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

This standard is issued under the fixed designation A6/A6M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This general requirements specification[2] covers a group of common requirements that, unless otherwise specified in the applicable product specification, apply to rolled structural steel bars, plates, shapes, and sheet piling covered by each of the following product specifications issued by ASTM:

ASTM Designation[3]	Title of Specification
A36/A36M	Carbon Structural Steel
A131/A131M	Structural Steel for Ships
A242/A242M	High-Strength Low-Alloy Structural Steel
A283/A283M	Low and Intermediate Tensile Strength Carbon Steel Plates
A328/A328M	Steel Sheet Piling
A514/A514M	High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
A529/A529M	High-Strength Carbon-Manganese Steel of Structural Quality
A572/A572M	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A573/A573M	Structural Carbon Steel Plates
A588/A588M	High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
A633/A633M	Normalized High-Strength Low-Alloy Structural Steel Plates
A656/A656M	Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability
A690/A690M	High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments
A709/A709M	Structural Steel for Bridges
A710/A710M	Precipitation–Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium (Niobium) Alloy Structural Steel Plates
A769/A769M	Carbon and High-Strength Electric Resistance Forge-Welded Steel Structural Shapes
A786/A786M	Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
A827/A827M	Plates, Carbon Steel, for Forging and Similar Applications

[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.

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

***A Summary of Changes section appears at the end of this standard**

A829/A829M	Alloy Structural Steel Plates
A830/A830M	Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements
A857/A857M	Steel Sheet Piling, Cold Formed, Light Gage
A871/A871M	High-Strength Low-Alloy Structural Steel Plate With Atmospheric Corrosion Resistance
A913/A913M	High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)
A945/A945M	High-Strength Low-Alloy Structural Steel Plate with Low Carbon and Restricted Sulfur for Improved Weldability, Formability, and Toughness
A950/A950M	Fusion-Bonded Epoxy-Coated Structural Steel H-Piles and Sheet Piling
A992/A992M	Structural Steel Shapes
A1043/A1043M	Structural Steel with Low Yield to Tensile Ratio for Use in Buildings
A1066/A1066M	High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)
A1077/A1077M	Structural Steel with improved Yield Strength at High Temperature for Use in Buildings

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 coil as a source of structural products.

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

1.9 In case of any conflict in requirements, the requirements of the applicable product specification prevail over those of this general requirements 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 requirements of this general requirements specification or the applicable product specification.

1.11 For purposes of determining conformance with this general requirements specification and the applicable product specification, values are to 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 E29.

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

1.13 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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with this specification.

1.14 This general requirements specification and the applicable product specification are expressed in both inch-pound units and SI units; however, unless the order specifies the applicable "M" specification designation (SI units), the structural product is furnished to inch-pound units.

1.15 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.16 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A36/A36M Specification for Carbon Structural Steel
A131/A131M Specification for Structural Steel for Ships
A242/A242M Specification for High-Strength Low-Alloy Structural Steel
A283/A283M Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
A328/A328M Specification for Steel Sheet Piling
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
A514/A514M Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
A529/A529M Specification for High-Strength Carbon-Manganese Steel of Structural Quality
A572/A572M Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A573/A573M Specification for Structural Carbon Steel Plates
A588/A588M Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
A633/A633M Specification for Normalized High-Strength Low-Alloy Structural Steel Plates
A656/A656M Specification for Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability
A673/A673M Specification for Sampling Procedure for Impact Testing of Structural Steel
A678/A678M Specification for Quenched-and-Tempered Carbon and High-Strength Low-Alloy Structural Steel Plates (Withdrawn 2010)[4]
A690/A690M Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments
A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment
A709/A709M Specification for Structural Steel for Bridges
A710/A710M Specification for Precipitation–Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium (Niobium) Alloy Structural Steel Plates
A751 Test Methods and Practices for Chemical Analysis of Steel Products
A769/A769M Specification for Carbon and High-Strength Electric Resistance Forge-Welded Steel Structural Shapes
A786/A786M Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
A808/A808M Specification for High-Strength, Low-Alloy Carbon, Manganese, Columbium, Vanadium Steel of Structural Quality with Improved Notch Toughness (Withdrawn 2005)[4]
A827/A827M Specification for Plates, Carbon Steel, for Forging and Similar Applications
A829/A829M Specification for Alloy Structural Steel Plates
A830/A830M Specification for Plates, Carbon Steel, Structural Quality, Furnished to Chemical Composition Requirements
A852/A852M Specification for Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi [485 MPa] Minimum Yield Strength to 4 in. [100 mm] Thick (Withdrawn 2010)[4]
A857/A857M Specification for Steel Sheet Piling, Cold Formed, Light Gage
A871/A871M Specification for High-Strength Low-Alloy Structural Steel Plate With Atmospheric Corrosion Resistance
A913/A913M Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)
A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
A945/A945M Specification for High-Strength Low-Alloy Structural Steel Plate with Low Carbon and Restricted Sulfur for Improved Weldability, Formability, and Toughness
A950/A950M Specification for Fusion-Bonded Epoxy-Coated Structural Steel H-Piles and Sheet Piling

[4] The last approved version of this historical standard is referenced on www.astm.org.

A992/A992M Specification for Structural Steel Shapes
A1043/A1043M Specification for Structural Steel with Low Yield to Tensile Ratio for Use in Buildings
A1066/A1066M Specification for High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)
A1077/A1077M Specification for Structural Steel with Improved Yield Strength at High Temperature for Use in Buildings
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E112 Test Methods for Determining Average Grain Size
E208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

2.2 ~~*American Welding Society*~~ *AWS Standards:*[5]
A5.1/A5.1M Mild Steel Covered Arc-Welding Electrodes
A5.5/A5.5M Low-Alloy Steel Covered Arc-Welding Electrodes
A5.17/A5.17M Specification For Carbon Steel Electrodes And Fluxes For Submerged Arc Welding
A5.18/A5.18M Specification For Carbon Steel Electrodes And Rods For Gas Shielded Arc Welding
A5.20/A5.20M Carbon Steel Electrodes For Flux Cored Arc Welding
A5.23/A5.23M Low Alloy Steel Electrodes And Fluxes For Submerged Arc Welding
A5.28/A5.28M Specification For Low-Alloy Steel Electrodes And Rods For Gas Shielded Arc Welding
A5.29/A5.29M Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding
D1.1/D1.1M Structural Welding Code Steel

2.3 *U.S. Military Standards:*[6]
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage

2.4 *U.S. Federal Standard:*[6]
Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

2.5 ~~*American Society of Mechanical Engineers*~~ *ASME Code:*[7]
ASME Boiler and Pressure Vessel Code, Section IX

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *plates (other than floor plates)*—flat, hot-rolled steel, ordered to thickness or weight [mass] 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. [6 mm] or over in thickness.
(2) Over 48 in. [1200 mm] in width and 0.180 in. [4.5 mm] or over 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 Coils are excluded from qualification to the applicable product specification until they are decoiled, leveled or straightened, formed (if applicable), cut to length, and, if required, properly tested by the processor in accordance with ASTM specification requirements (see Sections 9 – 15, 18, and 19 and the applicable product specification).

[5] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.
[6] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.
[7] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

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.

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.

3.1.3 *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 in. to 8 in. [150 mm 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 in. to 72 in. [1500 mm 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 *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.

3.1.11 *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.

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

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

3.1.14 *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.

3.1.15 *sketch*—when used to describe a form of plate, denotes a plate other than rectangular, circular, or semi-circular.

3.1.16 *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.

3.1.17 *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.

3.1.18 *fine grain practice*—a steelmaking practice for other than stainless steel that is intended to produce a killed steel that is capable of meeting the requirements for fine austenite grain size when and if the as-rolled or as-forged product is reheated to a temperature at or above the transformation temperature, Ac3.

3.1.18.1 *Discussion*—

When stated as a requirement, fine grain practice 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. Austenite grain refining elements include, but are not limited to, aluminum, columbium (niobium), titanium, and vanadium. A fine grain practice requirement *(1)* does not specify a minimum austenite grain refining element addition; *(2)* does not require prior austenite grain size testing; *(3)* does not require meeting any prior austenite grain size test result; and *(4)* does not apply to, nor in any way control, the prior austenite grain size or the ferrite grain size of the steel in the as-rolled or as-forged condition. The prior austenite grain size and the ferrite grain size of as-rolled or as-forged steel products are controlled by the manufacturing process and may be assisted by suitable chemistry. The appropriate manufacturing process controls needed to meet the mechanical property requirements of the specification in the as-rolled or as-forged condition are neither defined nor implied by the inclusion of a fine grain practice requirement.

3.1.19 *structural product*—a hot-rolled steel plate, shape, sheet piling, or bar.

3.1.20 *coil*—hot-rolled steel in coiled form that is intended to be processed into a finished structural product.

3.1.21 *manufacturer*—the organization that directly controls the conversion of steel ingots, slabs, blooms, or billets, by hot-rolling, into an as-rolled structural product or into coil; and for structural products produced from as-rolled structural products, the organization that directly controls, or is responsible for, the operations involved in finishing the structural product.

3.1.21.1 *Discussion*—

Such finishing operations include leveling or straightening, hot forming or cold forming (if applicable), welding (if applicable), cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

3.1.22 *processor*—the organization that directly controls, or is responsible for, the operations involved in the processing of coil into a finished structural product. Such processing operations include decoiling, leveling or straightening, hot-forming or cold-forming (if applicable), welding (if applicable), cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

3.1.22.1 *Discussion*—

The processing operations need not be done by the organization that did the hot rolling of the coil. If only one organization is involved in the hot rolling and processing operations, that organization is termed the *manufacturer* for the hot rolling operation and the *processor* for the processing operations. If more than one organization is involved in the hot rolling and processing operations, the organization that did the hot rolling is termed the *manufacturer* and an organization that does one or more processing operations is termed a *processor*.

3.2 Refer to Terminology A941 for additional definitions of terms used in this standard.

4. Ordering Information

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

4.1.1 ASTM product specification designation (see 1.1) and year-date;

4.1.2 Name of structural product (plate, shape, bar, 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 produced from coil or structural product produced from an as-rolled structural product (see 5.4 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 a basic-oxygen or electric-arc furnace, possibly followed by additional 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 killed.

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

5.3.1 *Strand Cast:*

5.3.1.1 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.

5.3.1.2 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.

5.4 Structural products shall be produced from an as-rolled structural product or from coil.

5.5 Where part of a heat is rolled into an as-rolled structural product and the balance of the heat is rolled into coil, each part shall be tested separately.

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

6. Heat Treatment

6.1 Where the structural product 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 applicable product specification.

NOTE 2—When no heat treatment is required, the manufacturer or processor has the option of heat treating the structural product by normalizing, stress relieving, or normalizing then stress relieving to meet the applicable product specification.

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

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

6.3 Where the heat treatment is to be performed by the manufacturer or the processor, the structural product shall be heat treated as specified in the applicable product 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 applicable product specification.

6.4 Where normalizing is to be performed by the fabricator, the structural product shall be either normalized or heated uniformly for hot forming, provided that the temperature to which the structural product is 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 °F to 1300 °F [595 °C 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 Terminology A751.

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 (niobium); 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). Boron shall be reported if intentionally added.

NOTE 3—For steels that do not have intentional boron additions for hardenability, the boron content will not normally exceed 0.0008 %.

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 A751. 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 A. 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 A751 shall be used.

7.4 *Grade Substitution*—Alloy steel grades that meet the chemical requirements of Table 1 of Specification A829/A829M 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 E112 and at least 70 % of the grains in the area examined shall meet the specified grain size requirement.

8.1.1 *Discussion—Austenitic Grain Size*—All requirements for austenitic grain size control in Section 8, Metallurgical Structure, refer to a size of austenite grains that form when and if the structural product is reheated to a temperature at or above the transformation temperature, Ac_3, after the product has experienced the complete rolling operation and has cooled to ambient temperature. The requirements for austenitic grain size control in Section 8, including the results of the referenced testing methods, do not measure or control the prior austenitic grain size or the ferritic grain size of the structural product in the as-rolled condition.

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 4—Such austenitic grain size numbers may be achieved with lower contents of austenitic grain refining elements 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*—Structural products shall be free of injurious defects and shall have a workmanlike finish.

NOTE 5—Unless otherwise specified, structural products are normally furnished in the as-rolled condition and are subjected to visual inspection by the manufacturer or processor. Non-injurious surface or internal imperfections, or both, may be present in the structural product as delivered and the structural

product may require conditioning by the purchaser to improve its appearance or in preparation for welding, coating, or other further operations.

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

Structural products that exhibit injurious defects during subsequent fabrication are deemed not to comply with the applicable product 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 the heat-affected zone.

The conditioning requirements in 9.2, 9.3, and 9.4 limit the conditioning allowed to be performed by the manufacturer or processor. Conditioning of imperfections beyond the limits of 9.2, 9.3, and 9.4 may be performed by parties other than the manufacturer or processor at the discretion of the purchaser.

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 A131/A131M 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 in. to 2 in. [10 mm 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.~~ 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).

TABLE A 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 10.00 incl	0.10	0.10
	over 10.00 to 15.00 incl	0.15	0.15
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 0.15 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 (Niobium)[D]	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 %.
[D] Columbium and niobium are interchangeable names for the same element.

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

9.4.2 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.