METRIC AEROSPACE STANDARD

SAE MA3374B

Issued 1986-02
Reaffirmed 2006-05
Revised 2011-06

Superseding MA3374A

Bolts and Screws, UNS S66286, Corrosion and Heat Resistant Steel, Procurement Specification, Metric

FSC 5306

RATIONALE

To revise paragraph 3.5 by adding "two to" three threads in agreement with NASM1312 test methodology and general updating of specifications and SAE formatting requirements.

1. SCOPE

1.1 Type

This document covers metric 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:

MA3374 900 MPa minimum ultimate tensile strength at room temperature
480 MPa stress-rupture strength at 650 °C

MA3374-1 900 MPa minimum ultimate tensile strength at room temperature
590 MPa minimum ultimate shear strength at room temperature

1.2 Application

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

1.3 Safety - Hazardous Materials

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

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

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

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

MA1370 Screw Threads - MJ Profile, Metric

MA1518 Bolts, Screws and Nuts - External Wrenching, Metric Threads - Design Parameters for

MA1520 Areas for Calculating Stress or Load Values 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 AIA Publications

AIA Publications: Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington,VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM1312-6 Fastener Test Methods, Method 6, Hardness

NASM1312-10 Fastener Test Methods, Method 10, Stress Rupture

NASM1312-13 Fastener Test Methods, Method 13, Double Shear Test

NASM1312-108 Fastener Test Methods, Method 108, Metric Tenslie Testing

2.1.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

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

2.1.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 8M Tension Testing of Metallic Materials

ASTM E112 Determining Average Grain Size

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

ASTM E 140 Standard Hardness Tables for Metals

ASTM A 967 Chemical Passivation for Stainless Steel Parts

ASTM E 1417 Liquid Penetrant Examination

ASTM D 3951 Commercial Packaging

2.2 Definitions

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

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

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

°C degree Celsius

°F degree Fahrenheit

mm millimeter

cm^3 cubic centimeter

g gram (mass)

h hour

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 AMS5731 steel heading stock.

3.2 Design

Finished (completely manufactured) parts shall conform to the following requirements:

3.2.1 Dimensions

The dimensions of finished parts, after all processing including plating, shall conform to the part drawing. Dimensions shall apply after plating but before coating with dry film lubricants.

3.2.2 Surface Texture

Surface texture of finished parts, prior to plating or coating, shall conform to the requirements as specified on the part drawing, determined in accordance with 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 the juncture of the unthreaded portion of the shank or adjacent to the head as specified in AS3062.

3.2.3.2 Chamfer

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

3.2.4 Geometric Tolerances

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

3.3 Fabrication

3.3.1 Blanks

Heads shall be formed by hot or cold forging; machined heads are not permitted, except lightening holes may be produced by any suitable method. Wrenching recesses may be forged or machined. Flash or chip clearance in machined recesses shall not cause recess dimensions to exceed the specified limits. Heading stock to be hot forged shall not be heated to a temperature higher than 1150 °C.

3.3.2 Heat Treatment

Shall conform to the technical requirements and other provisions specified in AMS2759/3 for A-286, 980 °C solution treatment and 720 °C aging treatment.

3.3.2.1 Solution Heat Treatment

Headed blanks of AMS5731 shall, before finishing the shank and the bearing surface of the head, cold rolling the head-to-shank fillet radius, and rolling the threads, be solution heat treated as in 3.3.2.

3.3.2.2 Aging Treatment

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

3.3.3 Oxide Removal

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

3.3.4 Cold 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 Figure 2. In configurations having an undercut connected with the fillet radius, the cold rolling will be required only for 90 degrees of fillet arc, starting at the point of tangency of the fillet radius and the bearing surface of the head. For shouldered bolts, having an unthreaded shank diameter larger than the thread major diameter and having an undercut connected with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold working will be required only for 90 degrees of fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank.

3.3.5 Thread Rolling

Threads shall be formed on the heat treated and 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 copper sulfate test in accordance with ASTM A 967.

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 Mechanical Properties

Where MA3374 is specified, parts shall conform to the requirements of 3.5.1, 3.5.2, and 3.5.4. Where MA3374-1 is specified, parts shall conform to the requirements of 3.5.1, 3.5.2, and 3.5.3. 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. The loaded portion of the shank shall have two to three full thread turns from the thread runout exposed beween the loading fixtures during the tensile and stress-rupture tests.

MA3374 finished parts shall be tested in accordance with the following test methods:

a. Hardness: NASM 1312-6

b. Ultimate Tensile Strength at Room Temperature: NASM 1312-108

c. Stress-Rupture Strength at 650 °C NASM 1312-10

MA3374-1 finished parts shall be tested in accordance with the following test methods:

a. Hardness: NASM 1312-6

b. Ultimate Tensile Strength at Room Temperature: NASM 1312-108

c. Room Temperature Ultimate Shear Strength: NASM 1312-13

3.5.1 Ultimate Tensile Strength at Room Temperature

3.5.1.1 Finished Parts

Tension bolts shall have an ultimate tensile load not lower than that specified in Table 1 and shall be tested to failure in order to observe fracture location, first measuring and recording the maximum tensile load achieved. Screws, such as 100 degree flush head, pan head, and fillister head, shall have an ultimate tensile load not lower than that specified in Table 1; screws need not be tested to failure, however, the maximum tensile load achieved shall be measured and recorded. If the size or shape of the part is such that failure would occur outside the threaded section but the part can be tested satisfactorily, such as parts having a shank diameter equal to or less than the thread root diameter or having an undercut, parts shall conform to only the ultimate tensile strength requirements of 3.5.1.2; 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.

3.5.1.2 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 the purchaser to perform confirmatory tests. Such specimens shall meet the following requirements:

a. Ultimate Tensile Strength, minimum: 900 MPa

b. Yield Strength at 0.2% Offset, minimum: 590 MPa

c. Elongation in 5D, minimum: 15%

d. Reduction of Area, minimum: 20%

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

3.5.2 Hardness

Shall be uniform and within the range 24 to 36 HRC (see 8.1), but hardness of the threaded section and of the head-to-shank fillet area may be higher as a result of the cold rolling operations. Parts shall not be rejected on the basis of hardness if the tensile strength properties specified in 3.5.1 are met.

3.5.3 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 ultimate double shear load has been reached, first measuring and recording the maximum dobule shear load achieved. Shear bolts having special shank diameters shall have the minimum ultimate double shear load based on 590 MPa minimum shear strength. Shear tests are not required for screws, such as 100 degree flush head, having a grip less than 2.5 times the nominal diameter or protruding head screws, such as pan head and fillister head, having a grip less than 2 times the nominal diameter. Shear test is not required for the following conditions:

a. Bolts 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.

3.5.4 Stress-Rupture Strength at 650 °C

3.5.4.1 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 h. 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 3.5.4.1.1. Screws, such as 100 degree flush head, pan head, and fillister head, are not required to be tested for stress-rupture strength at 650 °C.

3.5.4.1.1 Parts having a shank diameter less than the maximum root diameter of the thread shall be tested as in 3.5.4.1 except that the load shall be as specified in 3.5.4.2. The diameter of the area on which stress is based shall be the actual measured minimum diameter of the part.

3.5.4.2 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 650 °C ± 2 °C while a load sufficient to produce an initial axial stress of 480 MPa is applied continuously, shall not rupture in less than 23 h. Tests shall be conducted in accordance with ASTM E 139.

3.6 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.

3.6.1 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 10X to determine conformance to the requirements of 3.6.1.1 and 3.6.1.2. 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.

3.6.1.1 Flow Lines

3.6.1.1.1 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.

3.6.1.1.2 Head-To-Shank, Finished Part

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

3.6.1.1.3 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.

3.6.1.2 Internal Defects

Examination of longitudinal sections of the head and shank shall reveal no cracks, laps, or porosity. Thread imperfections as in 3.6.2.4 shall be examined in accordance with 3.6.2.

3.6.2 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), 20 cm^3 of water, and 4 g of cupric sulfate pentahydrate], or other suitable etchant, and examined at a magnification not lower than 100X to determine conformance to the requirements of 3.6.2.1, 3.6.2.2, 3.6.2.3 and 3.6.2.4.

3.6.2.1 Microstructure

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

3.6.2.2 Grain Size

Shall be ASTM No. 5 or finer as determined by the comparison method of ASTM E 112. 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 0.65 mm. Bands of fine or coarse grains are not permitted. In case of dispute, the intercept (Heyn) method shall be used.

3.6.2.3 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 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.

3.6.2.4 Threads

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

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

3.6.2.4.3 Single 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 slight 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.

3.6.3 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.

3.6.3.1 The following conditions shall be cause for rejection of parts inspected.

3.6.3.1.1 Discontinuities transverse to grain flow (i.e., at an angle of more than 10 degrees to the axis of the shank), such as grinding checks and quench cracks.

3.6.3.1.2 Longitudinal indications (i.e., at an angle of 10 degrees or less to the axis of the shank) due to imperfections other than seams, forming laps, and non metallic inclusions.

3.6.3.2 The following conditions shall be considered acceptable on parts inspected.

3.6.3.2.1 Parts having longitudinal indications (i.e., at an angle of 10 degrees or less to the axis of the shank) of seams and forming laps parallel to the grain flow that are within the limits specified in 3.6.3.2.2 through 3.6.3.2.5 provided the separation between indications is not less than 1.6 mm in all directions.

3.6.3.2.2 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.

3.6.3.2.3 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.

3.6.3.2.4 Threads

There shall be no indications, except as permitted in 3.6.2.4. Rateable lap indications shall conform to 3.6.2.4.3(a).

3.6.3.2.5 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 3.6.3.2.2, shall break over an edge.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of parts shall supply all samples and shall be responsible for performing all required tests. Purchaser reserves the right to perform such confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance

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

4.3 Production Acceptance Tests

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

4.3.1 Tests for all technical requirements are acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 3.

4.4 Acceptance Test Sampling

4.4.1 Material

Sampling for material composition on each heat shall be in accordance with AMS5731.

4.4.2 Nondestructive Tests, Visual and Dimensional

A random sample of parts shall be taken from each production inspection lot; the size of the sample to be as specified in Table 4. The classification of dimensional characteristics shall be as specified in Table 5. All dimensional characteristics are considered defective when out of tolerance.

4.4.3 Fluorescent Penetrant Inspection

A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 4 and classified as in Table 5. The sample units may be selected from those that have been subjected to and passed the visual and dimensional inspection, with additional units selected at random from the production inspection lot as necessary.

4.4.4 Stress-Rupture Test

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

4.4.5 Destructive Tests

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

4.4.6 Acceptance Quality

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

4.4.7 Test Specimens

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

4.5 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, double shear test (if required), and stress-rupture requirements, and stating that the parts conform to the other technical requirements. This report shall include the purchase order number, MA3374B, 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 BOLTS (SCREWS), UNS S66286 TENSILE STRENGTH 900 MPa
MA3374B (or MA3374-1, 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

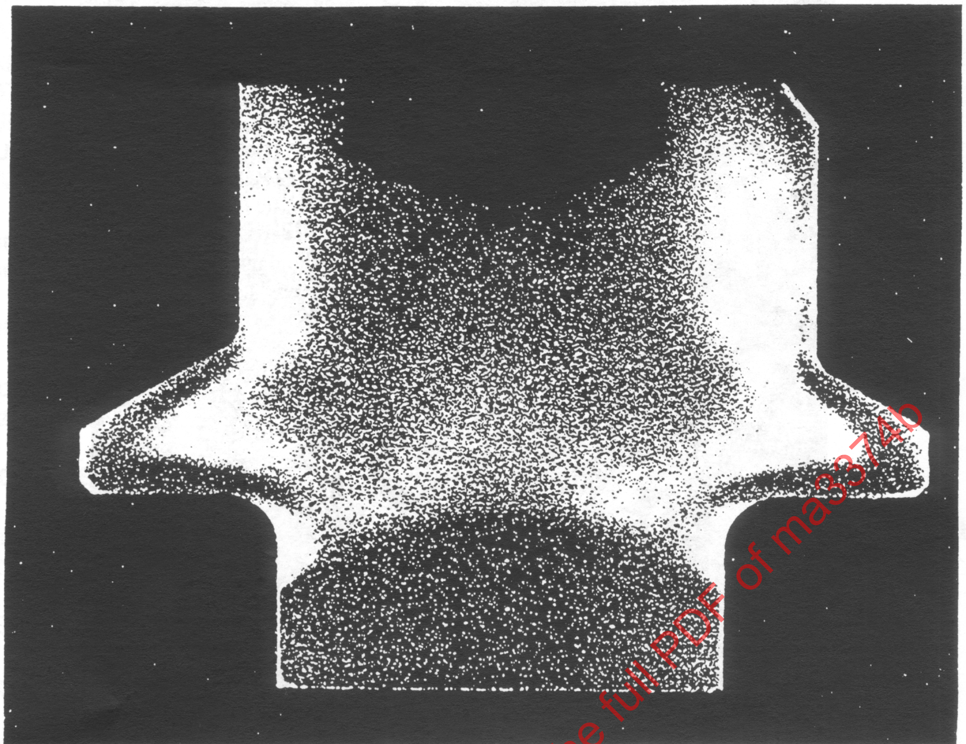
8.1 Hardness Conversion Tables

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

8.2 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

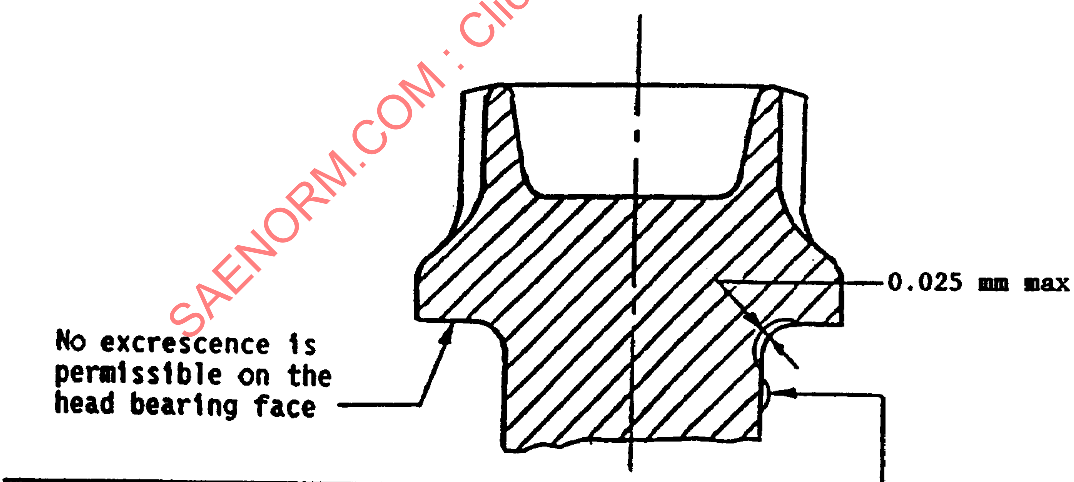
SHOWING A SMOOTH, WELL FORMED GRAIN FLOW FOLLOWING
THE CONTOUR OF THE HEAD-TO-SHANK FILLET RADIUS.

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



SHOWS EVIDENCE THAT HEAD WAS FORMED BY FORGING.

FIGURE 1A - HEAD-TO-SHANK SECTION THROUGH FINISHED PART



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

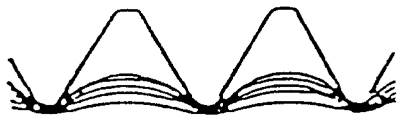


FIGURE 3 - FLOW LINES, ROLLED THREAD

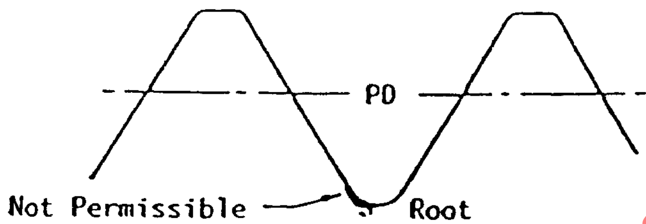


FIGURE 4 - ROOT DEFECTS, ROLLED THREAD

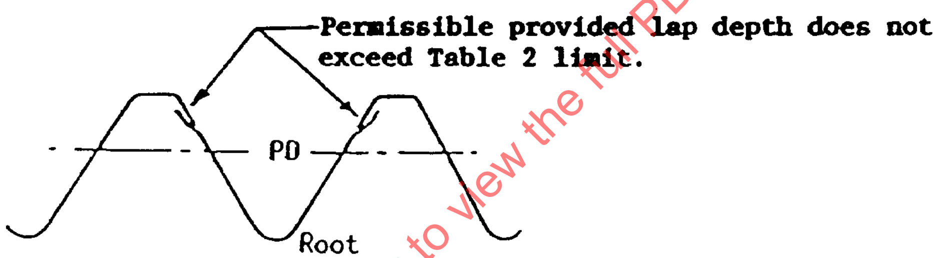


FIGURE 5 - LAPS ABOVE PITCH DIAMETER EXTENDING TOWARDS CREST, ROLLED THREAD

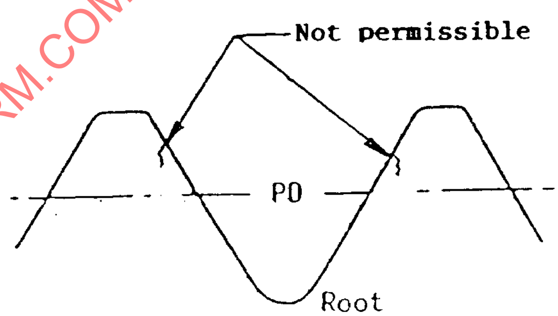


FIGURE 6 - LAPS ABOVE PD EXTENDING TOWARD ROOT, ROLLED THREAD

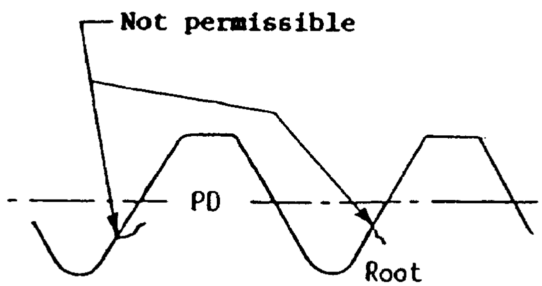
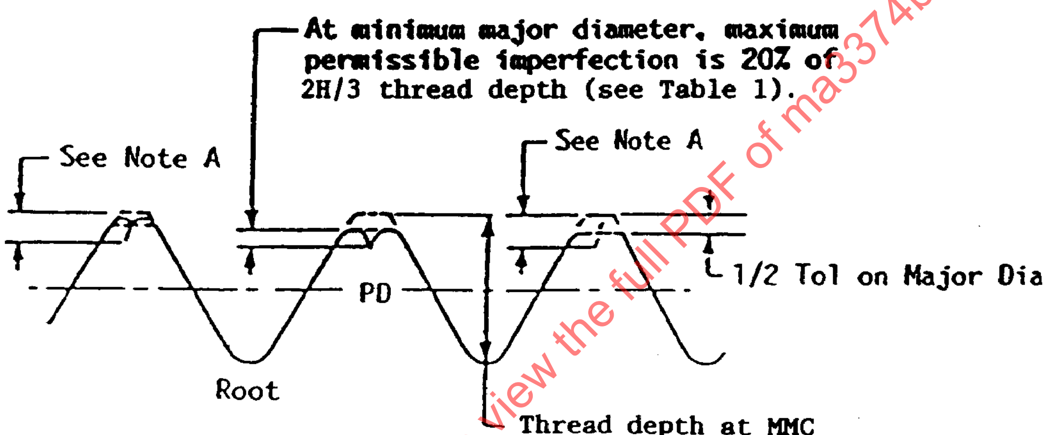


FIGURE 7 - LAPS BELOW PD EXTENDING IN ANY DIRECTION, ROLLED THREAD



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 - TEST LOADS

Thread Size	Ultimate Tensile Strength Room Temperature Test Load kN minimum Bolts	Ultimate Tensile Strength Room Temperature Test Load kN minimum Screws	Stress-Rupture Test Load kN	Ultimate Double Shear kN minimum
3 x 0.5	4.895	4.463	2.213	8.341
3.5 x 0.6	6.602	6.008	2.970	11.35
4 x 0.7	8.565	7.782	3.841	14.83
5 x 0.8	13.77	12.59	6.263	23.17
6 x 1	19.58	17.85	8.850	33.36
7 x 1	27.84	25.67	12.88	45.41
8 x 1	37.51	34.89	17.66	59.31
10 x 1.25	58.62	54.52	27.60	92.68
12 x 1.25	87.42		42.02	133.5
14 x 1.5	118.4		56.74	181.6
16 x 1.5	158.1		76.75	237.3
18 x 1.5	203.4		99.77	300.3
20 x 1.5	254.3		125.8	370.7
22 x 1.5	310.9		154.9	448.6
24 x 2	361.5		177.4	533.8

Bolt - Hexagon Head, Double Hexagon Head, and Spline Drive Head as in MA1518.
Screw - 100° Flush Head, Pan Head, Fillister Head

NOTE 1: Requirements above apply to parts with metric MJ threads to the sizes shown, to Class 4h6h tolerances. Area upon which stress for ultimate tensile strength load for bolts is based on the tensile stress area as defined in MA1520, for threads rolled after heat treatment, and calculated from Equation 1:

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

where:

A_1 = tensile stress area for bolts
d_2 = maximum pitch diameter
d_3 = maximum root diameter

Area upon which stress for ultimate tensile strength for screws is based on the tensile stress area at 0.5625H thread depth, where H is the height of sharp V-thread, calculated as follows in Equation 2:

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

where:

d = maximum major diameter
p = thread pitch