Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 7455E
Superseding AMS 7455D
Issued 9-15-57
Revised 1-15-80

UNS K14675

BOLTS AND SCREWS, STEEL, LOW-ALLOY HEAT-RESISTANT
Hardened and Tempered, Roll Threaded

1. SCOPE:

1.1 Type: This specification covers aircraft-quality bolts and screws made from a low-alloy, heat-resistant steel.

1.2 Application: Primarily for joining parts where high strength up to 900°F (480°C) is 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) 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 2373 - Quality Assurance Sampling of Bolts and Screws
AMS 6304 - Steel Bars, Forgings, and Tubing, Low-Alloy, Heat-Resistant, 0.95Cr - 0.55Mo - 0.30V (0.40 - 0.50C)

2.1.2 Aerospace Standards:

AS 1132 - Design Parameters for Bolts and Screws, External Wrenching, Unified Thread Inch Series
AS 1177 - Nondestructive Inspection Standards for Bolts and Screws
AS 3062 - Bolts, Screws, and Studs, Screw Thread Requirements
AS 3063 - 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 A370 - Mechanical Testing of Steel Products

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

2.3.1 Federal Standards:

FED-STD-H28 - Screw Thread Standards for Federal Services

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-1312 - Fasteners, Test Methods

Printed in U.S.A.

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be AMS 6304 steel.

3.2 Fabrication:

3.2.1 Blanks: Heads shall be formed by hot forging or cold forging.

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

3.2.2.1 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. The heating medium or atmosphere shall cause neither surface hardening nor decarburization other than that permitted by 3.4.3.2 and 3.4.3.3.

3.2.2.2 Hardening: Blanks shall be uniformly heated to 1750° F ± 25 (900°C ± 15), held at heat for 60 - 90 min., and quenched in oil or water.

3.2.2.3 Tempering: Hardened blanks shall be tempered by heating uniformly to the temperature necessary to produce the specified hardness and microstructure but not lower than 1000° F (540°C), holding at heat for not less than 6 hr, and cooling in air.

3.2.3 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 3.4.3.3. 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 than shown in Fig. 1B.

3.2.4 Cold Working of Fillet Radius: After removal of oxide and decarburization as in 3.2.3, the head-to-shank fillet radius of 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 not raise metal more than 0.002 in. (0.05 mm) above the contour at "A" or depress metal more than 0.002 in. (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.

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

3.3 Properties: Parts shall conform to the requirements of 3.3.1.1 or 3.3.1.2, as applicable, and to the requirements of 3.3.2. 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. Finished parts shall be tested in accordance with the following applicable test methods of MIL-STD-1312:

Property	Test Method
Hardness	No. 6
Tensile Strength	No. 8

3.3.1 Tensile Properties:

3.3.1.1 Finished Parts: Parts having hardness within the range 42 - 46 HRC shall have breaking load not lower than that specified in Table II. Parts requiring minimum hardness lower than 42 HRC shall have breaking load not lower than the product of the load specified in Table II and the factor listed in Note 2 of Table II applicable to the hardness range specified on the drawing. 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 minor diameter or having an undercut, parts shall have tensile strength not lower than specified in 3.3.1.2 for the applicable minimum hardness; 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 double-hexagon or hexagon-type heads having a minimum metal condition in the head equal to the design parameters specified in AS 1132 shall not fracture in the head-to-shank fillet radius except when this radius is associated with an undercut.

3.3.1.2 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 A370 on specimens prepared as in 4.3.1. Such specimens shall conform to the following requirements for the applicable hardness:

Minimum Hardness of Specified Range HRC	Tensile Strength		Elongation in 4D % , min	Reduction of Area % , min
	psi, min	(MPa, min)		
30	140,000	(965)	15	50
36	165,000	(1,138)	12	47
42	195,000	(1,345)	10	30

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

3.3.2 Hardness: Shall be uniform and within the range specified on the drawing but hardness of the threaded section and of the head-to-shank fillet area may be higher than that of other areas as a result of the cold working operations. When hardness is not specified on the drawing, it shall be within the range 42 - 46 HRC or equivalent.

3.4 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. Parts shall conform to AS 4177.

3.4.1 Dimensional Examination: Parts shall conform to the following:

3.4.1.1 Straightness, Concentricity, and Squareness: Parts shall be within the limits of the drawing, determined in accordance with AS 3063.

3.4.1.2 Threads: Shall be as specified on the drawing and shall conform to AS 3062.

3.4.2 Macroscopic Examination: Parts or sections of parts, as applicable, etched in a solution consisting 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., shall be examined at approximately 20X magnification to determine conformance to the following requirements except that examination for the thread imperfections of 3.4.2.3 may be made by microscopic examination of specimens polished and etched as in 3.4.3:

3.4.2.1 Flow Lines:

3.4.2.1.1 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 3.2.3 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 upset heads on parts having special heads, such as Dee- or Tee-shaped heads or heads thinner-than-standard as in AS 1132, shall be as agreed upon by purchaser and vendor.

3.4.2.1.2 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).

3.4.2.2 Internal Defects: Examination of longitudinal sections of the head and shank and of the threads shall reveal no cracks or other injurious imperfections. The head and shank section shall extend not less than 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.

3.4.2.3 Threads:

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

3.4.2.3.2 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).

3.4.2.3.3 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 non-pressure 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).

3.4.2.3.4 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 the actual major diameter as measured on the part.

3.4.3 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 3.4.3.1, 3.4.3.2, and 3.4.3.3.

3.4.3.1 Microstructure: Parts shall have microstructure of tempered martensite.

3.4.3.2 Surface Hardening: Parts shall have no surface hardening 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, recarburization, 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 0.003 in. (0.08 mm) of the surface more than 30 points higher than the reading in the core will be evidence of nonconformance to this requirement.

3.4.3.3 Decarburization:

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

3.4.3.3.2 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.

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

3.4.3.3.4 Depth of decarburization at any point on any surface not covered by 3.4.3.3.1, 3.4.3.3.2, or 3.4.3.3.3 shall not exceed 0.002 in. (0.05 mm).

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: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each lot.

4.3 Sampling: Shall be in accordance with AMS 2373 and the following; a lot shall be all parts of one size and configuration made from a single heat of steel processed in one continuous run and submitted for vendor's inspection at one time.

4.3.1 Specimens for tensile testing of machined test specimens shall be of standard proportions in accordance with ASTM A370 with either 0.250 in. (6.25 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 from coupons of the same heat of steel processed with the parts.

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 the other technical requirements of this specification. This report shall include the purchase order number, this specification number and its revision letter, contractor or other direct supplier of material, part number, and quantity.

4.5 Resampling and Retesting: If any part or specimen used in the above tests fails to meet the specified requirements, disposition of the parts may be based on the results of testing three additional parts or specimens for each original nonconforming 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 packaged in separate containers.

5.1.2 Each container of parts shall be marked to show not less than the following information:

FASTENERS, LOW-ALLOY, HEAT-RESISTANT STEEL
AMS 7455E
PART NUMBER _____
PURCHASE ORDER NUMBER _____
QUANTITY _____
MANUFACTURER'S IDENTIFICATION _____

5.1.3 Ø Containers of parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.1.4 Ø For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1.1 and 5.1.3 will be acceptable if it meets the requirements of level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter 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 Marginal Indicia: The phi (Ø) symbol is used to indicate technical changes from the previous issue of this specification.

8.2 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Part number or size of parts desired
Quantity of parts desired
Applicable level of packaging (See 5.1.4).

TABLE I

Threads Per Inch	Basic Thread Height Ref (See Note 1)		20% Basic Thread Height	
	Inch	(Millimetres)	Inch	(Millimetres)
80	0.0081	(0.206)	0.0016	(0.041)
72	0.0090	(0.229)	0.0018	(0.046)
64	0.0102	(0.259)	0.0020	(0.051)
56	0.0116	(0.295)	0.0023	(0.058)
48	0.0135	(0.343)	0.0027	(0.069)
44	0.0148	(0.376)	0.0030	(0.076)
40	0.0162	(0.411)	0.0032	(0.081)
36	0.0180	(0.457)	0.0036	(0.091)
32	0.0203	(0.516)	0.0041	(0.104)
28	0.0232	(0.589)	0.0046	(0.117)
24	0.0271	(0.688)	0.0054	(0.137)
20	0.0325	(0.826)	0.0065	(0.165)
18	0.0361	(0.917)	0.0072	(0.183)
16	0.0406	(1.031)	0.0081	(0.206)
14	0.0464	(1.179)	0.0093	(0.236)
13	0.0500	(1.270)	0.0100	(0.254)
12	0.0541	(1.374)	0.0108	(0.274)
11	0.0590	(1.499)	0.0118	(0.300)
10	0.0650	(1.651)	0.0130	(0.330)
9	0.0722	(1.834)	0.0144	(0.366)
8	0.0812	(2.062)	0.0163	(0.414)

Note 1. Basic thread height is defined as being equivalent to 0.650 times the pitch.

TABLE II

Bolt Size	Tensile Breaking Load, min: Standard Pitch Diam UN and UNJ Threads, Pounds	(Newtons)	Tensile Breaking Load, min: Reduced Pitch Diam UN Threads Only, Pounds	(Newtons)
0.112 -40	1,180	(5,250)	1,100	(4,890)
0.112 -48	1,290	(5,740)	1,200	(5,340)
0.138 -32	1,770	(7,870)	1,670	(7,430)
0.138 -40	1,980	(8,810)	1,870	(8,320)
0.164 -32	2,730	(12,100)	2,610	(11,600)
0.164 -36	2,870	(12,800)	2,750	(12,200)
0.190 -32	3,900	(17,300)	3,750	(16,700)
0.250 -28	7,100	(31,600)	6,900	(30,700)
0.3125-24	11,300	(50,300)	11,100	(49,400)
0.375 -24	17,100	(76,100)	16,800	(74,700)
0.4375-20	23,100	(103,000)	22,800	(101,000)
0.500 -20	31,200	(139,000)	30,800	(137,000)
0.5625-18	39,600	(176,000)	39,100	(174,000)
0.625 -18	49,900	(222,000)	49,500	(220,000)
0.750 -16	72,700	(323,000)	72,100	(321,000)
0.875 -14	99,300	(442,000)	98,600	(439,000)
1.000 -12	129,000	(574,000)	128,000	(569,000)

Note 1. Requirements above apply to parts with UNC, UNF, UNJC, or UNJF threads, as applicable to the sizes shown, having hardness within the range 42 - 46 HRC; requirements for reduced pitch diameter parts are based on 0.003 in. (0.08 mm) reduction below standard. Area upon which stress is based is the tensile stress area as defined in FED-STD-H28 and calculated from the equation:

$$A = 0.7854\ (D - 0.9743/n)^2$$

where, A = Tensile stress area
D = Maximum major (nominal major) diameter
n = Number of threads per inch

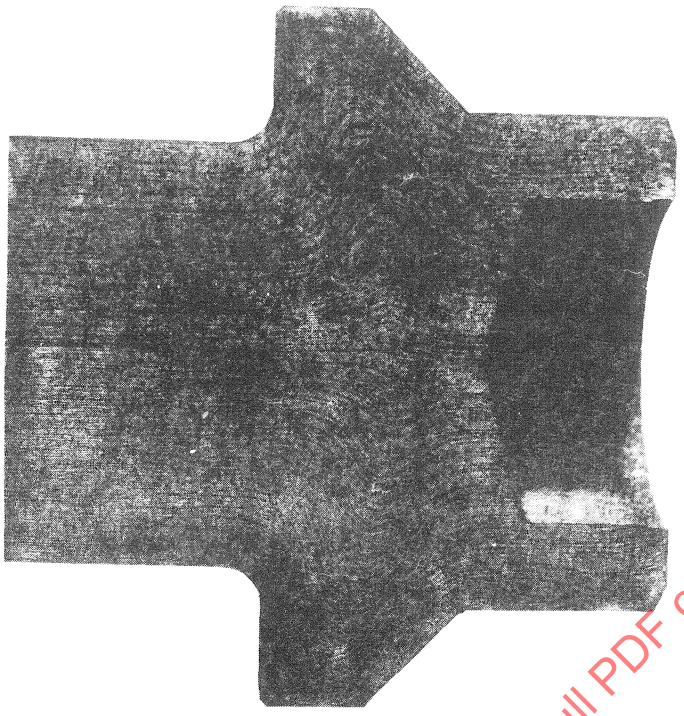
Tensile breaking load is based on 195,000 psi (1345 MPa)

Note 2. For the sizes shown, tensile breaking load requirements shall be multiplied by the factor shown below for parts requiring hardness ranges as follows:

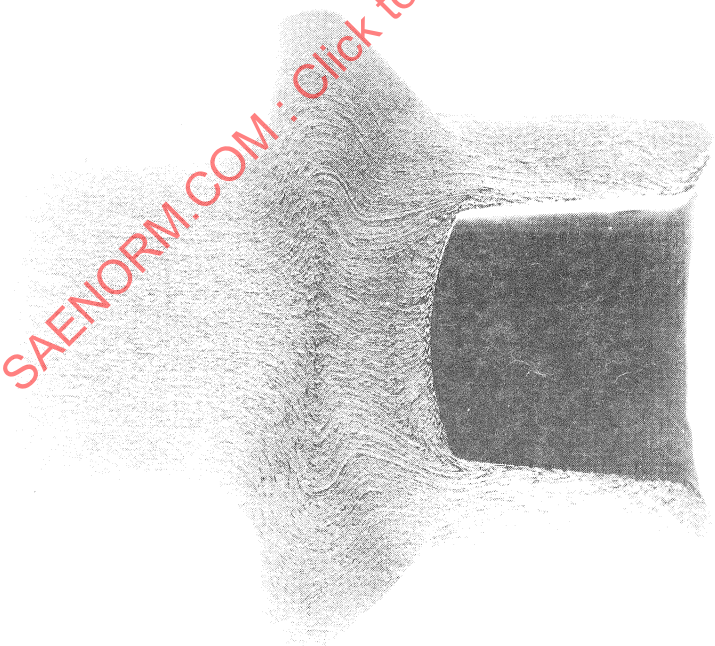
Minimum Hardness of Specified Range HRC	Factor
30	0.718
36	0.845

Note 3. For sizes not shown, tensile breaking 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 hardness range. The tensile stress area shall be as in Note 1 above.

Minimum Hardness of Specified Range HRC	Tensile Stress psi, min	(MPa, min)
30	140,000	(965)
36	165,000	(1138)
42	195,000	(1345)



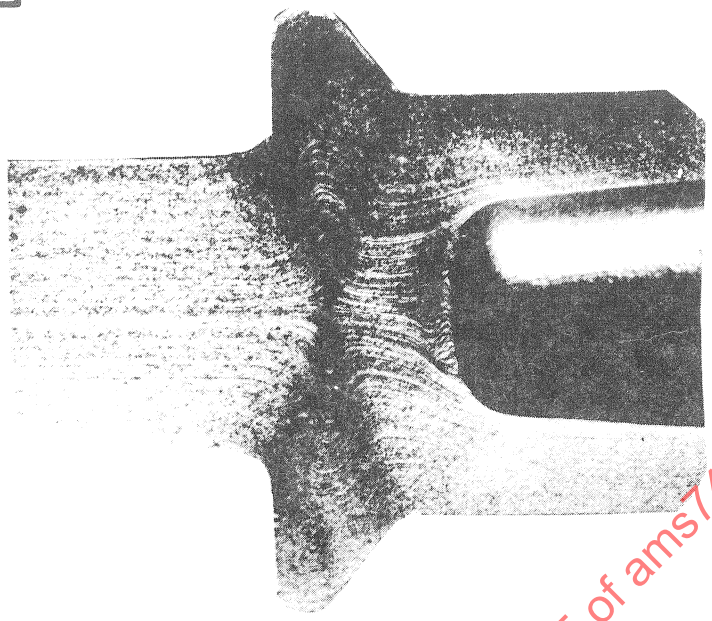
SATISFACTORY GRAIN FLOW
FIGURE 1A



MINIMUM ACCEPTABLE STANDARD

Showing maximum permissible cutting of flow lines after machining to remove oxide and decarburization as in 3.2.3.

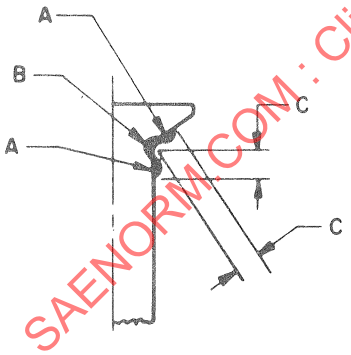
FIGURE 1B

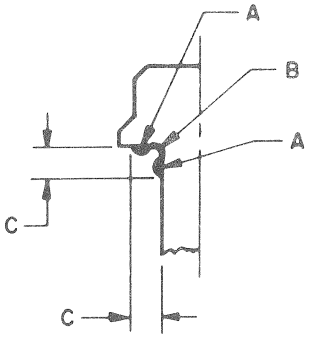


UNACCEPTABLE GRAIN FLOW

Excessive cutting of flow lines in the shank, head to shank fillet, and bearing surface is not permissible.

FIGURE 1C





Nominal Bolt Diameter		C, max	
Inches	(Millimetres)	Inch	(Millimetres)
Up to 0.3125, excl	(Up to 7.94, excl)	0.062	(1.57)
0.3125 and 0.375	(7.94 and 9.52)	0.094	(2.39)
0.4375 - 0.625, incl	(11.11 - 15.88, incl)	0.125	(3.18)
0.750 - 1.000, incl	(19.05 - 25.40, incl)	0.156	(3.96)
Over 1.000	(Over 25.40)	0.188	(4.78)

PERMISSIBLE DISTORTION FROM FILLET WORKING
FIGURE 2