

## 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
GM289M	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.

NOTE: The grain flow must follow the contour of the fillet. No end grain exposure shall be acceptable. Larger sizes and longer lengths may be hot or cold headed at option of the manufacturer.

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 pre-heat-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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# MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M

TABLE 1 - MECHANICAL REQUIREMENTS AND IDENTIFICATION MARKING FOR BOLTS, SCREWS, STUDS, U-BOLTS<sup>2</sup> 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) <sup>1</sup>	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	35,000	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	—	
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	
M300M	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	
			1/4 thru 1-1/2	120,000	150,000	130,000	150,000	10	35	C32	C39		
—	8.1	Studs	1/4 thru 1-1/2	120,000	150,000	130,000	150,000	10	35	C32	C39	—	None
GM455M <sup>4</sup>	None	Bolts, Screws, Studs	No. 6 thru 1-1/2	40,000	55,000	—	—	—	—	B79	—	—	

<sup>1</sup> Yield strength is the stress at which a permanent set of 0.2 percent of gage length occurs.

<sup>2</sup> Surface hardness shall not exceed base metal hardness by more than two points (HRC equivalent) and in case of GM300M shall not exceed HR15N80.

<sup>3</sup> U-Bolts, see Paragraph 1.2, Page B-151.101.

<sup>4</sup> 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 <sup>1</sup>	5	Medium Carbon Steel (Product Quenched and Tempered)	0.28	0.55	0.058	0.048
GM275M <sup>1,2</sup>	5.1	Low or Medium Carbon Steel (Product Quenched and Tempered)	0.15	0.30	0.058	0.048
GM290M <sup>1,3</sup>	7	Medium Carbon Alloy Steel (Product Quenched and Tempered)	0.28	0.55	0.045	0.040
GM300M <sup>3</sup>	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			

<sup>1</sup> The manufacturer may use for sizes thru 3/4 inch a low carbon martensite steel with 0.15 - 0.27 percent carbon, 0.74 - 1.48 percent manganese, 0.038 percent maximum phosphorus, 0.048 percent maximum sulfur and 0.0005 - 0.003 percent boron.

<sup>2</sup> 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.

<sup>3</sup> 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

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## APPENDIX A

**A1** Proof load and tensile strength values are computed by multiplying the proof stresses and tensile stresses given in Table 1 of this standard by the stress area of the thread. The values in Table 5 were determined using stress areas (NOTE 1) computed from formula 1, below. Formula 2 is also applicable. Values for sizes and thread series not included in Table 5 may be computed by this means also.

$$\text{Formula 1 } A_s = 0.7854 \left[ D - \frac{0.9743}{n} \right]^2$$

$$\text{Formula 2 } A_s = 3.1416 \left[ \frac{E}{2} - \frac{3H}{16} \right]^2$$

where:  $A_s$  = Tensile stress area  
 $D$  = Basic major diameter<sup>2</sup>  
 $E$  = Basic pitch diameter<sup>2</sup>  
 $H$  = Height of sharp V-thread<sup>2</sup>  
 $n$  = Number of threads per inch

**A2** Tensile stress area values (NOTE 1) shown in the following table were derived from these formulas.

**A3** While these values do not correlate with test results for steels over 100 000 psi (as used for Grades 5, 5.1, 7 and 8), the small discrepancies are considered less objectionable than the questions which would be precipitated by the use of a different basis for the high strength products.

**A4** Values which do correlate with steels having tensile strengths over 100 000 psi may be computed with Formula 3, below. The values obtained will be slightly less than those computed with Formulas 1 and 2. In the case of the Class 2A UNC and Class 2A UNF thread series, the reduction in area varies from approximately 5% for the 1/4 inch nominal size to approximately 2% for the 1 inch nominal size. In the fine thread series, the reduction in area varies from approximately 2.5% for the 1/4 inch nominal size to approximately 1% for the 1 inch nominal size.

$$\text{Formula 3 } A_s = 3.1416 \left[ \frac{E_{\min}}{2} - \frac{3H}{16} \right]^2$$

where:  $E$  = Minimum pitch diameter for  
class of thread involved (NOTE 2)  
 $H$  = Height of sharp V-thread (NOTE 2).

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described in GM6104M, "Decarburization of Hardened and Tempered Steel Bolts."

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 diameters, 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.

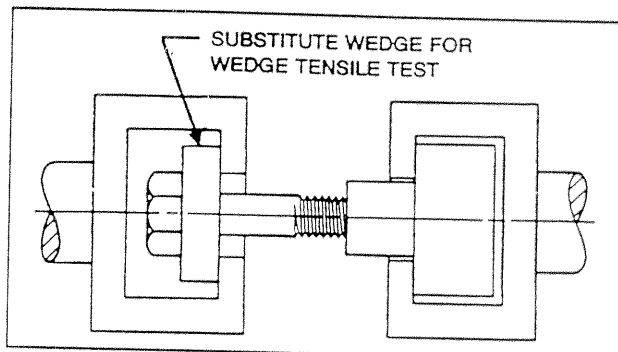


FIGURE 2 - TENSILE TEST OF FULL SIZE BOLT OR SCREW

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TABLE 3 - MECHANICAL TESTS REQUIRED FOR BOLTS, SCREWS, STUDS, AND SEMS<sup>1</sup>

Product	SAE Grade Number	Specified Minimum Tensile Strength of Product	Length of Product <sup>3</sup>	Base Metal Hardness		Surface Hardness <sup>4</sup>	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 <sup>2</sup>	1,2, 5,7,8	All	All	*	*	*	*	-	-	-	-	-	-	-
Square and Hex Head Bolts and Screws <sup>6</sup>	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
			3D to 8D or 8 inch whichever is greater	-	*	*	*	*	-	*	-	-	-	-
All Other Bolts and Screws <sup>8</sup>	1,2, 5,7,8	100,000 lb and Less	Over 8D or 8 inch whichever is greater	-	*	*	*	Option A	-	Option A	Option B	Option B	Option B	Option B
			3D and longer	-	*	*	*	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	-	*	*	-	-	-	-	*	*	*	*

<sup>1</sup> 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.

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

<sup>3</sup> D equals nominal diameter of the product.

<sup>4</sup> Applicable to Grades 5, 7, and 8 only.

<sup>5</sup> Applicable to Grades 5, 5.1, 7, and 8 only.

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

<sup>7</sup> Heat treated sems.

<sup>8</sup> Includes such products as round, pan, truss, oval, and flat head screws.

<sup>9</sup> Corrosion resistant steel products only. Same tests required as for Grade 2.

(Table 3 continued on following page)

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TABLE 3 (Continued)

Product	SAE Grade Number	Specified Minimum Tensile Strength of Product	Length of Product <sup>3</sup>	Base Metal Hardness		Surface Hardness <sup>4</sup>	Decarburization (note 5)	Tests Conducted Using Full Size Product			Test Conducted Using Machined Test Specimens			
				Min	Max			Proof Load	Wedge Tensile Strength	Axial Tensile Strength	Yield Strength	Axial Tensile Strength	Elongation	Reduction of Area
All Other Studs	1,2,5,8,8.1	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 Sems <sup>7</sup>	5.1	All	Less than 3D	*	*	-	*	-	-	-	-	-	-	-
Hex Sems <sup>7</sup>	5.1	All	3D and longer	-	*	-	*	*	*	-	-	-	-	-
Other Sems <sup>7</sup>	5.1	All	3D and longer	-	*	-	*	*	-	*	-	-	-	-
GM455M, See Note 9				*	-	-	-	Same as Grade 2 above						
Test to be performed in accordance with paragraph				5.1.1	5.1.2	5.6	5.2	5.4	5.3	5.5	5.5	5.5	5.5	5.5

Note: See notes on preceding page.

## 5.4 Wedge Tensile Strength.

5.4.1 Bolts and Screws. Bolts or screws shall be assembled with a wedge inserted under the head, as illustrated in Figure 3, installed in the testing machine and tensile tested to failure, as described in 5.3. The angle of the wedge for the bolt or screw size and grade is specified in Table 4. The wedge shall be placed that no corner of the square or hex bolt or screw head takes the bearing load; that is, a flat of the head shall be aligned with the direction of uniform thickness of the wedge. The wedge shall have a minimum hardness of HRC 45. 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 degrees to the following dimensions:

Nominal Bolt or Screw Size inch	Clearance in Hole inch	Radius or Depth of Chamfer inch
1/4 through 1/2	0.030	0.030
9/16 through 3/4	0.050	0.060
7/8 and 1	0.060	0.060
1-1/8 and 1-1/4	0.060	0.125
1-3/8 and 1-1/2	0.094	0.125

5.4.1.1 The wedge may be either circular or square. The recommended outside dimension of the wedge is 1-3/4 inch

for bolt and screw sizes 1/4 through 3/4 inch, and 3-1/2 inch for bolt and screw sizes 7/8 to 1-1/2 inch.

5.4.1.2 To meet the requirements of Item 4.1 the bolt or screw 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, the

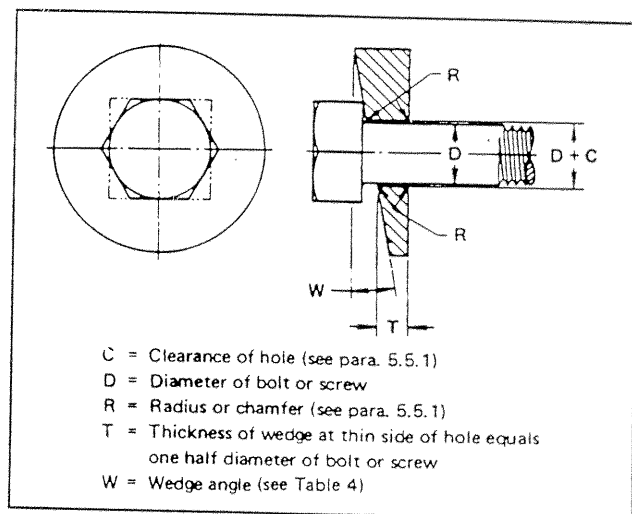


FIGURE 3 - TENSILE TEST DETAILS FOR BOLTS AND SCREWS

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fracture shall occur in the body or threaded section with no failure at the junction of head and shank.

5.4.2 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 diameters, the end with smaller diameter shall be inserted in a threaded wedge and unscrewed six full turns, thus leaving six complete threads exposed between the grips, as illustrated in Figure 4. The angle of the wedge for the stud size and grade shall be as specified in Table 4. The stud shall be assembled in the testing machine and tensile tested to failure, as described in 5.3.

5.4.2.1 The minimum hardness of the threaded wedge shall be HRC 45. 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 Class 3B tolerances, 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 Figure 4, shall have a hole clearance over the nominal size of the stud and shall have its top and bottom edges rounded to the same limits specified for the hardened wedge in 5.4.1.

5.4.2.2 To meet the requirements of Item 4.1, the stud shall fracture at a load not less than the minimum tensile strength specified for the applicable size, thread series, and grade in Table 5.

Testing of Machined Test Specimens. Where bolts, screws and studs cannot be tested in full size for proof load

and tensile strength requirements, tests shall be conducted using test specimens machined from the bolt, screw or stud.

5.5.1 For 1-1/2 inch diameter bolts, screws and studs, a standard 0.500 inch round 2 inch gage length test specimen shall be turned from the bolt, screw or stud with the axis of the specimen located midway between the center and outside surface of the bolt, screw or stud shank, as shown in Figure 5. Bolts, screws and studs 3/4 through 1-3/8 inch diameter shall have their shanks machined to the dimensions of a standard 0.500 inch round 2 inch gage length test specimen concentric with the axis of the bolt, screw or stud, leaving the bolt or screw head and threaded section intact, as shown in Figure 6. Bolts, screws and studs 1/4 through 5/8 inch diameter shall have their shanks machined to subsize specimens having dimensions shown in Figure 6 and Table 6.

5.5.2 The test specimen shall be tensile tested as described in 5.3; and the yield strength, tensile strength, elongation, and reduction of area determined.

5.5.3 To meet the requirement of Item 4.1, the test specimen must have a yield strength, tensile strength, elongation, and reduction of area equal to or greater than the values for these properties specified for the applicable product size and grade in Table 1.

5.6 Decarburization. The decarburization classification of bolts, screws and studs shall be determined by methods outlined in GM6104M.

5.7 Surface Discontinuities. Shall be determined by methods outlined in GM6102M.

TABLE 4 - TENSILE TEST WEDGE ANGLES

Product	SAE Grade Number	Nominal Diameter	Wedge Angle Degree
Hex and hex washer head machine screws and studs	1, 5 & 5.1	Thru 1/2	6
Hex bolts and screws threaded one diameter close to under side of head	5 thru 8	Thru 3/4	6
		Over 3/4 to 1-1/2	4
Hex flange and hex washer head bolts and screws	1 thru 8	Thru 1-1/2	6
All other square hex bolts and screws	1 thru 8	Thru 1	10
		Over 1 to 1-1/2	6
Studs	All	Thru 3/4	6
		Over 3/4 to 1-1/2	4

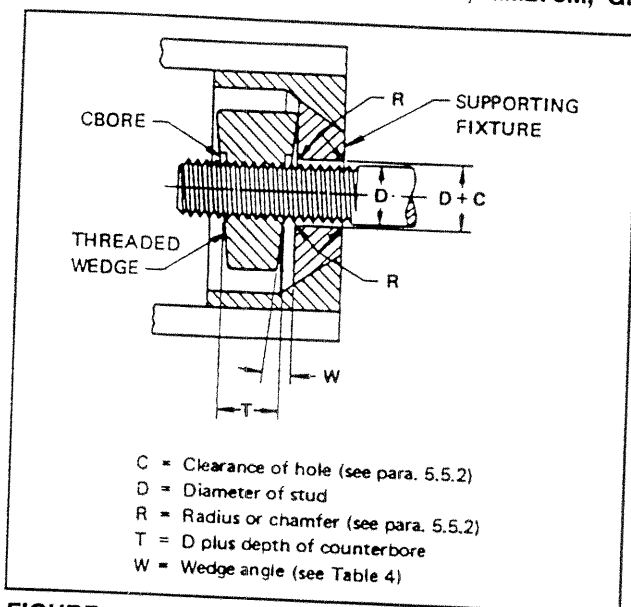
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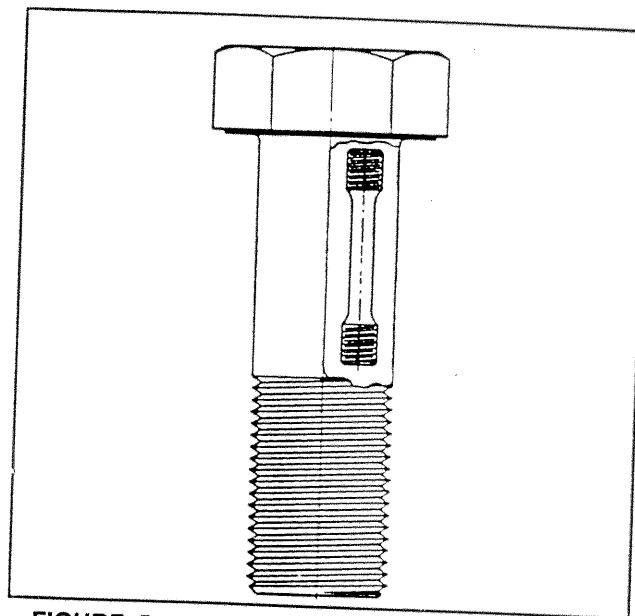
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# MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M



**FIGURE 4 - WEDGE TEST DETAILS FOR STUDS**



**FIGURE 5 - LOCATION OF STANDARD TEST SPECIMENS WHEN TURNED FROM BOLTS OR SCREWS 1-1/2 INCH DIAMETER**

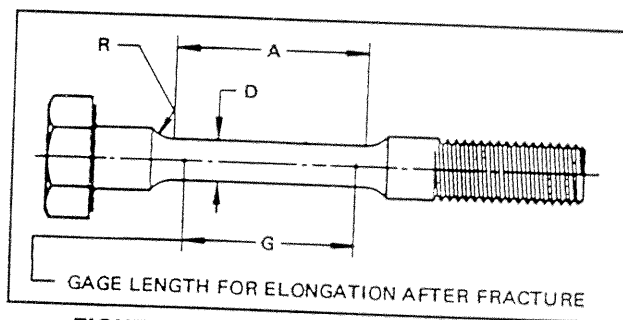
6.1 Hex head bolts and screws shall be clearly marked with the grade identification symbol shown in Table 1, and with the manufacturer's identification symbol. Unless otherwise specified by purchaser, markings shall be located on the top of the head, and may be either raised or depressed at option of the manufacturer.

6.2 Unless otherwise specified by purchaser, studs need not be marked.

**7 GENERAL.** A suggested sampling plan is shown below:

Number of Pieces in a Lot	Minimum Number of Specimens to be Tested
50 and under	2
51 - 500 Incl	3
501 - 35 000 Incl	5
35 001 and over	8

7.1 A Lot, for purpose 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.



**FIGURE 6 - TENSILE TEST SPECIMEN FOR BOLTS OR SCREWS WITH TURNED DOWN SHANKS**

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

7.3 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.

**8 INITIAL SOURCE APPROVAL.** No shipment shall be made by any supplier until representative initial production samples have been approved by engineering as meeting the requirements of this specification.

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## MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M

TABLE 5 - PROOF LOAD AND TENSILE STRENGTH REQUIREMENTS

GM Number		GM255M		GM260M		GM280M	
Grade		Grade 1		Grade 2		Grade 5	
Nominal Diameter of Product and Threads Per Inch	Stress Area	Proof Load	Tensile Strength	Proof Load	Tensile Strength	Proof Load	Tensile Strength
	sq in.	lb	min lb	lb	min lb	lb	min lb
COARSE THREAD SERIES - UNC							
6 - 32	0.00909	-	-	-	-	-	-
8 - 32	0.0140	-	-	-	-	-	-
10 - 24	0.0175	-	-	-	-	-	-
12 - 24	0.0242	-	-	-	-	-	-
1/4 - 20	0.0318	1,050	1,900	1,750	2,350	2,700	3,800
5/16 - 18	0.0524	1,750	3,150	2,900	3,900	4,450	6,300
3/8 - 16	0.0775	2,550	4,650	4,250	5,750	6,600	9,300
7/16 - 14	0.1063	3,500	6,400	5,850	7,850	9,050	12,800
1/2 - 13	0.1419	4,700	8,500	7,800	10,500	12,100	17,000
9/16 - 12	0.182	6,000	10,900	10,000	13,500	15,500	21,800
5/8 - 11	0.226	7,450	13,600	12,400	16,700	19,200	27,100
3/4 - 10	0.334	11,000	20,000	18,400	24,700	28,400	40,100
7/8 - 9	0.462	15,200	27,700	15,200	27,700	39,300	55,400
1 - 8	0.606	20,000	36,400	20,000	36,400	51,500	72,700
1-1/8 - 7	0.763	25,200	45,800	25,200	45,800	56,500	80,100
1-1/4 - 7	0.969	32,000	58,100	32,000	58,100	71,700	101,700
1-3/8 - 6	1.155	38,100	69,300	38,100	69,300	85,500	121,300
1-1/2 - 6	1.405	46,400	84,300	46,400	84,300	104,000	147,500
GM Number		GM275M		GM290M		GM300M	
Grade		Grade 5.1		Grade 7		Grade 8 and 8.1	
6 - 32	0.00909	750	1,100	-	-	-	-
8 - 32	0.0140	1,200	1,700	-	-	-	-
10 - 24	0.0175	1,500	2,100	-	-	-	-
12 - 24	0.0242	2,050	2,900	-	-	-	-
1/4 - 20	0.0318	2,700	3,800	3,350	4,250	3,800	4,750
5/16 - 18	0.0524	4,450	6,300	5,500	6,950	6,300	7,850
3/8 - 16	0.0775	6,600	9,300	8,150	10,300	9,300	11,600
7/16 - 14	0.1063	-	-	11,200	14,100	12,800	15,900
1/2 - 13	0.1419	-	-	14,900	18,900	17,000	21,300
9/16 - 12	0.182	-	-	19,100	24,200	21,800	27,300
5/8 - 11	0.226	-	-	23,700	30,100	27,100	33,900
3/4 - 10	0.334	-	-	35,100	44,400	40,100	50,100
7/8 - 9	0.462	-	-	48,500	61,400	55,400	69,300
1 - 8	0.606	-	-	63,600	80,600	72,700	90,900
1-1/8 - 7	0.763	-	-	80,100	101,500	91,600	114,400
1-1/4 - 7	0.969	-	-	101,700	127,700	116,300	145,400
1-3/8 - 6	1.155	-	-	121,300	153,600	138,600	173,200
1-1/2 - 6	1.405	-	-	147,500	186,900	168,600	210,800

Note: Proof loads and tensile strengths are computed by multiplying the proof load stresses and tensile strength stresses given in Table 1 by the stress area of the thread. (See Appendix A for further information on computation of values for products shown above and for sizes and thread series not listed.)

(Table 5 - Continued)

## MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M

TABLE 5 (Continued)

GM Number		GM255M		GM260M		GM280M	
Grade		Grade 1		Grade 2		Grade 5	
Nominal Diameter of Product and Threads Per Inch	Stress Area	Proof Load	Tensile Strength	Proof Load	Tensile Strength	Proof Load	Tensile Strength
	sq in.	lb	min lb	lb	min lb	lb	min lb
FINE THREAD SERIES - UNF							
6 - 40	0.01015	-	-	-	-	-	-
8 - 36	0.01474	-	-	-	-	-	-
10 - 32	0.0200	-	-	-	-	-	-
12 - 28	0.0258	-	-	-	-	-	-
1/4 - 28	0.0364	1,200	2,200	2,000	2,700	3,100	4,350
5/16 - 24	0.0580	1,900	3,500	3,200	4,300	4,900	6,950
3/8 - 24	0.0878	2,900	5,250	4,800	6,500	7,450	10,500
7/16 - 20	0.1127	3,900	7,100	6,350	8,800	10,100	14,200
1/2 - 20	0.1599	5,300	9,600	8,800	11,800	13,600	19,200
9/16 - 18	0.203	6,700	12,200	11,200	15,000	17,300	24,400
5/8 - 18	0.256	8,450	15,400	14,100	18,900	21,800	30,700
3/4 - 16	0.373	12,300	22,400	20,500	27,600	31,700	44,800
7/8 - 14	0.509	16,800	30,500	16,800	30,500	43,300	61,100
1 - 12	0.663	21,900	39,800	21,900	39,800	56,400	79,600
1-14 UNS	0.679	22,400	40,700	22,400	40,700	57,700	81,500
1-1/8 - 12	0.856	28,200	51,400	28,200	51,400	63,300	89,900
1-1/4 - 12	1.073	35,400	64,400	35,400	64,400	79,400	112,700
1-3/8 - 12	1.315	43,400	78,900	43,400	78,900	97,300	138,100
1-1/2 - 12	1.581	52,200	94,900	52,200	94,900	117,000	166,000
GM Number		GM275M		GM290M		GM300M	
Grade		Grade 5.1		Grade 7		Grade 8 and 8.1	
6 - 40	0.01015	850	1,200	-	-	-	-
8 - 36	0.01474	1,250	1,750	-	-	-	-
10 - 32	0.0200	1,700	2,400	-	-	-	-
12 - 28	0.0258	2,200	3,100	-	-	-	-
1/4 - 28	0.0364	3,100	4,350	3,800	4,850	4,350	5,450
5/16 - 24	0.0580	4,900	6,950	6,100	7,700	6,950	8,700
3/8 - 24	0.0878	7,450	10,500	9,200	11,700	10,500	13,200
7/16 - 20	0.1187	-	-	12,500	15,800	14,200	17,800
1/2 - 20	0.1599	-	-	16,800	21,300	19,200	24,000
9/16 - 18	0.203	-	-	21,300	27,000	24,400	30,400
5/8 - 18	0.256	-	-	26,900	34,000	30,700	38,400
3/4 - 16	0.373	-	-	39,200	49,600	44,800	56,000
7/8 - 14	0.509	-	-	53,400	67,700	61,100	76,400
1 - 12	0.663	-	-	69,600	88,200	79,600	99,400
1-14 UNS	0.679	-	-	71,300	90,300	81,500	101,900
1-1/8 - 12	0.856	-	-	89,900	113,800	102,700	128,400
1-1/4 - 12	1.073	-	-	112,700	142,700	128,800	161,000
1-3/8 - 12	1.315	-	-	138,100	174,900	157,800	197,200
1-1/2 - 12	1.581	-	-	166,000	210,300	189,700	237,200

NOTE: See note on preceding page.

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# MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M

TABLE 6 - DIMENSIONS OF MACHINED SPECIMENS

(See Figures 5 & 6 and Item 5.5)				
Nominal Diameter of Product	A	D	G	R
	Length Parallel Section	Diameter Parallel Section	Gage Length	Fillet Radius
1/4 thru 5/8	1.75 min	0.350 ±0.007	1.400 ±0.005	0.25 min
	1.25 min	0.250 ±0.005	1.000 ±0.005	0.19 min
3/4 thru 1-1/2	2.25 min	0.500 ±0.010	2.000 ±0.005	0.38 min (see note)

NOTE: Minimum radius recommended 0.38 in; 0.12 min permitted.

9 INSPECTION AND REJECTION. All shipments of material or parts under contract or purchase order manufac-

tured to this specification shall be equivalent in every respect to the initial samples approved by engineering. There shall be no changes in either formulation or manufacturing processes permitted without prior notification and approval by engineering. Lack of notification by the supplier constitutes grounds for rejection of any shipment. While samples may be taken from incoming shipments and checked for conformance to this specification, the supplier shall accept the responsibility for incoming shipments meeting this specification without dependence upon purchaser's inspection.

10 GENERAL INFORMATION. These standards were first issued as shown:

GM260M - November, 1939  
 GM280M - November, 1939  
 GM290M - November, 1939  
 GM300M - November, 1939  
 GM255M - November, 1945  
 GM455M - July, 1946  
 GM275M - September, 1959

The latest revisions include the following: April, 1989 editorial changes; March 1987 revised Table 2, NOTE 3.

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# MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS

GM255M, GM260M, GM275M, GM280M, GM290M, GM300M, GM455M

## APPENDIX A

**A1** Proof load and tensile strength values are computed by multiplying the proof stresses and tensile stresses given in Table 1 of this standard by the stress area of the thread. The values in Table 5 were determined using stress areas (NOTE 1) computed from formula 1, below. Formula 2 is also applicable. Values for sizes and thread series not included in Table 5 may be computed by this means also.

$$\text{Formula 1 } A_s = 0.7854 \left[ D - \frac{0.9743}{n} \right]^2$$

$$\text{Formula 2 } A_s = 3.1416 \left[ \frac{E}{2} - \frac{3H}{16} \right]^2$$

where:  $A_s$  = Tensile stress area  
 $D$  = Basic major diameter<sup>2</sup>  
 $E$  = Basic pitch diameter<sup>2</sup>  
 $H$  = Height of sharp V-thread<sup>2</sup>  
 $n$  = Number of threads per inch

**A2** Tensile stress area values (NOTE 1) shown in the following table were derived from these formulas.

**A3** While these values do not correlate with test results for steels over 100 000 psi (as used for Grades 5, 5.1, 7 and 8), the small discrepancies are considered less objectionable than the questions which would be precipitated by the use of a different basis for the high strength products.

**A4** Values which do correlate with steels having tensile strengths over 100 000 psi may be computed with Formula 3, below. The values obtained will be slightly less than those computed with Formulas 1 and 2. In the case of the Class 2A UNC and Class 2A UNF thread series, the reduction in area varies from approximately 5% for the 1/4 inch nominal size to approximately 2% for the 1 inch nominal size. In the fine thread series, the reduction in area varies from approximately 2.5% for the 1/4 inch nominal size to approximately 1% for the 1 inch nominal size.

$$\text{Formula 3 } A_s = 3.1416 \left[ \frac{E_{\min}}{2} - \frac{3H}{16} \right]^2$$

where:  $E$  = Minimum pitch diameter for  
class of thread involved (NOTE 2)  
 $H$  = Height of sharp V-thread (NOTE 2).

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**MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY THREADED FASTENERS**

GM255M GM260M GM275M GM280M GM290M GM300M GM455M

**APPENDIX A**

**TABLE A1 - TENSILE STRESS AREAS OF THREADED SECTIONS**

Nominal Size	Threads Per Inch	Tensile Stress Area	Nominal Size	Threads Per Inch	Tensile Stress Area	Nominal Size	Threads Per Inch	Tensile Stress Area
		Square Inches			Square Inches			Square Inches
0	80	0.00180	12	24	0.0242	7/8	9	0.462
1	64	0.00263	12	28	0.0258	7/8	14	0.509
1	72	0.00278	1/4	20	0.0318	1	8	0.606
2	56	0.00370	1/4	28	0.0364	1	12	0.663
2	64	0.00394	5/16	18	0.0524	1	14	0.680
3	48	0.00487	5/16	24	0.0580	1-1/8	7	0.763
3	56	0.00523	3/8	16	0.0775	1-1/8	12	0.856
4	40	0.00604	3/8	24	0.0878	1-1/4	7	0.969
4	48	0.00661	7/16	14	0.1063	1-1/4	12	1.073
5	40	0.00796	7/16	20	0.1187	1-3/8	6	1.155
5	44	0.00830	1/2	13	0.1419	1-3/8	12	1.315
			1/2	20	0.1599			
6	32	0.00909	9/16	12	0.182	1-1/2	6	1.405
6	40	0.01015	9/16	18	0.203	1-1/2	12	1.581
8	32	0.0140	5/8	11	0.226	1-3/4	5	1.90
8	36	0.01474	5/8	18	0.256	1-3/4	12	2.19
10	24	0.0175	3/4	10	0.334	2	4-1/2	2.50
10	32	0.0200	3/4	16	0.373	2	12	2.89

<sup>1</sup> The stress area values computed with Formula 1 and Formula 2, and shown in table above, correlate with test results for steels having tensile strength up to 100,000 psi.

<sup>2</sup> See GM Standards for Unified Screw Threads (published in Section X of the GM Engineering Standards) for dimensions of thread components referred to above.

**APPENDIX B**

**B1 Note to Bolt and Stud Producers.**

Following is a list of some typical steels which have been used to meet the bolt specifications shown. The SAE steels listed for each size of GM290M and GM300M are also applicable to all smaller sizes. This data is presented here for information only and is not to be considered mandatory:

GM255M and GM260M .....	1018, 1020
GM275M .....	1018, 1022
GM280M .....	1038, 1045
GM290M and GM300M, Nominal Size;	
Up to 3/8, Incl .....	1335, 4047, 5135
Up to 3/4, Incl .....	1340, 4135, 5140, 8637, 8735
Up to 1, Incl .....	3140, 4135, 5147, 6480

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MECHANICAL AND QUALITY REQUIREMENTS FOR EXTERNALLY  
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GM255M GM260M GM275M GM280M GM290M GM300M GM455M  
APPENDIX B

B1 Note to Bolt and Stud Producers.

Following is a list of some typical steels which have been used to meet the bolt specifications shown. The SAE steels listed for each size of GM290M and GM300M are also applicable to all smaller sizes. This data is presented here for information only and is not to be considered mandatory:

GM255M and GM260M .....	1018, 1020
GM275M.....	1018, 1022
GM280M.....	1038, 1045
GM290M and GM300M, Nominal Size;	
Up to 3/8, Incl.....	1335, 4047, 5135
Up to 3/4, Incl.....	1340, 4135, 5140, 8637, 8735
Up to 1, Incl.....	3140, 4135, 5147, 6480

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