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

This standard is issued under the fixed designation A 400; 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 Department of Defense.*

## 1. Scope

1.1 This practice is intended as a guide for 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.

## 2. Referenced Documents

2.1 *ASTM Standards:*

A 108 Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality[2]

A 304 Specification for Steel Bars, Alloy, Subject to End-Quench Hardenability Requirements[2]

A 311/A 311M Specification for Steel Bars, Carbon, Stress-Relieved, Cold-Drawn, Subject to Mechanical Property Requirements[2]

A 322 Specification for Steel Bars, Alloy, Standard Grades[2]

A 633/A 633M Specification for Normalized High-Strength Low-Alloy Structural Steel Plates[3]

A 675/A 675M Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties[2]

## 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 strength (90 000 psi (621 MPa) and over), good ductility, and relatively high notch toughness. The applicable section sizes,

[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] *Annual Book of ASTM Standards*, Vol 01.05.

[3] *Annual Book of ASTM Standards*, Vol 01.04.

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**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 ASTM Specification A 304), 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<br>4130<br>5132<br>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<br>*3135*<br>4042<br>5135 | 94B30 | *3140*<br>*4135*<br>*4640*<br>8640<br>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<br>*3140*<br>4047<br>*4135*<br>5140<br>8637<br>*TS14B50*<br>*50B40* | | 4137<br>*6145*<br>8642<br>8645<br>*8742* | 4140<br>*TS4140*<br>94B40 | | 4145<br>9840 | 4147<br>*4337*<br>*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<br>*4063*<br>*4068*<br>4140<br>*4640*<br>5145<br>5150<br>8640<br>8642 | 8645<br>8740<br>*8742*<br>9260<br>*9261*<br>*TS4140*<br>50B46<br>50B44<br>50B50 | 5147<br>5155<br>5160<br>6150<br>*9262*<br>*94B40* | 4142<br>4145<br>*4337*<br>*8650*<br>8655<br>50B60<br>51B60<br>81B45 | *8660*<br>*9840* | 4147<br>4161<br>4340<br>*86B45* | 4150<br>4161<br>*TS4150* | E4340<br>*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.

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 A 108, Specification A 304, Specification A 311/

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**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 ASTM Specification A 304), 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<br>8627 | 4130<br>5130<br>8630<br>*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*<br>4037<br>4130<br>5130<br>8630<br>*TS14B35*<br>*508B30* | 1330<br>5132<br>94B30 | 1335<br>5135<br>5140<br>*50B40* | | 1340[D]<br>*3135*[D]<br>*4640*<br>8637[D]<br>8640<br>8740 | *3140*<br>*4135* | 4137<br>*4337*<br>*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.

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A 311M, Specification A 322, Specification A 633/ A 633M, and Specification A 675/A 675M.

## 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 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 ASTM Specification A 304), 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, 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 |
| 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 8630<br>4130 *50B30*<br>5132 | 8637 | 3140<br>8740 | 4140<br>*TS4140*<br>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<br>*4042* *50B30*<br>5135<br>94B30 | *3140* 8740<br>*4135*<br>*4640*<br>8640 | 4137 *TS4140*<br>4140<br>8642<br>8645<br>*8742* | 81B45 | 4142 | 4145 | 4147<br>*4337*<br>*9840*<br>*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 8637<br>*3135* *TS14B50*<br>*3140* *50B40*<br>4047<br>*4135*<br>5140 | 1345 *8742*<br>4137 *TS4140*<br>4140 50B50<br>5150<br>8642<br>8645 | 4142 *94B40*<br>5147<br>5155<br>6150 | 51B60 | 4145<br>8655<br>*9840* | 4147<br>*4337*<br>*86B45* | 4150<br>4340<br>*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 8645<br>4047 8740<br>*4063* *8742*<br>*4068* 9260<br>4140 *TS4140*<br>*4640* 50B46<br>5145 50B44<br>5150 50B50<br>8640<br>8642 | 4142<br>5147<br>5155<br>6150<br>*9261*<br>*94B40* | 4145<br>*4337*<br>5160<br>*8650*<br>8655<br>*9262*<br>50B60<br>51B60<br>81B45 | *9840* | 4147<br>4340<br>*8660*<br>*86B45* | 4150<br>*TS4150* | E4340<br>*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.

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