SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS7471 REV. D

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Superseding AS7471C

Bolts and Screws, Nickel Alloy, UNS N07001 Tensile Strength 165 ksi, Corrosion and Heat Resistant Procurement Specification

FSC 5306

RATIONALE

Delete fatigue testing from 1.1 as there is no requirement for this test.

1. SCOPE

1.1 Type

This procurement specification covers bolts and screws made from a corrosion and heat resistant, age hardenable nickel base alloy of the type identified under the Unified Numbering System as UNS N07001. The following specification designations and their properties are covered:

AS7471 165 ksi minimum ultimate tensile strength at room temperature.
75 ksi stress-rupture strength at 1350 °F.

AS7471-1 165 ksi minimum ultimate tensile strength at room temperature.
99 ksi minimum ultimate shear strength at room temperature.

1.2 Application

Primarily for aerospace propulsion systems applications where a good combination of tensile strength, and resistance to relaxation at elevated temperatures up to approximately 1500 °F is required.

1.3 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.

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Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

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 specification 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 724-776-4970 (outside USA), www.sae.org.

2.1.1.1 Aerospace Material Specifications

AMS 2750 Pyrometry

AMS 5708 Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings, and Rings 58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al Consumable Electrode or Vacuum Induction Melted 1975°F (1079°C) Solution Heat Treated

2.1.1.2 Aerospace Standards

AS1132 Bolts, Screws and Nuts - External Wrenching UNJ Thread, Inch - Design Standard

AS3062 Bolts, Screws and Studs - Screw Thread Requirements

AS3063 Bolts, Screws and Studs - Geometric Control Requirements

AS8879 Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter

2.1.2 AIA/NAS Publications

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

NASM1312-6 Fastener Test Methods, Method 6, Hardness

NASM1312-8 Fastener Test Methods, Method 8, Tensile Strength

NASM1312-10 Fastener Test Methods, Method 10, Stress-Rupture

NASM1312-13 Fastener Test Methods, Method 13, Double Shear Test

2.1.3 ASTM Publications

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 D 3951	Commercial Packaging
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 140	Standard Hardness Conversion Tables for Metals
ASTM E 340	Standard Test Methods for Microetching Metals and Alloys
ASTM E 407	Standard Practice for Microetching Metals and Alloys
ASTM E 930	Standard Test Methods for Estimating the Largest Grains Observed in a Metallographic Section (ALA Grain Size)
ASTM E 1417	Liquid Penetrant Examination

2.1.4 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

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

2.2 Definitions

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

COLD ROLLING: Forming material below the recrystallation temperature.

CRACK: Rupture in the material which may extend in any direction and which may be intercrystalline or transcrystalline in character.

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

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

DISCONTINUITY: An interruption in the normal physical structure or configuration of a part; such as a lap, seam, inclusion, crack, machining tear, or stringer.

HEAT PATTERN: A discernible difference in etched appearance between the head and the shank caused by plastic forming of the head.

INCLUSION: Nonmetallic particles originating from the material making process. They may exist as discrete particles or strings of particles extending longitudinally.

LAP: Surface imperfection caused by folding over metal fins or sharp corners and then rolling or forging them into the surface. The allowable lap depth shall not exceed the limit specified herein. The minimum condition that shall be rated as a lap is a fold having its length equal to or greater than three times its width with a depth of 0.0005 in when viewed at 200X magnification.

MACHINING TEAR: A pattern of short jagged individual cracks, generally at right angles to the direction of machining, frequently the result of improperly set cutting tools, or dull cutting tools.

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.

SEAM: Longitudinal surface imperfection in the form of an unwelded, open fold in the material.

STRINGER: A solid nonmetallic impurity in the metal bar, often the result of an inclusion that has been extended during the rolling process.

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

2.3 Unit Symbols

°C - degree Celsius

°F - degree Fahrenheit

cm^3 - cubic centimeter

g - gram (mass)

HRC - hardness Rockwell C scale

lbf - pound-force

% - percent (1% = 1/100)

sp gr - specific gravity

ksi - kips (1000 pounds) per square inch

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be AMS 5708 alloy heading stock.

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. Dimensions apply after plating but before coating with dry film lubricants.

3.2.2 Surface Texture

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

3.2.3 Threads

Screw thread UNJ profile and dimensions shall be in accordance with AS8879, unless otherwise specified on the part drawing.

3.2.3.1 Incomplete Lead and Runout Threads

Incomplete threads are permissible at the entering end and the juncture of the unthreaded portion of the shank or adjacent to the head as specified in AS3062.

3.2.3.2 Chamfer

The entering end of the thread shall be chamfered as specified on the part drawing.

3.2.4 Geometric Tolerances

Part features shall be within the geometric tolerances specified on the part drawing and, where applicable, controlled in accordance with AS3063.

3.3 Fabrication

3.3.1 Blanks

Heads shall be formed by forging; machined heads are not permitted, except lightening holes may be produced by any suitable method. Wrenching recesses may be forged or machined. Flash or chip clearance in machined recesses shall not cause recess dimensions to exceed the specified limits.

3.3.2 Heat Treatment

Before finishing the shank and the bearing surface of the head, cold rolling the head-to-shank fillet radius, and rolling the threads, headed blanks shall be solution and stabilization heat treated as follows; precipitation heat treatment shall follow cold rolling of the fillet radius and rolling the threads.

3.3.2.1 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 and data recorders conforming to AMS 2750. The heating medium or atmosphere shall cause no surface hardening by carburizing or nitriding.

3.3.2.2 Solution Heat Treatment

Headed blanks shall be solution heat treated by heating to a temperature within the range 1900 to 1975 °F, holding at the selected temperature within ±25 °F for 1 to 4 h, and cooling at a rate equivalent to air cool or faster.

3.3.2.2.1 A temperature lower than 1900 °F may be used provided the furnace control is such that during the holding period no part is below 1875 °F.

3.3.2.3 Stabilization Heat Treatment

Solution heated blanks shall be stabilization heat treated by heating to 1550 °F ± 15 °F, holding at heat for 4 h ± 0.5 h, and cooling in air.

3.3.2.4 Precipitation Heat Treatment

After cold rolling the fillet radius as in 3.3.4 and rolling the threads as in 3.3.5, parts shall be precipitation heat treated by heating to 1400 °F ± 15 °F in a controlled atmosphere, holding at heat for 16 h ± 1 h, and cooling at a rate equivalent to air cool.

3.3.3 Oxide Removal

Surface oxide and oxide penetration resulting from prior heat treatment shall be removed from the full body diameter and bearing surface of the head of the solution and stabilization heat treated blanks prior to cold rolling the underhead 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 with a metallic sheen able to reflect light.

3.3.4 Cold Rolling of Fillet Radius

After removal of oxide as in 3.3.3, the head-to-shank fillet radius of headed parts having the radius complete throughout the circumference of the part shall be cold rolled sufficiently to remove all visual evidence of grinding or tool marks. Distortion due to cold rolling shall conform to Figure 2, unless otherwise specified on the part drawing. It shall not raise metal more than 0.002 in above the contour at "A" or depress metal more than 0.002 in below the contour at "B" as shown in Figure 2; distorted areas shall not extend beyond “C” as shown in Figure 2. In configurations having an undercut connected with the fillet radius, the cold rolling will be required only for 90 degrees of fillet arc, starting at the point of tangency of the fillet radius and the bearing surface of the head. For shouldered parts, having an unthreaded shank diameter larger than the thread major diameter and having an undercut connected with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold rolling will be required only for 90 degrees of fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank. The shank diameter on close tolerance full shank parts shall not exceed its maximum diameter limit after cold rolling the head-to-shank fillet radius.

3.3.5 Thread Rolling

Threads shall be formed on the finished blanks by a single rolling process after removal of oxide as in 3.3.3.

3.3.6 Cleaning

Parts, after finishing, shall be degreased and immersed in one of the following solutions for the time and 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 to 40 min at room temperature.

c. One volume of nitric acid (sp gr 1.42) and 4 volumes of water for 10 to 15 min at 140 to 160 °F.

3.3.6.1 Water Rinse

Immediately after removal from the cleaning solution, the parts shall be thoroughly rinsed in clean water at 70 to 200 °F.

3.4 Product Marking

Each part shall be identification marked as specified by the part drawing. The markings may be formed by forging or stamping, raised or depressed no more than 0.010 in maximum, with rounded root form on depressed characters.

3.5 Plating or Coating

Where required, surfaces shall be plated or coated as specified by the part drawing. When coating with a dry film lubricant is required, the underhead bearing surface, unthreaded shank and threads shall be coated as specified on the part drawing; other surfaces are optional to coat, unless otherwise specified. Plating thickness shall be determined in accordance with the plating specification.

3.6 Mechanical Properties

Where AS7471 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, 3.6.3. Where AS7471-1 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, and 3.6.4. 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.

AS7471 finished parts shall be tested in accordance with the following test methods:

a. Hardness: NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: NASM1312-8

c. Stress-Rupture Strength at 1350 °F: NASM1312-10

AS7471-1 finished parts shall be tested in accordance with the following test methods:

a. Hardness: NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: NASM1312-8

c. Ultimate Shear Strength at Room Temperature: NASM1312-13

3.6.1 Ultimate Tensile Strength at Room Temperature

3.6.1.1 Finished Parts

Tension bolts, such as hexagon, double hexagon, and spline drive head, shall have an ultimate tensile load not lower than that specified in Table 2A and shall be tested to failure in order to observe fraction location, first measuring and recording the maximum tensile load achieved. Screws, such as 100 degree flush head, pan head, and fillister head, shall have an ultimate tensile load not lower than that specified in Table 2B; screws need not be tested to failure, however the maximum tensile load achieved shall be measured and recorded. 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 thread minor (root) diameter or having an undercut, parts shall have an ultimate tensile strength not lower than 165 ksi; for such parts, the diameter of the area on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with either standard hexagon, double hexagon, or spline drive type heads having a minimum metal condition in the head equal to the design parameters specified in AS1132 shall not fracture in the head-to-shank fillet radius except when this radius is connected with an undercut or with a shank diameter less than the minimum pitch diameter of the thread.

3.6.1.2 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 E 8 on specimens prepared as in 4.4.8. Specimens may be required by the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 165 ksi

b. Yield Strength at 0.2% Offset, minimum 105 ksi

c. Elongation in 4D, minimum: 15%

d. Reduction of Area, minimum: 18%

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

3.6.2 Hardness

Shall be uniform and within the range 34 to 44 HRC (see 8.1), but hardness of the threaded section and the head-to-shank fillet may be higher as a result of the cold rolling operations. Parts shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.1 are met.

3.6.3 Stress-Rupture Strength at 1350 °F

3.6.3.1 Finished Parts

Finished tension bolts, maintained at 1350 °F ±3 °F while the tensile load specified in Table 2A is applied continuously, shall not rupture in less than 23 h. If the shank diameter of the part is less than the maximum minor (root) diameter of the thread but the parts can be tested satisfactorily, parts shall conform to the requirements of 3.6.3.1.1.

3.6.3.1.1 Parts having a shank diameter less than the maximum minor (root) diameter of the thread shall be tested as in 3.6.3.1, except that the load shall be as specified in 3.6.3.2. The diameter of the area on which the stress is based shall be the actual measured minimum diameter of the part.

3.6.3.2 Machined Test Specimens

If the size or shape of the part is such that a stress-rupture test cannot be made on the part, a test specimen shall be prepared as in 4.4.8, maintained at 1350 °F ± 3 °F while a load sufficient to produce an axial stress of 75 ksi is applied continuously, shall not rupture in less than 23 h. Tests shall be conducted in accordance with ASTM E 139. Specimens may be required by purchaser to perform confirmatory tests.

3.6.4 Ultimate Shear Strength

Finished bolts having a close toleranced full shank as in AS1132 shall have an ultimate double shear load not lower than that specified in Table 2A. The double shear test may be discontinued without a complete shear failure after the ultimate shear load has been reached, first measuring and recording the maximum double shear load achieved. Shear bolts having special shank diameters shall have the minimum ultimate shear load based on 99 ksi minimum shear strength. Shear tests are not required for screws, such as 100 degree flush head, having a grip length less than 2.5 times the nominal diameter, or protruding head screws, such as pan head and fillister head, having a grip length less than 2 times the nominal diameter. Shear tests are not required for the following conditions:

a. Bolts and screws threaded to head.

b. Protruding head bolts and screws having coarse toleranced full shank.

c. Protruding head bolts and screws having PD or relieved shank.

3.7 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 parts.

3.7.1 Macroscopic Examination, Headed Blank

A longitudinal specimen cut from a headed blank shall be etched in accordance with ASTM E 340 and ASTM E 407, and examined at a magnification of 20X to determine conformance to the requirements of 3.7.1.1 and 3.7.1.2. The head and shank section shall extend not less than D/2 from the bearing surface of the head, where “D” is the nominal diameter of the shank after heading.

3.7.1.1 Flow Lines

After heading and prior to heat treatment, examination of an etched section taken longitudinally through the blank as in 3.7.1 shall show flow lines or heat pattern in the shank, head-to-shank fillet, and bearing surface which follow the contour of the blank. See Figure 1 or Figure 1A for satisfactory flow lines or heat pattern for headed blank of double hexagon bolt. The head style shown is for illustration only. The requirements apply to other head styles unless otherwise specified. Flow lines or heat pattern in headed blanks having special heads, such as Dee- or Tee-shaped heads, or thinner than AS1132 standard heads, shall as a minimum follow the fillet radius in the head-to-shank area.

3.7.1.2 Internal Defects

Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity.

3.7.2 Microscopic Examination, Finished Parts

Specimens cut from finished parts shall be polished, etched in accordance with ASTM E 340 and ASTM E 407, and examined at a magnification not lower than 200X to determine conformance to the requirements of 3.7.2.1, 3.7.2.2, 3.7.2.3, 3.7.2.4, 3.7.2.5, and 3.7.2.6.

3.7.2.1 Flow Lines, Threads

Examination of a longitudinal section through the threaded portion of the shank shall show evidence that the threads were rolled with continuous flow lines that follow the general thread contour with maximum density at the bottom of the root radius. See Figure 3.

3.7.2.2 Internal Defects

Examination of longitudinal sections of the head and shank and shall reveal no cracks, laps, or porosity. Thread imperfections shall conform to the requirements of 3.7.2.6.

3.7.2.3 Microstructure

Parts shall have microstructure of completely recrystallized material except in the area of the threads and the head-to-shank fillet radius.

3.7.2.4 Grain Size

Grain size shall be an average ASTM No. 2 to No. 6, as determined in accordance with ASTM E 112. Individual coarse grains larger than ASTM No. 2 but not as large as (ALA) ASTM No. 00, as determined by ASTM E 930, may occur at an occasional (5 to 16% of structure) frequency. Coarse grains ALA ASTM No. 00 may occur at an isolated (0 to 5% of structure) frequency. Coarse grains shall be surrounded by grains which are ASTM No. 1 to No. 7 and at least two layers of grain distance away from the bearing surface and the fillet radius. Individual grains, which are as fine as ASTM No. 7, may occur at an occasional frequency. In the case of disagreement on grain size by the comparison method, the intercept (Heyn) procedure shall be used.

3.7.2.5 Surface Hardening

Parts shall have no change in hardness from core to surface except as produced during cold rolling of the head-to-shank fillet radius and during rolling of threads. In case of dispute over results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance to this requirement.

3.7.2.6 Threads

3.7.2.6.1 Root defects such as laps, seams, notches, slivers, folds, and roughness are not permissible (see Figure 4). Oxide scale greater than 0.001 in is not permissible.

3.7.2.6.2 Multiple laps on the flanks of threads are not permissible regardless of location.

3.7.2.6.3 Single Laps on Thread Profile

Shall conform to the following:

a. Thread Flank Above the Pitch Diameter: A single lap is permissible along the flank of the thread above the pitch diameter on either the pressure or the nonpressure flank (one lap at any cross-section through the thread) provided it extends toward the crest and is generally parallel to the flank (see Figure 5). The lap depth shall not exceed the limit specified in Table 1 for the applicable thread pitch. A lap extending toward the root is not permissible (see Figure 6).

b. Thread Flank Below the Pitch Diameter: A lap along the thread flank below the pitch line, regardless of direction it extends, is not permissible (see Figure 7).

c. 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 the limit specified in Table 1 as measured from the thread crest when the thread major diameter is at minimum size (see Figure 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 1 may be increased by one-half of the difference between the minimum major diameter and the actual major diameter as measured on the part.

3.7.3 Fluorescent Penetrant Inspection

Prior to any required plating or coating, parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E 1417, Type 1, Sensitivity Level 2 minimum.

3.7.3.1 The following conditions shall be cause for rejection of parts inspected.

3.7.3.1.1 Discontinuities transverse to grain flow (i.e., at an angle of more than 10 degrees to the axis of the shank), such as grinding checks and cracks.

3.7.3.1.2 Longitudinal indications (i.e., at an angle of 10 degrees or less to the axis of the shank) due to imperfections other than seams, forming laps, and nonmetallic inclusions.

3.7.3.2 The following conditions shall be considered acceptable on parts inspected.

3.7.3.2.1 Parts having longitudinal indications (i.e., at an angle of 10 degrees or less to the axis of the shank) of seams and forming laps parallel to the grain flow that are within the limits specified in 3.7.3.2.2 through 3.7.3.2.5 provided the separation between indications is not less than 0.062 inch in all directions.

3.7.3.2.2 Sides of Head

There shall be not more than three indications per head. The length of each indication may be the full height of the surface but no indication shall break over either edge to a depth greater than 0.031 inch or the equivalent of the 2H/3 thread depth (see Table 1), whichever is less.

3.7.3.2.3 Shank or Stem

There shall be not more than five indications. The length of any indication may be the full length of the surface but the total length of all indications shall not exceed twice the length of the surface. No indication shall break into a fillet or over an edge.

3.7.3.2.4 Threads

There shall be no indications, except as permitted in 3.7.2.6.

3.7.3.2.5 Top of Head and End of Stem

The number of indications is not restricted, but the depth of any individual indication shall not exceed 0.010 in, as shown by sectioning representative samples. No indication, except those of 3.7.3.2.2, shall break over an edge.

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. Purchaser reserves the right to perform such confirmatory testing as 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 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 Test for all technical requirements are acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.

4.4 Acceptance Test Sampling

4.4.1 Material

Sampling for material composition on each heat shall be in accordance with AMS 5708.

4.4.2 Nondestructive Test - Visual and Dimensional

A random sample of parts shall be taken from each production inspection lot; the size of the sample shall be as specified in Table 4. The classification of dimensional characteristics shall be as specified in Table 5. All dimensional characteristics are considered defective when out of tolerance.

4.4.3 Fluorescent Penetrant Inspection

A random sample shall be selected from each production inspection lot: the size of the sample shall be as specified in Table 4 and classified as in Table 5. The sample units may be selected from those that have been subjected to and passed the visual and dimensional inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.4 Stress-Rupture Test

A random sample of a minimum of one part (or one test specimen where required) shall be selected from each production inspection lot.

4.4.5 Macroscopic Examination

A random sample of one part shall be selected from each production inspection lot.

4.4.6 Destructive Tests

A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 6. The sample units may be selected from those that have been subjected to and passed the nondestructive tests and the fluorescent penetrant inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.7 Acceptance Quality

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

4.4.8 Test Specimens

Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E 8. Specimens shall be machined from finished parts or coupons of the same lot of alloy and be processed together with the parts they represent. Specimens shall be machined from the center of parts.

4.5 Reports

The vendor of parts shall furnish with each shipment a report stating that the chemical composition of the parts conforms to the applicable material specification, showing the results of tests to determine conformance to the room temperature ultimate tensile property, hardness, ultimate shear property where applicable, and stress-rupture strength requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS7471D (or AS7471-1D, as applicable), lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.6 Rejected Lots

If a production inspection lot is rejected, the vendor of parts may perform corrective action to screen out or rework the defective parts, and resubmit for acceptance tests inspection as in Table 3, or scrap the entire lot. Resubmitted lots shall be clearly identified as reinspected lots.

5. PREPARATION FOR DELIVERY

5.1 Packaging and Identification

5.1.1 Packaging shall be in accordance with ASTM D 3951.

5.1.2 Parts having different part numbers shall be packed in separate containers.

5.1.3 Each container of parts shall be marked to show not less than the following information:

BOLTS (SCREWS), NICKEL ALLOY, CORROSION AND HEAT RESISTANT
AS7471 (OR AS7471-1, as applicable)
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.4 Threaded fasteners shall be suitably protected from abrasion and chafing during handling, transportation, and storage.

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 modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Hardness conversion tables for metals are presented in ASTM E 140.

8.2 Key Words

Bolts, Screws, Procurement Specification

8.3 The change bar (|) 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.

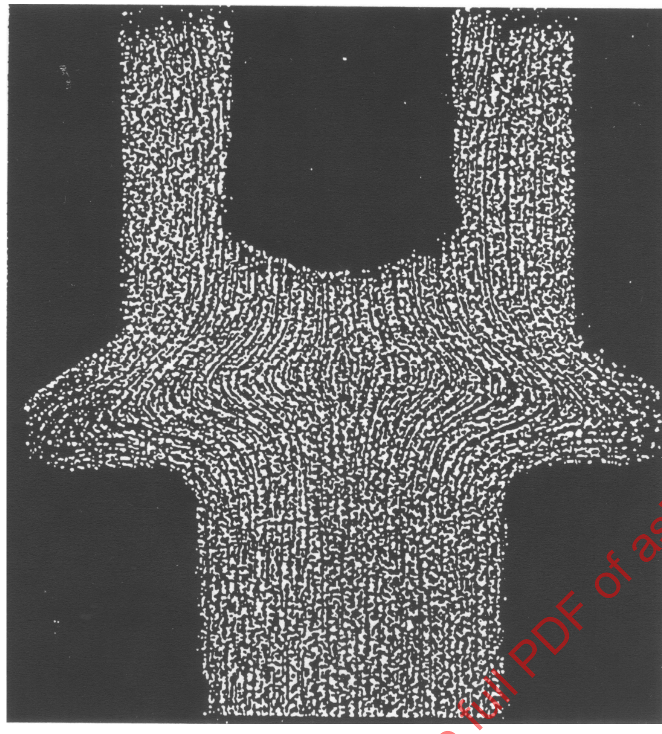


FIGURE 1 - TYPICAL VIEW OF DOUBLE HEXAGONAL BOLT WITH SATISFACTORY GRAIN FLOW, HEADED BLANK, BEFORE HEAT TREATMENT SHOWING A SMOOTH, WELL FORMED GRAIN FLOW FOLLOWING THE CONTOUR OF THE HEAD-TO-SHANK FILLET RADIUS

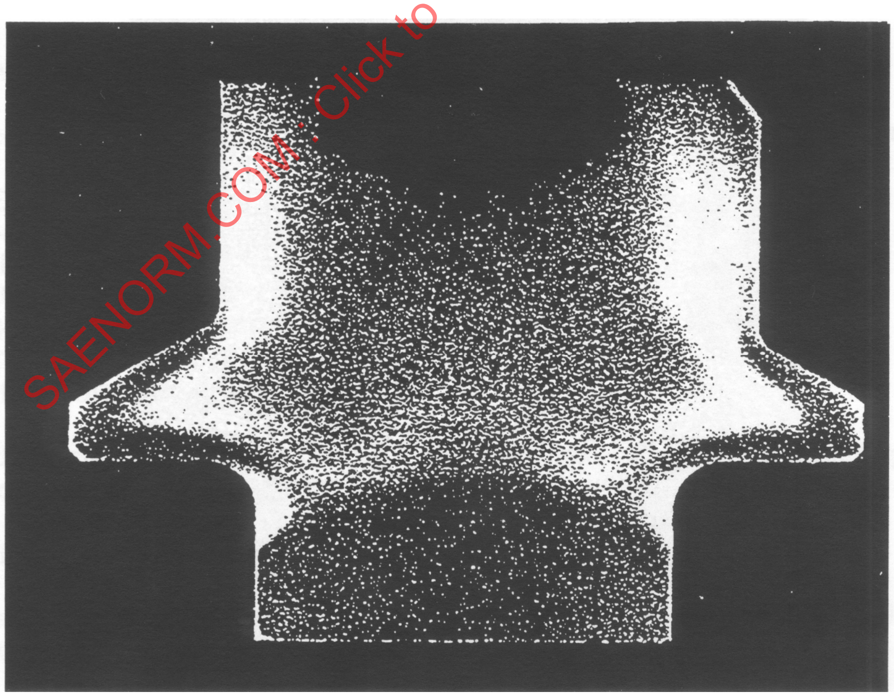
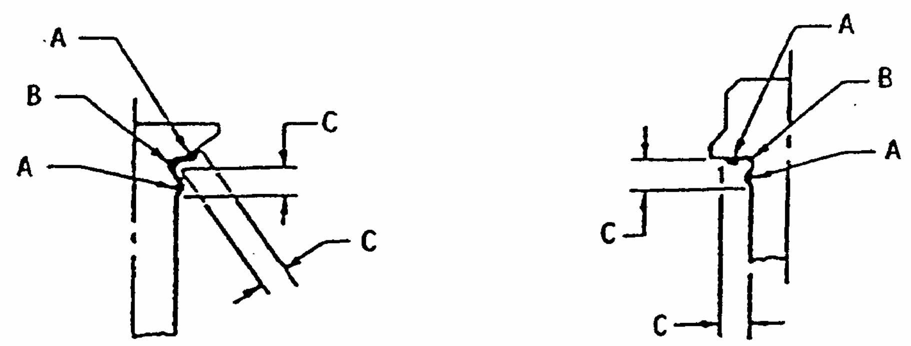


FIGURE 1A - TYPICAL VIEW OF DOUBLE HEXAGONAL BOLT WITH SATISFACTORY HEAT PATTERN, HEADED BLANK, BEFORE HEAT TREATMENT



Nominal Bolt Diameter, inch	C, max inch
Up to 0.3125, excl	0.062
0.3125 & 0.375	0.094
0.4375 to 0.625, incl	0.125
0.750 to 1.000, incl	0.156
Over 1.000	0.188

FIGURE 2 - PERMISSIBLE DISTORTION FROM FILLET WORKING

FIGURE 3 - FLOW LINES, ROLLED THREAD

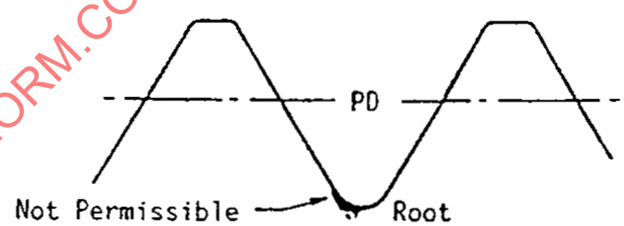


FIGURE 4 - ROOT DEFECTS, ROLLED THREAD

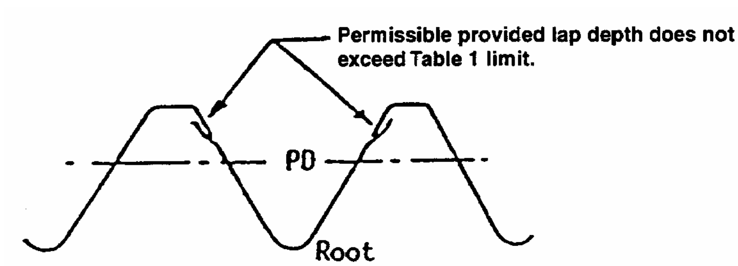


FIGURE 5 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS CREST, ROLLED THREAD

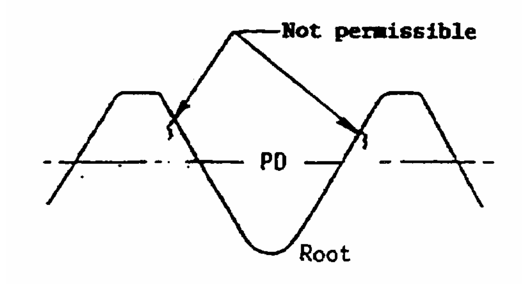


FIGURE 6 - LAPS ABOVE PD EXTENDING TOWARD ROOT, ROLLED THREAD

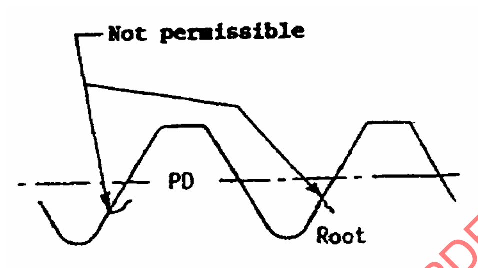


FIGURE 7 - LAPS BELOW PD EXTENDING IN ANY DIRECTION, ROLLED THREAD

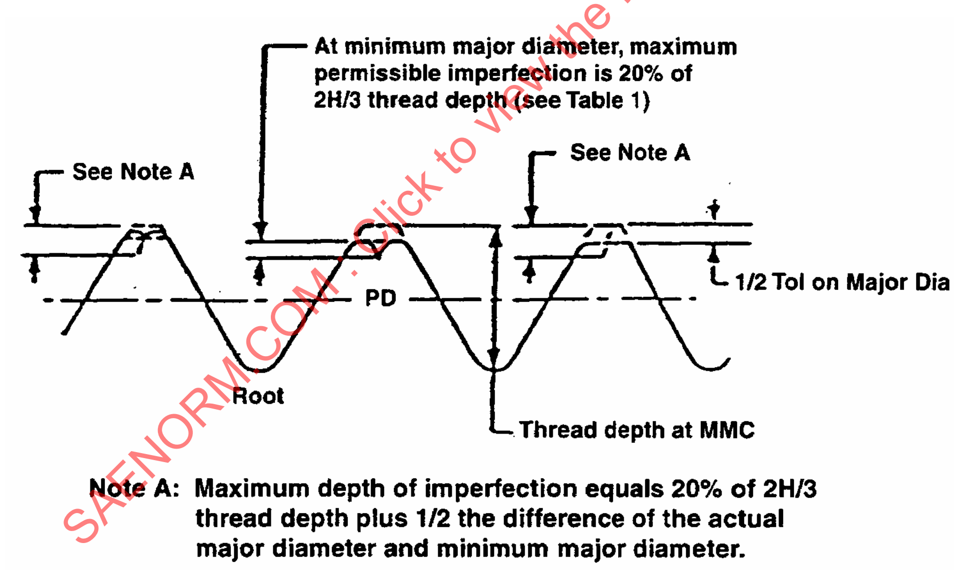


FIGURE 8 - CREST CRATERS AND CREST LAPS, ROLLED THREAD

TABLE 1 - UNJ EXT THREAD DEPTH AT 2H/3 AND ALLOWABLETHREAD LAP DEPTHS

Thread Pitches Per Inch n	UNJ External Thread Depth at 2H/3 inch	Allowable Thread Lap Depth inch
80	0.0072	0.0014
72	0.0080	0.0016
64	0.0090	0.0018
56	0.0103	0.0021
48	0.0120	0.0024
44	0.0131	0.0026
40	0.0144	0.0029
36	0.0160	0.0032
32	0.0180	0.0036
28	0.0206	0.0041
24	0.0241	0.0048
20	0.0289	0.0058
18	0.0321	0.0064
16	0.0361	0.0072
14	0.0412	0.0082
13	0.0444	0.0089
12	0.0481	0.0096
11	0.0525	0.0105
10	0.0577	0.0115
9	0.0642	0.0128
8	0.0722	0.0144

Note 1 - Allowable lap depth is based on 20% of UNJ external thread depth at 2H/3 in accordance with AS8879, and is calculated as follows:

Ext thread depth = 2H/3 = (2/3) (cos 30°)/n = 0.57735/n
Lap depth = 0.2(2H/3) = 0.2(2/3)(cos 30°)/n = 0.115447/N

TABLE 2A - TEST LOADS FOR BOLTS

Thread Size	Ultimate Tensile Strength Test Load, lbf, minimum Standard Pitch Dia UN and UNJ Threads	Ultimate Tensile Strength Test Load, lbf, minimum Reduced Pitch Dia UN Threads Only	Stress-Rupture Strength Test Load lbf, maximum Standard Pitch Dia UN and UNJ Threads	Stress-Rupture Strength Test Load lbf, maximum Reduced Pitch Dia UN and UNJ Threads Only	Ultimate Double Shear Test Load lbf, minimum Room Temp.
0.1120 - 40	995	928	390	361	1950
0.1120 - 48	1090	1020	440	410	1950
0.1380 - 32	1500	1420	585	550	2960
0.1380 - 40	1670	1590	670	641	2960
0.1640 - 32	2310	2210	930	886	4180
0.1640 - 36	2430	2320	994	949	4180
0.1900 - 32	3300	3180	1360	1300	5610
0.2500 - 28	6000	5840	2500	2430	9720
0.3125 - 24	9580	9370	4020	3030	15,200
0.3750 - 24	14,500	14,200	6180	6060	21,900
0.4375 - 20	19,600	19,300	8340	8200	29,800
0.5000 - 20	26,400	26,000	11,300	11,200	38,900
0.5625 - 18	33,500	33,100	14,400	14,200	49,200
0.6250 - 18	42,200	41,800	18,300	18,100	60,700
0.7500 - 16	61,500	61,000	26,700	26,500	87,500
0.8750 - 14	84,100	63,400	36,500	36,200	119,000
1.0000 - 12	109,400	108,700	47,500	47,200	155,500

NOTE 1: Requirements above apply to parts with UNC, UNF, UNJC, or UNJF threads, as applicable for the sizes shown, to Class 3A tolerances; requirements for reduced pitch diameter parts are based on 0.003 inch reduction below standard. The diameter of the area upon which stress for ultimate tensile strength test load is based is the UNJ basic minor diameter at 0.5625H thread depth, where H is the height of sharp V-thread, calculated from Equation 1:

$$\text{Std PD } A_1 = 0.7854\,[d - 1.125H]^2 = 0.7854\,[d - (0.9743/n)]^2 = 0.7854\,[d - (0.9743p)]^2 \quad \text{(Eq. 1)}$$

$$\text{Reduced PD } A_2 = 0.7854\,[d - 0.003 - 1.125H]^2 = 0.7854\,[d - 0.003 - (0.9743/n)]^2 = 0.7854\,[d - 0.003 - (0.9743p)]^2 \quad \text{(Eq. 2)}$$

where:

A_1 = area at the UN basic pitch diameter at 0.5625H thread depth, in^2
A_2 = area at the UN reduced basic pitch diameter at 0.5625H thread depth, in^2
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch
P = pitch (1/n)

The diameter of the area upon which stress for stress-rupture strength test load requirements is based is the area at 17h/24 thread depth below the basic major diameter and calculated from Equation 3:

$$\text{Std PD } A_3 = 0.7854\,[d - (17H/12)]^2 = 0.7854\,[d - (1.2269/n)]^2 = 0.7854\,[d - (1.2269)]^2 \quad \text{(Eq. 3)}$$

$$\text{Reduced PD } A_4 = 0.7854\,[d-0.003 - (17H/12)]^2 = 0.7854\,[d - 0.003 - (1.2269/n)]^2 = 0.7854\,[d-0.003 - (1.2269)]^2 \quad \text{(Eq. 4)}$$

where:

A_3 = area at 17H/24 thread depth for standard PD, in^2
A_4 = area at 17H/24 thread depth for reduced PD, in^2
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch
P = pitch (1/n)

NOTE 1 (Continued):