SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS7477 REV. E

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Superseding AS7477D

Bolts and Screws, Steel, UNS S66286 Tensile Strength 130 ksi, Procurement Specification

FSC 5306

RATIONALE

Paragraph 3.3.4 changed to ensure correct interpretation is assured, change to correct call up NASM 1312 tests.

1. SCOPE

This document covers bolts and screws made from a corrosion and heat resistant, precipitation hardenable iron base alloy of the type identified under the Unified Numbering System as UNS S66286.

1.1 Type

The following specification designations and their properties are covered:

AS7477: 130 ksi minimum ultimate tensile strength at room temperature

70 ksi stress-rupture strength at 1200 °F

AS7477-1: Inactive for Design

AS7477-2: 130 ksi minimum ultimate tensile strength at room temperature

78 ksi minimum ultimate shear strength at room temperature

1.1.1 Classification

130 ksi minimum tensile strength at room temperature

1200 °F maximum test temperature of parts

1.2 Application

Primarily for aerospace propulsion system applications where a good combination of fatigue resistance, tensile strength, shear strength, and resistance to relaxation at elevated temperatures 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.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

Available from SAE 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.

AMS2759/3 Heat Treatment of Precipitation Hardening, Corrosion Resistant and Maraging Steel Parts

AMS5731 Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant, 15Cr 25.5Ni 1.2Mo 2.1Ti 0.006B 0.30V, Consumable Electrode Melted, 1800 °F (982 °C) Solution Heat Treated

AS1132 Design Parameters for Bolts and Screws, External Wrenching, Unified Thread Inch Series

AS3062 Bolts, Screws, and Studs, Screw Thread Requirements

AS3063 Bolts, Screws, and Studs, Geometric Control Requirements

AS8879 Screw Threads - UNJ Profile, Inch

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 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)

2.1.4 ASTM International 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 E 8 Tension Testing of Metallic Materials

ASTM E 112 Determining Average Grain Size

ASTM E 139 Conducting Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

ASTM E 140 Standard Hardness Tables for Metals

ASTM E 1417 Liquid Penetrant Examination

ASTM D 3951 Commercial Packaging

2.2 Definitions

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

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

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.

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

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

INCLUSION: Nonmetallic particles origination 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.

NON-CONFORMANCE: A departure from a specified requirement for any characteristic.

NON-CONFORMING UNIT: A unit of the product that has one or more non-conformances.

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.

2.3 Unit Symbols and Abbreviations

°C degree Celsius

°F degree Fahrenheit

% percent (1% = 1/100)

lbf pound-force

ksi kips (1000 pounds) per square inch

sp gr specific gravity

HRC hardness, Rockwell C scale

3. TECHNICAL REQUIREMENTS

3.1 Material

Shall be AMS5731 steel 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 shall 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; 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. Heading stock to be hot forged shall be heated to a temperature not higher than 2100 °F.

3.3.2 Heat Treatment: Headed blanks shall, before finishing the shank and the bearing surface of the head, cold rolling the head-to-shank fillet radius, and rolling the threads, conform to the technical requirements and other provisions specified in AMS 2759/3 for A-286, 1800 °F solution treatment and aging treatment.

3.3.2.1 Solution Heat Treatment: Headed blanks of AMS 5731 shall be solution heat treated as in 3.3.2.

3.3.2.2 Aging Treatment: After solution heat treatment as in 3.3.2.1, blanks shall be heat treated by aging as in 3.3.2.

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 aged heat treated blanks prior to cold rolling the 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 Working of Fillet Radius: After removal of oxide as in 3.3.3, the head-to-shank fillet radius of parts having the radius complete throughout the circumference of the part shall be cold worked. The fillet shall be cold worked sufficiently to remove all visual evidence of grinding or tool marks. If there is no visual evidence of grinding or tool marks prior to cold working, the fillet shall still be cold worked. Distortion due to cold working shall conform to Figure 2, unless otherwise specified on the part drawing. It shall not raise metal more than 0.002 inches above the contour at “A” or depress metal more than 0.002 inches 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 working 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 the fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank. The shank diameter on full shank close tolerance bolts shall not exceed its maximum diameter limit after cold rolling the head to shank fillet radius.

3.3.5 Thread Rolling: Thread shall be formed on the finished 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.

3.3.6.1 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 0.010 inch maximum, with rounded root form on depressed characters.

3.5 Plating or Coating

Where required, surfaces shall be plated as specified by the part drawing. Where coating with solid film lubricants is required, the under-head bearing surface, the unthreaded shank, and the 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 requirements in the applicable plating specification.

3.6 Mechanical Properties

Where AS7477 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, and 3.6.3. Where AS7477-2 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.

AS7477 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. Stress-Rupture Strength at 1200 °F: MIL-STD-1312-12 in accordance with NASM1312-12

AS7477-2 finished parts shall be tested in accordance with the following test methods:

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

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

f. Ultimate Double Shear 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: Parts shall have an ultimate tensile load not lower than that specified in Table 1 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 1; 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 root diameter or having an undercut, parts shall have an ultimate tensile strength not lower than 130 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 hexagon, double hexagon or spline drive 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 4.4.7. Specimens may be required by the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 130 ksi

b. Yield Strength at 0.2% Offset, minimum: 85 ksi

c. Elongation in 2 inches or 4D, minimum: 15%

d. Reduction of Area, minimum: 20%

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 24 to 35 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 strength properties specified in 3.6.1 are met.

3.6.3 Stress-Rupture Strength at 1200 °F

3.6.3.1 Finished Parts: Finished tension bolts, maintained at 1200 °F ± 3 °F while the tensile load specified in Table 1 is applied continuously, shall not rupture in less than 23 hours. If the shank diameter of the part is less than the maximum minor (root) diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 3.6.3.1.1. 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.

3.6.3.1.1 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 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 prepared as in 4.4.7, maintained at 1200 °F ± 3 °F while a load sufficient to produce an initial axial stress of 70 ksi is applied continuously, shall not rupture in less than 23 hours. 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: Finish parts having a close toleranced full shank as in AS1132 shall have an ultimate double shear load not lower than that specified in Table 1. The double shear test may be discontinued without a complete shear failure after the ultimate double 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 78 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 test is not required for the following conditions:

a. Bolts having a grip less than 2 times the nominal diameter.

b. Bolts and screws having coarse tolerance full shank.

c. Bolts and screws having a 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 specimen cut from 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 = nominal thread diameter.

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 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 Imperfections: 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 100X magnification 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: 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: Shall be ASTM No. 5 or finer as determined by comparison of the specimen with the chart in ASTM E 112. Up to 25% of the area examined may exhibit a grain size as large as ASTM No. 2. Such areas shall be separated by at least 0.025 inch. Bands of fine or coarse grains are not permitted. In case of disagreement on grain size by 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 the 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 PD: A lap is permissible along the flank of the thread above the pitch diameter on either the pressure or non pressure flank (one lap at any cross-section through the thread) provided it extends towards the crest and generally parallel to the flank (see Figure 5). The lap depth shall not exceed the limit specified in Table 2 for the applicable thread pitch. A lap extending toward the root is not permissible (see Figure 6).

b. Thread Flank Below the PD: 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 2 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 2 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 E 1417, 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.

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, such as quench cracks, 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 in all directions is not less than 0.062 inch.

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 2), 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. Rateable lap indications shall conform to 3.7.2.6.3(a).

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 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 Tests 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 AMS5731.

4.4.2 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.

4.4.3 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 one part (or one specimen where required) shall be selected from each production inspection lot.

4.4.5 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.

4.4.6 Acceptance Quality: Of random samples tested, acceptance quality shall be based on zero defectives.

4.4.7 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.

4.4.8 Macroscopic Examination: A random sample of one part shall be selected from each production lot.

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, and showing the results of tests to determine conformance to the room temperature ultimate tensile property, hardness, double shear test (if required), and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, AS7477 and revision letter, 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 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 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), STEEL, CORROSION AND HEAT RESISTANT
AS7477 (or AS7477-2 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 inspection number in all quotations and when acknowledging purchase orders.

7. REJECTIONS

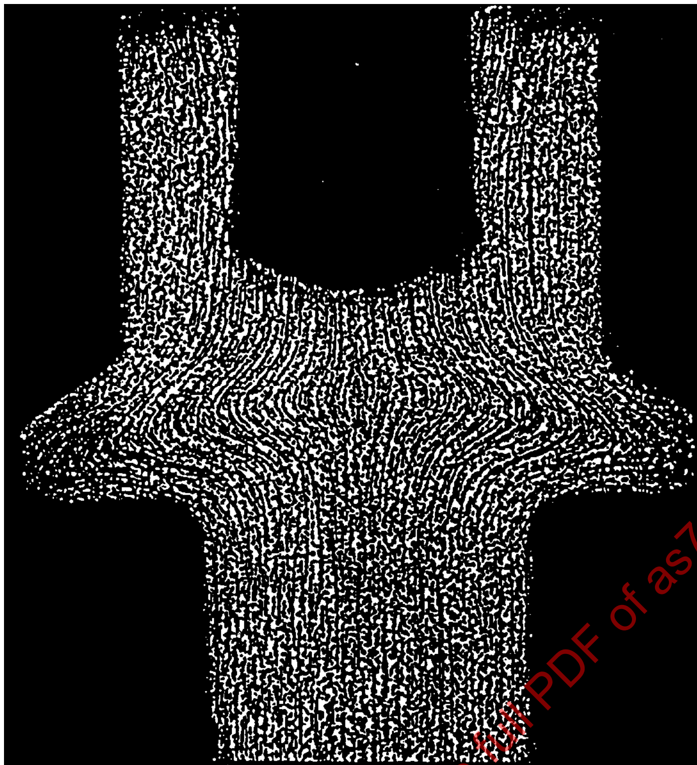
Parts not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 Hardness Conversion Tables

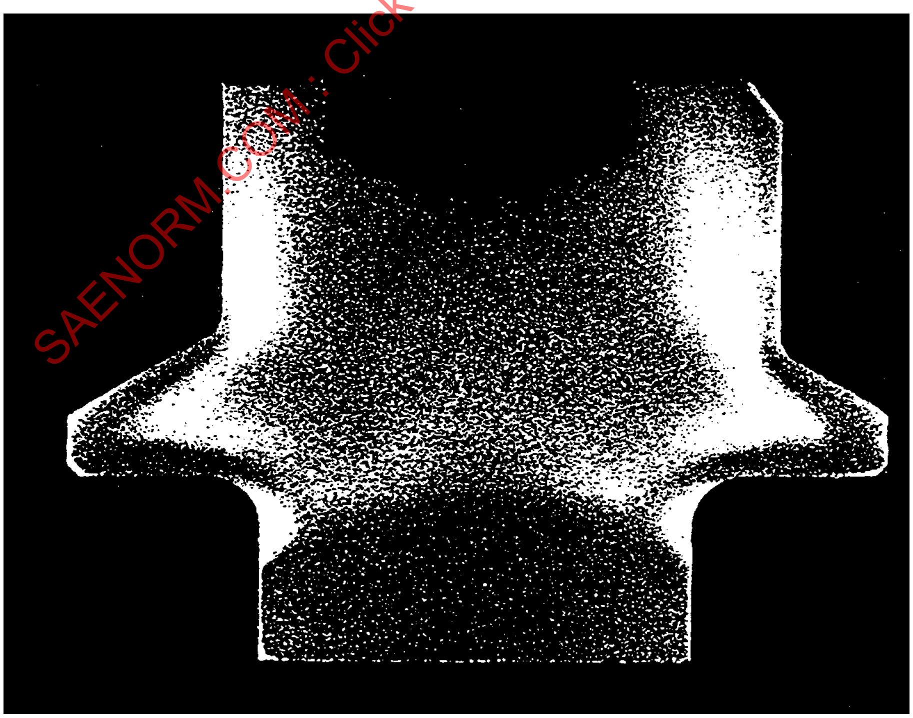
Hardness conversion tables for metals are presented in ASTM E 140.

8.2 A 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, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.



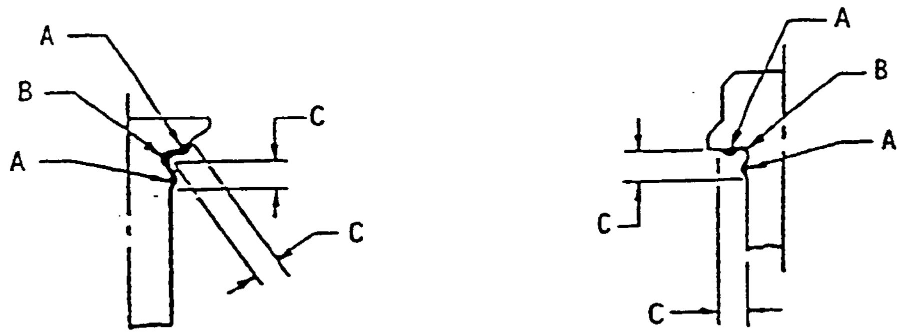
Showing a smooth, well formed grain flow following
the contour of the head-to-shank fillet radius.

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



Shows evidence that head was formed by forging.

FIGURE 1A - SATISFACTORY HEAT PATTERN, HOT HEADED BLANK, BEFORE HEAT TREATMENT



Nominal Bolt Diameter, inch	C max. inch
Less than 0.3125	0.062
0.3125 and 0.3750	0.094
0.4375 and 0.6250	0.125
0.7500 to 1.000	0.156
Greater than 1.000	0.188

FIGURE 2 - PERMISSIBLE DISTORTION FROM FILLET WORKING

FIGURE 3 - FLOW LINES, ROLLED THREAD

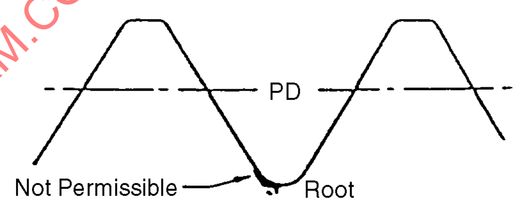


FIGURE 4 - ROOT DEFECTS, ROLLED THREAD

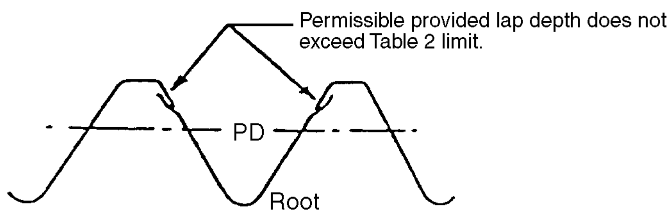


FIGURE 5 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS CREST, ROLLED THREAD

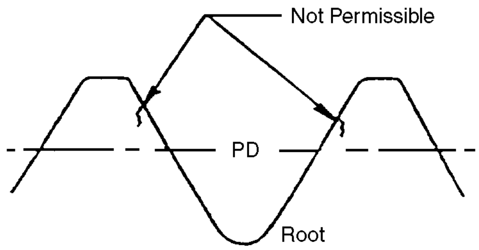


FIGURE 6 - LAPS ABOVE PD EXTENDING TOWARD ROOT, ROLLED THREAD

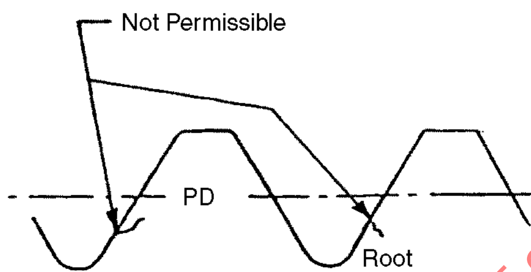


FIGURE 7 - LAPS BELOW PD EXTENDING IN ANY DIRECTION, ROLLED THREAD

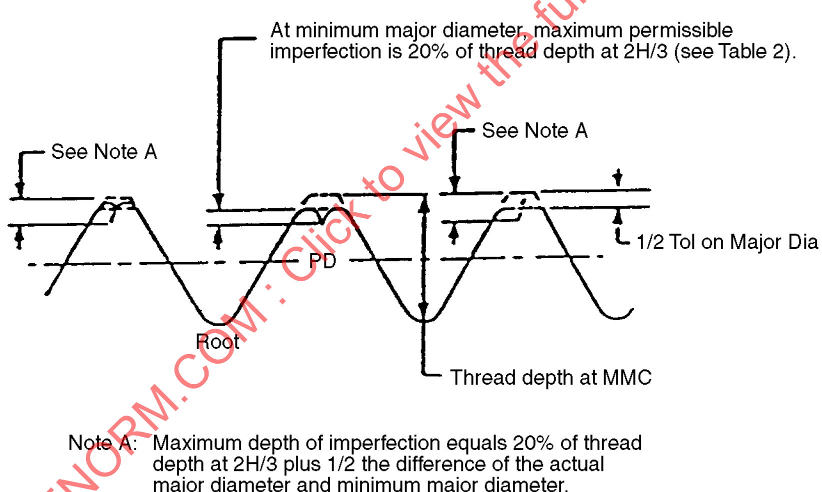


FIGURE 8 - CREST CRATERS AND CREST LAPS, ROLLED THREAD

TABLE 1 – TEST LOADS

Nominal Thread Size	Ultimate Tensile Strength Test Load, lbf min Room Temp. Bolt, Std PD UN and UNJ Threads	Ultimate Tensile Strength Test Load, lbf min Room Temp. Bolt, Red PD UN THD Only	Ultimate Tensile Strength Test Load, lbf min Room Temp. Screw, Std PD UN and UNJ Threads	Stress-Rupture Strength Test Load, lbf at 1200 °F Bolt, Std PD UN and UNJ Thread	Stress-Rupture Strength Test Load, lbf at 1200 °F Bolt, Red PD UN THD Only	Ultimate Double Shear Test Load lbf min Room Temp.
0.112 -40	784	731	627	364	337	1540
0.112 -48	859	803	687	411	383	1540
0.138 -32	1180	1120	945	546	514	2330
0.138 -40	1320	1250	1060	633	598	2330
0.164 -32	1820	1740	1467	868	827	3300
0.164 -36	1920	1830	1530	928	886	3300
0.190 -32	2600	2500	2080	1260	1220	4420
0.250 -28	4730	4600	3780	2340	2270	7660
0.3125-24	7550	7380	6040	3760	3670	12000
0.375 -24	11400	11200	9130	5770	5660	17200
0.4375-20	15400	15200	--	7780	7660	23500
0.500 -20	20800	20500	--	10600	10400	30600
0.5625-18	26400	26100	--	13400	13300	38800
0.625 -18	33300	32900	--	17000	16900	47900
0.750 -16	48500	48100	--	24900	24700	68900
0.875 -14	66200	65700	--	34100	33800	93800
1.000 -12	86200	85600	--	44300	44000	122500

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

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

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

where:

A_1 = area at 0.5625H thread depth, standard PD
A_2 = area at 0.5625H thread depth for reduced PD
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch

TABLE 1 – TEST LOADS (CONT'D)

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 as follows:

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

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

where:

A_3 = area at 17H/24 thread depth below basic major diameter, std PD
A_4 = area at 17H/24 thread depth for reduced PD
d = maximum major diameter
H = height of sharp V-thread = (cos 30°)/n
n = number of thread pitches per inch

Area upon which stress for ultimate double shear strength test load requirements is based is twice the area at the nominal shank diameter which is equal to the basic major diameter of the thread, calculated as follows:

$$A_5 = 0.7854(d)^2 \quad \text{(Eq. 5)}$$

where:

A_5 = area of nominal full shank diameter = basic major diameter of thd
d = nominal shank diameter = basic major diameter of thread

Load requirements are based on:

A_1 x 130000 psi for bolts, ultimate tensile strength, std PD
A_2 x 130000 psi for bolts, ultimate tensile strength, red PD
k(A_1 x 104000 psi) for screws, ultimate tensile strength, std thd
A_3 x 70000 psi for bolts, stress-rupture strength, std PD
A_4 x 70000 psi for bolts, stress-rupture strength, red PD
2(A_5 x 78000 psi) for ultimate double shear strength

k = 1.0 for pan head or fillister head screws
k = 0.8 for normal 100° flush head screws
k = 0.5 for reduced 100° flush head screws without a drive recess
k = 0.45 for reduced 100° flush head screws with a drive recess

NOTE 2: For sizes not shown and for parts other than Class 3A tolerances, test loads for ultimate tensile strength, stress-rupture strength, and ultimate double shear strength for parts tested as parts, not as specimens machined from parts or from coupons of the stock, shall be based upon the respective areas and stresses given in Note 1.