706	Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings, and Rings, 57Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.006B - 0.05Zr, Consumable Electrode or Vacuum Induction Melted, 1825 to 1900 °F Solution Heat Treated
AMS5707	Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings and Rings, 57Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode Remelted or Vacuum Induction Melted, 1825 to 1900 °F (996 to 1038 °C) Solution, Stabilization and Precipitation Heat Treated
AMS5708	Nickel Alloy, Corrosion and Heat-Resistant, Bars, Wire Forgings, and Rings, 58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode or Vacuum Induction Melted, 1975 °F (1079 °C) Solution Heat Treated
AMS5709	Nickel Alloy, Corrosion and Heat-Resistant, Bars and Forgings, 58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode or Vacuum Induction Melted, 1975 °F (1079 °C) Solution, Stabilization and Precipitation Heat Treated

2.1.1.2 Aerospace Standards

AS1310	Fastener Torque for Threaded Applications, Definitions of
MA1370	Screw Threads - MJ Profile, Metric
MA1520	Areas for Calculating Stress or Load Values for Metric MJ Externally Threaded Fasteners
MA1566	Gaging Practice and Gage Requirements for MJ Metric Screw Threads
MA1586	Wrench Configuration, 12 Spline Drive, Metric
MA3378	Bolts and Screws, UNS N07001, Tensile Strength 1210 MPa, Thread and Fillet Radius Rolled Before Aging, Procurement Specification, Metric

2.1.1.3 Aerospace Information Reports

AIR1551	Torque Tightening Metric Screw Threaded Fasteners

2.1.2 U.S. Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

2.1.2.1 Military Specifications

MIL-PRF-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

2.1.2.2 Military Standards

MIL-STD-2073-1	DOD Material, Procedures for Development and Application of Packaging Requirements

2.1.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org

ASME B1.13M Metric Screw Threads - M Profile

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

2.1.4 ASTM Publication

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E112 Estimating the Average Grain Size of Metals

ASTM E1417/E1417M Standard Practice for Liquid Penetrant Testing

2.1.5 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NA0012 Fixture - Bearing Surface Squareness Test, Self Locking Nuts, Metric

NASM1312-6 Fastener Test Methods, Method 6, Hardness

NAM1312-107 Fastener Test Methods, Metric, Method 107, Vibration

NAM1312-108 Fastener Test Methods, Metric, Method 108, Tensile Strength

2.2 Definitions

Refer to AS1310 for definitions related to fastener torque.

BURR: A rough edge or ridge left on the metal due to cutting, grinding, piercing, or blanking operation. (See also TIGHT BURR.)

DEFECT: Any nonconformance of the unit of product with specified requirements.

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

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same part number, made 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.

ROOM TEMPERATURE: Ambient temperature (20 °C, approximately).

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.

2.3 Unit Symbols

°C degree, Celsius

% percent (1% = 1/100)

μm Ra micrometer, roughness average

HB hardness, Brinnel

HRC hardness, Rockwell C scale

HV hardness, Vickers

Hz Hertz

m meter

mm millimeter ($m \times 10^{-3}$)

mm^2 square millimeter

μm micrometer ($m \times 10^{-6}$)

N newton

kN kilonewton ($N \times 10^{3}$)

N-m newton-meter

Pa pascal

Mpa megapascal ($Pa \times 10^{6}$)

GPa gigapascal ($Pa \times 10^{9}$)

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be corrosion and heat resistant nickel alloy, AMS5706, AMS5707, AMS5708, or AMS5709 bars or forgings, as specified on the part drawing, for wrenching nuts, shank nuts, nut elements of plate, and gang channel nuts. When specified on the part drawing, wrenching nuts, nut elements of plate, and gang channel nuts may be formed from AMS5544 sheet stock. Material for the retaining plate for plate nuts and channel for gang channel nuts shall be capable of withstanding the requirements of this specification, and shall be 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 including plating, shall conform to the part drawing.

3.2.1.1 Bearing Surface Perpendicularity

Shall be as specified on the part drawing when tested in accordance with Appendix A.

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 bearing surface perpendicularity as in 3.2.1.1.

3.2.2 Surface Texture

Surface texture of finished parts, prior to plating, shall conform to the requirements on the part drawing, determined in accordance with ASME B46.1.

3.2.3 Threads

Metric screw thread MJ profile and dimensions in accordance with MA1370.

3.2.3.1 Countersink

The entering end of the thread at the bearing surface and the end of the thread at the top of the nut shall be countersunk as specified on the part drawing.

3.2.3.2 Plated Threads

Threads in nuts requiring plating shall meet the coating requirements of MA1370 before forming the self-locking feature.

3.2.3.3 After 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 plated nut shall allow the GO thread plug gage to enter a minimum of three turns before engagement of the locking element for nuts having overall length of threaded portion not less than 1.2 times the nominal thread diameter; nuts having shorter threaded portion shall allow GO thread plug gage to enter a minimum of three quarters of a turn.

3.2.4 Construction

The 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 locking action. Tool marks resulting from producing the self-locking feature shall blend smoothly without abrupt change.

3.3 Heat Treatment

The nuts shall be solution, stabilization, and precipitation heat treated in accordance with the heat treating procedure specified in the material specification.

3.4 Product Marking

Each part shall be identification marked as specified on the part drawing. Markings shall be stamped, depressed 0.25 mm maximum, using a rounded tool form.

3.5 Plating

Unless otherwise specified on the part drawing, parts shall be silver plated in accordance with AMS2411. On nuts with nominal thread sizes 6 mm and larger, the plating on the thread shall be not less than 5 μm when measured on the pitch diameter. Microscopic measurement of a sectioned nut shall be used as the referee method. Nuts with nominal thread size below 6 mm shall show complete coverage on the thread surfaces. Plating on other surfaces shall be 8 to 15 μm thick, unless otherwise specified on the part drawing. No plating shall be applied to the retaining plate for plate nuts and channel for channel nuts, unless otherwise specified on the part drawing.

3.6 Mechanical Properties

3.6.1 Hardness

Unless otherwise specified on the part drawing, the hardness after heat treatment as in 3.3 shall be uniform and within the range of 32 to 42 HRC, 301 to 390 HB, or 318 to 412 HV when tested in per MIL-STD-1312-6 in accordance with NASM1312-6. Sizes up to and including 10 mm nominal thread size shall be sectioned and mounted. Mounting is optional for other sizes.

3.7 Metallurgical Properties

3.7.1 Microstructure

Wrenching nuts, shank nuts, and nut elements of plate and gang channel nuts shall have a microstructure of completely recrystallized material.

3.7.2 Grain Size

Shall be predominantly two to six with no grains finer than seven or coarser than one as determined by comparison of a polished and etched specimen with the chart in ASTM E112. In the case of disagreement on the grain size by the comparison method, then intercept (Heyn) procedure shall be used.

3.8 Quality

Parts shall be uniform in quality and condition, clean, sound, smooth, and free from burrs, foreign materials, and imperfections detrimental to their performance.

3.8.1 Fluorescent Penetrant Inspection

Parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E1417/E1417M. Acceptance criteria of surface discontinuities shall be in accordance with Appendix J.

3.9 Product Performance Tests

See Tables 7 and 8 for details of sample sizes for Acceptance Test Plan and Qualification Test Plan.

3.9.1 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:

3.9.1.1 As Received Condition at Room Temperature

Nuts in as received condition tested per DOD-STD-1312-108, in accordance with NAM1312-108, using alloy steel test bolts hardened and tempered to 40 HRC minimum, 371 HB minimum, or 392 HV minimum, shall withstand the axial tensile load specified in Table 1, applied at the rate specified at room temperature.

3.9.1.2 After 730 °C Bake at Room Temperature

Prior to testing, the nut shall be assembled on a bolt as specified in 3.10 with at least two thread pitches protruding and baked for 6 hours ± 0.25 hours at 730 °C ± 8 °C and cooled to room temperature. A new test bolt shall be used for each axial tensile test. Nuts shall be tested, after baking, at room temperature per DOD-STD-1312-108, in accordance with NAM1312-108, and shall withstand the axial tensile load specified in Table 1, applied at the rate specified.

Table 1 - Axial tensile load and tensile area

Nut Thread Size	Tensile Stress Area mm²	Axial Tensile Load at Room Temp. T, kN min[1] Tension Height Nuts	Axial Tensile Load at Room Temp. T, kN min[1] Shear Height Nuts
MJ5 x 0.8-4H6H	15.296	18.5	16.8
MJ6 x 1-4H5H	21.753	26.3	23.9
MJ7 x 1-4H5H	30.930	37.4	34.0
MJ8 x 1-4H5H	41.682	50.4	45.9
MJ10 x 1.25-4H5H	65.136	78.8	71.6
MJ12 x 1.25-4H5H	97.128	117.5	106.8

[1]Requirements above apply to companion bolts with metric MJ threads to class 4H6H tolerances. The area upon which stress for axial tensile strength load requirements is based on is the tensile stress area as defined in MA1520, Equation 2, for companion bolt thread rolled after heat treatment, and calculated from the following:

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

where:

A = tensile sress area

d_2 = maximum pitch diameter of bolt thread

d_3 = maximum root diameter of bolt thread

The load requirements for axial tensile strength load are based on the following stresses:

a. 1210 MPa for tension height nuts

b. 1100 MPa for shear height nuts

Axial tensile strength load, T = (stress x A)/1000 to obtain load in kN.

For sizes not shown, tensile strength loads for nuts shall be bsed upon the respective compansion bolt stress area and stress given above.

3.9.1.3 Shank Nuts

Nuts with shanks designed to be flared at assembly (see Figure 1) shall be tested as in 3.9.1 except that the bearing plate hole shall be 0.1 to 0.2 mm greater than the maximum shank diameter. It is not necessary to flare the shank for this test. The bearing plate hole shall be chamfered sufficiently to clear the shank nut bearing surface-to-shank maximum fillet.

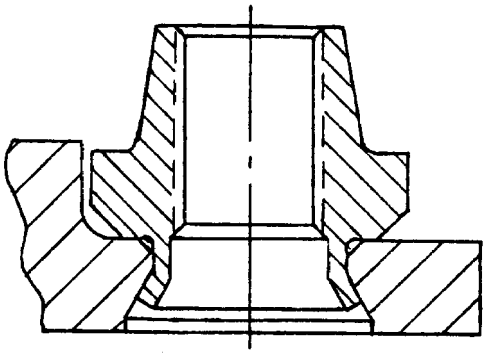


Figure 1 - Flange assembly, flared shank nut

3.9.2 Wrench Torque

Wrenching nuts with a spline drive wrenching feature shall be tested as specified in Appendix B and shall withstand the wrench torques specified in Table 2 applied through 15 engagement cycles without any permanent deformation which can interfere with the use of socket wrenches conforming to MA1586. Wrenching nuts with hexagon wrenching features shall be tested in the same manner and shall withstand Table 2 wrench torques in the same manner as spline drive nuts except a double hexagon socket-type wrench shall be used.

Table 2 - Wrench torque

Thread Size	Wrench Torque, N·m Tension Height Nut	Wrench Torque, N·m Shear Height Nut
MJ5 x 0.8	22	11
MJ6 x 1	38	19
MJ7 x 1	64	32
MJ8 x 1	96	48
MJ10 x 1.25	184	92
MJ12 x 1.25	320	160

3.9.3 Push Out Load

Anchor nuts of the types in 3.9.3.1 shall be tested as specified in Appendix C and shall withstand the push out loads specified in Table 3 without separating from the plate or channel. Nuts shall be serviceable after this test.

Table 3 - Push out load

Thread Size	Push Out Load N
MJ5 x 0.8	900
MJ6 x 1	950
MJ7 x 1	1050
MJ8 x 1	1100

3.9.3.1 The push out test in 3.9.3 is applicable to gang channel nuts, plate nuts (floating and nonfloating nuts except side by side, corner and side mounted types). See Appendix A for definition of types.

3.9.4 Torque Out

Anchor nuts of the types in 3.9.3.1 shall be tested as specified in Appendix D and shall withstand the torque out loads specified in Table 4 without cracking, rupture, or being deformed to a degree which will prevent normal use. This test shall be performed with no axial load on the bearing surface of the nut retainer plate.

Table 4 - Torque out load

Thread Size	Torque Out Load N·m
MJ5 x 0.8	10
MJ6 x 1	16
MJ7 x 1	22
MJ8 x 1	33

3.9.5 Permanent Set

Nuts shall be tested as specified in Appendix E and shall not exceed the maximum permissible locking torque or be less than the minimum breakaway torque values specified in Table 5. The bolt or mandrel shall project through the nut a minimum of three thread pitches.

3.9.6 Reusability Test at Room Temperature After 730 °C Bake

Nuts 5 mm nominal thread size and larger shall be tested for five consecutive cycles as specified in Appendix F, loading initially to 590 MPa in accordance with 3.9.6.3 for tension height nuts, and for shear height nuts, the initial load shall be 517 MPa in accordance with 3.9.6.3. The assembly shall be heated in a furnace to 730 °C ± 8 °C and held for 6 hours ± 0.25 hours, removed from the furnace, and cooled to room temperature.

3.9.6.1 Wrenching and Reference Recordings

Wrench type nuts shall be turned relative to the fixture. The wrenchability of the tested nuts shall permit assembly of standard wrench. For nonwrenchable nuts, the bolt head shall be turned. For reference information, the assembly and breakloose torques shall be recorded for each heat cycle.

3.9.6.2 Locking Feature Torque Requirements

Nuts tested as in 3.9.6 shall conform to the minimum breakaway torque in Table 5, Column 1, for each cycle. The self-locking torque shall be measured on installation and removal, and shall not exceed the torque in Table 5, Column 4, nor shall be less than the breakaway torque in Table 5, Column 1.

3.9.6.3 Loading by Elongation

Loading shall be determined by measurement of bolt elongation at room temperature using bolts having a shank diameter equal to the thread pitch diameter. The correct loading shall be determined by using a modulus of elasticity of 213.7 GPa. Stress area for the bolt shall be based on Equation 2 areas given in MA1520. For tension height nuts, the elongation shall be equal to 0.002761L (where L = length of bushing) elongation of bolts using standard bushing as specified in Appendix F; similarly, for shear height nuts, the bolt elongation shall be equal to 0.002419L.

3.9.7 Reusability Test at Room Temperature, As Received Condition

Nuts shall be tested for 15 cycles as specified in Appendix G, loading to assembly torque specified in Table 5, Column 5, for shear height nuts, and Column 6 for tension height nuts. Wrenching type nuts shall be turned relative to the fixture. For nonwrenchable nuts, the bolt head shall be turned. The locking feature torque shall conform to the minimum breakaway and maximum self-locking torque in Table 5, Columns 1 and 3, respectively, for each cycle. The self-locking torque shall be measured on installation and removal, and shall not exceed the torque in Table 5, Column 3, nor be less than the breakaway torque in Table 5, 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.

3.9.8 Three-Cycle Test at Room Temperature

Nuts shall be tested as specified in Appendix H, loading to assembly torque specified in Table 5, Column 5, for shear height nuts, and Column 6 for tension height nuts. Wrenching type nuts shall be turned relative to the fixture. For nonwrenchable nuts, the bolt head shall be turned. Nuts shall conform to the minimum breakaway torque in Table 5, Column 2a, for the first cycle, and Column 2b for the subsequent two cycles. The self-locking torque shall be measured on installation and removal, and shall not exceed the torque in Table 5, Column 3, nor shall be less than the breakaway torque in Table 5, Column 2b.

Table 5 - Locking feature torques and assembly torque

Thread Size	Breakaway Torque Min, N·m	Breakaway Torque Min, N·m	Breakaway Torque Min, N·m	Self-Locking Torque, Max, N·m	Self-Locking Torque, Max, N·m	Assembly Torque, N·m	Assembly Torque, N·m
	1	2a	2b	3	4	5	6
MJ5 x 0.8	0.25	0.5	0.3	2.0	4.0	7.0	8.0
MJ6 x 1	0.35	0.7	0.4	3.2	6.4	11.9	13.6
MJ7 x 1	0.50	1.0	0.6	4.6	9.2	19.6	22.4
MJ8 x 1	0.65	1.3	0.8	6.0	12.0	30.0	34.2
MJ10 x 1.25	1.20	2.4	1.4	9.5	19.0	58.4	66.6
MJ12 x 1.25	1.80	3.6	2.2	15.0	30.0	103.9	118.6

Column 1. Minimum breakaway torque for 15-cycle test, and permanent set test.

2a. Minimum breakaway torque for first cycle of 3-cycle test.

2b. Minimum breakaway torque for second and third cycles of 3-cycle test.

3. Maximum self-locking torque for 15-cycle test, 3-cycle test, and permanent set test.

4. Maximum self-locking torque for 5-cycle test.

5. Assembly torque for 15-cycle and 3-cycle tests for shear height nuts. Based on 517 MPa stress in companion test bolt, f = 0.14, calculated per AIR1551 formula.

6. Assembly torque for 15-cycle and 3-cycle tests for tension height nuts. Based on 590 MPa stress in companion test bolt, f = 0.14, calculated per AIR1551 formula.

3.9.9 Accelerated Vibration Test

Nuts shall be tested in per DOD-STD-1312-107 in accordance with NAM1312-107 and shall be loaded to assembly torques specified in Table 6. The loaded nut assembly shall withstand 30000 cycles continuous vibration at 30 Hz and amplitude (total travel) 11.25 mm without relative rotation exceeding 360 degrees, without cracking of nut, and without being capable of turning the nut by hand.

Table 6 - Assembly torque for accelerated vibration test

Thread Size	Assembly Torque, N·m
MJ5 x 0.8	4.0
MJ6 x 1	6.4
MJ7 x 1	9.2
MJ8 x 1	12.0
MJ10 x 1.25	19.0
MJ12 x 1.25	30.0

3.9.9.1 At Room Temperature, As Received Condition

The nut shall be loaded as specified in 3.9.9 on spacer then removed and reinstalled four additional times on the same bolt to the assembly torques in Table 6. 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 3.9.9 requirements, and nuts shall conform to the requirements of 3.9.9 after the vibration test.

3.9.9.2 At Room Temperature After 730 °C Baking

Nuts shall be loaded as specified in 3.9.9 on spacer as specified in Appendix F, and the loaded nut assembly shall be heated in a furnace to 730 °C ± 8 °C and held for 6 hours ± 0.25 hours, and cooled to room temperature. The nut shall then be removed from the assembly and reinstalled four additional times on the same bolt to the assembly torque in Table 6. The final assembly shall be on the test fixture in the block ready for the vibration test. The loaded nut assembly shall be vibrated at room temperature in accordance with the requirements of 3.9.9, and nuts shall conform to the requirements of 3.9.9 after the vibration test.

3.9.10 Flareability

Unless otherwise specified on the part drawing, the shank of shank nuts shall be capable of being flared with a 60 degree included angle conical tool to a diameter equal to 115% of maximum shank diameter without cracking.

3.10 Test Bolts

Except as specified in 3.9.1.1, test bolts shall be unplated and conform to MA3378 with threads to MA1370 class 4H6H.

3.11 Test Lubrication

Stud-mandrel or bolt threads and nut bearing surface, and for nonwrenching nut tests the bolt bearing surface, shall be lubricated with engine oil MIL-PRF-7808 or equivalent before each installation of the nut.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of parts shall supply all parts for vendor tests and shall be responsible for performing all required tests. Subsequent to qualification, there shall be no changes in the manufacturing method and operations sequence without requalification of the parts. The purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during production of parts.

4.3 Classification of Tests

The inspection and testing of parts shall be classified as follows:

a. Production Acceptance tests

b. Qualification tests

4.3.1 Production Acceptance Tests

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1.1 A summary of acceptance tests is specified in Table 7.

4.3.2 Qualification Tests

Tests to determine conformance to all technical requirements of this specification and the part drawing are listed in Table 8.

4.4 Sampling

4.4.1 Acceptance Tests

4.4.1.1 Nondestructive Tests - Visual and Dimensional

A random sample of parts shall be taken from each production inspection lot, the size of the sample to be as specified in Table 10. The classification of dimensional characteristics shall be as specified in Table 9. All dimensional characteristics are considered defective when out of tolerance.

4.4.1.2 Destructive Tests

A random sample shall be selected from each production inspection lot, the size of the sample shall be as specified in Table 11. The sample nuts may be selected from those that have been subjected to and passed the nondestructive tests.

4.4.2 Qualification Tests

The qualification approval test samples shall consist of the applicable number of nuts for each thread size to be tested as specified in Table 8.

4.4.3 Acceptance Quality

Of random samples tested, acceptance quality shall be based on zero defectives.

4.5 Reports

4.5.1 The vendor shall furnish with, or prior to, the first shipment of parts of each part number, a report of test data showing that the parts conform to all technical requirements of this specification, and the part drawing.

4.5.2 The vendor shall furnish with each production lot shipment 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 acceptance tests, and where applicable, the flareability requirements of this specification. This report shall include the purchase order number, production lot number, MA1943 and revision letter, contractor or direct supplier of material, material specification number, part number, nominal size, and quantity.

4.6 Rejected Lots

If a production inspection lot is rejected, the vendor of parts shall perform corrective action to screen out or rework the defective parts, resubmit for acceptance tests inspection as in Table 1, or scrap the entire lot. Resubmitted lots shall be clearly identified as reinspected lots.

5. PREPARATION FOR DELIVERY

5.1 Identification

Nuts of each different part number shall be packed in separate containers. Each container of parts shall be marked to show not less than the following information:

NUTS, SELF-LOCKING, NICKEL ALLOY, CORROSION AND HEAT RESISTANT
MA1943C
PART NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION
PRODUCTION LOT NUMBER
INSPECTION

5.2 Packaging

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 the product to ensure carrier acceptance and safe delivery.

5.2.1 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-2073-1, industrial packaging, unless Level A is specified in the request for procurement.

6. ACKNOWLEDGMENT

A vendor shall mention MA1943 in all quotations and when acknowledging purchase orders.

7. REJECTIONS

Parts not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Revision Indicator

The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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

Title, number, and date of this specification
Part number of parts desired
Quantity of parts desired
Applicable level of packaging

Table 7 - Summary of acceptance tests

Characteristic	Paragraph	Sample Size	Test Method
		Nondestructive Tests	
Dimensions	3.2.1	Tables 9 & 10	Conventional measuring methods.
Bearing Surface Squareness	3.2.1.1	Tables 9 & 10	Appendix A.
Geometric Tolerances	3.2.1.2	Tables 9 & 10	Conventional measuring methods.
Thread Size	3.2.3	Tables 9 & 10	Gaging methods per MA1566.
Surface Texture	3.2.2	Table 11	Per ASME B46.1 by visual or fingernail comparison with standard texture specimens. In case of conflict, stylus instrument may be used if surface is accessible.
Product Marking	3.4	Tables 9 & 10	Visual examination.
Workmanship	3.8	Tables 9 & 10	Visual examination.
Fluorescent Penetrant Inspection	3.8.1	Tables 9 & 10	ASTME1417/E1417M and criteria per Appendix J.
Packaging & Identification	5.1 & 5.2	100%	Visual examination.
		Destructive Tests	
Hardness	3.6.1	Table 11	MIL-STD-1312-6 in accordance with NASM1312-6.
Microstructure	3.7.1	Table 11	Microscopic examination 100X.
Grain Size	3.7.2	Table 11	ASTM E112.
Flareability	3.9.10	Table 11	Convention flaring tool.
Plating	3.5	Table 11	Microscopic measurement of sectioned nut.
Three Cycle Test	3.9.8	Table 11	Appendix H.

Table 8 - Summary of qualifications tests

Characteristic	Paragraph	Sample Size	Test Method
		Nondestructive Tests [1]	
Dimensions	3.2.1	All	Conventional measuring methods.
Bearing Surface Squareness	3.2.1.1	All	Appendix A.
Geometric Tolerances	3.2.1.2	All	Conventional measuring methods.
Thread Size	3.2.3	All	Gaging methods per MA1566.
Surface Texture	3.2.2	All	Per ASME B46.1 by visual, fingernail comparison or by stylus instrument.
Product Marking	3.4	All	Visual examination.
Workmanship	3.8	All	Visual examination.
Fluorescent Penetrant Inspection	3.8.1	All	ASTM E1417/E1417M and criteria per Appendix J.
		Destructive Tests [2]	
Hardness	3.6.1	5	MIL-STD-1312-6 in accordance with NASM1312-6.
Microstructure	3.7.1	5	Microscopic examination 100X.
Grain Size	3.7.2	5	ASTM E112.
Plating	3.5	5	Microscopic examination of sectioned nut.
Axial Tensile Strength,	3.9.1		
As Received	3.9.1.1	4	MIL-STD-1312-108 in accordance with NAM1312-108.
After 730 °C Bake	3.9.1.2	4	MIL-STD-1312-108 in accordance with NAM1312-108.
Wrench Torque	3.9.2	3	Appendix B.
Push Out Load	3.9.3	5	Appendix C.
Torque Out	3.9.4	5	Appendix D.
Permanent Set Test	3.9.5	3	Appendix E.
Reusability Test,			
After 730 °C Bake	3.9.6	10	Appendix F.
As Received	3.9.7	10	Appendix G.
Accelerated Vibration Test	3.9.9		
As Received	3.9.9.1	5	MIL-STD-1312-107 in accordance with NAM1312-107.
After 730 °C Bake	3.9.9.2	5	MIL-STD-1312-107 in accordance with NAM1312-107.
Flareability	3.9.10	3	Conventional flaring tool.

[1] Sample size includes all samples for destructive tests.
[2] Total number of samples for destructive tests equals 77; all samples shall be subjected to the nondestructive tests prior to being subjected to the destructive tests. The same test sample may be used for more than one test provided that none of the characteristics of the samples are altered during the test procedure.

Table 9 - Classification of visual and dimensional characteristics

Class	Characteristic
Major A	
101	Presence of locking element
102	Surface discontinuities revealed by fluorescent penetrant inspection
Major B	
201	Thread size
202	Squareness of bearing face to thread
203	Plating or coating
204	Product marking
205	Shank diameter
206	Shank length
207	Rivet hole size
208	Rivet hole location
209	Surface texture
210	Three-cycle test
Minor A	
301	Wrenching size and configuration
302	Nut height
303	Bearing diameter
304	Float of nut element
305	Burrs and sharp corners
306	Depth of counterbore
307	Flange thickness
Minor B	
401	Runout of wrenching form to thread
402	Runout of shank OD to thread
403	Runout of flange ON to thread
404	Countersink on thread end
405	Other dimensional characteristics

Table 10 - Sampling data: visual and dimensional characteristics

Production Inspection Lot Size	Major A Sample Size	Major B Sample Size	Minor A Sample Size	Minor B Sample Size
2 to 8	All	All	5	3
9 to 15	All	13	5	3
16 to 25	All	13	5	3
26 to 50	32	13	7	5
51 to 90	32	13	11	6
91 to 150	32	13	11	7
151 to 280	32	20	13	10
281 to 500	48	29	16	11
501 to 1200	73	34	19	15
1201 to 3200	73	42	23	18
3201 to 10 000	86	50	29	22
10001 to 35000	108	60	35	29
35001 to 150000	123	74	40	29
150001 to 500000	156	90	40	29
500001 and over	189	102	40	29

Table 11 - Sampling data: mechanical and metallurgical characteristics

Production Inspection Lot Size	Sample Size Nondestructive Tests	Sample Size Destructive Tests
Up to 500	8	3
501 to 3200	13	5
3201 to 35000	20	5
35001 and over	32	8

PREPARED BY SAE COMMITTEE E-25,
GENERAL STANDARDS FOR AEROSPACE PROPULSION SYSTEMS

APPENDIX A - MEASUREMENT OF PERPENDICULARITY VARIATION OF THE BEARING SURFACE

A.1 SCOPE

This appendix is a mandatory part of this specification.

A.1.1 To measure the variation from perpendicularity of the nut bearing surface "A" (see Figure A1) relative to the thread. This inspection is applicable to all nuts.

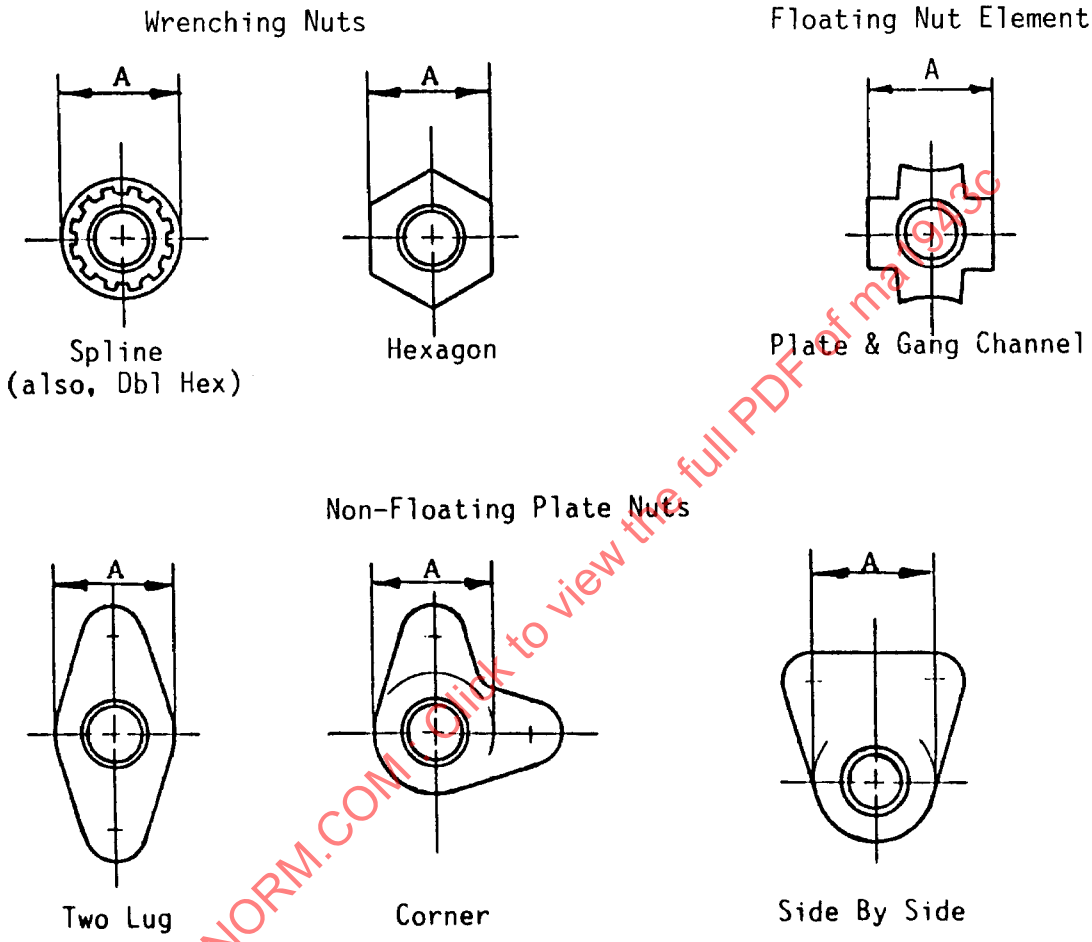


Figure A1 - Bearing surface area "A" under perpendicularity control for various types of nuts

A.1.2 For floating nuts this measurement applies only to the nut element when the retaining plate or channel has been removed.

A.2 APPLICABLE DOCUMENTS

MA1370 Screw Threads - MJ Profile, Metric

NA0012 Fixture - Bearing Surface Squareness Test, Self-Locking Nuts, Metric

A.3 APPARATUS

A.3.1 Particulars of the fixture are given in NA0012 except the mandrel shall be in accordance with the maximum mandrel in Appendix E, Figure E1.

A.4 PROCEDURE

A.4.1 The perpendicularity of the bearing surface relative to the thread shall be measured within the basic area "A" as defined in Figure A1.

A.4.2 Nuts may be checked for perpendicularity before or after forming the self-locking feature.

A.4.3 The maximum threaded mandrel is manually assembled into the nut a minimum of three turns if checked before forming the locking feature, or until the end of the mandrel is through the locking feature if checked after forming. The variation from perpendicularity is evaluated with a shim of the required thickness.

APPENDIX B - WRENCH TORQUE TEST

B.1 SCOPE

This appendix is a mandatory part of this specification.

B.1.1 This test is applied to externally wrenched nuts of spline and hexagon wrenching configuration.

B.1.2 The purpose is to test that the wrenching configuration is capable of withstanding the high breakloose torques encountered with nuts in hot areas of aerospace propulsion systems.

B.2 APPLICABLE DOCUMENTS

MA1370 Screw Threads - MJ Profile, Metric

MA1586 Wrench Configuration, 12 Spline Drive, Metric

ASME B1.13M Metric Screw Threads M Profile

B.3 APPARATUS

B.3.1 The typical test apparatus is shown in Figure B1 and comprises the following:

a. Stud with threads conforming to MA1370 or ASME B1.13M, tolerance class 4H6H

b. Two wrenches conforming to MA1586; double hexagon sockets for hexagon drive nuts

c. Square drive adapter for socket wrenches

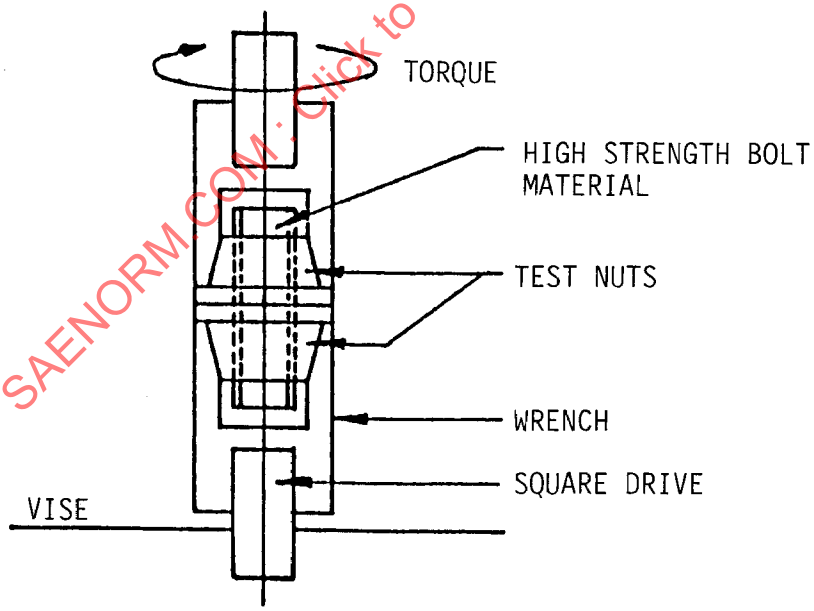


Figure B1 - Wrench torque test apparatus

B.4 PROCEDURE

B.4.1 Method Using Stud and Wrenches

B.4.1.1 Place adapter in vise. For hexagon nuts, bottom hexagon nut is gripped in vise.

B.4.1.2 Locate first wrench socket on adapter.

B.4.1.3 Assemble nuts to be tested onto stud until bearing surfaces contact at mid length of stud. Ensure stud engages full length of nut thread but protrusion must not prevent full location of nut wrenching configuration into wrench socket.

B.4.1.4 Locate assembly into first wrench.

B.4.1.5 Engage second wrench onto upper nut and test to the requirement of this specification.

APPENDIX C - PUSH OUT TEST

C.1 SCOPE

This appendix is a mandatory part of this specification.

C.1.1 This test is applicable to floating plate nuts and gang channel nuts. It is not applicable to nonfloating plate nuts that are side by side mounting, and also, to floating angle plate nuts (see Figure C1).

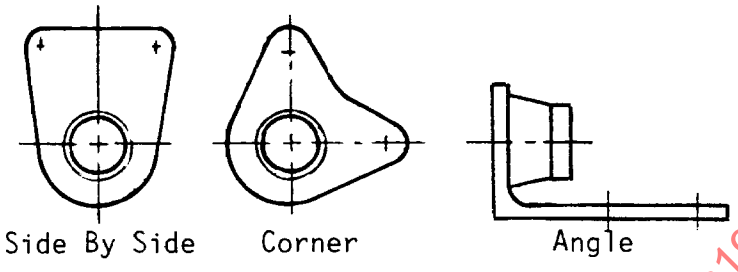


Figure C1 - Types of nuts not applicable to push out test

C.1.2 This test is to determine whether the nut retainer plate or channel is capable of withstanding the axial push out load specified in this specification after the nut is installed.

C.2 APPLICABLE DOCUMENTS

MA1370 Metric Screw Threads - MJ Profile

C.3 APPARATUS

C.3.1 The test apparatus is shown in Figure C2 and comprises the following:

a. The retention plate

b. Rivets or bolts to attach test nut to plate

c. A push-out mandrel with spherical end

d. A bolt with threads conforming to MA1370, tolerance class 4H6H

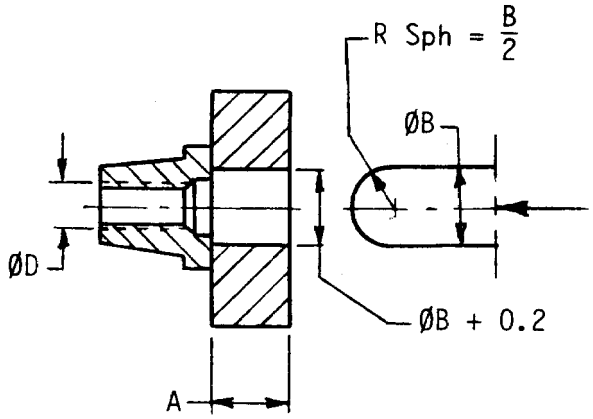


Figure C2 - Push out test apparatus

Table C1 - Dimensions for test apparatus, mm

Nom Thread Size, D	5	6	7	8
A	8	8	14	14
B	5.5	6.5	7.5	8.5

C.4 PROCEDURE

C.4.1 Attach the plate nut or section of gang channel to be tested to the plate by riveting or with bolts.

C.4.2 Apply the push-out load given in this specification to the spherically ended mandrel as shown in Figure C2.

C.4.3 Install a standard bolt with the fingers up to the locking feature using no supporting pressure on the nut.

C.4.4 Remove the bolt and detach the nut from the retention plate or channel.

C.4.5 Submit the nut for visual examination and, if necessary, to an examination at low magnification after sectioning.

APPENDIX D - TORQUE OUT TEST

D.1 SCOPE

This appendix is a mandatory part of this specification.

D.1.1 This test is applicable to nuts produced as multipiece nuts as the following:

a. Floating plate nuts or gang channel nuts

b. Fixed plate nuts which have the nut body assembled on a plate by brazing or swaging

D.1.2 This test is to determine that the retention device is capable of holding the nut element against rotation when tightening or untightening the mating bolt.

D.2 APPLICABLE DOCUMENTS

MA1370 Screw Threads - MJ Profile, Metric

ASME B1.13M Metric Screw Threads, M Profile

D.3 APPARATUS

D.3.1 A typical test apparatus is shown in Figure D1 and comprises the following:

a. A retention plate

b. Rivets or bolts to attach test nut to plate

c. A bolt with threads conforming to MA1370 or ASME B1.13M, tolerance class 4H6H

d. A hardened steel sleeve that bears the axial load against the base of nut element and bolt bearing surface, with no axial load on the retention plate during the test

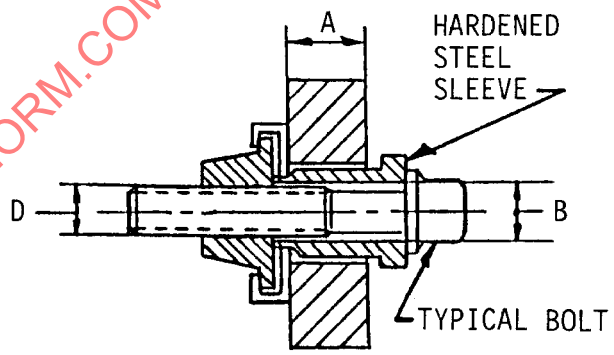


Figure D1 - Torque out test apparatus

Table D1 - Dimensions for test apparatus, mm

Nom Thread Size, D	5	6	7	8
A	8	8	14	14
B	5.2	6.2	7.2	8.2

D.4 PROCEDURE

D.4.1 Attach the plate nut or section of gang channel to be tested to the plate by riveting or with bolts.

D.4.2 Apply the torque-out torque given in this specification in a clockwise direction.

D.4.3 Remove the bolt and detach the nut from the retention plate or channel.

D.4.4 Submit the nut for visual examination and, if necessary, to an examination at low magnification after sectioning.

APPENDIX E - PERMANENT SET TEST

E.1 SCOPE

This appendix is a mandatory part of this specification.

E.1.1 This test is applicable to all self-locking nuts (wrenching nuts and anchor nuts) and is to verify the ability of the nut locking feature to perform within the locking torques of this specification when assembled on a minimum threaded mandrel (or bolt) after having first been assembled onto a maximum threaded mandrel (or bolt).

E.2 APPLICABLE DOCUMENTS

MA1370 Screw Threads - MJ Profile, Metric

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

E.3 APPARATUS

E.3.1 The apparatus shown in Figures E1 and E2 comprises the following:

a. Maximum mandrel (see Figure E1)

b. Minimum mandrel (see Figure E2)

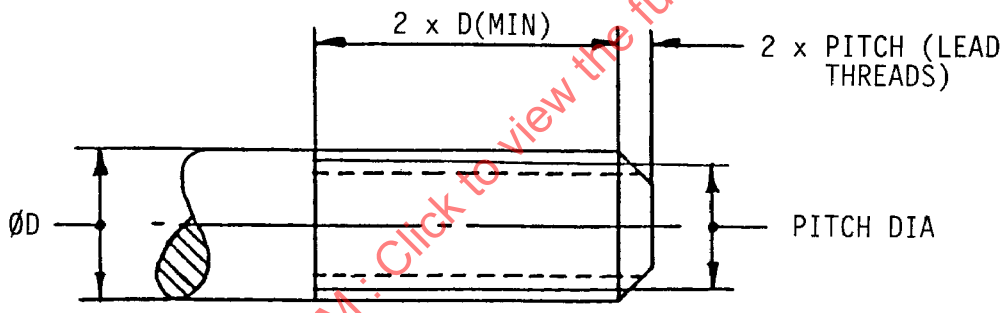


Figure E1 - Maximum mandrel

Table E1 - Maximum mandrel pitch diameter

Nominal Thread Size	Pitch Ø, mm Max	Pitch Ø, mm Min
MJ5 x 0.8	4.464	4.454
MJ6 x 1	5.333	5.323
MJ7 x 1	6.333	6.323
MJ8 x 1	7.332	7.322
MJ10 x 1.25	9.169	9.159
MJ12 x 1.25	11.167	11.157

Material: Steel heat treated to 39 HRC minimum.
Surface Roughness: Thread flanks to be 0.8 µm Ra in accordance with ASME B46.1.
Threads: MA1370 except pitch diameter shall be as specified in Table E1.

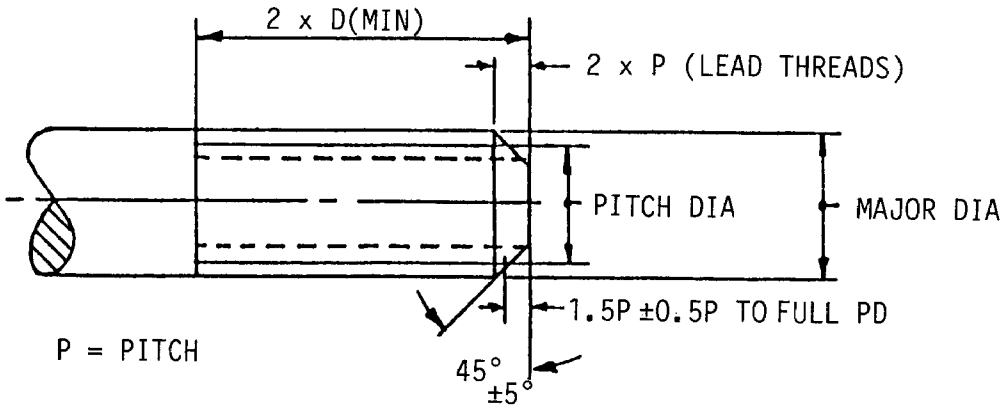


Figure E2 - Minimum mandrel

Table E2 - Minimum mandrel thread dimensions

Nominal Thread Size	Major Ø, mm Max	Major Ø, mm Min	Pitch Ø, mm Max	Pitch Ø, mm Min	Tolerance on Half Angle, minutes	Helix Tolerance, µm [1]
MJ5 x 0.8	4.850	4.840	4.420	4.410		
MJ6 x 1	5.820	5.810	5.279	5.269		
MJ7 x 1	6.820	6.810	6.279	6.269	±15	8
MJ8 x 1	7.820	7.810	7.279	7.269		
MJ10 x 1.25	9.788	9.778	9.113	9.103		
MJ12 x 1.25	11.788	11.778	11.103	11.093		

Material: Steel heat treated to 39 HRC minimum.
Surface Roughness: Thread flanks to be 0.8 µm Ra in accordance with ASME B46.1.
Threads: MA1370 except as otherwise specified in specified in Table E2. Lead threads may be dressed or stoned to break sharp edges 0.1 to 0.4 mm.

[1] The form tolerances on flank half-angle and helix are independent of pitch diameter limits; thus, the effective pitch cylinder size may be increased beyond the maximum pitch diameter limit by the cumulative effect on pitch diameter due to the form tolerance.

E.4 PROCEDURE

E.4.1 Lubricate the maximum mandrel (see Figure E1) and nut in accordance with this specification.

E.4.2 Assemble nut onto the maximum mandrel until a minimum of three pitches protrude through the top of nut. Record the maximum self-locking torque achieved at any time during this assembly.

E.4.3 Remove the nut from the maximum mandrel.

E.4.4 Lubricate the minimum mandrel (see Figure E2) in accordance with this specification.

E.4.5 Assemble the same nut onto the minimum mandrel until three thread pitches protrude through the top of the nut. Record the self-locking torque on installation.

E.4.6 Remove the nut from the minimum mandrel, recording the breakaway torque.

NOTE: Nuts used for this test shall not be reused.

APPENDIX F - REUSABILITY TEST AT ROOM TEMPERATURE AFTER 730 °C BAKE

F.1 SCOPE

This appendix is a mandatory part of this specification.

F.1.1 This test is applicable to all self-locking nuts (wrenching nuts and anchor nuts) 5 mm nominal thread size and larger, and is to verify the performance and reusability of the nut self-locking feature at room temperature after a specified time of 730 °C bake under load for a specified number of cycles.

F.2 APPLICABLE DOCUMENTS

AMS5707 Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings and Rings, 57Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode Remelted or Vacuum Induction Melted, 1825 to 1900 °F (996 to 1038 °C) Solution, Stabilization, and Precipitation Heat Treated

AMS5709 Nickel Alloy, Corrosion and Heat-Resistant, Bars and Forgings, 58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B, Consumable Electrode or Vacuum Induction Melted, 1975 °F (1079 °C) Solution, Stabilization, and Precipitation Heat Treated

MA1370 Screw Threads - MJ Profile, Metric

MA3378 Bolts and Screws, UNS N07001, Tensile Strength 1210 MPa, Thread and Fillet Radius Rolled Before Aging, Procurement Specification, Metric

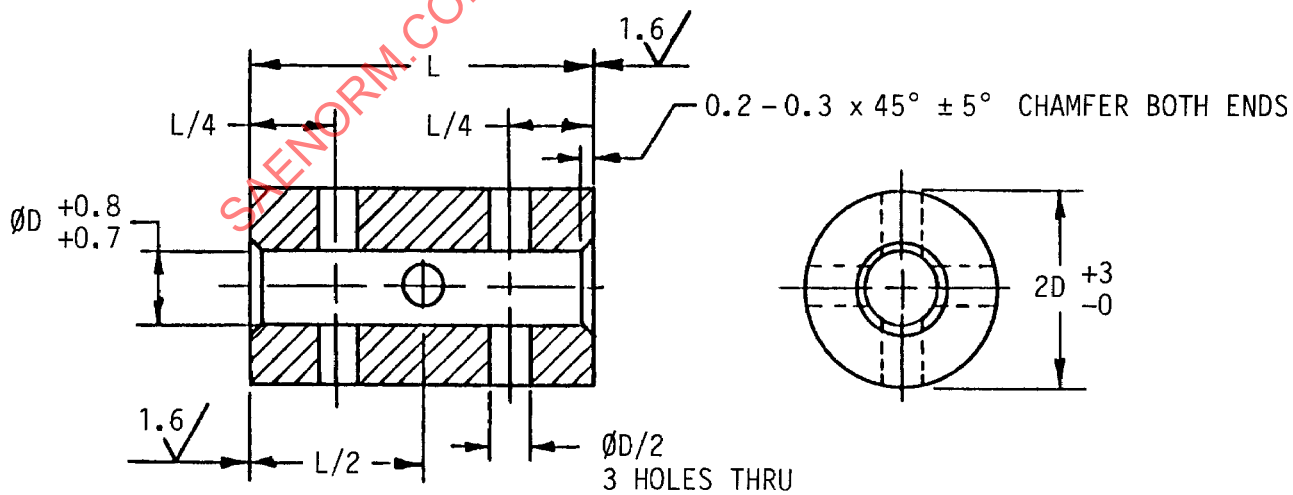
ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

F.3 APPARATUS

F.3.1 The apparatus shown in Figures F1 through F3 comprises the following:

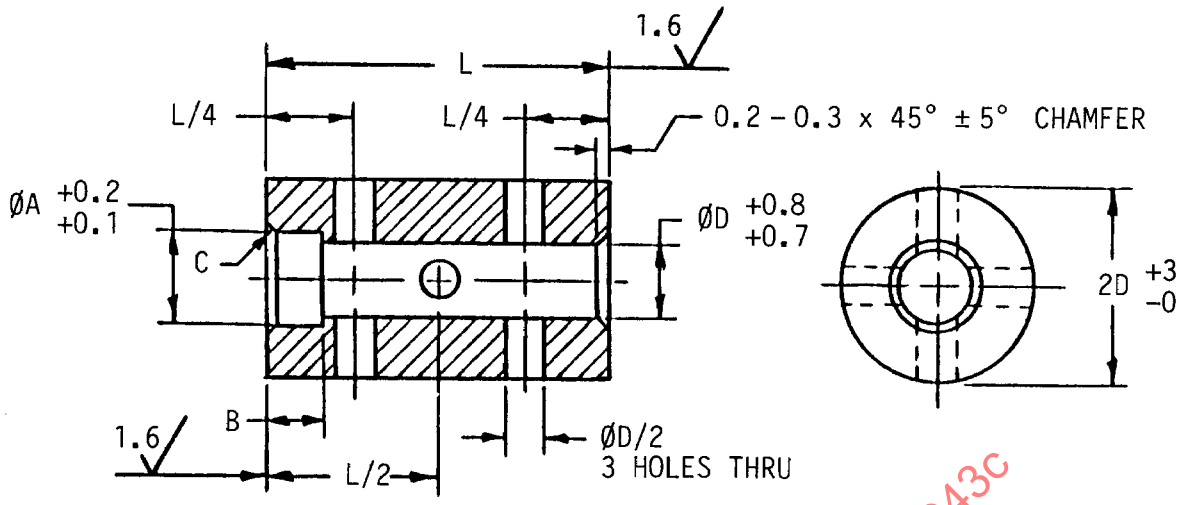
a. Spacer

b. Bolt with threads conforming to MA1370 and manufactured to MA3378



D = nominal diameter of bolt
Dimensions in millimeters; surface roughness in micrometers, Ra

Figure F1 - Spacer for nuts (except shank nuts)



Dimensions in millimeters; surface roughness in micrometers, Ra
A = maximum diameter of nut shank uninstalled
B = maximum length of nut shank + 1 mm
C = 45° chamfer clearing maximum radius bearing face and shank of nut
D = nominal diameter of bolt

Figure F2 - Spacer for shank nuts

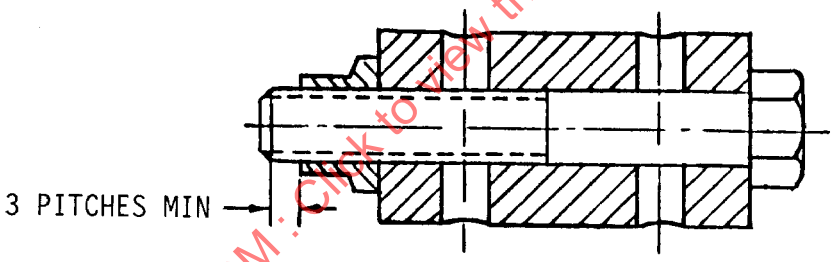


Figure F3 - Heat soak test assembly

F.3.1.1 Spacer for Nuts (Except Shank Nuts)

Material AMS5707 or AMS5709; dimensions Table F1.

F.3.1.2 Spacer for Shank Nuts

Material AMS5707 or AMS5709; dimensions Table F1.