Designation: A 6/A 6M – 99

Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling[1]

This standard is issued under the fixed designation A 6/A 6M; 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 specification[2] covers a group of common requirements that, unless otherwise specified in the material specification, apply to rolled steel plates, shapes, sheet piling, and bars under each of the following specifications issued by ASTM:

ASTM Designation[3]	Title of Specification
A 36/A 36M	Carbon Structural Steel
A 131/A 131M	Structural Steel for Ships
A 242/A 242M	High-Strength Low-Alloy Structural Steel
A 283/A 283M	Low and Intermediate Tensile Strength Carbon Steel Plates
A 328/A 328M	Steel Sheet Piling
A 514/A 514M	High-Yield Strength, Quenched and Tempered Alloy Steel Plate Suitable for Welding
A 529/A 529M	High-Strength Carbon-Manganese Steel of Structural Quality
A 572/A 572M	High-Strength Low-Alloy Columbium-Vanadium Steel
A 573/A 573M	Structural Carbon Steel Plates of Improved Toughness
A 588/A 588M	High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 in. [100 mm] Thick
A 633/A 633M	Normalized High-Strength Low-Alloy Structural Steel Plates
A 656/A 656M	Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability
A 678/A 678M	Quenched-and-Tempered Carbon and High-Strength Low-Alloy Structural Steel Plates
A 690/A 690M	High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments
A 709/A 709M	Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges
A 710/A 710M	Age-Hardening Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Structural Steel Plates
A 769/A 769M	Carbon and High-Strength Electric Resistance Welded Steel Structural Shapes
A 786/A 786M	Rolled Steel Floor Plates
A 808/A 808M	High-Strength Low-Alloy Carbon, Manganese, Columbium, Vanadium Steel of Structural Quality with Improved Notch Toughness
A 827/A 827M	Plates, Carbon Steel, for Forging and Similar Applications
A 829/A 829M	Plates, Alloy Steel, Structural Quality
A 830/A 830M	Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements
A 852/A 852M	Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi [485 Mpa] Minimum Yield Strength to 4 in. [100 mm] Thick
A 857/A 857M	Steel Sheet Piling, Cold Formed, Light Gage
A 871/A 871M	High-Strength Low Alloy Structural Steel Plate with Atmospheric Corrosion Resistance
A 913/A 913M	Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)
A 945/A 945M	Specification for High-Strength Low-Alloy Structural Steel Plate with Low Carbon and Restricted Sulfur for Improved Weldability, Formability, and Toughness
A 992/A 992M	Specification for Steel for Structural Shapes for Use in Building Framing

1.2 Annex A1 lists permissible variations in dimensions and mass (Note 1) in SI units. The values listed are not exact conversions of the values in Tables 1-31 but are, instead, rounded or rationalized values. Conformance to Annex A1 is mandatory when the "M" specification designation is used.

NOTE 1—The term "weight" is used when inch-pound units are the standard; however, under SI, the preferred term is "mass."

1.3 Annex A2 lists the dimensions of some shape profiles.

1.4 Appendix X1 provides information on coiled product as a source of structural plates, shapes, sheet piling, and bars.

1.5 Appendix X2 provides information on the variability of tensile properties in plates and structural shapes.

1.6 Appendix X3 provides information on weldability.

1.7 Appendix X4 provides information on cold bending of plates, including suggested minimum inside radii for cold bearing.

1.8 This specification also covers a group of supplementary requirements that are applicable to several of the above specifications as indicated therein. Such requirements are provided for use where additional testing or additional restrictions are required by the purchaser, and apply only when specified individually in the purchase order.

1.9 In case of any conflict in requirements, the requirements of the individual material specification shall prevail over those of this general specification.

1.10 Additional requirements that are specified in the purchase order and accepted by the supplier are permitted, provided that such requirements do not negate any of the

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-6/SA-6M in Section II of that Code.

requirements of this general specification or the individual material specification.

1.11 For purposes of determining conformance with this specification and the various material specifications referenced in 1.1, values shall be rounded to the nearest unit in the right-hand place of figures used in expressing the limiting values in accordance with the rounding method of Practice E 29.

1.12 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system is to be used independently of the other, without combining values in any way.

1.13 This specification and the applicable material specifications are expressed in both inch-pound units and SI units; however, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.14 The text of this specification contains notes and/or footnotes that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3]

A 673/A 673M Specification for Sampling Procedure for Impact Testing of Structural Steel[4]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[5]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[3]

A 829 Specification for Plates, Alloy Steel, Structural Quality[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[6]

E 112 Test Methods for Determining Average Grain Size[7]

E 208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels[7]

2.2 *American Welding Society Standards:*

A5.1 Mild Steel Covered Arc-Welding Electrodes[8]

A5.5 Low-Alloy Steel Covered Arc-Welding Electrodes[8]

2.3 *U.S. Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[9]

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[9]

2.4 *U.S. Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[9]

2.5 *AIAG Standard:*

B-1 Bar Code Symbology Standard[10]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *Plates* (other than floor plates or coiled product)—Flat, hot-rolled steel, classified as follows:

3.1.1.1 *When Ordered to Thickness*:

(1) Over 8 in. [200 mm] in width and 0.230 in. or over [over 6 mm] in thickness.

(2) Over 48 in. [1200 mm] in width and 0.180 in. or over [over 4.5 mm] in thickness.

3.1.1.2 *When Ordered to Weight*:

(1) Over 8 in. [200 mm] in width and 9.392 lb/ft^2[47.10 kg/m^2] or heavier.

(2) Over 48 in. [1200 mm] in width and 7.350 lb/ft^2[35.32 kg/m^2] or heavier.

3.1.1.3 Slabs, sheet bars, and skelp, though frequently falling in the foregoing size ranges, are not classed as plates.

3.1.1.4 Coiled product is excluded from qualification to individual material specifications governed by this specification until decoiled, leveled, cut to length, and, if required, properly tested by the processor in accordance with ASTM specification requirements (see 6.4.2 and the individual material specification).

3.1.2 *Shapes (Flanged Sections)*:

3.1.2.1 *structural-size shapes*—rolled flanged sections having at least one dimension of the cross section 3 in. [75 mm] or greater. Structural shape size groupings used for tensile property classification are listed in Table A.

3.1.2.2 *bar size shapes*—rolled flanged sections having a maximum dimension of the cross section less than 3 in. [75 mm].

3.1.2.3 *"W" shapes*—doubly-symmetric, wide-flange shapes with inside flange surfaces that are substantially parallel.

3.1.2.4 *"HP" shapes*—are wide-flange shapes generally used as bearing piles whose flanges and webs are of the same nominal thickness and whose depth and width are essentially the same.

3.1.2.5 *"S" shapes*—doubly-symmetric beam shapes with inside flange surfaces that have a slope of approximately 16⅔ %.

3.1.2.6 *"M" shapes*—doubly-symmetric shapes that cannot be classified as "W," S," or "HP" shapes.

3.1.2.7 *"C" shapes*—channels with inside flange surfaces that have a slope of approximately 16⅔ %.

3.1.2.8 *"MC" shapes*—channels that cannot be classified as "C" shapes.

3.1.2.9 *"L" shapes*—shapes having equal-leg and unequal-leg angles.

[3] *Annual Book of ASTM Standards*, Vol 01.03.

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

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

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] *Annual Book of ASTM Standards*, Vol 03.01.

[8] Available from the American Welding Society, 550 N.W. LaJeune Rd., Miami, FL 33135.

[9] Available from the procuring activity or as directed by the contracting office or from the Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094 Attn: NPODS.

[10] Available from the Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, MI 48034.

TABLE A Shape Size Groupings for Tensile Property Classification

NOTE 1—SI designations, from Annex A2, are shown in brackets.Tees cut from W, M, and S shapes fall within the same group as the shape from which they are cut.

Shape Type	Group 1	Group 2	Group 3	Group 4	Group 5
W Shapes	W24 × 55 & 62 [W610 × 82& 92] W21 × 44 to 57 incl [W530 × 66 to 85 incl] W18 × 35 to 71 incl [W460 × 52 to 106 incl] W16 × 26 to 57 incl [W410 × 38.8 to 85 incl] W14 × 22 to 53 incl [W360 × 32.9 to 79 incl] W12 × 14 to 58 incl [W310 × 21.0 to 86 incl] W10 × 12 to 45 incl [W250 × 17.9 to 67 incl] W8 × 10 to 48 incl [W200 × 15.0 to 71 incl] W6 × 9 to 25 incl [W150 × 13.5 to 37.1 incl] W5 × 16 & 19 [W130 × 23.8& 28.1] W4 × 13 [W100 × 19.3]	W40 × 149 to 268 incl [W1000 × 222 to 399 incl] W36 × 135 to 210 incl [W920 × 201 to 313 incl] W33 × 118 to 152 incl [W840 × 176 to 226 incl] W30 × 90 to 211 incl [W760 × 134 to 314 incl] W27 × 84 to 178 incl [W690 × 125 to 263 incl] W24 × 68 to 162 incl [W610 × 101 to 241 incl] W21 × 62 to 147 incl [W530 × 92 to 219 incl] W18 × 76 to 143 incl [W460 × 113 to 213 incl] W16 × 67 to 100 incl [W410 × 100 to 149 incl] W14 × 61 to 132 incl [W360 × 91 to 196 incl] W12 × 65 to 106 incl [W310 × 97 to 158 incl] W10 × 49 to 112 incl [W250 × 73 to 167 incl] W8 × 58 & 67 [W200 × 86 & 100]	W40 × 277 to 328 incl [W1000 × 412 to 488 incl] W36 × 230 to 300 incl [W920 × 342 to 446 incl] W33 × 201 to 291 incl [W840 × 299 to 433 incl] W30 × 235 to 261 incl [W760 × 350 to 389 incl] W27 × 194 to 258 incl [W690 × 289 to 384 incl] W24 × 176 to 229 incl [W610 × 262 to 341 incl] W21 × 166 to 223 incl [W530 × 248 to 331 incl] W18 × 158 to 192 incl [W460 × 235 to 286 incl] W14 × 145 to 211 incl [W360 × 216 to 314 incl] W12 × 120 to 190 incl [W310 × 179 to 283 incl]	W40 × 362 to 655 incl [W1000 × 539 to 976 incl] W36 × 328 to 798 incl [W920 × 488 to 1188 incl] W33 × 318 to 619 incl [W920 × 473 to 922 incl] W30 × 292 to 581 incl [760 × 434 to 865 incl] W27 × 281 to 539 incl [W690 × 419 to 802 incl] W24 × 250 to 492 incl [W610 × 372 to 732 incl] W21 × 248 to 402 incl [W530 × 370 to 599 incl] W18 × 211 to 311 incl [W460 × 315 to 464 incl] W14 × 233 to 550 incl [W360 × 347 to 818 incl] W12 × 210 to 336 incl [W310 × 313 to 500 incl]	W36 × 920 [W920 × 1369] W14 × 605 to 873 incl [W360 × 900 to 1299 incl]
M Shapes	to 18.9 lb/ft, incl [to 28.1 kg/m, incl]				
S Shapes	to 35 lb/ft, incl [to 52 kg/m, incl]	over 35 lb/ft [over 52 kg/m]			
HP Shapes		to 102 lb/ft, incl [to 152 kg/m, incl]	over 102 lb/ft [over 152 kg/m]		
C Shapes	to 20.7 lb/ft, incl [to 30.8 kg/m, incl]	over 20.7 lb/ft [over 30.8 kg/m]			
MC Shapes	to 28.5 lb/ft, incl [to 42.4 kg/m, incl]	over 28.5 lb/ft [over 42.4 kg/m]			
L Shapes	to ½ in., incl [to 13 mm, incl]	over ½ to ¾ in., incl [over 13 to 19 mm, incl]	over ¾ in. [over 19 mm]		

3.1.3 *Sheet Piling*—rolled steel sections that are capable of being interlocked, forming a continuous wall when individual pieces are driven side by side.

3.1.4 *bars*—rounds, squares, and hexagons, of all sizes; flats $^{13}/_{64}$ in. (0.203 in.) and over [over 5 mm] in specified thickness, not over 6 in. [150 mm] in specified width; and flats 0.230 in. and over [over 6 mm] in specified thickness, over 6 to 8 in. [150 to 200 mm] inclusive, in specified width.

3.1.5 *exclusive*—when used in relation to ranges, as for ranges of thickness in the tables of permissible variations in dimensions, is intended to exclude only the greater value of the range. Thus, a range from 60 to 72 in. [1500 to 1800 mm] exclusive includes 60 in. [1500 mm], but does not include 72 in. [1800 mm].

3.1.6 *rimmed steel*—steel containing sufficient oxygen to give a continuous evolution of carbon monoxide during solidification, resulting in a case or rim of metal virtually free of voids.

3.1.7 *semi-killed steel*—incompletely deoxidized steel containing sufficient oxygen to form enough carbon monoxide during solidification to offset solidification shrinkage.

3.1.8 *capped steel*—rimmed steel in which the rimming action is limited by an early capping operation. Capping is carried out mechanically by using a heavy metal cap on a bottle-top mold or chemically by an addition of aluminum or ferrosilicon to the top of the molten steel in an open-top mold.

3.1.9 *killed steel*—steel deoxidized, either by addition of strong deoxidizing agents or by vacuum treatment, to reduce the oxygen content to such a level that no reaction occurs between carbon and oxygen during solidification.

3.1.10 *groupings for tensile property classification*—in some of the material specifications, the tensile property requirements vary for different sizes of shapes due to mass effect, etc. For the convenience of those using the specifications, the various sizes of shapes have been divided into groups based on section thickness at the standard tension test location (webs of beams, channels, and zees; legs of angles; and stems of tees). The material specifications designate shape sizes by reference to the group designations. The groupings are shown in Table A.

3.1.11 *mill edge*—the normal edge produced by rolling between horizontal finishing rolls. A mill edge does not conform to any definite contour. Mill edge plates have two mill edges and two trimmed edges.

3.1.12 *universal mill edge*—the normal edge produced by rolling between horizontal and vertical finishing rolls. Universal mill plates, sometimes designated UM Plates, have two

universal mill edges and two trimmed edges.

3.1.13 *sheared edge*—the normal edge produced by shearing. Sheared edge plates are trimmed on all edges.

3.1.14 *gas cut edge*—the edge produced by gas flame cutting.

3.1.15 *special cut edge*—usually the edge produced by gas flame cutting involving special practices such as pre-heating or post-heating, or both, in order to minimize stresses, avoid thermal cracking and reduce the hardness of the gas cut edge. In special instances, special cut edge is used to designate an edge produced by machining.

3.1.16 *sketch*—when used to describe a form of plate, denotes a plate other than rectangular, circular, or semicircular. Sketch plates may be furnished to a radius or with four or more straight sides.

3.1.17 *normalizing*—a heat treating process in which a steel plate is reheated to a uniform temperature above the upper critical temperature and then cooled in air to below the transformation range.

3.1.18 *plate-as-rolled*—when used in relation to the location and number of tests, the term refers to the unit plate rolled from a slab or directly from an ingot. It does not refer to the condition of the plate.

4. Ordering Information

4.1 Information items to be considered, if appropriate, for inclusion in purchase orders are as follows:

4.1.1 ASTM specification designation (see 1.1) and year of issue,

4.1.2 Name of material (plates, shapes, bars, or sheet piling),

4.1.3 Shape designation, or size and thickness or diameter,

4.1.4 Grade, class, and type designation, if applicable,

4.1.5 Condition (see Section 7), if other than as-rolled,

4.1.6 Quantity (weight [mass] or number of pieces),

4.1.7 Length,

4.1.8 Exclusion of either structural product from coil or discrete cut lengths of flat product (see 6.3 and Appendix X1), if applicable,

4.1.9 Heat treatment requirements (see 7.2 and 7.3), if any,

4.1.10 Mechanical property test report requirements (see Section 15), if any,

4.1.11 Special packaging, marking, and loading for shipment requirements (see Section 18), if any,

4.1.12 Supplementary requirements, if any, including any additional requirements called for in the supplementary requirements,

4.1.13 End use, if there are any end-use-specific requirements (see 5.1, 12.3.4, Table 22 or Table A1.23, and Table 24 or Table A1.25), and

4.1.14 Special requirements (see 1.10), if any,

4.1.15 Repair welding requirements (see 10.5), if any.

5. Identification of Material

5.1 *Plates*—Each plate shall be steel die-stamped, marked, or stenciled in one place with specification number (year of issue not required), grade, heat number, manufacturer's name, brand, or trademark (mill identification marks), size and thickness. For plates provided from coils, the processor identity rather than that of the manufacturer shall be used. For secured lifts of all sizes of plates 3/8 in. [10 mm] (or 5/16in. [8 mm] for material specified for bridge construction end use) or under in thickness, and for secured lifts of all thicknesses of plates 36 in. [900 mm] or under in width, the manufacturer or processor shall have the option of placing such markings on only the top piece of each lift, or of showing such markings on a substantial tag attached to each lift, unless otherwise specified. (See also 5.6.)

5.2 *Shapes*—Shapes shall be marked with the heat number, size of section, length, and mill identification marks on each piece. Either the manufacturer's name, brand, or trademark (mill identification marks) shall be shown in raised letters at intervals along the length. In addition, shapes shall be identified with the specification number (year of issue not required) and grade, either by marking each piece individually or, if bundled, by attaching a substantial tag to the bundle. For small shapes with the greatest cross-sectional dimension not greater than 6 in. [150 mm], the manufacturer or processor shall have the option of bundling the product for shipment, with each lift marked or tagged showing the previously listed identification. (See also 5.6.)

5.3 *Steel Sheet Piling*—Steel sheet piling shall be marked with the heat number, size of section, length, and mill identification marks on each piece. Either the manufacturer's name, brand, or trademark (mill identification marks) shall be shown in raised letters at intervals along the length.

5.4 *Bars*—Bars of all sizes, when loaded for shipment, shall be properly identified with the name or brand of manufacturer (mill identification marks), purchaser's name and order number, the specification number, grade number where appropriate, size and length, weight [mass] of lift, and the heat number for identification. Unless otherwise specified, the method of marking is at the manufacturer's option and shall be made by hot stamping, cold stamping, painting, or marking tags attached to the lifts of bars. Bars are not required to be die-stamped.

5.5 *Bar Coding*—In addition to the requirements of 5.1 to 5.4 inclusive, the manufacturer or processor shall have the option of using bar coding as a supplementary identification method.

NOTE 2—Bar coding should be consistent with AIAG Standard B-1.

5.6 *Specification Identification*—In addition to the requirements of 5.1 or 5.2, material ordered to one of the specifications and grades for which a color code is given in 5.6.3 shall be marked with the applicable specification number and grade. The year of issue of the specification to which the material is furnished need not be included in the marking. Color identification shall be applied as follows:

5.6.1 *Plates*—When specified by the purchaser, each plate (except for plates in secured lifts) shall be marked with the color designated in 5.6.3 along one edge or on the rolled surface within 12 in. [300 mm] of the heat number identification. For plates in secured lifts, the manufacturer or processor shall have the option of marking the color identification with a vertical stripe for the full height of the lift, such that each plate is marked with the stripe.

5.6.2 *Shapes*—Each structural shape or lift shall be marked with the color designated in 5.6.3 on one cut end or across the

rolled face of one flange or leg, adjacent to one cut end. Color markings shall be distinct and of sufficient size to be clearly visible.

5.6.3 *Colors*—The following color system shall be used to identify the individual specifications:

A 242/A 242M	blue
A 283/A 283M (Grade D)	orange
A 514/A 514M	red
A 529/A 529M Grade 50	black and yellow
A 529/A 529M Grade 55	black and red
A 572 Grade 42/A 572M Grade 290	green and white
A 572 Grade 50/A 572M Grade 345	green and yellow
A 572/A 572M Grade 55	green and red
A 572 Grade 60/A 572M Grade 415	green and gray
A 572 Grade 65/A 572M Grade 450	green and blue
A 588/A 588M	blue and yellow
A 709 Grade 50/A 709M Grade 345	green and yellow
A 709 Grade 50W/A 709M Grade 345W	blue and yellow
A 709 Grade 70W/A 709M Grade 485W	blue and orange
A 709 Grade HPS70W/A 709M Grade HPS485W	blue and red
A 709 Grade 100/A 709M Grade 690	red
A 709 Grade 100W/A 709M Grade 690W	red and orange
A 852/A 852M	blue and orange
A 913 Grade 50	red and yellow
A 913 Grade 60	red and gray
A 913 Grade 65	red and blue
A 913 Grade 70	red and white

5.7 *Heat Treatment Identification*:

5.7.1 Material that is eventually required to be heat treated by the material specification, but that is released on the basis of heat-treated test specimens, shall be identified with the letter "G" following the specification designation.

5.7.2 Material that has been given the required full heat treatment by the manufacturer or processor shall be identified with the letters "MT" following the specification designation.

5.8 *Subdivided Material*:

5.8.1 Pieces separated from master material by a supplier shall be identified with the specification number (year of issue not required), grade, heat number, and the heat treatment identification, if applicable, along with the trademark, brand, or name of the organization subdividing the material. The identification methods shall be in accordance with the requirements of 5.1 to 5.4 inclusive, except that the raised letters method for shapes and steel sheet piling is not required. If the original manufacturer's identification remains intact, the material need not be additionally identified by the organization supplying the material.

5.8.2 As an alternative, pieces from the same heat of material shall be bundled or placed in secured lifts, with the identification specified in 5.8.1 placed on the top piece of each lift or shown on a substantial tag attached to each lift or bundle.

6. Manufacture

6.1 Unless otherwise specified in the material specification, the steel shall be made by the open-hearth, basic-oxygen, or electric-furnace process. Additional refining by vacuum-arc-remelt (VAR) or electroslag-remelt (ESR) is permitted.

6.2 The steel shall be strand cast or cast in stationary molds.

6.2.1 *Strand Cast*:

6.2.1.1 When heats of the same nominal chemical composition are consecutively strand cast at one time, the heat number assigned to the cast product need not be changed until all of the steel in the cast product is from the following heat.

6.2.1.2 When two consecutively strand cast heats have different nominal chemical composition ranges, the manufacturer shall remove the transition material by an established procedure that positively separates the grades.

6.3 Structural products are produced in either discrete cut lengths of flat product or from coils.

6.3.1 Structural products produced from coil means structural products that have been cut to individual lengths from a coiled product and are furnished without heat treatment. For the purposes of this paragraph, stress relieving is not considered to be a heat treatment.

6.3.2 Structural products that are heat treated (except stress relieving) after decoiling shall be considered to be discrete cut lengths of flat product.

6.4 When structural products are produced from coils:

6.4.1 The manufacturer directly controls one or more of the operations (that is, melting, rolling, coiling, etc.), that affect the chemical composition or the mechanical properties, or both, of the material.

6.4.2 The processor decoils, forms, cuts to length, and marks; performs and certifies tests, examinations, repairs, and inspection; and except as allowed by Section 7, performs operations not intended to affect the properties of the material. The processor may subsequently heat treat the structural product (see Section 7). Specific sections of this specification for which the processor is responsible are 10, 11, 12, 5, 13, 16, 14, 15, and 18.

6.4.3 When part of a heat is rolled into discrete lengths of flat product and the balance of the heat into coiled product, each part must be tested separately.

6.4.4 Structural products produced from coils shall not contain splice welds, unless previously approved by the purchaser.

7. Heat Treatment

7.1 When material is required to be heat treated, such heat treatment shall be performed by the manufacturer, the processor, or the fabricator, unless otherwise specified in the material specification.

NOTE 3—When no heat treatment is required, the manufacturer or processor has the option of heat treating the products by normalizing, stress relieving, or normalizing then stress relieving to meet the material specification.

7.2 When heat treatment is to be performed by other than the material manufacturer, the order shall so state.

7.2.1 When heat treatment is to be performed by other than the material manufacturer, the structural products shall be accepted on the basis of tests made on specimens taken from full thickness coupons heat treated in accordance with the requirements specified in the material specification or on the order. If the heat-treatment temperatures are not specified, the manufacturer or processor shall heat treat the coupons under conditions he considers appropriate. The purchaser shall be informed of the procedure followed in heat treating the specimens.

7.3 When heat treatment is to be performed by the manufacturer or the processor, the material shall be heat treated as specified in the material specification, or as specified in the purchase order, provided that the heat treatment specified by the purchaser is not in conflict with the requirements of the

material specification.

7.4 When normalizing is to be performed by the fabricator, the material shall be either normalized or heated uniformly for hot forming, provided that the temperature to which the structural products are heated for hot forming does not significantly exceed the normalizing temperature.

7.5 The use of cooling rates that are faster than those obtained by cooling in air to improve the toughness shall be subject to approval by the purchaser, and structural products so treated shall be tempered subsequently in the range from 1100 to 1300°F [595 to 705°C].

8. Chemical Analysis

8.1 *Heat Analysis*—An analysis of each heat shall be made by the manufacturer to determine the percentage of carbon, manganese, phosphorus, sulfur, and any other elements specified or restricted by the applicable specification. This analysis shall be made from a test sample preferably taken during the pouring of the heat. The heat analysis shall be reported to the purchaser or his representative and shall conform to the heat analysis requirements of the applicable specification.

8.1.1 When vacuum-arc-remelting or electroslag remelting is used, a heat is defined as all the ingots remelted from a single primary melt. The heat analysis shall be obtained from one remelted ingot, or the product of one remelted ingot, of each primary melt providing the heat analysis of the primary melt meets the heat analysis requirements of the material specification. If the heat analysis of the primary melt does not meet the heat analysis requirements of the material specification, one test sample shall be taken from the product of each remelted ingot. In either case, the analyses so obtained from the remelted material shall conform to the heat analysis requirements of the applicable specification.

8.1.2 In addition to the elements specified by the applicable specification, test reports shall include for information the chemical analyses for copper, columbium, chromium, nickel, molybdenum, silicon, and vanadium.

NOTE 4—When the amount of copper, chromium, nickel, molybdenum or silicon is less than 0.02 %, the analysis may be reported as "<0.02 %." When the amount of columbium or vanadium is less than 0.008 %, the analysis may be reported as "<0.008 %."

8.2 *Product Analysis*—The purchaser shall have the option of analyzing finished material representing each heat. Sampling shall be in accordance with Test Methods, Practices, and Terminology A 751. The chemical composition thus determined shall conform to the requirements of the product specification subject to the product analysis tolerances in Table B. If a range is specified, the determinations of any element in a heat shall not vary both above and below the specified range. Rimmed or capped steel is characterized by a lack of homogeneity in its composition, especially for the elements carbon, phosphorus, and sulfur. Therefore, the limitations for these elements shall not be applicable unless misapplication is clearly indicated.

8.3 *Referee Analysis*—For referee purposes, Test Methods, Practices, and Terminology A 751 shall be used.

8.4 *Grade Substitution*—Alloy steel grades that meet the chemical requirements of Table 1 of Specification A 829 shall not be substituted for carbon steel grades.

9. Metallurgical Structure

9.1 When a grain size is specified, it shall be specified as fine austenitic grain size or coarse austenitic grain size. Austenitic grain size shall be determined in accordance with Test Methods E 112.

9.2 *Coarse Austenitic Grain Size*—When coarse austenitic grain size is specified, steel having grain size number of 1 to 5 as determined by the method described in 9.1 shall be acceptable. Conformance to the specified grain size for at least 70 % of the area examined shall constitute the basis of acceptance. One test per heat shall be made and the grain size results shall be reported.

9.3 *Fine Austenitic Grain Size*:

9.3.1 When fine austenitic grain size is specified, steel having grain size number 5 or higher as determined by the method described in 9.1 shall be acceptable. Conformance to the specified grain size for at least 70 % of the area examined shall constitute the basis of acceptance. One grain size test per heat shall be performed except as described in 9.3.2 and the grain size results shall be reported.

9.3.2 When aluminum is used as the grain refining element and on heat analysis the aluminum content is not less than 0.020 % total aluminum, or alternatively, 0.015 % acid soluble aluminum, the fine austenitic grain size requirement shall be deemed fulfilled and the testing requirement of 9.1 shall be waived. The aluminum content shall be reported if the testing requirement is waived.

9.3.3 When specified on the order, one grain size test (see 9.1) per heat shall be made regardless of type or content of grain refining element. Austenitic grain size shall conform to 9.3.1.

9.3.4 Where elements other than aluminum are used for grain refining, the content of such elements shall be reported with the heat analysis.

10. Quality

10.1 *General*—The material shall be free of injurious defects and shall have a workmanlike finish.

NOTE 5—Unless otherwise specified, structural quality steels are normally furnished in the as-rolled condition and subjected to visual inspection by the manufacturer. Non-injurious surface or internal imperfections *or both* may be present in the steel as delivered and may require conditioning by the *purchaser* to improve the appearance of the steel or in preparation for welding, coating, or other further processing.

More *restrictive* requirements may be specified by invoking supplementary requirements or by agreement between purchaser and supplier.

Materials that exhibit injurious defects during subsequent fabrication are deemed not to comply with the specification. (See 17.2.) Fabricators should be aware that cracks may initiate upon bending a sheared or burned edge during the fabrication process. This is not considered to be a fault of the steel but is rather a function of the induced cold-work or heat-affected zone.

The conditioning requirements in 10.2, 10.3, and 10.4 limit the conditioning allowed to be performed by the manufacturer. Conditioning of imperfections beyond the limits of 10.2, 10.3, and 10.4 may be performed by parties other than the manufacturer at the discretion of the *purchaser.*

TABLE B Product Analysis Tolerances

NOTE 1—Where "..." appears in this table there is no requirement.

Element	Upper Limit, or Maximum Specified Value, %	Tolerances, %	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15 incl	0.02	0.03
	over 0.15 to 0.40 incl	0.03	0.04
	over 0.40 to 0.75 incl	0.04	0.05
	over 0.75	0.04	0.06
Manganese[A]	to 0.60 incl	0.05	0.06
	over 0.60 to 0.90 incl	0.06	0.08
	over 0.90 to 1.20 incl	0.08	0.10
	over 1.20 to 1.35 incl	0.09	0.11
	over 1.35 to 1.65 incl	0.09	0.12
	over 1.65 to 1.95 incl	0.11	0.14
	over 1.95	0.12	0.16
Phosphorus	to 0.04 incl	...	0.010
	over 0.04 to 0.15 incl	...	NA[B]
Sulfur	to 0.06 incl	...	0.010
	over 0.06	N/A[B]	N/A[B]
Silicon	to 0.30 incl	0.02	0.03
	over 0.30 to 0.40 incl	0.05	0.05
	over 0.40 to 2.20 incl	0.06	0.06
Nickel	to 1.00 incl	0.03	0.03
	over 1.00 to 2.00 incl	0.05	0.05
	over 2.00 to 3.75 incl	0.07	0.07
	over 3.75 to 5.30 incl	0.08	0.08
	over 5.30	0.10	0.10
Chromium	to 0.90 incl	0.04	0.04
	over 0.90 to 2.00 incl	0.06	0.06
	over 2.00 to 4.00 incl	0.10	0.10
Molybdenum	to 0.20 incl	0.01	0.01
	over 0.20 to 0.40 incl	0.03	0.03
	over 0.40 to 1.15 incl	0.04	0.04
Copper	0.20 minimum only	0.02	...
	to 1.00 incl	0.03	0.03
	over 1.00 to 2.00 incl	0.05	0.05
Titanium	to 0.10 incl	0.01[C]	0.01[C]
Vanadium	to 0.10 incl	0.01[C]	0.01[C]
	over 0.10 to 0.25 incl	0.02	0.02
	over 0.25	0.02	0.03
	minimum only specified	0.01	...
Boron	any	NA[B]	NA[B]
Columbium	to 0.10 incl	0.01[C]	0.01[C]
Zirconium	to 0.15 incl	0.03	0.03
Nitrogen	to 0.030 incl	0.005	0.005

[A]Manganese product analyses tolerances for bars and bar size shapes shall be: to 0.90 incl ±0.03; over 0.90 to 2.20 incl± 0.06.

[B]NA—Product analysis not applicable.

[C]If the minimum of the range is 0.01 %, the under tolerance is 0.005 %.

Index to Tables of Permissible Variations

Dimension	Table	
	Inch-Pound Units	SI Units
Camber		
Plates, Carbon Steel; Sheared and Gas-Cut	12	A1.12
Plates, Carbon Steel; Universal Mill	11	A1.11
Plates, Other than Carbon Steel; Sheared, Gas-Cut and Universal Mill	11	A1.11
Shapes, Rolled; S, M, C, MC, and L	21	A1.21
Shapes, Rolled; W and HP	24	A1.24
Shapes, Split; L and T	25	A1.25
Cross Section of Shapes and Bars		
Flats	26	A1.26
Hexagons	28	A1.28
Rounds and Squares	27	A1.27
Shapes, Rolled; L, Bulb Angles, and Z	17	A1.17
Shapes, Rolled; W, HP, S, M, C, and MC	16	A1.16
Shapes, Rolled; T	18	A1.18
Shapes, Split; L and T	25	A1.25
Diameter		
Plates, Sheared	6	A1.6
Plates, Other than Alloy Steel, Gas-Cut	7	A1.7
Plates, Alloy Steel, Gas-Cut	10	A1.10
Rounds	27	A1.27
Ends Out-of-Square		
Shapes, Other than W	20	A1.20
Shapes, W	22	A1.22
Shapes, Milled, Other than W	23	A1.23
Flatness		
Plates, Carbon Steel	13	A1.13
Plates, Other than Carbon Steel	14	A1.14
Plates, Restrictive—Carbon Steel	S27.1	S27.2
Plates, Restrictive—Other than Carbon Steel	S27.3	S27.4
Length		
Bars	30	A1.30
Bars, Recut	31	A1.31
Plates, Sheared and Universal Mill	3	A1.3
Plates, Other than Alloy Steel, Gas-Cut	9	A1.9
Plates, Alloy Steel, Gas-Cut	8	A1.8
Plates, Mill Edge	4	A1.4
Shapes, Rolled; Other than W	19	A1.19
Shapes, Rolled; W and HP	22	A1.22
Shapes, Split; L and T	25	A1.25
Shapes, Milled	23	A1.23
Straightness		
Bars	29	A1.29
Shapes, Other than W	21	A1.21
Sweep		
Shapes, W and HP	24	A1.24
Thickness		
Flats	26	A1.26
Plates, Ordered to Thickness	1	A1.1
Waviness		
Plates	15	A1.15
Weight [Mass]		
Plates, Ordered to Weight [Mass]	2	A1.2
Width		
Flats	26	A1.26
Plates, Sheared	3	A1.3
Plates, Universal Mill	5	A1.5
Plates, Other than Alloy Steel, Gas-Cut	9	A1.9
Plates, Alloy Steel, Gas-Cut	8	A1.8
Plates, Mill Edge	4	A1.4

10.2 *Plate Conditioning*:

10.2.1 The grinding of plates by the manufacturer or processor to remove imperfections on the top or bottom surface shall be subject to the limitations that the area ground is well faired without abrupt changes in contour and the grinding does not reduce the thickness of the plate by (*1*) more than 7 % under the nominal thickness for plates ordered to weight per square foot or mass per square metre, but in no case more than ⅛ in. [3 mm]; or (*2*) below the permissible minimum thickness for plates ordered to thickness in inches or millimetres.

10.2.2 The deposition of weld metal (see 10.5) following the removal of imperfections on the top or bottom surface of plates by chipping, grinding, or arc-air gouging shall be subject to the following limiting conditions:

10.2.2.1 The chipped, ground, or gouged area shall not exceed 2 % of the area of the surface being conditioned.

10.2.2.2 After removal of any imperfections preparatory to welding, the thickness of the plate at any location shall not be reduced by more than 30 % of the nominal thickness of the plate. (Specification A 131/A 131M restricts the reduction in thickness to 20 % maximum.)

10.2.3 The deposition of weld metal (see 10.5) following the removal of injurious imperfections on the edges of plates by grinding, chipping, or arc-air gouging by the manufacturer or processor shall be subject to the limitation that, prior to welding, the depth of the depression, measured from the plate edge inward, is not more than the thickness of the plate or 1 in. [25 mm], whichever is the lesser.

10.3 *Structural Size Shapes, Bar Size Shapes, and Sheet Piling Conditioning*:

10.3.1 The grinding, or chipping and grinding, of structural size shapes, bar size shapes, and sheet piling by the manufacturer or processor to remove imperfections shall be subject to the limitations that the area ground is well faired without abrupt changes in contour and the depression does not extend below the rolled surface by more than (*1*) 1/32 in. [1 mm], for material less than ⅜ in. [10 mm] in thickness; (*2*) 1/16in. [2 mm], for material ⅜ to 2 in. [10 to 50 mm] inclusive in thickness; or (*3*) ⅛ in. [3 mm], for material over 2 in. [50 mm] in thickness.

10.3.2 The deposition of weld metal (see 10.5) following removal of imperfections that are greater in depth than the limits listed in 10.3.1 shall be subject to the following limiting conditions:

10.3.2.1 The total area of the chipped or ground surface of any piece prior to welding shall not exceed 2 % of the total surface area of that piece.

10.3.2.2 The reduction of thickness of the material resulting from removal of imperfections prior to welding shall not exceed 30 % of the nominal thickness at the location of the imperfection, nor shall the depth of depression prior to welding exceed 1¼ in. [32 mm] in any case except as noted in 10.3.2.3.

10.3.2.3 The deposition of weld metal (see 10.5) following grinding, chipping, or arc-air gouging of the toes of angles, beams, channels, and zees and the stems and toes of tees shall be subject to the limitation that, prior to welding, the depth of the depression, measured from the toe inward, is not more than the thickness of the material at the base of the depression or ½ in. [12.5 mm], whichever is the lesser.

10.3.2.4 The deposition of weld metal (see 10.5) and grinding to correct or build up the interlock of any sheet piling section at any location shall be subject to the limitation that the total surface area of the weld does not exceed 2 % of the total surface area of the piece.

10.4 *Bar Conditioning*:

10.4.1 The conditioning of bars by the manufacturer or processor to remove imperfections by grinding, chipping, or some other means shall be subject to the limitations that the conditioned area is well faired and the affected sectional area is not reduced by more than the permissible variations prescribed in the applicable tables designated in Section 13.

10.4.2 The deposition of weld metal (see 10.5) following chipping or grinding to remove imperfections that are greater in depth than the limits listed in 10.4.1 shall be subject to the following conditions:

10.4.2.1 The total area of the chipped or ground surface of any piece, prior to welding, shall not exceed 2 % of the total surface area of the piece.

10.4.2.2 The reduction of sectional dimension of a round, square, or hexagon bar, or the reduction in thickness of a flat bar, resulting from removal of an imperfection, prior to welding, shall not exceed 5 % of the nominal dimension or thickness at the location of the imperfection.

10.4.2.3 For the edges of flat bars, the depth of the conditioning depression prior to welding shall be measured from the edge inward and shall be limited to a maximum depth equal to the thickness of the flat bar or ½ in. [12.5 mm], whichever is less.

10.5 *Repair by Welding*:

10.5.1 *General Requirements*:

10.5.1.1 Repair by welding shall be in accordance with a welding procedure specification (WPS) using shielded metal arc welding (SMAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), or submerged arc welding (SAW) processes. Shielding gases used shall be of welding quality.

10.5.1.2 Electrodes and electrode-flux combinations shall be in accordance with the requirements of AWS Specification A5.1, A5.5, A5.17, A5.18, A5.20, A5.23, A5.28, or A5.29, whichever is applicable. For SMAW, low hydrogen electrodes shall be used.

10.5.1.3 Electrodes and electrode-flux combinations shall be selected so that the tensile strength of the deposited weld metal (after any required heat treatment) is consistent with the tensile strength specified for the base metal being repaired.

10.5.1.4 Welding electrodes and flux materials shall be dry and protected from moisture during storage and use.

10.5.1.5 Prior to repair welding, the surface to be welded shall be inspected to verify that the imperfections intended to be removed have been removed completely. Surfaces to be welded and surfaces adjacent to the weld shall be dry and free of scale, slag, rust, moisture, grease, and other foreign material that would prevent proper welding.

10.5.1.6 Welders and welding operators shall be qualified in accordance with the requirements of ANSI/AWS D1.1 or ASME Section IX, except that any complete joint penetration groove weld qualification also qualifies the welder or welding

operator to do repair welding.

10.5.1.7 Repair welding of materials shall be in accordance with a welding procedure specification (WPS) that is in accordance with the requirements of ANSI/AWS D1.1 or ASME Section IX, with the following exceptions or clarifications:

(*a*) The WPS shall be qualified by testing a complete joint penetration groove weld or a surface groove weld.

(*b*) The geometry of the surface groove weld need not be described in other than a general way.

(*c*) An ANSI/AWS D1.1 prequalified complete joint penetration groove weld WPS is acceptable.

(*d*) Any material not listed in the prequalified base metal-filler metal combinations of ANSI/AWS D1.1 also is considered to be prequalified if its chemical composition and mechanical properties are comparable to those for one of the prequalified base metals listed in ANSI/AWS D1.1.

(*e*) Any material not listed in ASME Section IX also is considered to be a material with an S-number in ASME Section IX if its chemical composition and its mechanical properties are comparable to those for one of the materials listed in ASME Section IX with an S-number.

10.5.1.8 When so specified in the purchase order, the WPS shall include qualification by Charpy V-notch testing, with the test locations, test conditions, and the acceptance criteria meeting the requirements specified for repair welding in the purchase order.

10.5.1.9 When so specified in the purchase order, the welding procedure specification (WPS) shall be subject to approval by the purchaser prior to repair welding.

10.5.2 *Steels with Specified Minimum Tensile Strength of 100 ksi [690 MPa] and Higher*—Repair welding of steels with specified minimum tensile strength of 100 ksi [690 MPa] shall be subject to the following additional requirements:

10.5.2.1 When so specified in the purchase order, prior approval for repair by welding shall be obtained from the purchaser.

10.5.2.2 The surface to be welded shall be inspected using a magnetic particle method or a liquid penetrant method to verify that the imperfections intended to be removed have been completely removed. When magnetic particle inspection is employed, the surface shall be inspected both parallel and perpendicular to the length of the area to be repaired.

10.5.2.3 When weld repairs are to be post-weld heat-treated, special care shall be exercised in the selection of electrodes to avoid those compositions that embrittle as a result of such heat treatment.

10.5.2.4 Repairs on material that subsequently is heat-treated at the mill shall be inspected after heat treatment; repairs on material that subsequently is not heat-treated at the mill shall be inspected no sooner than 48 h after welding. Such inspection shall use a magnetic particle method or a liquid penetrant method; when magnetic particle inspection is involved, such inspection shall be both parallel to and perpendicular to the length of the repair.

10.5.2.5 The location of the weld repairs shall be marked on the finished piece.

10.5.3 *Repair Quality*—The welds and adjacent heat-affected zone shall be sound and free of cracks, the weld metal being thoroughly fused to all surfaces and edges without undercutting or overlap. Any visible cracks, porosity, lack of fusion, or undercut in any layer shall be removed prior to deposition of the succeeding layer. Weld metal shall project at least 1/16 in. (2 mm) above the rolled surface after welding, and the projecting metal shall be removed by chipping or grinding, or both, to make it flush with the rolled surface, and to produce a workmanlike finish.

10.5.4 *Inspection of Repair*—The manufacturer or processor shall maintain an inspection program to inspect the work to see that:

10.5.4.1 Imperfections have been completely removed.

10.5.4.2 The limitations specified above have not been exceeded.

10.5.4.3 Established welding procedures have been followed, and

10.5.4.4 Any weld deposit is of acceptable quality as defined above.

11. Test Methods

11.1 All tests shall be conducted in accordance with Test Methods and Definitions A 370.

11.2 Yield strength shall be determined either by the 0.2 % offset method or by the 0.5 % extension under load method, unless otherwise stated in the material specification.

11.3 *Rounding Procedures*—For purposes of determining conformance with the specification, a calculated value shall be rounded to the nearest 1 ksi [5 MPa] tensile and yield strength, and to the nearest unit in the right-hand place of figures used in expressing the limiting value for other values in accordance with the rounding method given in Practice E 29.

11.4 For full-section test specimens of angles, the cross-sectional area used for calculating the yield and tensile strengths shall be a theoretical area calculated on the basis of the weight of the test specimen (see 13.1).

12. Tension Tests

12.1 *Condition*—Test specimens for non-heat-treated material shall be prepared for testing from the material in its delivered condition. Test specimens for heat-treated material shall be prepared for testing from the material in its delivered condition or from a separate piece of full thickness or full section from the same heat similarly heat treated.

12.1.1 When the plate is heat treated with a cooling rate faster than still-air cooling from the austenitizing temperature, one of the following shall apply in addition to other requirements specified herein:

12.1.1.1 The gage length of the tension test specimen shall be taken at least $1T$ from any as-heat treated edge where T is the thickness of the plate and shall be at least ½ in. [12.5 mm] from flame cut or heat-affected-zone surfaces.

12.1.1.2 A steel thermal buffer pad, $1T$ by $1T$ by at least $3T$, shall be joined to the plate edge by a partial penetration weld completely sealing the buffered edge prior to heat treatment.

12.1.1.3 Thermal insulation or other thermal barriers shall be used during the heat treatment adjacent to the plate edge where specimens are to be removed. It shall be demonstrated that the cooling rate of the tension test specimen is no faster

than, and not substantially slower than, that attained by the method described in 12.1.1.2.

12.1.1.4 When test coupons cut from the plate but heat treated separately are used, the coupon dimensions shall be not less than $3T$ by $3T$ by T and each tension specimen cut from it shall meet the requirements of 12.1.1.1.

12.1.1.5 The heat treatment of test specimens separately in the device shall be subject to the limitations that (*1*) cooling rate data for the plate are available; (*2*) cooling rate control devices for the test specimens are available; and, (*3*) the method has received prior approval by the purchaser.

12.2 *Orientation*—For plates wider than 24 in. [600 mm], test specimens shall be taken such that the longitudinal axis of the specimen is transverse to the final direction of rolling of the plate. Test specimens for all other products shall be taken such that the longitudinal axis of the specimen is parallel to the final direction of rolling.

12.3 *Location*:

12.3.1 *Plates*—Test specimens shall be taken from a corner of the plate.

12.3.2 *W, HP, S, and M Shapes with Flanges 6 in. [150 mm] or Wider*—Test specimens shall be selected from a point in the flange ⅔ of the way from the flange centerline to the flange toe.

12.3.3 *Shapes Other Than Those in 12.3.2*—Test specimens shall be selected from the webs of beams, channels, and zees; from the stems of rolled tees; and from the legs of angles and bulb angles, except where full-section test specimens for angles are used and the elongation acceptance criteria are increased accordingly. (See 12.6.2)

12.3.4 *Bars*:

12.3.4.1 Test specimens for bars to be used for pins and rollers shall be taken so that the axis is: midway between the center and the surface for pins and rollers less than 3 in. [75 mm] in diameter; 1 in. [25 mm] from the surface for pins and rollers 3 in. [75 mm] and over in diameter; or as specified in Annex A1 of Test Methods and Definitions A 370 if the applicable foregoing requirement is not practicable.

12.3.4.2 Test specimens for bars other than those to be used for pins and rollers shall be taken as specified in Annex A1 of Test Methods and Definitions A 370.

12.4 *Test Frequency*:

12.4.1 *Structural Products Produced in Discrete Cut Lengths*—For structural products produced in discrete cut lengths, the minimum number of pieces or plates-as-rolled to be tested for each heat and strength gradation, where applicable, shall be as follows, except that it shall be permissible for any individual test to represent multiple strength gradations:

12.4.1.1 As given in Table C, or

12.4.1.2 One taken from the minimum thickness in the heat and one taken from the maximum thickness in the heat, where thickness means the specified thickness, diameter, or comparable dimension, whichever is appropriate for the specific structural product rolled.

12.4.2 *Structural Products Produced from Coils*:

12.4.2.1 For structural products produced from coils, the minimum number of coils to be tested for each heat and strength gradation, where applicable, shall be as given in Table D, except that it shall be permissible for any individual coil to represent multiple strength gradations.

12.4.2.2 Except as required by 12.4.2.3, two tension test specimens shall be taken from each coil tested, with the first being taken immediately prior to the first structural product to be qualified, and the second being taken from the approximate center lap.

12.4.2.3 If, during decoiling, the amount of material decoiled is less than that required to reach the approximate center lap, the second test for the qualification of the decoiled portion of such a coil shall be taken from a location adjacent to the end of the innermost portion decoiled. For qualification of successive portions from such a coil, an additional test shall be taken adjacent to the innermost portion decoiled, until a test is obtained from the approximate center lap.

12.5 *Preparation*:

12.5.1 *Plates*:

12.5.1.1 Tension test specimens for plates ¾ in. [20 mm] and under in thickness shall be the full thickness of the plates. The test specimens shall conform to the requirements of Fig. 3 of Test Methods and Definitions A 370 for either 1½-in.[40-mm] wide specimen or the ½-in. [12.5-mm] wide specimen.

12.5.1.2 For plates up to 4 in. [100 mm], inclusive, in thickness, the use of 1½-in. [40-mm] wide specimens, full thickness of the material and conforming to the requirements of Fig. 3 of Test Methods and Definitions A 370, shall be subject to the limitations that adequate testing machine capacity is available and the material is not quenched and tempered.

12.5.1.3 For plates over ¾ in. [20 mm] in thickness, except as permitted in 12.5.1.2, tension test specimens shall conform to the requirements as shown in Fig. 4 of Test Methods and Definitions A 370, for the 0.500-in. [12.5-mm] diameter specimen. The axis of such specimens shall be located midway between the center of thickness and the top or bottom surface of the plate.

12.5.1.4 Test specimens for quenched and tempered plates over 1½ in. [40 mm] in thickness shall conform to the requirements as shown in Fig. 4 of Test Methods and Definitions A 370, for the 0.500-in. [12.5-mm] diameter specimen. The axis of such specimens shall be located midway between the center of thickness and the top or bottom surface of the plate.

12.5.2 *Shapes*:

12.5.2.1 Except when angles are tested in full section, tension test specimens for shapes ¾in. [20 mm] and under in thickness shall be the full thickness of the material. The test specimen shall conform to the requirements of Fig. 3 of Test Methods and Definitions A 370 for either the 1½-in. [40-mm] wide specimen or the ½-in. [12.5-mm] wide specimen.

12.5.2.2 For shapes up to 4 in. [100 mm], inclusive, in thickness, the use of 1½-in. [40-mm] wide test specimens, full thickness of the material and conforming to the requirements of Fig. 3 of Test Methods and Definitions A 370, shall be subject to the limitation that adequate testing machine capacity is available.

TABLE C Structural Products Produced in Discrete Cut Lengths—Minimum Number of Tension Tests Required

Thickness[A] Range Rolled for the Heat	Thickness[A] Difference Between Pieces or Plates-as-rolled in the Thickness[A] Range	Minimum Number of Tension Tests Required
Under 3/8 in. [10 mm]	1/16 in. [2 mm] or less	Two[B] tests per heat, taken from different pieces or plates-as-rolled having any thickness[A] in the thickness[A] range
	More than 1/16 in. [2 mm]	Two[B] tests per heat, one taken from the minimum thickness[A] in the thickness[A] range and one taken from the maximum thickness[A] in the thickness[A] range
3/8 to 2 in. [10 to 50 mm], incl	Less than 3/8 in. [10 mm]	Two[B] tests per heat, taken from different pieces or plates-as-rolled having any thickness[A] in the thickness[A] range
	3/8 in. [10 mm] or more	Two[B] tests per heat, one taken from the minimum thickness[A] in the thickness[A] range and one taken from the maximum thickness[A] in the thickness[A] range
Over 2 in. [50 mm]	Less than 1 in. [25 mm]	Two[B] tests per heat, taken from different pieces or plates-as-rolled having any thickness[A] in the thickness[A] range
	1 in. [25 mm] or more	Two[B] tests per heat, one taken from the minimum thickness[A] in the thickness[A] range and one taken from the maximum thickness[A] in the thickness[A] range

[A]Thickness means the specified thickness, diameter, or comparable dimension, whichever is appropriate for the specific structural product rolled.
[B]One test, if only one piece or plate-as-rolled is to be qualified.

TABLE D Structural Products Produced from Coils—Minimum Number of Coils Required to be Tension Tested

NOTE—See 12.4.2.2 and 12.4.2.3 for the number of tests to be taken per coil.

Thickness[A] Difference Between Coils in the Heat	Minimum Number of Coils Required to Be Tension Tested
Less than 1/16 in. [2 mm]	Two[B] coils per heat, at any thickness[A] in the heat
1/16 in. [2 mm] or more	Two[B] coils per heat, one at the minimum thickness[A] in the heat and one at the maximum thickness[A] in the heat

[A]Thickness means the specified thickness, diameter, or comparable dimension, whichever is appropriate for the specific structural product rolled.
[B]One coil, if the product of only one coil is to be qualified.

12.5.2.3 For shapes over 3/4 in. [20 mm] in thickness, except as permitted in 12.5.2.2, tension test specimens shall conform to the requirements as shown in Fig. 4 of Test Methods and Definitions A 370, for the 0.500 in. [12.5 mm] diameter specimens. The axis of such specimens shall be located midway between the center of thickness and the top or bottom surface of the material.

12.5.3 *Bars*:

12.5.3.1 Except as otherwise provided below, test specimens for bars shall be in accordance with Annex A1 of Test Methods and Definitions A 370.

12.5.3.2 Except as provided in 12.5.3.5, test specimens for bars 3/4 in. [20 mm] and under in thickness may conform to the requirements of Fig. 3 of Test Methods and Definitions A 370 for either the 1½-in. [40-mm] wide specimen or the ½-in. [12.5-mm] wide specimen.

12.5.3.3 Except as provided in 12.5.3.4 and 12.5.3.5, test specimens for bars over 3/4 in. [20 mm] in thickness or diameter shall conform either to the requirements for the 1½-in. [40-mm] or ½-in. [12.5-mm] wide specimen of Fig. 3 of Test Methods and Definitions A 370, or to the requirements for the 0.500–in. [12.5–mm] diameter specimen of Fig. 4 of Test Methods and Definitions A 370.

12.5.3.4 For bars other than those to be used for pins and rollers, the manufacturer or processor shall have the option of using test specimens that are machined to a thickness or diameter of at least 3/4 in. [20 mm] for a length of at least 9 in. [230 mm].

12.5.3.5 Test specimens for bars to be used for pins and rollers shall conform to the requirements of Fig. 4 of Test Methods and Definitions A 370 for the 0.500–in. [12.5–mm] diameter specimen.

12.6 *Elongation Requirement Adjustments*:

12.6.1 Due to the specimen geometry effect encountered when using the rectangular tension test specimen for testing thin material, adjustments in elongation requirements must be provided for thicknesses under 0.312 in. [8 mm]. Accordingly, the following deductions from the base elongation requirements shall apply:

Nominal Thickness Range, in. [mm]	Elongation Deduction, %[A]
0.299—0.311 [7.60—7.89]	0.5
0.286—0.298 [7.30—7.59]	1.0
0.273—0.285 [7.00—7.29]	1.5
0.259—0.272 [6.60—6.99]	2.0
0.246—0.258 [6.20—6.59]	2.5
0.233—0.245 [5.90—6.19]	3.0
0.219—0.232 [5.50—5.89]	3.5
0.206—0.218 [5.20—5.49]	4.0
0.193—0.205 [4.90—5.19]	4.5
0.180—0.192 [4.60—4.89]	5.0

0.166—0.179 [4.20—4.59]	5.5
0.153—0.165 [3.90—4.19]	6.0
0.140—0.152 [3.60—3.89]	6.5
0.127—0.139 [3.20—3.59]	7.0
0.114—0.126 [2.90—3.19]	7.5

[A] Elongation deductions for thicknesses less than 0.180 in. [4.60 mm] apply to structural shapes only.

12.6.2 Due to the specimen geometry effect encountered when using full-section test specimens for angles, the elongation requirements for structural-size angles shall be increased by six percentage points when full-section test specimens are used.

12.6.3 Due to the inherently lower elongation that is obtainable in thicker material, adjustments in elongation requirements must be provided. For material over 3.5 in. [90 mm] in thickness, a deduction of 0.5 percentage point from the specified percentage of elongation in 2 in. [50 mm] shall be made for each 0.5–in. [12.5–mm] increment of thickness over 3.5 in. [90 mm]. This deduction shall not exceed 3 percentage points. Accordingly, the following deductions from the base elongation requirements shall apply:

Nominal Thickness Range, in. [mm]	Elongation Deduction,%
3.500—3.999 [90.00—102.49]	0.5
4.000—4.499 [102.50—114.99]	1.0
4.500—4.999 [115.00—127.49]	1.5
5.000—5.499 [127.50—139.99]	2.0
5.500—5.999 [140.00—152.49]	2.5
6.000 and thicker [152.50 and thicker]	3.0

12.6.4 When so stated in the material specification, for plates up to ¾ in. [20 mm], inclusive, in thickness, if the percentage of elongation of an 8-in. [200-mm] gage length test specimen falls not more than 3 percentage points below the amount prescribed, the elongation shall be considered satisfactory, provided the percentage of elongation in 2 in. [50 mm] across the break is not less than 25 %.

NOTE 6—A characteristic of certain types of alloy steels is a local disproportionate increase in the degree of necking down or contraction of the specimens under tension test, resulting in a decrease in the percentage of elongation as the gage length is increased. The effect is not so pronounced in the thicker plates.

12.6.5 The tensile property requirements tables in many of the material specifications covered by this general specification specify elongation requirements in both 8-in. [200–mm] and 2-in. [50–mm] gage lengths. Unless otherwise provided in the individual material specification, both requirements are not required to be applied simultaneously and elongation need only be determined in gage length appropriate for the test specimen used. After selection of the appropriate gage length, the elongation requirement for the alternative gage length shall be deemed not applicable.

12.7 *Yield Strength Application*:

12.7.1 When test specimens do not exhibit a well-defined disproportionate yield point, yield strength shall be determined and substituted for yield point.

12.7.2 The manufacturer or processor shall have the option of substituting yield strength for yield point if the test specimen exhibits a well-defined disproportionate yield point.

12.7.3 Yield strength shall be determined either by the 0.2 % offset method or by the 0.5 % extension-under-load method.

12.8 *Product Tension Tests*—This specification does not provide requirements for product tension testing subsequent to shipment (see 16.1). Therefore, the requirements of 12.1 to12.7 inclusive and Section 14 apply only for tests conducted at the place of manufacture prior to shipment.

NOTE 7—Compliance to Specification A 6/A 6M and the individual material specifications by a manufacturer does not preclude the possibility that product tension test results might vary outside specified ranges. The tensile properties will vary within the same heat or piece, be it as-rolled, control-rolled, or heat-treated. Tension testing according to the requirements of Specification A 6/A 6M does not provide assurance that all products of a heat will be identical in tensile properties with the products tested. If the purchaser wishes to have more confidence than that provided by Specification A 6/A 6M testing procedures, additional testing or requirements, such as Supplementary Requirement S4, should be imposed.

12.8.1 Appendix X2 provides additional information on the variability of tensile properties in plates and structural shapes

13. Permissible Variations in Dimensions or Weight [Mass]

13.1 One cubic foot of rolled steel is assumed to weigh 490 lb. One cubic metre of rolled steel is assumed to have a mass of 7850 kg.

13.2 *Plates*—The permissible variations for dimensions and weight [mass] shall not exceed the applicable limits in Tables 1-15 [Annex A1, Tables A1.1 to A1.15], inclusive.

13.3 *Shapes*:

13.3.1 Annex A2 lists the designations and dimensions, in both inch-pound and SI units, of shapes that are most commonly available. Radii of fillets and toes of shape profiles vary with individual manufacturers and therefore are not specified.

13.3.2 The permissible variations for dimensions shall not exceed the applicable limits in Table 16 to Table 25 [Annex A1, Tables A1.16 to A1.25], inclusive. Permissible variations for special shapes not listed in those tables are subject to negotiation between the manufacturer and the purchaser.

NOTE 8—Tolerances are shown in Table 16 to Table 25 [Annex A1, Tables A1.16 to A1.25], inclusive, for some shapes that are not listed in Annex A2 (that is, bulb angles, tees, zees). Addition of such sections to Annex A2 will be considered by Subcommittee A01.02 when and if a need for such listing is shown.

13.3.3 *Shapes Having One Dimension of the Cross Section 3 in. [75 mm] or Greater (Structural-Size Shapes)*—The cross-sectional area or weight [mass] of each shape shall not vary more than 2.5 % from the theoretical or specified amounts.

13.4 *Sheet Piling*—The weight of each steel sheet pile shall not vary more than 2.5 % from the theoretical or specified weight [mass]. The length of each steel sheet pile shall not vary more than 5 in. [125 mm] over, and shall not be less than the length specified.

13.5 *Bars*—The variations from nominal dimensions of hot-rolled bars shall not exceed the applicable limits in Table 26 to Table 31 [Annex A1, Tables A1.26 to A1.31], inclusive.

14. Retests

14.1 If any test specimen shows defective machining or

develops flaws, the manufacturer or processor shall have the option of discarding it and substituting another test specimen.

14.2 If the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is more than ¾ in. [20 mm] from the center of the gage length of a 2-in. [50-mm] specimen or is outside the middle half of the gage length of an 8-in. [200-mm] specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

14.3 Except as provided in 14.3.1, if the results from an original tension specimen fails to meet the specified requirements, but are within 2 ksi [14 MPa] of the required tensile strength, within 1 ksi [7 MPa] of the required yield strength or yield point, or within 2 percentage points of the required elongation, a retest shall be permitted to replace the failing test. A retest shall be performed for the failing original test, with the specimen being randomly selected from the heat. If the results of the retest meet the specified requirements, the heat or lot shall be approved.

14.3.1 For structural products produced from coils, both tests from each coil tested to qualify a heat are required to meet all mechanical property requirements. Should either test fail to do so, then that coil cannot be used to qualify the parent heat, however, the portion of that individual coil that is bracketed by acceptable tests (see 12.4.2.3) is considered to be qualified.

14.4 Quenched and tempered steel plates are subject to the additional retest requirements contained in the material specification.

14.5 When the full-section option of 12.3.3 is used and the elongation falls below the specified requirement, the manufacturer or processor shall have the option of making another test using a test specimen permitted in 12.5.2.

15. Test Reports

15.1 Test reports for each heat supplied are required and they shall report the following:

15.1.1 The specification designation, including year of issue, and the grade or class if applicable, to which the material is furnished.

15.1.2 The heat number, heat analysis, and nominal sizes.

15.1.3 Two tension test results appropriate to qualify the material shipped (see 12.4), except that only one test result need be reported if the shipment consists of a single piece or plate-as-rolled.

15.1.3.1 In reporting elongation values, both the percentage increase and the original gage length shall be stated.

15.1.4 When the material is required to be heat treated, either by the designated ASTM specification, or when specified in the purchase order, all heat treatments, including temperature ranges and time at temperature.

15.1.4.1 The supply of a heat treatment procedure in place of the actual temperatures and times shall be subject to agreement between the purchaser and the supplier.

15.1.4.2 Subcritical heat treatment to soften thermally cut edges need not be reported except for materials having specified minimum tensile strengths of 95 ksi [655 MPa] or higher, unless such subcritical heating is accomplished at temperatures at least 75°F [40°C] lower than the minimum tempering temperature.

15.1.5 The results of all other tests required by the material specification, applicable supplementary requirements, and the order.

15.2 The thickness of the product tested is not necessarily the same as an individual ordered thickness since it is the heat that is tested rather than each ordered item. Tests from material thicknesses in accordance with 12.4 and encompassing the thicknesses in a shipment shall be sufficient for qualifying the material in the shipment. These test thicknesses are not required to be within previously tested and shipped thicknesses from the same heat.

15.3 For structural products produced from coils, both test results shall be reported for each qualifying coil.

15.4 For structural products produced from coils, both the manufacturer and processor shall be identified on the test report.

15.5 When full-section test specimens have been used for the qualification of angles, that information shall be stated on the test report.

15.6 A signature is not required on the test report. However, the document shall clearly identify the organization submitting the report. Notwithstanding the absence of a signature, the organization submitting the report is responsible for the content of the report.

15.7 When finished material is supplied to a purchase order specifying an ASTM material specification listed in the Scope section of Specification A 6/A 6M, the organization supplying that material shall provide the purchaser with a copy of the original manufacturer's test report.

15.8 A material test report, certficate of inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 9—The industry definition as invoked here is: EDI is the computer to computer exchange of business information in a standard format such as ANSI ASC X12.

16. Inspection and Testing

16.1 The inspector representing the purchaser shall have free entry, at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be conducted so as not to interfere with the operation of the works.

16.2 When structural products are produced from coils, 16.1 shall apply to the processor instead of the manufacturer, and the place of process shall apply instead of the place of manufacture. When structural products are produced from coils

and the processor is different from the manufacturer, the inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works that concerns the manufacturer of the material ordered.

17. Rejection

17.1 Any rejection based on product analysis made in accordance with the material specification shall be reported to the supplier and samples that represent the rejected material shall be preserved for 2 weeks from the date of notification of such rejection. In case of dissatisfaction with the results of the tests, the supplier shall have the option of making claim for a rehearing within that time.

17.2 The purchaser shall have the option of rejecting material that exhibits injurious defects subsequent to its acceptance at the manufacturer's works, and so notifying the manufacturer or processor.

18. Packaging, Marking, and Loading for Shipment

18.1 Packaging, marking, and loading for shipment shall be in accordance with Practices A 700.

18.2 When Level A is specified, and when specified in the contract or order, and for direct procurement by or direct shipment to the U.S. government, preservation, packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163.

18.3 When specified in the contract or order, and for direct procurement by or direct shipment to the U.S.government, marking for shipment, in addition to require-ments specified in the contract or order, shall be in accordance with MIL-STD-129 for military agencies and with Fed. Std. No. 123 for civil agencies.

19. Retreatment

19.1 If any heat-treated material fails to meet the mechanical property requirements of the applicable specification, the manufacturer or the processor shall have the option of heat treating the material again. All mechanical property tests shall be repeated and the material surface shall be reexamined for defects when the material is resubmitted for inspection.

20. Keywords

20.1 bars; general requirements; plates; rolled; shapes; sheet piling; structural steel

TABLE 1 Permissible Variations in Thickness for Rectangular, Carbon, High-Strength, Low-Alloy, and Alloy-Steel Plates, 15 in. and Under in Thickness When Ordered to Thickness

NOTE 1—Tables 1-31, inclusive, contain permissible variations in dimensions stated in inch-pound units.
NOTE 2—Permissible variation under specified thickness, 0.01 in.
NOTE 3—Thickness to be measured at ⅜ to ¾ in. from the longitudinal edge.
NOTE 4—For thickness measured at any location other than that specified in Note 3, the permissible maximum over tolerance shall be increased by 75 %, rounded to the nearest 0.01 in.
NOTE 5—Where "..." appears in this table, there is no requirement.

Specified Thickness, in.	Tolerance Over Specified Thickness for Widths Given, in.											
	48 and under	Over 48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 132, excl	132 to 144, excl	144 to 168, excl	168 to 182, excl	182 and over
To ¼, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	...	...	...
¼ to 5/16, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	...	...	...
5/16 to ⅜, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	...	...
⅜ to 7/16, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
7/16 to ½, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
½ to ⅝, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.07	...
⅝ to ¾, excl	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.07	0.07
¾ to 1, excl	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09
1 to 2, excl	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.10	0.10	0.11	0.13	0.16
2 to 3, excl	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.15	...
3 to 4, excl	0.11	0.11	0.11	0.11	0.11	0.13	0.14	0.14	0.14	0.15	0.17	...
4 to 6, excl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.20	0.20	...
6 to 10, excl	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.27	0.28	...
10 to 12, excl	0.29	0.29	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.35	...
12 to 15, incl	0.29	0.29	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	...

TABLE 2 Permissible Variations in Weight for Rectangular Sheared Plates and Universal Mill Plates 613.0 lb/ft² and Under When Ordered to Weight

NOTE 1—Permissible variations in overweight for lots of circular and sketch plates shall be 1¼ times the amounts in this table.
NOTE 2—Permissible variations in overweight for single plates shall be 1⅓ times the amounts in this table.
NOTE 3—Permissible variations in overweight for single circular and sketch plates shall be 1⅔ times the amounts in this table.
NOTE 4—The adopted standard density of rolled steel is 490 lb/ft³.
NOTE 5—Where "..." appears in this table, there is no requirement.

Specified Weights, lb/ft²	Permissible Variation in Average Weight of Lots[A] for Widths Given in Inches, Expressed in Percentage of the Specified Weights per Square Foot																					
	48 and under		Over 48 to 60, excl		60 to 72, excl		72 to 84, excl		84 to 96, excl		96 to 108, excl		108 to 120, excl		120 to 132, excl		132 to 144, excl		144 to 168, excl		168 and over	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
To 10, excl	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	7.5	3.0	9.0	3.0	11.0	3.0	13.0	3.0	...	...	...	...
10 to 12.5, excl	4.0	3.0	4.5	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.5	3.0	7.0	3.0	8.0	3.0	9.0	3.0	12.0	3.0	...	...
12.5 to 15.0, excl	4.0	3.0	4.0	3.0	4.5	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	7.5	3.0	8.0	3.0	11.0	3.0	...	...
15 to 17.5, excl	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	7.0	3.0	9.0	3.0	10.0	3.0
17.5 to 20, excl	3.5	2.5	3.5	2.5	3.5	3.0	4.0	3.0	4.5	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	8.0	3.0	9.0	3.0
20 to 25, excl	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0	4.0	3.0	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	7.0	3.0	8.0	3.0
25 to 30, excl	3.0	2.5	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0	5.0	3.0	6.5	3.0	7.0	3.0
30 to 40, excl	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.5	3.5	2.5	4.0	3.0	4.5	3.0	6.0	3.0	6.5	3.0
40 to 81.7, excl	2.5	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.0	3.5	2.5	3.5	3.0	4.0	3.0	5.5	3.0	6.0	3.0
81.7 to 122.6, excl	2.5	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.0	3.5	2.5	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0
122.6 to 163.4, excl	2.5	1.5	2.5	1.5	2.5	1.5	2.5	1.5	2.5	2.0	2.5	2.0	2.5	2.0	2.5	2.0	2.5	2.0	3.0	2.0	3.5	2.0
163.4 to 245.1, excl	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	3.0	1.0	3.5	1.0
245.1 to 409.0, excl	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	3.0	1.0
409.0 to 490.1, excl	2.0	1.0	2.0	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0
490.1 to 613.0, excl	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0

[A] The term "lot" means all the plates of each tabular width and weight group represented in each shipment.

TABLE 3 Permissible Variations in Width and Length for Sheared Plates 1½ in. and Under in Thickness; Length Only of Universal Mill Plates 2½ in. and Under in Thickness

Specified Dimensions, in.		Variations over Specified Width and Length[A] for Thicknesses, in., and Equivalent Weights, lb/ft², Given							
		To 3/8, excl		3/8 to 5/8, excl		5/8 to 1, excl		1 to 2, incl[B]	
Length	Width	To 15.3, excl		15.3 to 25.5, excl		25.5 to 40.8, excl		40.8 to 81.7, incl	
		Width	Length	Width	Length	Width	Length	Width	Length
To 120, excl	To 60, excl	3/8	1/2	7/16	5/8	1/2	3/4	5/8	1
	60 to 84, excl	7/16	5/8	1/2	11/16	5/8	7/8	3/4	1
	84 to 108, excl	1/2	3/4	5/8	7/8	3/4	1	1	1 1/8
	108 and over	5/8	7/8	3/4	1	7/8	1 1/8	1 1/8	1 1/4
120 to 240, excl	To 60, excl	3/8	3/4	1/2	7/8	5/8	1	3/4	1 1/8
	60 to 84, excl	1/2	3/4	5/8	7/8	3/4	1	7/8	1 1/4
	84 to 108, excl	9/16	7/8	11/16	15/16	13/16	1 1/8	1	1 3/8
	108 and over	5/8	1	3/4	1 1/8	7/8	1 1/4	1 1/8	1 3/8
240 to 360, excl	To 60, excl	3/8	1	1/2	1 1/8	5/8	1 1/4	3/4	1 1/2
	60 to 84, excl	1/2	1	5/8	1 1/8	3/4	1 1/4	7/8	1 1/2
	84 to 108, excl	9/16	1	11/16	1 1/8	7/8	1 3/8	1	1 1/2
	108 and over	11/16	1 1/8	7/8	1 1/4	1	1 3/8	1 1/4	1 3/4
360 to 480, excl	To 60, excl	7/16	1 1/8	1/2	1 1/4	5/8	1 3/8	3/4	1 5/8
	60 to 84, excl	1/2	1 1/4	5/8	1 3/8	3/4	1 1/2	7/8	1 5/8
	84 to 108, excl	9/16	1 1/4	3/4	1 3/8	7/8	1 1/2	1	1 7/8
	108 and over	3/4	1 3/8	7/8	1 1/2	1	1 5/8	1 1/4	1 7/8
480 to 600, excl	To 60, excl	7/16	1 1/4	1/2	1 1/2	5/8	1 5/8	3/4	1 7/8
	60 to 84, excl	1/2	1 3/8	5/8	1 1/2	3/4	1 5/8	7/8	1 7/8
	84 to 108, excl	5/8	1 3/8	3/4	1 1/2	7/8	1 5/8	1	1 7/8
	108 and over	3/4	1 1/2	7/8	1 5/8	1	1 3/4	1 1/4	1 7/8
600 to 720, excl	To 60, excl	1/2	1 3/4	5/8	1 7/8	3/4	1 7/8	7/8	2 1/4
	60 to 84, excl	5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1	2 1/4
	84 to 108, excl	5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1 1/8	2 1/4
	108 and over	7/8	1 3/4	1	2	1 1/8	2 1/4	1 1/4	2 1/2
720 and over	To 60, excl	9/16	2	3/4	2 1/8	7/8	2 1/4	1	2 3/4
	60 to 84, excl	3/4	2	7/8	2 1/8	1	2 1/4	1 1/8	2 3/4
	84 to 108, excl	3/4	2	7/8	2 1/8	1	2 1/4	1 1/4	2 3/4
	108 and over	1	2	1 1/8	2 3/8	1 1/4	2 1/2	1 3/8	3

[A] Permissible variation under specified width and length, 1/4 in.
[B] Permissible variations in length apply also to Universal Mill plates up to 12 in. in width for thicknesses over 2 to 2½in., incl, except for alloy steel up to 1¾ in. thick.

TABLE 4 Permissible Variations in Width for Mill Edge Carbon and High-Strength, Low-Alloy Plates Produced on Strip Mills (Applies to either Plates Produced from Coils or Plates Produced in Discrete Cut Lengths of Flat Product)

Specified Width, in.	Variations over Specified Width, in.[A]
To 14, excl	7/16
14 to 17, excl	1/2
17 to 19, excl	9/16
19 to 21, excl	5/8
21 to 24, excl	11/16
24 to 26, excl	13/16
26 to 28, excl	15/16
28 to 35, excl	1 1/8
35 to 50, excl	1 1/4
50 to 60, excl	1 1/2
60 to 65, excl	1 5/8
65 to 70, excl	1 3/4
70 to 80, excl	1 7/8
80 and over	2

[A] No permissible variation under specified width.

TABLE 5 Permissible Variations in Rolled Width for Universal Mill Plates 15 in. and Under in Thickness

Specified Width, in.	Variations over Specified Width[A] for Thickness, in., or Equivalent Weights, lb/ft², Given					
	To 3/8, excl	3/8 to 5/8, excl	5/8 to 1, excl	1 to 2, incl	Over 2 to 10, incl	Over 10 to 15, incl
	To 15.3, excl	15.3 to 25.5, excl	25.5 to 40.8, excl	40.8 to 81.7, incl	81.7 to 409.0, incl	409.0 to 613.0, incl
Over 8 to 20, excl	1/8	1/8	3/16	1/4	3/8	1/2
20 to 36, excl	3/16	1/4	5/16	3/8	7/16	9/16
36 and over	5/16	3/8	7/16	1/2	9/16	5/8

[A] Permissible variation under specified width, 1/8 in.

TABLE 6 Permissible Variations in Diameter for Sheared Circular Plates 1 in. and Under in Thickness

Specified Diameters, in.	Permissible Variations over Specified Diameter for Thicknesses Given, in.[A]		
	To 3/8, excl	3/8 to 5/8, excl	5/8 to 1, incl
To 32, excl	1/4	3/8	1/2
32 to 84, excl	5/16	7/16	9/16
84 to 108, excl	3/8	1/2	5/8
108 to 130, excl	7/16	9/16	11/16
130 and over	1/2	5/8	3/4

[A]No permissible variations under specified diameter.

TABLE 7 Permissible Variations in Diameter for Gas-Cut Circular Plates (Not Applicable to Alloy Steel)

Specified Diameter, in.	Variations over Specified Diameter for Thicknesses Given, in.[A]					
	to 1, excl	1 to 2, excl	2 to 4, excl	4 to 6, excl	6 to 8, excl	8 to 15, incl
To 32, excl	3/8	3/8	1/2	1/2	5/8	3/4
32 to 84, excl	3/8	1/2	1/2	5/8	3/4	7/8
84 to 108, excl	1/2	9/16	5/8	3/4	7/8	1
108 to 130, excl	1/2	9/16	11/16	7/8	1	1 1/8
130 and over	5/8	3/4	7/8	1	1 1/8	1 1/4

[A]No permissible variation under specified diameter.

TABLE 8 Permissible Variations in Width and Length for Rectangular Plates When Gas Cuttings is Specified or Required (Applies to Alloy Steel Specifications Only).

NOTE 1—These variations may be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Variations Over for All Specified Widths or Lengths, in.
To 2, excl	3/4
2 to 4, excl	1
4 to 6, excl	1 1/8
6 to 8, excl	1 5/16
8 to 15, incl	1 1/2

TABLE 9 Permissible Variations in Width and Length for Rectangular Plates When Gas Cutting is Specified or Required (Not Applicable to Alloy Steel)

NOTE 1—These variations may be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Variations Over for All Specified Widths or Lengths, in.
To 2, excl	1/2
2 to 4, excl	5/8
4 to 6, excl	1 3/4
6 to 8, excl	1 7/8
8 to 15, incl	1

TABLE 10 Permissible Variations in Diameter for Gas-Cut Circular Plates (Applies to Alloy Steel Specifications Only)

Specified Diameter, in.	Variations over Specified Diameter for Thicknesses Given, in.[A]					
	to 1, excl	1 to 2, excl	2 to 4, excl	4 to 6, excl	6 to 8, excl	8 to 15, incl
To 32, excl	1/2	1/2	3/4	3/4	1	1
32 to 84, excl	1/2	5/8	7/8	1	1 1/8	1 1/4
84 to 108, excl	5/8	3/4	1	1 1/8	1 1/4	1 3/8
108 to 130, incl	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2

[A]No permissible variations under specified diameter.

TABLE 11 Permissible Camber[A] for Carbon, Alloy, and High-Strength, Low-Alloy Universal Mill Plates and Alloy and High-Strength, Low-Alloy Sheared, Special-Cut or Gas-Cut Rectangular Plates

Thickness, in.	Specified Weights, lb/ft²	Widths, in.	Camber Tolerances for Thicknesses and Widths Given
To 2, incl	to 81.7, incl	all	1/8 in. × (no. of feet of length/5)
Over 2 to 15, incl	81.7 to 613.0, incl	to 30, incl	3/16 in. × (no. of feet of length/5)
Over 2 to 15, incl	81.7 to 613.0, incl	over 30	1/4 in. × (no. of feet of length/5)

[A]Camber as it relates to plates is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

TABLE 12 Permissible Camber[A] for Sheared Plates and Gas-Cut Rectangular Plates, All Thicknesses (Applies to Carbon Steel Only)

Maximum permissible camber, in. = 1/8 in. × (number of feet of length/5)

[A]Camber as it relates to plates is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

TABLE 13 Permissible Variations From Flatness for Carbon Steel Plates

NOTE 1—When the longer dimension is under 36 in., the permissible variation from a flat surface shall not exceed ¼in. When the longer dimension is from 36 to 72 in., incl, the permissible variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width, but in no case less than ¼ in.

NOTE 2—These variations apply to plates which have a specified minimum tensile strength of not more than 60 ksi or comparable chemical composition or hardness. The limits in the table are increased 50 % for plates specified to a higher minimum tensile strength or compatible chemistry or hardness.

NOTE 3—This table and these notes cover the permissible variations for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 4—Where "..." appears in this table, there is no requirement.

NOTE 5—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Specified Weight, lb/ft²	Permissible Variations from a Flat Surface for Specified Widths, in.[A,B]									
		To 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and Over
To ¼, excl	To 10.2, excl	9/16	¾	15/16	1¼	1⅜	1½	1⅝	1¾	1⅞	...	...
¼to ⅜, excl	10.2 to 15.3, excl	½	⅝	¾	15/16	1⅛	1¼	1⅜	1½	1⅝	...	...
⅜to ½, excl	15.3 to 20.4, excl	½	9/16	⅝	⅝	¾	⅞	1	1⅛	1¼	1⅞	2⅛
½to ¾, excl	20.4 to 30.6, excl	7/16	½	9/16	⅝	⅝	¾	1	1	1⅛	1½	2
¾to 1, excl	30.6 to 40.8, excl	7/16	½	9/16	⅝	⅝	⅝	¾	⅞	1	1⅜	1¾
1 to 2, excl	40.8 to 81.7, excl	⅜	½	½	9/16	9/16	⅝	⅝	⅝	11/16	1⅛	1½
2 to 4, excl	81.7 to 163.4, excl	5/16	⅜	7/16	½	½	½	½	9/16	⅝	⅞	1⅛
4 to 6, excl	163.4 to 245.1, excl	⅜	7/16	½	½	9/16	9/16	⅝	¾	⅞	⅞	1
6 to 8, excl	245.1 to 326.8, excl	7/16	½	½	⅝	11/16	¾	⅞	⅞	1	1	1
8 to 10, excl	326.8 to 409.0, excl	½	½	⅝	11/16	¾	13/16	⅞	15/16	1	1	1
10 to 12, excl	409.0 to 490.1, excl	½	⅝	¾	13/16	⅞	15/16	1	1	1	1	1
12 to 15, excl	490.1 to 613.0, incl	⅝	¾	13/16	⅞	15/16	1	1	1	1	1	...

[A] *Flatness Variations for Length*—The longer dimension specified is considered the length, and the permissible variation from a flat surface along the length shall not exceed the tabular amount for the specified width for plates up to 12 ft in length, or in any 12 ft for longer plates.

[B] *Flatness Variations for Width*—The permissible variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

TABLE 14 Permissible Variations From Flatness for High-Strength, Low-Alloy, and Alloy Steel Plates, Hot Rolled or Thermally Treated

NOTE 1—When the longer dimension is under 36 in., the permissible variation from a flat surface shall not exceed ⅜in. When the longer dimension is from 36 to 72 in. incl, the permissible variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width.

NOTE 2—This table and notes cover the tolerances for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 3—Where "..." appears in this table, there is no requirement.

NOTE 4—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Specified Weights, lb/ft²	Permissible Variations from a Flat Surface for Specified Widths, in.[A,B]										
		To 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and Over
To ¼, excl	To 10.2 excl	13/16	1⅛	1⅜	1⅞	2	2¼	2⅜	2⅝	2¾	...	...
¼ to ⅜, excl	10.2 to 15.3, excl	¾	15/16	1⅛	1⅜	1¾	1⅞	2	2¼	2⅜	...	...
⅜ to ½, excl	15.3 to 20.4, excl	¾	⅞	15/16	15/16	1⅛	15/16	1½	1⅝	1⅞	2¾	3⅛
½ to ¾, excl	20.4 to 30.6, excl	⅝	¾	13/16	⅞	1	1⅛	1¼	1⅜	1⅝	2¼	3
¾ to 1, excl	30.6 to 40.8, excl	⅝	¾	⅞	⅞	15/16	1	1⅛	1⅝	1½	2	2⅝
1 to 2, excl	40.8 to 81.7, excl	9/16	⅝	¾	13/16	⅞	15/16	1	1	1	1⅝	2¼
2 to 4, excl	81.7 to 163.4, excl	½	9/16	11/16	¾	¾	¾	¾	⅞	1	1¼	1⅝
4 to 6, excl	163.4 to 245.1, excl	9/16	11/16	¾	¾	⅞	⅞	15/16	1⅛	1¼	1¼	1½
6 to 8, excl	245.1 to 326.8, excl	⅝	¾	¾	15/16	1	1⅛	1¼	1⅝	1½	1½	1½
8 to 10, excl	326.8 to 409.0, excl	¾	13/16	15/16	1	1⅛	1¼	15/16	1⅜	1½	1½	1½
10 to 12, excl	409.0 to 490.1, excl	¾	15/16	1⅛	1¼	15/16	1⅜	1½	1½	1½	1½	1½
12 to 15, incl	490.1 to 613.0, incl	⅞	1	1⅜16	15/16	1⅜	1½	1½	1½	1½	1½	1½

[A] *Flatness Variations for Length*—The longer dimension specified is considered the length, and the permissible variation from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft for longer plates.

[B] *Flatness Variations for Width*—The permissible variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

TABLE 15 Permissible Variations in Waviness for Plates

NOTE 1—Waviness denotes the maximum deviation of the surface of the plate from a plane parallel to the surface of the point of measurement and contiguous to the surface of the plate at each of the two adjacent wave peaks, when the plate is resting on a flat horizontal surface, as measured in an increment of less than 12 ft of length.

NOTE 2—Plates must be in a horizontal position on a flat surface when waviness is measured.

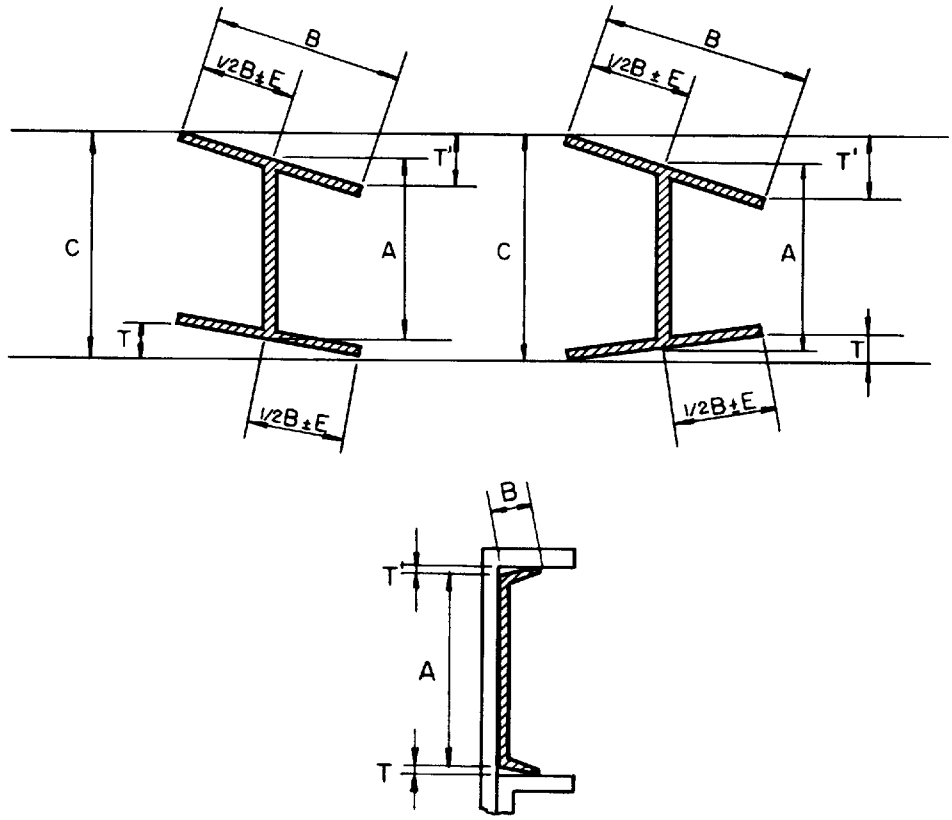
The waviness tolerance is a function of the flatness tolerance as obtained from Table 13 or 14 as appropriate.

Flatness Tolerance, in., from Tables 13 or 14	Waviness Tolerance, in., When Number of Waves in 12 ft is						
	1	2	3	4	5	6	7
5/16	5/16	1/4	3/16	1/8	1/8	1/16	1/16
3/8	3/8	5/16	3/16	3/16	1/8	1/16	1/16
7/16	7/16	5/16	1/4	3/16	1/8	1/8	1/16
1/2	1/2	3/8	5/16	3/16	3/16	1/8	1/16
9/16	9/16	7/16	5/16	1/4	3/16	1/8	1/8
5/8	5/8	1/2	3/8	1/4	3/16	1/8	1/8
11/16	11/16	1/2	3/8	5/16	3/16	3/16	1/8
3/4	3/4	9/16	7/16	5/16	1/4	3/16	1/8
13/16	13/16	5/8	7/16	5/16	1/4	3/16	1/8
7/8	7/8	11/16	1/2	3/8	1/4	3/16	1/8
15/16	15/16	11/16	1/2	3/8	5/16	1/4	3/16
1	1	3/4	9/16	7/16	5/16	1/4	3/16
1 1/8	1 1/8	7/8	5/8	1/2	3/8	1/4	3/16
1 1/4	1 1/4	15/16	11/16	1/2	3/8	5/16	1/4
1 3/8	1 3/8	1 1/16	3/4	9/16	7/16	5/16	1/4
1 1/2	1 1/2	1 1/8	7/8	5/8	1/2	3/8	1/4
1 5/8	1 5/8	1 1/4	15/16	11/16	1/2	3/8	5/16
1 3/4	1 3/4	1 5/16	1	3/4	9/16	7/16	5/16
1 7/8	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16	5/16
2	2	1 1/2	1 1/8	7/8	5/8	1/2	3/8
2 1/8	2 1/8	1 5/8	1 3/16	7/8	11/16	1/2	3/8
2 1/4	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16	3/8
2 3/8	2 3/8	1 13/16	1 5/16	1	3/4	9/16	7/16
2 1/2	2 1/2	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16
2 5/8	2 5/8	2	1 1/2	1 1/8	13/16	5/8	7/16
2 3/4	2 3/4	2 1/16	1 9/16	1 1/8	7/8	5/8	1/2
2 7/8	2 7/8	2 3/16	1 5/8	1 3/16	15/16	11/16	1/2
3	3	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16
3 1/8	3 1/8	2 3/8	1 3/4	1 5/16	1	3/4	9/16

TABLE 16 Permissible Variations in Cross Section for W, HP, S, M, C, and MC Shapes

NOTE 1—*A* is measured at center line of web for S, M, and W and HP shapes; at back of web for C and MC shapes. Measurement is overall for C shapes under 3 in. *B* is measured parallel to flange. *C* is measured parallel to web.

NOTE 2—Where "..." appears in this table, there is no requirement.

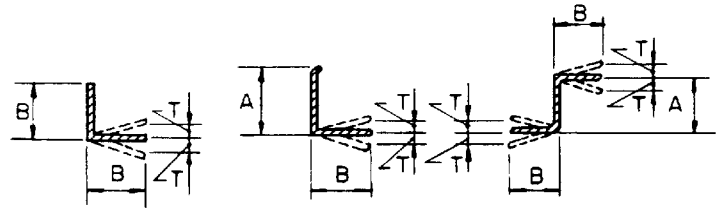


Shape	Section Nominal Sizes in.	*A*, Depth, in.		*B*, Flange Width, in.		*T* + *T'* [A] Flanges Out-of-Square, max, in.[B]	*E*, Web off Center, max, in.[C]	*C*, Maximum Depth at any Cross Section over Theoretical Depth, in.	Thickness of Web Over and Under for Thickness Given, in.	
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical				3/16 and under	Over 3/16
W and HP	Up to 12, incl	1/8	1/8	1/4	3/16	1/4	3/16	1/4	...	...
	Over 12	1/8	1/8	1/4	3/16	5/16	3/16	1/4	...	...
S and M	3 to 7, incl	3/32	1/16	1/8	1/8	1/32	3/16	...	...	...
	Over 7 to 14, incl	1/8	3/32	5/32	5/32	1/32	3/16	...	...	...
	Over 14 to 24, incl	3/16	1/8	3/16	3/16	1/32	3/16	...	...	...
C and MC	1½ and under	1/32	1/32	1/32	1/32	1/32	...	...	0.010	0.015
	Over 1½ to 3, excl	1/16	1/16	1/16	1/16	1/32	...	...	0.015	0.020
	3 to 7, incl	3/32	1/16	1/8	1/8	1/32	...	...	...	...
	Over 7 to 14, incl	1/8	3/32	1/8	5/32	1/32	...	...	...	...
	Over 14	3/16	1/8	1/8	3/16	1/32	...	...	...	...

[A] *T* + *T'* applies when flanges of channels are toed in or out. For channels 5/8 in. and under in depth, the permissible out-of-square is 3/64 in./in. of depth.
[B] Tolerance is per inch of flange width for S, M, C, and MC shapes.
[C] Variation of 5/16 in. max for sections over 426 lb/ft.

TABLE 17 Permissible Variations in Cross Section for Angles (L Shapes), Bulb Angles, and Zees

NOTE 1—Where "..." appears in this table, there is no requirement.



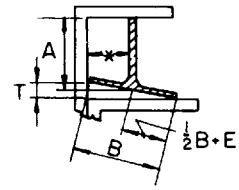
Angles Bulb angles Zees

Section	Nominal Size, in.	A, Depth, in.		B, Flange Width or Length of Leg, in.		T, Out of Square per Inch of B, in.	Variations from Thickness for Thicknesses Given, Over and Under, in.		
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical		3/16 and under	Over 3/16 to 3/8, incl	Over 3/8
Angles[A] (L Shapes)	1 and under	...	...	1/32	1/32	3/128[B]	0.008	0.010	...
	Over 1 to 2, incl	...	...	3/64	3/64	3/128[B]	0.010	0.010	0.012
	Over 2 to 3, excl	...	...	1/16	1/16	3/128[B]	0.012	0.015	0.015
	3 to 4, incl	...	...	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	...	...	1/8	1/8	3/128[B]	...	...	...
	Over 6	...	...	3/16	1/8	3/128[B]	...	...	...
Bulb angles	(Depth) 3 to 4, incl	1/8	1/16	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	1/8	1/16	1/8	1/8	3/128[B]	...	...	...
	Over 6	1/8	1/16	3/16	1/8	3/128[B]	...	...	...
Zees	3 to 4, incl	1/8	1/16	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	1/8	1/16	1/8	1/8	3/128[B]	...	...	...

[A]For unequal leg angles, longer leg determines classification.
[B]3/128 in./in. = 1½°.

TABLE 18 Permissible Variations in Sectional Dimensions for Rolled Tees

NOTE 1—* = Back of square and center line of stem are to be parallel when measuring "out-of-square."
NOTE 2—Where "..." appears in this table, there is no requirement.



Tees

Nominal Size,[A] in.	A, Depth,[B] in.		B, Width,[B] in.		T, Out-of-Square per Inch of B, in.	E, Web-off-Center, max, in.	Stem Out-of-Square,[C] in.	Thickness of Flange, in.		Thickness of Stem, in.	
	Over	Under	Over	Under				Over	Under	Over	Under
1¼ and under	3/64	3/64	3/64	3/64	...	...	1/32	0.010	0.010	0.005	0.020
Over 1¼ to 2, incl	1/16	1/16	1/16	1/16	...	...	1/16	0.012	0.012	0.010	0.020
Over 2 to 3, excl	3/32	3/32	3/32	3/32	...	...	3/32	0.015	0.015	0.015	0.020
3 to 5, incl	3/32	1/16	1/8	1/8	1/32	3/32	...	...	...	...	...
Over 5 to 7, incl	3/32	1/16	1/8	1/8	1/32	1/8	...	...	...	...	...

[A]The longer member of an unequal tee determines the size for permissible variations.
[B]Measurements for both depth and width are overall.
[C]Stem-out-of-square is the variation from its true position of the center line of stem, measured at the point.

TABLE 19 Permissible Variations in Length for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

NOTE 1—Where "..." appears in this table, there is no requirement.

Nominal Size,[A] in.	Variations from Specified Length for Lengths Given, in.													
	5 to 10 ft, excl		10 to 20 ft, excl		20 to 30 ft, incl		Over 30 to 40 ft, incl		Over 40 to 50 ft, incl		Over 50 to 65 ft, incl		Over 65 ft	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
Under 3	5/8	0	1	0	1½	0	2	0	2½	0	2½	0	...	...
3 and over	1	0	1½	0	1¾	0	2¼	0	2¾	0	2¾	0	...	...

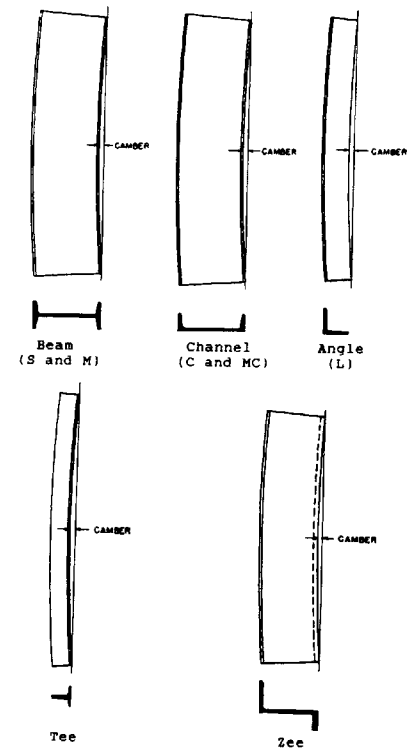
[A] Greatest cross-sectional dimension.

TABLE 20 Permissible Variations in Ends Out-Of-Square for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

Shapes	Permissible Variations
S, M, C, and MC	1/64 in./in. of depth
L[A]	3/128in./in. of leg length or 1½°
Bulb angles	3/128 in./in. of depth or 1½°
Rolled Tees[A]	1/64in./in. of flange or stem
Zees	3/128 in./in. of sum of both flange lengths

[A] Permissible variations for ends out-of-square are determined on the longer members of the shape.

TABLE 21 Permissible Variations in Straightness for S, M, C, MC, L, T, Z, and Bulb Angle Shapes



Positions for Measuring Camber of Shapes

Variable	Nominal Size,[A] in.	Permissible Variation, in.
Camber	under 3	¼ in. in any 5 ft, or ¼ × (number of feet of total length/5)
	3 and over	⅛ × (number of feet of total length/5)
Sweep	all	Due to the extreme variations in flexibility of these shapes, straightness tolerances for sweep are subject to negotiations between the manufacturer and the purchaser for the individual sections involved.

[A]Greatest cross-sectional dimension.

TABLE 22 Permissible Variations in Length for W and HP Shapes[A,B]

W and HP Shapes	Variations from Specified Length for Lengths Given, in.			
	30 ft and under		Over 30 ft	
	Over	Under	Over	Under
Beams 24 in. and under in nominal depth	⅜	⅜	⅜ plus 1/16 for each additional 5 ft or fraction thereof	⅜
Beams over 24 in. in nominal depth and all columns	½	½	½ plus 1/16 for each additional 5 ft or fraction thereof	½

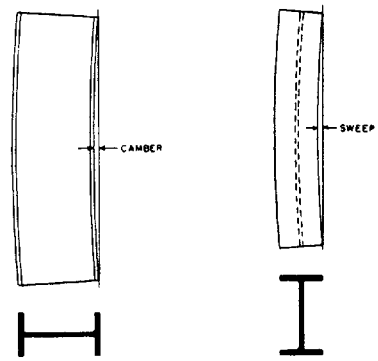
[A]For HP shapes or W shapes when used as bearing piles, the length tolerance is plus 5 in. and minus 0 in. This length tolerance also applies to steel sheet piles.
[B]The ends out-of-square tolerance for W and HP shapes shall be 1/64 in./in. of depth, or of flange width if it is greater than the depth.

TABLE 23 Permissible Variations for Length and Ends Out-of-Square, Milled Shapes

Nominal, Depth, in.	Length, ft[A,B]	Milled Both Ends[C]			Milled One-End[C]		
		Length, in.		Maximum End Out-of-Square, in.	Length, in.		Maximum End Out-of-Square, for Milled End, in.
		Over	Under		Over	Under	
6 to 36	6 to 70	1/32	1/32	1/32	1/4	1/4	1/32

[A]Length is measured along center line of web. Measurements are made with the steel and tape at the same temperature.
[B]Length variation and out-of-square variation are additive.
[C]Ends out-of-square are measured by (*a*) squaring from the center line of the web and (*b*) squaring from the center line of the flange. The measured variation from true squareness in either plane shall not exceed the total tabular amount.

TABLE 24 Permissible Variations in Straightness for W and HP Shapes



Positions for Measuring Camber and Sweep of W and HP Shapes

	Permissible Variation
Camber and sweep	1/8 in. × (number of feet of total length[A]/10)
When certain sections[B] with a flange width approximately equal to depth are specified, order as columns:	
Lengths of 45 ft and under	1/8 in. × (number of feet of total length/10) but not over 3/8 in.
Lengths over 45 ft	3/8 in. + [1/8 in. × ([number of feet of total length – 45]/10)]

[A]Sections with a flange width less than 6 in., tolerance for sweep = 1/8in. × (number of feet of total length/5).
[B]Applies only to:
8-in. deep sections 31 lb/ft and heavier,
10-in. deep sections 49 lb/ft and heavier,
12-in. deep sections 65 lb/ft and heavier, and
14-in. deep sections 90 lb/ft and heavier.
If other sections are specified on the order as columns, the tolerance will be subject to negotiation with the manufacturer.

TABLE 25 Permissible Variations in Dimensions for Split Tees and Split Angles (L Shapes)[A]

Specified Depth, in.	Variations from Depth,[B] Over and Under, in.
To 6, excl (beams and channels)	1/8
6 to 16, excl (beams and channels)	3/16
16 to 20, excl (beams and channels)	1/4
20 to 24, excl (beams)	5/16
24 and over (beams)	3/8

[A]The length tolerance for split tees or angles are the same as those applicable to the section from which the tees or angles are split.
[B]The above tolerances for depth of tees or angles include the allowable tolerances in depth for the beams or channels before splitting. Tolerances both for dimensions and straightness, as set up for the beams or channels from which these tees or angles are cut will apply, except:
straightness = 1/8 in. × (length in feet/5)

TABLE 26 Permissible Variations in Sectional Dimensions for Square Edge and Round Edge Flat Bars

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Widths, in.	Variations from Thickness, for Thicknesses Given Over and Under, in.							Variations from Width, in.	
	0.203 to 0.230, excl	0.230 to ¼, excl	¼ to ½, incl	Over ½ to 1, incl	Over 1 to 2, incl	Over 2 to 3, incl	Over 3	Over	Under
To 1, incl	0.007	0.007	0.008	0.010	...	...	...	1/64	1/64
Over 1 to 2, incl	0.007	0.007	0.012	0.015	1/32	...	...	1/32	1/32
Over 2 to 4, incl	0.008	0.008	0.015	0.020	1/32	3/64	3/64	1/16	1/32
Over 4 to 6, incl	0.009	0.009	0.015	0.020	1/32	3/64	3/64	3/32	1/16
Over 6 to 8, incl	[A]	0.015	0.016	0.025	1/32	3/64	1/16	1/8[B]	3/32[B]

[A] Flats over 6 to 8 in., incl, in width are not available as hot-rolled carbon steel bars in thickness under 0.230 in.
[B] For flats over 6 to 8 in., in width, and to 3 in. incl in thickness.

TABLE 27 Permissible Variations in Sectional Dimensions for Round and Square Bars and Round-Cornered Squares

Specified Size, in.	Variations from Size, in.		Out-of-Round or Out-of-Square, in.[A]
	Over	Under	
To 5/16	0.005	0.005	0.008
Over 5/16 to 7/16, incl	0.006	0.006	0.009
Over 7/16 to 5/8, incl	0.007	0.007	0.010
Over 5/8 to 7/8, incl	0.008	0.008	0.012
Over 7/8 to 1, incl	0.009	0.009	0.013
Over 1 to 1 1/8, incl	0.010	0.010	0.015
Over 1 1/8 to 1 1/4, incl	0.011	0.011	0.016
Over 1 1/4 to 1 3/8, incl	0.012	0.012	0.018
Over 1 3/8 to 1 1/2, incl	0.014	0.014	0.021
Over 1 1/2 to 2, incl	1/64	1/64	0.023
Over 2 to 2 1/2, incl	1/32	0	0.023
Over 2 1/2 to 3 1/2, incl	3/64	0	0.035
Over 3 1/2 to 4 1/2, incl	1/16	0	0.046
Over 4 1/2 to 5 1/2, incl	5/64	0	0.058
Over 5 1/2 to 6 1/2, incl	1/8	0	0.070
Over 6 1/2 to 8 1/4, incl	5/32	0	0.085
Over 8 1/4 to 9 1/2, incl	3/16	0	0.100
Over 9 1/2 to 10, incl	1/4	0	0.120

[A] Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same transverse cross section. Out-of-square section is the difference in perpendicular distance between opposite faces, measured at the same transverse cross section.

TABLE 28 Permissible Variations in Sectional Dimensions for Hexagons

Specified Sizes Between Opposite Sides, in.	Variations from Size, in.		Maximum Difference, Three Measurements, in.[A]
	Over	Under	
½ and under	0.007	0.007	0.011
Over ½ to 1, incl	0.010	0.010	0.015
Over 1 to 1 1/2, incl	0.021	0.013	0.025
Over 1 1/2 to 2, incl	1/32	1/64	1/32
Over 2 to 2 1/2, incl	3/64	1/64	3/64
Over 2 1/2 to 3 1/2, incl	1/16	1/64	1/16

[A] Out-of-hexagon section is the greatest difference in distance between any two opposite faces measured at the same transverse cross section.

TABLE 29 Permissible Variations in Straightness for Bars

Maximum Permissible Variations in Straightness, in.[A]
¼ in any 5 ft, or ¼ × (number of feet of total length/5)

[A]Permissible variations in straightness do not apply to hot-rolled bars if any subsequent heating operation has been performed.

TABLE 30 Permissible Variations in Length for Hot-Cut Steel Bars[A]

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Sizes of Rounds, Squares, and Hexagons, in.	Specified Sizes of Flats, in.		Permissible Variations Over Specified Length Given in Feet, in. (No Variation Under)				
	Thickness	Width	5 to 10 ft. excl	10 to 20 ft. excl	20 to 30 ft. excl	30 to 40 ft. excl	40 to 60 ft. incl
To 1, incl	To 1, incl	To 3, incl	½	¾	1¼	1¾	2¼
Over 1 to 2, incl	Over 1	To 3, incl	⅝	1	1½	2	2½
Over 1 to 2, incl	To 1, incl	Over 3 to 6, incl	⅝	1	1½	2	2½
Over 2 to 5, incl	Over 1	Over 3 to 6, incl	1	1½	1¾	2¼	2¾
Over 5 to 10, incl	...	...	2	2½	2¾	3	3¼
	0.230 to 1, incl	Over 6 to 8, incl	¾	1¼	1¾	3½	4
	Over 1 to 3, incl	Over 6 to 8, incl	1¼	1¾	2	3½	4
		Hot Sawing					
2 to 5, incl[B]	1 and over	3 and over	[B]	1½	1¾	2¼	2¾
Over 5 to 10, incl	...	...	[B]	2½	2¾	3	3¼

[A]For flats over 6 to 8 in., incl, in width and over 3 in. in thickness, consult the producer for length tolerances.
[B]Smaller sizes and shorter lengths are not commonly hot sawed.

TABLE 31 Permissible Variations in Length for Bars Recut Both Ends After Straightening[AB]

Sizes of Rounds, Squares, Hexagons, Width of Flats and Maximum Dimension of Other Sections, in.	Permissible Variations for Specified Length, in.			
	To 12 ft, incl		Over 12 ft	
	Over	Under	Over	Under
To 3, incl	3/16	1/16	¼	1/16
Over 3 to 6, incl	¼	1/16	⅜	1/16
Over 6 to 8, incl	⅜	1/16	½	1/16
Rounds over 8 to 10, incl	½	1/16	⅝	1/16

[A]For flats over 6 to 8 in., incl, in width, and over 3 in. in thickness, consult the producer for length tolerances.
[B]Variations are sometimes required all over or all under the specified length, in which case the sum of the two tolerances applies.

SUPPLEMENTARY REQUIREMENTS

The following standardized supplementary requirements are for use when desired by the purchaser. Those that are considered suitable for use with each material specification are listed in the specification. Other tests may be performed by agreement between the supplier and the purchaser. These additional requirements shall apply only when specified in the order, in which event the specified tests shall be made by the manufacturer or processor before shipment of the material.

S1. Vacuum Treatment

S1.1 The steel shall be made by a process that includes vacuum degassing while molten. Unless otherwise agreed upon with the purchaser, it is the responsibility of the manufacturer to select suitable process procedures.

S2. Product Analysis

S2.1 Product analyses shall be made for those elements listed in the material specification. Test frequency shall be as specified on the order. Specimens for analysis shall be taken adjacent to or from the tension test specimen, or from a sample taken from the same relative location as that from which the tension test specimen was taken.

S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons

S3.1 Prior to testing, the test specimens representing the structural product for acceptance purposes for mechanical properties shall be thermally treated to simulate a post-weld heat treatment below the critical temperature (Ac_3), using the heat treatment parameters (such as temperature range, time, and cooling rates) specified in the order. The test results for such heat-treated test specimens shall meet the applicable product specification requirements.

S4. Additional Tension Test

S4.1 *Plate*—One tension test shall be made from each unit plate rolled from a slab or directly from an ingot, except that

for quenched and tempered plates, a test shall be taken from each unit plate heat treated. The results obtained shall be reported on the mill test reports when such tests are required by the order.

S5. Charpy V-Notch Impact Test

S5.1 Charpy V-notch impact tests shall be conducted in accordance with Specification A 673/A 673M.

S5.2 The frequency of testing, the test temperature to be used, and the absorbed energy requirements shall be as specified on the order.

S6. Drop-Weight Test (for Material 0.625 in. [16 mm] and over in Thickness)

S6.1 Drop-weight tests shall be made in accordance with Method E 208. The specimens shall represent the material in the final condition of heat treatment. Agreement shall be reached between the purchaser and the manufacturer or processor as to the number of pieces to be tested and whether a maximum nil-ductility transition (NDT) temperature is mandatory or if the test results are for information only.

S8. Ultrasonic Examination

S8.1 The material shall be ultrasonically examined in accordance with the requirements specified on the order.

S15. Reduction of Area Measurement

S15.1 The reduction of area, as determined on the 0.500-in. [12.5-mm] diameter round tension test specimen in accordance with Methods and Definitions A 370, shall not be less than 40 %.

S18. Maximum Tensile Strength

S18.1 Steel having a specified minimum tensile strength of less than 70 ksi [485 MPa] shall not exceed the minimum specified tensile strength by more than 30 ksi [205 MPa].

S18.2 Steel having a minimum specified tensile strength of 70 ksi [485 MPa] or higher shall not exceed the minimum specified tensile strength by more than 25 ksi [170 MPa].

S23. Copper-Bearing Steel (for improved atmospheric corrosion resistance)

S23.1 The copper content shall be a minimum of 0.20 % on heat analysis, 0.18 on product analysis.

S26. Subdivided Material—Marking of Individual Pieces

S26.1 Subdivided pieces shall be individually identified by marking, stenciling, or die stamping the specification number (year-date not required), grade, heat number, and the heat treatment identification, if applicable, along with the trademark, brand, or name of the organization subdividing the material. As an alternative, individual subdivided pieces shall be identified by a code traceable to the original required identification, provided that the trademark, name, or brand of the organization subdividing the material is also placed on the material and the original required identification, cross referenced on the code, is furnished with the material.

S27. Restrictive Plate Flatness

S27.1 Carbon steel plates, as-rolled or normalized shall conform to the permissible restrictive variations from flatness as detailed in Table S27.1 or Table S27.2.

S27.2 High-strength low-alloy steel plates, as-rolled or normalized shall conform to the permissible restrictive variations from flatness as detailed in Table S27.3 or Table S27.4.

S74. Maximum Carbon Equivalent for Weldability

S74.1 Plates and shapes shall be supplied with a specific maximum carbon equivalent value as specified by the purchaser. This value shall be based on heat analysis. The required chemical analysis as well as the carbon equivalent shall be reported.

S74.2 The carbon equivalent shall be calculated using the following formula:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

S74.3 For additional information on the weldability of steel, see Appendix X3.

TABLE S27.1 Permissible Variations from Flatness for Carbon Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length and variation in flatness along the length should not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width should not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation in flatness along the length and across the width should not exceed ¼ in. in each direction. When the longer dimension is from 36 to 72 in., incl., the permissible flatness variation should not exceed 75 % of the tabular amount for the specified width, but in no case less than ¼ in.

NOTE 4—The variations given in this table apply to plates that have a minimum specified tensile strength not over 60 ksi or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or compatible chemistry or hardness, the permissible variations are 1½ times the amounts shown in the table below.

NOTE 5—This table and notes cover the flatness variations of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 6—Waviness tolerances do not apply.

NOTE 7—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Specified Weights, lb/ft²	Permissible Variations from a Flat Surface for Specified Widths, in.					
		48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, incl.
To ¼, excl.	To 10.2 excl.	3/4	15/16	A	A	A	A
¼ to ⅜, excl.	10.2 to 15.3, excl.	9/16	3/4	7/8	15/16	1-1/16	1-1/8
⅜ to ½, excl.	15.3 to 20.4, excl.	5/16	5/16	3/8	7/16	1/2	9/16
½ to ¾, excl.	20.4 to 30.6, excl.	5/16	5/16	5/16	3/8	1/2	1/2
¾ to 1, excl.	30.6 to 40.8, excl.	5/16	5/16	5/16	5/16	3/8	7/16
1 to 2, incl.	40.8 to 51.7, incl.	1/4	5/16	5/16	5/16	5/16	3/8

[A] There is no published restricted value for this size.

TABLE S27.2 Permissible Variations from Flatness for Carbon Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length and variation in flatness along the length should not exceed the tabular amount for the specified width in plates up to 3700 mm in length, or in any 3700 mm of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width should not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation in flatness along the length and across the width should not exceed 6 mm in each direction. When the longer dimension is from 900 to 1800 mm, incl., the permissible flatness variation should not exceed 75 % of the tabular amount for the specified width, but in no case less than 6 mm.

NOTE 4—The variations given in this table apply to plates that have a minimum specified tensile strength not over 415 MPa or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or compatible chemistry or hardness, the permissible variations are 1½ times the amounts shown in the table below.

NOTE 5—This table and notes cover the flatness variations of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 6—Waviness tolerances do not apply.

NOTE 7—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Specified Weights, kg/m²	Permissible Variations from a Flat Surface for Specified Widths, mm					
		1200 to 1500, excl.	1500 to 1800, excl.	1800 to 2100, excl.	2100 to 2400, excl.	2400 to 2700, excl.	2700 to 3000, incl.
To 6, excl.	To 47.1 excl.	18	24	[A]	[A]	[A]	[A]
6 to 10, excl.	47.1 to 78.5, excl.	15	18	22	24	27	29
10 to 12, excl.	78.5 to 94.2, excl.	8	8	10	11	13	15
12 to 20, excl.	94.2 to 157.0, excl.	7	8	8	10	13	13
20 to 25, excl.	157.0 to 196.2, excl.	7	8	8	8	10	11
25 to 50, incl.	196.2 to 392.5, incl.	7	7	7	8	8	8

[A]There is no published restricted value for this size.

TABLE S27.3 Permissible Variations from Flatness for High-Strength Low-Alloy Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length and variation in flatness along the length should not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width should not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation in flatness along the length and across the width should not exceed ⅜ in. in each direction. When the larger dimension is from 36 to 72 in., incl., the permissible flatness variation should not exceed 75 % of the tabular amount for the specified width, but in no case less than ⅜ in.

NOTE 4—This table and notes cover the variations for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 5—Waviness tolerances do not apply.

NOTE 6—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Specified Weights, lb/ft²	Permissible Variations from a Flat Surface for Specified Widths, in.					
		48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, incl.
To ¼, excl.	To 10.2 excl.	1-1/16	1-7/16	[A]	[A]	[A]	[A]
¼ to ⅜, excl.	10.2 to 15.3, excl.	⅞	1-1/16	1-5/16	1-7/16	1-½	1-11/16
⅜ to ½, excl.	15.3 to 20.4, excl.	½	½	9/16	11/16	¾	13/16
½ to ¾, excl.	20.4 to 30.6, excl.	7/16	7/16	½	9/16	⅝	11/16
¾ to 1, excl.	30.6 to 40.8, excl.	7/16	7/16	½	½	9/16	11/16
1 to 2, incl.	40.8 to 51.7, incl.	⅜	7/16	7/16	½	½	½

[A]There is no published restricted value for this size.

TABLE S27.4 Permissible Variations from Flatness for High-Strength Low-Alloy Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1— *Flatness Variations for Length*—The longer dimension specified is considered the length and variation in flatness along the length should not exceed the tabular amount for the specified width in plates up to 3700 mm in length, or in any 3700 mm of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width should not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation in flatness along the length and across the width should not exceed 10 mm in each direction. When the larger dimension is from 900 to 1800 mm, incl., the permissible flatness variation should not exceed 75 % of the tabular amount for the specified width but in no case less than 10 mm.

NOTE 4—This table and notes cover the variations for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 5—Waviness tolerances do not apply.

NOTE 6—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Specified Weights, kg/m²	Permissible Variations from a Flat Surface for Specified Widths, mm					
		1200 to 1500, excl.	1500 to 1800, excl.	1800 to 2100, excl.	2100 to 2400, excl.	2400 to 2700, excl.	2700 to 3000, incl.
To 6, excl.	To 47.1 excl.	27	36	[A]	[A]	[A]	[A]
6 to 10, excl.	47.1 to 78.5, excl.	22	27	33	36	39	43
10 to 12, excl.	78.5 to 94.2, excl.	12	12	15	17	19	21
12 to 20, excl.	94.2 to 157.0, excl.	11	11	13	15	16	18
20 to 25, excl.	157.0 to 196.2, excl.	11	11	12	13	15	17
25 to 50, incl.	196.2 to 392.5, incl.	10	11	11	12	13	13

[A]There is no published restricted value for this size.

ANNEXES

(Mandatory Information)

A1. PERMISSIBLE VARIATIONS IN DIMENSIONS AND MASS IN SI UNITS

A1.1 Listed in Table A1.1 to Table A1.2 are permissible variations in dimensions and mass expressed in the SI Units.

TABLE A1.1 Permissible Variations in Thickness for Rectangular Carbon, High-Strength Low Alloy, and Alloy Steel Plates, 300 mm and Under in Thickness When Ordered to Thickness

NOTE 1—Permissible variation under specified thickness, 0.3 mm.

NOTE 2—Thickness to be measured at 10 to 20 mm from the longitudinal edge.

NOTE 3—For specified thicknesses other than those shown, the next higher thickness will apply.

NOTE 4—For thickness measured at any location other than that specified in Note 5, the permissible maximum over tolerance shall be increased by 75 %, rounded to the nearest 0.1 mm.

NOTE 5— Where "..." appears in this table, there is no requirement.

Specified Thickness, mm	Tolerance Over Specified Thickness for Widths Given in Millimetres, mm										
	1200 and Under	Over 1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, excl	3000 to 3300, excl	3300 to 3600, excl	3600 to 4200, excl	4200 and Over
5.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	...	...
5.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	...	...
6.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.1	...	...
7.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.4	...
8.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.4	...
9.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	...
10.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	1.7
11.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	1.7
12.0	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.3	1.5	1.8
14.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.8
16.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.8
18.0	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	2.0
20.0	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.2	1.4	1.6	2.0
22.0	0.8	0.9	0.9	0.9	1.0	1.1	1.3	1.3	1.5	1.8	2.0
25.0	0.9	0.9	1.0	1.0	1.0	1.2	1.3	1.5	1.5	1.8	2.2
28.0	1.0	1.0	1.1	1.1	1.1	1.3	1.4	1.8	1.8	2.0	2.2
30.0	1.1	1.1	1.2	1.2	1.2	1.4	1.5	1.8	1.8	2.1	2.4
32.0	1.2	1.2	1.3	1.3	1.3	1.5	1.6	2.0	2.0	2.3	2.6
35.0	1.3	1.3	1.4	1.4	1.4	1.6	1.7	2.3	2.3	2.5	2.8
38.0	1.4	1.4	1.5	1.5	1.5	1.7	1.8	2.3	2.3	2.7	3.0
40.0	1.5	1.5	1.6	1.6	1.6	1.8	2.0	2.5	2.5	2.8	3.3
45.0	1.6	1.6	1.7	1.8	1.8	2.0	2.3	2.8	2.8	3.0	3.5
50.0	1.8	1.8	1.8	2.0	2.0	2.3	2.5	3.0	3.0	3.3	3.8
55.0	2.0	2.0	2.0	2.2	2.2	2.5	2.8	3.3	3.3	3.5	3.8
60.0	2.3	2.3	2.3	2.4	2.4	2.8	3.0	3.4	3.4	3.8	4.0
70.0	2.5	2.5	2.5	2.6	2.6	3.0	3.3	3.5	3.6	4.0	4.0
80.0	2.8	2.8	2.8	2.8	2.8	3.3	3.5	3.5	3.6	4.0	4.0
90.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.6	4.0	4.4
100.0	3.3	3.3	3.3	3.3	3.5	3.8	3.8	3.8	3.8	4.4	4.4
110.0	3.5	3.5	3.5	3.5	3.5	3.8	3.8	3.8	3.8	4.4	4.4
120.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	4.8	4.8
130.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	5.2	5.2
140.0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	5.6	5.6
150.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	5.6	5.6
160.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	5.6	5.6
180.0	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	6.3	6.3
200.0	5.8	5.8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	7.0	7.0
250.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	8.8
300.0	7.5	7.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

TABLE A1.2 Permissible Variations in Length for Bars Recut Both Ends After Straightening[A,B]

Sizes of Rounds, Squares, Hexagons, Widths of Flats and Maximum Dimensions of Other Sections, mm	Permissible Variations for Specified Length, mm (No Variation Under)	
	to 3700, incl	over 3700
To 75, incl	6	8
Over 75 to 150, incl	8	11
Over 150 to 200, incl	11	14
Rounds over 200 to 250, incl	14	18

[A] For flats over 150 to 200 mm, incl, in width, and over 75 mm in thickness, consult the producer for length tolerances.

[B] Variations are sometimes required all over or all under the specified length, in which case the sum of the two tolerances applies.

TABLE A1.3 Permissible Variations in Mass for Rectangular Sheared Plates and Universal Mill Plates 2983 kg/m² and Under When Ordered to Mass

NOTE 1—Permissible variations in excess mass for lots of circular and sketch plates shall be 1¼ times the amounts in this table.
NOTE 2—Permissible variations in excess mass for single plates shall be 1⅓ times the amounts in this table.
NOTE 3—Permissible variations in excess mass for single circular and sketch plates shall be 1⅔ times the amounts in this table.
NOTE 4—The adopted standard density for rolled steel is 7850 kg/m³.
NOTE 5—Where " ..." appears in this table, there is no requirement.

Specified Mass, kg/m²	Permissible Variation in Average Mass of Lots[A] for Widths Given in Millimetres, Expressed in Percentage of the Specified Masses per Square Metre																					
	1200 and Under		Over 1200 to 1500, excl		1500 to 1800, excl		1800 to 2100, excl		2100 to 2400, excl		2400 to 2700, excl		2700 to 3000, excl		3000 to 3300, excl		3300 to 3600, excl		3600 to 4200, excl		4200 and Over	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
To 51.02, excl	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	7.5	3.0	9.0	3.0	...	...	...	...	...	...	...	...
51.02 to 62.80, excl	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	6.5	3.0	7.0	3.0	8.0	3.0	9.0	3.0	...	...	...	...
62.80 to 74.58, excl	4.0	3.0	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	5.5	3.0	6.0	3.0	7.5	3.0	8.0	3.0	11	3.0	...	...
74.58 to 86.35, excl	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0	5.0	3.0	5.0	3.0	5.5	3.0	6.0	3.0	7.0	3.0	9.0	3.0	10	3.0
86.35 to 102.0, excl	3.5	2.5	3.5	2.5	3.5	3.0	4.0	3.0	4.5	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0	8.0	3.0	9.0	3.0
102.0 to 125.6, excl	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0	4.0	3.0	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	7.0	3.0	8.0	3.0
125.6 to 149.2, excl	3.0	2.5	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0	5.0	3.0	6.5	3.0	7.0	3.0
149.2 to 196.2, excl	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.5	3.5	2.5	4.0	3.0	4.5	3.0	6.0	3.0	6.5	3.0
196.2 to 392.5, excl	2.5	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.0	3.5	2.5	3.5	3.0	4.0	3.0	5.5	3.0	6.0	3.0
392.5 to 588.8, excl	2.5	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0	3.5	2.0	3.5	2.5	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0
588.8 to 785.0, excl	2.5	1.5	2.5	1.5	2.5	1.5	2.5	1.5	2.5	2.0	2.5	2.0	2.5	2.0	2.5	2.0	2.5	2.0	3.0	2.0	3.5	2.0
785.0 to 1178, excl	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	3.0	1.0	3.5	1.0
1178 to 1962, excl	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	3.0	1.0
1962 to 2355, excl	2.0	1.0	2.0	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0
2355 to 2983, incl	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0	2.5	1.0

[A]The term "lot" means all the plates of each tabular width and mass group represented in each shipment.

TABLE A1.4 Permissible Variations in Width and Length for Sheared Plates 40 mm and Under in Thickness; Length Only of Universal Mill Plates 65 mm and Under in Thickness

Specified Dimensions, mm		Variations Over Specified Width and Length[A] for Thickness, mm, and Equivalent Masses, kg/m^2, Given							
		To 10.5, excl		10.5 to 16, excl		16 to 25, excl		25 to 50, incl[B]	
Length	Width	To 78.50, excl		78.50 to 125.6, excl		125.6 to 196.2, excl		196.2 to 392.5, excl	
		Width	Length	Width	Length	Width	Length	Width	Length
To 3000, excl	To 1500, excl	10	13	11	16	13	19	16	25
	1500 to 2100, excl	11	16	13	18	16	22	19	25
	2100 to 2700, excl	13	19	16	22	19	25	25	29
	2700 and over	16	22	19	25	22	29	29	32
3000 to 6000, excl	To 1500, excl	10	19	13	22	16	25	19	29
	1500 to 2100, excl	13	19	16	22	19	25	22	32
	2100 to 2700, excl	14	22	18	24	21	29	25	35
	2700 and over	16	25	19	29	22	32	29	35
6000 to 9000, excl	To 1500, excl	10	25	13	29	16	32	19	38
	1500 to 2100, excl	13	25	16	29	19	32	22	38
	2100 to 2700, excl	14	25	18	32	22	35	25	38
	2700 and over	18	29	22	32	25	35	32	44
9000 to 12 000, excl	To 1500, excl	11	29	13	32	16	35	19	41
	1500 to 2100, excl	13	32	16	35	19	38	22	41
	2100 to 2700, excl	14	32	19	35	22	38	25	48
	2700 and over	19	35	22	38	25	41	32	48
12 000 to 15 000, excl	To 1500, excl	11	32	13	38	16	41	19	48
	1500 to 2100, excl	13	35	16	38	19	41	22	48
	2100 to 2700, excl	16	35	19	38	22	41	25	48
	2700 and over	19	38	22	41	25	44	32	48
15 000 to 18 000, excl	To 1500, excl	13	44	16	48	19	48	22	57
	1500 to 2100, excl	16	44	19	48	22	48	25	57
	2100 to 2700, excl	16	44	19	48	22	48	29	57
	2700 and over	22	44	25	51	29	57	32	64
18 000 and over	To 1500, excl	14	51	19	54	22	57	25	70
	1500 to 2100, excl	19	51	22	54	25	57	29	70
	2100 to 2700, excl	19	51	22	54	25	57	32	70
	2700 and over	25	51	29	60	32	64	35	76

[A]Permissible variations under specified width and length, 6 mm.
[B]Permissible variations in length apply also to Universal Mill plates up to 300 mm in width for thicknesses over 50 to 65 mm, inc, except for alloy steel up to 50 mm thick.

TABLE A1.5 Permissible Variations in Width for Mill Edge Carbon and High Strength Low-Alloy Plates Produced on Strip Mills (Applies to Either Plates Produced from Coils or Plates Produced in Discrete Cut Lengths of Flat Product)

Specified Width, mm	Variations Over Specified Width, mm[A]
To 360, excl	11
360 to 430, excl	13
430 to 480, excl	14
480 to 530, excl	16
530 to 610, excl	17
610 to 660, excl	21
660 to 710, excl	24
710 to 890, excl	29
890 to 1270, excl	32
1270 to 1520, excl	38
1520 to 1650, excl	41
1650 to 1780, excl	44
1780 to 2030, excl	47
2030 and over	51

[A]No permissible variation under specified width.

TABLE A1.6 Permissible Variations in Rolled Width for Universal Mill Plates 380 mm and Under in Thickness

Specified Width, mm	Variations Over Specified Width[A] for Thickness, mm, or Equivalent Masses, kg/m^2, Given					
	To 10, excl	10 to 16, excl	16 to 25, excl	25 to 50, incl	Over 50 to 250, incl	Over 250 to 400, incl
	To 78.50, excl	78.50 to 125.6, excl	125.6 to 196.2, excl	196.2 to 392.5, incl	Over 392.5 to 1962, incl	Over 1962 to 3140, incl
Over 200 to 500, excl	3	3	5	6	10	13
500 to 900, excl	5	6	8	10	11	14
900 and over	8	10	11	13	14	16

[A]Permissible variation under specified width, 3 mm.

TABLE A1.7 Permissible Variations in Diameter for Sheared Circular Plates 25 mm and Under in Thickness

Specified Diameters, mm	Permissible Variations Over Specified Diameter for Thicknesses Given, mm[A]		
To 800, excl	6	10	13
800 to 2100, excl	8	11	14
2100 to 2700, excl	10	13	16
2700 to 3300, excl	11	14	17
3300 and over	13	16	19

[A]No permissible variations under specified diameter.

TABLE A1.8 Permissible Variations in Diameter for Gas-Cut Circular Plates (Not Applicable to Alloy Steel)

Specified Diameters, mm	Variations Over Specified Diameter for Thicknesses Given, mm[A]					
	To 25, excl	25 to 50, excl	50 to 100, excl	100 to 150, excl	150 to 200, excl	200 to 400, incl
To 800, excl	10	10	13	13	16	19
800 to 2100, excl	10	13	13	16	19	22
2100 to 2700, excl	13	14	16	19	22	25
2700 to 3300, excl	13	14	17	22	25	29
3300 and over	16	19	22	25	29	32

[A]No permissible variations under specified diameter.

TABLE A1.9 Permissible Variations in Width and Length for Rectangular Plates When Gas Cuttings is Specified or Required (Applies to Alloy Steel Specifications Only).

NOTE 1—Plates with universal rolled edges will be gas cut to length only.

NOTE 2—These variations may be taken all under or divided over and under, if so specified.

Specified Thickness, mm	Variations Over for All Specified Widths or Lengths, mm
To 50, excl	19
50 to 100, excl	25
100 to 150, excl	29
150 to 200, excl	33
200 to 400, excl	38

TABLE A1.10 Permissible Variations in Width and Length for Rectangular Plates When Gas Cutting is Specified or Required (Not Applicable to Alloy Steel)

NOTE 1—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, mm	Variations Over for All Specified Widths or Lengths, mm[A]
To 50, excl	13
50 to 100, excl	16
100 to 150, excl	19
150 to 200, excl	22
200 to 400, incl	25

[A]These variations shall be taken all under or divided over and under, if so specified.

TABLE A1.11 Permissible Variations in Diameter for Gas-Cut Circular Plates (Applies to Alloy Steel Specifications Only)

Specified Diameter, mm	Variations Over Specified Diameter for Thickness Given, mm[A]					
	To 25, excl	25 to 50, excl	50 to 100, excl	100 to 150, excl	150 to 200, excl	200 to 400, incl
To 800, excl	13	13	19	19	25	25
800 to 2100, excl	13	16	22	25	29	32
2100 to 2700, excl	16	19	25	29	32	35
2700 to 3300, incl	22	25	29	32	35	38

[A]No permissible variations under specified diameter.

TABLE A1.12 Permissible Camber[A] for Carbon Steel, High-Strength Low-Alloy Steel, and Alloy Steel Universal Mill Plates and High-Strength Low-Alloy Steel and Alloy Steel Sheared or Gas-Cut Rectangular Plates

Width, mm	Camber for Width given, mm
To 750, incl	Length in millimetres/300
Over 750 to 1500	Length in millimetres/250

[A] Camber as it relates to plates is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

TABLE A1.13 Permissible Camber[A] for Sheared Plates and Gas-Cut Rectangular Plates All Thicknesses (Applies to Carbon Steel Only)

Maximum permissible camber, mm = length in millimetres/500

[A] Camber as it relates to plates is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

TABLE A1.14 Permissible Variations From Flatness for Carbon Steel Plates

NOTE 1—When the longer dimension is under 900 mm, the permissible variation from a flat surface shall not exceed 6 mm. When the longer dimension is from 900 to 1800 mm, incl, the permissible variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width, but in no case less than 6 mm.

NOTE 2—These variations apply to plates that have a specified minimum tensile strength of not more than 415 MPa or comparable chemical composition or hardness. The limits in the table are increased 50 % for plates specified to a higher minimum tensile strength or compatible chemistry or hardness.

NOTE 3—This table and these notes cover the permissible variations for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 4—Where "..." appears in this table, there is no requirement.

NOTE 5—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Specified Mass, kg/m²	Permissible Variations from a Flat Surface for Specified Widths, mm[A,B]										
		To 900, excl	900 to 1200, excl	1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, excl	3000 to 3600, excl	3600 to 4200, excl	4200 and over
To 6, excl	To 47.1, excl	14	19	24	32	35	38	41	44	48	...	...
6 to 10, excl	47.1 to 78.5, excl	13	16	19	24	29	32	35	38	41	...	...
10 to 12, excl	78.5 to 94.2, excl	13	14	16	16	19	22	25	29	32	48	54
12 to 20, excl	94.2 to 157.0, excl	11	13	14	16	16	19	25	25	29	38	51
20 to 25, excl	157.0 to 196.2, excl	11	13	14	16	16	16	19	22	25	35	44
25 to 50, excl	196.2 to 392.5, excl	10	13	13	14	14	16	16	16	18	29	38
50 to 100, excl	392.5 to 785.0, excl	8	10	11	13	13	13	13	14	16	22	29
100 to 150, excl	785.0 to 1178, excl	10	11	13	13	14	14	16	19	22	22	25
150 to 200, excl	1178 to 1570, excl	11	13	13	16	18	19	22	22	25	25	25
200 to 250, excl	1570 to 1962, excl	13	13	16	18	19	21	22	24	25	25	25
250 to 300, excl	1962 to 2355, excl	13	16	19	21	22	24	25	25	25	25	25
300 to 400, incl	2355 to 3140, incl	16	19	21	22	24	25	25	25	25	25	...

[A] *Flatness Variations for Length*—The longer dimension specified is considered the length, and the permissible variation from a flat surface along the length shall not exceed the tabular amount for the specified width for plates up to 4000 mm in length, or in any 4000 mm for longer plates.

[B] *Flatness Variations for Width*—The permissible variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

TABLE A1.15 Permissible Variations From Flatness for High-Strength Low-Alloy and Alloy Steel Plates, Hot Rolled or Thermally Treated

NOTE 1—When the longer dimension is under 900 mm, the permissible variation from a flat surface shall not exceed 10 mm. When the longer dimension is from 900 to 1800 mm, incl, the permissible variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width.

NOTE 2—This table and notes cover the tolerances for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 3—Where "..." appears in this table, there is no requirement.

NOTE 4—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Specified Mass, kg/m²	Permissible Variations from a Flat Surface for Specified Widths, mm[A,B]										
		To 900, excl	900 to 1200, excl	1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, excl	3000 to 3600, excl	3600 to 4200, excl	4200 and over
To 6, excl	To 47.1, excl	21	29	35	48	51	57	60	67	70	...	...
6 to 10, excl	47.1 to 78.5, excl	19	24	29	35	44	48	51	57	60	...	...
10 to 12, excl	78.5 to 94.2, excl	19	22	24	24	29	33	38	41	48	70	79
12 to 20, excl	94.2 to 157.0, excl	16	19	22	22	25	29	32	35	41	57	76
20 to 25, excl	157.0 to 196.2, excl	16	19	22	22	24	25	29	33	38	51	67
25 to 50, excl	196.2 to 392.5, excl	14	16	19	21	22	24	25	25	25	41	57
50 to 100, excl	392.5 to 785.0, excl	13	14	18	19	19	19	19	22	25	32	41
100 to 150, excl	785.0 to 1178, excl	14	18	19	19	22	22	24	29	32	32	38
150 to 200, excl	1178 to 1570, excl	16	19	19	24	25	29	32	33	38	38	38
200 to 250, excl	1570 to 1962, excl	19	21	24	25	29	32	33	35	38	38	38
250 to 300, excl	1962 to 2355, excl	19	24	29	32	33	35	38	38	38	38	38
300 to 400, incl	2355 to 3140, incl	22	25	30	33	35	38	38	38	38	38	38

[A] *Flatness Variations for Length*—The longer dimension specified is considered the length, and the permissible variation from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 4000 mm in length, or in any 4000 mm for longer plates.

[B] *Flatness Variations for Width*—The permissible variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

TABLE A1.16 Permissible Variations in Waviness for Plates

NOTE 1—Waviness denotes the maximum deviation of the surface of the plate from a plane parallel to the surface of the point of measurement and contiguous to the surface of the place at each of the two adjacent wave peaks, when the plate is resting on a flat horizontal surface, as measured in an increment of less than 4000 mm of length.

The waviness tolerance is a function of the flatness tolerance as obtained from Table A1.13 or A1.14 as appropriate.

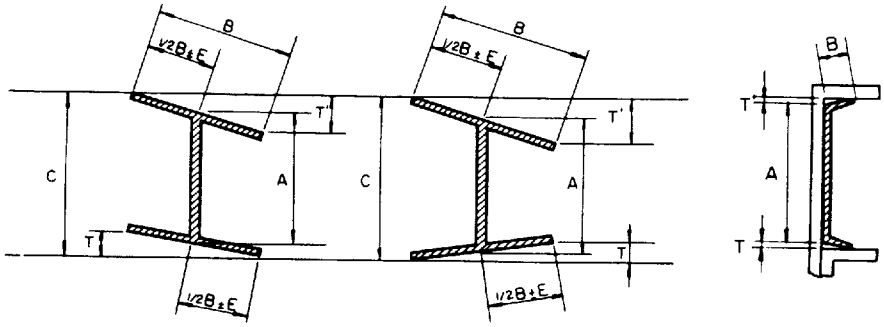
NOTE 2—Plates must be in a horizontal position on a flat surface when waviness is measured.

Flatness Tolerance, mm, from Tables A1.13 or A1.14	Waviness Tolerance, mm, When Number of Waves in 4000 mm is						
	1	2	3	4	5	6	7
8	8	6	5	3	3	2	2
10	10	8	5	5	3	2	2
11	11	8	6	5	3	3	2
13	13	10	8	5	5	3	2
14	14	11	8	6	5	3	2
16	16	13	10	6	5	3	2
17	17	13	10	8	5	5	2
19	19	14	11	8	6	5	2
21	21	16	11	8	6	5	2
22	22	17	13	10	6	5	2
24	24	17	13	10	8	6	5
25	25	19	14	11	8	6	5
29	29	22	16	13	10	6	5
32	32	24	17	13	10	8	6
35	35	27	19	14	11	8	6
38	38	29	22	16	13	10	6
41	41	32	24	17	13	10	8
44	44	33	25	19	14	11	8
48	48	37	27	21	14	11	8
51	51	38	29	22	16	13	10
54	54	41	30	22	17	13	10
57	57	43	32	24	17	14	10
60	60	46	33	25	19	14	11
64	64	48	37	27	21	14	11
67	67	51	38	29	21	16	11
70	70	52	40	29	22	16	13
73	73	56	41	30	24	17	13
76	76	57	43	32	24	17	14
79	79	60	44	33	25	19	14

TABLE A1.17 Permissible Variations in Cross Section for W, HP, S, M, C, and MC Shapes

NOTE 1—*A* is measured at center lines of web for S, M, W, and HP shapes; at back of web for C and MC shapes. Measurement is overall for C shapes under 75 mm. *B* is measured parallel to flange. *C* is measured parallel to web.

NOTE 2—Where "..." appears in this table, there is no requirement.



Shape	Section Nominal Size, mm	*A*, Depth, mm		*B*, Flange Width, mm		$T + T'^{A}$ Flanges Out-of-Square, max, mm[B]	*E*, Web off Center, max[C]	*C*, Maximum Depth at any Cross Section over Theoretical Depth, mm	Thickness of Web Over and Under for Thicknesses Given, mm	
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical				5 and Under	Over 5
W and HP	up to 310, incl	4	3	6	5	6	5	6	...	...
	over 310	4	3	6	5	8	5	6	...	...
S and M	75 to 180, incl	2	2	3	3	0.03	5	...	...	...
	over 180 to 360, incl.	3	2	4	4	0.03	5	...	...	...
	over 360 to 610, incl	5	3	5	5	0.03	5	...	...	...
C and MC	40 and under	1	1	1	1	0.03	...	...	0.2	0.4
	over 40 to 75, excl	2	2	2	2	0.03	...	...	0.4	0.5
	75 to 180, incl	3	2	3	3	0.03	...	...	...	...
	over 180 to 360, incl	3	3	3	4	0.03	...	...	...	...
	over 360	5	4	3	5	0.03	...	...	...	...

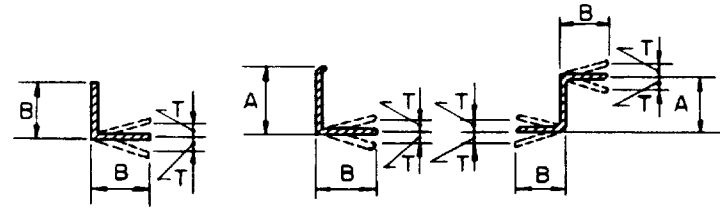
[A] $T + T'$ applies when flanges of channels are toed in or out. For channels 16 mm and under in depth, the permissible out-of-square is 0.05 mm/mm of depth. The tolerance shall be rounded to the nearest millimetre after calculation.

[B] Tolerance is per millimetre of flange width for S, M, C, and MC shapes.

[C] Variation of 8 mm max for sections over 634 kg/m.

TABLE A1.18 Permissible Variations in Cross Section for Angles (L Shapes), Bulb Angles, and Zees

NOTE 1—Where "..." appears in this table, there is no requirement.



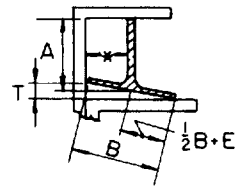
Angles Bulb angles Zees

Section	Nominal Size, mm	A, Depth, mm		B, Flange Width, or Length of Leg, mm		T, Out-of-Square, per mm of B, mm	Variations from Thickness for Thicknesses Given, Over and Under, mm		
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical		5 and Under	Over 5 to 10	Over 10
Angles[A] (L shapes)	25 and under	...	...	1	1	0.026[B]	0.2	0.2	...
	over 25 to 50, incl	...	...	1	1	0.026[B]	0.2	0.2	0.3
	over 50 to 75, excl	...	...	2	2	0.026[B]	0.3	0.4	0.4
	75 to 100, incl	...	...	3	2	0.026[B]	...	...	...
	over 100 to 150 incl	...	...	3	3	0.026[B]	...	...	...
	over 150	...	...	5	3	0.026[B]	...	...	...
Bulb angles	(depth) 75 to 100, incl	3	2	4	2	0.026[B]	...	...	...
	over 100 to 150, incl	3	2	4	3	0.026[B]	...	...	...
	over 150	3	2	5	3	0.026[B]	...	...	...
Zees	75 to 100, incl	3	2	4	2	0.026[B]	...	...	...
	over 100 to 150, incl	3	2	4	3	0.026[B]	...	...	...

[A]For unequal leg angles, longer leg determines classification.
[B]0.026 mm/mm = 1½°. The tolerance shall be rounded to the nearest millimetre after calculation.

TABLE A1.19 Permissible Variations in Sectional Dimensions for Rolled Tees

NOTE 1—* = Back of square and center line of stem are to be parallel when measuring "out-of-square."
NOTE 2—Where "..." appears in this table there is no requirement.



Tees

Nominal Size[A], mm	A, Depth[B], mm		B, Width[B], mm		T, Out-of-Square per mm of B, mm	E, Web-off-Center, max, mm	Stem Out-of-Square[C], mm	Thickness of Flange, mm		Thickness of Stem, mm	
	Over	Under	Over	Under				Over	Under	Over	Under
30 and under	1	1	1	1	...	...	1	0.2	0.2	0.1	0.5
Over 30 to 50, incl	2	2	2	2	...	...	2	0.3	0.3	0.2	0.5
Over 50 to 75, excl	2	2	2	2	...	...	2	0.4	0.4	0.4	0.5
75 to 125, incl	2	2	3	3	0.03	2	...	...	...	...	...
Over 125 to 180, incl	2	2	3	3	0.03	3	...	...	...	...	...

[A]The longer member of an unequal tee determines the size for permissible variations.
[B]Measurements for both depth and width are overall.
[C]Stem-out-of-square is the variation from its true position of the center line of stem, measured at the point.

TABLE A1.20 Permissible Variations in Length for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

NOTE 1—Where "..." appears in this table, there is no requirement.

Nominal Size,[A] mm	Variations from Specified Length for Lengths Given, mm													
	1.5 to 3 m, excl		3 to 6 m, excl		6 to 9 m, incl		9 to 12 m, incl		12 to 15 m, incl		15 to 20 m, incl		Over 20 m	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
Under 75	16	0	25	0	38	0	51	0	64	0	64	0	...	...
75 and over	25	0	38	0	45	0	57	0	70	0	70	0	...	...

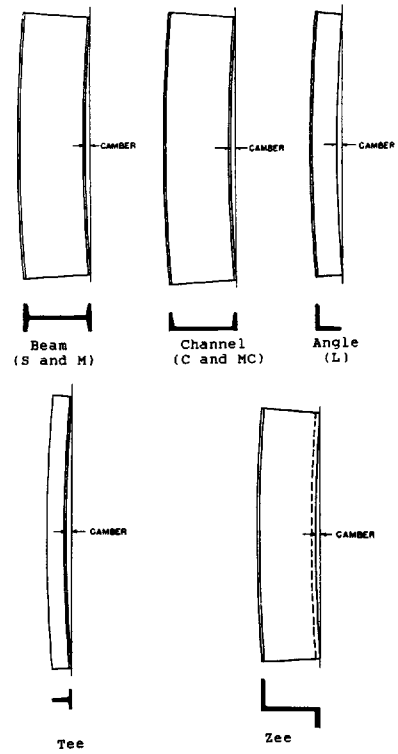
[A]Greatest cross-sectional dimension.

TABLE A1.21 Permissible Variations in Ends Out-of-Square for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

Shapes	Permissible Variations
S, M, C, and MC	0.017 mm/mm of depth
L[A]	0.026 mm/mm of leg length or 1½°
Bulb angles	0.026 mm/mm of depth or 1½°
Rolled tees[A]	0.017 mm/mm of flange or stem
Zees	0.026 mm/mm of sum of both flange lengths

[A]Permissible variations for ends out-of-square are determined on the longer members of the shape.

TABLE A1.22 Permissible Variations in Straightness for S, M, C, MC, L, T, Z, and Bulb Angle Shapes



Positions for Measuring Camber of Shapes

Variable	Nominal Size,[A] mm	Permissible Variation, mm
Camber	under 75	4 × number of metres of total length
	75 and over	2 × number of metres of total length
Sweep	all	Due to the extreme variations in flexibility of these shapes, straightness tolerances for sweep are subject to negotiations between the manufacturer and the purchaser for the individual sections involved.

[A]Greatest cross-sectional dimension.

TABLE A1.23 Permissible Variations in Length for W and HP Shapes[A,B]

W Shapes	Variations from Specified Length for Lengths Given, mm			
	9 m and Under		Over 9 m	
	Over	Under	Over	Under
Beams 610 mm and under in nominal depth	10	10	10 plus 1 for each additional 1 m or fraction thereof	10
Beams over 610 mm in nominal depth and all columns	13	13	13 plus 1 for each additional 1 m or fraction thereof	13

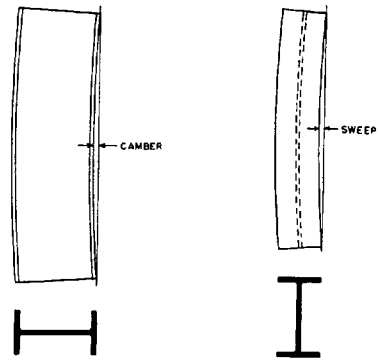
[A]For HP shapes or W shapes when used as bearing piles, the length tolerance is plus 125 and minus 0 mm. This length tolerance also applies to steel sheet piles.
[B]The ends out-of-square tolerance for W and HP shapes shall be 0.016 mm/mm of depth, or of flange width if it is greater than the depth. The tolerance shall be rounded to the nearest millimetre after calculation.

TABLE A1.24 Permissible Variations for Length and Ends Out-of-Square, Milled Shapes

Nominal Depth, mm	Length,[A,B] m	Milled Both Ends[C]			Milled One End[C]		
		Length, mm		Maximum End Out-of-Square, mm	Length, mm		Maximum End Out-of-Square-for Milled End, mm
		Over	Under		Over	Under	
150 to 920	2 to 21	1	1	1	6	6	1

[A]Length is measured along center line of web. Measurements are made with the steel and tape at the same temperature.
[B]Length variation and out-of-square variation are additive.
[C]Ends out-of-square are measured by (*a*) squaring from the center line of the web and (*b*) squaring from the center line of the flange. The measured variation from true squareness in either plane shall not exceed the total tabular amount.

TABLE A1.25 Permissible Variations in Straightness for W and HP Shapes



Positions for Measuring Camber and Sweep of W and HP Shapes

	Permissible Variation
Camber and sweep	1 mm × number of metres of total length[A]
When certain section[B] with a flange width approximately equal to depth are specified on order as columns:	
Lengths of 14 m and under	1 mm × number of metres of total length, but not over 10 mm
Lengths over 14 m	10 mm + [1 mm × (number of metres of total length − 14 m)]

[A]Sections with a flange width less than 150 mm tolerance for sweep = 2 mm × number of metres of total length.
[B]Applies only to:
200-mm deep sections—46.1 kg/m and heavier,
250-mm deep sections—73 kg/m and heavier,
310-mm deep sections—97 kg/m and heavier, and
360-mm deep sections—116 kg/m and heavier.
If other sections are specified on the order as columns, the tolerance will be subject to negotiation with the manufacturer.

TABLE A1.26 Permissible Variations in Dimensions for Split Tees and Split Angles (L Shapes)[A]

Specified Depth, mm	Variations from Depth,[B] Over and Under, mm
To 150, excl (beams and channels)	3
150 to 410, excl (beams and channels)	5
410 to 510, excl (beams and channels)	6
510 to 610, excl (beams)	8
610 and over (beams)	10

[A]The length tolerance for split tees or angles are the same as those applicable to the section from which the tees or angles are split.
[B]The above tolerances for depth of tees or angles include the allowable tolerances in depth for the beams or channels before splitting. Tolerances both for dimensions and straightness, as set up for the beams or channels from which these tees or angles are cut, will apply, except

straightness = 2 mm × length in metres

TABLE A1.27 Permissible Variations in Sectional Dimensions for Square-Edge and Round-Edge Flat Bars

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Widths, mm	Permissible Variations from Thickness, for Thicknesses Given, Over and Under, mm						Permissible Variations from Specified Width, mm	
	Over 5 to 6, incl	Over 6 to 12, incl	Over 12 to 25, incl	Over 25 to 50, incl	Over 50 to 75	Over 75	Over	Under
To 25, incl	0.18	0.20	0.25	...	...	...	0.5	0.5
Over 25 to 50, incl	0.18	0.30	0.40	0.8	...	...	1.0	1.0
Over 50 to 100, incl	0.20	0.40	0.50	0.8	1.2	1.2	1.5	1.0
Over 100 to 150, incl	0.25	0.40	0.50	0.8	1.2	1.2	2.5	1.5
Over 150 to 200, incl	[A]	0.40	0.65	0.8	1.2	1.6	3.0	2.5

[A] Flats over 150 to 200 mm, incl, in width are not available as hot-rolled bars in thickness 6 mm and under.

TABLE A1.28 Permissible Variations in Sectional Dimensions for Round and Square Bars and Round-Cornered Squares

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Sizes, mm	Variations from Size, ±		Out-of-Round or Out-of-Square Section[A]	
	mm	%	mm	%
Up to 7.0, incl	0.13	...	0.20	...
Over 7.0 to 11.0, incl	0.15	...	0.22	...
Over 11.0 to 15.0, incl	0.18	...	0.27	...
Over 15.0 to 19.0, incl	0.20	...	0.30	...
Over 19.0 to 250, incl	...	1[B]	...	1½[B]

[A] Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same transverse cross section. Out-of-square section is the difference in perpendicular distance between opposite faces, measured at the same transverse cross section.

[B] The tolerance shall be rounded to the nearest tenth of a millimetre after calculation.

TABLE A1.29 Permissible Variations in Sectional Dimensions for Hexagons

Specified Sizes Between Opposite Sides, mm	Variation from Specified Size, mm		Out-of-Hexagon Section, mm[A]
	Over	Under	
To 13 incl	0.18	0.18	0.3
Over 13 to 25 incl	0.25	0.25	0.4
Over 25 to 40 incl	0.55	0.35	0.6
Over 40 to 50 incl	0.8	0.40	0.8
Over 50 to 65 incl	1.2	0.40	1.2
Over 65 to 80 incl	1.6	1.6	

[A] Out-of-hexagon section is the greatest difference in distance between any two opposite faces measured at the same transverse cross section.

TABLE A1.30 Permissible Variations in Straightness for Bars

Maximum Permissible Variation in Straightness, mm[A]
6 mm in any 1500 mm, or (length in millimetres/250)[B]

[A] Permissible variations in straightness do not apply to hot-rolled bars if any subsequent heating operation has been performed.

[B] Round to the nearest whole millimetre.

TABLE A1.31 Permissible Variations in Length for Hot-Cut Steel Bars[A]

NOTE 1—Where "..." appears in this table, there is no requirement.

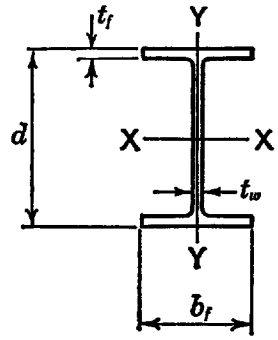
Specified Sizes of Rounds, Squares, and Hexagons, mm	Specified Sizes of Flats, mm		Permissible Variations over Specified Length, mm (No Variation Under)				
	Thickness	Width	1500 to 3000, excl	3000 to 6000, excl	6000 to 9000, excl	9000 to 12 000, excl	12 000 to 18 000, excl
To 25, incl	to 25, incl	to 75, incl	15	20	35	45	60
Over 25 to 50, incl	over 25	to 75, incl	15	25	40	50	65
	to 25, incl	over 75 to 150, incl	15	25	40	50	65
Over 50 to 125, incl	over 25	over 75 to 150, incl	25	40	45	60	70
Over 125 to 250, incl	...	...	50	65	70	75	85
	over 6 to 25, incl	over 150 to 200, incl	20	30	45	90	100
	over 25 to 75, incl	over 150 to 200, incl	30	45	50	90	100
Bar size sections	...	...	15	25	40	50	65
		Hot Sawing					
50 to 125, incl	25 and over	75 and over	[B]	40	45	60	70
Over 125 to 250, incl	...	...	[B]	65	70	75	85

[A]For flats over 150 to 200 mm, incl, in width and over 75 mm in thickness, consult the producer for length tolerances.
[B]Smaller sizes and shorter lengths are not commonly hot sawed.

A2. DIMENSIONS OF STANDARD SHAPE PROFILES

A2.1 Listed herein are dimensions and weight [mass] of some standard shape profiles. The values stated in inch-pound units are independent of the values stated in SI units, and the values from the two systems are not to be combined in any way. Unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

TABLE A2.1 "W" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area *A*, in.^{2}	Depth *d*, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area *A*, mm^2	Depth *d*, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
W44 X 335	98.7	44.02	15.945	1.772	1.024	W1100 X 499	63 521	1 118	405	45.0	26.0
X 290	85.8	43.62	15.827	1.575	0.866	X 433	55 119	1 108	402	40.0	22.0
X 262	77.2	43.31	15.748	1.417	0.787	X 390	49 703	1 100	400	36.0	20.0
X 230	67.9	42.91	15.748	1.220	0.709	X 343	43 647	1 090	400	31.0	18.0
W40 X 593	174.4	42.99	16.690	3.230	1.790	W1000 X 883	112 517	1 092	424	82.0	45.5
X 503	147.8	42.05	16.417	2.756	1.535	X 748	95 345	1 068	417	70.0	39.0
X 431	126.7	41.26	16.220	2.362	1.339	X 642	81 765	1 048	412	60.0	34.0
X 397	117	40.95	16.12	2.20	1.22	X 591	75 300	1 040	409	55.9	31.0
X 372	109.4	40.63	16.063	2.047	1.161	X 554	70 581	1 032	408	52.0	29.5
X 362	107	40.55	16.02	2.01	1.12	X 539	68 700	1 030	407	51.1	28.4
X 331	97.5	40.79	12.165	2.126	1.220	X 494	62 913	1 036	309	54.0	31.0
X 324	95.3	40.16	15.91	1.81	1.00	X 483	61 500	1 020	404	46.0	25.4
X 297	87.4	39.84	15.825	1.650	0.930	X 443	56 387	1 012	402	41.9	23.6
X 277	81.3	39.69	15.830	1.575	0.830	X 412	52 470	1 008	402	40.0	21.1
X 249	73.3	39.38	15.750	1.420	0.750	X 371	47 271	1 000	400	36.1	19.0
X 215	63.3	38.98	15.750	1.220	0.650	X 321	40 849	990	400	31.0	16.5
X 199	58.4	38.67	15.750	1.065	0.650	X 296	37 699	982	400	27.1	16.5
W40 X 392	115.3	41.57	12.362	2.520	1.417	W1000 X 584	74 373	1 056	314	64.0	36.0
X 327	95.9	40.79	12.13	2.13	1.18	X 486	61 900	1 036	308	54.1	30.0
X 278	81.9	40.16	11.969	1.811	1.024	X 415	52 869	1 020	304	46.0	26.0
X 264	77.6	40.00	11.930	1.730	0.960	X 393	50 100	1 016	303	43.9	24.4
X 235	68.9	39.69	11.890	1.575	0.830	X 350	44 600	1 008	302	40.0	21.1
X 211	62.0	39.37	11.810	1.415	0.750	X 314	40 000	1 000	300	35.9	19.1
X 183	53.7	38.98	11.810	1.200	0.650	X 272	34 647	990	300	31.0	16.5
X 167	49.1	38.59	11.810	1.025	0.650	X 249	31 675	980	300	26.0	16.5
X 149	43.8	38.20	11.810	1.830	0.630	X 222	28 232	970	300	21.1	16.0
W36 X 798	234.6	41.97	17.990	4.290	2.380	W920 X 1188	151 347	1066	457	109.0	60.5
X 650	191.0	40.47	17.575	3.540	1.970	X 967	123 210	1028	446	89.9	50.0
X 527	154.7	39.21	17.220	2.910	1.610	X 784	99 835	996	437	73.9	40.9
X 439	129.0	38.26	16.965	2.440	1.360	X 653	83 195	972	431	62.0	34.5
X 393	115.6	37.80	16.830	2.200	1.220	X 585	71 559	960	427	55.9	31.0
X 359	105.4	37.40	16.730	2.010	1.120	X 534	68 004	950	425	51.1	28.4
X 328	96.4	37.09	16.630	1.850	1.020	X 488	62 165	942	422	47.0	25.9
X 300	88.3	36.74	16.655	1.680	0.945	X 446	57 000	933	423	42.7	24.0
X 280	82.4	36.52	16.595	1.570	0.885	X 417	53 200	928	422	39.9	22.5
X 260	76.5	36.26	16.550	1.440	0.840	X 387	49 400	921	420	36.6	21.3
X 256	75.4	37.43	12.215	1.730	0.960	X 381	48 600	951	310	43.3	24.4
X 245	72.1	36.08	16.510	1.350	0.800	X 365	46 500	916	419	34.3	20.3
X 232	68.1	37.12	12.120	1.570	0.870	X 345	44 000	943	308	39.9	22.1
X 230	67.6	35.90	16.470	1.260	0.760	X 342	43 600	912	418	32.0	19.3
W36 X 210	61.8	36.69	12.180	1.360	0.830	W920 X 313	39 900	932	309	34.5	21.1
X 194	57.0	36.49	12.15	1.260	0.765	X 289	36 800	927	308	32.0	19.4
X 182	53.6	36.33	12.075	1.180	0.725	X 271	34 600	923	307	30.0	18.4
X 170	44.2	35.85	11.975	0.940	0.625	X 253	32 300	919	306	27.9	17.3
X 160	47.0	36.01	12.000	1.020	0.650	X 238	30 300	915	305	25.9	16.5

TABLE A2.1 *Continued*

Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
X 150	44.2	35.85	11.975	0.940	0.625	X 223	28 500	911	304	23.9	15.9
X 135	39.7	35.55	11.950	0.790	0.600	X 201	25 600	903	304	20.1	15.2
W33 X 387	114	35.95	16.20	2.28	1.26	W840 X 576	73 500	913	411	57.9	32.0
X 354	104.1	35.55	16.100	2.090	1.160	X 527	67 173	903	409	53.1	29.5
X 318	93.5	35.16	15.985	1.890	1.040	X 473	60 316	893	406	48.0	26.4
X 291	85.6	34.84	15.905	1.730	0.960	X 433	55 218	885	404	43.9	24.4
X 263	77.4	34.53	15.805	1.570	0.870	X 392	49 915	877	401	39.9	22.1
X 241	70.9	34.18	15.860	1.400	0.830	X 359	45 700	868	403	35.6	21.1
X 221	65.0	33.93	15.805	1.275	0.775	X 329	41 900	862	401	32.4	19.7
X 201	59.1	33.68	15.745	1.150	0.715	X 299	38 100	855	400	29.2	18.2
X 169	49.5	33.82	11.500	1.220	0.670	X 251	31 900	859	292	31.0	17.0
W33 X 152	44.7	33.49	11.565	1.055	0.635	W840 X 226	28 800	851	294	26.8	16.1
X 141	41.6	33.30	11.535	0.960	0.605	X 210	26 800	846	293	24.4	15.4
X 130	38.3	33.09	11.510	0.855	0.580	X 193	24 700	840	292	21.7	14.7
X 118	34.7	32.86	11.480	0.740	0.550	X 176	22 400	835	292	18.8	14.0
W30 X 391	115.0	33.19	15.590	2.440	1.360	W760 X 582	74 171	843	396	62.0	34.5
X 357	104.8	32.80	15.470	2.240	1.240	X 531	67 617	833	393	56.9	31.5
X 326	95.7	32.40	15.370	2.050	1.140	X 484	61 718	823	390	52.1	29.0
X 292	85.7	32.01	15.255	1.850	1.020	X 434	55 293	813	387	47.0	25.9
X 261	76.7	31.61	15.155	1.650	0.930	X 389	49 499	803	385	41.9	23.6
X 235	69.0	31.30	15.055	1.500	0.830	X 350	44 541	795	382	38.1	21.1
X 211	62.0	30.94	15.105	1.315	0.775	X 314	40 000	786	384	33.4	19.7
X 191	56.1	30.68	15.040	1.185	0.710	X 284	36 200	779	382	30.1	18.0
X 173	50.8	30.44	14.985	1.065	0.655	X 257	32 800	773	381	27.1	16.6
X 148	43.5	30.67	10.480	1.180	0.650	X 220	28 100	779	266	30.0	16.5
W30 X 132	38.9	30.31	10.545	1.000	0.615	W760 X 196	25 100	770	268	25.4	15.6
X 124	36.5	30.17	10.515	0.930	0.585	X 185	23 500	766	267	23.6	14.9
X 116	34.2	30.01	10.495	0.850	0.565	X 173	22 100	762	267	21.6	14.4
X 108	31.7	29.83	10.475	0.760	0.545	X 161	20 500	758	266	19.3	13.8
X 99	29.1	29.65	10.450	0.670	0.520	X 147	18 800	753	265	17.0	13.2
X 90	26.4	29.53	10.400	0.610	0.470	X 134	17 041	750	264	15.5	11.9
W27 X 539	158.4	32.52	15.255	3.540	1.970	W690 X 802	102 208	826	387	89.9	50.0
X 368	108.1	30.39	14.665	2.480	1.380	X 548	69 762	772	372	63.0	35.1
X 336	98.7	30.00	14.55	2.28	1.26	X 500	63 700	762	369	57.9	32.0
X 307	90.2	29.61	14.445	2.090	1.160	X 457	58 180	752	367	53.1	29.5
X 281	82.6	29.29	14.35	1.93	1.06	X 419	53 300	744	364	49.0	26.9
X 258	75.7	28.98	14.270	1.770	0.980	X 384	48 869	736	362	45.0	24.9
X 235	69.1	28.66	14.190	1.610	0.910	X 350	44 608	728	360	40.9	23.1
X 194	57.0	28.11	14.035	1.340	0.750	X 289	36 765	714	356	34.0	19.0
X 178	52.3	27.81	14.085	1.190	0.725	X 265	33 700	706	358	30.2	18.4
X 161	47.4	27.59	14.020	1.080	0.660	X 240	30 600	701	356	27.4	16.8
X 146	42.9	27.38	13.965	0.975	0.605	X 217	27 700	695	355	24.8	15.4
W27 X 217	63.8	28.43	14.115	1.500	0.830	W690 X 323	41 100	722	359	38.1	21.1
X 129	37.8	27.63	10.010	1.100	0.610	X 192	24 400	702	254	27.9	15.5
W27 X 114	33.5	27.29	10.070	0.930	0.570	W690 X 170	21 600	693	256	23.6	14.5
X 102	30.0	27.09	10.015	0.830	0.515	X 152	19 400	688	254	21.1	13.1
X 94	27.7	26.92	9.990	0.745	0.490	X 140	17 900	684	254	18.9	12.4
X 84	24.8	26.71	9.960	0.640	0.460	X 125	16 000	678	253	16.3	11.7
W24 X 370	108	27.99	13.66	2.72	1.52	W610 X 551	70 211	711	347	69.1	38.6
X 335	98.4	27.52	13.520	2.480	1.380	X 498	63 495	699	343	63.0	35.1
X 306	89.8	27.13	13.405	2.28	1.26	X 455	57 859	689	340	57.9	32.0
X 279	82.0	26.73	13.305	2.090	1.160	X 415	52 902	679	338	53.1	29.5
X 250	73.5	26.34	13.185	1.890	1.040	X 372	47 437	669	335	48.0	26.4
X 229	67.2	26.02	13.110	1.730	0.960	X 341	43 383	661	333	43.9	24.4
X 207	60.7	25.71	13.010	1.570	0.870	X 307	39 169	653	330	39.9	22.1
X 192	56.3	25.47	12.950	1.460	0.810	X 285	36 125	647	329	37.1	20.6
X 176	51.7	25.24	12.890	1.340	0.750	X 262	33 348	641	327	34.0	19.0
X 162	47.7	25.00	12.955	1.220	0.705	X 241	30 800	635	329	31.0	17.1
X 146	43.0	24.74	12.900	1.090	0.650	X 217	27 700	628	328	27.7	16.5
X 131	38.5	24.48	12.855	0.960	0.605	X 195	24 800	622	327	24.4	15.4
X 117	34.4	24.26	12.800	0.850	0.550	X 174	22 200	616	325	21.6	14.0
X 104	30.6	24.06	12.750	0.750	0.500	X 155	19 700	611	324	19.0	12.7

TABLE A2.1 *Continued*

Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
X 103	30.3	24.53	9.000	0.980	0.550	W610 X 153	19 600	623	229	24.9	14.0
W24 X 94	27.7	24.31	9.065	0.875	0.515	W610 X 140	17 900	617	230	22.2	13.1
X 84	24.7	24.10	9.020	0.770	0.470	X 125	15 900	612	229	19.6	11.9
X 76	22.4	23.92	8.990	0.680	0.440	X 113	14 500	608	228	17.3	11.2
X 68	20.1	23.73	8.965	0.585	0.415	X 101	13 000	603	228	14.9	10.5
W24 X 62	18.2	23.74	7.040	0.590	0.430	W610 X 92	11 700	603	179	15.0	10.9
X 55	16.2	23.57	7.005	0.505	0.395	X 82	10 500	599	178	12.8	10.0
W21 X 201	59.2	23.03	12.575	1.630	0.910	X 300	38 222	585	319	41.4	23.1
X 182	53.7	22.72	12.500	1.480	0.830	X 272	34 620	577	317	37.6	21.1
X 166	48.9	22.48	12.420	1.360	0.750	X 248	31 524	571	315	34.5	19.0
X 147	43.2	22.06	12.510	1.150	0.720	X 219	27 900	560	318	29.2	18.3
X 132	38.8	21.83	12.440	1.035	0.650	X 196	25 000	554	316	26.3	16.5
X 122	35.9	21.68	12.390	0.960	0.600	X 182	23 200	551	315	24.4	15.2
X 111	32.7	21.51	12.340	0.875	0.550	X 165	21 100	546	313	22.2	14.0
X 101	29.8	21.36	12.290	0.800	0.500	X 150	19 200	543	312	20.3	12.7
W21 X 93	27.3	21.62	8.420	0.930	0.580	W530 X 138	17 600	549	214	23.6	14.7
X 83	24.3	21.43	8.355	0.835	0.515	X 123	15 700	544	212	21.2	13.1
X 73	21.5	21.24	8.295	0.740	0.455	X 109	13 900	539	211	18.8	11.6
X 68	20.0	21.13	8.270	0.685	0.430	X 101	12 900	537	210	17.4	10.9
X 62	18.3	20.99	8.240	0.615	0.400	X 92	11 800	533	209	15.6	10.2
X 55	16.2	20.80	8.220	0.522	0.375	X 82	10 500	528	209	13.3	9.50
X 48	14.1	20.62	8.140	0.430	0.350	X 72	9 180	524	207	10.9	9.00
W21 X 57	16.7	21.06	6.555	0.650	0.405	W530 X 85	10 800	535	166	16.5	10.3
X 50	14.7	20.83	6.530	0.535	0.380	X 74	9 480	529	166	13.6	9.7
X 44	13.0	20.66	6.500	0.450	0.350	X 66	8 390	525	165	11.4	8.9
W18 X 175	51.3	20.04	11.375	1.590	0.890	W460 X 260	33 120	509	289	40.4	22.6
X 158	46.3	19.72	11.300	1,440	0.810	X 235	29 899	501	287	36.6	20.6
X 143	42.1	19.49	11.220	1.320	0.730	X 213	27 148	495	285	33.5	18.5
X 130	38.2	19.25	11.160	1.200	0.670	X 193	24 666	489	283	30.5	17.0
X 119	35.1	18.97	11.265	1.060	0.655	X 177	22 600	482	286	26.9	16.6
X 106	31.1	18.73	11.200	0.940	0.590	X 158	20 100	476	284	23.9	15.0
X 97	28.5	18.59	11.145	0.870	0.535	X 144	18 400	472	283	22.1	13.6
X 86	25.3	18.39	11.090	0.770	0.480	X 128	16 300	467	282	19.6	12.2
X 76	22.3	18.21	11.035	0.680	0.425	X 113	14 400	463	280	17.3	10.8
X 71	20.8	18.47	7.635	0.810	0.495	X 106	13 400	469	194	20.6	12.6
X 65	19.1	18.35	7.590	0.750	0.450	X 97	12 300	466	193	19.0	11.4
X 60	17.6	18.24	7.555	0.695	0.415	X 89	11 400	463	192	17.7	10.5
X 55	16.2	18.11	7.530	0.630	0.390	X 82	10 500	460	191	16.0	9.9
X 50	14.7	17.99	7.495	0.570	0.355	X 74	9 480	457	190	14.5	9.0
W18 X 46	13.5	18.06	6.060	0.605	0.360	W460 X 68	8 710	459	154	15.4	9.1
X 40	11.8	17.90	6.015	0.525	0.315	X 60	7 610	455	153	13.3	8.0
X 35	10.3	17.70	6.000	0.425	0.300	X 52	6 650	450	152	10.8	7.6
W16 X 100	29.4	16.97	10.425	0.985	0.585	W410 X 149	19 000	431	265	25.0	14.9
X 89	26.2	16.75	10.365	0.875	0.525	X 132	16 900	425	263	22.2	13.3
X 77	22.6	16.52	10.295	0.760	0.455	X 114	14 600	420	261	19.3	11.6
X 67	19.7	16.33	10.235	0.665	0.395	X 100	12 700	415	260	16.9	10.0
W16 X 57	16.8	16.43	7.120	0.715	0.430	W410 X 85	10 800	417	181	18.2	10.9
X 50	14.7	16.26	7.070	0.630	0.380	X 75	9 480	413	180	16.0	9.7
X 45	13.3	16.13	7.035	0.565	0.345	X 67	8 580	410	179	14.4	8.8
X 40	11.8	16.01	6.995	0.505	0.305	X 60	7 610	407	178	12.8	7.7
X 36	10.6	15.86	6.985	0.430	0.295	X 53	6 840	403	177	10.9	7.5
W16 X 31	9.12	15.88	5.525	0.440	0.275	W410 X 46.1	5 880	403	140	11.2	7.0
X 26	7.68	15.69	5.500	0.345	0.250	X 38.8	4 950	399	140	8.8	6.4
W14 X 808	237.4	22.84	18.560	5.120	3.740	W360 X 1202	153 000	580	471	130.0	95.0
X 730	215.0	22.42	17.890	4.910	3.070	X 1086	139 000	569	454	125.0	78.0
X 665	196.0	21.64	17.650	4.520	2.830	X 990	126 000	550	448	115.0	71.9
X 605	178.0	20.92	17.415	4.160	2.595	X 900	115 000	531	442	106.0	65.9
X 550	162.0	20.24	17.200	3.820	2.380	X 818	105 000	514	437	97.0	60.5
X 500	147.0	19.60	17.010	3.500	2.190	X 744	94 800	498	432	88.9	55.6

TABLE A2.1 *Continued*

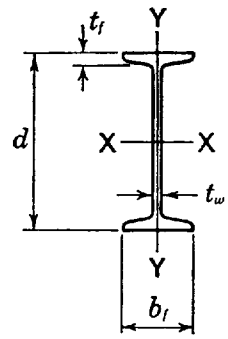
Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
X 455	134.0	19.02	16.835	3.210	2.015	X 677	86 500	483	428	81.5	51.2
X 426	125.0	18.67	16.695	3.035	1.875	X 634	80 600	474	424	77.1	47.6
X 398	117.0	18.29	16.590	2.845	1.770	X 592	75 500	465	421	72.3	45.0
X 370	109.0	17.92	16.475	2.660	1.655	X 551	70 300	455	418	67.6	42.0
X 342	101.0	17.54	16.360	2.470	1.540	X 509	65 200	446	416	62.7	39.1
X 311	91.4	17.12	16.230	2.260	1.410	X 463	59 000	435	412	57.4	35.8
X 283	83.3	16.74	16.110	2.070	1.290	X 421	53 700	425	409	52.6	32.8
X 257	75.6	16.38	15.995	1.890	1.175	X 382	48 800	416	406	48.0	29.8
X 233	68.5	16.04	15.890	1.720	1.070	X 347	44 200	407	404	43.7	27.2
X 211	62.0	15.72	15.800	1.560	0.980	X 314	40 000	399	401	39.6	24.9
X 193	56.8	15.48	15.710	1.440	0.890	X 287	36 600	393	399	36.6	22.6
X 176	51.8	15.22	15.650	1.310	0.830	X 262	33 400	387	398	33.3	21.1
X 159	46.7	14.98	15.565	1.190	0.745	X 237	30 100	380	395	30.2	18.9
X 145	42.7	14.78	15.500	1.090	0.680	X 216	27 500	375	394	27.7	17.3
W14 X 132	38.8	14.66	14.725	1.030	0.645	W360 X 196	25 000	372	374	26.2	16.4
X 120	35.3	14.48	14.670	0.940	0.590	X 179	22 800	368	373	23.9	15.0
X 109	32.0	14.32	14.605	0.860	0.525	X 162	20 600	364	371	21.8	13.3
X 99	29.1	14.16	14.565	0.780	0.485	X 147	18 800	360	370	19.8	12.3
X 90	26.5	14.02	14.520	0.710	0.440	X 134	17 100	356	369	18.0	11.2
X 82	24.1	14.31	10.130	0.855	0.510	X 122	15 500	363	257	21.7	13.0
X 74	21.8	14.17	10.070	0.785	0.450	X 110	14 100	360	256	19.9	11.4
X 68	20.0	14.04	10.035	0.720	0.415	X 101	12 900	357	255	18.3	10.5
X 61	17.9	13.89	9.995	0.645	0.375	X 91	11 500	353	254	16.4	9.5
W14 X 53	15.6	13.92	8.060	0.660	0.370	W360 X 79	10 100	354	205	16.8	9.4
X 48	14.1	13.79	8.030	0.595	0.340	X 72	9 100	350	204	15.1	8.6
X 43	12.6	13.66	7.995	0.530	0.305	X 64	8 130	347	203	13.5	7.7
W14 X 38	11.2	14.10	6.770	0.515	0.310	W360 X 57.8	7 230	358	172	13.1	7.9
X 34	10.0	13.98	6.745	0.455	0.285	X 51	6 450	355	171	11.6	7.2
X 30	8.85	13.84	6.730	0.385	0.270	X 44	5 710	352	171	9.8	6.9
W14 X 26	7.69	13.91	5.025	0.420	0.255	W360 X 39.0	4 960	353	128	10.7	6.5
X 22	6.49	13.74	5.000	0.335	0.230	X 32.9	4 190	349	127	8.5	5.8
W12 X 336	98.8	16.82	13.385	2.955	1.775	W310 X 500	63 700	427	340	75.1	45.1
X 305	89.6	16.32	13.235	2.705	1.625	X 454	57 800	415	336	68.7	41.3
X 279	81.9	15.85	13.140	2.470	1.530	X 415	52 800	403	334	62.7	38.9
X 252	74.1	15.41	13.005	2.250	1.395	X 375	47 800	391	330	57.2	35.4
X 230	67.7	15.05	12.895	2.070	1.285	X 342	43 700	382	328	52.6	32.6
X 210	61.8	14.71	12.790	1.900	1.180	X 313	39 900	374	325	48.3	30.0
X 190	55.8	14.38	12.670	1.735	1.060	X 283	36 000	365	322	44.1	26.9
X 170	50.0	14.03	12.570	1.560	0.960	X 253	32 300	356	319	39.6	24.4
X 152	44.7	13.71	12.480	1.400	0.870	X 226	28 800	348	317	35.6	22.1
X 136	39.9	13.41	12.400	1.250	0.790	X 202	25 700	341	315	31.8	20.1
X 120	35.3	13.12	12.320	1.105	0.710	X 179	22 800	333	313	28.1	18.0
X 106	31.2	12.89	12.220	0.990	0.610	X 158	20 100	327	310	25.1	15.5
X 96	28.2	12.71	12.160	0.900	0.550	X 143	18 200	323	309	22.9	14.0
X 87	25.6	12.53	12.125	0.810	0.515	X 129	16 500	318	308	20.6	13.1
X 79	23.2	12.38	12.080	0.735	0.470	X 117	15 000	314	307	18.7	11.9
X 72	21.1	12.25	12.040	0.670	0.430	X 107	13 600	311	306	17.0	10.9
X 65	19.1	12.12	12.000	0.605	0.390	X 97	12 300	308	305	15.4	9.9
W12 X 58	17.0	12.19	10.010	0.640	0.360	W310 X 86	11 000	310	254	16.3	9.1
X 53	15.6	12.06	9.995	0.575	0.345	X 79	10 100	306	254	14.6	8.8
W12 X 50	14.7	12.19	8.080	0.640	0.370	W310 X 74	9 480	310	205	16.3	9.4
X 45	13.2	12.06	8.045	0.575	0.335	X 67	8 520	306	204	14.6	8.5
X 40	11.8	11.94	8.005	0.515	0.295	X 60	7 610	303	203	13.1	7.5
W12 X 35	10.3	12.50	6.560	0.520	0.300	W310 X 52	6 650	317	167	13.2	7.6
X 30	8.79	12.34	6.520	0.440	0.260	X 44.5	5 670	313	166	11.2	6.6
X 26	7.65	12.22	6.490	0.380	0.230	X 38.7	4 940	310	165	9.7	5.8
W12 X 22	6.48	12.31	4.030	0.425	0.260	W310 X 32.7	4 180	313	102	10.8	6.6
X 19	5.57	12.16	4.005	0.350	0.235	X 28.3	3 590	309	102	8.9	6.0
X 16	4.71	11.99	3.990	0.265	0.220	X 23.8	3 040	305	101	6.7	5.6
X 14	4.16	11.91	3.970	0.225	0.200	X 21.0	2 680	303	101	5.7	5.1
W10 X 112	32.9	11.36	10.415	1.250	0.755	W250 X 167	21 200	289	265	31.8	19.2
X 100	29.4	11.10	10.340	1.120	0.680	X 149	19 000	282	263	28.4	17.3

TABLE A2.1 *Continued*

Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
X 88	25.9	10.84	10.265	0.990	0.605	X 131	16 700	275	261	25.1	15.4
X 77	22.6	10.60	10.190	0.870	0.530	X 115	14 600	269	259	22.1	13.5
X 68	20.0	10.40	10.130	0.770	0.470	X 101	12 900	264	257	19.6	11.9
X 60	17.6	10.22	10.080	0.680	0.420	X 89	11 400	260	256	17.3	10.7
X 54	15.8	10.09	10.030	0.615	0.370	X 80	10 200	256	255	15.6	9.4
X 49	14.4	9.98	10.000	0.560	0.340	X 73	9 290	253	254	14.2	8.6
W10 X 45	13.3	10.10	8.020	0.620	0.350	W250 X 67	8 580	257	204	15.7	8.9
X 39	11.5	9.92	7.985	0.530	0.315	X 58	7 420	252	203	13.5	8.0
X 33	9.71	9.73	7.960	0.435	0.290	X 49.1	6 260	247	202	11.0	7.4
W10 X 30	8.84	10.47	5.810	0.510	0.300	W250 X 44.8	5 700	266	148	13.0	7.6
X 26	7.61	10.33	5.770	0.440	0.260	X 38.5	4 910	262	147	11.2	6.6
X 22	6.49	10.17	5.750	0.360	0.240	X 32.7	4 190	258	146	9.1	6.1
W10 X 19	5.62	10.24	4.020	0.395	0.250	W250 X 28.4	3 630	260	102	10.0	6.4
X 17	4.99	10.11	4.010	0.330	0.240	X 25.3	3 220	257	102	8.4	6.1
X 15	4.41	9.99	4.000	0.270	0.230	X 22.3	2 850	254	102	6.9	5.8
X 12	3.54	9.87	3.960	0.210	0.190	X 17.9	2 280	251	101	5.3	4.8
W8 X 67	19.7	9.00	8.280	0.935	0.570	W200 X 100	12 700	229	210	23.7	14.5
X 58	17.1	8.75	8.220	0.810	0.510	X 86	11 000	222	209	20.6	13.0
X 48	14.1	8.50	8.110	0.685	0.400	X 71	9 100	216	206	17.4	10.2
X 40	11.7	8.25	8.070	0.560	0.360	X 59	7 550	210	205	14.2	9.1
X 35	10.3	8.12	8.020	0.495	0.310	X 52	6 650	206	204	12.6	7.9
X 31	9.13	8.00	7.995	0.435	0.285	X 46.1	5 890	203	203	11.0	7.2
W8 X 28	8.25	8.06	6.535	0.465	0.285	W200 X 41.7	5 320	205	166	11.8	7.2
X 24	7.08	7.93	6.495	0.400	0.245	X 35.9	4 570	201	165	10.2	6.2
W8 X 21	6.16	8.28	5.270	0.400	0.250	W200 X 31.3	3 970	210	134	10.2	6.4
X 18	5.26	8.14	5.250	0.330	0.230	X 26.6	3 390	207	133	8.4	5.8
W8 X 15	4.44	8.11	4.015	0.315	0.245	W200 X 22.5	2 860	206	102	8.0	6.2
X 13	3.84	7.99	4.000	0.255	0.230	X 19.3	2 480	203	102	6.5	5.8
X 10	2.96	7.89	3.940	0.205	0.170	X 15.0	1 910	200	100	5.2	4.3
W6 X 25	7.34	6.38	6.080	0.455	0.320	W150 X 37.1	4 740	162	154	11.6	8.1
X 20	5.87	6.20	6.020	0.365	0.260	X 29.8	3 790	157	153	9.3	6.6
X 15	4.43	5.99	5.990	0.260	0.230	X 22.5	2 860	152	152	6.6	5.8
W6 X 16	4.74	6.28	4.030	0.405	0.260	W150 X 24.0	3 060	160	102	10.3	6.6
X 12	3.55	6.03	4.000	0.280	0.230	X 18.0	2 290	153	102	7.1	5.8
X 9	2.68	5.90	3.940	0.215	0.170	X 13.5	1 730	150	100	5.5	4.3
X 8.5	2.52	5.83	3.940	0.194	0.170	X 13	1 630	148	100	4.9	4.3
W5 X 19	5.54	5.15	5.030	0.430	0.270	W130 X 28.1	3 590	131	128	10.9	6.9
X 16	4.68	5.01	5.000	0.360	0.240	X 23.8	3 040	127	127	9.1	6.1
W4 X 13	3.83	4.16	4.060	0.345	0.280	W100 X 19.3	2 470	106	103	8.8	7.1

[A]Actual flange and web thicknesses vary due to mill rolling practices; however, permissible variations for such dimensions are not addressed.

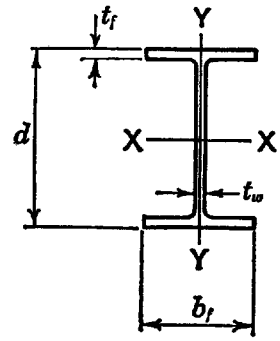
TABLE A2.2 "S" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area *A*, in.^{2}	Depth *d*, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area *a*, mm^2	Depth *d*, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
S 24 X 121	35.6	24.50	8.050	1.090	0.800	S 610 X 180	23 000	622	204	27.7	20.3
X 106	31.2	24.50	7.870	1.090	0.620	X 158	20 100	622	200	27.7	15.7
S 24 X 100	29.3	24.00	7.245	0.870	0.745	S 610 X 149	18 900	610	184	22.1	18.9
X 90	26.5	24.00	7.125	0.870	0.625	X 134	17 100	610	181	22.1	15.9
X 80	23.5	24.00	7.000	0.870	0.500	X 119	15 200	610	178	22.1	12.7
S 20 X 96	28.2	20.30	7.200	0.920	0.800	S 510 X 143	18 200	516	183	23.4	20.3
X 86	25.3	20.30	7.060	0.920	0.660	X 128	16 300	516	179	23.4	16.8
S 20 X 75	22.0	20.00	6.385	0.795	0.635	S 510 X 112	14 200	508	162	20.2	16.1
X 66	19.4	20.00	6.255	0.795	0.505	X 98.2	12 500	508	159	20.2	12.8
S 18 X 70	20.6	18.00	6.251	0.691	0.711	S 460 X 104	13 300	457	159	17.6	18.1
X 54.7	16.1	18.00	6.001	0.691	0.461	X 81.4	10 400	457	152	17.6	11.7
S 15 X 50	14.7	15.00	5.640	0.622	0.550	S 380 X 74	9 480	381	143	15.8	14.0
X 42.9	12.6	15.00	5.501	0.622	0.411	X 64	8 130	381	140	15.8	10.4
S 12 X 50	14.7	12.00	5.477	0.659	0.687	S 310 X 74	9 480	305	139	16.7	17.4
X 40.8	12.0	12.00	5.252	0.659	0.462	X 60.7	7 740	305	133	16.7	11.7
S 12 X 35	10.3	12.00	5.078	0.544	0.428	S 310 X 52	6 650	305	129	13.8	10.9
X 31.8	9.35	12.00	5.000	0.544	0.350	X 47.3	6 030	305	127	13.8	8.9
S 10 X 35	10.3	10.00	4.944	0.491	0.594	S 250 X 52	6 650	254	126	12.5	15.1
X 25.4	7.46	10.00	4.661	0.491	0.311	X 37.8	4 810	254	118	12.5	7.9
S 8 X 23	6.77	8.00	4.171	0.425	0.441	S 200 X 34	4 370	203	106	10.8	11.2
X 18.4	5.41	8.00	4.001	0.425	0.271	X 27.4	3 480	203	102	10.8	6.9
S 6 X 17.25	5.07	6.00	3.565	0.359	0.465	S 150 X 25.7	3 270	152	91	9.1	11.8
X 12.5	3.67	6.00	3.332	0.359	0.232	X 18.6	2 360	152	85	9.1	5.9
S 5 X 10	2.94	5.00	3.004	0.326	0.214	S 130 X 15	1 880	127	76	8.3	5.4
S 4 X 9.5	2.79	4.00	2.796	0.293	0.326	S 100 X 14.1	1 800	102	71	7.4	8.3
X 7.7	2.26	4.00	2.663	0.293	0.193	X 11.5	1 450	102	68	7.4	4.9
S 3 X 7.5	2.21	3.00	2.509	0.260	0.349	S 75 X 11.2	1 430	76	64	6.6	8.9
X 5.7	1.67	3.00	2.330	0.260	0.170	X 8.5	1 080	76	59	6.6	4.3

[A]Actual flange and web thicknesses vary due to mill rolling practices; however, permissible variations for such dimensions are not addressed.

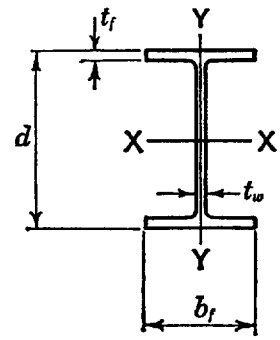
TABLE A2.3 "M" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
M 12 X11.8	3.47	12.00	3.065	0.225	0.177	M 310 X17.6	2 240	305	78	5.7	4.5
M 12 X10.8	3.18	11.97	3.065	0.210	0.160	M 310 X16.1	2 050	304	78	5.3	4.1
M 12 X10.0	2.94	11.97	3.250	0.180	0.149	M 310 X14.9	1 900	304	82.55	4.57	3.78
M 10 X9	2.65	10.00	2.690	0.206	0.157	M 250 X13.4	1 710	254	68	4.6	3.6
M 10 X8	2.35	9.95	2.690	0.182	0.141	M 250 X11.9	1 520	253	68	5.2	4.0
M 10 X7.5	2.21	9.99	2.688	0.173	0.130	M 250 X11.2	1 430	253.7	68.3	4.39	3.3
M 8 X6.5	1.92	8.00	2.281	0.189	0.135	M 200 X9.7	1 240	203	57	4.8	3.4
M 8 X6.2	1.81	8.00	2.281	0.177	0.129	M 200 X9.2	1 170	203.2	58	4.5	3.28
M 6 X4.4	1.29	6.00	1.844	0.171	0.114	M 150 X6.6	832	152.4	46.84	4.34	2.90
M 6 X3.7	1.09	5.922	2.00	0.129	0.0980	M 150 X5.5	703	150.4	50.8	3.28	2.49
M 5 X18.9	5.55	5.00	5.003	0.416	0.316	M 130 X28.1	3 580	127	127	10.6	8.0
M 4 X6	1.78	3.80	3.80	0.160	0.130	M 100 X8.9	1 150	97.0	96.52	4.06	3.30

[A]Actual flange and web thicknesses vary due to mill rolling practices; however, permissible variations for such dimensions are not addressed.

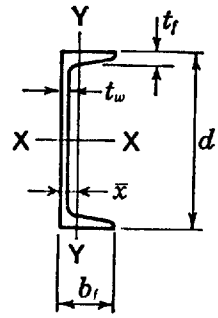
TABLE A2.4 "HP" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area *A*, in.^{2}	Depth *d*, in.	Flange		Web Thickness *tw*, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area *A*, mm^2	Depth *d*, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness, t_f, mm[A]	
HP14 X 117	34.4	14.21	14.885	0.805	0.805	HP360 X 174	22 200	361	378	20.4	20.4
X 102	30.0	14.01	14.785	0.705	0.705	X 152	19 400	356	376	17.9	17.9
X 89	26.1	13.83	14.695	0.615	0.615	X 132	16 800	351	373	15.6	15.6
X 73	21.4	13.61	14.585	0.505	0.505	X 108	13 800	346	370	12.8	12.8
HP12 X 84	24.6	12.28	12.295	0.685	0.685	HP310 X 125	15 900	312	312	17.4	17.4
X 74	21.8	12.13	12.215	0.610	0.605	X 110	14 100	308	310	15.5	15.4
X 63	18.4	11.94	12.125	0.515	0.515	X 93	11 900	303	308	13.1	13.1
X 53	15.5	11.78	12.045	0.435	0.435	X 79	10 000	299	306	11.0	11.0
HP10 X 57	16.8	9.99	10.225	0.565	0.565	HP250 X 85	10 800	254	260	14.4	14.4
X 42	12.4	9.70	10.075	0.420	0.415	X 62	8 000	246	256	10.7	10.5
HP8 X 36	10.6	8.02	8.155	0.445	0.445	HP200 X 53	6 840	204	207	11.3	11.3

[A]Actual flange and web thicknesses vary due to mill rolling practices; however, permissible variations for such dimensions are not addressed.

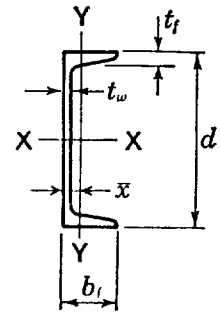
TABLE A2.5 "C" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area *A*, in.^{2}	Depth *d*, in.	Flange		Web Thickness *tw*, in.[A]	Designation [Nominal Depth in Millimetres in Mass in Kilograms per Metre]	Area *A*, mm^2	Depth *d*, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness t_f, mm[A]	
C 15 X 50	14.7	15.00	3.716	0.650	0.716	C 380 X 74	9 480	381	94	16.5	18.2
X 40	11.8	15.00	3.520	0.650	0.520	X 60	7 610	381	89	16.5	13.2
X 33.9	9.96	15.00	3.400	0.650	0.400	X 50.4	6 430	381	86	16.5	10.2
C 12 X 30	8.82	12.00	3.170	0.501	0.510	C 310 X 45	5 690	305	80	12.7	13.0
X 25	7.35	12.00	3.047	0.501	0.387	X 37	4 740	305	77	12.7	9.8
X 20.7	6.09	12.00	2.942	0.501	0.282	X 30.8	3 930	305	74	12.7	7.2
C 10 X 30	8.82	10.00	3.033	0.436	0.673	C 250 X 45	5 690	254	76	11.1	17.1
X 25	7.35	10.00	2.886	0.436	0.526	X 37	4 740	254	73	11.1	13.4
X 20	5.88	10.00	2.739	0.436	0.379	X 30	3 790	254	69	11.1	9.6
X 15.3	4.49	10.00	2.600	0.436	0.240	X 22.8	2 900	254	65	11.1	6.1
C 9 X 20	5.88	9.00	2.648	0.413	0.448	C 230 X 30	3 790	229	67	10.5	11.4
X 15	4.41	9.00	2.485	0.413	0.285	X 22	2 850	229	63	10.5	7.2
X 13.4	3.94	9.00	2.433	0.413	0.233	X 19.9	2 540	229	61	10.5	5.9
C 8 X 18.75	5.51	8.00	2.527	0.390	0.487	C 200 X 27.9	3 550	203	64	9.9	12.4
X 13.75	4.04	8.00	2.343	0.390	0.303	X 20.5	2 610	203	59	9.9	7.7
X 11.5	3.38	8.00	2.260	0.390	0.220	X 17.1	2 180	203	57	9.9	5.6
C 7 X 14.75	4.33	7.00	2.299	0.366	0.419	C 180 X 22	2 790	178	58	9.3	10.6
X 12.25	3.60	7.00	2.194	0.366	0.314	X 18.2	2 320	178	55	9.3	8.0
X 9.8	2.87	7.00	2.090	0.366	0.210	X 14.6	1 850	178	53	9.3	5.3
C 6 X 13	3.83	6.00	2.157	0.343	0.437	C 150 X 19.3	2 470	152	54	8.7	11.1
X 10.5	3.09	6.00	2.034	0.343	0.314	X 15.6	1 990	152	51	8.7	8.0
X 8.2	2.40	6.00	1.920	0.343	0.200	X 12.2	1 550	152	48	8.7	5.1
C 5 X 9	2.64	5.00	1.885	0.320	0.325	C 130 X 13	1 700	127	47	8.1	8.3
X 6.7	1.97	5.00	1.750	0.320	0.190	X 10.4	1 270	127	44	8.1	4.8
C 4 X 7.25	2.13	4.00	1.721	0.296	0.321	C 100 X 10.8	1 370	102	43	7.5	8.2
X 5.4	1.59	4.00	1.584	0.296	0.184	X 8	1 030	102	40	7.5	4.7
X 4.5	1.32	4.00	1.584	0.296	0.125	X 6.7	852	102	40	7.5	3.2
C 3 X 6	1.76	3.00	1.596	0.273	0.356	C 75 X 8.9	1 130	76	40	6.9	9.0
X 5	1.47	3.00	1.498	0.273	0.258	X 7.4	948	76	37	6.9	6.6
X 4.1	1.21	3.00	1.410	0.273	0.170	X 6.1	781	76	35	6.9	4.3
X 3.5	1.03	3.00	1.372	0.273	0.132	X 5.2	665	76	35	6.9	3.4

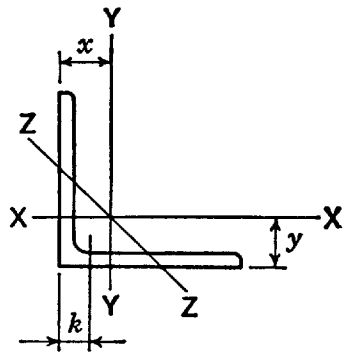
[A]Actual flange and web thicknesses vary due to mill rolling practices; however, permissible variations for such dimensions are not addressed.

TABLE A2.6 "MC" Shapes



Designation (Nominal Depth in Inches and Weight in Pounds per Linear Foot)	Area A, in.^{2}	Depth d, in.	Flange		Web Thickness t_w, in.[A]	Designation [Nominal Depth in Millimetres and Mass in Kilograms per Metre]	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm[A]
			Width b_f, in.	Thickness t_f, in.[A]					Width b_f, mm	Thickness t_f, mm	
MC 18 X 58	17.1	18.00	4.200	0.625	0.700	MC 460 X 86	11 000	457	107	15.9	17.8
X 51.9	15.3	18.00	4.100	0.625	0.600	X 77.2	9 870	457	104	15.9	15.2
X 45.8	13.5	18.00	4.000	0.625	0.500	X 68.2	8 710	457	102	15.9	12.7
X 42.7	12.6	18.00	3.950	0.625	0.450	X 63.5	8 130	457	100	15.9	11.4
MC 13 X 50	14.7	13.00	4.412	0.610	0.787	MC 330 X 74	9 480	330	112	15.5	20.0
X 40	11.8	13.00	4.185	0.610	0.560	X 60	7 610	330	106	15.5	14.2
X 35	10.3	13.00	4.072	0.610	0.447	X 52	6 640	330	103	15.5	11.4
X 31.8	9.35	13.00	4.000	0.610	0.375	X 47.3	6 030	330	102	15.5	9.5
MC 12 X 50	14.7	12.00	4.135	0.700	0.835	MC 310 X 74	9 480	305	105	17.8	21.2
X 45	13.2	12.00	4.010	0.700	0.710	X 67	8 502	305	102	17.8	18.0
X 40	11.8	12.00	3.890	0.700	0.590	X 60	7 610	305	98	17.8	15.0
X 35	10.3	12.00	3.765	0.700	0.465	X 52	6 620	305	96	17.8	11.8
X 31	9.12	12.00	3.670	0.700	0.370	X 46	5 890	305	93	17.8	9.4
MC 12 X 10.6	3.10	12.00	1.500	0.309	0.190	MC 310 X 15.8	2 000	305	38	7.8	4.8
MC 10 X 41.1	12.1	10.00	4.321	0.575	0.796	MC 250 X 61.2	7 810	254	110	14.6	20.2
X 33.6	9.87	10.00	4.100	0.575	0.575	X 50	6 370	254	104	14.6	14.6
X 28.5	8.37	10.00	3.950	0.575	0.425	X 42.4	5 400	254	100	14.6	10.8
MC 10 X 25	7.35	10.00	3.405	0.575	0.380	MC 250 X 37	4 740	254	86	14.6	9.7
X 22	6.45	10.00	3.315	0.575	0.290	X 33	4 160	254	84	14.6	7.4
MC 10 X 8.4	2.46	10.00	1.500	0.280	0.170	MC 250 X 12.5	1 590	254	38	7.1	4.3
MC 9 X 25.4	7.47	9.00	3.500	0.550	0.450	MC 230 X 37.8	4 820	229	88	14.0	11.4
X 23.9	7.02	9.00	3.450	0.550	0.400	X 35.6	4 530	229	87	14.0	10.2
MC 8 X 22.8	6.70	8.00	3.502	0.525	0.427	MC 200 X 33.9	4 320	203	88	13.3	10.8
X 21.4	6.28	8.00	3.450	0.525	0.375	X 31.8	4 050	203	87	13.3	9.5
MC 8 X 20	5.88	8.00	3.025	0.500	0.400	MC 200 X 29.8	3 790	203	76	12.7	10.2
X 18.7	5.50	8.00	2.978	0.500	0.353	X 27.8	3 550	203	75	12.7	9.0
MC 8 X 8.5	2.50	8.00	1.874	0.311	0.179	MC 200 X 12.6	1 610	203	47	7.9	4.5
MC 7 X 22.7	6.67	7.00	3.603	0.500	0.503	MC 180 X 33.8	4 300	178	91	12.7	12.8
X 19.1	5.61	7.00	3.452	0.500	0.352	X 28.4	3 620	178	87	12.7	8.9
MC 6 X 18	5.29	6.00	3.504	0.475	0.379	MC 150 X 26.8	3 410	152	88	12.1	9.6
X 15.3	4.50	6.00	3.500	0.385	0.340	X 22.8	2 900	152	88	9.8	8.6
MC 6 X 16.3	4.79	6.00	3.000	0.475	0.375	MC 150 X 24.3	3 090	152	76	12.1	9.5
X 15.1	4.44	6.00	2.941	0.475	0.316	X 22.5	2 860	152	74	12.1	8.0
MC 6 X 12	3.53	6.00	2.497	0.375	0.310	MC 150 X 17.9	2 280	152	63	9.5	7.9

TABLE A2.7 "L" Shapes (Equal Legs)

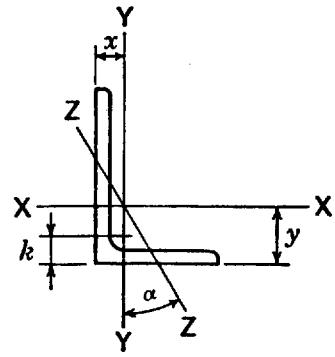


Size and Thickness, in.	Weight per Foot, lb	Area, in.^{2}	Size and Thickness, mm	Mass per Metre, kg	Area, mm^2
L8 × 8 × 1⅛	56.9	16.7	L203 × 203 × 28.6	84.7	10 800
L8 × 8 × 1	51.0	15.0	L203 × 203 × 25.4	75.9	9 680
L8 × 8 × ⅞	45.0	13.2	L203 × 203 × 22.2	67.0	8 502
L8 × 8 × ¾	38.9	11.4	L203 × 203 × 19.0	57.9	7 360
L8 × 8 × ⅝	32.7	9.61	L203 × 203 × 15.9	48.7	6 200
L8 × 8 × 9/16	29.6	8.68	L203 × 203 × 14.3	44.0	5 600
L8 × 8 × ½	26.4	7.75	L203 × 203 × 12.7	39.3	5 000
L6 × 6 × 1	37.4	11.0	L152 × 152 × 25.4	55.7	7 100
L6 × 6 × ⅞	33.1	9.73	L152 × 152 × 22.2	49.3	6 280
L6 × 6 × ¾	28.7	8.44	L152 × 152 × 19.0	42.7	5 450
L6 × 6 × ⅝	24.2	7.11	L152 × 152 × 15.9	36.0	4 590
L6 × 6 × 9/16	21.9	6.43	L152 × 152 × 14.3	32.6	4 150
L6 × 6 × ½	19.6	5.75	L152 × 152 × 12.7	29.2	3 710
L6 × 6 × 7/16	17.2	5.06	L152 × 152 × 11.1	25.6	3 270
L6 × 6 × ⅜	14.9	4.36	L152 × 152 × 9.5	22.2	2 810
L6 × 6 × 5/16	12.4	3.65	L152 × 152 × 7.9	18.5	2 360
L5 × 5 × ⅞	27.2	7.98	L127 × 127 × 22.2	40.5	5 150
L5 × 5 × ¾	23.6	6.94	L127 × 127 × 19.0	35.1	4 480
L5 × 5 × ⅝	20.0	5.86	L127 × 127 × 15.9	29.8	3 780
L5 × 5 × ½	16.2	4.75	L127 × 127 × 12.7	24.1	3 070
L5 × 5 × 7/16	14.3	4.18	L127 × 127 × 11.1	21.3	2 700
L5 × 5 × ⅜	12.3	3.61	L127 × 127 × 9.5	18.3	2 330
L5 × 5 × 5/16	10.3	3.03	L125 × 127 × 7.9	15.3	1 960
L4 × 4 × ¾	18.5	5.44	L102 × 102 × 19.0	27.5	3 510
L4 × 4 × ⅝	15.7	4.61	L102 × 102 × 15.9	23.4	2 970
L4 × 4 × ½	12.8	3.75	L102 × 102 × 12.7	19.0	2 420
L4 × 4 × 7/16	11.3	3.31	L102 × 102 × 11.1	16.8	2 140
L4 × 4 × ⅜	9.8	2.86	L102 × 102 × 9.5	14.6	1 850
L4 × 4 × 5/16	8.2	2.40	L102 × 102 × 7.9	12.2	1 550
L4 × 4 × ¼	6.6	1.94	L102 × 102 × 6.4	9.8	1 250
L3½ × 3½ × ½	11.1	3.25	L89 × 89 × 12.7	16.5	2 100
L3½ × 3½ × 7/16	9.8	2.87	L89 × 89 × 11.1	14.6	1 850
L3½ × 3½ × ⅜	8.5	2.48	L89 × 89 × 9.5	12.6	1 600
L3½ × 3½ × 5/16	7.2	2.09	L89 × 89 × 7.9	10.7	1 350
L3½ × 3½ × ¼	5.8	1.69	L89 × 89 × 6.4	8.6	1 090
L3 × 3 × ½	9.4	2.75	L76 × 76 × 12.7	14.0	1 770
L3 × 3 × 7/16	8.3	2.43	L76 × 76 × 11.1	12.4	1 570
L3 × 3 × ⅜	7.2	2.11	L76 × 76 × 9.5	10.7	1 360
L3 × 3 × 5/16	6.1	1.78	L76 × 76 × 7.9	9.1	1 150
L3 × 3 × ¼	4.9	1.44	L76 × 76 × 6.4	7.3	929
L3 × 3 × 3/16	3.71	1.09	L76 × 76 × 4.8	5.5	703
L2½ × 2½ × ½	7.7	2.25	L64 × 64 × 12.7	11.4	1 450
L2½ × 2½ × ⅜	5.9	1.73	L64 × 64 × 9.5	8.7	1 120
L2½ × 2½ × 5/16	5.0	1.46	L64 × 64 × 7.9	7.4	942
L2½ × 2½ × ¼	4.1	1.19	L64 × 64 × 6.4	6.1	768
L2½ × 2½ × 3/16	3.07	0.90	L64 × 64 × 4.8	4.6	581
L2 × 2 × ⅜	4.7	1.36	L51 × 51 × 9.5	7.0	877
L2 × 2 × 5/16	3.92	1.15	L51 × 51 × 7.9	5.8	742
L2 × 2 × ¼	3.19	0.938	L51 × 51 × 6.4	4.7	605

TABLE A2.7 *Continued*

Size and Thickness, in.	Weight per Foot, lb	Area, in.^{2}	Size and Thickness, mm	Mass per Metre, kg	Area, mm^2
L2 × 2 × 3/16	2.44	0.715	L51 × 51 × 4.8	3.6	461
L2 × 2 × 1/8	1.65	0.484	L51 × 51 × 3.2	2.4	312
L1 3/4 × 1 3/4 × 1/4	2.77	0.813	L44 × 44 × 6.4	4.1	525
L1 3/4 × 1 3/4 × 3/16	2.12	0.621	L44 × 44 × 4.8	3.1	401
L1 3/4 × 1 3/4 × 1/8	1.44	0.422	L44 × 44 × 3.2	2.1	272
L1 1/2 × 1 1/2 × 1/4	2.34	0.688	L38 × 38 × 6.4	3.4	444
L1 1/2 × 1 1/2 × 3/16	1.80	0.527	L38 × 38 × 4.8	2.7	340
L1 1/2 × 1 1/2 × 5/32	1.52	0.444	L38 × 38 × 4.0	2.2	286
L1 1/2 × 1 1/2 × 1/8	1.23	0.359	L38 × 38 × 3.2	1.8	232
L1 1/4 × 1 1/4 × 1/4	1.92	0.563	L32 × 32 × 6.4	2.8	363
L1 1/4 × 1 1/4 × 3/16	1.48	0.434	L32 × 32 × 4.8	2.2	280
L1 1/4 × 1 1/4 × 1/8	1.01	0.297	L32 × 32 × 3.2	1.5	192
L1 × 1 × 1/4	1.49	0.438	L25 × 25 × 6.4	2.2	283
L1 × 1 × 3/16	1.16	0.340	L25 × 25 × 4.8	1.8	219
L1 × 1 × 1/8	0.80	0.234	L25 × 25 × 3.2	1.2	151
L3/4 × 3/4 × 1/8	0.59	0.172	L19 × 19 × 3.2	0.9	111

TABLE A2.8 "L" Shapes (Unequal Legs)



Size and Thickness, in.	Weight per Foot, lb	Area, in²	Size and Thickness, mm	Mass per Metre, kg	Area, mm²
L8 × 6 × 1	44.2	13.0	L203 × 152 × 25.4	65.5	8 390
L8 × 6 × 7/8	39.1	11.5	L203 × 152 × 22.2	57.9	7 420
L8 × 6 × 3/4	33.8	9.94	L203 × 152 × 19.0	50.1	6 410
L8 × 6 × 5/8	28.5	8.36	L203 × 152 × 15.9	42.2	5 390
L8 × 6 × 9/16	25.7	7.56	L203 × 152 × 14.3	38.1	4 880
L8 × 6 × 1/2	23.0	6.75	L203 × 152 × 12.7	34.1	4 350
L8 × 6 × 7/16	20.2	5.93	L203 × 152 × 11.1	29.9	3 830
L8 × 4 × 1	37.4	11.0	L203 × 102 × 25.4	55.4	7 100
L8 × 4 × 3/4	28.7	8.44	L203 × 102 × 19.0	42.5	5 450
L8 × 4 × 9/16	21.9	6.43	L203 × 102 × 14.3	32.4	4 150
L8 × 4 × 1/2	19.6	5.75	L203 × 102 × 12.7	29.0	3 710
L8 × 4 × 7/8	33.1	9.73	L203 × 102 × 22.2	49.3	6 280
L8 × 4 × 5/8	24.2	7.11	L203 × 102 × 15.9	36.0	4 590
L8 × 4 × 7/16	17.2	5.06	L203 × 102 × 11.1	25.6	3 260
L7 × 4 × 3/4	26.2	7.69	L178 × 102 × 19.0	38.8	4 960
L7 × 4 × 5/8	22.1	6.48	L178 × 102 × 15.9	32.7	4 180
L7 × 4 × 1/2	17.9	5.25	L178 × 102 × 12.7	26.5	3 390
L7 × 4 × 3/8	13.6	3.98	L178 × 102 × 9.5	20.2	2 570
L7 × 4 × 7/16	15.7	4.62	L178 × 102 × 11.1	23.4	2 980
L6 × 4 × 7/8	27.2	7.98	L152 × 102 × 22.2	40.3	5 150
L6 × 4 × 3/4	23.6	6.94	L152 × 102 × 19.0	35.0	4 480
L6 × 4 × 5/8	20.0	5.86	L152 × 102 × 15.9	29.6	3 780
L6 × 4 × 9/16	18.1	5.31	L152 × 102 × 14.3	26.8	3 430
L6 × 4 × 1/2	16.2	4.75	L152 × 102 × 12.7	24.0	3 060
L6 × 4 × 7/16	14.3	4.18	L152 × 102 × 11.1	21.2	2 700
L6 × 4 × 3/8	12.3	3.61	L152 × 102 × 9.5	18.2	2 330
L6 × 4 × 5/16	10.3	3.03	L152 × 102 × 7.9	15.3	1 950
L6 × 3½ × 1/2	15.3	4.50	L152 × 89 × 12.7	22.7	2 900
L6 × 3 ½ × 3/8	11.7	3.42	L152 × 89 × 9.5	17.3	2 210
L6 × 3½ × 5/16	9.8	2.87	L152 × 89 × 7.9	14.5	1 850
L5 × 3½ × 3/4	19.8	5.81	L127 × 89 × 19.0	29.3	3 750
L5 × 3½ × 5/8	16.8	4.92	L127 × 89 × 15.9	24.9	3 170
L5 × 3½ × 1/2	13.6	4.00	L127 × 89 × 12.7	20.2	2 580
L5 × 3½ × 3/8	10.4	3.05	L127 × 89 × 9.5	15.4	1 970
L5 × 3½ × 5/16	8.7	2.56	L127 × 89 × 7.9	12.9	1 650
L5 × 3½ × 1/4	7.0	2.06	L127 × 89 × 6.4	10.4	1 330
L5 × 3 × 1/2	12.8	3.75	L127 × 76 × 12.7	19.0	2 420
L5 × 3 × 7/16	11.3	3.31	L127 × 76 × 11.1	16.7	2 140
L5 × 3 × 3/8	9.8	2.86	L127 × 76 × 9.5	14.5	1 850
L5 × 3 × 5/16	8.2	2.40	L127 × 76 × 7.9	12.1	1 550
L5 × 3 × 1/4	6.6	1.94	L127 × 76 × 6.4	9.8	1 250
L4 × 3½ × 1/2	11.9	3.50	L102 × 89 × 12.7	17.6	2 260
L4 × 3½ × 3/8	9.1	2.67	L102 × 89 × 9.5	13.5	1 720
L4 × 3½ × 5/16	7.7	2.25	L102 × 89 × 7.9	11.4	1 450
L4 × 3½ × 1/4	6.2	1.81	L102 × 89 × 6.4	9.2	1 170

TABLE A2.8 *Continued*

Size and Thickness, in.	Weight per Foot, lb	Area, in²	Size and Thickness, mm	Mass per Metre, kg	Area, mm²
L4 × 3 × 5/8	13.6	3.98	L102 × 76 × 15.9	20.2	2 570
L4 × 3 × 1/2	11.1	3.25	L102 × 76 × 1.27	16.4	2 100
L4 × 3 × 3/8	8.5	2.48	L102 × 76 × 9.5	12.6	1 600
L4 × 3 × 5/16	7.2	2.09	L102 × 76 × 7.9	10.7	1 350
L4 × 3 × 1/4	5.8	1.69	L102 × 76 × 6.4	8.6	1 090
L3½ × 3 × 1/2	10.2	3.00	L89 × 76 × 12.7	15.1	1 940
L3½ × 3 × 7/16	9.1	2.65	L89 × 76 × 11.1	13.5	1 710
L3½ × 3 × 3/8	7.9	2.30	L89 × 76 × 9.5	11.7	1 480
L3½ × 3 × 5/16	6.6	1.93	L89 × 76 × 7.9	9.8	1 250
L3½ × 3 × 1/4	5.4	1.56	L89 × 76 × 6.4	8.0	1 010
L3½ × 2½ × 1/2	9.4	2.75	L89 × 64 × 12.7	13.9	1 770
L3½ × 2½ × 3/8	7.2	2.11	L89 × 64 × 9.5	10.7	1 360
L3½ × 2½ × 5/16	6.1	1.78	L89 × 64 × 7.9	9.0	1 150
L3½ × 2½ × 1/4	4.9	1.44	L89 × 64 × 6.4	7.3	929
L3 × 2½ × 1/2	8.5	2.50	L76 × 64 × 12.7	12.6	1 610
L3 × 2½ × 7/16	7.6	2.21	L76 × 64 × 11.1	11.3	1 430
L3 × 2½ × 3/8	6.6	1.92	L76 × 64 × 9.5	9.8	1 240
L3 × 2½ × 5/16	5.6	1.62	L76 × 64 × 7.9	8.3	1 050
L3 × 2½ × 1/4	4.5	1.31	L76 × 64 × 6.4	6.7	845
L3 × 2½ × 3/16	3.39	0.996	L76 × 64 × 4.8	5.1	643
L3 × 2 × 1/2	7.7	2.25	L76 × 51 × 12.7	11.5	1 450
L3 × 2 × 3/8	5.9	1.73	L76 × 51 × 9.5	8.8	1 120
L3 × 2 × 5/16	5.0	1.46	L76 × 51 × 7.9	7.4	942
L3 × 2 × 1/4	4.1	1.19	L76 × 51 × 6.4	6.1	768
L3 × 2 × 3/16	3.07	0.902	L76 × 51 × 4.8	4.6	582
L2½ × 2 × 3/8	5.3	1.55	L64 × 51 × 9.5	7.9	1 000
L2½ × 2 × 5/16	4.5	1.31	L64 × 51 × 7.9	6.7	845
L2½ × 2 × 1/4	3.62	1.06	L64 × 51 × 6.4	5.4	684
L2½ × 2 × 3/16	2.75	0.809	L64 × 51 × 4.8	4.2	522
L2½ × 1½ × 1/4	3.19	0.938	L64 × 38 × 6.4	4.8	605
L2½ × 1½ × 3/16	2.44	0.715	L64 × 38 × 4.8	3.6	461
L2 × 1½ × 1/4	2.77	0.813	L51 × 38 × 6.4	4.2	525
L2 × 1½ × 3/16	2.12	0.621	L51 × 38 × 4.8	3.1	401
L2 × 1½ × 1/8	1.44	0.422	L51 × 38 × 3.2	2.1	272

APPENDIXES

(Nonmandatory Information)

X1. COILED PRODUCT AS A SOURCE OF STRUCTURAL PLATES, SHAPES, SHEET PILING, AND BARS

X1.1 Continuous wide hot strip rolling mills are normally equipped with coilers. Regardless of the different types of systems employed during or following the rolling operations, it is common for the steel to be reeled into the coiler at temperatures in the stress-relieving range. In general, these temperatures are higher as material thickness increases. The coils subsequently cool to ambient temperature with outer and inner laps cooling more rapidly than central laps. The difference in cooling rate can result in measurable differences in the mechanical properties throughout a coil. Data confirm reduced yield and tensile strength with increased percent elongation for the product with slower cooling rates from the coiling temperature to ambient. These differences are in addition to the effects on mechanical properties caused by differences in heat analysis and chemical segregation.

X2. VARIATION OF TENSILE PROPERTIES IN PLATES AND STRUCTURAL SHAPES

X2.1 The tension testing requirements of Specification A 6/A 6M are intended only to characterize the tensile properties of a heat of steel for determination of conformance to the requirements of the material specifications. These testing procedures are not intended to define the upper or lower limits of tensile properties at all possible test locations within a heat of steel. It is well known and documented that tensile properties will vary within a heat or individual piece of steel as a function of chemical composition, processing, testing procedure and other factors. It is, therefore, incumbent on designers and engineers to use sound engineering judgement when using tension test results shown on mill test reports. The testing procedures of Specification A 6/A 6M have been found to provide material adequate for normal structural design criteria.

X2.2 A survey of the variation to be expected in tensile properties obtained from plates and structural shapes was conducted by the American Iron and Steel Institute (AISI).[11] The results of this survey are contained in a *Contributions to the Metallurgy of Steel*entitled "The Variation of Product Analysis and Tensile Properties—Carbon Steel Plates and Wide Flange Shapes" (SU/18, SU/19 and SU/20), published in September 1974. The data are presented in tables of probability that tensile properties at other than the official location may differ from those of the reported test location.

X2.3 Specification A 6/A 6M contains no requirements applicable to product tension tests; conformance to the material specifications is determined on the basis of tests performed at the place of manufacture prior to shipment, unless otherwise specified.

X2.4 A Task Group of ASTM Subcommittee A01.02 has determined, based on review of the AISI data,[9] that the variation in tensile properties of plates and structural shapes can be expressed as a function of specified requirements: one standard deviation equals approximately 4 % of required tensile strength, 8 % of required yield strength, and 3 percentage units of required elongation.

X2.5 Acceptance criteria for product testing based on these values either below the minimum or above the maximum allowed by the material specification are generally acceptable to material manufacturers. Such tolerances could be considered by users of this product as a reasonable basis for acceptance of materials which, due to their inherent variability, deviate from material specification requirements when subjected to product tension testing.

[11] Originally published by the American Iron and Steel Institute, 1133 15th St., N.W., Washington, DC 20005. Available from ASTM Headquarters as PCN: 29-000390-02.

X3. WELDABILITY OF STEEL

X3.1 *Weldability* is a term that usually refers to the relative ease with which a metal can be welded using conventional practice. Difficulties arise in steel when the cooling rates associated with weld thermal cycles produce microstructures (for example, martensite) that are susceptible to brittle fracture or, more commonly, hydrogen-induced (or *cold*) cracking.[12] (Solidification or *hot*cracking is a relatively rare phenomenon that will not be addressed here. See Randall[13] for further information.)

X3.2 The relative sensitivity of steels to forming cold cracking microstructures is called hardenability and can be measured in a number of ways. Perhaps the most popular method of assessing this is by the carbon equivalent (CE) formula, which attempts to equate the relative hardening contributions of a steel's constituent elements (for example, manganese, vanadium) to an equivalent amount of carbon, which is the most significant hardening agent. The most popular formula is the IIW (International Institute of Welding) equation presented in S74.2, which has been found suitable for predicting hardenability in a wide range of commonly used carbon-manganese and low alloy steels.[14]

X3.3 It should be noted, however, that for the current generation of low carbon (<0.10 %) low alloy steels that derive strength from a combination of microalloys and thermal processing methods the use of other formulae may more accurately assess hardenability and cold cracking sensitivity.[15]

X3.4 For a vast number of common structural applications it is unnecessary to specify the use of CE limits. However, in order to obtain a higher level of confidence in avoiding cold cracking, the chemistry controls in S74 are available. A purchaser who specifies the use of S74 should be aware that there are several factors involved in the judicious selection of a maximum CE value, such as the following:

X3.4.1 Actual production joint restraint/base metal thickness(es),

X3.4.2 Filler metal and base metal strength compatibility,

X3.4.3 Deposited weld metal diffusible hydrogen content,

X3.4.4 Preheat and interpass temperatures,

X3.4.5 Filler metal and base metal cleanliness, and

[12] Graville, B. A., *The Principles of Cold Cracking Control in Welds*, Dominion Bridge Company, 1975.

[13] Randall, M. D., "Welding Procedure Factors Affecting Weldability for Service," *Weldability of Steels*, by Stout and Doty, Welding Research Council.

[14] Bailey, N., "The Development and Use of Carbon Equivalent in Britain," *Hardenability of Steels*, Abington Publishing, 1990.

[15] International Institute of Welding, "Guide to the Metallurgy of Welding and Weldability of Low Carbon Microalloyed Hot Rolled Steels," Document IIS/IIW-843-87.

X3.4.6 Heat input.

X3.5 Though it is widely believed that *low* CE steels are immune to weld cracking problems, failure to consider these factors and others have resulted in weld or base metal HAZ (heat affected zone) cracks in such steels.[13]

X3.6 It is important to note that carbon equivalence is only a qualitative assessment of potential welding problems, and should never be solely relied on to ensure weld integrity. The proper use of welding specifications, coupled with the knowledge of actual construction conditions, must also be used.

X4. RADIUS FOR COLD BENDING

X4.1 Suggested minimum inside bend radii for cold forming are referenced to Group Designations A to F inclusive as defined in Table X4.1. The suggested radii listed in Table X4.2 should be used as minimums in typical shop fabrication. Material that does not form satisfactorily when fabricated in accordance with Table X4.2 may be subject to rejection pending negotiation with the steel supplier. When tighter bends are required, the manufacturer should be consulted.

X4.2 The bend radius and the radius of the male die should be as liberal as the finished part will permit. The width across the shoulders of the female die should be at least eight times the plate thickness. Higher strength steels require larger die openings. The surface of the dies in the area of radius should be smooth.

TABLE X4.1 Group Designations for Cold Bending

Specification	Grade	Group Designation[A]
A 36/A 36M	[B]	B
A 242/A 242M	[B]	C
A 283/A 283M	A or B	A
	C or D	B
A 514/A 514M	any	F
A 529/A 529M	50 [345] or 55 [380]	C
A 572/A 572M	42 [290]	B
	50 [345]	C
	55 [380]	D
	60 [415] or 65 [450]	E
A 573/A 573M	58 [400] or 65 [450]	B
	70 [485]	C
A 588/A 588M	any	C
A 633/A 633M	any	B
A 656/A 656M	50 [345]	B
	60 [415]	D
	70 [485]	E
	80 [550]	F
A 678/A 678M	A or B	C
	C or D	D
A 690/A 690M	[B]	C
A 709/A 709M	36 [250]	B
	50 [345] or 50W [345W]	C
	70W [485W] or HPS70W [HPS485W]	D
	100 [690] or 100W [690W]	F
A 710/A 710M	A	F
A 808/A 808M	[B]	C
A 852/A 852M	[B]	D
A 871/A 871M	60 [415] or 65 [450]	E
A 945/A 945M	50 [345] or 65 [450]	B

[A]Steels having a ratio of specified minimum tensile strength to specified minimum yield strength of 1.15 or less are in Group F; other steels are in Groups A to E inclusive, which are grouped on the basis of their having similar specified values for minimum elongation in 2 in. [50 mm].

[B]Grade designations are not applicable for this specification.

TABLE X4.2 Suggested Minimum Inside Radii for Cold Bending[A]

Group Designation[B]	Thickness (t), in. [mm]			
	Up to ¾ in. [20 mm]	Over ¾ in. [20 mm] To 1 [25 mm, incl.]	Over 1 in. [25 mm] To 2 in. [50 mm], incl.	Over 2 in. [50 mm]
A	1.5t	1.5t	1.5t	1.5t
B	1.5t	1.5t	1.5t	2.0t
C	1.5t	1.5t	2.0t	2.5t
D	1.5t	1.5t	2.5t	3.0t
E	1.5t	1.5t	3.0t	3.5t
F	1.75t	2.25t	4.5t	5.5t

[A]Values are for bend lines perpendicular to the direction of final rolling. These radii apply when the precautions listed in X4.2 are followed. If bend lines are parallel to the direction of final rolling, multiply values by 1.5.

[B]Steel specifications included in the group designations may not include the entire thickness range shown in this table.

X4.2.1 Since cracks in cold bending commonly originate from the outside edges, shear burrs and gas cut edges should be removed by grinding. Sharp corners on edges and on punched or gas cut holes should be removed by chamfering or grinding to a radius.

X4.2.2 If possible, parts should be formed such that the bend line is perpendicular to the direction of final rolling. If it is necessary to bend with the bend line parallel to the direction of final rolling, a more generous radius is suggested (1½times applicable value given in Table X4.2 for bend lines perpendicular to the direction of rolling).

X4.3 *References:*

X4.3.1 Holt, G. E., et al, "Minimum Cold Bend Radii Project—Final Report," Concurrent Technologies Corporation, January 27, 1997.

X4.3.2 Brockenbrough, R. L., "Fabrication Guidelines for Cold Bending," R. L. Brockenbrough & Associates, June 28, 1998.

X4.3.3 Both of these references are available from American Iron and Steel Institute, 1101 17th Street NW, Washington, DC 20036-4700.