SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS4959

Issued 1997-10
Reaffirmed 2012-11

Bolts and Screws, Steel, UNS S66286
Tensile Strength 140 ksi
1650 °F Solution Heat Treatment
Aged Before Fillet and Thread Rolling
Procurement Specification

FSC 5306

RATIONALE

AS4959 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Type:

This procurement specification covers bolts and screws made from a corrosion and heat resistant, age hardenable iron base alloy of the type identified under the Unified Numbering System as UNS S66286. The following specification designations and their properties are covered:

AS4959	140 ksi minimum ultimate tensile strength at room temperature 70 ksi stress-rupture strength at 1200 °F
AS4959-1	140 ksi minimum ultimate tensile strength at room temperature 84 ksi minimum ultimate shear strength at room temperature

1.2 Application:

Primarily for aerospace propulsion system applications where a good combination of tensile strength, shear strength, stress-rupture strength, and resistance to relaxation at elevated temperature is required.

1.3 Safety - Hazardous Materials:

While the materials, 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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http://www.sae.org/technical/standards/AS4959

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2759/3	Heat Treatment of Precipitation Hardening, Corrosion Resistant and Maraging Steel Parts
AMS 5734	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant 15Cr 25.5Ni 1.2Mo 2.1Ti 0.006B 0.30V Consumable Electrode Melted, 1650°F (900°C), Solution 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

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

ISO 3161	Aerospace - UNJ threads with controlled root radius, for aerospace - Inch series
ISO 9001	Quality systems - Model for quality assurance in design, development, production, installation and servicing
ISO 9002	Quality systems - Model for quality assurance in production and installation

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

MIL-STD-1312-6	Fastener Test Methods, Method 6, Hardness
MIL-STD-1312-8	Fastener Test Methods, Method 8, Tensile Strength
MIL-STD-1312-10	Fastener Test Methods, Method 10, Stress-Rupture
MIL-STD-1312-13	Fastener Test Methods, Method 13, Double Shear Test

2.1.4 ASTM Publications: Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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

2.1.5 ASME Publication: Available from ASME, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900.

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

3. DEFINITIONS:

3.1 BURR:

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

3.2 CRACK:

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

3.3 DEFECT:

Any nonconformance of the unit of product with specified requirements.

3.4 DEFECTIVE:

A unit of product which contains one or more defects.

3.5 DISCONTINUITY:

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

3.6 FINISHED PART:

A part ready for use, inclusive of any possible treatments and/or surface coatings, as specified on the part drawing.

3.7 HEAT PATTERN:

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

3.8 INCLUSION:

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

3.9 LAP:

Surface defect 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.

3.10 PART DRAWING:

Document specifying all the requirements for the part, i.e., metallurgical, geometrical and dimensional, mechanical properties and testing, ND inspection, etc.

3.11 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.

3.12 SEAM:

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

SIMPLE RANDOM SAMPLING:

The taking of n items from a population of N items in such a way that all possible combinations of n items have the same probability of being chosen.

3.13 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.

3.14 Unit Symbols and Abbreviations:

° - degree, angle
°C - degree, Celsius
°F - degree Fahrenheit
% - percent (1% = 1/100)
lbf - pounds force
ksi - kips (1000 pounds) per square inch
HRC - hardness Rockwell C scale
PD - pitch diameter of thread
ND - nondestructive

4. QUALITY ASSURANCE PROVISIONS:

The allocation of tests corresponding to the requirements of this standard is as follows:

4.1 Qualification:

4.1.1 Purpose: To ensure that the bolt design and bolt manufacturing conditions allow the bolt to comply with the requirements of this standard.

4.1.2 Conditions: The qualification tests summarized in Table 8 shall be performed on each type and diameter of bolt. Proposed changes in manufacturing source or procedure shall be subject to the approval of purchaser.

25 bolts selected from a single inspection lot by simple random sampling shall be subjected to the qualification tests.

The number of bolts to be subjected to each test as well as the method(s) to be used are specified in Table 1.

The tests to be applied to each bolt are shown in Table 8.

The test program may possibly be reduced; this decision will be based on the comparison of results obtained from parts of similar design, size, and manufacturing conditions.

All or part of these tests may also be performed for production acceptance, when a reinforced inspection seems to be necessary, or to survey bolts that have not proved satisfactory in use.

In that case, the sample to be subjected to these tests is the same as that used for production acceptance tests.

4.2 Production Acceptance Tests:

4.2.1 Purpose: 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 standard.

4.2.2 Conditions: Acceptance tests are summarized in Table 3. They shall be performed on each production inspection lot. Table 1 specifies the test method and sampling plan to be used for each test. Bolts from the lot to be tested shall be selected by simple random sampling.

The bolts to be subjected to destructive tests may be those on which nondestructive tests have been performed.

Acceptance quality of random samples tested shall be based on zero defectives.

4.3 Quality System Approval:

4.3.1 Purpose: To ensure that the manufacturer has demonstrated the acceptability of his/her quality system and his/her ability for continuing production of parts to this standard to the required level of quality.

4.3.2 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 to the approval of the purchaser, and used during production of parts.

4.3.3 Requirements for Quality Assurance System: As prescribed in ISO 9001 or ISO 9002, as applicable.

4.4 Responsibility for Inspection and Tests:

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 standard.

4.5 Reports:

The vendor of parts shall furnish with each shipment a report certifying that the chemical composition of the parts conform to the applicable material specification, showing the results of tests required by this standard, and stating that the parts conform to the technical requirements. This report shall include the purchase order number, AS4959 (or AS4959-1, 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 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.

4. TECHNICAL REQUIREMENTS AND TEST METHOD:

See Table 1.

TABLE 1 - Technical Requirements and Test Method

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.1	Material	Shall be AMS 5734 steel heading stock, unless otherwise specified on part drawing.	Per AMS 5734. Certify composition of each heat of alloy.		
5.2	Design	Finished (completely manufactured) parts shall conform to the following requirements:			
5.2.1	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.	Conventional measuring methods.	Q A	25 Tables 4 & 5
5.2.2	Surface Texture	Finished parts, prior to plating or coating, shall conform to the requirements as specified on the part drawing.	Determined in accordance with ANSI/ASME B46.1.	Q A	25 Tables 4 & 5
5.2.3	Threads	ISO 3161, unless otherwise specified on the part drawing.	Inspection per ISO 3161.	Q A	25 Tables 4 & 5
5.2.3.1	Incomplete Threads	Permissible at the chamfered end and the juncture of the unthreaded portion of the shank or adjacent to the head as specified in AS3062.	Comparator Chart per AS3062.	Q A	25 Tables 4 & 5
5.2.3.2	Chamfer	The entering end of the thread shall be chamfered as specified on the part drawing.	Visual and conventional measuring methods.	Q A	25 Tables 4 & 5
5.2.4	Geometric Tolerances	Part features shall be within the geometric tolerances specified on the part drawing and, where applicable, controlled in accordance with AS3063.	Conventional measuring methods.	Q A	25 Tables 4 & 5

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.3	Fabrication				
5.3.1	Blanks	Heads shall be forged by hot or cold forging. The forging temperature shall not exceed 2100 °F, and forged heads shall be air cooled. Lightening holes may be made by any suitable method.			
5.3.1.1	Wrenching Recess	May be forged or machined.			
5.3.2	Heat Treatment	Shall conform to the technical requirements and other provisions specified in AMS 2759/3 for A-286, 1650 °F solution treatment, and aging treatment before finishing the shank and bearing surface, cold rolling the head-to-shank fillet radius and rolling the threads.			
5.3.2.1	Solution Heat Treatment	Headed blanks of AMS 5734 shall be solution heat treated as in 5.3.2.			
5.3.2.2	Aging Treatment	After solution heat treatment as in 5.3.2.1, blanks shall be heat treated by aging as in 5.3.2.			
5.3.3	Oxide Removal	After heat treatment, the headed blanks shall have the oxide and oxide penetration removed from the shank and bearing surface. The oxide removal process shall produce no intergranular attack or corrosion of the blanks. The metal removed from underneath the head and the shank diameter shall be as little as practicable to obtain a clear, smooth surface.			

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.3.4	Cold Rolling of Fillet Radius	After removal of oxide as in 5.3.3, the head-to-shank fillet radius of 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 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° of fillet arc, starting at the point of tangency of the fillet radius and 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 rolling will be required only for 90° 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 full shank close tolerance bolts shall not exceed the nominal thread diameter after cold rolling the head-to-shank fillet radius.	Dimensional check (see Figure 2) and visual examination.	Q A	25 Tables 4 & 5
5.3.5	Thread Rolling	Shall be formed on the heat treated and finished blank by a single cold rolling process after removal of oxide as in 5.3.3.			

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.3.6	Cleaning	After finishing, parts shall be degreased and submerged 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.			
5.3.6.1	Water Rinse	Immediately after removal from the cleaning solution, the parts shall be thoroughly rinsed in (70 to 200 °F) water.			
5.4	Product Marking	Each part shall be identification marked as specified on the part drawing. Unless otherwise specified, the markings may be formed by forging or stamping, raised or depressed 0.010 inch max, with rounded root form on depressed characters.	Visual examination	Q A	25 Tables 4 & 5
5.5	Plating	Where required, surfaces shall be plated (or coated) as specified on the part drawing.	Plating thickness determined in accordance with plating specification.	Q A	3 Table 6
5.6	Mechanical Properties	Where AS4959 is specified, parts shall conform to 5.6.1, 5.6.2, and 5.6.3. Where AS4959-1 is specified, parts shall conform to 5.6.1, 5.6.2, and 5.6.4. 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.			
5.6.1	Ultimate Tensile Strength at Room Temperature				

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.6.1.1	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° 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 bolt is such that failure would occur outside the threaded section but the bolt can be tested satisfactorily, such as bolts 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 140 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 bolts 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.	Tested per MIL-STD-1312-8	Q A	4 Table 6
5.6.1.2	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 on specimens as in 5.6.5. Such specimens shall meet the following requirements: Ultimate Tensile Strength, min 140 ksi Yield Strength at 0.2% Offset, min 95 ksi Elongation in 2 inches or 4D, min 12% Reduction of Area, min 15%	Tested per ASTM E 8	Q A	4 Table 6
5.6.1.2.1	Finished Parts	When permitted by purchaser, hardness tests on the end of parts may be substituted for tensile tests of machined specimens.	Tested per MIL-STD-1312-6	A	Table 6

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.6.2	Hardness	Shall be uniform and within the range 29 to 38 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 tensile strength properties specified in 5.6.1 are met.	Tested per MIL-STD-1312-6	Q A	4 Table 6
5.6.3	Stress-Rupture Strength at 1200 °F				
5.6.3.1	Finished Parts	Finished tension bolts, maintained at 1200 °F ± 3 °F while the tensile load specified in Table 2A is applied continuously, shall not rupture in less than 23 hours. If the shank diameter of the part is less than the max minor (root) diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 5.6.3.1.1. Screws, such as 100° flush head, pan head, and fillister head, are not required to be tested for stress-rupture strength at 1200 °F.	Tested per MIL-STD-1312-10	Q A	3 1
5.6.3.1.1	Finished Parts	Parts having a shank diameter less than the max minor (root) diameter of the thread shall be tested as in 5.6.3.1, except that the load shall be as specified in 5.6.3.2. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.	Tested per MIL-STD-1312-10	Q A	3 1
5.6.3.2	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 5.6.5, 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.	Tested per ASTM E 139	Q A	3 1

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.6.4	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 max double shear load achieved. Shear bolts having special shank diameters shall have the min ultimate double shear load based on 84 ksi min shear strength. Shear tests are not required for screws, such as 100° 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 and screws threaded to head. b. Protruding head bolts and screws having a coarse toleranced full shank. c. Protruding head bolts and screws having a PD or relieved shank.	Tested per MIL-STD-1312-13	Q A	4 Table 6
5.6.5	Test Specimens	Test specimens shall be per ASTM E 8. Specimens shall be machined from finished parts or coupons of the same lot of alloy and be processed with the parts they represent. Specimens shall be machined from the center of parts.			
5.7	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 part.	Visual examination	Q A	25 Tables 4 & 5
5.8	Metallurgical Properties		Note: The same test sample may be used for more than one test provided that none of the characteristics of the samples are altered during the examination procedure (see Table 8).		

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.8.1	Macroscopic Examination, Headed Blank	Specimens cut from headed blanks shall be etched in a suitable etchant and examined at a magnification of 20X to determine conformance to the requirements of 5.8.1.1 and 5.8.1.2.	The head and shank section shall extend not less than D/2 from the bearing surface of the head, where D = nom thd dia.		
5.8.1.1	Flow Lines	After heading and prior to heat treatment, examination of an etched section taken longitudinally through the blank as in 5.8.1 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 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.	Macroscopic examination	Q A	1 1
5.8.1.2	Internal Defects	Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity.	Macroscopic examination	Q A	1 1
5.8.2	Microscopic Examination, Finished Part	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 5.8.2.1, 5.8.2.2, 5.8.2.3, 5.8.2.4, 5.8.2.5, and 5.8.2.6.			
5.8.2.1	Flow Lines, Threads	Examination of a longitudinal section through the threaded portion of the shank shall show evidence that the threads were rolled. See Figure 3.	Microscopic examination	Q A	4 Table 6
5.8.2.2	Internal Defects, Finished Part	Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity. Thread imperfections shall conform to the requirements of 5.8.2.6.	Microscopic examination	Q A	4 Table 6
5.8.2.3	Microstructure	Parts shall have microstructure of completely recrystallized material except in the area of the threads and the head-to-shank fillet radius.	Microscopic examination	Q A	4 Table 6

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.8.2.4	Grain Size	Shall be ASTM No. 5 or finer. Up to 25% of the areas 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 dispute, the intercept (Heyn) method shall be used.	Comparison method of ASTM E 112	Q A	4 Table 6
5.8.2.5	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. There shall be no evidence of carburization or nitriding. 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.	Microscopic examination	Q A	4 Table 6
5.8.2.6	Threads				
5.8.2.6.1	Root Defects	Defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 4).	Microscopic examination	Q A	4 Table 6
5.8.2.6.2	Multiple Laps on Thread Flanks	Not permissible regardless of location.	Microscopic examination	Q A	4 Table 6
5.8.2.6.3	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 nonpressure 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 7 for the applicable thread pitch. A lap extending toward the root is not permissible (see Figure 6.) b. Thread Flank below PD: A lap along the thread flank below the pitch diameter, regardless of direction it extends, is not permissible (see Figure 7).	Microscopic examination	Q A	4 Table 6

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.8.2.6.3 (Contd.)		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 7 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 7 may be increased by one-half of the difference between the minimum major diameter and actual major diameter as measured on the part.			
5.8.3	Fluorescent Penetrant Inspection	Parts (before plating or coating) shall be subject to fluorescent penetrant inspection.	ASTM E 1417, Type I, Sensitivity Level 2 minimum	Q A	25 Tables 4 & 5
5.8.3.1	Criteria	The following conditions shall be cause for rejection of parts inspected:			
5.8.3.1.1	Transverse Discontinuities	Discontinuities transverse to grain flow (i.e., at an angle of more than 10° to the axis of the shank), such as grinding checks and quench cracks.	See 5.8.3		
5.8.3.1.2	Longitudinal Discontinuities	Longitudinal indications (i.e., at an angle of 10° or less to the axis of the shank) due to imperfections other than seams, forming laps, and nonmetallic inclusions.	See 5.8.3		
5.8.3.2	Criteria	The following conditions shall be considered acceptable on parts inspected:			
5.8.3.2.1	Longitudinal Discontinuities	Parts having longitudinal indications (i.e., at an angle of 10° 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 5.8.3.2.2 through 5.8.3.2.5 provided the separation between indications in all directions is not less than 0.062 inch.	See 5.8.3		

TABLE 1 (Continued)

Q = Qualification approval requirements (4.1)
A = Production acceptance requirements (4.2)

Clause	Characteristic	Technical Requirement	Inspection and Test Method	Q/A	Sample Size
5.8.3.2.2	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 7), whichever is less.	See 5.8.3		
5.8.3.2.3	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.	See 5.8.3		
5.8.3.2.4	Threads	There shall be no indications, except as permitted in 5.8.2.7.	See 5.8.3		
5.8.3.2.5	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 5.8.3.2.2, shall break over an edge.	See 5.8.3		
5.8.4	Material Identification	Each finished part shall be subjected to a nondestructive physical test to verify the type of material. The test equipment shall be standardized by samples of known chemical composition of the same type and form and in the same heat treatment condition as the parts to be tested.	The test equipment shall be approved by purchaser.	Q A	25 100%
5.9	Preparation for Delivery		Visual examination	A	100%
5.9.1	Packaging	Parts having different part numbers shall be packed in separate containers. Parts shall be suitably protected from abrasion and chafing during handling, transportation, and storage. Packaging shall be per ASTM D 3951.	See 5.9		
5.9.2	Labelling	Each container of parts shall be marked to show not less than the following information: BOLTS, STEEL, CORROSION AND HEAT RESISTANT AS4959 (or AS4959-1, as applicable) PART NUMBER LOT NUMBER PURCHASE ORDER NUMBER QUANTITY MANUFACTURER'S IDENTIFICATION	See 5.9		

5. ACKNOWLEDGMENT

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

6. REJECTIONS

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

7. NOTES:

7.1 Hardness Conversion Tables

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

7.2 Key Words:

Bolts, screws, procurement specification

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

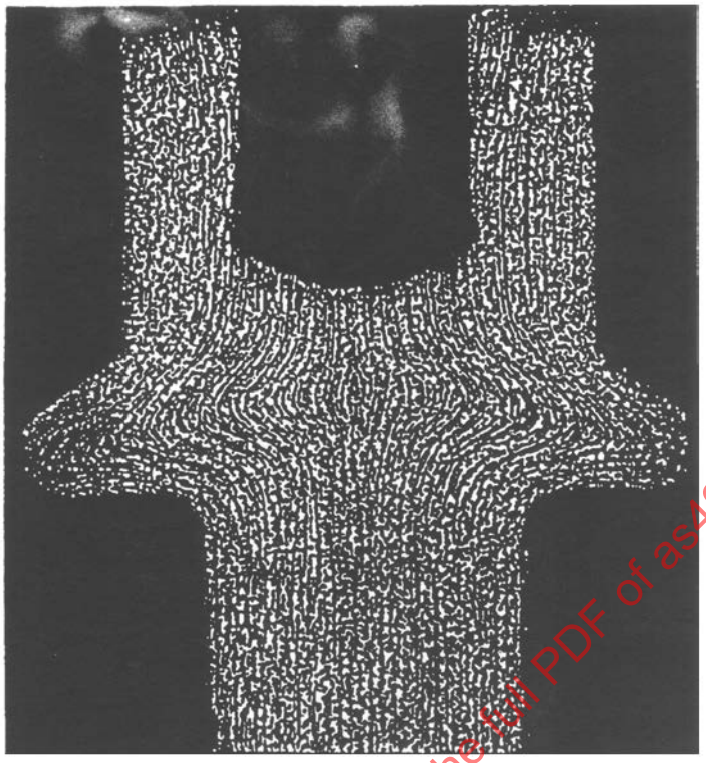


FIGURE 1 - Satisfactory Grain Flow, Headed Blank, Before Heat Treatment
Showing a smooth, well formed grain flow following the contour of the head-to-shank fillet radius.

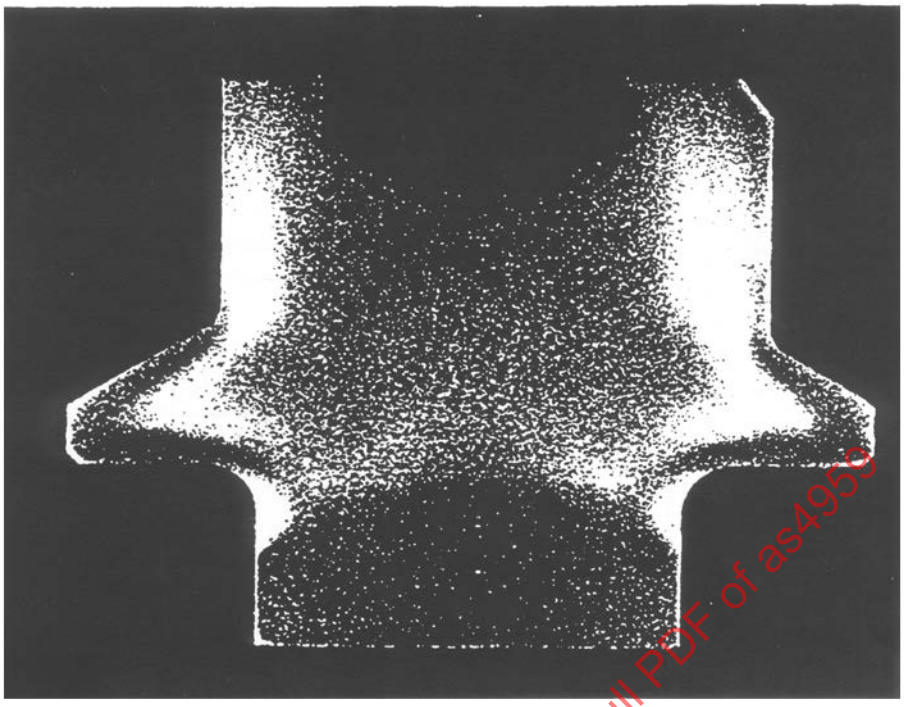
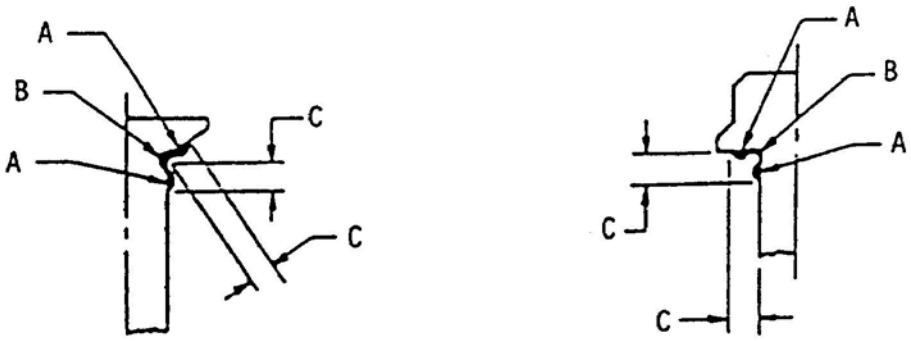


FIGURE 1A - Satisfactory Heat Pattern, Headed Blank, Before Heat Treatment



Nominal Bolt Diameter inch	C, maximum 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

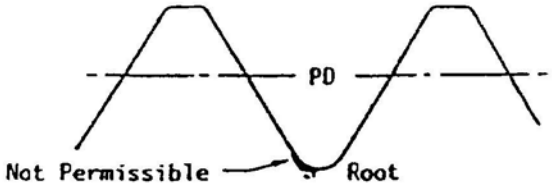


FIGURE 4 - Root Defects, Rolled Thread

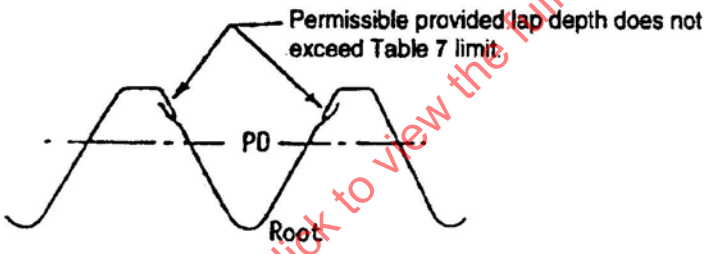


FIGURE 5 - Laps Above Pitch Diameter Extending Towards Crest, Rolled Thread

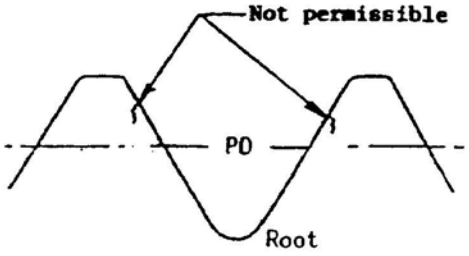


FIGURE 6 - Laps Above PD Extending Toward Root, Rolled Thread

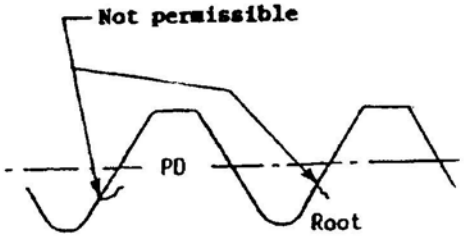
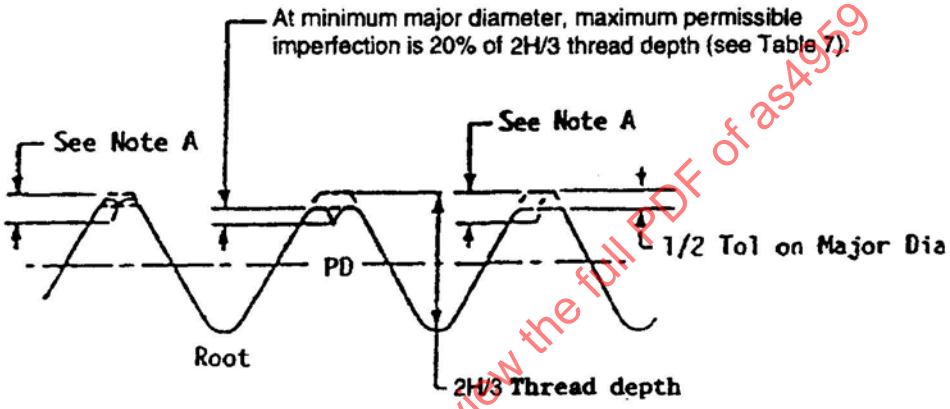


FIGURE 7 - Laps Below PD Extending in Any Direction, Rolled Thread



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

FIGURE 8 - Crest Craters and Crest Laps, Rolled Thread

TABLE 2A - Test Loads for Bolts

Thread Size	Ultimate Tensile Strength at Room Temperature Test Load lbf, min	Stress-Rupture at 1200 °F Maximum Test Load lbf	Ultimate Double Shear at Room Temperature Test Load lbf, min
0.1120-40	845	422	1655
0.1120-48	925	462	1655
0.1380-32	1272	636	2513
0.1380-40	1420	710	2513
0.1640-32	1961	981	3549
0.1640-36	2062	1031	3549
0.1900-32	2799	1400	4763
0.2500-28	5092	2546	8247
0.3125-24	8129	4065	12880
0.3750-24	12300	6148	18560
0.4375-20	16620	8310	25260
0.5000-20	22390	11200	32990
0.5625-18	28420	14210	41750
0.6250-18	35830	17920	51540
0.7500-16	52220	26110	74220
0.8750-14	71330	35660	101000
1.0000-12	92830	46410	131900

NOTE 1: Requirements above apply to parts with UNJ profile threads to Class 3A tolerances. The diameter of the area on which stress for ultimate tensile strength and stress-rupture test load requirements is based on the UNJ basic minor diameter at 0.5625H thread depth, where H is the height of sharp V-thread, and its area is calculated from Equation 1:

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

where, A_1 = area for ultimate tensile stress and stress-rupture stress
d = basic major diameter of external thread
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 ultimate double shear test load requirements is based is the nominal diameter of the close tolerance full shank bolt, calculated from Equation 2:

$$A_2 = 0.7854(d)^2 \quad \text{(Eq.2)}$$

where, A_2 = area for ultimate shear stress
d = nominal diameter of close tolerance full shank bolt