SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE MA3377 REV. A

Issued 1986-08
Revised 1995-10
Reaffirmed 2006-05

Superseding MA3377

Bolts and Screws, Nickel Alloy UNS N07718, Tensile Strength 1275 MPa Procurement Specification, Metric

FSC 5306

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

1. SCOPE:

1.1 Type:

This document covers metric 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:

MA3377	1275 MPa minimum ultimate tensile strength at room temperature
	1000 MPa minimum ultimate tensile strength at 650 °C
	690 MPa stress-rupture strength at 650 °C
	720 MPa tension to 72 MPa tension fatigue at room temperature
MA3377-1	1275 MPa minimum ultimate tensile strength at room temperature
	765 MPa minimum ultimate shear strength at room temperature
	720 MPa tension to 72 MPa tension fatigue at room temperature

1.2 Application:

Primarily for use in aerospace propulsion systems as follows:

a. For use up to approximately 650 °C where elevated temperature tensile strength, stress-rupture strength, and resistance to relaxation are required.
b. For use up to approximately 425 °C where fatigue resistance, tensile strength, and shear strength are required.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

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

AMS 2750	Pyrometry
AMS 5662	Alloy Bars, Forgings, and Rings, Corrosion and Heat Resistant, 52.5Ni-19Cr-3.0Mo-5.1(Cb + Ta)-0.90Ti-0.50A1-18Fe, Consumable Electrode or Vacuum Induction Melted, 1775 °F (970 °C) Solution Heat Treated
MA1370	Screw Threads - MJ Profile, Metric
MA1518	Bolts, Screws and Nuts - External Wrenching, Metric MJ Threads, Design Parameters for
MA1520	Areas for Calculating Stress or Load for Metric MJ Externally Threaded Fasteners
MA1566	Gaging Practice and Gage Requirements for MJ Metric Screw Threads
AS3062	Bolts, Screws, and Studs, Screw Thread Requirements
AS3063	Bolts, Screws, and Studs, Geometric Control Requirements

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

QQ-P-35	Passivation Treatments for Corrosion Resistant Steel
MIL-STD-1312-6	Fastener Test Methods, Method 6, Hardness
MIL-STD-1312-10	Fastener Test Methods, Method 10, Stress Rupture
MIL-STD-1312-12	Fastener Test Methods, Method 12, Thickness of Metallic Coatings
MIL-STD-1312-18	Fastener Test Methods, Method 18, Elevated Temperature Tensile Strength
DOD-STD-1312-108	Fastener Test Methods, Metric Method 108, Tensile Strength
DOD-STD-1312-111	Fastener Test Methods, Method 111, Tension Fatigue
DOD-STD-1312-113	Fastener Test Methods, Method 113, Double Shear Test

2.1.3 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 8M	Tension Testing of Metallic Materials
ASTM E 21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Test of Metallic Materials
ASTM E 140	Standard Hardness Conversion Tables for Metals
ASTM E 1417	Liquid Penetrant Examination
ASTM D 3951	Commercial Packaging

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

ANSI/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.

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.

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

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

2.3 Unit Symbols:

°	degree, angle
°C	degree Celsius
°F	degree Fahrenheit
mm	millimeter
cm^3	cubic centimeter
g	gram (mass)
HRC	hardness, Rockwell C scale
%	percent (1% = 1/100)
kN	kilonewton (force)
MPa	megapascal (stress)
sp gr	specific gravity

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Shall be AMS 5662 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 ANSI/ASME B46.1.

3.2.3 Threads: Screw thread MJ profile and dimensions shall be in accordance with MA1370, 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 900 to 1095 °C. 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 and precipitation heat treated as follows:

3.3.2.1 Heating Equipment: Furnaces may be any type ensuring uniform temperature throughout the parts being heated and shall be equipped with, and operated by, automatic temperature controllers and data recorders conforming to AMS 2750. The heating medium or atmosphere shall cause no surface hardening by carburizing or nitriding.

3.3.2.2 Solution Heat Treatment: Headed blanks shall be solution heat treated by heating to a temperature within the range 925 to 1010 °C, holding at the selected temperature within ±15 °C for 1 hour ± 0.1 hour, and quenching in oil or water.

3.3.2.3 Precipitation Heat Treatment: After solution heat treatment as in 3.3.2.2, headed blanks shall be precipitation heat treated by heating to 718 °C ± 8 °C in a controlled atmosphere, holding at heat for 8 hours ± 0.25 hour, furnace cooling at 56 °C ± 8 °C per hour to 620 °C ± 8 °C, holding at 620 °C ± 8 °C for 8 hours ± 0.25 hour and cooling at a rate equivalent to air cool. Instead of the 56 °C per hour cooling rate to 620 °C ± 8 °C, parts may be furnace cooled at any rate provided the time at 620 °C ± 8 °C 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 and precipitation 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 Rolling 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 rolled sufficiently to remove all visual evidence of grinding or tool marks. Distortion due to cold rolling shall conform to Figure 2, unless otherwise specified on the part drawing. It shall not raise metal more than 0.05 mm above the contour at “A” or depress metal more than 0.05 mm 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 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 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.

3.3.5 Thread Rolling: Threads 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 Passivation Treatment: Parts, after finishing, shall be degreased and then subjected to the passivation treatment and high humidity test in accordance with QQ-P-35.

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 0.25 mm 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 MIL-STD-1312-12.

3.6 Mechanical Properties:

Where MA3377 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, .3.6.3, 3.6.4, and 3.6.5. Where MA3377-1 is specified, parts shall conform to the requirements of 3.6.1, 3.6.3, 3.6.4, and 3.6.6. Threaded members of gripping fixtures for tensile, fatigue and stress-rupture tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread. The loaded portion of the shank shall have a minimum of three full thread turns from the thread runout exposed between the loading fixtures during tensile, fatigue and stress-rupture tests.

MA3377 finished parts shall be tested in accordance with the following test methods:

a.	Hardness:	MIL-STD-1312-6
b.	Ultimate Tensile Strength at Room Temperature:	DOD-STD-1312-108
c.	Ultimate Tensile Strength at 650 °C:	MIL-STD-1312-18
d.	Stress-Rupture Strength at 650 °C:	MIL-STD-1312-10
e.	Fatigue Strength:	DOD-STD-1312-111

MA3377-1 finished parts shall be tested in accordance with the following test methods:

a.	Hardness:	MIL-STD-1312-6
b.	Ultimate Tensile Strength at Room Temperature:	DOD-STD-1312-108
c.	Ultimate Shear Strength at Room Temperature:	DOD-STD-1312-113
d.	Fatigue Strength:	DOD-STD-1312-111

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 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° 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 1275 MPa; 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 either standard hexagon, double hexagon or spline drive heads having a minimum metal condition in the head equal to the design parameters specified in MA1518, 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 8M on specimens prepared as in 4.5.7. Specimens may be required by the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum:	1275 MPa
b. Yield Strength at 0.2% Offset, minimum:	1035 MPa
c. Elongation in 5D, minimum:	12%
d. Reduction of Area, minimum:	15%

3.6.2 Ultimate Tensile Strength at 650 °C:

3.6.2.1 Finished Parts: Tension bolts heated to 650 °C ± 3 °C, held at heat for 30 minutes before testing, and tested at 650 °C ± 3 °C, shall have an ultimate tensile load not lower than the value 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. 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 1000 MPa; 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 heads having a minimum metal condition in the head equal to the design parameters specified in MA1518 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° flush head, pan head, and fillister head, are not required to be tested for tensile strength at 650 °C.

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 E 21 on specimens as in 4.5.7. Specimens may be required by purchaser to perform confirmatory tests. Such specimens shall meet the following requirements when heated to 650 °C ± 3 °C, held at heat for not less than 30 minutes before testing, and tested at 650 °C ± 3 °C.

a. Ultimate Tensile Strength, minimum:	1000 MPa
b. Yield Strength at 0.2% Offset, minimum:	860 MPa
c. Elongation in 5D, minimum:	12%
d. Reduction of Area, minimum:	15%

3.6.3 Hardness: Shall be uniform and within the range 40 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 in 3.6.1 are met.

3.6.4 Fatigue Strength: Finished tension bolts tested in tension-tension fatigue at room temperature, with maximum load as specified in Table 1 and minimum load equal to 10% of maximum load, shall have average life of not less than 65 000 cycles with no part having life less than 45 000 cycles. Tests need not be run beyond 130 000 cycles. Life of parts which do not fail in less than 130 000 cycles shall be taken as 130 000 cycles for purposes of computing average life. If the shank diameter of the part is less than the minimum pitch diameter of the thread, parts shall withstand fatigue testing as above, using loads sufficient to produce a maximum stress of 720 MPa and a minimum stress of 72 MPa. The above requirements apply only to tension bolts, such as hexagon, double hexagon, and spline drive heads per design parameters specified in MA1518, 4 mm and larger in nominal thread size, and having a head-to-shank fillet radius equal to or larger than that specified in MA1518, and not having an undercut; for all parts to which the above requirements do not apply, fatigue test requirements shall be as specified on the part drawing.

3.6.5 Stress-Rupture Strength at 650 °C:

3.6.5.1 Finished Parts: Finished tension bolts, maintained at 650 °C ± 2 °C 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 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 3.6.5.2. Screws, such as 100° flush head, pan head, and fillister head, are not required to be tested for stress-rupture strength at 650 °C.

3.6.5.1.1 Bolts having a shank diameter less than the minimum pitch diameter of the thread shall be tested as in 3.6.5.1 except that the load shall be as specified in 3.6.5.2. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the bolt.

3.6.5.2 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 4.5.7, maintained at 650 °C ± 2 °C while a load sufficient to produce an initial axial stress of 690 MPa 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.

3.6.6 Ultimate Shear Strength: Finished bolts having a close toleranced full shank as in MA1518 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 minimum 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 765 MPa minimum 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 or screws having a coarse toleranced full shank.
c. Protruding head bolts or 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 free from imperfections detrimental to the usage of the parts.

3.7.1 Macroscopic Examination: Specimens cut from headed blanks and from finished parts shall be etched in a suitable etchant and examined at a magnification of approximately 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 and the threaded shank section shall extend not less than D/2 beyond the thread runout where "D" is the nominal diameter of the shank after heading. If the two sections would overlap, the entire length of the part shall be sectioned and examined as a whole.

3.7.1.1 Flow Lines:

3.7.1.1.1 Head-To-Shank, Headed Blanks: After heading and prior to heat treatment, examination of an etched section taken longitudinally through the blank shall show flow lines in the shank, head-to-shank fillet, and bearing surface which follow the contour of the blank as shown in Figure 1. Flow lines in headed blanks having special heads, such as Dee- or Tee-shaped heads or thinner than MA1518 standard heads, shall be as agreed upon by purchaser and vendor.

3.7.1.1.2 Head-To-Shank, Finished Part: Examination of a longitudinal section through the part shall show evidence that the heads were formed by forging. This evidence shall include traces of flow lines as shown in Figure 1A.

3.7.1.1.3 Threads: Examination of a longitudinal section through the threaded portion of the shank shall show evidence that the threads were rolled. This evidence shall include traces of flow lines as shown in Figure 3.

3.7.1.2 Internal Defects: Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity. Thread imperfections as in 3.7.2.4 shall be examined in accordance with 3.7.2.

3.7.2 Microscopic Examination: Specimens cut from parts shall be polished, etched in Kalling's reagent [100 cm^3 of absolute ethyl alcohol, 100 cm^3 of hydrochloric acid (sp gr 1.19), and 5 g of cupric chloride], Marble's reagent [20 cm^3 of hydrochloric acid (sp gr 1.19), 30 cm^3 of water, and 4 g of cupric sulfate pentahydrate], or other suitable etchant, and examined at not lower than 100X magnification to determine conformance to the requirements of 3.7.2.1, 3.7.2.2, 3.7.2.3 and 3.7.2.4.

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

3.7.2.2 Grain Size: Shall be ASTM No. 3 or finer, determined in accordance with the comparative method of ASTM E 112. In case of disagreement, the intercept (Heyn) procedure shall be used.

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

3.7.2.4 Threads:

3.7.2.4.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 4).

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

3.7.2.4.3 Singve Lap on Thread Profile: Shall conform to the following:

a. Rateable Lap: Shall have its length equal to or greater than three times its width. The minimum interpretable lap size is 0.013 mm in length or depth when viewed at 200X magnification.

b. 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 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).

c. 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).

d. 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.

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° to the axis of the shank), such as grinding checks and quench cracks.

3.7.3.1.2 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.

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° 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 1.6 mm.

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 0.8 mm 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 3.7.2.4. Rateable lap indications shall conform to 3.7.2.4.3(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 0.25 mm, 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.

4.4 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 650 °C 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 withAMS 5662.

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 whererequired) shall be selected from each production inspection lot.

4.5.5 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.

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

4.5.7 Test Specimens: Specimens for tensile and stress-rupture testing of machined test specimens shall be of standard proportions in accordance with ASTM E 8M with either 6 mm diameter at the reduced parallel gage section or smaller specimens proportional to the standard when required. 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 18 mm and under in nominal diameter, from the center of coupons 20 mm and under in nominal diameter or distance between parallel sides, and from mid-radius of larger size parts or coupons.

4.6 Periodic Test Samples:

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 3.1, showing the results of tests to determine conformance to the room temperature ultimate tensile property, ultimate shear property where applicable, hardness, fatigue, and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, MA3377, 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 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:

METRIC BOLTS (SCREWS), NICKEL ALLOY UNS N07718, TENSILE STRENGTH 1275 MPa
MA3377 (or MA3377-1, 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:

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

8.2 Key Words:

Bolts, screws, procurement specification

8.3 The change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

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

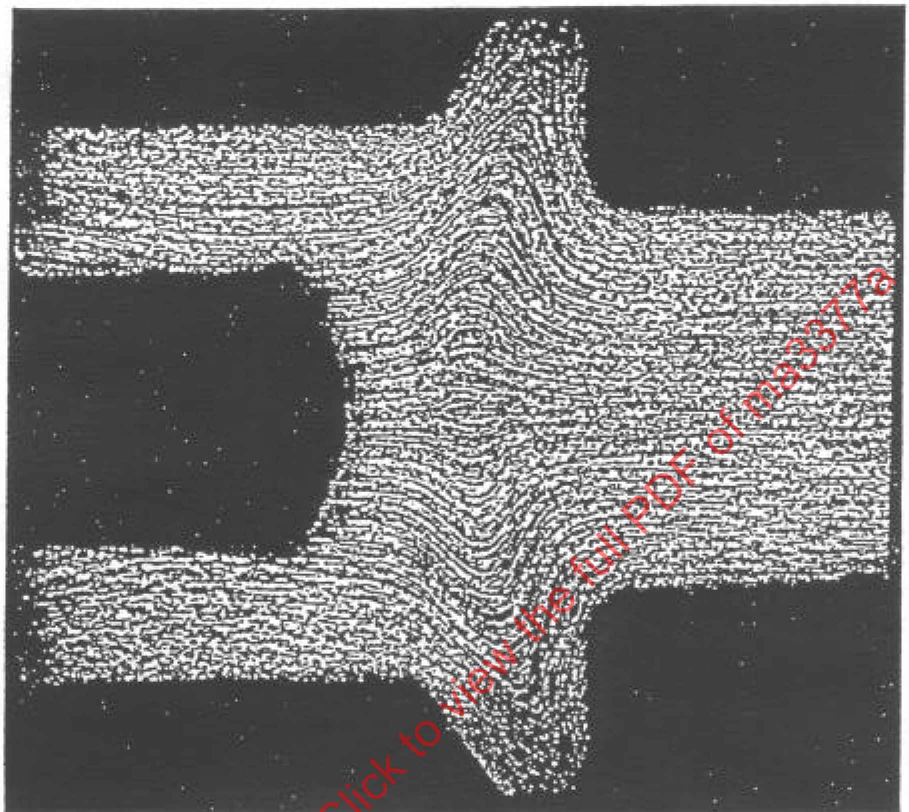


FIGURE 1 - Satisfactory Grain Flow, Headed Blank, Before Heat Treatment

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

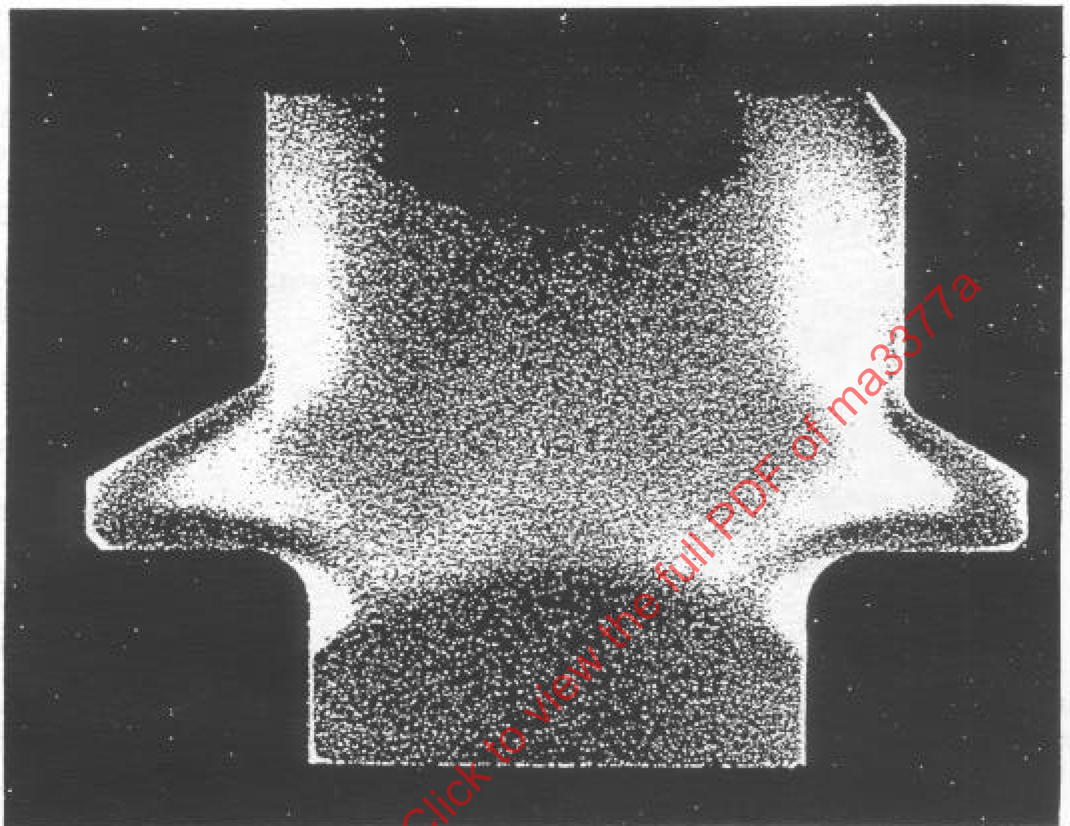
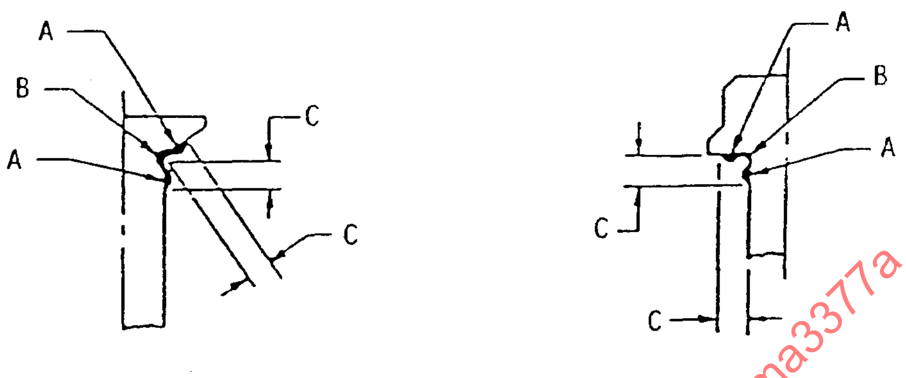


FIGURE 1A - Head-to-Shank Section Through Finished Part

Shows evidence that head was formed by forging.



Nominal Bolt Diameter, mm	C, max mm
Up to 8, excl	1.6
8 & 10	2.4
12 - 16 incl	3.2
18 - 24 incl	4.0
Over 24	4.8

FIGURE 2 - Permissible Distortion from Fillet Working

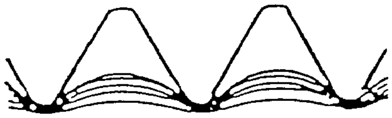


FIGURE 3 - Flow Lines, Rolled Thread

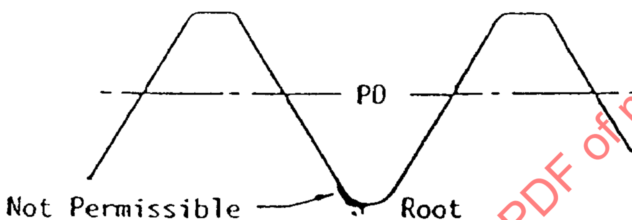


FIGURE 4 - Root Defects, Rolled Thread

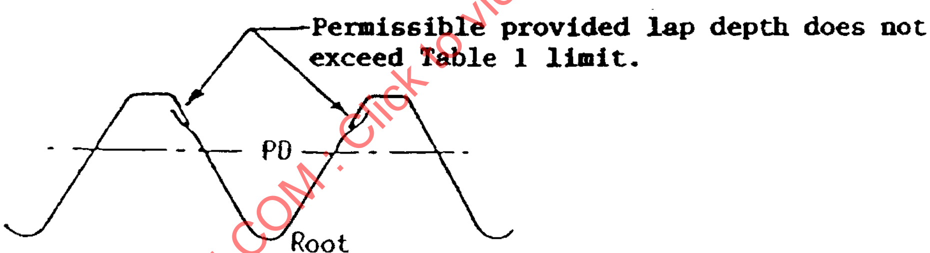


FIGURE 5 - Laps Above Pitch Diameter Extending Towards Crest, Rolled Thread

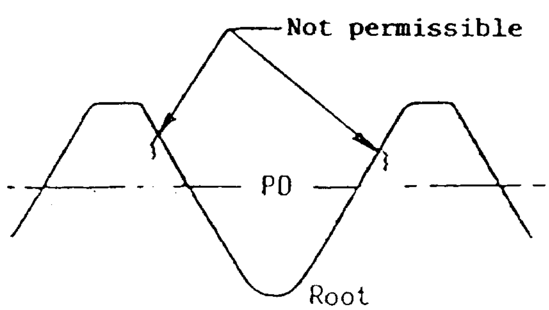


FIGURE 6 - Laps Above PD Extending Toward Root, Rolled Thread

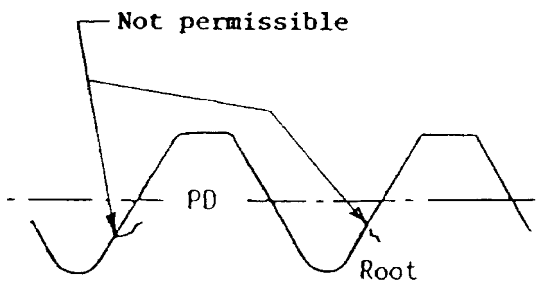
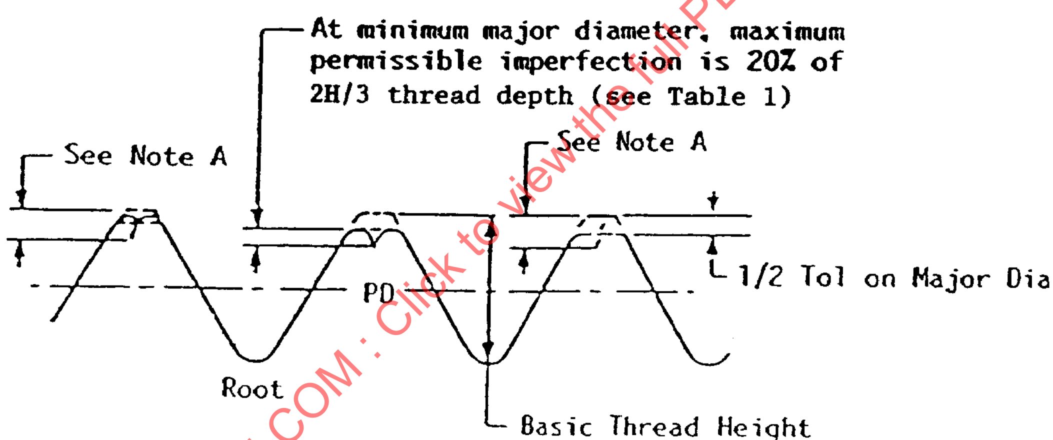


FIGURE 7 - Laps Below PD Extending in Any Direction, Rolled Thread



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 1 - Test Loads

Thread Size Class 4h6h	Ultimate Tensile Strength Test Load, kN min Bolt Room Temp.	Ultimate Tensile Strength Test Load, kN min Bolt at 650 °C	Ultimate Tensile Strength Test Load, kN min Screw Room Temp.	Fatigue Test Load kN max Bolt Room Temp.	Stress-Rupture Test Load kN Bolt at 650 °C	Ultimate Double Shear Test Load kN min Room Temp.
MJ3 x 0.5	6.93	5.44	6.32	---	3.18	10.81
MJ3.5 x 0.6	9.35	7.34	8.51	---	4.27	14.72
MJ4 x 0.7	12.13	9.52	11.02	5.76	5.52	19.23
MJ5 x 0.8	19.50	15.30	17.84	9.39	9.00	30.04
MJ6 x 1	27.73	21.75	25.29	13.27	12.72	43.26
MJ7 x 1	39.44	30.93	36.36	19.32	18.51	58.88
MJ8 x 1	53.14	41.68	49.43	26.50	25.39	76.91
MJ10 x 1.25	83.05	65.14	77.23	41.41	39.68	120.2
MJ12 x 1.25	123.8	97.13		63.02	60.40	173.0
MJ14 x 1.5	167.7	131.6		85.11	81.56	235.5
MJ16 x 1.5	223.9	175.6		115.1	110.3	307.6
MJ18 x 1.5	288.1	226.0		149.7	143.4	389.3
MJ20 x 1.5	360.3	282.6		188.7	180.8	480.7
MJ22 x 1.5	440.5	345.5		232.3	222.6	581.6
MJ24 x 2	512.1	401.7		266.1	255.0	692.2

NOTE 1: Area upon which stress is based for ultimate tensile strength test load on bolts is the tensile stress area defined in MA1520 for threads rolled after heat treatment, and calculated using Equation 1:

$$A_1 = 0.7854(d_3)^2(2 - (d_3/d_2)^2) \quad \text{(Eq.1)}$$

where:

A_1 = area for ultimate tensile stress
d_2 = maximum pitch diameter of ext thread ($d_2 = d - .649519p$)
d_3 = maximum minor (root) diameter of ext thread ($d_3 = d - 1.1547p$)
d = maximum major diameter of ext thread
p = pitch

Area upon which stress is based for ultimate tensile strength test load on screws is based on the UNJ basic minor diameter at 0.5625H thread depth where H is height of sharp V-thread, calculated as follows:

$$A_2 = 0.7854(d - 1.125H)^2 = 0.7854(d - 0.9743p)^2 \quad \text{(Eq.2)}$$

where:

A_2 = area at 0.5625H thread depth
H = height of sharp V-thread = (cos 30°)p
d = maximum major diameter
p = thread pitch