SAE Aerospace
An SAE International Group

METRIC AEROSPACE STANDARD

SAE MA3378 REV. C

Issued 1986-01
Revised 1997-06
Reaffirmed 2012-12

Superseding MA3378B

Bolts and Screws, UNS N07001 Tensile Strength 1210 MPa, Thread and Fillet Radius Rolled Before Aging, Procurement Specification, Metric

FSC 5306

RATIONALE

MA3378C has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Type:

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

MA3378	1210 MPa minimum ultimate tensile strength at room temperature 520 MPa stress-rupture strength at 730 °C
MA3378-1	1210 MPa minimum ultimate tensile strength at room temperature 726 MPa minimum ultimate shear strength at room temperature

1.2 Application:

Primarily for aerospace propulsion system applications where a good combination of tensile strength and resistance to relaxation at elevated temperature up to approximately 815 °C is required.

1.3 Safety-Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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SAE values your input. To provide feedback on this Technical Report, please visit http://www.sae.org/technical/standards/MA3378C

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 2750	Pyrometry
AMS 5708	Alloy Bars and Forgings, Corrosion and Heat Resistant, 58Ni 19.5Cr 13.5Co 4.3Mo 3.0Ti 1.4Al, Consumable Electrode or Vacuum Induction Melted, 1975°F (1080°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.

MIL-STD-1312-6	Fastener Test Methods, Method 6, Hardness
DOD-STD-1312-108	Fastener Test Methods, Metric Method 108, Tensile Strength
MIL-STD-1312-10	Fastener Test Methods, Method 10, Stress Rupture
DOD-STD-1312-113	Fastener Test Methods, Method 113, Double Shear Test

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

ASTM E 8M	Tension Testing 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 ASME Publications: Available from ASME, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900.

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.

COLD ROLLING: Forming material below the recrystallation temperature.

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

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

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

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

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

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

LAP: Surface imperfection caused by folding over metal fins or sharp corners and then rolling or forging them into the surface. The allowable lap depth shall not exceed the limit specified herein. The minimum condition that shall be rated as a lap is a fold having its length equal to or greater than three times its width with a depth of 0.0127 mm when viewed at 200X magnification.

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

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

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

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

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

2.3 Unit Symbols:

°	- degree, angle
°C	- degree Celsius
°F	- degree Fahrenheit
mm	- millimeter
mm^2	- square millimeter
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 5708 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 or coating, shall conform to the requirements as specified on 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: Metric 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 at the juncture of the unthreaded portion of the shank or adjacent to the head in accordance with AS3062.

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

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

3.3 Fabrication:

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

3.3.2 Heat Treatment: 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 stabilization heat treated as follows: precipitation heat treatment shall follow cold rolling of the fillet radius and rolling the threads.

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

3.3.2.2 Solution Heat Treatment: Headed blanks shall be solution heat treated by heating to a temperature within the range 1040 to 1080 °C, holding at the selected temperature within ±15 °C for 1 to 4 hours, and cooling at a rate equivalent to air cool or faster.

3.3.2.2.1 A temperature lower than 1040 °C may be used provided that the furnace control is such that during the holding period no part is below 1025 °C.

3.3.2.3 Stabilization Heat Treatment: Solution heat treated blanks shall be stabilization heat treated by heating to 845 °C ± 8 °C, holding at heat for 4 hours ± 0.5 hour, and cooling in air.

3.3.2.4 Precipitation Heat Treatment: After cold working the fillet radius as in 3.3.4 and rolling the threads as in 3.3.5, parts shall be precipitation heat treated by heating to 760 °C ± 8 °C, holding at heat for 16 hours ± 1 hour, and cooling at a rate equivalent to air cool.

3.3.3 Oxide Removal: Surface oxide and oxide penetration resulting from prior heat treatment shall be removed from the full body diameter and bearing surface of the head of the solution and stabilization heat treated blanks prior to cold rolling the under fillet radius and rolling the threads. The oxide removal process shall produce no intergranular attack or corrosion of the blanks. The metal removed from the bearing surface of the head and the full body diameter of the shank shall be as little as practicable to obtain a clean, smooth surface.

3.3.4 Cold Rolling of Fillet Radius: After removal of oxide as in 3.3.3, the head-to-shank fillet radius of headed parts having the radius complete throughout the circumference of the part shall be cold rolled 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. No raised metal (excrescence) is permitted on the head bearing surface (face) or depressed metal more than 0.025 mm below the fillet radius contour as shown in Figure 2. The unthreaded shank at the position shown in Figure 2, inclusive of distortion, shall not exceed the unthreaded shank diameter by an amount more than that specified in Figure2. 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 maximum shank diameter after cold rolling the head-to-shank fillet radius.

3.3.5 Thread Rolling: Thread shall be formed on the finished, solution and stabilization heat treated blanks by a single cold rolling process after removal of oxide as in 3.3.3.

3.3.6 Cleaning: Parts, after finishing, shall be degreased and immersed in one of the following solutions for the time and the 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 60 to 71 °C.

Immediately after removal from the cleaning solution, parts shall be thoroughly rinsed in clean water at 20 to 90 °C.

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 0.25 mm maximum, with rounded root form on depressed characters.

3.5 Plating or Coating:

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

3.6 Mechanical Properties:

Where MA3378 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, and 3.6.3. Where MA3378-1 is specified, parts shall conform to the requirements of 3.6.1, 3.6.2, and 3.6.4. Threaded members of gripping fixtures for tensile and stress-rupture tests shall be of sufficient size and strength to develop the full strength of the part without stripping the thread.

MA3378 finished parts shall be tested in accordance with the following applicable test methods:

a. Hardness:	MIL-STD-1312-6
b. Ultimate Tensile Strength at Room Temperature:	DOD-STD-1312-108
c. Stress-Rupture Strength at 730 °C:	MIL-STD-1312-10

MA3378-1 finished parts shall be tested in accordance with the following applicable test methods:

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

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 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 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 1210 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 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 4.4.7. Specimens may be required by purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum:	1210 MPa
b. Yield Strength at 0.2% Offset, minimum:	790 MPa
c. Elongation in 5D, minimum:	15%
d. Reduction of Area, minimum:	18%

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

3.6.2 Hardness: Shall be uniform and within the range 34 to 44 HRC (see 8.1), but hardness of the threaded section, and of the head-to-shank fillet area, may be higher as a result of the cold working operations. Parts shall not be rejected on the basis of hardness if the tensile strength properties specified in 3.5.1 are met.

3.6.3 Stress-Rupture Strength at 730 °C:

3.6.3.1 Finished Parts: Finished parts, maintained at 730 °C ± 2 °C 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 maximum root diameter of the thread but the part can be tested satisfactorily, parts shall conform to the requirements of 3.6.3.1.1.

3.6.3.1.1 Parts having a shank diameter less than the maximum 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 730 °C ± 2 °C while a load sufficient to produce an initial axial stress of 520 MPa is applied continuously, shall not rupture in less than 23 hours. Tests shall be conducted in accordance with ASTM E 139.

3.6.4 Ultimate Shear Strength at Room Temperature: Finished parts having a close toleranced full shank as in MA1518 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 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 726 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 or 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 from imperfections detrimental to the usage of the part.

3.7.1 Macroscopic Examination, Headed Blank: A specimen cut from a headed blank shall be etched in a suitable etchant and examined at a magnification of 20X to determine conformance to the requirements of 3.7.1.1 and 3.7.1.2. The head and shank section shall extend not less than D/2 from the bearing surface of the head, where "D" is the nominal diameter of the shank after heading.

3.7.1.1 Flow Lines: After heading and prior to heat treatment, examination of an etched section taken longitudinally through the blank 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 shall be as agreed upon by purchaser and vendor.

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

3.7.2 Microscopic Examination, Finished Parts: Specimens cut from finished parts shall be polished, etched in Kalling's reagent, Marble's reagent, or other suitable etchant, and examined at a magnification not lower than 100X to determine conformance to the requirements of 3.7.2.1, 3.7.2.2, 3.7.2.3, 3.7.2.4, 3.7.2.5, and 3.7.2.6.

3.7.2.1 Flow Lines: 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: An isolated grain as large as ASTM No. 00 and as small as ASTM No. 7, as determined by comparison of the specimen with the chart in ASTM E 112, may be accepted provided it is surrounded by grains which are ASTM No. 2 to ASTM No. 6 and the fastener has passed all required testing per specification. No large grain near the bearing surface or in the fillet radius will be permitted. In case of disagreement on grain size by the comparison method, the intercept (Heyn) procedure shall be used.

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

3.7.2.6 Threads: 3.7.2.6.1Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (see Figure 4).

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

3.7.2.6.3 Single Lap on Thread Profile: Shall conform to the following:

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

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

c. Crest craters, crest laps, or a crest lap in combination with a crest crater are permissible provided that the imperfections do not extend deeper than the limit specified in Table 1 as measured from the thread crest when the thread major diameter is at minimum size (see Figure 8). The major diameter of the thread shall be measured prior to sectioning. As the major diameter of the thread approaches maximum size, values for depth of crest crater and crest lap imperfections listed in Table 1 may be increased by one-half of the difference between the minimum major diameter and actual major diameter as measured on the part.

3.7.3 Fluorescent Penetrant Inspection: Prior to any required plating or coating, parts shall be subject to fluorescent penetrant inspection in accordance with ASTM 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° to the axis of the shank), such as grinding checks and cracks.

3.7.3.1.2 Longitudinal indications (i.e., at an angle of 10° 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 is not less than 1.6 mm in all directions.

3.7.3.2.2 Sides of Head: There shall be not more than three indications per head. The length of each indication may be the full height of the surface but no indication shall break over either edge to a depth greater than 0.8 mm or the equivalent of the 2H/3 thread depth (see Table 1), whichever is less.

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

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

3.7.3.2.5 Top of Head and End of Stem: The number of indications is not restricted but the depth of any individual indication shall not exceed 0.25 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 as deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance:

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during production of parts.

4.3 Production Acceptance Tests:

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1 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 AMS 5708.

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

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

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

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

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

4.5 Reports:

The vendor of parts shall furnish with each shipment a report stating that the chemical composition of the parts conforms to the applicable material specification, showing the results of tests to determine conformance to the room temperature ultimate tensile property, hardness, ultimate shear property where applicable, and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, MA3378, 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:

METRIC FASTENERS, NICKEL BASE ALLOY, CORROSION AND HEAT RESISTANT
MA3378 (or MA3378-1, as applicable)
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

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

6. ACKNOWLEDGMENT:

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

7. REJECTIONS:

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

8. NOTES:

8.1 Hardness conversion tables for metals are presented in ASTM 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

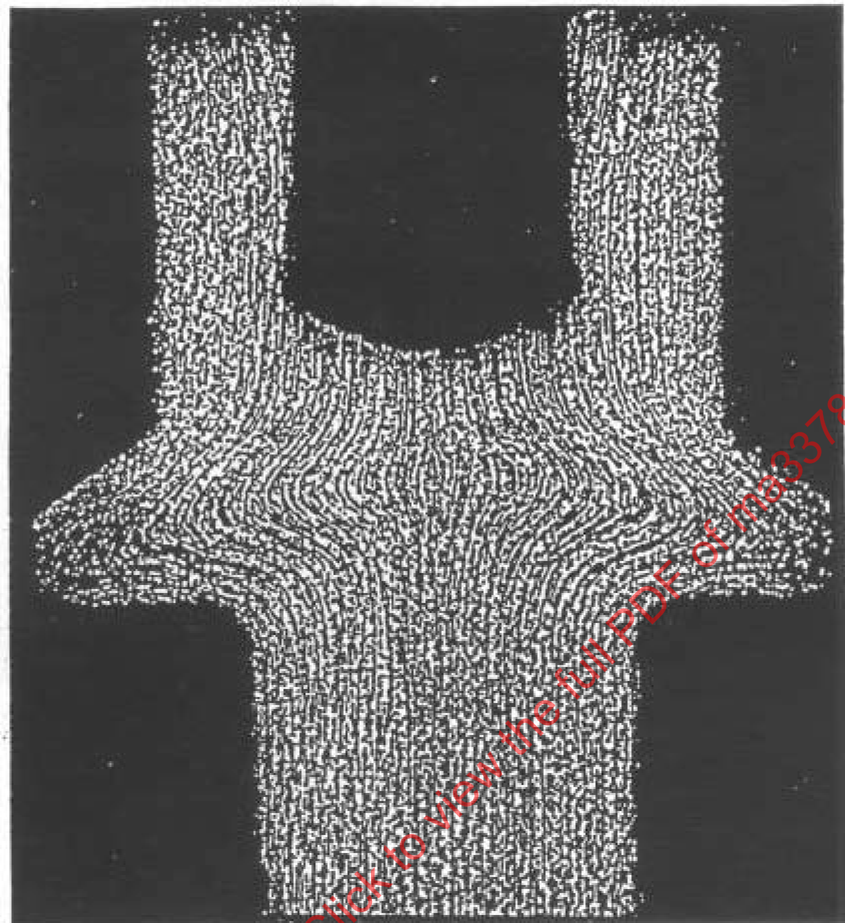


FIGURE 1 - Satisfactory Grain Flow, Headed Blank, Before Heat Treatment
Showing a smooth, well formed grain flow following the contour of the head-to-shank fillet radius.

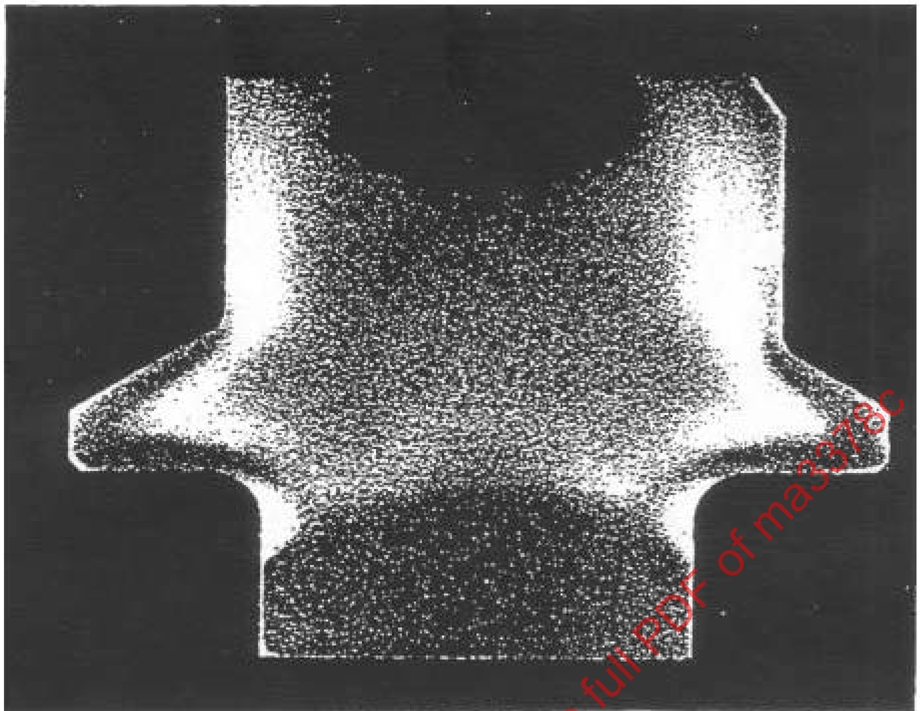
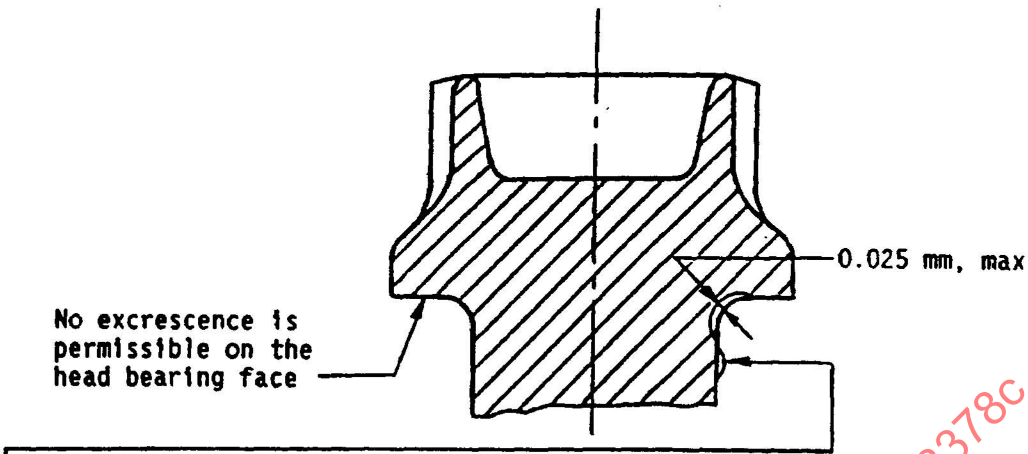


FIGURE 1A - Satisfactory Heat Pattern, Headed Blank, Before Heat Treatment



The shank diameter at this position, inclusive of distortion shall:

a. On full shank close tolerance bolts, not to exceed the **maximum shank** diameter.
b. On full shank coarse tolerance bolts, not to exceed the actual shank diameter, prior to distortion, by more than 0.06 mm on diameter.
c. On PD shank bolts, not to exceed the actual PD shank diameter, prior to distortion, by more than 0.06 mm on diameter.

FIGURE 2 - Permissible Distortion From Fillet Working

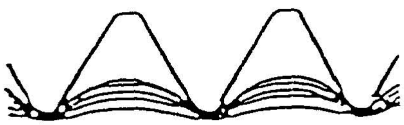


FIGURE 3 - Flow Lines, Rolled Thread

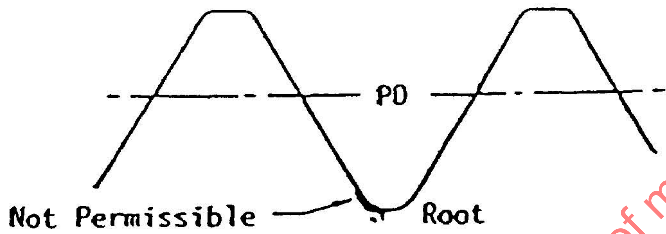


FIGURE 4 - Root Defects, Rolled Thread

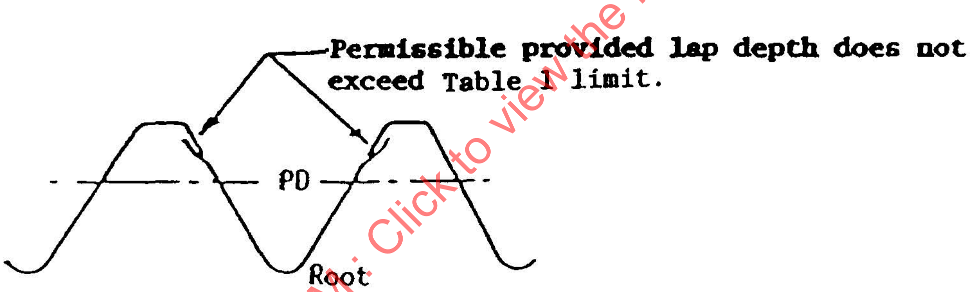


FIGURE 5 - Laps Above Pitch Diameter Extending Towards Crest, Rolled Thread

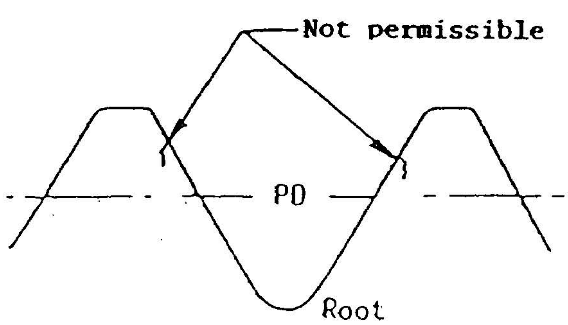


FIGURE 6 - Laps Above PD Extending Toward Root, Rolled Thread

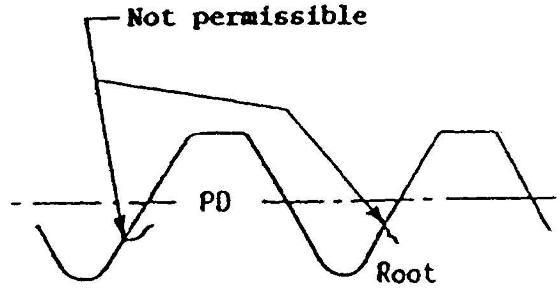
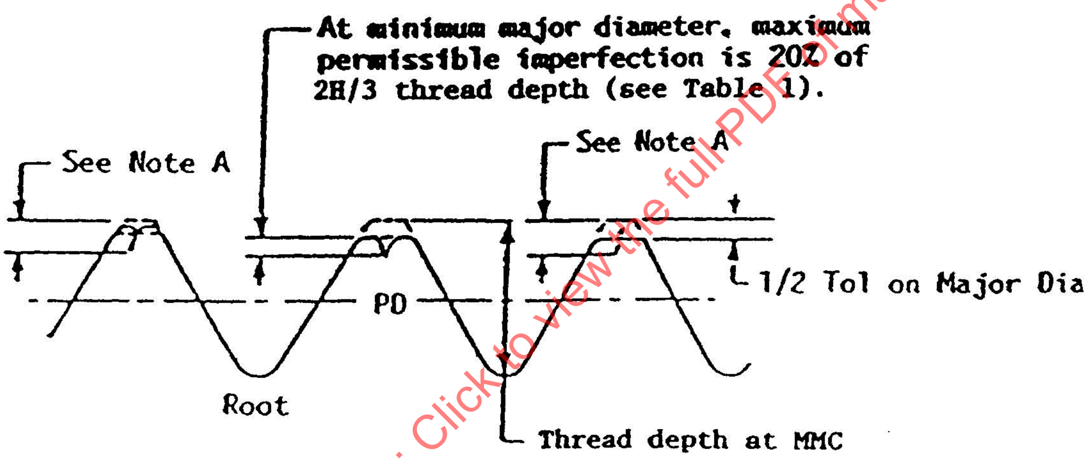


FIGURE 7 - Laps Below PD Extending In Any Direction, Rolled Thread



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 - MJ Ext Thread Depth at 2H/3 and Allowable Thread Lap Depth

Thread Pitch mm	MJ Ext Thread Depth at 2H/3 mm	Allowable Thread Lap Depth mm
0.5	0.29	0.06
0.6	0.35	0.07
0.7	0.40	0.08
0.8	0.46	0.09
1	0.58	0.12
1.25	0.72	0.14
1.5	0.87	0.17
1.75	1.01	0.20
2	1.16	0.23
2.5	1.44	0.29
3	1.73	0.35

Note 1: Allowable lap depth is based upon 20% of MJ external thread depth at 2H/3 in accordance with MA1370, and is calculated as follows:

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

where:

H = height of sharp V-thread
p = pitch

TABLE 2A - Test Loads for Bolts

Thread Size	Ultimate Tensile Strength Test Load kN, minimum	Stress-Rupture Strength Test Load kN	Double Shear Strength Test Load kN, minimum
3 x 0.5	6.175	2.398	10.26
3.5 x 0.6	8.318	3.218	13.97
4 x 0.7	10.78	4.161	18.25
5 x 0.8	17.39	6.785	28.51
6 x 1	24.69	9.587	41.05
7 x 1	35.33	13.95	55.88
8 x 1	47.87	19.14	72.99
10 x 1.25	74.81	29.90	114.0
12 x 1.25	112.3	45.52	164.2
14 x 1.5	152.0	61.47	223.5
16 x 1.5	203.9	83.14	291.9
18 x 1.5	263.4	108.1	369.5
20 x 1.5	330.4	136.3	456.2
22 x 1.5	405.1	167.8	552.0
24 x 2	468.2	192.2	656.9

NOTE 1: Requirements above for ultimate tensile strength and stress-rupture strength apply to parts with metric MJ threads to the sizes shown, to class 4h6h tolerances. Above requirements for ultimate double shear strength apply to close toleranced, full shank metric fasteners as in MA1518. Area upon which stress for ultimate tensile strength load requirements is based is the tensile stress area as defined in MA1520, for threads rolled prior to precipitation heat treatment, and calculated from Equation 1:

$$A1 = 0.7854[0.5(d_2 + d_3)]^2 \quad \text{(Eq.1)}$$

where:

A_1 = tensile stress area at mean diameter between d_2 and d_3, mm^2
d_2 = maximum pitch diameter, mm
d_3 = maximum root diameter, mm

Area upon which stress-rupture tensile test load requirements is based is the area at the maximum root diameter for MJ threads as defined in MA1520, and calculated from Equation 2:

$$A2 = 0.7854(d_3)^2 \quad \text{(Eq.2)}$$

where:

A2 = area at maximum root diameter, mm^2
d_3 = maximum root diameter, mm