SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS7467 | REV. B

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Superseding AS7467A

Bolts and Screws, Nickel Alloy, UNS N07718
Tensile Strength 185 ksi
Stress Rupture Rated
Procurement Specification

FSC 5306

RATIONALE

Update all references including update to AS8879 thread specification, clarify requirements for cold working the under head filet radius, and general editorial update.

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 N07718. The following specification designations and their properties are covered:

AS7467 185 ksi minimum ultimate tensile strength at room temperature
145 ksi minimum ultimate tensile strength at 1200 °F
100 ksi stress rupture strength at 1200 °F

AS7467-1 185 ksi minimum ultimate tensile strength at room temperature
111 ksi minimum ultimate shear strength at room temperature

1.2 Application

Primarily for aerospace propulsion systems applications where a good combination of tensile strength, stress rupture strength, and resistance to relaxation is required for use up to approximately 1200 °F; also, where a good combination of tensile strength, and shear strength 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 take necessary precautionary measures to ensure the health and safety of all personnel involved.

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SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AS7467B

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

AMS2750	Pyrometry
AMS5662	Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings, and Rings 52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe, Consumable Electrode or Vacuum Induction Melted, 1775 °F (968 °C) Solution Heat Treated, Precipitation-Hardenable
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 Root Radius and 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
NASM1312-11	Fastener Test Methods, Method 10,Stress Rupture
NASM1312-13	Fastener Test Methods, Method 13, Double Shear Test
NASM1312-18	Fastener Test Methods, Method 18, Elevated Temperature Tensile Strength

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 D3951	Commercial Packaging
ASTM E8/E8M	Standard Test Methods for Tension Testing of Metallic Materials
ASTM E21	Elevated Temperature Tension Tests of Metallic Materials

ASTM E112 Determining Average Grain Size

ASTM E139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

ASTM E140 Standard Hardness Conversion Tables for Metals, Relationship Among Brinell Hardness, Vickers Harness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Sclerscope Hardness

ASTM E1417/E1417M Standard Practice for Liquid Penetrant Testing

2.1.4 ASME Publication

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 a 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 of product with specified requirements.

DEFECTIVE: A unit of 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 shank caused by the 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 inch 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 inclusions that have been extended during the rolling process.

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 and Abbreviations

°C - degree, Celsius
°F - degree Fahrenheit
HRC - hardness Rockwell C scale
lbf - pounds force
% - percent (1% = 1/100)
sp gr - specific gravity
ksi - kips (1000 pounds) per square inch

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be AMS5662 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 hot or cold forging; temperature for hot forging blanks shall be within the range of 1650 to 2000 °F. 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

Headed blanks, before finishing the shank and the bearing surface of the head, cold rolling the head-to-shank fillet radius, and rolling the threads, shall be solution heat treated as follows; precipitation heat treatment shall follow cold working 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 AMS2750. 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 1725 to 1850 °F, holding at the selected temperature within ±25 °F for 1 hour ± 0.1 hour, and quenching in oil, water, or an inert gas.

3.3.2.3 Precipitation Heat Treatment

After cold working 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 1325 °F ± 15 °F in a controlled atmosphere, holding at heat for 8 hours ± 0.25 hour, furnace cooling at 100 °F ± 15 °F per hour to 1150 °F ± 15 °F, holding at 1150 °F ± 15 °F for 8 hours ± 0.25 hour and cooling at a rate equivalent to air cool. Instead of the 100 °F per hour cooling rate to 1150 °F ± 15 °F, parts may be furnace cooled at any rate provided the time at 1150 °F ± 15 °F is adjusted to give a total precipitation heat treatment time of approximately 18 hours.

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 heat treated blanks prior to cold working 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.

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. The cold rolling shall be sufficient 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 inch above the contour at “A” or depress metal more than 0.002 inch 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 bolts, 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 working 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.

3.3.5 Thread Rolling

Threads shall be formed on the finished, solution heat treated blanks by a single cold 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 minutes at room temperature.

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

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

Immediately after removal from the cleaning solution, 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 not more than 0.010 inch maximum, with rounded root form on depressed characters.

3.5 Plating

Where required, surfaces shall be plated as specified by the part drawing; plating thickness determined in accordance with plating specification.

3.6 Mechanical Properties

Where AS7467 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, 3.6.3, and 3.6.4. Where AS7467-1 is specified, parts shall conform to the requirements of 3.6.1, 3.6.3, and 3.6.5. 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.

AS7467 finished parts shall be tested in accordance with the following applicable test methods:

a. Hardness: MIL-STD-1312-6 in accordance with NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: MIL-STD-1312-8 in accordance with NASM1312-8

c. Ultimate Tensile Strength at 1200 °F: MIL-STD-1312-18 in accordance with NASM1312-18

d. Stress Rupture Strength at 1200 °F: MIL-STD-1312-10 in accordance with NASM1312-10

AS7467-1 finished parts shall be tested in accordance with the following test methods:

a. Hardness: MIL-STD-1312-6 in accordance with NASM1312-6

b. Ultimate Tensile Strength at Room Temperature: MIL-STD-1312-8 in accordance with NASM1312-8

c. Ultimate Shear Strength at Room Temperature: MIL-STD-1312-13 in accordance with 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 fracture 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 minimum pitch diameter or having an undercut, parts shall have an ultimate tensile strength not lower than 185 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 Machine Test Specimens

If the size or shape of the part is such that a tensile test cannot be made on the part, tensile tests shall be conducted in accordance with ASTM E8/E8M on specimens as in 4.5.8. Specimens may be required by purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 185 ksi

b. Yield Strength at 0.2% Offset, minimum: 150 ksi

c. Elongation in 4D, minimum: 12%

d. Reduction of Area, minimum: 15%

3.6.2 Ultimate Tensile Strength at 1200 °F

3.6.2.1 Finished Parts

Tension bolts heated to 1200 °F ± 5 °F, held at heat for 20 minutes before testing, and tested at 1200 °F ± 5 °F, shall have an ultimate tensile load not lower than the value specified in Table 2A and shall be tested to failure in order to observe fracture location, first measuring and recording the maximum tensile load achieved. If the size or shape of the part is such that failure would occur outside the threaded section but the part can be tested satisfactorily, such as parts having a shank diameter equal to or less than the minimum pitch diameter or having an undercut, parts shall have an ultimate tensile strength not lower than 145 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. Screws, such as 100 degree flush head, pan head, and fillister head, are not required to be tested for tensile strength at 1200 °F.

3.6.2.2 Machined Test Specimens

If the size or shape of the part is such that a tensile test cannot be made on the part, tensile tests shall be conducted in accordance with ASTM E21 on specimens as in 4.5.8. Specimens may be required by purchaser to perform confirmatory tests. Such specimens shall meet the following requirements when heated to 1200 °F ± 5 °F, held at heat for not less than 20 minutes before testing, and tested at 1200 °F ± 5 °F:

a. Ultimate Tensile Strength, minimum: 145 ksi

b. Yield Strength at 0.2% Offset, minimum: 125 ksi

c. Elongation in 4D, minimum: 12%

d. Reduction of Area, minimum: 15%

3.6.3 Hardness

Shall be uniform and within the range 36 to 46 HRC (see 8.1), but hardness of the threaded section and of the head-to-shank fillet area 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.

3.6.4 Stress Rupture Strength at 1200 °F

3.6.4.1 Finished Parts

Finished tension bolts, maintained at 1200 °F ± 3 °F while the tension load specified in Table 2A is applied continuously, shall not rupture in less than 23 hours. If the shank diameter of the bolt is less than the minimum pitch diameter of the thread but the bolt can be tested satisfactorily, bolts shall conform to the requirements of 3.6.4.1.1. Screws, such as 100 degree flush head, pan head, and fillister head, are not required to be tested for stress rupture strength at 1200 °F.

3.6.4.1.1 Bolts having a shank diameter less than the minimum pitch diameter of the thread shall be tested as in 3.6.4.1 except that the load shall be as specified in 3.6.4.2. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.

3.6.4.2 Machined Test Specimens

If the size or shape of the bolt is such that a stress rupture test cannot be made on the bolt, a test specimen prepared as in 4.5.8, maintained at 1200 °F ± 3 °F while a load sufficient to produce an initial axial stress of 100 ksi is applied continuously, shall not rupture in less than 23 hours. Tests shall be conducted in accordance with ASTM E139. Specimens may be required by purchaser to perform confirmatory tests.

3.6.5 Ultimate Shear Strength

Finished parts having a close tolerance 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 double shear load based on 111 ksi minimum shear strength. Shear tests are not required for screws, such as 100 degree flush head, having a grip less than 2.5 times the nominal diameter or protruding head screws, such as pan head and fillister head, having a grip 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 tolerance 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), from foreign materials, and from imperfections detrimental to the usage of the part.

3.7.1 Macroscopic Examination, Headed Blank

A specimen cut from a headed blank shall be etched in a suitable etchant 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 shall show flow lines or heat pattern in the shank, head-to-shank fillet, and bearing surface which follow the contour of the blank as shown in Figure 1 or Figure 1A. 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 be as agreed upon by purchaser and vendor.

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 Kalling's reagent, Marble's reagent, or other suitable etchant, and examined at a magnification not lower than 100X 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

3.7.2.1.1 Head-to-Shank, Finished Part

Examination of a longitudinal section through the part shall show evidence that the heads were formed by forging (see Figure 1A).

3.7.2.1.2 Threads

Examination of a longitudinal section through the threaded portion of the shank shall show evidence that the threads were rolled (see Figure 3).

3.7.2.2 Internal Defects

Examination of longitudinal sections of the head and shank 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

The grain size shall be ASTM No. 3 or finer, determined in accordance with the comparative method of ASTM E112. In case of disagreement, 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 working 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, roughness, and oxide scale are not permissible (see Figure 4).

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

3.7.2.6.3 Single Lap 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 nonpressure flank (one lap at any cross-section through the thread) provided it extends toward the crest and 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 diameter, 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 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 E1417/E1417M, Type I, 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 inch 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.

4.4 Classification of Tests

a. Acceptance tests which are to be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.

b. Periodic tests which are to be performed periodically on production lots at the discretion of the vendor or purchaser. Ultimate tensile strength test at 1200 °F as in 3.6.2 is classified as a periodic test and shall be performed when requested by the purchaser.

4.5 Acceptance Test Sampling

4.5.1 Material

Sampling for material composition on each heat shall be in accordance with AMS5662.

4.5.2 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 4. The classification of dimensional characteristics shall be as specified in Table 5. All dimensional characteristics are considered defective when out of tolerance.

4.5.3 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.

4.5.4 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.

4.5.5 Macroscopic Examination

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

4.5.6 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.

4.5.7 Acceptance Quality

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

4.5.8 Test Specimens

Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E8/E8M. 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.

4.6 Periodic Test Sampling

As agreed upon by purchaser and vendor.

4.7 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, ultimate shear property where applicable, hardness, and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS7467B, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.8 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 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 D3951.

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:

FASTENERS, NICKEL BASE ALLOY, UNS N07718, STRESS-RUPTURE RATED
AS7467 (or AS7467-1, as applicable)
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.4 Threaded fasteners shall be 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

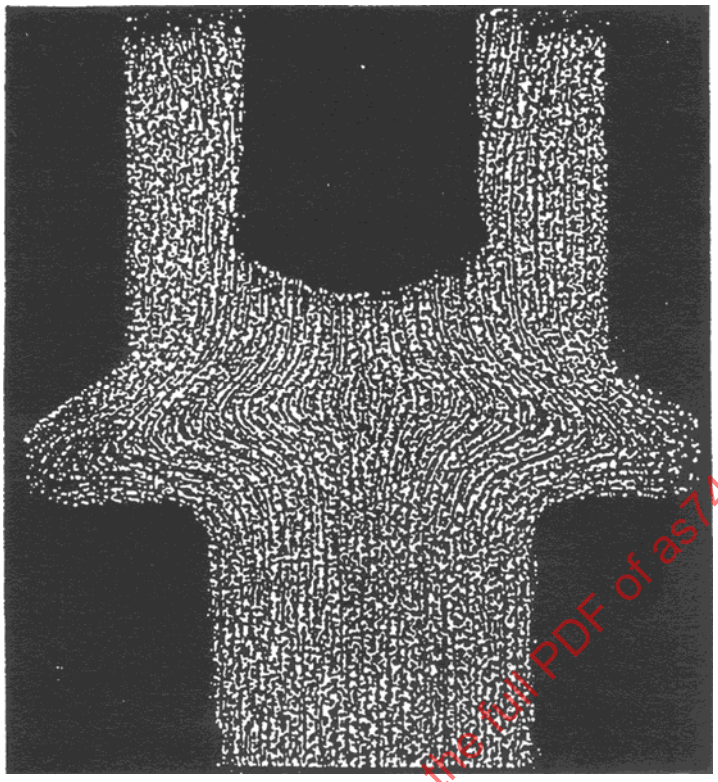
Parts not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Hardness conversion tables for metals are presented in ASTM E140.

8.2 A change bar (l) 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.

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



Showing a smooth, well formed grain flow following the contour of the head-to-shank fillet radius.

FIGURE 1 - SATISFACTORY GRAIN FLOW, HEADED BLANK, BEFORE HEAT TREATMENT

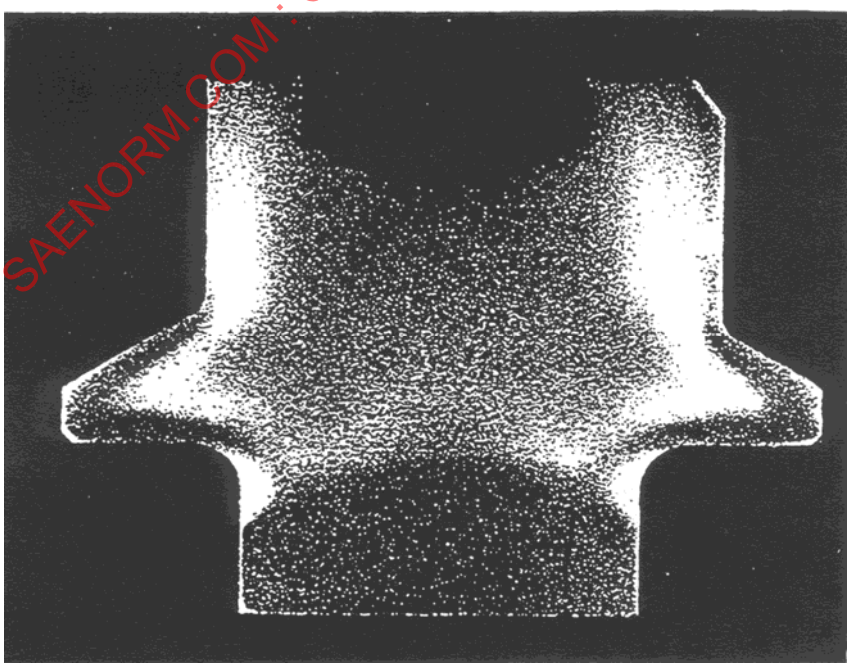
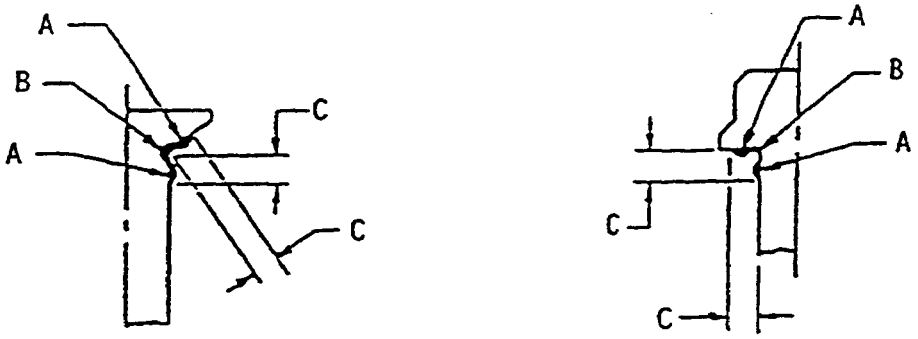


FIGURE 1A - SATISFACTORY HEAT PATTERN, HEADED BLANK, BEFORE HEAT TREATMENT AND FINISHED PART



Nominal Bolt Diameter, inch	C max inch
Up to 0.3125, excl	0.062
0.3125 and 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

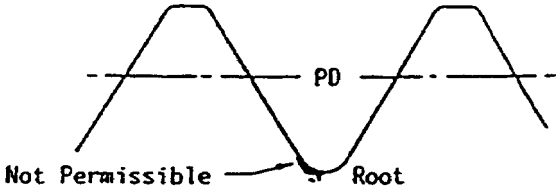


FIGURE 4 - ROOT DEFECTS, ROLLED THREAD

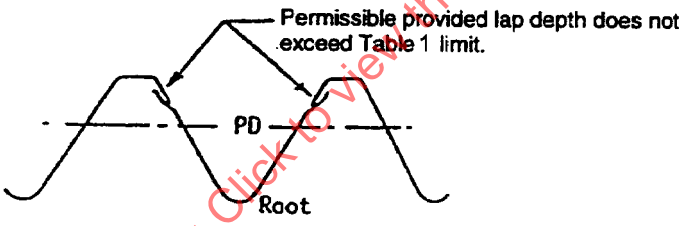


FIGURE 5 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS CREST, ROLLED THREAD

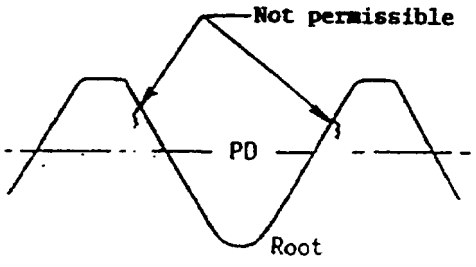


FIGURE 6 - LAPS ABOVE PD EXTENDING TOWARD ROOT, ROLLED THREAD

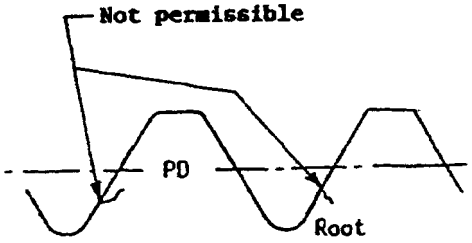
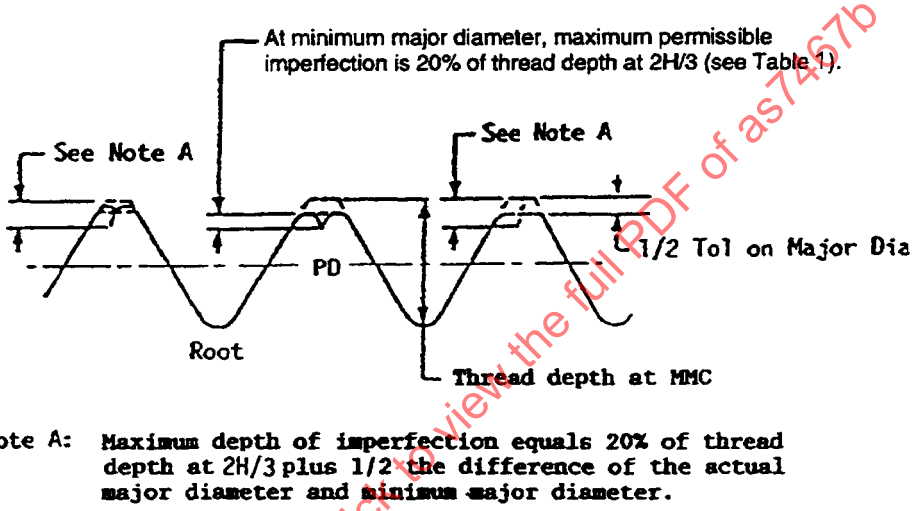


FIGURE 7 - LAPS BELOW PD EXTENDING IN ANY DIRECTION, ROLLED THREAD



Note A: Maximum depth of imperfection equals 20% of thread depth at 2H/3 plus 1/2 the difference of the actual major diameter and minimum major diameter.

FIGURE 8 - CREST CRATERS AND CREST LAPS, ROLLED THREAD

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

Thread Pitches Per Inch n	UNJ Ext Thread Depth at 2H/3 inch	Allowable Thread Lap Depth inch
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 upon 20% of UNJ external thread depth at 2H/3 in accordance with MIL-S-8879, and is calculated as follows:

Ext thd depth = 2H/3 = (2/3) (cos 30°)/n = 0.57735/n
Lap depth = 0.2(2H/3) = 0.2(2/3)(cos 30°)/n = 0.11547/n

TABLE 2A - TEST LOADS FOR BOLTS

Thread Size UNJC, UNJF Class 3A	Ultimate Tensile Strength Test Load, lbf min Room Temp.	Ultimate Tensile Strength Test Load, lbf min at 1200 °F	Stress Rupture Test Load lbf max at 1200 °F	Ultimate Double Shear Test Load lbf min Room Temp.
0.112 -40	1116	875	553	2187
0.112 -48	1222	958	607	2187
0.138 -32	1681	1317	816	3320
0.138 -40	1876	1471	935	3320
0.164 -32	2592	2031	1285	4690
0.164 -36	2725	2135	1367	4690
0.190 -32	3699	2899	1861	6294
0.250 -28	6729	5274	3423	10897
0.3125-24	10740	8420	5490	17030
0.375 -24	16250	12740	8392	24520
0.4375-20	21960	17210	11330	33370
0.500 -20	29590	23190	15360	43590
0.5625-18	37550	29430	19510	55170
0.625 -18	47350	37110	24700	68110
0.750 -16	69000	54080	36090	98080
0.875 -14	94250	73870	49330	133500
1.000 -12	122700	96140	64150	174400

NOTE 1: Requirements above apply to parts with UNJC or UNJF threads as applicable for thread sizes shown, to Class 3A tolerances. 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:

$$A_1 = .7854(d - 1.125H)^2 = 0.7854[d - (0.9743/n)]^2 \quad \text{(Eq.1)}$$

where, A_1 = area at UNJ basic minor diameter at 0.5625H thread depth
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch

The diameter of the area upon which stress for stress rupture strength test load requirements is based is the area at the maximum minor (root) diameter for UNJ thread at 2H/3 thread depth, calculated from Equation 2:

$$A_2 = 0.7854[d - (4H/3)]^2 = 0.7854[d - (1.1547/n)]^2 \quad \text{(Eq.2)}$$

where, A_2 = area at maximum minor (root) diameter of UNJ thread at 2H/3 thread depth
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch

NOTE 1 (Continued):

The diameter of the area upon which stress for ultimate double shear test load requirements is based is the nominal diameter of the close tolerance full shank bolt (see AS1132), calculated from Equation 3:

$$A_3 = 0.7854(d)^2 \quad \text{(Eq.3)}$$

where, A_3 = area of the nominal close tolerance shank diameter
d = nominal diameter of close tolerance full shank

Load requirements are based on:

185 ksi for ultimate tensile strength test load, minimum, room temperature
145 ksi for ultimate tensile strength test load, minimum, 1200 °F
100 ksi for stress rupture strength test load, 1200 °F
111 ksi for ultimate double shear test load, minimum, room temperature

Test loads are computed as follows:

$185000A_1$ = bolt ultimate tensile strength test load at room temperature
$145000A_1$ = bolt ultimate tensile strength test load at 1200 °F
$100000A_2$ = bolt stress rupture test load at 1200 °F
$111000(2A_3)$ = bolt and screw ultimate double shear test load

NOTE 2: For UNJ sizes not shown, ultimate tensile strength test load, stress rupture strength test load, and ultimate double shear test load for parts tested as parts, not as specimens machined from parts or coupons of stock, shall be based upon the respective areas and stresses given in Note 1.