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400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE STANDARD

MA3376

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Revised

BOLTS & SCREWS, SAE 8740 HEAT TREATED, ROLL THREADED PROCUREMENT SPECIFICATION FOR, METRIC

1. SCOPE:

1.1 Type: This procurement specification covers aircraft quality metric bolts and screws made of a low-alloy steel, SAE 8740.

1.2 Application: Primarily for joining parts where minimum strengths of 860 MPa and 1000 MPa are required.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Standards (AS & MA) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2640 - Magnetic Particle Inspection
AMS 6322 - Steel Bars and Forgings, 0.50Cr-0.55Ni-0.25Mo(0.38-0.43C) (SAE 8740)

2.1.2 Aerospace Standards:

MA1518 - Bolts, Screws and Nuts - External Wrenching, Metric MJ Threads - Design Parameters For
AS1520 - 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

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials

2.3 ANSI Publications: Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI B1.21M - Metric Screw Threads - MJ Profile
ANSI B46.1 - Surface Texture

2.4 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

2.4.1 Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-1312 - Fasteners, Test Methods

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be AMS 6322 steel, unless otherwise specified.

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 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.

3.2.3 Threads: Metric screw thread MJ profile and dimensions per ANSI B1.21M, unless otherwise specified on the part drawing.

3.2.3.1 Incomplete Threads: Incomplete threads are permissible at the chamfered 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 point of the thread shall be chamfered as specified on the part drawing.

3.2.4 Geometric Tolerances: Part features shall be within the geometric tolerance specified on the part drawing and, where applicable, controlled per 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.

3.3.2 Heat Treatment: Headed blanks shall, before finishing the shank and bearing surface of the head, cold working the head-to-shank fillet radius, and rolling the threads, be heat treated as follows:

3.3.2.1 Heating Equipment: Furnaces may be any type ensuring uniform temperature throughout the parts and shall be equipped with, and operated by, automatic temperature controllers. The heating medium or atmosphere shall cause neither surface hardening nor decarburization other than that permitted by 3.7.2.2 and 3.7.2.3.

3.3.2.2 Hardening: Headed blanks of AMS 6322 shall be unifromly heated to 815° - 840°C, held at heat for not less than 15 min, and quenched in oil. For other steels, when specified, the temperature shall be as agreed by purchaser and vendor.

3.3.2.3 Tempering: Hardened blanks shall be tempered by heating uniformly to the temperature necessary to produce the specified hardness and microstructure, holding at heat for not less than 1 hr, and cooling.

3.3.3 Oxide and Decarburization Removal: The heat treated blanks, before cold working the fillet radius and rolling the threads, shall have all surfaces free from surface oxide, oxide penetration, and decarburization except as permitted in 3.7.2.3. The 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 and in no case shall be so great as to produce more cutting of flow lines in the head-to-shank junction of upset headed parts than shown in Fig. 1B.

3.3.4 Cold Working 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 worked sufficiently to remove all visual evidence of grinding or tool marks. Distortion due to cold working shall conform to Fig. 2 unless otherwise specified on 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 Fig. 2; distorted areas shall not extend beyond "C" as shown in Fig. 2. In configurations having an undercut associated with the fillet radius, the cold working will be required only for 90 deg 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 associated

with a fillet between the threaded shank and the shoulder of the unthreaded shank, the cold working will be required only for 90 deg of fillet arc, starting at the point of tangency of the fillet radius and the shouldered surface of the unthreaded shank, For parts with compound radii between head and shank, cold work only the radius that blends with the head.

3.3.5 Thread Rolling: Threads shall be formed on the heat treated and finished blanks by a single rolling process.

3.4 Product Marking: Each part shall be identification marked as specified by the part drawing. Unless otherwise specified, the markings may be formed by forging or stamping, raised or depressed 0.25 mm max, with rounded root form on depressed characters.

3.5 Plating: Where required, all surfaces shall be plated as specified by the part drawing.

3.6 Mechanical Properties: Parts shall conform to the requirements of 3.6.1.1 or 3.6.1.2, as applicable, and to the requirements of 3.6.2. Threaded members of gripping fixtures for tensile 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 three full thread turns from thread runout exposed between the loading fixtures during tensile tests. Finished parts shall be tested in accordance with MIL-STD-1312, Test No. 8.

3.6.1 Tensile Strength at Room Temperature:

3.6.1.1 Finished Parts: Parts having hardness not lower that 26 HRC shall withstand the minimum tensile load specified in Table II. 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 tensile strength requirement of 3.6.1.2; for such parts, the diameter on which stress is based shall be the actual measured minimum diameter of the part. Tension fasteners with either standard spline drive or hexagon-type 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 associated 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 E8 on specimens prepared as in 4.3.3. Such specimens shall meet the following requirements:

Minimum Hardness of Specified Range HRC	Tensile Strength, min MPa	Elongation in 5D, min	Reduction of Area, min
26	860	15 %	52 %
32	1000	13 %	50 %

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 specified on the part drawing, determined in accordance with MIL-STD-1312, Test No. 6, but hardness of the threaded section, and of the head-to-shank fillet area, may be higher as result of the cold working operations. When hardness is not specified on the part drawing, hardness shall be within the range 26 - 32 HRC or equivalent.

3.7 Quality: Parts shall be uniform in quality and condition, clean, sound, smooth, and free from burrs and foreign materials and from internal and external imperfections detrimental to their performance.

3.7.1 Macroscopic Examination: Parts or sections of parts, as applicable, shall be etched in a solution of approximately 50 % hydrochloric acid (sp gr 1.19) and 50 % water for sufficient time to reveal flow lines but not longer than 15 min. and examined at approximately 20X magnification to determine conformance to the following requirements, except that examination for the thread imperfections as specified in 3.7.1.3 may be made by microscopic examination of specimens polished and etched as in 3.7.2.

3.7.1.1 Flow Lines:

3.7.1.1.1 Head-to-Shank: Examination of a longitudinal section through the part shall show flow lines in the shank, head-to-shank fillet, and bearing surface which follow the contour of the part as shown in Fig. 1A, except that slight cutting of flow lines by the oxide and decarburization removal process of 3.3.3 is permissible, as shown in Fig. 1B; excessive cutting of flow lines in the shank, head-to-shank fillet, and bearing surface, as shown in Fig. 1C, is not permissible except when an undercut is associated with the fillet radius. The head style shown in Figs. 1A through 1C is for illustrative purposes only but other symmetrical head styles shall conform to the above requirements. Flow lines in heads on parts 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 Threads: Flow lines in threads shall be continuous, shall follow the general thread contour, and shall be of maximum density at root of thread (See Fig. 3).

3.7.1.2 Internal Defects: Examination of longitudinal sections of the head and shank of the threads shall reveal no cracks, laps, or porosity except laps in threads as permitted in 3.7.1.3.3 and 3.7.1.3.4. The head and shank section shall extend not less that D/2 from the bearing surface of the head and the threaded 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.

3.7.1.3 Threads:

3.7.1.3.1 Root defects such as laps, seams, notches, slivers, folds, roughness, and oxide scale are not permissible (See Fig. 4).

3.7.1.3.2 Multiple laps on the flanks of threads are not permissible regardless of location. Single laps on the flanks of threads that extend toward the root are not permissible (See Figs. 5 and 6).

3.7.1.3.3 There shall be no laps along the flank of the thread below the pitch diameter (See Fig. 7). 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 toward the crest and generally parallel to the flank (See Fig. 7).

3.7.1.3.4 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 20 % of the basic thread height (See Table I) as measured from the thread crest when the thread major diameter is at minimum size (See Fig. 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 I may be increased by one-half of the difference between the minimum major diameter and actual major diameter as measured on the part.

3.7.2 Microscopic Examination: Specimens cut from parts shall be polished, etched in 2 % Nital, and examined at not lower than 100X magnification to determine conformance to the requirements of 3.7.1.3, 3.7.2.1, 3.7.2.2, and 3.7.2.3.

3.7.2.1 Microstructure: Parts shall have microstructure of tempered martensite.

3.7.2.2 Surface Hardening: Parts shall have no change in hardness from core to surface except as produced during cold working of the head-to-shank fillet radius and during rolling of threads. There shall be no evidence of carburization or nitriding. In case of dispute over results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading within 0.08 mm of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of nonconformance of this requirement.

3.7.2.3 Decarburization:

3.7.2.3.1 The bearing surface of the head, the head-to-shank fillet radius, the shank, and the threads shall be free from decarburization.

3.7.2.3.2 Depth of decarburization on those surfaces of the head which are the original surfaces of the bar shall be not greater than that permitted by the applicable material specification.

3.7.2.3.3 Depth of decarburization on the OD of the head of cylindrical head parts is not restricted.

3.7.2.3.4 Depth of decarburization at any point on any surface not covered by 3.7.2.3.1, 3.7.2.3.2, or 3.7.2.3.3, shall not exceed 0.05 mm.

3.7.3 Magnetic Particle Inspection: Parts shall be subject to magnetic particle inspection in accordance with AMS 2640; any method may be used but resolution of disputed rejections shall be based upon wet, residual, black oxide suspension method using amperages shown in 3.7.3.3.

3.7.3.1 The following conditions shall be cause for rejection of parts inspected:

3.7.3.1.1 Discontinuities transverse to grain flow (i.e., at an angle of more than 10 degrees to the axis of the shank) due to imperfections other than seams forming laps, and nonmetallic inclusions.

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

3.7.3.2 The following conditions shall be considered acceptable on parts inspected:

3.7.3.2.1 Parts having longitudinal indications (i.e., at an angle of 10 degrees or less to the axis of the shank) of seams and forming laps parallel to the grain flow that are within the limits specified in 3.7.3.2.2 thru 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 basic thread height (See Table I), 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 5 mm with a depth not exceeding 0.05 mm but the total length of all indiations 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 3.7.1.3.

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.

3.7.3.3 Procedures:

3.7.3.3.1 Circular Magnetization: 1.2 - 1.6 A/mm^2 of contact area, passed through the part longitudinally.

3.7.3.3.2 Longitudinal Magnetization: Sufficient to produce 200 ampere turns/mm of shank diameter with the part placed in a standard solenoid of appropriate size.

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. Results of such tests shall be reported to the purchaser as required by 4.4. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the parts conform to the requirements of this specification.

4.2 Classification of Tests: The inspection and testing of parts are classified as follows:

a) Acceptance tests as in 4.3.1 which are to be performed on each production inspection lot.

b) Periodic tests which are to be performed periodically on production lots at the discretion of the vendor or purchaser. None required in this specification.

4.3 Production Inspection Lot: A 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.

4.3.1 Acceptance Tests: The acceptance tests shall be performed on each production inspection lot. The acceptance tests consist of all the tests specified in Table III.

4.3.2 Acceptance Test Sampling:

4.3.2.1 Non-Destructive Test - Visual and Dimensional: A random sample will be selected from each production inspection lot; the size of the sample to be as specified in Table IV. The classification of defects for parts shall be as specified in Table V. Defects not classified in Table V shall be classified as Minor B defects. All dimensional characteristics are considered defective when out of tolerance.

4.3.2.2 Hardness Test (See 3.6.2): A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table VI, column A. 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.

4.3.2.3 Non-Destructive Inspection: Parts shall be subject to magnetic particle inspection.

4.3.2.4 Destructive Tests: A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table VI, column B. The sample units may be selected from those that have been subjected to and passed the non-destructive tests with additional units selected at random from the production inspection lot as necessary.

4.3.3 Test Specimens: Specimens for tensile testing of machined test specimens shall be of standard proportions in accordance with ASTM E8 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 diameter, from the center of coupons 20 mm and under in nominal diameter or distance between parallel sides, and from mid-radius of larger parts or coupons.

4.3.4 Acceptance Quality: The acceptance quality level and acceptance number of defectives for the acceptance tests shall be as specified in Tables IV and VI.

4.4 Reports: The vendor of parts shall furnish with each shipment three copies of 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 hardness and tensile strength requirements, and stating that the parts conform to all other technical requirements of this specification. This report shall include the purchase order number, this specification number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.5 Resampling and Retesting: If any part or specimen used in the above tests fails to meet the specified requirements for mechanical properties and quality as in 3.6 and 3.7, disposition of the parts may be based on the results of testing three additional parts or specimens for each original nonconforming part or specimen. Failure of any retest part or specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Parts having different part numbers shall be packed in separate containers.

5.1.2 Each container of parts shall be marked to show the following information:

METRIC FASTENERS, ALLOY STEEL
MA3376
PART NUMBER _____
PURCHASE ORDER NUMBER _____
QUANTITY _____
MANUFACTURER'S IDENTIFICATION _____

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

5.1.4 Containers of parts shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.1.5 For direct U.S.A. Military procurement, packaging shall be as specified in the request for procurement.

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 authorized modifications will be subject to rejection.

8. NOTES:

8.1 For direct U.S. Military procurement, purchase documents should specify the following:

Title, number, and date of this specification.
Part number or size of parts desired.
Quantity of parts desired.
Applicable level of packaging.

PREPARED BY
SAE COMMITTEE E-25
ENGINE & PROPELLER STANDARD UTILITY PARTS

TABLE I

Thread Pitch, mm	Basic Thread Height, mm, Ref (See Note 1)	20 % Basic Thread Height, mm
0.5	0.30	0.06
0.6	0.36	0.07
0.7	0.42	0.08
0.8	0.48	0.09
1	0.60	0.12
1.25	0.75	0.15
1.5	0.90	0.18
1.75	1.05	0.21
2	1.20	0.24
2.5	1.50	0.30
3	1.80	0.36

Note 1. Basic thread height is defined as being equivalent to 0.6 times the pitch.

TABLE II

Thread Size	Tensile Strength Load kN min Standard MJ Threads Room Temp.
3 x 0.5	4.8
3.5 x 0.6	6.5
4 x 0.7	8.5
5 x 0.8	13.6
6 x 1	19.4
7 x 1	27.3
8 x 1	36.5
10 x 1.25	57.0
12 x 1.25	84.5
14 x 1.5	114
16 x 1.5	152
18 x 1.5	196
20 x 1.5	244
22 x 1.5	298
24 x 2	348

Note 1. Requirements above apply to parts with metric MJ threads to the sizes shown, to class 4h6h tolerances, and having hardness within the range 26 - 32 HRC or equivalent. Area upon which stress for tensile strength load requirements is based is the tensile stress area as defined in AS 1520, for threads rolled after heat treatment, and calculated from equation:

$$A = 0.7854(d_2)^2$$

where, A = tensile stress area
d_2 = basic pitch diameter

Tensile strength load is based on 860 MPa.

Note 2. For the sizes shown, tensile strength load requirements shall be multiplied by the factor 1.163 for parts requiring 32 HRC min hardness.

Note 3. For sizes not shown, tensile strength loads for parts tested as parts, not as specimens machined from parts or from coupons of the stock, shall be based upon the stress shown below for the applicable min hardness. The tensile stress area shall be as in Note 1 above.

Min Hardness of Specified Range HRC	Tensile Stress, min MPa
26	860
32	1000

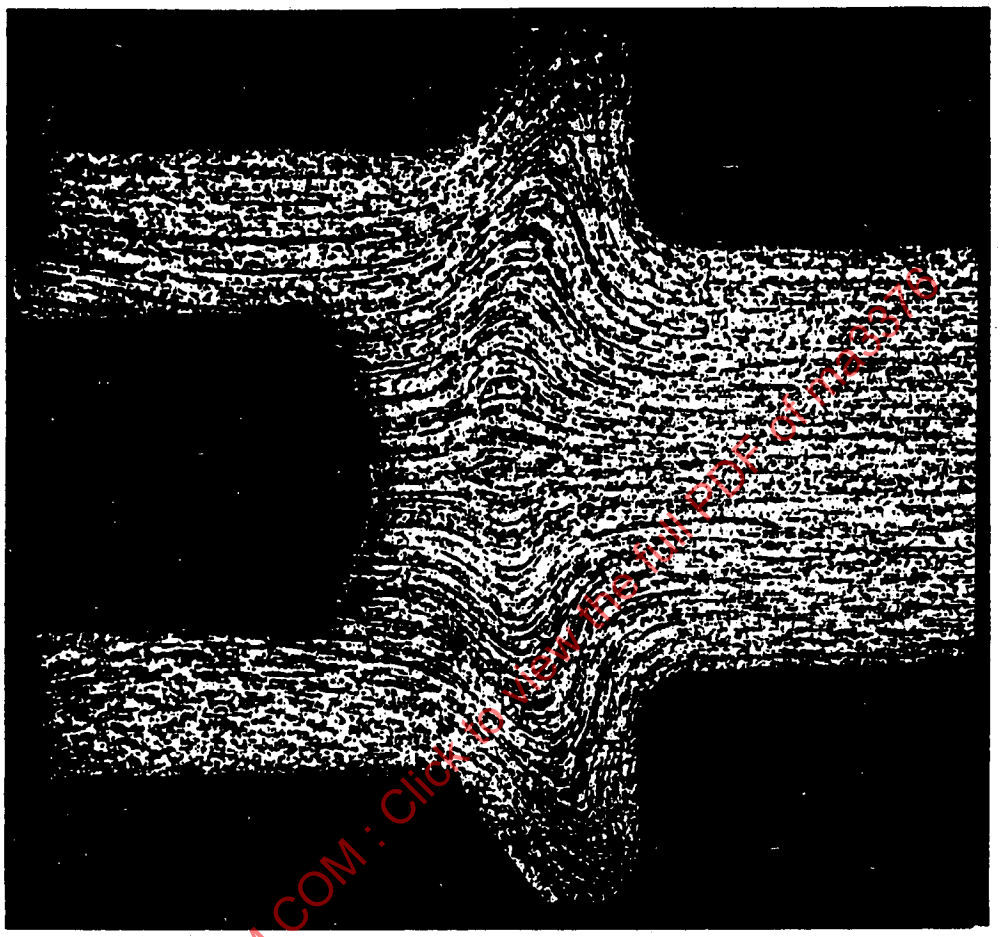


FIGURE 1A - SATISFACTORY GRAIN FLOW

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

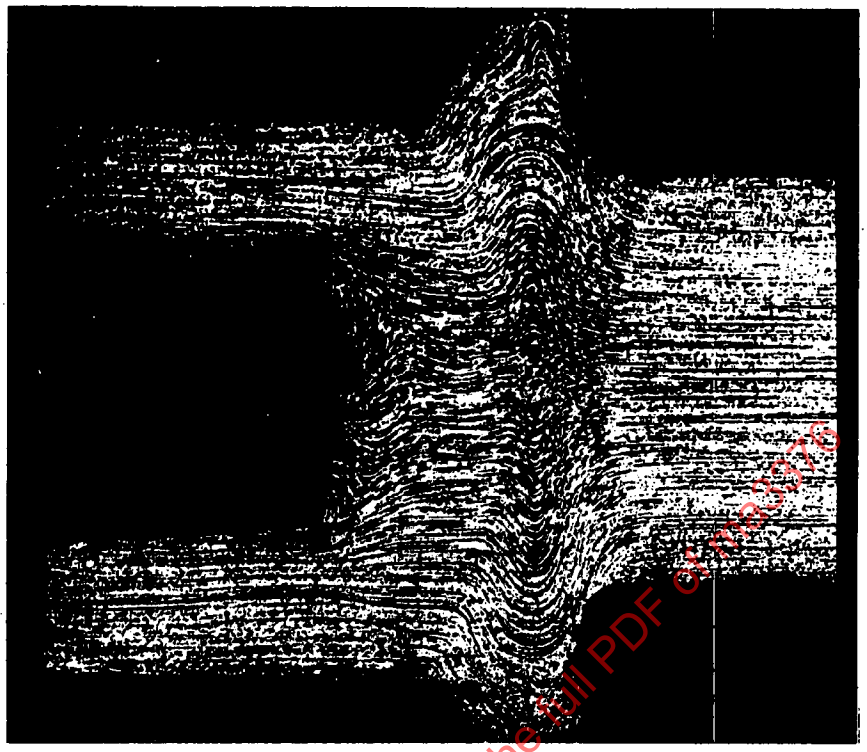


FIGURE 1B - MINIMUM ACCEPTABLE STANDARD

Showing maximum permissible cutting of grain flow after machining to remove contamination oxide.

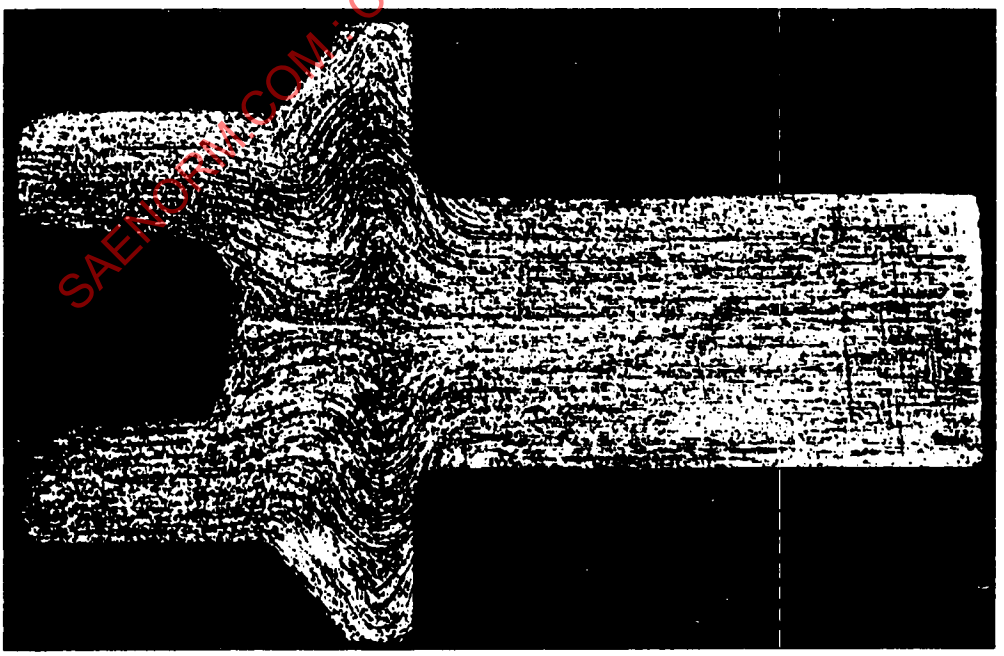
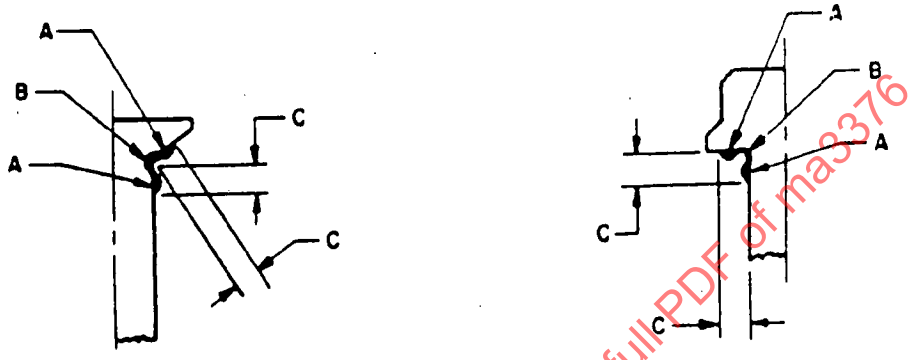


FIGURE 1C - UNACCEPTABLE GRAIN FLOW

Showing excessive cutting of grain flow in the shank, fillet and bearing surface which is not permissible.

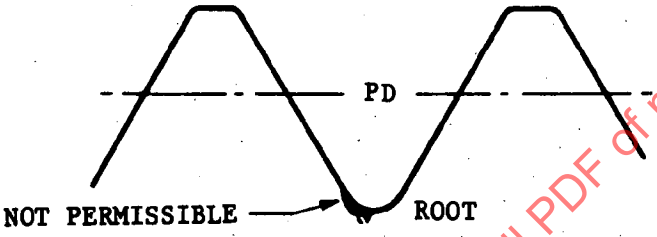


Nominal Bolt Diameter	C, max mm
Up to 8, excl	1.6
8 & 10	2.4
12 - 16 incl	3.2
18 - 24 incl	4.0
Over 24	4.8

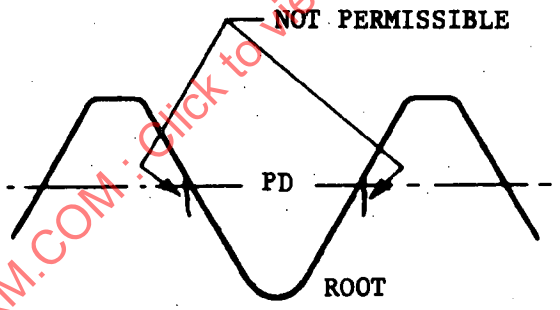
PERMISSIBLE DISTORTION FROM FILLET WORKING

FIGURE 2

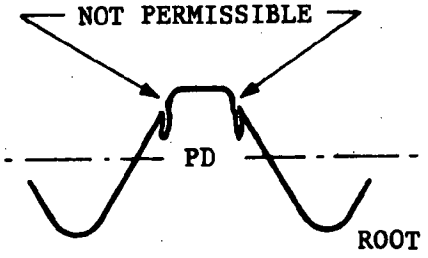
FLOW LINES, ROLLED THREAD
FIGURE 3



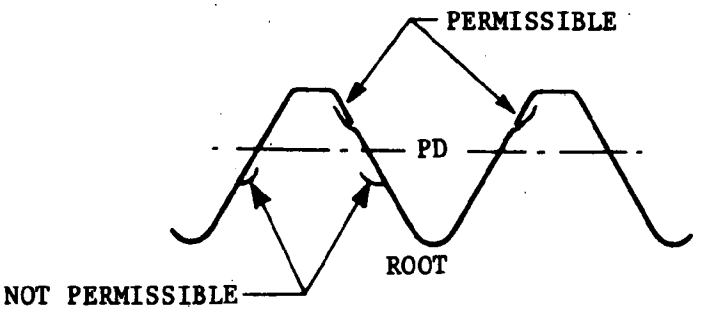
ROOT DEFECTS, ROLLED THREAD
FIGURE 4



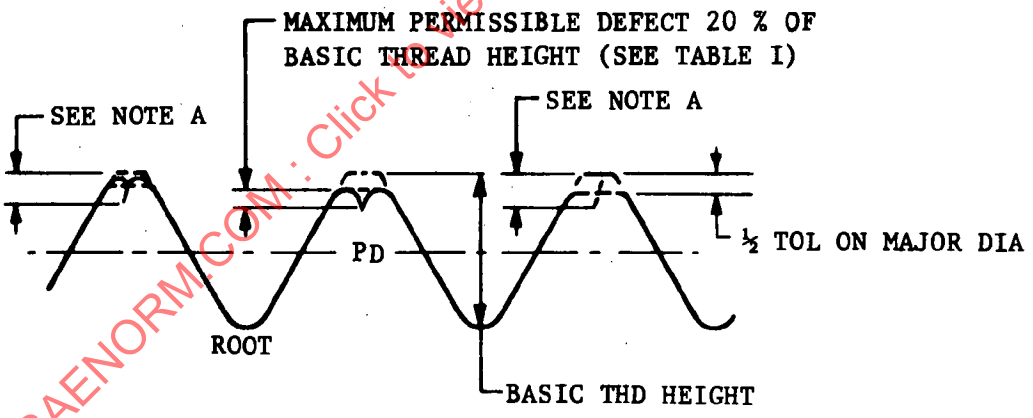
MULTIPLE LAPS BELOW PD EXTENDING TOWARD ROOT, ROLLED THREAD
FIGURE 5



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



LAPS EXTENDING TOWARDS CREST, ROLLED THREAD
FIGURE 7



Note A: Depth of defect equals 20 % of basic thread height plus ½ the difference of the actual major diameter and minimum major diameter.

CREST CRATERS & CREST LAPS, ROLLED THREAD
FIGURE 8