designations. Then, for a given UNS number, stress lines are next ordered by strength — first tensile strength and then yield strength. Finally, for a given UNS number, tensile strength, and yield strength, stress lines are ordered by increasing specification number. Again, some materials may have two or more stress lines even if their UNS number, tensile strength, yield strength, and specification number are the same. The Notes provide direction for the applicability of each line.

For those material specifications that may not show UNS numbers associated with alloy grades, one again can refer to Section IX’s Table QW/QB-422 for that information.

For Table 1B, nominal compositions are shown only for the NXXXX and RXXXX materials, but they have no influence on the location of alloys in the table. In this Table, the nominal compositions are simply for information.

2.3 TABLE 2A

Table 2A provides design stress intensities for ferrous materials for Section III, Division 1, Classes 1, TC, and SC construction, and for Section VIII, Division 2, Class 1 construction. This Table is organized in the same manner as Table 1A. Refer back to para. 2.1 for that description.

2.4 TABLE 2B

Table 2B provides design stress intensities for nonferrous materials for Section III, Division 1, Classes 1, TC, and SC construction, and for Section VIII, Division 2, Class 1 construction. Table 2B is organized in the same manner as in Table 1B for ferrous materials. For the ordering logic, again refer to paras. 2.1 and 2.2 for ferrous and nonferrous materials, respectively.

2.7 TABLE 5A

Table 5A provides allowable stresses for ferrous materials for Section VIII, Division 2 construction. This Table is organized in the same manner as Table 1A. Refer back to para. 2.1 for that description.

2.8 TABLE 5B

Table 5B provides allowable stresses for nonferrous materials for Section VIII, Division 2 construction. This Table is organized in the same manner as Table 1B. Refer back to para. 2.2 for that description.

2.9 TABLE 6A

Table 6A provides allowable stresses for ferrous materials for Section IV construction. This Table is organized in the same manner as Table 1A. Refer back to para. 2.1 for that description.

2.10 TABLE 6B

Table 6B provides allowable stresses for nonferrous materials for Section IV construction. This Table is organized in the same manner as Table 1B. Refer back to para. 2.2 for that description.

3 MECHANICAL PROPERTY TABLES

Ultimate tensile strength values and yield strength values are to be used in design calculations according to the rules of the Construction Codes. However, they are not to be construed as minimum strength values at temperature. This is explained in the General Notes to these tables. Paragraphs 3.1 through 3.3 provide a table-by-table listing of the materials-organization logic.

3.1 TABLE U

Table U provides tensile strength values for ferrous and nonferrous materials, in that order. The ordering logic for ferrous materials is the same as used in Table 1A, except...
yield strength level is not shown. Using the logic described in para. 2.1, stress lines are organized by nominal composition, then by increasing tensile strength level, and then by increasing specification number.

Nonferrous materials coverage begins following the last of the high alloy steels (25Cr–22Ni–2Mo–N). Coverage of nonferrous alloys begins with the UNS AXXXXX alloys, followed by NXXXXX and RXXXXX alloys. The ordering of materials within these three groups has been previously described in para. 2.2.

3.2 TABLE U-2

Table U-2 provides ultimate tensile strengths for special ferrous materials used in Section VIII, Division 3 construction. The only material covered is wire produced to either SA-231 or SA-232, and lines are arranged in order of decreasing tensile strength, resulting from increasing wire diameter.

3.3 TABLE Y-1

Table Y-1 provides yield strength values for ferrous and nonferrous materials, in that order. Again, the ordering of yield strength lines parallels the logic described for ferrous and nonferrous materials in paras. 2.1 and 2.2, respectively. Unlike Table U, for ferrous materials, the tensile strength level does enter into the ordering process, again following nominal composition designation. Table Y-1’s nonferrous materials listings begin with the aluminum-base alloys (UNS AXXXXX). These are followed by the copper materials (CXXXXX), nickel-base materials (NXXXXX), and the reactive and refractory metals and alloys (RXXXXX).

4 PHYSICAL PROPERTY TABLES

Since physical properties (thermal conductivity, thermal diffusivity, thermal expansion, and density), Young’s modulus, and Poisson’s ratio values can be shown for numerous materials with a single set of property values, most of the tables found in Subpart 2 of Section II, Part D are based on nominal composition. Paragraphs 4.1 through 4.4 describe how these tables are organized.

4.1 TABLE TE

Table TE covers thermal expansion behavior, presented in terms of A (instantaneous coefficient of thermal expansion), B (mean coefficient of thermal expansion), and C (linear thermal expansion). This Table is split into five parts as follows:

(a) Table TE-1 covers numerous individual ferrous materials and ferrous material groupings. Notes at the end of Table TE-1 list the nominal compositions covered by the designated groupings. Again, knowledge of the nominal composition for a given material is essential, and it was noted previously that these can be extracted from Table QW/QB-422 of Section IX, given the specification number and grade or type designation.

(b) Table TE-2 covers aluminum alloys. One set of A/B/C values covers all of the aluminum-base materials listed in General Note (a) of Table TE-2.

(c) Table TE-3 covers copper alloys, currently in five general groupings: C1XXXXX alloys, bronze alloys, brass alloys, 70Cu–30Ni, and 90Cu–10Ni. According to an article in ASM International’s “Advanced Materials & Processes” (December 1999), the general terms of bronze and brass cover the following alloys:

1. wrought copper-base alloys
   (a) C20500–C28580 — brasses (Cu–Zn)
   (b) C31200–C38590 — leaded brasses (Cu–Zn–Pb)
   (c) C40400–C49080 — tin brasses (Cu–Zn–Sn–Pb)
   (d) C60600–C64400 — aluminum bronzes (Cu–Al–Ni–Fe–Si–Sn)
   (e) C64700–C66100 — silicon bronzes (Cu–Si–Sn)

2. cast copper-base alloys
   (a) C83300–C85800 — red and leaded red brasses (Cu–Zn–Sn–Pb)
   (b) C66100–C68600 — manganese bronzes and leaded manganese bronzes (Cu–Zn–Mn–Fe–Pb)
   (c) C90200–C94500 — tin bronzes and leaded tin bronzes (Cu–Sn–Zn–Pb)
   (d) C95300–C95810 — aluminum bronzes (Cu–Al–Fe–Ni)

This guidance should help define which group of A/B/C values of thermal expansion to select for a given brass or bronze.

(d) Table TE-4 provides thermal expansion values for nickel alloys and refractory alloys. The thermal expansion values are represented by increasing UNS NXXXXX numbers.

(e) Table TE-5 provides thermal expansion values for two groupings of titanium-base alloys. One group covers only Grade 9; the other group covers the other alloys. In this Table, there is no reference to the UNS number, just to the grade number.

4.2 TABLE TCD

Table TCD provides both thermal conductivity (TC) and thermal diffusivity (TD) values for numerous ferrous and nonferrous materials and material groupings. The table begins with ferrous materials, split into groups of carbon and low alloy steels, followed by groups of high chromium steels and groups of high alloy steels. For each of these groups, there is a listing of nominal composition designations found at the end of the table, defining the extent of coverage.

The next series of materials are the nickel-base alloys, covered by TC/TD listings for nickel alloys (arranged by increasing UNS number) and refractory alloys. Then there
NONMANDATORY APPENDIX D
GUIDELINES FOR ROUNDOING MINIMUM SPECIFIED TENSILE AND
YIELD STRENGTH VALUES AND FOR ESTABLISHING ANCHOR
POINTS FOR TENSILE AND YIELD STRENGTH TREND CURVES IN
TABLES 1A, 1B, 2A, 2B, 3, 4, 5A, 5B, U, U-2, AND Y-1

D-100 MINIMUM TENSILE STRENGTH AND
MINIMUM YIELD STRENGTH
COLUMNS

D-110 DUAL UNIT SPECIFICATIONS

For specifications that contain both U.S. Customary and Metric minimum specified tensile and yield strength values, do the following:

(a) List the U.S. Customary values from the material specification in the columns for Minimum Tensile Strength, ksi and Minimum Yield Strength, ksi in the U.S. Customary edition tables of Section II, Part D.

(b) List the Metric values from the material specification in the columns for Minimum Tensile Strength, MPa and Minimum Yield Strength, MPa in the Metric edition tables of Section II, Part D.

D-120 TWO SEPARATE SPECIFICATIONS FOR
THE SAME PRODUCT FORM

When two separate specifications exist for the same product form, one in U.S. Customary units and one in Metric units (a common situation for some fastener specifications), do the following:

(a) List the values from the U.S. Customary edition of the material specification in the columns for Minimum Tensile Strength, ksi and Minimum Yield Strength, ksi in the U.S. Customary edition tables of Section II, Part D.

(b) List the values from the Metric edition of the material specification in the columns for Minimum Tensile Strength, MPa and Minimum Yield Strength, MPa in the Metric edition tables of Section II, Part D.

D-130 SPECIFICATION EXISTS IN ONLY ONE SET
OF UNITS

When a specification exists for only one set of units (common for EN and other non-U.S. specifications for which only Metric editions exist), do the following:

(a) Specification Exists Only in U.S. Customary Units

(1) List the U.S. Customary values in the columns for Minimum Tensile Strength, ksi and Minimum Yield Strength, ksi in the U.S. Customary edition tables of Section II, Part D.

(2) Multiply the U.S. Customary specification values by 6.894757, round to the nearest MPa (i.e., do a soft conversion), and list these rounded values in the columns for Minimum Tensile Strength, MPa and Minimum Yield Strength, MPa in the Metric edition tables of Section II, Part D.

(b) Specification Exists Only in Metric Units

(1) List the Metric values in the columns for Minimum Tensile Strength, MPa and Minimum Yield Strength, MPa in the Metric edition tables of Section II, Part D.

(2) Divide the Metric specification values by 6.894757, round to the nearest 0.5 ksi (i.e., do a soft conversion), and list these rounded values in the columns for Minimum Tensile Strength, ksi and Minimum Yield Strength, ksi in the U.S. Customary edition tables of Section II, Part D.

D-200 SELECTING ANCHOR POINT FOR
TENSILE AND YIELD STRENGTH
TREND CURVES FOR ALL
SITUATIONS IN WHICH THE
MINIMUM RT SPECIFIED VALUES IN
ONE UNIT SYSTEM ARE NOT PRECISE
CONVERSIONS OF THE UNITS IN THE
OTHER SYSTEM

D-210 ONE MATERIAL HAS ONE TREND CURVE
RULE

This rule requires that the trend curves in either system of units are precisely congruent with one another. That is, if the Metric and U.S. Customary curves are placed on top of one another, they appear to be only one curve. Thus, a material does not have two trend curves of the same shape, but has one curve shifted up or down because of slight differences between the U.S. Customary and Metric RT specified values.

It should be recognized that following the "one material: one trend curve" rule will result in certain inconsistencies with the criteria established by Mandatory Appendices 1, 2, and 10 of Section II, Part D. The rule was first established when the Section II-D tables were metricated. An example of the inconsistency with
Appendix 1 can be seen in the Metric values for Type 347H stainless steel, on pp. 102–105 of the 2010 Edition, 2011 Addenda of Section II, Part D Metric. Inspection of Line No. 1 on these pages, for SA-312 seamless pipe, shows that the values in the Min. Tensile Strength and Min. Yield Strength columns on p. 103 are, respectively, 515 MPa and 205 MPa, as they appear in the SA-312 specification in Section II, Part A. However, the value in the −30 to 40°C and the 65°C columns, 138 MPa, is not equal to either 515/3.5 = 147.14 = 147 MPa or (205 × 2)/3 = 136.67 = 137 MPa. Instead, 138 MPa is obtained from (30 ksi × 6.894757 × 2)/3 = 137.89514 = 138 MPa. In this example, the "one material: one trend curve" rule results in a value at two temperatures that is slightly higher than would have been obtained from applying the Appendix 1 criteria to the Metric minimum specified yield strength. For other materials, slightly lower values might result. However, in either example, the values will be identical (within rounding variances) to those of the U.S. Customary values at the same temperatures.

D-220 ANCHORING THE TREND CURVE

When anchoring the yield and tensile strength trend curve, the U.S. Customary tensile and yield strengths are used when the specification is either a dual unit specification or exists only in U.S. Customary units. The Metric trend curve is then anchored to the conversion of the U.S. Customary values — the U.S. Customary values multiplied by 6.894757. Rounding is delayed until the last step (see D-300). However, when the specification exists only in a Metric version, the U.S. Customary trend curves are anchored to the soft conversion from the Metric-specified minimum tensile and yield strengths, in all cases, i.e., the U.S. Customary trend curves are anchored to the Metric-specified minimum tensile and yield strengths divided by 6.894757. Again, rounding is delayed until the last step.

D-230 EQUIVALENT MATERIALS

When a non-ASTM specification that, in the judgment of the Committee, has chemistry and heat treatment requirements so similar to an ASTM specification and grade that is already listed in Section II, Part D, that it is indistinguishable from the ASTM material, the Committee may choose to use the same trend curves for the non-ASTM specification as were used to develop the values for the ASTM material, regardless of any differences between the U.S. Customary minimum specified values and the Metric minimum specified values.

D-300 SIGNIFICANT FIGURES IN THE ALLOWABLE STRESS, TENSILE STRENGTH, AND YIELD STRENGTH TABLES IN SECTION II, PART D AND IN CODE CASES

D-310 U.S. CUSTOMARY TABLES

When listing allowable stress values in ksi, the last step in the analysis is to round the calculated values to three significant figures for values of 10.0 ksi and greater, and to two significant figures for values less than 10.0 ksi. When listing tensile strength and yield strength values in ksi, the last step in the analysis is to round the calculated values to four significant figures for values of 100.0 ksi and greater, to three significant figures for values less than 100.0 ksi down to and including 10.0 ksi, and to two significant figures for values less than 10.0 ksi.

D-320 METRIC TABLES

When listing allowable stress, tensile strength, and yield strength values in MPa, the last step in the analysis is to round the calculated values to three significant figures, except that, for values greater than 999 MPa, round the value of the fourth figure to 0 or 5. For example, 1022 rounds to 1020, while 1023 rounds to 1025 MPa.