

MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M GM260M GM275M GM280M GM290M GM300M GM455M

1 SCOPE. This standard covers the mechanical and quality requirements for nine grades of steel bolts, screws, studs, sems, and U-bolts with hardness of HRC 39 maximum. Tapping screws, thread rolling screws and self drilling tapping screws are not included.

1.1 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 closely characterized by requirements shown herein for bolts.

1.2 For specification purposes this standard treats 'U-bolts' as studs. Thus, wherever the word 'studs' appears 'U-bolts' are also implied. U-bolts covered by this standard are those used primarily in the suspension and related area 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 DESIGNATION SYSTEM. Grades are designated by "SAE Grade Numbers" (where increasing numbers represent increasing tensile strength) and by decimals of whole numbers (where decimals represent variations at the same strength level). Certain grades are designated also by "GM Numbers." The grade designations and related GM numbers are shown below:

GM Number	SAE Grade Number	GM Number	SAE Grade Number
GM255M	1	GM290M	7
GM260M	2	GM300M	8
—	4	—	8.1
GM280M	5	GM455M	None
GM275M	5.1		

2.2 GRADES. Bolts and screws are normally available only in Grades 1, 2, 5, 7 and 8. Studs are normally available only in Grades 1, 2, 4, 5, 8 and 8.1. Grade 5.1 is normally used only for sems which are heat treated following assembly of the washer on the screw. GM455M is applicable to bolts, screws and studs made from corrosion resistant steel only.

3 MATERIALS AND PROCESSES.

3.1 STEEL CHARACTERISTICS. Bolts, screws and studs shall be made from steel conforming to the description and chemical composition requirements specified in Table 2 for the applicable grade.

3.2 HEADING PRACTICE. Methods other than upsetting and/or extrusion are permitted only by special agreement between purchaser and supplier.

3.2.1 Grade 1 bolts and screws may be hot or cold headed at option of the manufacturer.

3.2.2 Grades 2, 5, 7 and 8 bolts and screws in sizes up to 3/4 inch, inclusive, and in lengths up to 6 inch, inclusive, shall be cold headed, except that by special agreement they may be hot headed. A photograph of typical grain flow pattern showing grain flow at the head-shank junction of a flange head bolt (Figure 1) is not shown here. The photograph is available from GM Engineering Standards Department.

3.2.3 Grade 5.1 screws shall be cold headed.

3.2.4 GM455M shall be same as Grade 2.

3.3 THREADING PRACTICE.

3.3.1 Grades 2, 5, and 8 bolts and screws in sizes up to 3/4 inch, inclusive, and lengths up to 6 inch, inclusive, shall be roll threaded, unless otherwise approved by purchaser.

3.3.2 Grade 7 bolts and screws shall be roll threaded after heat treatment.

3.3.3 Grade 5.1 screws shall be roll threaded.

3.3.4 Threads of all sizes of Grade 1 bolts and screws and Grades 2, 5, and 8 bolts and screws in sizes over 3/4 inch and/or lengths longer than 6 inch may be rolled, cut or ground at option of the manufacturer.

3.3.5 Threads of all grades and sizes of studs may be rolled, cut or ground at option of the manufacturer.

3.3.6 GM455M shall be same as Grade 2.

3.4 HEAT TREATMENT PRACTICE.

3.4.1 Grade 1 bolts and screws and Grades 1 and 2 studs need not be heat treated.

3.4.2 Grade 2 cold headed bolts and screws shall be stress relieved at a temperature of 470 C minimum.

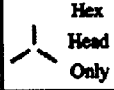
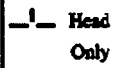
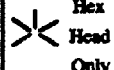
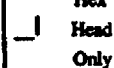
3.4.3 Grades 4 and 8.1 studs are manufactured from preheat-treated material and the studs, as manufactured, need no further heat treatment.

3.4.4 Grade 5 bolts, screws and studs shall be austenitized and quenched to obtain a structure of minimum 90% martensite and then tempered at a temperature of 425 C min.

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TABLE 1 – MECHANICAL REQUIREMENTS AND IDENTIFICATION MARKING FOR BOLTS, SCREWS, STUDS, U-BOLTS² AND SEMS

(See Table 3 for tests required for specific type, grade, size and length of product)													
GM Number	SAE Grade Designation	Product	Nominal Size Diameter (inch)	Full Size Bolts,Screws, Studs and Sems		Machined Test Specimens of Bolts,Screws, and Studs				Base Metal Hardness		Surface Hardness	Grade Identification Marking
				Proof Load Stress (psi)	Tensile Strength Min (psi)	Yield Strength Min (psi) ¹	Tensile Strength Min (psi)	Elongation in 2 inch (min %)	Reduction of Area (min %)	Rockwell			
										Min	Max		
GM255M	1	Bolts, Screws, Studs	No. 6 thru 1-1/2	33,000	60,000	36,000	60,000	18	35	B70	B100	—	None
GM260M	2	Bolts, Screws, Studs	No. 6 thru 3/4	55,000	74,000	57,000	74,000	18	35	B80	B100	—	None
			over 3/4 to 1-1/2	33,000	60,000	36,000	60,000	18	35	B70	B100	—	
—	4	Studs	1/4 thru 1-1/2	—	115,000	100,000	115,000	10	35	C22	C32	—	None
GM280M	5	Bolts, Screws, Studs	No. 6 thru 1	85,000	120,000	92,000	120,000	14	35	C25	C34	See Note 2	
			over 1 to 1-1/2	74,000	105,000	81,000	105,000	14	35	C19	C30		
GM275M	5.1	Heat Treated Sems	No. 6 thru 3/8	85,000	120,000	—	—	—	—	C25	C39	—	 Hex Head Only
GM290M	7	Bolts and Studs	1/4 thru 1-1/2	105,000	133,000	115,000	133,000	12	35	C28	C34	See Note 2	 Hex Head Only
GM300M	8	Bolts, Screws, Studs	1/4 thru 1-1/2	120,000	150,000	130,000	150,000	12	35	C33	C39	See Note 2	 Hex Head Only
—	8.1	Studs	1/4 thru 1-1/2	120,000	150,000	130,000	150,000	10	35	C32	C39	—	None
GM455M ⁴	None	Bolts, Screws, Studs	No. 6 thru 1-1/2	40,000	55,000	—	—	—	—	B79	—	—	 Hex Head Only

¹ Yield strength is the stress at which a permanent set of 0.2 percent of gage length occurs.² Surface hardness shall not exceed base metal hardness by more than two points (HRC equivalent) and in case of GM300M shall not exceed HR15N80.³ U-Bolts, see Paragraph 1.2, Page B – 151.101.⁴ Corrosion resistant steel products only.

3.4.5 Grade 5.1 screws shall be austenitized and quenched to obtain a structure of 90% martensite minimum and then tempered at temperature of 340 C min. For Grade 5.1 sems, quenchant whose principal constituent is water shall not be used unless approved by user.

3.4.6 Grades 7 and 8 bolts and screws and Grade 8 studs shall be austenitized and quenched to obtain a structure of 90% martensite minimum and then tempered at a temperature of 425 C minimum.

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TABLE 2 - CHEMICAL COMPOSITION REQUIREMENTS

GM Number	SAE Grade Number	Material and Treatment	Carbon		Sulfur	Phosphorus
			Min	Max	Max	Max
GM255M	1	Low or Medium Carbon Steel	—	0.55	0.058	0.048
GM260M	2	Low or Medium Carbon Steel	—	0.28	0.058	0.048
—	4	Medium Carbon Cold Drawn Steel	—	0.55	0.058	0.048
GM280M ¹	5	Medium Carbon Steel (Product Quenched and Tempered)	0.28	0.55	0.058	0.048
GM275M ^{1,2}	5.1	Low or Medium Carbon Steel (Product Quenched and Tempered)	0.15	0.30	0.058	0.048
GM290M ^{1,3}	7	Medium Carbon Alloy Steel (Product Quenched and Tempered)	0.28	0.55	0.045	0.040
GM300M ³	8	Medium Carbon Alloy Steel (Product Quenched and Tempered)	0.28	0.55	0.045	0.040
—	8.1	Elevated Temperature Drawn Steel- Medium Carbon Alloy or SAE 1041 Modified.	0.28	0.55	0.058	0.048
GM455M	None	Corrosion Resistant Steel	Chromium: 12.00 minimum			

¹ The manufacturer may use for sizes thru 3/4 inch a low carbon martensite steel with 0.15–0.27 percent carbon, 0.74–1.46 percent manganese, 0.038 percent maximum phosphorus, 0.048 percent maximum sulfur and 0.0005–0.008 percent boron.

² For GM275M screw and washer assemblies (sems), sizes No. 6 thru 3/8 inch, carbon content may be 0.15–0.55 percent. This is to allow relatively higher carbon steel for washers of sems.

³ Medium carbon alloy steel shall be fine grained with hardenability that will produce a minimum hardness of HRC 47 at the center of the threaded section, one diameter from the end of the bolt, screw or stud after oil quenching. SAE 1541 (AISI1041) steel may be used, oil quenched and tempered, at option of the producer for products 7/16 inch diameter and smaller. Use of alloy steel with Boron to increase hardenability for sizes larger than 7/16 inch diameter is permissible.

3.4.7 GM455M shall be same as Grade 2.

3.4.8 Under no circumstances shall heat treatment or carbon restoration be performed in the presence of nitrogen compounds, such as carbonitriding or cyaniding.

3.4.9 Tempering Temperature - Audit Test. This test is a means of checking whether products were tempered at the specified temperature. The hardness (mean of 3 hardness readings) of a bolt, screw or stud as manufactured shall be measured. The product shall then be retempered for 30 minutes minimum per 1.0 inch of nominal diameter, but not less than 30 minutes at a temperature of 10 C less than the minimum tempering temperature specified for the grade. (See 3.4.4, 3.4.5 and 3.4.6.) Hardness of the retempered product shall then be measured. The difference between the hardness of product before and after retempering shall not exceed HRC 2 points for Grade 8 and HRC 3 points for Grade 5.

4 REQUIREMENTS.

4.1 MECHANICAL PROPERTIES.

4.1.1 Bolts, screws, studs and sems shall be tested in accordance with the mechanical testing requirements for the applicable type grade, size and length of product as specified in Table 3 and shall meet the requirements of mechanical properties specified for the product in Table 1.

4.1.2 In case of U-bolts having thread length equal to 3D or longer, cut stud-like specimens from either leg of the "U" (utilize the maximum available thread length) and test as shown for studs. Where thread length is less than 3D, test hardness only as shown for "short studs" (applicable mechanical tests are shown in Table 3 and requirements in Table 1).

4.2 DECARBURIZATION. Unless otherwise agreed by purchaser, Grades 5, 5.1, 7 and 8 bolts, screws, studs and sems shall conform to decarburization limits for Class B or Class C, as described in GM6104M, "Decarburization of Hardened and Tempered Steel Bolts."

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4.3 SURFACE DISCONTINUITIES. Grades 5, 5.1, 7 and 8 bolts, screws, studs and sems shall conform to GM6102M, which specifies allowable limits for the various types of surface discontinuities that may occur during the manufacture and processing of such products. Surface discontinuities for sizes and lengths of products not covered in the scope of GM6102M shall be within limits specified by purchaser.

5 METHODS OF TEST.

5.1 PRODUCT (BASE METAL) HARDNESS.

5.1.1 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 to assure an accurate base metal hardness. Hardness of cold formed nonheat-treated products shall be determined on the threaded end.

5.1.2 For referee purposes, the hardness of bolts, screws and studs shall be determined at mid radius of a transverse section through the threaded portion of the product taken at a distance of 1 diameter from the end of the product. The reported hardness shall be the average of 4 hardness readings located at 90 degrees to one another, where size of product permits. The preparation of test specimens and the performance of hardness tests shall be in conformity with the requirements of SAE J417 and/or ASTM E18.

5.1.3 Surface Hardness. Tests to determine "surface hardness" shall be conducted on ends, hexagon flats or unthreaded shanks which have been prepared by polishing to insure 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.

5.2 PROOF LOAD. The proof load test consists of stressing the bolt, screw and stud with a specified load which the product must withstand without permanent set.

5.2.1 The overall length of the specimen shall be measured between conical or ball centers on the center line 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 of 0.0001 inch. In the case of sems, washers shall be removed prior to testing. The grips of the testing machine shall be self-aligning to minimize side thrust on the specimen. For bolts and screws, the specimen shall be assembled in the fixture of the tensile machine so that 6 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 6 full turns. When proof load testing studs, one end of the 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 of unlike diame-

ters, the end with smaller diameter shall be inserted in a threaded wedge and unscrewed 6 full turns, thus leaving 6 complete threads exposed between the grips. The bolt, screw or stud shall then be axially loaded to the proof load specified for the applicable size, thread series, and grade in Table 5, with the load retained for a period of 15 seconds, the load removed, and the overall length again measured. The speed of testing shall not exceed 1/8 inch per minute.

5.2.2 To meet the requirements of Item 4, the length of the bolt, screw or stud after loading shall be the same as before loading within a tolerance of plus and minus 0.0005 inch.

5.2.3 Variables, such as straightness and thread alignment (plus measurement error) may result in apparent elongation of the fasteners when the proof load is initially applied. In such cases, the fastener 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 0.0005 inch tolerance for measurement error).

5.3 AXIAL TENSILE STRENGTH. Following proof load testing, the same bolt, screw or stud shall be reassembled in the testing machine with 6 complete threads exposed between the grips and axial loading applied until failure. In the case of sems, washers may be removed prior to testing; however, for referee testing, washer shall be removed. The grips of the testing machine shall be self-aligning to minimize side thrust on the specimen. Typical fixturing is illustrated in Figure 2. The speed of testing, as determined with a free running crosshead, shall not exceed 1 inch per minute.

5.3.1 To meet the requirements of Item 4, the bolt, screw or stud shall support a load not less than the minimum tensile strength specified for the applicable size, thread series, and grade in Table 5 prior to product fracture. In addition, for bolts and screws, the fracture shall occur in the body or threaded section with no failure at the junction of the head and shank.

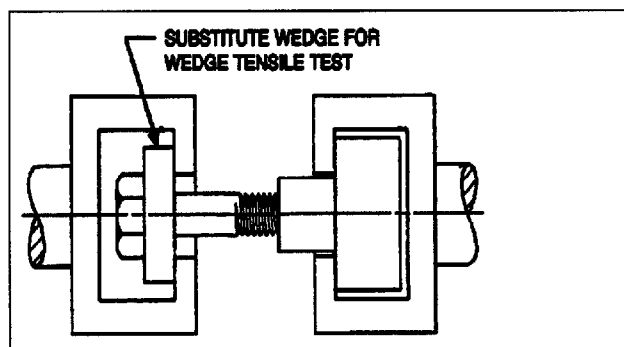


**FIGURE 2 – TENSILE TEST OF FULL SIZE BOLT
OR SCREW**

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TABLE 3 – MECHANICAL TESTS REQUIRED FOR BOLTS, SCREWS, STUDS, AND SEMS¹

Product	SAE Grade Number	Specified Minimum Tensile Strength of Product	Length of Product ³	Base Metal Hardness		Surface Hardness ⁴	Decarburization (note 5)	Tests Conducted Using Full Size Product			Tests Conducted Using Machined Test Specimens			
				Min	Max			Proof Load	Wedge Tensile Strength	Axial Tensile Strength	Yield Strength	Axial Tensile Strength	Elongation	Reduction of Area
Short Bolts and Screws	1,2, 5,7,8	All	Less than 3D	*	*	*	*	—	—	—	—	—	—	—
Special Head Bolts and Screws ²	1,2, 5,7,8	All	All	*	*	*	*	—	—	—	—	—	—	—
Square and Hex Head Bolts and Screws ⁶	1,2, 5,7,8	100,000 lb and Less	3D to 8D or 8 inch whichever is greater	—	*	*	*	*	*	—	—	—	—	—
			Over 8D or 8 inch whichever is greater Thru and incl 12 inch	—	*	*	*	Option A	*	—	Option B	Option B	Option B	Option B
			Over 12 inch	—	*	*	*	Option A	Option A	—	Option B	Option B	Option B	Option B
		Over 100,000 lb	3D and longer	—	*	*	*	Option A	Option A	—	Option B	Option B	Option B	Option B
All Other Bolts and Screws ⁸	1,2, 5,7,8	100,000 lb and Less	3D to 8D or 8 inch whichever is greater	—	*	*	*	*	—	*	—	—	—	—
			Over 8D or 8 inch whichever is greater	—	*	*	*	Option A	—	Option A	Option B	Option B	Option B	Option B
		Over 100,000 lb	3D and longer	—	*	*	*	Option A	—	Option A	Option B	Option B	Option B	Option B
Short Studs	1,2,4, 5,8,8.1	All	Less than 3D	*	*	*	*	—	—	—	—	—	—	—
Studs	4	All	3D and longer	—	*	*	—	—	—	—	*	*	*	*

¹ Asterisks (*) denote mandatory tests. Where options are indicated, all Option A tests (which apply to full size products) or all Option B tests (which apply to machined specimens) shall be performed. Option B tests shall be performed in case arbitration is necessary. Dashes (—) denote tests which are not required.

² Special head bolts and screws are those with special configurations or with drilled heads which are weaker than the threaded section.

³ D equals nominal diameter of the product.

⁴ Applicable to Grades 5, 7, and 8 only.

⁵ Applicable to Grades 5, 5.1, 7, and 8 only.

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

⁷ Heat treated sems.

⁸ Includes such products as round, pan, truss, oval, and flat head screws.

⁹ Corrosion resistant steel products only. Same tests required as for Grade 2.

(Table 3 continued on following page)