Designation: A400 – 69 (Reapproved 2012)

Standard Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties[1]

This standard is issued under the fixed designation A400; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice covers the selection of steel bars according to section and to the mechanical properties desired in the part to be produced. This is not a specification for the procurement of steel. Applicable procurement specifications are listed in Section 5.

1.2 Several steel compositions intended for various sections and mechanical property requirements are presented in Tables 1-6. The criteria for placing a steel composition in one of the three general class designations, Classes P, Q, and R (described in Section 4) are as follows:

1.2.1 *Classes P and Q* should be capable of developing the mechanical properties shown in Tables 1-4 by liquid quenching from a suitable austenitizing temperature, and tempering at 800°F (427°C) or higher. A hardness indicated by tests made at a location shown in Fig. 1, A, B, or C, is taken as evidence that a composition is capable of meeting other equivalent mechanical properties shown in the tables. Normal good shop practices are assumed, with control of austenitizing and tempering temperatures, and mild agitation of the part in the quenching bath.

1.2.2 *Class R* should be capable of developing the mechanical properties shown in Tables 5 and 6 as hot rolled, by cold drawing, or by cold drawing with additional thermal treatment. The locations for obtaining tension tests are described in 6.2.

1.3 It is not implied that the compositions listed in the tables are the only ones satisfactory for a certain class and mechanical property requirement. Steels with lower alloy contents are often satisfactory through the use of special processing techniques.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A108 Specification for Steel Bar, Carbon and Alloy, Cold-Finished

A304 Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements

A311/A311M Specification for Cold-Drawn, Stress-Relieved Carbon Steel Bars Subject to Mechanical Property Requirements

A322 Specification for Steel Bars, Alloy, Standard Grades

A633/A633M Specification for Normalized High-Strength Low-Alloy Structural Steel Plates

A675/A675M Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

3. Significance and Use

3.1 If the desired mechanical properties are as described in 4.1.1 for material identified as Classes P-1 through P-7, or in 4.1.2 for material identified as Classes Q-1 through Q-7, the strength level desired can be based on hardness or the equivalent tensile or yield strength as shown in Tables 1-4. If the desired mechanical properties are as set forth in 4.1.3 for material identified as Classes R-1 through R-6, the strength level is based on yield strength as shown in Tables 5 and 6.

3.2 The user, after determining the mechanical property requirements of the critical section (that carrying the greatest stress) of the part, should select the composition or compositions from Tables 1-6 that fulfills these requirements and is most suitable for processing.

4. Classification

4.1 Steel bar compositions under this practice are classified according to mechanical property requirements and the critical section size of the part to be produced, as follows:

4.1.1 *Classes P-1 through P-7* comprise bars for parts to operate under severe service conditions requiring high yield

[1] This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.15 on Bars.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Steels for Moderately Quenched Parts—Classes P-1 Through P-7
(Applicable to oil-quenching or equivalent rate of heat-removal.)

NOTE 1—Steels listed as approved for a certain section or strength may be used for lighter sections and lower strengths.

NOTE 2—Steel composition numbers correspond to SAE, AISI, or ASTM designations. Those in italics are no longer considered standard grades due to decreased usage.

NOTE 3—An H-steel with the same grade designation as a standard SAE-AISI steel is capable of meeting the same section and strength requirements as the standard steel (see Specification A304), and is the preferred method of specification.

NOTE 4—Steels having a maximum carbon content of 0.40 % or over, or a hardness of HB 293 or over after heat-treating, are not recommended for applications involving welding.

Desired Minimum Hardness		Equivalent Tensile Strength, psi[A]	Equivalent Yield Strength, psi[A]	Minimum[B] As-Quenched Hardness		Class						
						P-1	P-2	P-3	P-4	P-5	P-6	P-7
						Diameter of Round (or Distance Between Faces of Square or Hexagonal) Sections, in.[C]						
						To ½, incl	Over ½ to 1, incl	Over 1 to 1½, incl	Over 1½ to 2, incl	Over 2 to 2½, incl	Over 2½ to 3, incl	Over 3 to 3½, incl
						Thickness of Flat Sections, in.[C]						
HB	HRC			HB	HRC	To 0.3, incl	Over 0.3 to 0.6, incl	Over 0.6 to 1, incl	Over 1 to 1.3, incl	Over 1.3 to 1.6, incl	Over 1.6 to 2.0, incl	Over 2.0 to 2.3, incl
229 to 293, incl	20 to 33, incl	110 000 to 145 000, incl	90 000 to 125 000, incl	388	42	1330 4130 5132 8630	*50B30*					
Over 293 to 341, incl	Over 33 to 38, incl	Over 145 000 to 170 000, incl	Over 125 000 to 150 000, incl	409	44	1335 *3135* 4042 5135	94B30	*3140* *4135* *4640* 8640 8740	4137		4142	9840	4337
Over 341 to 388, incl	Over 38 to 42, incl	Over 170 000 to 190 000, incl	Over 150 000 to 170 000, incl	455	48	1340 *3140* 4047 *4135* 5140 8637 *TS14B50* *50B40*		4137 *6145* 8642 8645 *8742*	4140 *TS4140* 94B40		4145 9840	4147 *4337* *86B45*	4340
Over 388 to 429, incl	Over 42 to 45, incl	Over 190 000 to 205 000, incl	Over 170 000 to 185 000, incl	496	51	1345 *4063* *4068* 4140 *4640* 5145 5150 8640 8642	8645 8740 *8742* 9260 *9261* *TS4140* 50B46 50B44 50B50	5147 5155 5160 6150 *9262* *94B40*	4142 4145 *4337* *8650* 8655 50B60 51B60 81B45	*8660* *9840*	4147 4161 4340 *86B45*	4150 4161 *TS4150*	E4340 *9850*

[A] 1 psi = 0.006895 MPa.
[B] Minimum as-quenched hardness for obtaining desired hardness after tempering at 800°F (427°C) or higher.
[C] 1 in. = 25.4 mm.

strength (90 000 psi (621 MPa) and over), good ductility, and relatively high notch toughness. The applicable section sizes, identified as Classes P-1 through P-7, are shown in Table 7. The steel compositions suitable for Classes P-1 through P-7 and for various desired mechanical properties are listed in Tables 1 and 2.

4.1.2 *Classes Q-1 through Q-7* comprise bars for parts operating under moderate service conditions requiring moderate to high yield strength (75 000 to 185 000 psi (517 to 1276 MPa)), corresponding tensile-strength levels, and good ductility. The applicable section sizes, identified as Classes Q-1 through Q-7, are shown in Table 7. The steel compositions suitable for Classes Q-1 through Q-7 and various desired mechanical properties are listed in Tables 3 and 4.

4.1.3 *Classes R-1 through R-6* comprise bars for parts requiring a lower yield strength (30 000 to 120 000 psi (207 to 827 MPa)), with fair to good ductility. The applicable section sizes, identified as Classes R-1 through R-6, are shown in Table 7. The steel compositions capable of developing the various desired mechanical properties are listed in Tables 5 and 6.

5. Applicable Procurement Specifications

5.1 For procurement of steel, it is recommended that the following ASTM specifications of latest issue be used: Specification A108, Specification A304, Specification A311/A311M, Specification A322, Specification A633/A633M, and Specification A675/A675M.

6. Location at Which Desired Properties Are Obtained

6.1 *Classes P-1 Through P-7 and Q-1 Through Q-7*—The mechanical properties shown in Tables 1-4 are based on

TABLE 2 Steels for Drastically Quenched Parts—Classes P-1 Through P-7
(Applicable to water-quenching or equivalent rate of heat-removal — See Note 5)

NOTE 1—Steels listed as approved for heavier sections or higher strengths may be used in the same conditions for lighter sections and lower strengths.

NOTE 2—Steel composition numbers correspond to ASE, AISI, or ASTM designations. Those in italics are no longer considered standard grades due to decreased usage.

NOTE 3—An H-steel with the same grade designation as a standard SAE-AISI steel is capable of meeting the same section and strength requirements as the standard steel (see Specification A304), and is the preferred method of specification.

NOTE 4—Steels having a maximum carbon content of 0.40 % or over, or a hardness of HB 293 or over after heat-treating, are not recommended for applications involving welding.

NOTE 5—Parts made of steel with a carbon content of 0.33 % or higher, where the section is under 1 1/2 in. (38.1 mm) should not be quenched in water without careful exploration for quench-cracking.

Desired Minimum Hardness		Equivalent Tensile Strength, psi[A]	Equivalent Yield Strength, psi[A]	Minimum[B] As-Quenched Hardness		Class						
						P-1	P-2	P-3	P-4	P-5	P-6	P-7
						Diameter of Round (or Distance Between Faces of Square or Hexagonal) Sections, in.[C]						
						To ½ , incl	Over ½ to 1, incl	Over 1 to 1½, incl	Over 1½ to 2, incl	Over 2 to 2½, incl	Over 2½ to 3, incl	Over 3 to 3½, incl
						Thickness of Flat Sections, in.[C]						
HB	HRC			HB	HRC	To 0.3, incl	Over 0.3 to 0.6, incl	Over 0.6 to 1.0, incl	Over 1.0 to 1.3, incl	Over 1.3 to 1.6, incl	Over 1.6 to 2.0, incl	Over 2.0 to 2.3, incl
229 to 293, incl	20 to 33, incl	110 000 to 145 000, incl	90 000 to 125 000, incl	388	42	8625 8627	4130 5130 8630 *50B30*	94B30				
Over 293 to 341, incl	Over 33 to 38, incl	Over 145 000 to 170 000, incl	Over 125 000 to 150 000, incl	409	44	*4032* 4037 4130 5130 8630 *TS14B35* *508B30*	1330 5132 94B30	1335 5135 5140 *50B40*		1340[D] *3135*[D] *4640* 8637[D] 8640 8740	*3140* *4135*	4137 *4337* *9840*

[A] 1 psi = 0.006895 MPa.
[B] Minimum as-quenched hardness for obtaining desired hardness after tempering at 800°F (427°C) or higher.
[C] 1 in. = 25.4 mm.
[D] These steels have insufficient hardenability for Class P-4, because of difference in test locations, but are satisfactory for other smaller sizes.

obtaining hardness test specimens from the locations shown in Fig. 1, A, B, and C. For bars, the location should be at least twice the diameter or minimum distance between faces from an end; and for flat sections, at least twice the thickness from an edge.

6.2 *Classes R-1 Through R-6*—The mechanical properties shown in Tables 5 and 6 are based on obtaining tension test specimens from the following locations:

6.2.1 Center of bars or plates under 1½ in. (38.1 mm) in diameter or in distance between parallel surfaces, and

6.2.2 Mid-radius or a quarter of the distance between parallel faces from the surface for larger sections.

7. Hardness Criteria for Quenched and Tempered Parts

7.1 *Classes Q-1 Through Q-7*—To obtain the properties stated in 4.1.2 at the locations shown in Fig. 1, A, B, and C, a microstructure containing a minimum of 50 % martensite is necessary.

8. Keywords

8.1 steel bars

TABLE 3 Steels for Moderately Quenched Parts—Classes Q-1 Through Q-7
(Applicable to oil-quenching or equivalent rate of heat-removal.)

NOTE 1—Steels listed as approved for heavier sections or higher strengths may be used in the same conditions for lighter sections and lower strengths.

NOTE 2—Steel composition numbers correspond to ASE, AISI, or ASTM designations. Those in italics are no longer considered standard grades due to decreased usage.

NOTE 3—An H-steel with the same grade designation as a standard SAE-AISI steel is capable of meeting the same section and strength requirements as the standard steel (see Specification A304), and is the preferred method of specification.

NOTE 4—Steels having a maximum carbon content of 0.40 % or over, or a hardness of HB 293 or over after heat-treating, are not recommended for applications involving welding.

Desired Minimum Hardness		Equivalent Tensile Strength, psi[A]	Equivalent Yield Strength, psi[A]	Minimum[B] As-Quenched Hardness		Class						
						Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7
						Diameter of Round (or Distance Between Faces of Square or Hexagonal) Sections, in.[C]						
						To ½, incl	Over ½ to 1, incl	Over 1 to 1½, incl	Over 1½ to 2, incl	Over 2 to 2½, incl	Over 2½ to 3, incl	Over 3 to 3½, incl
						Thickness of Flat Sections, in.[C]						
HB	HRC			HB	HRC	To 0.3, incl	Over 0.3 to 0.6, incl	Over 0.6 to 1.0, incl	Over 1.0 to 1.3, incl	Over 1.3 to 1.6, incl	Over 1.6 to 2.0, incl	Over 2.0 to 2.3, incl
187 to 293, incl	91 (R_b) to 33, incl	95 000 to 145 000, incl	75 000 to 125 000, incl	388	42	1330 4130 5132 8630 *50B30*	8637	3140 8740	4140 *TS4140* 94B40		4142	
Over 293 to 341, incl	Over 33 to 38, incl	Over 145 000 to 170 000, incl	Over 125 000 to 150 000, incl	409	44	1335 *4042* 5135 *50B30* 94B30	*3140* *4135* *4640* 8640 8740	4137 4140 8642 8645 *8742* *TS4140*	81B45	4142	4145	4147 *4337* *9840* *86B45*
Over 341 to 388, incl	Over 38 to 42, incl	Over 170 000 to 190 000, incl	Over 150 000 to 170 000, incl	455	48	1340 *3135* *3140* 4047 *4135* 5140 8637 *TS14B50* *50B40*	1345 4137 4140 5150 8642 8645 *8742* *TS4140* 50B50	4142 5147 5155 6150 *94B40*	51B60	4145 8655 *9840*	4147 *4337* *86B45*	4150 4340 *TS4150*
Over 388 to 429, incl	Over 42 to 45, incl	Over 190 000 to 205 000, incl	Over 170 000 to 185 000, incl	496	51	1345 4047 *4063* *4068* 4140 *4640* 5145 5150 8640 8642 8645 8740 *8742* 9260 *TS4140* 50B46 50B44 50B50 *9261* *94B40*	4142 5147 5155 6150 8655 *9262* 50B60 51B60 81B45	4145 *4337* 5160 *8650*	*9840*	4147 4340 *8660* *86B45*	4150 *TS4150*	E4340 *9850*

[A] 1 psi = 0.006895 MPa.
[B] Minimum as-quenched hardness for obtaining desired hardness after tempering at 800°F (427°C) or higher.
[C] 1 in. = 25.4 mm.