ϕ TABLE 5—PROOF LOAD AND TENSILE STRENGTH VALUES (1)

Nominal Thread Dia and Thread Pitch	Stress Area (2) mm²	Class 4.6		Class 4.8		Class 5.8		Class 8.8		Class 9.8		Class 10.9	
		Proof Load kN	Tensile Strength Min kN	Proof Load kN	Tensile Strength Min kN	Proof Load kN	Tensile Strength Min kN	Proof Load kN	Tensile Strength Min kN	Proof Load kN	Tensile Strength Min kN	Proof Load kN	Tensile Strength Min kN
M1.6 x 0.35	1.27			0.39	0.53					0.83	1.14		
M2 x 0.4	2.07			0.64	0.87					1.35	1.86		
M2.5 x 0.45	3.39			1.05	1.42					2.20	3.05		
M3 x 0.5	5.03			1.56	2.11					3.27	4.53		
M3.5 x 0.6	6.78			2.10	2.85					4.41	6.10		
M4 x 0.7	8.78			2.72	3.69					5.71	7.90		
M5 x 0.8	14.2	3.20	5.68	4.40	5.96	5.40	7.38			9.23	12.8	11.8	14.8
M6 x 1	20.1	4.52	8.04	6.23	8.44	7.64	10.4			13.1	18.1	16.7	20.9
M8 x 1.25	36.6	8.24	14.6	11.3	15.4	13.9	19.0			23.8	32.9	30.4	38.1
M10 x 1.5	58.0	13.1	23.2	18.0	24.4	22.0	30.2			37.7	52.2	48.1	60.3
M12 x 1.75	84.3	19.0	33.7	26.1	35.4	32.0	43.8			54.8	75.9	70.0	87.7
M14 x 2	115	25.9	46.0	35.7	48.3	43.7	59.8			74.8	104	95.4	120
M16 x 2	157	35.3	62.8	48.7	65.9	59.7	81.6			102	141	130	163
M20 x 2.5	245	55.1	98.0			93.1	127	147	203			203	255
M24 x 3	353	79.4	141			134	184	212	293			293	367
M30 x 3.5	561	126	224					337	466			466	583
M36 x 4	817	184	327					490	678			678	850

NOTES: 1. Proof loads and tensile strengths are computed by multiplying the stresses given in Table 1 by the stress area of the thread.
2. Stress area = 0.7854 (D—0.9382P)² where D is nominal thread diameter in mm and P is thread pitch in mm.

Property class marking shall conform to the following:

Bolt or Screw Size mm	Height of Symbol mm
5 thru 6	1.5 min
8 thru 10	2.3 min
12 and 14	3.2 min
16 and larger	4.0 min

Metric bolts and screws shall not be marked with radial line symbols.

6.2 **Studs**—All studs of sizes M5 and larger shall be marked permanently and clearly to identify the property class. The symbols used shall be as given in Table 6. Markings shall be located on the extreme end of the stud, and may be raised or depressed at the option of the manufacturer. For studs with an interference fit thread, the markings shall be located at the nut end. Studs of sizes smaller than M12 may be marked using the property class symbols given in Table 6.

ϕ TABLE 6—PROPERTY CLASS IDENTIFICATION SYMBOLS

Property Class	Identification Symbol	
	Bolts, Screws, and Studs Sizes M5 and Larger	Optional for Studs Sizes M5 thru M11
4.6	4.6	
4.8	4.8	
5.8	5.8	
8.8 (1)	8.8	○
9.8 (1) (2)	9.8	+
10.9 (1)	10.9	□

NOTES: 1. Products made of low carbon martensite steel shall be additionally identified by underlining the numerals.
2. Products manufactured same as sems except without washer, from steel having optional carbon content permitted in Table 2, shall be additionally identified with an inverted T located between the numerals 9.8 as follows: 9|8.

TEST METHODS FOR METRIC THREADED FASTENERS—SAE J1216

SAE Standard

Report of Iron and Steel Technical Committee approved March 1978.

1. Scope

1.1 This standard establishes procedures for conducting tests to determine the mechanical properties of externally and internally threaded fasteners.

1.2 Property requirements and the applicable tests for their determination are specified in individual product standards. In those instances where the testing requirements are unique or at variance with these standard procedures, the product standard shall specify the controlling testing requirements.

1.3 This standard describes mechanical tests for determining the following properties:

For externally threaded fasteners:
- Product hardness (Section 3.1)
- Surface hardness (Section 3.2)
- Proof load (Section 3.3)
- Yield strength (Section 3.4)
- Axial tensile strength (Section 3.5)

Wedge tensile strength (Section 3.6)
Elongation (Section 3.7)
Reduction of area (Section 3.7)

For internally threaded fasteners:
Product hardness (Section 4.1)
Proof load (Section 4.2)

2. General Precautions

2.1 Improper machining or preparation of test specimens may give erroneous results. Care should be exercised to assure good workmanship in machining. Improperly machined specimens should be discarded and other specimens substituted.

2.2 If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it shall be discarded and another test specimen substituted.

3. Test Methods for Externally Threaded Fasteners

3.1 **Product Hardness**—For routine inspection, hardness of bolts, screws, and studs may be determined on head, end, or shank after removal of any plating or other coating and after suitable preparation of the specimen. For referee purposes, the hardness shall be determined at mid-radius of a transverse section through the threaded portion of the product taken at a distance of one diameter from the end of the product. For sizes smaller than M6 the reported hardness shall be the average of two hardness readings. For sizes M6 and larger, the reported hardness shall be the average of four hardness readings located at 90 deg to one another. The preparation of test specimens and the performance of hardness tests shall be in conformity with the requirements of SAE J417.

3.2 **Surface Hardness**—Tests to determine surface hardness conditions shall be conducted on the ends, hexagon flats, or unthreaded shanks which have been prepared by lightly grinding or polishing to ensure accurate reproducible readings in accordance with SAE J417. Proper correction factors shall be used when hardness tests are made on curved surfaces, per ASTM E18.

3.3 **Proof Load**

3.3.1 The proof load of a bolt, screw, or stud is the axially applied load which the product must withstand without permanent set.

3.3.2 The overall length of the specimen shall be measured between conical or ball centers on the centerline of the specimen, using mating centers on the measuring anvils. The specimen shall be marked so that it can be placed in the measuring fixture in the same position for all measurements. The measurement instrument shall be capable of measurement to 2.5 μm.

3.3.3 The grips of the testing machine shall be self-aligning to avoid side thrust on the specimen. For bolts and screws the specimen shall be assembled in the fixture of the tensile machine so that six complete threads are exposed between the grips. This is obtained by freely running the nut or fixture to the thread runout of the specimen and then unscrewing the specimen six full turns (two turns for products less than 3 D in length and threaded to within 2.5 thread pitches of the bearing surface). Typical fixturing is illustrated in Fig. 1. When proof load testing sems, the washer may be removed prior to testing; however, for referee testing the washer shall be removed. When proof load testing studs one end of the specimen shall be assembled in a threaded fixture to the thread runout. For studs having unlike threads, this shall be the end with the finer pitch thread. For studs having unlike diameters (step studs), this shall be the end with the larger minor diameter. The other end of the stud shall likewise be assembled in a threaded fixture, except it shall be unscrewed six full turns from the thread runout, thus leaving six complete threads exposed between the grips (two turns for products less than 3 D in length and threaded to within 2.5 thread pitches of the bearing surface).

3.3.4 The bolt, screw, or stud shall then be axially loaded to the proof load specified for the applicable size and class in the product standard, the load retained for a period of 15 s, the load removed, and the overall length again measured. The speed of testing, as determined with a free running cross head, shall not exceed 3 mm/min.

3.3.5 To meet requirements, the length of the specimen after loading shall be the same as before loading within a tolerance of 12.5 μm allowed for measurement error.

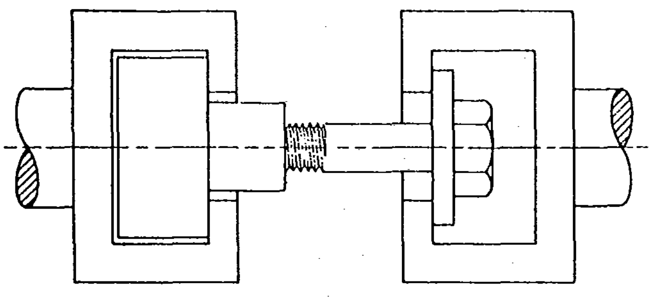


FIG. 1—TENSILE TESTING OF FULL SIZE BOLT OR SCREW

3.3.6 Variables, such as straightness and thread alignment (plus measurement error), may result in apparent elongation of the specimen when the proof load is initially applied. In such cases, the specimen may be retested using a 3% greater load, and may be considered satisfactory if the length after this loading is the same as before this loading within the 12.5 μm tolerance for measurement error.

3.4 **Yield Strength**

3.4.1 The yield strength of a bolt, screw, or stud is the stress at which the fastener exhibits a specified limiting deviation from the proportionality of stress to strain. The deviation is expressed in terms of strain.

3.4.2 The yield strength test shall be set up as outlined in Section 3.3.3 using, however a machined product as shown in Fig. 4. The speed of testing (determined with a free running cross head), shall not exceed 3 mm/min. Load shall be applied axially and as the load is applied the total elongation of the specimen or any part of the specimen which includes the six exposed threads shall be measured. Yield strength shall be determined by the offset method.

3.4.3 It is necessary to obtain data (autographic or numerical) from which a stress-strain diagram may be drawn. On the stress-strain diagram an offset line is then drawn parallel to the modulus line at a distance equal to the specified offset from the modulus line (for the specified offset refer to the product standard). The yield strength load is the load at which the offset line intersects the stress-strain diagram. Yield strength is then obtained by dividing the yield strength load by the original nominal tensile stress area of the exposed threaded section.

3.4.4 To meet requirements, the yield strength shall not be less than the minimum yield strength specified in the product standard.

3.5 **Axial Tensile Strength**

3.5.1 The axial tensile strength of a bolt, screw, or stud is the maximum tensile stress which the fastener is capable of sustaining when axially loaded. Tensile strength is calculated from the original nominal tensile stress area of the threaded section and the maximum load occurring during a tensile test.

3.5.2 When bolt, screw, or stud is to be proof load or yield strength as well as axial tensile tested, both tests may be conducted on the same specimen.

3.5.3 The axial tensile test shall be set-up as outlined in Section 3.3.3. Loading shall be continued until fracture occurs. The speed of testing, as determined with a free running cross head, shall not exceed 25 mm/min.

3.5.4 When tensile testing sems, the washer may be removed prior to testing; however, for referee testing the washer shall be removed.

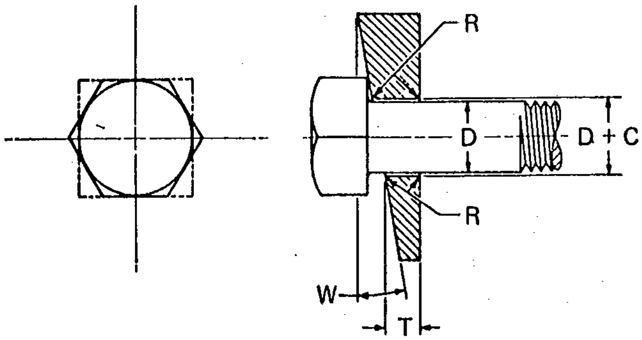
3.5.5 To meet requirements, the specimen shall support a load, prior to fracture, not less than the minimum tensile strength specified for the applicable size and class in the product standard. In addition, for bolts and screws, (except flat and oval head machine screws) the fracture shall occur in the body or threaded section with no failure at the junction of the head and shank.

3.6 **Wedge Tensile Strength**—The wedge tensile strength of a bolt, screw, or stud is the maximum tensile stress which the fastener is capable of sustaining when loaded eccentrically. Wedge tensile strength is calculated as specified in Section 3.5.1.

3.6.1 Bolts and Screws

3.6.1.1 When bolt or screw is to be proof load tested as well as wedge tensile tested the same specimen may be used for both tests. This shall be assembled with a wedge inserted under the head, as illustrated in Fig. 2, installed in the testing machine and tensile tested to failure, as described in Section 3.3.3. The angle of the wedge for the bolt or screw type, size and class is specified in the product standard. The wedge shall be so placed that no corner of a hexagon head takes the bearing load; that is, a flat of the head shall be aligned with the direction of uniform thickness of the wedge. When wedge tensile testing sems, the washer may be removed prior to testing; however, for referee testing the washer shall be removed. The wedge shall have a minimum hardness of Rockwell C48. The wedge shall have a thickness of one-half the bolt or screw diameter measured at the thin side of the hole. The hole in the wedge shall have the following clearance over the nominal size of the bolt or screw, and its top and bottom edges shall be rounded or chamfered 45 deg to the following dimensions:

Nominal Product Size	Clearance in Hole approx mm	Radius or Depth of Chamfer approx mm
thru M6	0.5	0.7
Over M6 thru M12	0.8	0.8
Over M12 thru M20	1.6	1.3
Over M20 thru M39	3.2	1.6



C = Clearance of hole (see para. 3.6.1.1)
D = Diameter of bolt or screw
R = Radius or chamfer (see para. 3.6.1.1)
T = Thickness of wedge at thin side of hole equals one half diameter of bolt or screw
W = Wedge angle (given in product standard)

FIG. 2—WEDGE TEST DETAILS—BOLTS AND SCREWS

3.6.1.2 To meet requirements, the specimen shall support a load, prior to fracture, not less than the minimum tensile strength specified for the applicable size and class in the product standard. In addition, the fracture shall occur in the body or threaded section with no failure at the junction of head and shank.

3.6.2 Studs

3.6.2.1 When stud is to be proof load tested as well as wedge tensile tested the same specimen may be used for both tests. One end of stud shall be assembled in a threaded fixture to the thread runout. For studs having unlike threads, this shall be the end with the finer pitch thread. For studs having unlike diameters (step studs), this shall be the end with the larger minor diameter. The other end of the specimen shall be assembled in a threaded wedge to the runout and then unscrewed six full turns (two turns for products less than 3 D in length and threaded to within 2.5 thread pitches of the bearing surface), thus leaving six (or two) complete threads exposed between the grips, as illustrated in Fig. 3. The angle of the wedge for the stud size and class shall be as specified in the product standard. The stud shall be assembled in the testing machine and tensile tested to failure, as described in Section 3.3.3.

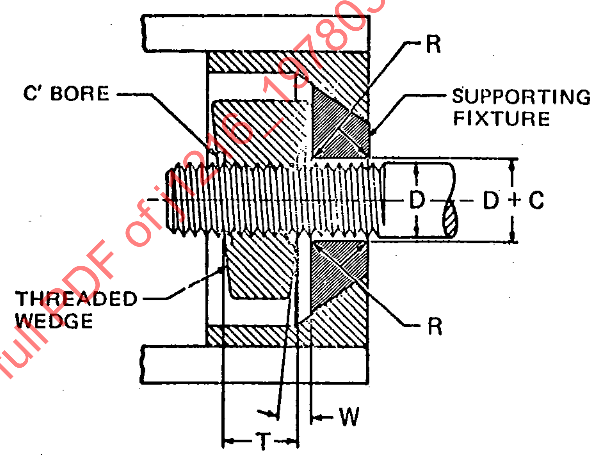
3.6.2.2 The minimum hardness of the threaded wedge shall be 48 HRC. The length of the threaded section of the wedge shall be equal to the diameter of the stud. To facilitate removal of the broken stud, the wedge shall be counterbored. The thickness of the wedge at the thin side of the hole shall equal the diameter of the stud plus the depth of counterbore. The thread in the wedge shall have Grade 4H tolerances in accordance with ISO 965/1, except when testing studs having an interference fit thread, in which case the wedge shall be threaded to provide a finger free fit. The supporting fixture, as shown in Fig. 3, shall have a hole clearance over the nominal size of the stud, and shall have its top and bottom edges rounded or chamfered to the same limits specified for the hardened wedge in Section 3.6.1.1.

3.6.2.3 To meet requirements, the specimen shall support a load, prior to fracture, not less than the minimum tensile strength specified for the applicable size and class in the product standard.

3.7 Testing of Machined Test Specimens

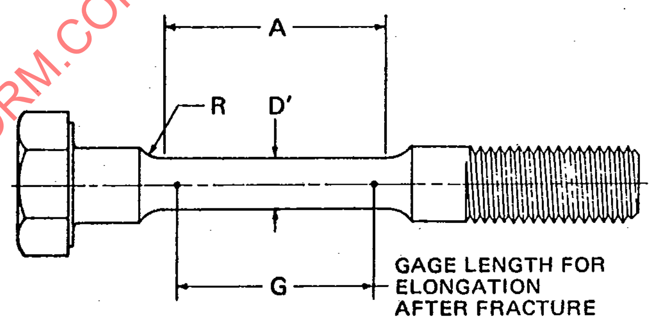
3.7.1 Where product specifications specify or authorize the testing of specimens machined from bolts, screws, or studs (normally nominal diameters over M24), standard specimens shall be turned from the product, as shown in Fig. 4.

3.7.2 The test specimen shall be axially tensile tested and the yield strength, tensile strength, elongation, and reduction of area shall be determined.



C = Clearance of hole (see para. 3.6.1.1)
D = Diameter of stud
R = Radius or chamfer (see para. 3.6.1.1)
T = D plus depth of counterbore
W = Wedge angle (given in product standard)

FIG. 3—WEDGE TEST DETAILS—STUDS



D' = Diameter of turned down shank (D'< minor dia of product thread).
G = Gage length = 5D'
A = Length of turned down shank = G + D'
R = Fillet radius (R ⩾ 4 mm)

The reduction of the shank diameter of bolts, screws or studs should not exceed 25 percent of the original nominal diameter of the product. This results in a cross sectional area of the turned down section of approximately 56 percent of the original nominal diameter cross sectional area.

FIG. 4—TENSILE TEST SPECIMEN FOR BOLTS OR SCREWS WITH TURNED DOWN SHANK