Designation: A 6/A 6M – 02

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 permitted variations in dimensions and mass (Note 1) in SI units. The values listed are not exact conversions of the values in Tables 1 to 31 inclusive 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 bending.

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,

[1] This specification is under the jurisdiction of ASTM Committee A01 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.

provided that such requirements do not negate any of the 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, ordered to thickness or weight and typically width and length, commonly 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 [Mass]*:

(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 *Discussion*—Steel products are available in various thickness, width, and length combinations depending upon equipment and processing capabilities of various manufacturers and processors. Historic limitations of a product based upon dimensions (thickness, width, and length) do not take into account current production and processing capabilities. To qualify any product to a particular product specification requires all appropriate and necessary tests be performed and that the results meet the limits prescribed in that product specification. If the necessary tests required by a product specification cannot be conducted, the product cannot be qualified to that specification. This general requirement standard contains permitted variations for the commonly available sizes. Permitted variations for other sizes are subject to agreement between the customer and the manufacturer or processor, whichever is applicable.

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

3.1.1.5 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 5.4.2 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] *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.

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.

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 × 8.5 to 25 incl [W150 × 13 to 37.1 incl] W5 × 16 & 19 [W130 × 23.8& 28.1] W4 × 13 [W100 × 19.3]	W40 × 149 to 249 incl [W1000 × 222 to 371 incl] W36 × 135 to 210 incl [W920 × 201 to 313 incl] W33 × 118 to 169 incl [W840 × 176 to 251 incl] W30 × 90 to 211 incl [W760 × 134 to 314 incl] W27 × 84 to 178 incl [W690 × 125 to 265 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]	W44 × 230 to 335 incl [W1100 × 343 to 499 incl] W40 × 264 to 331 incl [W1000 × 393 to 494 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 201 incl [W530 × 248 to 300 incl] W18 × 158 to 192 incl [W460 × 235 to 260 incl] W14 × 145 to 211 incl [W360 × 216 to 314 incl] W12 × 120 to 190 incl [W310 × 179 to 283 incl]	W40 × 362 to 593 incl [W1000 × 539 to 883 incl] W36 × 328 to 798 incl [W920 × 488 to 1188 incl] W33 × 318 to 387 incl [W840 × 473 to 576 incl] W30 × 292 to 391 incl [W760 × 434 to 582 incl] W27 × 281 to 539 incl [W690 × 419 to 802 incl] W24 × 250 to 370 incl [W610 × 372 to 551 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]	W14 × 605 to 730 incl [W360 × 900 to 1086 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.

3.1.19 *fine grain practice*—a steelmaking practice that is intended to produce a killed steel that is capable of meeting the requirements for fine austenitic grain size.

3.1.19.1 *Discussion*—It normally involves the addition of one or more austenitic grain refining elements in amounts that have been established by the steel producer as being sufficient. Austenitic grain refining elements include, but are not limited to, aluminum, columbium, titanium, and vanadium.

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 6), 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 5.3 and Appendix X1), if applicable,

4.1.9 Heat treatment requirements (see 6.2 and 6.3), if any,

4.1.10 Testing for fine austenitic grain size (see 8.3.2),

4.1.11 Mechanical property test report requirements (see Section 14), if any,

4.1.12 Special packaging, marking, and loading for shipment requirements (see Section 19), if any,

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

4.1.14 End use, if there are any end-use-specific requirements (see 18.1, 11.3.4, Table 22 or Table A1.22, and Table 24 or Table A1.24)

4.1.15 Special requirements (see 1.10), if any, and

4.1.16 Repair welding requirements (see 9.5), if any.

5. Materials and Manufacture

5.1 The steel shall be made in an open-hearth, basic-oxygen, or electric-arc furnace, possibly followed by additionl refining in a ladle metallurgy furnace (LMF), or secondary melting by vacuum-arc remelting (VAR) or electroslag remelting (ESR).

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

5.2.1 *Strand Cast*:

5.2.1.1 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.

5.2.1.2 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.

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

5.3.1 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.

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

5.4 When structural products are produced from coils:

5.4.1 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.

5.4.2 The processor decoils, forms, cuts to length, and marks; performs and certifies tests, examinations, repairs, and inspection; and except as allowed by Section 6, performs operations not intended to affect the properties of the material. Specific sections of this specification for which the processor is responsible are 9, 10, 11, 18, 12, 15, 13, 14, and 19.

5.4.3 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.

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

6. Heat Treatment

6.1 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 2—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.

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

6.2.1 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.

6.3 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.

6.4 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.

6.5 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].

7. Chemical Analysis

7.1 *Heat Analysis*:

7.1.1 Sampling for chemical analysis and methods of analysis shall be in accordance with Test Methods, Practices, and Terminolgy A 751.

7.1.2 For each heat, the heat analysis shall include determination of the content of carbon, manganese, phosphorus, sulfur, silicon, nickel, chromium, molybdenum, copper, vanadium, columbium; any other element that is specified or restricted by the applicable product specification for the applicable grade, class, and type; and any austenitic grain refining element whose content is to be used in place of austenitic grain size testing of the heat (see 8.3.2).

7.1.3 Except as allowed by 7.1.4 for primary heats, heat analyses shall conform to the heat analysis requirements of the applicable product specification for the applicable grade, class, and type.

7.1.4 Where vacuum-arc remelting or electroslag remelting is used, a remelted heat is defined as all ingots remelted from a single primary heat. If the heat analysis of the primary heat conforms to the heat analysis requirements of the applicable product specification for the applicable grade, class, and type, the heat analysis for the remelted heat shall be determined from one test sample taken from one remelted ingot, or the product of one remelted ingot, from the primary heat. If the heat analysis of the primary heat does not conform to the heat analysis requirements of the applicable product specification for the applicable grade, type, and class, the heat analysis for the remelted heat shall be determined from one test sample taken from each remelted ingot, or the product of each remelted ingot, from the primary heat.

7.2 *Product Analysis*—For each heat, the purchaser shall have the option of analyzing representative samples taken from the finished structural product. Sampling for chemical analysis and methods of analysis shall be in accordance with Test Methods, Practices, and Terminology A 751. The product analyses so determined shall conform to the heat analysis requirements of the applicable product specification for the applicable grade, class, and type, subject to the permitted variations in product analysis given 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.

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

7.4 *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.

8. Metallurgical Structure

8.1 Where austenitic grain size testing is required, such testing shall be in accordance with Test Methods E 112 and at least 70 % of the grains in the area examined shall meet the specified grain size requirement.

8.2 *Coarse Austenitic Grain Size*—Where coarse austenitic grain size is specified, one austenitic grain size test per heat shall be made and the austenitic grain size number so determined shall be in the range of 1 to 5, inclusive.

8.3 *Fine Austenitic Grain Size*:

8.3.1 Where fine austenitic grain size is specified, except as allowed in 8.3.2, one austenitic grain size test per heat shall be made and the austenitic grain size number so determined shall be 5 or higher.

NOTE 3—Such austenitic grain size numbers may be achieved with lower contents of austenitic grain refining elemenst than 8.3.2 requires for austenitic grain size testing to be waived.

8.3.2 Unless testing for fine austenitic grain size is specified in the purchase order, an austenitic grain size test need not be made for any heat that has, by heat analysis, one or more of the following:

8.3.2.1 A total aluminum content of 0.020% or more.

8.3.2.2 An acid soluble aluminum content of 0.015% or more.

8.3.2.3 A content for an austenitic grain refining element that exceeds the minimum value agreed to by the purchaser as being sufficient for austenitic grain size testing to be waived, or

8.3.2.4 Contents for the combination of two or more austenitic grain refining elements that exceed the applicable minimum values agreed to by the purchaser as being sufficient for austenitic grain size testing to be waived.

9. Quality

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

NOTE 4—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 9.2, 9.3, and 9.4 limit the conditioning allowed to be performed by the manufacturer. Conditioning of imperfections beyond the limits of 9.2, 9.3, and 9.4 may be performed by parties other than the manufacturer at the discretion of the *purchaser.*

TABLE B Permitted Variations in Product Analysis

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

Element	Upper Limit, or Maximum Specified Value, %	Permitted Variations, %	
		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	...	[B]
Sulfur	to 0.06 incl	...	0.010
	over 0.06	[B]	[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
Vanadium	to 0.10 incl	0.01[C]	0.01
	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	[B]	[B]
Columbium	to 0.10 incl	0.01[C]	0.01
Zirconium	to 0.15 incl	0.03	0.03
Nitrogen	to 0.030 incl	0.005	0.005

[A] Permitted variations in manganese content for bars and bar size shapes shall be: to 0.90 incl ±0.03; over 0.90 to 2.20 incl± 0.06.
[B] Product analysis not applicable.
[C] 0.005, if the minimum of the range is 0.01 %.

Index to Tables of Permitted 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
End 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

9.2 *Plate Conditioning*:

9.2.1 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.

9.2.2 The deposition of weld metal (see 9.5) 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:

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

9.2.2.2 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.)

9.2.3 The deposition of weld metal (see 9.5) 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.

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

9.3.1 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*) 1⁄16 in. [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.

9.3.2 The deposition of weld metal (see 9.5) following removal of imperfections that are greater in depth than the limits listed in 9.3.1 shall be subject to the following limiting conditions:

9.3.2.1 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.

9.3.2.2 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 9.3.2.3.

9.3.2.3 The deposition of weld metal (see 9.5) 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.

9.3.2.4 The deposition of weld metal (see 9.5) 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 not exceed 2 % of the total surface area of the piece.

9.4 *Bar Conditioning*:

9.4.1 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 applicable permitted variations (see Section 12).

9.4.2 The deposition of weld metal (see 9.5) following chipping or grinding to remove imperfections that are greater in depth than the limits listed in 9.4.1 shall be subject to the following conditions:

9.4.2.1 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.

9.4.2.2 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.

9.4.2.3 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.

9.5 *Repair by Welding*:

9.5.1 *General Requirements*:

9.5.1.1 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.

9.5.1.2 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.

9.5.1.3 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.

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

9.5.1.5 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.

9.5.1.6 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.

9.5.1.7 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.

9.5.1.8 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.

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

9.5.2 *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:

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

9.5.2.2 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.

9.5.2.3 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.

9.5.2.4 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.

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

9.5.3 *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.

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

9.5.4.1 Imperfections have been completely removed.

9.5.4.2 The limitations specified above have not been exceeded.

9.5.4.3 Established welding procedures have been followed, and

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

10. Test Methods

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

10.2 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.

10.3 *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.

10.4 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 12.1).

11. Tension Tests

11.1 *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.

11.1.1 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:

11.1.1.1 The gage length of the tension test specimen shall be taken at least 1*T* 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.

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

11.1.1.3 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 11.1.1.2.

11.1.1.4 When test coupons cut from the plate but heat treated separately are used, the coupon dimensions shall be not less than 3*T* by 3*T* by *T* and each tension specimen cut from it shall meet the requirements of 11.1.1.1.

11.1.1.5 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.

11.2 *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.

11.3 *Location*:

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

11.3.2 *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.

11.3.3 *Shapes Other Than Those in 11.3.2*—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 11.6.2)

11.3.4 *Bars*:

11.3.4.1 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.

11.3.4.2 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.

11.4 *Test Frequency*:

11.4.1 *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:

11.4.1.1 As given in Table C, or

11.4.1.2 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.

11.4.2 *Structural Products Produced from Coils*:

11.4.2.1 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.

11.4.2.2 Except as required by 11.4.2.3, 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.

11.4.2.3 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.

11.5 *Preparation*:

11.5.1 *Plates*:

11.5.1.1 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.

11.5.1.2 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 limitation that adequate testing machine capacity is available.

11.5.1.3 For plates over ¾ in. [20 mm] in thickness, except as permitted in 11.5.1.2, 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.

11.5.2 *Shapes*:

11.5.2.1 Except when angles are tested in full section, tension test specimens for shapes ¾ in. [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.

11.5.2.2 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 ⅜ 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
⅜ to 2 in. [10 to 50 mm], incl	Less than ⅜ 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
	⅜ 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 11.4.2.2 and 11.4.2.3 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.

11.5.2.3 For shapes over ¾ in. [20 mm] in thickness, except as permitted in 11.5.2.2, 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.

11.5.3 *Bars*:

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

11.5.3.2 Except as provided in 11.5.3.5, test specimens for bars ¾ 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.

11.5.3.3 Except as provided in 11.5.3.4 and 11.5.3.5, test specimens for bars over ¾ 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.

11.5.3.4 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 ¾ in. [20 mm] for a length of at least 9 in. [230 mm].

11.5.3.5 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.

11.6 *Elongation Requirement Adjustments*:

11.6.1 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.

11.6.2 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.

11.6.3 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

11.6.4 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 5—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.

11.6.5 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.

11.7 *Yield Strength Application*:

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

11.7.2 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.

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

11.8 *Product Tension Tests*—This specification does not provide requirements for product tension testing subsequent to shipment (see 15.1). Therefore, the requirements of 11.1 to11.7 inclusive and Section 13 apply only for tests conducted at the place of manufacture prior to shipment.

NOTE 6—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.

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

12. Permitted Variations in Dimensions and Weight [Mass]

12.1 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.

12.2 *Plates*—The permitted 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.

12.3 *Shapes*:

12.3.1 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.

12.3.2 The permitted variations in dimensions shall not exceed the applicable limits in Tables 16-25 [Annex A1, Tables A1.16 to A1.25], inclusive. Permitted variations for special shapes not listed in such tables shall be as agreed upon between the manufacturer and the purchaser.

NOTE 7—Permitted variations are given in Tables 16 to 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.

12.3.3 *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.

12.4 *Sheet Piling*—The weight [mass] 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 be not less than the specified length, and not more than 5 in. [125 mm] over the specified length..

12.5 *Hot-Rolled Bars*—The permitted variations in dimensions shall not exceed the applicable limits in Tables 26-31 [Annex A1, Tables A1.26 to A1.31], inclusive.

13. Retests

13.1 If any test specimen shows defective machining or

TABLE 1 Permitted 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 permitted variations in dimensions and weight stated in inch-pound units.
NOTE 2—Permitted variation under specified thickness, 0.01 in.
NOTE 3—Thickness to be measured at ⅜to ¾ in. from the longitudinal edge.
NOTE 4—For thicknesses measured at any location other than that specified in Note 3, the permitted variations over specified thickness shall be 1¾ times the amounts in this table, rounded to the nearest 0.01 in.
NOTE 5—Where "..." appears in this table, there is no requirement.

Specified Thickness, in.	Permitted Variations Over Specified Thickness for Widths Given in Inches, 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 Permitted Variations in Weight for Rectangular Sheared Plates and Universal Mill Plates 613.0 lb/ft² and Under When Ordered to Weight

NOTE 1—Permitted variations in overweight for lots of circular and sketch plates shall be 1¼ times the amounts in this table.
NOTE 2—Permitted variations in overweight for single plates shall be 1⅓ times the amounts in this table.
NOTE 3—Permitted 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	Permitted Variations 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.

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

13.2 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.

13.3 Except as provided in 13.3.1, 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

TABLE 3 Permitted 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.		Permitted Variations Over Specified Width and Length[A] for Thicknesses Given in Inches or Equivalent Weights Given in Pounds per Square Foot, in.							
		To ⅜, excl		⅜ to ⅝, excl		⅝ 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	⅜	½	7/16	⅝	½	¾	⅝	1
	60 to 84, excl	7/16	⅝	½	11/16	⅝	⅞	¾	1
	84 to 108, excl	½	¾	⅝	⅞	¾	1	1	1⅛
	108 and over	⅝	⅞	¾	1	⅞	1⅛	1⅛	1¼
120 to 240, excl	To 60, excl	⅜	¾	½	⅞	⅝	1	¾	1⅛
	60 to 84, excl	½	¾	⅝	⅞	¾	1	⅞	1¼
	84 to 108, excl	9/16	⅞	11/16	15/16	13/16	1⅛	1	1⅜
	108 and over	⅝	1	¾	1⅛	⅞	1¼	1⅛	1⅜
240 to 360, excl	To 60, excl	⅜	1	½	1⅛	⅝	1¼	¾	1½
	60 to 84, excl	½	1	⅝	1⅛	¾	1¼	⅞	1½
	84 to 108, excl	9/16	1	11/16	1⅛	⅞	1⅜	1	1½
	108 and over	11/16	1⅛	⅞	1¼	1	1⅜	1¼	1¾
360 to 480, excl	To 60, excl	7/16	1⅛	½	1¼	⅝	1⅜	¾	1⅝
	60 to 84, excl	½	1¼	⅝	1⅜	¾	1½	⅞	1⅝
	84 to 108, excl	9/16	1¼	¾	1⅜	⅞	1½	1	1⅞
	108 and over	¾	1⅜	⅞	1½	1	1⅝	1¼	1⅞
480 to 600, excl	To 60, excl	7/16	1¼	½	1½	⅝	1⅝	¾	1⅞
	60 to 84, excl	½	1⅜	⅝	1½	¾	1⅝	⅞	1⅞
	84 to 108, excl	⅝	1⅜	¾	1½	⅞	1⅝	1	1⅞
	108 and over	¾	1½	⅞	1⅝	1	1¾	1¼	1⅞
600 to 720, excl	To 60, excl	½	1¾	⅝	1⅞	¾	1⅞	⅞	2¼
	60 to 84, excl	⅝	1¾	¾	1⅞	⅞	1⅞	1	2¼
	84 to 108, excl	⅝	1¾	¾	1⅞	⅞	1⅞	1⅛	2¼
	108 and over	⅞	1¾	1	2	1⅛	2¼	1¼	2½
720 and over	To 60, excl	9/16	2	¾	2⅛	⅞	2¼	1	2¾
	60 to 84, excl	¾	2	⅞	2⅛	1	2¼	1⅛	2¾
	84 to 108, excl	¾	2	⅞	2⅛	1	2¼	1¼	2¾
	108 and over	1	2	1⅛	2⅜	1¼	2½	1⅜	3

[A] Permitted variation under specified width and length, ¼ in.
[B] Permitted 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 Permitted 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.	Permitted Variation Over Specified Width, in.[A]
To 14, excl	7/16
14 to 17, excl	½
17 to 19, excl	9/16
19 to 21, excl	⅝
21 to 24, excl	11/16
24 to 26, excl	13/16
26 to 28, excl	15/16
28 to 35, excl	1⅛
35 to 50, excl	1¼
50 to 60, excl	1½
60 to 65, excl	1⅝
65 to 70, excl	1¾
70 to 80, excl	1⅞
80 and over	2

[A] No permitted variation under specified width.

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

Specified Width, in.	Permitted Variations Over Specified Width[A] for Thicknesses Given in Inches or Equivalent Weights Given in Pounds per Square Foot, in.					
	To ⅜, excl	⅜ to ⅝, excl	⅝ 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	⅛	⅛	3/16	¼	⅜	½
20 to 36, excl	3/16	¼	5/16	⅜	7/16	9/16
36 and over	5/16	⅜	7/16	½	9/16	⅝

[A] Permitted variation under specified width, ⅛ in.

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.

13.3.1 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 11.4.2.3) is considered to be qualified.

13.4 Quenched and tempered steel plates are subject to the