TABLE 6—DIMENSIONS OF MACHINED TEST SPECIMENS
(SEE FIG. 5 AND PARAGRAPH 5.5)

Nominal Dia of Product	Gage Length G	Dia Parallel Section, D	Length Parallel Section, Min, A	Fillet Radius, Min, R
3/4 thru 1-1/2	2.000 ± 0.005	0.500 ± 0.010	2.25	0.38[a]
1/4 thru 5/8	1.400 ± 0.005	0.350 ± 0.007	1.75	0.25
	1.000 ± 0.005	0.250 ± 0.005	1.25	0.19

[a] Minimum radius recommended 0.38 in; 0.12 minimum permitted.

7. Testing Requirements

7.1 Manufacturer's Responsibility—During the manufacture of products to the requirements of this specification, the manufacturer shall make periodic tests to ensure that the properties of the product are being maintained within specified limits. Such tests shall be conducted in accordance with a sampling plan, preferably the sampling plan given in paragraph 7.3, and the test results shall be recorded in a test report. When requested in writing by the purchaser, the manufacturer shall furnish a copy of the test report certified to be a report of the results of the last completed set of tests for the specific type, size, length, and grade of product.

Additional tests of products in individual shipments are not normally contemplated. Unless otherwise agreed at time of original inquiry and purchase order, individual heats of steel need not be identified in the finished product.

7.2 Purchaser's Options—If the purchaser requires that additional tests be performed by the manufacturer to determine that the properties of products in an individual shipment are within specified limits, or if the purchaser requires that a sampling plan different from that given in paragraph 7.3 shall be used when determining the acceptability of a lot, or shipment, of products, the purchaser shall specify the complete testing requirements, including sampling plan and basis of acceptance, in the original inquiry and purchase order.

7.3 General—An acceptable sampling plan is outlined below:

Number of Pieces in Lot	Minimum Number of Specimens To Be Tested
50 and under	2
51 to 500	3
501 to 35 000	5
35 001 and over	8

A lot, for purposes of selecting test specimens, shall consist of all products offered for inspection and testing at one time that are of the same type, grade, size, length, and thread series and are manufactured essentially at one time and under the same process conditions.

The same test specimen may be used for different tests wherever practical.

When tested in accordance with this sampling plan, a lot shall be subject to rejection if any of the test specimens fail to meet the applicable test requirements. If the failure of a test specimen is due to improper preparation of the specimen or to incorrect testing technique, the specimen shall be discarded and another specimen substituted.

APPENDIX

(Relative to 150 000 psi tensile bolts and screws produced from low carbon martensite steels and designated as Grade 8.2)

Coverage for 150 000 psi tensile bolts and screws produced from low carbon martensite steels is included in SAE J429 (January, 1949) because several large steel and bolt producers and users have reported highly favorable results with such products over a period of more than three years. This coverage is designated by a separate grade number (Grade 8.2) to distinguish such fasteners from Grade 8 made of medium carbon and medium carbon alloy steels.

Limited data available concerning room temperature ductility and low temperature impact characteristics indicate that fasteners made to Grade 8.2 requirements may have advantages compared to alloy steels historically used for Grade 8 fasteners.

Heat treatment control for elements such as decarburization or carburization and quench medium heat transfer are more critical for Grade 8.2 than for Grade 8 steels. Thus, more attention should be given to verification of the use of proved practices. (It is suggested that users initially require details of heat treatment practices from the fastener producer until a broad spectrum of suppliers are familiar with the closer controls necessary.)

Users should recognize the difference in stress relaxation characteristics of various steels between the temperature range of 650°F, minimum, specified for Grade 8.2 and 800°F, minimum, specified for Grade 8, when considering bolts and screws that may be exposed to such temperature range. The data available on elevated temperature properties of Grade 8.2 indicates that performance testing is desirable in applications where the operating temperature exceeds 500°F (as may also be the case with Grade 8 fasteners).

The requirements stated, herein, limit the use of steels to those which have been used on a production basis with highly favorable results. There is much evidence that other steels are satisfactory also, but these are excluded from the standard until more widespread experience is had with them.

MECHANICAL AND MATERIAL REQUIREMENTS FOR METRIC EXTERNALLY THREADED STEEL FASTENERS—SAE J1199 SEP83

SAE Standard

Report of the Iron and Steel Technical Committee, approved February 1978, first revision, ISTC Division 29, September 1983.

1. Scope

1.1 This standard covers the mechanical and material requirements for eight property classes of steel, externally threaded metric fasteners in sizes M1.6 through M36, inclusive, and suitable for use in automotive and related applications.

1.2 Products included are bolts, screws, studs, U-bolts, pre-assembled screw and washer assemblies (sems), and products manufactured the same as sems except without washer.

1.3 Products not covered are tapping screws, thread rolling screws, and self-drilling screws. Mechanical and material requirements for these products are covered in other SAE documents.

1.4 The term *stud* as referred to herein applies to a cylindrical rod of moderate length, threaded on either one or both ends or throughout its entire length. It does not apply to headed, collared, or similar products which are more closely characterized by requirements shown herein for bolts.

1.5 For specification purposes, this standard treats U-bolts as studs. Thus, wherever the word *studs* appears, *U-bolts* is also implied. U-bolts covered by this standard are those used primarily in the suspension and related areas of vehicles. (Designers should recognize that the *U* configuration may not sustain a load equivalent to two bolts or studs of the same size and grade; thus actual load carrying capacity of U-bolts should be determined by saddle load tests.)

2. Designations

2.1 Property classes are designated by numbers where increasing numbers generally represent increasing tensile strengths. The designation symbol consists of two parts:

(a) The first numeral of a two-digit symbol or the first two numerals of a three-digit symbol approximates $\frac{1}{100}$ of the minimum tensile strength in MPa.

(b) The last numeral approximates $\frac{1}{10}$ of the ratio expressed as a percentage between minimum yield stress and minimum tensile stress.

ϕ **2.2** For specification purposes (on engineering drawings, purchase orders, etc.) all property class designations are used in combination with a single basic specification number as follows:

SAE J1199 (4.6)	SAE J1199 (8.8)
SAE J1199 (4.8)	SAE J1199 (9.8)
SAE J1199 (5.8)	SAE J1199 (10.9)

2.3 Property Classes

2.3.1 Machine screws are normally available only in classes 4.8 and 9.8; other bolts, screws, and studs are available in all classes within the specified product size limitations given in Table 1.

2.3.2 Screw and washer assemblies (sems) are covered by classes 4.8 and 9.8, and allowable deviations from normal 9.8 requirements are stated in footnotes throughout the standard.

2.3.3 At the option of the manufacturer, class 5.8 may be supplied when either class 4.6 or 4.8 is ordered, and class 4.8 may be supplied when class 4.6 is ordered.

2.4 Conversion Guidance

2.4.1 For guidance purposes only, to assist designers in selecting a property class:

(a) Class 4.6 is approximately equivalent to SAE J429, Grade 1 and ASTM A307, Grade A.

(b) Class 5.8 is approximately equivalent to SAE J429, Grade 2.

(c) Class 8.8 is approximately equivalent to SAE J429, Grade 5, and ASTM A449.

(d) Class 9.8 has properties approximately 9% stronger than SAE J429, Grade 5, and ASTM A449.

(e) Class 10.9 is approximately equivalent to SAE J429, Grade 8, and ASTM A354, Grade BD.

2.4.2 Note that class 8.8 is applicable to sizes above 16 mm, and class 9.8 is applicable to sizes 16 mm and smaller.

3. Materials and Processes

3.1 Steel Characteristics—Bolts, screws, and studs shall be made of steel conforming to the description and chemical composition requirements specified in Table 2 for the applicable property class.

3.2 Heading Practice

3.2.1 Methods other than upsetting and/or extrusion are permitted only by special agreement between purchaser and manufacturer.

3.2.2 Class 4.6 may be hot or cold headed at option of the manufacturer.

ϕ 3.2.3 Class 4.8, 5.8, 8.8, 9.8, and 10.9 bolts and screws in sizes up to M20 inclusive, and lengths up to 10 times the nominal product size or 150 mm, whichever is shorter, shall be cold headed, except that they may be hot headed by special agreement of the purchaser. Larger sizes and longer lengths may be cold or hot headed at option of the manufacturer.

ϕ **3.3 Threading Practice**—Class 4.8, 5.8, 8.8, 9.8, and 10.9 bolts and screws in sizes up to M 20 inclusive, and lengths up to 150 mm inclusive, shall be roll threaded, except by special agreement. Threads of all sizes ϕ of class 4.6 bolts and screws and class 4.8, 5.8, 8.8, 9.8, and 10.9 bolts and screws in sizes over M20 and/or lengths longer than 150 mm, may be rolled, cut, or ground, at option of the manufacturer. Threads of all classes and sizes of studs may be rolled, cut, or ground at option of the manufacturer.

3.4 Heat Treatment Practice

3.4.1 Class 4.6 bolts and screws and class 4.6, 4.8, and 5.8 studs need not be heat treated. Class 4.8 and 5.8 bolts and screws shall be stress relieved if necessary to assure the soundness of the head to shank junction. When specified by the purchaser, class 5.8 bolts and screws shall be stress relieved at a minimum stress relief temperature of 470°C. Where higher temperatures are necessary to relieve stresses in severely upset heads, mechanical requirements shall be agreed upon by manufacturer and purchaser.

3.4.2 Class 8.8 and 9.8 bolts, screws, and studs shall be heat treated, quenched in oil or water-base quenchant at the option of the manufacturer, and tempered at a minimum tempering temperature of 425°C for class 8.8 and 410°C for class 9.8. For class 9.8 screw and washer assemblies (sems), quenchants whose principal constituent is water shall NOT be used, and tempering temperature shall be no less than 340°C. See also paragraph 3.4.6.

3.4.3 Medium carbon alloy steel class 10.9 bolts, screws, and studs shall be heat treated, oil quenched, and tempered at a minimum tempering temperature of 425°C. Low carbon martensite steel class 10.9 bolts, screws, and studs shall be heat treated, quenched in oil or water-base quenchant at the option of the manufacturer, and tempered at a minimum tempering temperature of 340°C. See also paragraph 3.4.6.

3.4.4 Under no circumstances should heat treatment or carbon restoration be accomplished in the presence of nitrogen compounds, such as carbonitriding or cyaniding. ϕ

3.4.5 Tempering Temperature Audit Test (for checking whether products have been tempered at specified temperature). Conduct hardness test (SAE J1216, paragraph 3.1) on one or more bolts, screws, or studs; retemper the product(s) at a temperature 10°C less than the specified minimum tempering temperature for 30 min; repeat product hardness test. The difference between the mean hardnesses (before and after retempering) shall be no greater than 2 points Rockwell C (approximately 20 Vicker points). ϕ

4. Mechanical and Physical Properties

4.1 Mechanical—Bolts, screws, and studs shall be tested in accordance with the mechanical testing requirements for the applicable type, property class, size, and length of product as specified in Table 3, and shall meet the mechanical requirements specified for that product in Table 1.

4.2 Decarburization—Unless otherwise specified, class 8.8 and 9.8 products shall conform to decarburization class 1/2H, and class 10.9 products shall conform to decarburization class 2/3H as specified in SAE J121. ϕ ϕ ϕ

4.3 Surface Discontinuities

4.3.1 Bolts, screws, and studs of classes 8.8, 9.8, and 10.9 in sizes up to M24 inclusive, and lengths up to 150 mm inclusive, shall not have surface discontinuities exceeding the limits specified in SAE J1061.

Surface discontinuities for sizes and lengths of products not covered in the scope of SAE J1061 shall be within limits specified by purchaser.

4.3.2 When the engineering requirements of the application necessitate that surface discontinuities must be more closely controlled, the purchaser ϕ

ϕ **TABLE 1—MECHANICAL REQUIREMENTS FOR BOLTS, SCREWS, AND STUDS**

		Full Size Bolts, Screws, and Studs		Machined Test Specimens of Bolts, Screws, and Studs (Sizes larger than M24)				Surface Hardness	Product Hardness			
									Rockwell		Vickers	
Property Class	Nominal Dia	Proof Load (Stress) MPa (4)	Tensile Strength (Stress) Min MPa (4)	Yield Strength (Stress) Min(1) MPa	Tensile Strength (Stress) Min MPa	Elongation Min %	Reduction of Area Min %	Rockwell 30N Max	Min (8)	Max	Min (8)	Max
4.6	M5 thru M36	225	400	240(2)	400	22	35	—	B67	B87	120	180
4.8	M1.6 thru M16	310	420	—	—	—	—	—	B71	B87	130	180
5.8	M5 thru M24(3)	380	520	—	—	—	—	—	B82	B95	160	220
8.8	M17 thru M36	600	830	660	830	12	35	(6)	C23	C34	254	336
9.8	M1.6 thru M16(5)	650	900	—	—	—	—	(6)	C27	C36	279	354
10.9	M6 thru M36	830	1040	940	1040	9	35	(6)	C33	C39	327	382

NOTES:
1. Yield strength is stress at which a permanent set of 0.2% of gage length occurs.
2. Yield point shall apply instead of yield strength at 0.2% offset for class 4.6 products.
3. Class 5.8 requirements apply to bolts and screws with lengths 150 mm and shorter, and to studs of all lengths.
4. Proof load and tensile strength values for full size products of each property class are given in Table 5.
5. For class 9.8 screw and washer assemblies (sems), base metal hardness may be 25–40 HRC (270–390 HV) and surface hardness shall not exceed 60 HR30N. This requirement applicable also to products manufactured same as sems except without washer, sizes M1.6 thru M12.
ϕ 6. Surface hardness shall not exceed base metal hardness by more than 2 points (Rockewll C equivalent), and in the case of class 10.9 shall also not exceed 59 HR30N.
ϕ 7. Minimum hardness requirement is waived if minimum tensile strength is met.

ϕ TABLE 2—CHEMICAL COMPOSITION REQUIREMENTS
Product Analysis (% by mass)

Property Classes 4.6 and 4.8
Manufacturer's option—
Low or medium carbon steels (for all sizes), within following limits:
C 0.55 max, P 0.048 max, S 0.058 max

Property Class 5.8
Manufacturer's option—
Low or medium carbon steels (for all sizes), within following limits:
C 0.13–0.55, P 0.048 max, S 0.058 max
For studs only, sulfur content may be 0.33 max

Property Class 8.8
Manufacturer's option—
Medium carbon steels (for all sizes), within following limits:
C 0.28–0.55, P 0.048 max, S 0.058 max
For studs only, sulfur content may be 0.13 max
Medium carbon alloy steels (for sizes over M24), within following limits:
C 0.28–0.55, P 0.040 max, S 0.045 max

When authorized by purchaser—
Low carbon martensite steels (for sizes thru M20), within following limits:
C 0.15–0.27, Mn 0.74–1.46, P 0.038 max, S 0.048 max, B 0.0005–0.003 (See Note 1 below)
Medium carbon boron steels (for sizes thru M24), within following limits:
C 0.25–0.40, Mn 0.74 min, P 0.048 max, S 0.058 max, B 0.0005–0.003 (see Note 1 below)

Property Class 9.8
Medium carbon steels (for all sizes), within following limits:
C 0.28–0.55, P 0.048 max, S 0.058 max
For studs only, sulfur content may be 0.13 max
For screw and washer assemblies (sems) and for products manufactured same as sems except without washer, sizes thru M12 only, carbon content may be 0.15–0.40 (See Note 2, Table 6)

When authorized by purchaser—
Low carbon martensite steels (for sizes thru M20), within following limits:
C 0.15–0.27, Mn 0.74–1.46, P 0.038 max, S 0.048 max, B 0.0005–0.003 (See Note 1 below)
Medium carbon boron steels (for sizes thru M24), within following limits:
C 0.25–0.40, Mn 0.74 min, P 0.048 max, S 0.058 max, B 0.0005–0.003 (See Note 1 below)

Property Class 10.9
Manufacturer's option—
Medium carbon alloy steels (for all sizes), within following limits:
C 0.28–0.55, P 0.040 max, S 0.045 max
Fine grain
Hardenability—47 min HRC (See Note 2 below)
SAE 1541 or SAE 1541H (for sizes thru M12)
Fine grain
When authorized by purchaser—
Carbon steels (for sizes thru M20); Fine grain
Low carbon martensite steels (for sizes thru M20), within following limits:
C 0.15–0.27, Mn 0.74–1.46, P 0.038 max, S 0.048 max, B 0.0005–0.003 (See Note 1 below)
Hardenability—40 min HRC (See Note 2 below)
Medium carbon boron steels (for sizes thru M24), within following limits:
C 0.25–0.40, Mn 0.74 min, P 0.048 max, S 0.058 max, B 0.0005–0.003 (See Note 1 below)
Hardenability—47 min HRC (See Note 2 below)

NOTES: 1. Products made from low carbon martensite steels and medium carbon boron steels shall be identified as specified in Table 6, Note (1).
2. Steels shall have hardenability that is capable of producing the minimum hardness (Rockwell C) shown at the center of a transverse section one nominal diameter from the threaded end of bolt, screw, or stud (after quenching).

shall specify the applicable limits in the original inquiry and purchase order. For certain fasteners, this may be done by reference to SAE J123.

5. Methods of Test

5.1 General—Procedures for conducting the tests to determine the mechanical properties as specified in Table 3 for the applicable product, property class, size, and length are given in SAE J1216. Table 3 specifies the applicable test method to be followed when determining each mechanical property.

6. Marking

6.1 Bolts and Screws—Slotted and cross-recessed screws of all sizes and other screws and bolts of sizes smaller than M5 need not be marked. All other bolts and screws of sizes M5 and larger shall be marked permanently and clearly to identify the property class and the manufacturer. The property class symbols shall be as given in Table 6; the symbol for the manufacturer's identification shall be at his option. Markings shall be located on the top of the head of bolts and screws, and may be either raised or depressed at option of the manufacturer. Alternatively, for hex head products, the markings may be indented on the side of the head.

TABLE 3—MECHANICAL TESTING REQUIREMENTS FOR BOLTS, SCREWS, AND STUDS

Product	Property Class	Specified Min Tensile Strength of Product (See Table 5) kN	Length of Product (2)	Product Hardness		Surface Hardness (4)	Tests Conducted Using Full Size Products			Tests Conducted Using Machined Test Specimens				Decarburization in Threaded Section (4)
				Max	Min	Max	Proof Load	Wedge Tensile Strength (5)	Axial Tensile Strength	Yield Strength	Tensile Strength	Elongation	Reduction of Area	
Short bolts and screws	all	all	less than 2-1/4D	•	•	•	—	—	—	—	—	—	—	o
Special head bolts and screws (3)	all	all	all	•	•	•	—	—	—	—	—	—	—	o
Hex bolts and screws (6) (7)	all	450 and less	2-1/4D to 8D or 200 mm, whichever is greater	•	—	•	o	•	—	—	—	—	—	o
			over 8D or 200 mm, whichever is greater thru and incl 300 mm	•	—	•	o	•	—	—	—	—	—	o
			over 300 mm	•	—	•	o	A	—	B	B	B	B	o
		over 450	2-1/4D and longer	•	—	•	o	A	—	B	B	B	B	o
All other bolts and screws	all	450 and less	2-1/4D to 8D or 200 mm, whichever is greater	•	—	•	o	—	•	—	—	—	—	o
			over 8D or 200 mm, whichever is greater	•	—	•	o	—	A	B	B	B	B	o
		over 450	2-1/4D and longer	•	—	•	o	—	A	B	B	B	B	o
Short studs	all	all	less than 2-1/4D	•	•	•	—	—	—	—	—	—	—	o
All other studs	all	450 and less	2-1/4D to 8D or 200 mm, whichever is greater	•	—	•	o	•	—	—	—	—	—	o
			over 8D or 200 mm, whichever is greater	•	—	•	o	A	—	B	B	B	B	o
		over 450	2-1/4D and longer	•	—	•	o	A	—	B	B	B	B	o
Tests to be conducted in accordance with paragraph				See SAE J1216										See SAE J121
				3.1		3.2	3.3	3.6	3.5	3.7				

NOTES: 1. • denotes a mandatory test. For each product all mandatory tests (•) shall be performed. In addition, either all tests denoted A (which apply to full size products) or all tests denoted B (which apply to machined test specimens) shall be performed, except optional B tests are not applicable to products M24 and smaller. o denotes tests to be performed when ϕ specifically required in the original inquiry and purchase order. In case arbitration is necessary, both A tests and o tests shall be performed. Dashes (—) indicate tests which are not required.

2. D equals nominal diameter of product. For purposes of Table 3 requirements, "length of product" is the nominal length including point chamfer as defined in SAE J105, and all special point products shall be measured from the bearing surface to the crest of the last complete thread form.

3. Special head bolts and screws are those with special configurations or with drilled heads which are weaker than the threaded section.

ϕ 4. Surface hardness and decarburization requirements apply only to property classes 8.8, 9.8, and 10.9.

5. Tensile test wedge angles are specified in Table 4.

6. Includes flange, washer, and other hex head configurations which are not weaker than the threaded section.

7. Includes class 9.8 sems and 9.8 products manufactured same as sems except without washer (sizes M1.6 thru M12). For purposes of determining applicability of tensile testing, length of sems is the distance measured from the underside of bearing plane of the unflattened washer to the last full thread of the screw.

ϕ TABLE 4—TENSILE TEST WEDGE ANGLES

Product	Property Class	Nominal Dia	Wedge Angle Deg
Hex and hex washer head machine screws	4.8, 9.8	thru M10	6
Hex bolts and screws threaded 1D and closer to underside of head	8.8, 9.8, 10.9	thru M20	6
		over M20 to M36	4
Hex flange and hex washer head bolts and screws	4.6, 4.8, 5.8, 8.8, 9.8, 10.9	thru M36	6
All other hex bolts and screws	4.6, 4.8, 5.8, 8.8, 9.8, 10.9	thru M24	10
		over M24 to M36	6
Studs	All	thru M20	6
		over M20 to M36	4