SPECIFICATION FOR STEEL BARS, CARBON AND ALLOY, HOT-WROUGHT AND COLD-FINISHED, GENERAL REQUIREMENTS FOR

SA-29/SA-29M

(Identical with ASTM Specification A 29/A 29M-99) 01

1. Scope

1.1 This specification covers a group of common requirements which, unless otherwise specified in the purchase order or in an individual specification, shall apply to carbon and alloy steel bars under each of the following ASTM specifications (or under any other ASTM specification which invokes this specification or portions thereof):

Title of Specification	ASTM Designation
Hot-Rolled Carbon Steel Bars:	
Steel Bars, Carbon, Quenched and Tempered	A 321
Steel Bars and Shapes, Carbon Rolled from "T" Rails	A 499
Steel Bars, Carbon, Merchant Quality, M-Grades	A 575
Steel Bars, Carbon, Hot-Wrought, Special Quality	A 576
Steel Bars, Carbon, Merchant Quality, Mechanical Properties	A 663
Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties	A 675
Steel Bars for Springs, Carbon and Alloy	A 689
Steel Bars, Carbon, Hot-Wrought, Special Quality, for Fluid Power Applications	A 695
Cold-Finished Carbon Steel Bars:	
Steel Bars, Carbon, Cold-Finished, Standard Quality	A 108
Stress-Relieved Steel Bars Subject to Mechanical Property Requirements, Cold-Drawn Carbon	A 311/A 311M
Hot-Rolled Alloy Steel Bars:	
Steel Bars, Alloy, Standard Grades	A 322
Steel Bars, Alloy, Subject to End-Quench Hardenability Requirements	A 304
Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered	A 434
Steel Bars, Alloy, Hot-Wrought, for Elevated Temperature or Pressure-Containing Parts, or Both	A 739
Cold-Finished Alloy Steel Bars:	
Steel Bars, Alloy, Cold-Finished	A 331
Steel Bars, Alloy, Hot-Rolled or Cold-Finished, Quenched and Tempered	A 434
Steel Bars, Carbon, Hot-Wrought or Cold-Finished, Special Quality, for Pressure Piping Components	A 696

1.2 In case of any conflict in requirements, the requirements of the purchase order, the individual material specification, and this general specification shall prevail in the sequence named.

1.3 The values stated in inch-pound units or SI units are to be regarded as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 For purposes of determining conformance to this specification and the various material specifications referenced in 1.1, dimensional 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.

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2. Referenced Documents

2.1 *ASTM Standards:*

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

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

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

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

E 112 Test Methods for Determining the Average Grain Size

2.2 *Federal Standards:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products

2.3 *Military Standard:*

MIL-STD-163 Steel Mill Products — Preparation for Shipment and Storage

2.4 *Other Standards:*

AIAG B-1 Bar Code Symbology Standard for 3-of-9 Bar Codes

AIAG B-5 02.00 Primary Metals Tag Application Standard

3. Terminology

3.1 *Definitions of Terms Specific To This Standard:*

3.1.1 *Hot-Wrought Steel Bars* — Steel bars produced by hot forming ingots, blooms, billets, or other semifinished forms to yield straight lengths (or coils, depending upon size, section, and mill equipment) in sections which are uniform throughout their length, and in the following sections and sizes:

3.1.1.1 *Rounds,* $^{7}/_{32}$ to 10.0 in. [5.5 to 250 mm], inclusive,

3.1.1.2 *Squares,* $^{7}/_{32}$ to 6.0 in. [6 to 160 mm], inclusive

3.1.1.3 *Round-Cornered Squares,* $^{7}/_{32}$ to 8.0 in. [6 to 200 mm], inclusive,

3.1.1.4 *Flats,* $^{1}/_{4}$ to 8 in. inclusive, in width: $^{13}/_{64}$ in. in minimum thickness up to 6 in. in width; and 0.230 in. in minimum thickness for over 6 to 8 in. in width, inclusive [over 5 mm in thickness up to 150 mm in width; and over 6 mm in thickness for over 150 mm through 200 mm in width]. Maximum thickness for all widths is 4 in. [100 mm].

3.1.1.5 *Hexagons and Octagons,* $^{1}/_{4}$ to $4^{1}/_{16}$ in. [6 to 103 mm], inclusive, between parallel surfaces,

3.1.1.6 *Bar Size Shapes* — Angles, channels, tees, zees, when their greatest cross-sectional dimension is under 3 in. [75 mm], and

3.1.1.7 *Special Bar Sections* — Half-rounds, ovals, half-ovals, other special bar size sections.

3.1.2 *Cold-Finished Steel Bars* — Steel bars produced by cold finishing previously hot-wrought bars by means of cold drawing, cold forming, turning, grinding, or polishing (singly or in combination) to yield straight lengths or coils in sections which are uniform throughout their length and in the following sections and sizes:

3.1.2.1 *Rounds,* 9 in. [230 mm] and under in diameter,

3.1.2.2 *Squares,* 6 in. [150 mm] and under between parallel surfaces,

3.1.2.3 *Hexagons,* 4 in. [100 mm] and under between parallel surfaces,

3.1.2.4 *Flats,* $^{1}/_{8}$ in. [3 mm] and over in thickness and not over 12 in. [300 mm] in width, and

3.1.2.5 *Special Bar Sections.*

3.1.3 *Lot* — Unless otherwise specified in the contract or order, a lot shall consist of all bars submitted for inspection at the same time of the same heat, condition, finish, size, or shape. For bars specified in the quenched and tempered condition, when heat treated in batch-type furnaces, a lot shall consist of all bars from the same heat, of the same prior condition, the same size, and subjected to the same heat treatment in one tempering charge. For bars specified in the quenched and tempered condition, when heat treated without interruption in a continuous-type furnace, a lot shall consist of all bars from the same heat, of the same prior condition, of the same size, and subjected to the same heat treatment.

4. Chemical Composition

4.1 *Limits:*

4.1.1 The chemical composition shall conform to the requirements specified in the purchase order or the individual product specifications. For convenience the

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grades commonly specified for carbon steel bars are shown in Tables 1 and 2. Bars may be ordered to these grade designations and when so ordered shall conform to the specified limits by heat analysis.

4.1.2 When compositions other than those shown in Tables 1 and 2 are required, the composition limits shall be prepared using the ranges and limits shown in Table 3 for carbon steel and Table 4 for alloy steel.

4.2 *Heat or Cast Analysis:*

4.2.1 The chemical composition of each heat or cast shall be determined by the manufacturer in accordance with Test Methods, Practices, and Terminology A 751.

4.2.2 The heat or cast analysis shall conform to the requirements specified in the product specification or purchase order. These can be the heat chemical range and limit for a grade designated in Tables 1 and 2, or another range and limit in accordance with 4.1.2, or with requirements of the product specification.

NOTE 1 — Heat analysis for lead is not determinable since lead is added to the ladle stream while each ingot is poured. When specified as an added element to a standard steel, the percentage of lead is reported as 0.15 to 0.35 incl, which is the range commonly specified for this element.

4.2.3 If requested or required, the heat analysis shall be reported to the purchaser or his representative.

4.2.4 Reporting of significant figures and rounding shall be in accordance with Test Methods, Practices, and Terminology A 751.

4.3 *Product Analysis:*

4.3.1 Merchant quality carbon bar steel is not subject to rejection for product analysis unless misapplication of a heat is clearly indicated.

4.3.2 Analyses may be made by the purchaser from finished bars other than merchant quality representing each heat of open-hearth, basic-oxygen, or electric-furnace steel. The chemical composition thus determined shall not vary from the limits specified in the applicable specification by more than the amounts prescribed in Tables 5 and 6, but the several determinations of any element, excluding lead, in a heat may 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, when rimmed or capped steel is specified or required, the limitations for these elements shall not be applicable. Because of the degree to which phosphorus and sulfur segregate, the limitations for these elements shall not be applicable to rephosphorized or resulfurized steels.

4.3.3 Samples for product analysis shall be taken by one of the following methods:

4.3.3.1 Applicable to small sections whose cross-sectional area does not exceed 0.75 in.^{2} [500 mm^2] such as rounds, squares, hexagons, etc. Chips are taken by milling or machining the full cross section of the piece. Drilling is not a feasible method for sampling sizes 0.75 in.^{2} and smaller.

4.3.3.2 Applicable to products where the width of the cross section greatly exceeds the thickness, such as bar size shapes and light flat bars. Chips are taken by drilling entirely through the steel at a point midway between the edge and the middle of the section, or by milling or machining the entire cross section.

4.3.3.3 Applicable to large rounds, squares semi-finished, etc. Chips are taken at any point midway between the outside and the center of the piece by drilling parallel to the axis or by milling or machining the full cross section. In cases where these methods are not practicable, the piece may be drilled on the side, but chips are not taken until they represent the portion midway between the outside and the center.

4.3.3.4 When the steel is subject to tension test requirements, the tension test specimen can also be used for product analysis. In that case, chips for product analysis can be taken by drilling entirely through the tension test specimens or by the method described in 4.3.3.1.

4.3.4 When chips are taken by drilling, the diameter of the drill used shall conform to the following:

Area of Sample Cross Section, in.^{2} (cm^2)	Approximate Drill Diameter, in. (mm)
16 [100] or less	$\frac{1}{2}$ [12.5]
Over 16 [100]	1 [25.0]

4.3.5 The minimum number of samples to be taken from material representing the same heat or lot before rejection by the purchaser shall be as follows:

	Minimum Number of Samples
15 tons [15 Mg] and under	4
Over 15 tons [15 Mg]	6

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4.3.6 In case the number of pieces in a heat is less than the number of samples required, one sample from each piece shall be considered sufficient.

4.3.7 In the event that product analysis determinations are outside the permissible limits as prescribed in 4.3.2, additional samples shall be analyzed and the acceptability of the heat negotiated between the purchaser and the producer.

4.4 *Referee Analysis* — In case a referee analysis is required and agreed upon to resolve a dispute concerning the results of a chemical analysis, the referee analysis shall be performed in accordance with the latest issue of Test Methods, Practices, and Terminology A 751, unless otherwise agreed upon between the manufacturer and the purchaser.

5. Grain Size Requirement

5.1 *Austenitic Grain Size*

5.1.1 When a coarse austenitic grain size is specified, the steel shall have a grain size number of 1 to 5 exclusive as determined in accordance with Test Methods E 112. Conformance to this grain size of 70% of the grains in the area examined shall constitute the basis of acceptance. One test per heat shall be made.

5.1.2 When a fine austenitic grain size is specified, the steel shall have a grain size number of 5 or higher as determined in accordance with Test Methods E 112. Conformance to this grain size of 70% of the area examined shall constitute the basis of acceptance. One test per heat shall be made unless the provisions of 5.1.2.1 or 5.1.2.2 are exercised.

5.1.2.1 When aluminum is used as the grain refining element, the fine austenitic grain size requirement shall be deemed to be fulfilled if, on heat analysis, the aluminum content is not less than 0.020% total aluminum or, alternately, 0.015% acid soluble aluminum. The aluminum content shall be reported. The grain size test specified in 5.1.2 shall be the referee test.

5.1.2.2 By agreement between purchaser and supplier, columbium or vanadium or both may be used for grain refining instead of or with aluminum. When columbium or vanadium is used as a grain refining element, the fine austenitic grain size requirement shall be deemed to be fulfilled if, on heat analysis, the columbium or vanadium content is as follows (the content of the elements shall be reported with the heat analysis):

Steels having 0.25% carbon or less:	
Cb	0.025 min
V	0.05 min
Steels having over 0.25% carbon:	
Cb	0.015 min
V	0.02 min
The maximum contents shall be:	
Cb	0.05 max
V	0.08 max
Cb + V	0.06 max

5.1.2.3 When provisions of 5.1.2.1 or 5.1.2.2 are exercised, a grain size test is not required unless specified by the purchaser. Unless otherwise specified, fine austenitic grain size shall be certified using the analysis of grain refining elements(s).

5.1.2.4 *Referee Test* — In the event that the chemical analysis of columbium or vanadium does not meet the requirements of 5.1.2.2, the grain size test shown in 5.1.2 shall be the referee test unless an alternative test method is agreed upon between the manufacturer and the purchaser.

6. Mechanical Property Requirements

6.1 *Test Specimens:*

6.1.1 *Selection* — Test specimens shall be selected in accordance with the requirements of the applicable product specification or in accordance with Supplement I of the latest issue of Test Methods and Definitions A 370, in the sequence named.

6.1.2 *Preparation* — Unless otherwise specified in the applicable product specification, test specimens shall be prepared in accordance with the latest issue of Test Methods and Definitions A 370, and especially Supplement I thereof.

6.2 *Methods of Mechanical Testing* — All mechanical tests shall be conducted in accordance with the latest issue of Test Methods and Definitions A 370, and especially Supplement I thereof, on steel bar products.

6.3 *Retests:*

6.3.1 If any test specimen shows defective machining or develops flaws, the specimen may be discarded and another substituted.

6.3.2 If the percentage elongation of any tension specimen is less than that specified and any part of the fracture is more than $^{3}/_{4}$ in. [20 mm] from the center of a 2 in. [50 mm] specimen, or is outside the middle half of the gage length of an 8 in. [200 mm]

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specimen as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

6.3.3 For "as-wrought" material, if the results for any original tension specimen are within 2000 psi [14 MPa] of the required tensile strength, within 1000 psi [7 MPa] of the required yield point, or within 2% of the required elongation, retesting shall be permitted. If the original testing required only one test, the retest shall consist of two random tests from the heat or lot involved. If the original testing required two tests of which one failed by the amounts listed in this paragraph, the retest shall be made on one random test from the heat or lot. If the results on the retest specimen or specimens meet the specified requirements, the heat or test lot will be accepted. If the results of one retest specimen do not meet the specified requirements, the material is subject to rejection.

6.3.4 For thermally treated bars, if the results of the mechanical tests do not conform to the requirements specified, two more tests may be selected for each bar failing, and each of these retests shall conform to the requirements of the product specification.

6.3.5 If a bend specimen fails, due to conditions of bending more severe than required by the specification, a retest shall be permitted from the heat or test lot involved for which one random specimen for each original specimen showing failure shall be used. If the results on the retest specimen meet the requirements of the specification, the heat or test lot will be accepted.

7. Dimensions, Mass, and Permissible Variations

7.1 *Hot-Wrought Bars* — The permissible variations for dimensions of hot-wrought carbon and alloy steel bars shall not exceed the applicable limits stated in Annex A1 for inch-pound values and Annex A2 for metric values.

7.2 *Cold-Finished Bars* — The permissible variations for dimensions of cold-finished carbon and alloy steel bars shall not exceed the applicable limits stated in Annex A1 for inch-pound values and Annex A2 for metric values.

8. Workmanship, Finish, and Appearance

8.1 The material shall be free of injurious defects and shall have a workmanlike finish.

9. Rework and Retreatment

9.1 For thermally treated bars only, the manufacturer may retreat a lot one or more times, and retests shall be made in the same manner as the original tests. Each such retest shall conform to the requirements specified.

10. Inspection

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

10.2 All required tests and inspection shall be made by the manufacturer prior to shipment.

11. Rejection

11.1 Unless otherwise specified, any rejection because of noncompliance to the requirements of the specification shall be reported by the purchaser to the manufacturer within 30 working days after receipt of samples.

11.2 Material that shows imperfections capable of adversely affecting processability subsequent to its acceptance at the purchaser's works will be rejected, and the manufacturer shall be notified.

12. Rehearing

12.1 Samples that represent rejected material shall be preserved for two weeks from the date rejection is reported to the manufacturer. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

13. Product Marking

13.1 *Civilian Procurement* — Bars of all sizes, when loaded for shipment, shall be properly identified with the name or brand of manufacturer, purchaser's name and order number, the ASTM designation (year date is not required), grade number where appropriate, size

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and length, weight of lift, and the heat number for identification. Unless otherwise specified, the method of marking is at the manufacturer's option and may be made by hot stamping, cold stamping, painting, or marking tags attached to the lifts of bars.

13.1.1 Bar code marking may be used as an auxiliary method of identification. Such bar-code markings shall be of the 3-of-9 type and shall conform to AIAG B1. When bar-coded tags are used, they shall conform to AIAG B5.

13.2 *Government Procurement:*

13.2.1 Marking for shipment shall be in accordance with the requirements specified in the contract or order and shall be in accordance with MIL-STD-163 for military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

13.2.2 For government procurement by the Defense Supply Agency, the bars shall be continuously marked for identification in accordance with Fed. Std. No. 183.

14. Packaging

14.1 *Civilian Procurement* — Unless otherwise specified, the bars shall be packaged and loaded in accordance with Practices A 700.

14.2 *Government Procurement* — MIL-STD-163 shall apply when packaging is specified in the contract or order, or when Level A for preservation, packaging, and packing is specified for direct procurement by or direct shipment to the government.

15. Keywords

15.1 alloy steel bars; carbon steel bars; cold finished steel bars; general delivery requirements; hot wrought steel bars; steel bars.

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TABLE 1
GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS OF CARBON STEEL BARS

Grade Designation	Heat Chemical Ranges and Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max[A]
Nonresulfurized Carbon Steels[B,C,D,E,F]				
1005	0.06 max	0.35 max	0.040	0.050
1006	0.08 max	0.25–0.40	0.040	0.050
1008	0.10 max	0.30–0.50	0.040	0.050
1010	0.08–0.13	0.30–0.60	0.040	0.050
1011	0.08–0.13	0.60–0.90	0.040	0.050
1012	0.10–0.15	0.30–0.60	0.040	0.050
1013	0.11–0.16	0.50–0.80	0.040	0.050
1015	0.13–0.18	0.30–0.60	0.040	0.050
1016	0.13–0.18	0.60–0.90	0.040	0.050
1017	0.15–0.20	0.30–0.60	0.040	0.050
1018	0.15–0.20	0.60–0.90	0.040	0.050
1019	0.15–0.20	0.70–1.00	0.040	0.050
1020	0.18–0.23	0.30–0.60	0.040	0.050
1021	0.18–0.23	0.60–0.90	0.040	0.050
1022	0.18–0.23	0.70–1.00	0.040	0.050
1023	0.20–0.25	0.30–0.60	0.040	0.050
1025	0.22–0.28	0.30–0.60	0.040	0.050
1026	0.22–0.28	0.60–0.90	0.040	0.050
1029	0.25–0.31	0.60–0.90	0.040	0.050
1030	0.28–0.34	0.60–0.90	0.040	0.050
1034	0.32–0.38	0.50–0.80	0.040	0.050
1035	0.32–0.38	0.60–0.90	0.040	0.050
1037	0.32–0.38	0.70–1.00	0.040	0.050
1038	0.35–0.42	0.60–0.90	0.040	0.050
1039	0.37–0.44	0.70–1.00	0.040	0.050
1040	0.37–0.44	0.60–0.90	0.040	0.050
1042	0.40–0.47	0.60–0.90	0.040	0.050
1043	0.40–0.47	0.70–1.00	0.040	0.050
1044	0.43–0.50	0.30–0.60	0.040	0.050
1045	0.43–0.50	0.60–0.90	0.040	0.050
1046	0.43–0.50	0.70–1.00	0.040	0.050
1049	0.46–0.53	0.60–0.90	0.040	0.050
1050	0.48–0.55	0.60–0.90	0.040	0.050
1053	0.48–0.55	0.70–1.00	0.040	0.050
1055	0.50–0.60	0.60–0.90	0.040	0.050
1059	0.55–0.65	0.50–0.80	0.040	0.050
1060	0.55–0.65	0.60–0.90	0.040	0.050
1064	0.60–0.70	0.50–0.80	0.040	0.050
1065	0.60–0.70	0.60–0.90	0.040	0.050
1069	0.65–0.75	0.40–0.70	0.040	0.050
1070	0.65–0.75	0.60–0.90	0.040	0.050
1071	0.65–0.70	0.75–1.05	0.040	0.050
1074	0.70–0.80	0.50–0.80	0.040	0.050
1075	0.70–0.80	0.40–0.70	0.040	0.050
1078	0.72–0.85	0.30–0.60	0.040	0.050
1080	0.75–0.88	0.60–0.90	0.040	0.050
1084	0.80–0.93	0.60–0.90	0.040	0.050
1086	0.80–0.93	0.30–0.50	0.040	0.050
1090	0.85–0.98	0.60–0.90	0.040	0.050
1095	0.90–1.03	0.30–0.50	0.040	0.050
Resulfurized Carbon Steels[B,D,F]				
1108	0.08–0.13	0.60–0.80	0.040	0.08–0.13
1109	0.08–0.13	0.60–0.90	0.040	0.08–0.13
1110	0.08–0.13	0.30–0.60	0.040	0.08–0.13
1116	0.14–0.20	1.10–1.40	0.040	0.16–0.23
1117	0.14–0.20	1.00–1.30	0.040	0.08–0.13
1118	0.14–0.20	1.30–1.60	0.040	0.08–0.13
1119	0.14–0.20	1.00–1.30	0.040	0.24–0.33
1132	0.27–0.34	1.35–1.65	0.040	0.08–0.13
1137	0.32–0.39	1.35–1.65	0.040	0.08–0.13
1139	0.35–0.43	1.35–1.65	0.040	0.13–0.20
1140	0.37–0.44	0.70–1.00	0.040	0.08–0.13
1141	0.37–0.45	1.35–1.65	0.040	0.08–0.13
1144	0.40–0.48	1.35–1.65	0.040	0.24–0.33
1145	0.42–0.49	0.70–1.00	0.040	0.04–0.07
1146	0.42–0.49	0.70–1.00	0.040	0.08–0.13
1151	0.48–0.55	0.70–1.00	0.040	0.08–0.13

TABLE 1
GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS OF CARBON STEEL BARS (CONT'D)

Grade Designation	Rephosphorized and Resulfurized Carbon Steels[D,G,F]				
	Carbon	Manganese	Phosphorus	Sulfur	Lead
1211	0.13 max	0.60–0.90	0.07–0.12	0.10–0.15	. . .
1212	0.13 max	0.70–1.00	0.07–0.12	0.16–0.23	. . .
1213	0.13 max	0.70–1.00	0.07–0.12	0.24–0.33	. . .
1215	0.09 max	0.75–1.05	0.04–0.09	0.26–0.35	. . .
12L13	0.13 max	0.70–1.00	0.07–0.12	0.24–0.33	0.15–0.35
12L14	0.15 max	0.85–1.15	0.04–0.09	0.26–0.35	0.15–0.35
12L15	0.09 max	0.75–1.05	0.04–0.09	0.26–0.35	0.15–0.35

Grade Designation	High-Manganese Carbon Steels[B,C,D,E,F]				
	Former Designation	Carbon	Manganese	Phosphorus, max	Sulfur, max
1513	. . .	0.10–0.16	1.10–1.40	0.040	0.050
1518	. . .	0.15–0.21	1.10–1.40	0.040	0.050
1522	. . .	0.18–0.24	1.10–1.40	0.040	0.050
1524	1024	0.19–0.25	1.35–1.65	0.040	0.050
1525	. . .	0.23–0.29	0.80–1.10	0.040	0.050
1526	. . .	0.22–0.29	1.10–1.40	0.040	0.050
1527	1027	0.22–0.29	1.20–1.50	0.040	0.050
1536	1036	0.30–0.37	1.20–1.50	0.040	0.050
1541	1041	0.36–0.44	1.35–1.65	0.040	0.050
1547	. . .	0.43–0.51	1.35–1.65	0.040	0.050
1548	1048	0.44–0.52	1.10–1.40	0.040	0.050
1551	1051	0.45–0.56	0.85–1.15	0.040	0.050
1552	1052	0.47–0.55	1.20–1.50	0.040	0.050
1561	1061	0.55–0.65	0.75–1.05	0.040	0.050
1566	1066	0.60–0.71	0.85–1.15	0.040	0.050
1572	1072	0.65–0.76	1.00–1.30	0.040	0.050

Grade Designation	Heat Chemical Ranges and Limits, percent			
	Merchant Quality M Series Carbon Steel Bars			
	Carbon	Manganese[G]	Phosphorus, max	Sulfur, max
M 1008	0.10 max	0.25–0.60	0.04	0.05
M 1010	0.07–0.14	0.25–0.60	0.04	0.05
M 1012	0.09–0.16	0.25–0.60	0.04	0.05
M 1015	0.12–0.19	0.25–0.60	0.04	0.05
M 1017	0.14–0.21	0.25–0.60	0.04	0.05
M 1020	0.17–0.24	0.25–0.60	0.04	0.05
M 1023	0.19–0.27	0.25–0.60	0.04	0.05
M 1025	0.20–0.30	0.25–0.60	0.04	0.05
M 1031	0.26–0.36	0.25–0.60	0.04	0.05
M 1044	0.40–0.50	0.25–0.60	0.04	0.05

[A] Maximum unless otherwise indicated.

[B] When silicon is required, the following ranges and limits are commonly specified: 0.10%, max, 0.10% to 0.20%, 0.15% to 0.35%, 0.20% to 0.40%, or 0.30% to 0.60%.

[C] Copper can be specified when required as 0.20% minimum.

[D] When lead is required as an added element to a standard steel, a range of 0.15 to 0.35% inclusive is specified. Such a steel is identified by inserting the letter "L" between the second and third numerals of the grade designation, for example, 10 L 45. A cast or heat analysis is not determinable when lead is added to the ladle stream.

[E] When boron treatment for killed steels is specified, the steels can be expected to contain 0.0005 to 0.003% boron. If the usual titanium additive is not permitted, the steels can be expected to contain up to 0.005% boron.

[F] The elements bismuth, calcium, selenium, or tellurium may be added as agreed upon between purchaser and supplier.

[G] Unless prohibited by the purchaser, the manganese content may exceed 0.60% on heat analysis to a maximum of 0.75%, provided the carbon range on heat analysis has the minimum and maximum reduced by 0.01% for each 0.05% manganese over 0.60%.

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TABLE 2
GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS OF ALLOY STEEL BARS

NOTE 1 — Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: copper, 0.35%; nickel, 0.25%; chromium, 0.20%; and molybdenum, 0.06%.

NOTE 2 — Where minimum and maximum sulfur content is shown it is indicative of resulfurized steel.

NOTE 3 — The chemical ranges and limits shown in Table 2 are produced to product analysis tolerances shown in Table 6.

NOTE 4 — Standard alloy steels can be produced with a lead range of 0.15–0.35%. Such steels are identified by inserting the letter "L" between the second and third numerals of the AISI number, for example, 41 L 40. A cast or heat analysis is not determinable when lead is added to the ladle stream.

Grade Designation	Heat Chemical Ranges and Limits, %							
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon[A]	Nickel	Chromium	Molybdenum
1330	0.28–0.33	1.60–1.90	0.035	0.040	0.15 to 0.35	...	...	...
1335	0.33–0.38	1.60–1.90	0.035	0.040	0.15 to 0.35	...	...	...
1340	0.38–0.43	1.60–1.90	0.035	0.040	0.15 to 0.35	...	...	...
1345	0.43–0.48	1.60–1.90	0.035	0.040	0.15 to 0.35	...	...	...
4012	0.09–0.14	0.75–1.00	0.035	0.040	0.15 to 0.35	...	...	0.15–0.25
4023	0.20–0.25	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4024	0.20–0.25	0.70–0.90	0.035	0.035–0.050	0.15 to 0.35	...	...	0.20–0.30
4027	0.25–0.30	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4028	0.25–0.30	0.70–0.90	0.035	0.035–0.050	0.15 to 0.35	...	...	0.20–0.30
4032	0.30–0.35	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4037	0.35–0.40	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4042	0.40–0.45	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4047	0.45–0.50	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.20–0.30
4118	0.18–0.23	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.40–0.60	0.08–0.15
4120	0.18–0.23	0.90–1.20	0.035	0.040	0.15 to 0.35	...	0.40–0.60	0.13–0.20
4121	0.18–0.23	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.45–0.65	0.20–0.30
4130	0.28–0.33	0.40–0.60	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4135	0.33–0.38	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4137	0.35–0.40	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4140	0.38–0.43	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4142	0.40–0.45	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4145	0.43–0.48	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4147	0.45–0.50	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4150	0.48–0.53	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.80–1.10	0.15–0.25
4161	0.56–0.64	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.70–0.90	0.25–0.35
4320	0.17–0.22	0.45–0.65	0.035	0.040	0.15 to 0.35	1.65–2.00	0.40–0.60	0.20–0.30
4340	0.38–0.43	0.60–0.80	0.035	0.040	0.15 to 0.35	1.65–2.00	0.70–0.90	0.20–0.30
E4340	0.38–0.43	0.65–0.85	0.025	0.025	0.15 to 0.35	1.65–2.00	0.70–0.90	0.20–0.30
4419	0.18–0.23	0.45–0.65	0.035	0.040	0.15 to 0.35	...	...	0.45–0.60
4422	0.20–0.25	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.35–0.45
4427	0.24–0.29	0.70–0.90	0.035	0.040	0.15 to 0.35	...	...	0.35–0.45
4615	0.13–0.18	0.45–0.65	0.035	0.040	0.15 to 0.35	1.65–2.00	...	0.20–0.30
4620	0.17–0.22	0.45–0.65	0.035	0.040	0.15 to 0.35	1.65–2.00	...	0.20–0.30
4621	0.18–0.23	0.70–0.90	0.035	0.040	0.15 to 0.35	1.65–2.00	...	0.20–0.30
4626	0.24–0.29	0.45–0.65	0.035	0.040	0.15 to 0.35	0.70–1.00	...	0.15–0.25
4715	0.13–0.18	0.70–0.90	0.035	0.040	0.15 to 0.35	0.70–1.00	0.45–0.65	0.45–0.60
4718	0.16–0.21	0.70–0.90	0.035	0.040	0.15 to 0.35	0.90–1.20	0.35–0.55	0.30–0.40
4720	0.17–0.22	0.50–0.70	0.035	0.040	0.15 to 0.35	0.90–1.20	0.35–0.55	0.15–0.25
4815	0.13–0.18	0.40–0.60	0.035	0.040	0.15 to 0.35	3.25–3.75	...	0.20–0.30
4817	0.15–0.20	0.40–0.60	0.035	0.040	0.15 to 0.35	3.25–3.75	...	0.20–0.30
4820	0.18–0.23	0.50–0.70	0.035	0.040	0.15 to 0.35	3.25–3.75	...	0.20–0.30
5015	0.12–0.17	0.30–0.50	0.035	0.040	0.15 to 0.35	...	0.30–0.50	...
5046	0.43–0.48	0.75–1.00	0.035	0.040	0.15 to 0.35	...	0.20–0.35	...
5115	0.13–0.18	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.70–0.90	...
5120	0.17–0.22	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.70–0.90	...
5130	0.28–0.33	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.80–1.10	...
5132	0.30–0.35	0.60–0.80	0.035	0.040	0.15 to 0.35	...	0.75–1.00	...
5135	0.33–0.38	0.60–0.80	0.035	0.040	0.15 to 0.35	...	0.80–1.05	...
5140	0.38–0.43	0.70–0.90	0.035	0.040	0.15 to 0.35	...	0.70–0.90	...

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TABLE 2
GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS OF ALLOY STEEL BARS (CONT'D)

Grade Designation	Heat Chemical Ranges and Limits, %							
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon[A]	Nickel	Chromium	Molybdenum
5145	0.43–0.48	0.70–0.90	0.035	0.040	0.15 to 0.35	. . .	0.70–0.90	. . .
5147	0.46–0.51	0.70–0.95	0.035	0.040	0.15 to 0.35	. . .	0.85–1.15	. . .
5150	0.48–0.53	0.70–0.90	0.035	0.040	0.15 to 0.35	. . .	0.70–0.90	. . .
5155	0.51–0.59	0.70–0.90	0.035	0.040	0.15 to 0.35	. . .	0.70–0.90	. . .
5160	0.56–0.61	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.70–0.90	. . .
E50100	0.98–1.10	0.25–0.45	0.025	0.025	0.15 to 0.35	. . .	0.40–0.60	. . .
E51100	0.98–1.10	0.25–0.45	0.025	0.025	0.15 to 0.35	. . .	0.90–1.15	. . .
E52100	0.98–1.10	0.25–0.45	0.025	0.025	0.15 to 0.35	. . .	1.30–1.60	. . .
6118	0.16–0.21	0.50–0.70	0.035	0.040	0.15 to 0.35	. . .	0.50–0.70	(0.10–0.15 V)
6150	0.48–0.53	0.70–0.90	0.035	0.040	0.15 to 0.35	. . .	0.80–1.10	(0.15 min V)
8115	0.13–0.18	0.70–0.90	0.035	0.040	0.15 to 0.35	0.20–0.40	0.30–0.50	0.08–0.15
8615	0.13–0.18	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8617	0.15–0.20	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8620	0.18–0.23	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8622	0.20–0.25	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8625	0.23–0.28	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8627	0.25–0.30	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8630	0.28–0.33	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8637	0.35–0.40	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8640	0.38–0.43	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8642	0.40–0.45	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8645	0.43–0.48	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8650	0.48–0.53	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8655	0.51–0.59	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8660	0.56–0.64	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.15–0.25
8720	0.18–0.23	0.70–0.90	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.20–0.30
8740	0.38–0.43	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.20–0.30
8822	0.20–0.20	0.75–1.00	0.035	0.040	0.15 to 0.35	0.40–0.70	0.40–0.60	0.30–0.40
9254	0.51–0.59	0.60–0.80	0.035	0.040	1.20–1.60	. . .	0.60–0.80	. . .
9255	0.51–0.59	0.70–0.95	0.035	0.040	1.80–2.20	. . .	. . .	. . .
9259	0.56–0.64	0.75–1.00	0.035	0.040	0.70–1.10	. . .	0.45–0.65	. . .
9260	0.56–0.64	0.75–1.00	0.035	0.040	1.80–2.20	. . .	. . .	. . .
E9310	0.08–0.13	0.45–0.65	0.025	0.025	0.15 to 0.30	3.00–3.50	1.00–1.40	0.08–0.15
Standard Boron Steels[B]								
50B44	0.43–0.48	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.20–0.60	. . .
50B46	0.44–0.49	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.20–0.35	. . .
50B50	0.48–0.53	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.40–0.60	. . .
50B60	0.56–0.64	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.40–0.60	. . .
51B60	0.56–0.64	0.75–1.00	0.035	0.040	0.15 to 0.35	. . .	0.70–0.90	. . .
81B45	0.43–0.48	0.75–1.00	0.035	0.040	0.15 to 0.35	0.20–0.40	0.35–0.55	0.08–0.15
94B17	0.15–0.20	0.75–1.00	0.035	0.040	0.15 to 0.35	0.30–0.60	0.30–0.50	0.80–0.15
94B30	0.28–0.33	0.75–1.00	0.035	0.040	0.15 to 0.35	0.30–0.60	0.30–0.50	0.08–0.15

[A] Silicon may be specified by the purchaser as 0.10% maximum. The need for 0.10% maximum generally relates to severe cold-formed parts.
[B] These steels can be expected to contain 0.0005 to 0.003% boron. If the usual titanium additive is not permitted, the steels can be expected to contain up to 0.005% boron.

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TABLE 3
HEAT ANALYSIS CHEMICAL RANGES AND LIMITS OF CARBON STEEL BARS

Element	Chemical Ranges and Limits, %: When Maximum of Specified Elements is:	Range	Lowest Maximum
Carbon[A]	. . .	. . .	0.06
	to 0.12, incl	. . .	. . .
	over 0.12 to 0.25, incl	0.05	. . .
	over 0.25 to 0.40, incl	0.06	. . .
	over 0.40 to 0.55, incl	0.07	. . .
	over 0.55 to 0.80, incl	0.10	. . .
	over 0.80	0.13	. . .
Manganese	. . .	. . .	0.35
	to 0.40, incl	0.15	. . .
	over 0.40 to 0.50, incl	0.20	. . .
	over 0.50 to 1.65, incl	0.30	. . .
Phosphorus	to 0.040, incl	. . .	0.040[B]
	over 0.040 to 0.08, incl	0.03	. . .
	over 0.08 to 0.13, incl	0.05	. . .
Sulfur	to 0.050, incl	. . .	0.050[B]
	over 0.050 to 0.09, incl	0.03	. . .
	over 0.09 to 0.15, incl	0.05	. . .
	over 0.15 to 0.23, incl	0.07	. . .
	over 0.23 to 0.50, incl	0.09	. . .
Silicon[C]	. . .	. . .	0.10
	to 0.10, incl	. . .	. . .
	over 0.10 to 0.15, incl	0.08	. . .
	over 0.15 to 0.20, incl	0.10	. . .
	over 0.20 to 0.30, incl	0.15	. . .
	over 0.30 to 0.60, incl	0.20	. . .
Copper	When copper is required 0.20 min is generally used		
Lead[D]	When lead is required, a range of 0.15 to 0.35 is specified		
Bismuth[E]			
Calcium[E]			
Selenium[E]			
Tellurium[E]			

[A] The carbon ranges shown in the column headed "Range" apply when the specified maximum limit for manganese does not exceed 1.10%. When the maximum manganese limit exceeds 1.10%, add 0.01 to the carbon ranges shown above.
[B] For steels produced in merchant quality the phosphorus maximum is 0.04% and the sulfur maximum is 0.05%.
[C] It is not common practice to produce a rephosphorized and resulfurized carbon steel to specified limits for silicon because of its adverse effect on machinability.
[D] A cast or heat analysis is not determinable when lead is added to the ladle stream.
[E] Element specification range as agreed upon between purchaser and supplier.

TABLE 4
HEAT ANALYSIS CHEMICAL RANGES AND LIMITS OF ALLOY STEEL BARS

NOTE 1 — Boron steels can be expected to have 0.0005% minimum boron content.
NOTE 2 — Alloy steels can be produced with a lead range of 0.15–0.35%. A cast or heat analysis is not determinable when lead is added to the ladle stream.

Element	Chemical Ranges and Limits, %: When Maximum of Specified Element is:	Open-Hearth or Basic-Oxygen Steel	Electric Furnace Steel	Maximum Limit, %[A]
Carbon	To 0.55, incl	0.05	0.05	
	Over 0.55–0.70, incl	0.08	0.07	
	Over 0.70 to 0.80, incl	0.10	0.09	
	Over 0.80–0.95, incl	0.12	0.11	
	Over 0.95–1.35, incl	0.13	0.12	
Manganese	To 0.60, incl	0.20	0.15	
	Over 0.60–0.90, incl	0.20	0.20	
	Over 0.90–1.05, incl	0.25	0.25	
	Over 1.05–1.90, incl	0.30	0.30	
	Over 1.90–2.10, incl	0.40	0.35	
Phosphorus	Basic open-hearth or basic-oxygen steel			0.035
	Acid open-hearth steel			0.050
	Basic electric-furnace steel			0.025
	Acid electric-furnace steel			0.050
Sulfur	To 0.050, incl	0.015	0.015	
	Over 0.050–0.07, incl	0.02	0.02	
	Over 0.07–0.10, incl	0.04	0.04	
	Over 0.10–0.14, incl	0.05	0.05	
	Basic open-hearth or basic-oxygen steel			0.040
	Acid open-hearth steel			0.050
	Basic electric-furnace steel			0.025
	Acid electric-furnace steel			0.050
Silicon	To 0.20, incl	0.08	0.08	
	Over 0.20–0.30, incl	0.15	0.15	
	Over 0.30–0.60, incl	0.20	0.20	
	Over 0.60–1.00, incl	0.30	0.30	
	Over 1.00–2.20, incl	0.40	0.35	
	Acid steels[B]			
Nickel	To 0.50, incl	0.20	0.20	
	Over 0.50–1.50, incl	0.30	0.30	
	Over 1.50–2.00, incl	0.35	0.35	
	Over 2.00–3.00, incl	0.40	0.40	
	Over 3.00–5.30, incl	0.50	0.50	
	Over 5.30–10.00, incl	1.00	1.00	
Chromium	To 0.40, incl	0.15	0.15	
	Over 0.40–0.90, incl	0.20	0.20	
	Over 0.90–1.05, incl	0.25	0.25	
	Over 1.05–1.60, incl	0.30	0.30	
	Over 1.60–1.75, incl	[C]	0.35	
	Over 1.75–2.10, incl	[C]	0.40	
	Over 2.10–3.99, incl	[C]	0.50	
Molybdenum	To 0.10, incl	0.05	0.05	
	Over 0.10–0.20, incl	0.07	0.07	
	Over 0.20–0.50, incl	0.10	0.10	
	Over 0.50–0.80, incl	0.15	0.15	
	Over 0.80–1.15, incl	0.20	0.20	
Tungsten	To 0.50, incl	0.20	0.20	
	Over 0.50–1.00, incl	0.30	0.30	
	Over 1.00–2.00, incl	0.50	0.50	
	Over 2.00–4.00, incl	0.60	0.60	
Vanadium	To 0.25, incl	0.05	0.05	
	Over 0.25–0.50, incl	0.10	0.10	
Aluminum	Up to 0.10, incl	0.05	0.05	
	Over 0.10–0.20, incl	0.10	0.10	
	Over 0.20–0.30, incl	0.15	0.15	
	Over 0.30–0.80, incl	0.25	0.25	
	Over 0.80–1.30, incl	0.35	0.35	
	Over 1.30–1.80, incl	0.45	0.45	
Copper	To 0.60, incl	0.20	0.20	
	Over 0.60–1.50, incl	0.30	0.30	
	Over 1.50–2.00, incl	0.35	0.35	

[A] Applies to only nonrephosphorized and nonresulfurized steels.
[B] Minimum silicon limit for acid open-hearth or acid electric-furnace alloy steels is 0.15%.
[C] Not normally produced in open-hearth.

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TABLE 5
PERMISSIBLE VARIATIONS FOR PRODUCT ANALYSIS OF CARBON STEEL

Element	Limit, or Maximum of Specified Range, %	Over Maximum Limit, %	Under Minimum Limit, %
Carbon[A]	0.25 and under	0.02	0.02
	over 0.25 to 0.55, incl	0.03	0.03
	over 0.55	0.04	0.04
Manganese	0.90 and under	0.03	0.03
	over 0.90 to 1.65, incl	0.06	0.06
Phosphorus[A,B]	basic steels	0.008	. . .
	acid bessemer steel	0.01	0.01
Sulfur[A,B]		0.008	. . .
Silicon	0.35 and under	0.02	0.02
	over 0.35 to 0.60, incl	0.05	0.05
Copper	under minimum only	. . .	0.02
Lead[C]	0.15 to 0.35, incl	0.03	0.03

[A] Rimmed and capped steels are not subject to rejection on product analysis unless misapplication is clearly indicated.
[B] Resulfurized or rephosphorized steels are not subject to rejection on product analysis for these elements unless misapplication is clearly indicated.
[C] Product analysis tolerance for lead applies both over and under to a specified range of 0.15 to 0.35%.

TABLE 6
PERMISSIBLE VARIATIONS FOR PRODUCT ANALYSIS OF ALLOY STEEL

Elements	Limit, or Maximum of Specified Range, %	Permissible Variations Over Maximum Limit or Under Minimum Limit, %
Carbon	0.30 and under	0.01
	over 0.30 to 0.75, incl	0.02
	over 0.75	0.03
Manganese	0.90 and under	0.03
	over 0.90 to 2.10, incl	0.04
Phosphorus	over maximum only	0.005
Sulfur	0.060 and under	0.005
Silicon	0.40 and under	0.02
	over 0.40 to 2.20, incl	0.05
Nickel	1.00 and under	0.03
	over 1.00 to 2.00, incl	0.05
	over 2.00 to 5.30, incl	0.07
	over 5.30 to 10.00, incl	0.10
Chromium	0.90 and under	0.03
	over 0.90 to 2.10, incl	0.05
	over 2.10 to 3.99, incl	0.10
Molybdenum	0.20 and under	0.01
	over 0.20 to 0.40, incl	0.02
	over 0.40 to 1.15, incl	0.03
Vanadium	0.10 and under	0.01
	over 0.10 to 0.25, incl	0.02
	over 0.25 to 0.50, incl	0.03
	minimum value specified, under minimum limit only	0.01
Tungsten	1.00 and under	0.04
	over 1.00 to 4.00, incl	0.08
Aluminum	0.10 and under	0.03
	over 0.10 to 0.20, incl	0.04
	over 0.20 to 0.30, incl	0.05
	over 0.30 to 0.80, incl	0.07
	over 0.80 to 1.80, incl	0.10
Lead[A]	0.15 to 0.35, incl	0.03
Copper	to 1.00 incl	0.03
	over 1.00 to 2.00, incl	0.05

[A] Product analysis tolerance for lead applies both over and under to a specified range of 0.15 to 0.35%.

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SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the contract or order.

S1. Flat Bar Thickness Tolerances

S1.1 When flat bars are specified in metric units to a thickness under tolerance of 0.3 mm, the thickness tolerance of Table S1.1 shall apply.

TABLE S1.1
THICKNESS AND WIDTH TOLERANCES FOR HOT-WROUGHT SQUARE-EDGE AND ROUND-EDGE FLAT BARS ORDERED TO 0.3 MM UNDER TOLERANCE[A]

NOTE — Tolerance under specified thickness 0.3 mm.

	Tolerances over Specified Thickness for Thickness Given, mm					Tolerance from Specified Width, mm	
Specified Width, mm	Over 6 to 12, incl	Over 12 to 25, incl	Over 25 to 50, incl	Over 50 to 75, incl	Over 75	Over	Under
To 25, incl	. . .	. . .	. . .	. . .	. . .	0.5	0.5
Over 25 to 50, incl	. . .	0.5	1.3	. . .	. . .	1.0	1.0
Over 50 to 100, incl	0.5	0.7	1.3	2.1	2.1	1.5	1.0
Over 100 to 150, incl	0.5	0.7	1.3	2.1	2.1	2.5	1.5
Over 150 to 200, incl	0.5	1.0	1.3	2.1	2.9	3.0	2.5

[A] When a square is held against a face and an edge of a square-edge flat bar, the edge shall not deviate by more than 3° or 5% of the thickness.

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ANNEXES

(Mandatory Information)

A1. PERMISSIBLE VARIATIONS IN DIMENSIONS, ETC. — INCH-POUND UNITS

A1.1 Listed below are permissible variations in dimensions expressed in inch-pound units of measurement.

TABLE A1.1
PERMISSIBLE VARIATIONS IN CROSS SECTION FOR HOT-WROUGHT ROUND, SQUARE, AND ROUND-CORNERED SQUARE BARS OF STEEL

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

[A] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[B] Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section. Out-of-square is the difference in the two dimensions at the same cross section of a square bar between opposite faces.

TABLE A1.2
PERMISSIBLE VARIATIONS IN CROSS SECTION FOR HOT-WROUGHT HEXAGONAL BARS OF STEEL

Specified Sizes Between Opposite Sides, in.	Permissible Variations from Specified Size, in.[A] Over	Under	Out-of-Hexagon (Carbon Steel and Alloy Steel) or Out-of-Octagon (Alloy Steel), in.[B]
To 1/2, incl	0.007	0.007	0.011
Over 1/2 to 1, incl	0.010	0.010	0.015
Over 1 to 1 1/2, incl	0.021	0.013	0.025
Over 1 1/2 to 2, incl	1/32	1/64	1/32
Over 2 to 2 1/2, incl	3/64	1/64	3/64
Over 2 1/2 to 3 1/2, incl	1/16	1/64	1/16
Over 3 1/2 to 4 1/16, incl	5/64	1/64	5/64

[A] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[B] Out-of-hexagon or out-of-octagon is the greatest difference between any two dimensions at the same cross section between opposite faces.

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TABLE A1.3
PERMISSIBLE VARIATIONS IN THICKNESS AND WIDTH FOR HOT-WROUGHT SQUARE EDGE AND ROUND EDGE FLAT BARS[A]

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

[A] When a square is held against a face and an edge of a square edge flat bar, the edge shall not deviate by more than 3° or 5% of the thickness.
[B] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.
[C] Flats over 6 to 8 in., incl, in width, are not available as hot-wrought steel bars in thickness under 0.230 in.

TABLE A1.4
PERMISSIBLE VARIATIONS IN THICKNESS, LENGTH, AND OUT-OF-SQUARE FOR HOT-WROUGHT BAR SIZE ANGLES OF CARBON STEEL

Specified Length of Leg, in.[A]	Permissible Variations in Thickness, for Thicknesses Given, Over and Under, in.			Permissible Variations for Length of Leg, Over and Under, in.
	To 3/16, incl	Over 3/16 to 3/8, incl	Over 3/8	
To 1, incl	0.008	0.010	. . .	1/32
Over 1 to 2, incl	0.010	0.010	0.012	3/64
Over 2 to 3, excl	0.012	0.015	0.015	1/16

[A] The longer leg of an unequal angle determines the size for tolerance. The out-of-square tolerance in either direction is 1 1/2°.

TABLE A1.5
PERMISSIBLE VARIATIONS IN DIMENSIONS FOR HOT-WROUGHT BAR SIZE CHANNELS OF CARBON STEEL

Specified Size of Channel, in.	Permissible Variations in Size, Over and Under, in.				Out-of-Square[A] if Either Flange, in./in. of Flange Width
	Depth of Section[B]	Width of Flanges[B]	Thickness of Web for Thickness Given		
			To 3/16, incl	Over 3/16	
To 1 1/2, incl	1/32	1/32	0.010	0.015	1/32
Over 1 1/2 to 3, excl	1/16	1/16	0.015	0.020	1/32

[A] For channels 5/8 in. and under in depth, the out-of-square tolerance is 3/64 in./in. of depth.
[B] Measurements for depth of section and width of flanges are overall.

TABLE A1.6
PERMISSIBLE VARIATIONS IN DIMENSIONS FOR HOT-WROUGHT BAR SIZE TEES OF CARBON STEEL

Specified Size of Tee, in.[A]	Permissible Variations in Size, in.						
	Width or Depth[B]		Thickness of Flange		Thickness of Stem		Stem out-of-Square[C]
	Over	Under	Over	Under	Over	Under	
To 1 1/4, incl	3/64	3/64	0.010	0.010	0.005	0.020	1/32
Over 1 1/4 to 2, incl	1/16	1/16	0.012	0.012	0.010	0.020	1/16
Over 2 to 3, excl	3/32	3/32	0.015	0.015	0.015	0.020	3/32

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

TABLE A1.7
PERMISSIBLE VARIATIONS IN DIMENSIONS FOR HALF-ROUNDS, OVALS, HALF-OVALS, AND OTHER SPECIAL BAR SIZE SECTIONS

Due to mill facilities, tolerances on half-rounds, ovals, half-ovals, and other special bar size sections vary among the manufacturers and such tolerances should be negotiated between the manufacturer and the purchaser.

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TABLE A1.8
PERMISSIBLE VARIATIONS IN LENGTH FOR HOT-WROUGHT ROUNDS, SQUARES, HEXAGONS, FLATS, AND BAR SIZE SECTIONS OF STEEL

Specified Size of Rounds, Squares, and Hexagons, in.	Specified Size of Flats, in.		Permissible Variations Over Specified Length, in.[A]				
	Thickness	Width	5 to 10 ft, excl	10 to 20 ft, excl	20 to 30 ft, excl	30 to 40 ft, excl	40 to 60 ft, excl
Mill Shearing							
To 1, incl	to 1, incl	to 3, incl	1/2	3/4	1 1/4	1 3/4	2 1/4
Over 1 to 2, incl	over 1	to 3, incl	5/8	1	1 1/2	2	2 1/2
	to 1, incl	over 3 to 6, incl	5/8	1	1 1/2	2	2 1/2
Over 2 to 5, incl	over 1	over 3 to 6, incl	1	1 1/2	1 3/4	2 1/4	2 3/4
Over 5 to 10, incl	. . .	. . .	2	2 1/2	2 3/4	3	3 1/4
	0.230 to 1, incl	over 6 to 8, incl	3/4	1 1/4	1 3/4	3 1/2	4
	over 1 to 3, incl	over 6 to 8, incl	1 1/4	1 3/4	2	3 1/2	4
Bar Size Sections	. . .	. . .	5/8	1	1 1/2	2	2 1/2
Hot Sawing							
2 to 5, incl	1 and over	3 and over	[B]	1 1/2	1 3/4	2 1/4	2 3/4
Over 5 to 10, incl	. . .	. . .	[B]	2 1/2	2 3/4	3	3 1/4

[A] No permissible variations under.
[B] Smaller sizes and shorter lengths are not hot sawed.

TABLE A1.9
PERMISSIBLE VARIATIONS IN LENGTH FOR RECUTTING OF BARS MEETING SPECIAL STRAIGHTNESS TOLERANCES

Sizes of Rounds, Squares, Hexagons, Width of Flats and Maximum Dimension of Other Sections, in.[A]	Tolerances Over Specified Length, in.[A]	
	To 12 ft, incl	Over 12 ft
To 3, incl	1/4	5/16
Over 3 to 6, incl	5/16	7/16
Over 6 to 8, incl	7/16	9/16
Rounds over 8 to 10, incl	9/16	11/16

[A] No tolerance under.

TABLE A1.10
PERMISSIBLE VARIATIONS IN STRAIGHTNESS FOR HOT-WROUGHT BARS AND BAR SIZE SECTIONS OF STEEL[A]

Standard tolerances	1/4 in. in any 5 ft or (1/4 in. × length in ft)/5
Special tolerances	1/8 in. in any 5 ft or (1/8 in. × length in ft)/5

[A] Because of warpage, straightness tolerances do not apply to bars if any subsequent heating operation or controlled cooling has been performed.

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TABLE A1.11
SIZE TOLERANCES FOR COLD-FINISHED CARBON STEEL BARS, COLD DRAWN OR TURNED AND POLISHED[A]

Size, in.[B]	Maximum of Carbon Range 0.28% or less	Maximum of Carbon Range Over 0.28% to 0.55%, incl	Maximum of Carbon Range to 0.55%, incl, Stress Relieved or Annealed after Cold Finishing	Maximum of Carbon Range Over 0.55% or All Grades Quenched and Tempered or Normalized and Tempered before Cold Finishing
	All tolerances are in inches[B] and are minus[C]			
Rounds — Cold Drawn (to 4 in.) or Turned and Polished				
To 1½, incl	0.002	0.003	0.004	0.005
Over 1½ to 2½, incl	0.003	0.004	0.005	0.006
Over 2½ to 4, incl	0.004	0.005	0.006	0.007
Over 4 to 6, incl	0.005	0.006	0.007	0.008
Over 6 to 8, incl	0.006	0.007	0.008	0.009
Over 8 to 9, incl	0.007	0.008	0.009	0.010
Hexagons				
To ¾, incl	0.002	0.003	0.004	0.006
Over ¾ to 1½, incl	0.003	0.004	0.005	0.007
Over 1½ to 2½, incl	0.004	0.005	0.006	0.008
Over 2½ to 3⅛, incl	0.005	0.006	0.007	0.009
Over 3⅛ to 4, incl	0.005	0.006	. . .	. . .
Squares[C]				
To ¾, incl	0.002	0.004	0.005	0.007
Over ¾ to 1½, incl	0.003	0.005	0.006	0.008
Over 1½ to 2½, incl	0.004	0.006	0.007	0.009
Over 2½ to 4, incl	0.006	0.008	0.009	0.011
Over 4 to 5, incl	0.010	. . .	. . .	. . .
Over 5 to 6, incl	0.014	. . .	. . .	. . .
Flats[D]				
Width,[B] in.				
To ¾, incl	0.003	0.004	0.006	0.008
Over ¾ to 1½, incl	0.004	0.005	0.008	0.010
Over 1½ to 3, incl	0.005	0.006	0.010	0.012
Over 3 to 4, incl	0.006	0.008	0.011	0.016
Over 4 to 6, incl	0.008	0.010	0.012	0.020
Over 6	0.013	0.015		

[A] This table includes tolerances for bars that have been annealed, spheroidize annealed, normalized, normalized and tempered, or quenched and tempered before cold finishing. This table does not include tolerances for bars that are annealed, spheroidize annealed, normalized, normalized and tempered, or quenched and tempered after cold finishing; the producer should be consulted for tolerances for such bars.

[B] Width governs the tolerances for both width and thickness of flats. For example, when the maximum of carbon range is 0.28% or less, for a flat 2 in. wide and 1 in. thick, the width tolerance is 0.005 in. and the thickness tolerance is the same, namely, 0.005 in.

[C] Standard manufacturing practice is a shear cut for cold drawn bars (size limits vary by producer) which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[D] Tolerances may be ordered all plus, or distributed plus and minus with the sum equivalent to the tolerances listed.

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TABLE A1.12
SIZE TOLERANCES FOR COLD FINISHED ROUND BARS COLD DRAWN, GROUND AND POLISHED OR TURNED, GROUND AND POLISHED

Size, in. Cold Drawn, Ground and Polished	Turned, Ground and Polished	Tolerances from Specified Size, Minus Only, in.
To 1½, incl	To 1½, incl	0.001
Over 1½ to 2½, excl	Over 1½ to 2½, excl	0.0015
2½ to 3, incl	2½ to 3, incl	0.002
Over 3 to 4, incl	Over 3 to 4, incl	0.003
. . .	Over 4 to 6, incl	0.004[A]
. . .	Over 6	0.005[A]

[A] For non-resulfurized steels (steels specified to maximum sulphur limits under 0.08%), or for steels thermally treated, the tolerance is increased by 0.001 in.

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TABLE A1.13
SIZE TOLERANCE FOR COLD-FINISHED ALLOY STEEL BARS, COLD DRAWN, OR TURNED AND POLISHED

Size in.[A]	Maximum of Carbon Range 0.28% or less	Maximum of Carbon Range Over 0.28% to 0.55%, incl	Maximum of Carbon Range to 0.55%, incl, Stress Relieved or Annealed after Cold Finishing	Maximum of Carbon Range Over 0.55% With or Without Stress Relieving or Annealing after Cold Finishing. Also all Carbons, Quenched and Tempered (Heat Treated), or Normalized and Tempered, before Cold Finishing
	All tolerances are in inches and are minus[B]			
Rounds — Cold Drawn (to 4 in.) or Turned and Polished				
To 1, incl, in coils	0.002	0.003	0.004	0.005
Cut Lengths:				
To 1½, incl	0.003	0.004	0.005	0.006
Over 1½ to 2½, incl	0.004	0.005	0.006	0.007
Over 2½ to 4, incl	0.005	0.006	0.007	0.008
Over 4 to 6, incl	0.006	0.007	0.008	0.009
Over 6 to 8, incl	0.007	0.008	0.009	0.010
Over 8 to 9, incl	0.008	0.009	0.010	0.011
Hexagons				
To ¾, incl	0.003	0.004	0.005	0.007
Over ¾ to 1½, incl	0.004	0.005	0.006	0.008
Over 1½ to 2½, incl	0.005	0.006	0.007	0.009
Over 2½ to 3⅛, incl	0.006	0.007	0.008	0.010
Over 3⅛ to 4, incl	0.006	. . .	. . .	. . .
Squares				
To ¾, incl	0.003	0.005	0.006	0.008
Over ¾ to 1½, incl	0.004	0.006	0.007	0.009
Over 1½ to 2½, incl	0.005	0.007	0.008	0.010
Over 2½ to 4, incl	0.007	0.009	0.010	0.012
Over 4 to 5, incl	0.011	. . .	. . .	. . .
Flats[A]				
To ¾, incl	0.004	0.005	0.007	0.009
Over ¾ to 1½, incl	0.005	0.006	0.009	0.011
Over 1½ to 3, incl	0.006	0.007	0.011	0.013
Over 3 to 4, incl	0.007	0.009	0.012	0.017
Over 4 to 6, incl	0.009	0.011	0.013	0.021
Over 6	0.014	. . .	. . .	. . .

[A] Width governs the tolerances for both width and thickness of flats. For example, when the maximum of carbon range is 0.28% or less, for a flat 2 in. wide and 1 in. thick, the width tolerance is 0.006 in. and the thickness tolerance is the same, namely 0.006 in.

[B] Standard manufacturing practice is a shear cut for cold drawn bars (size limits vary by producer) which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

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TABLE A1.14
STRAIGHTNESS TOLERANCES FOR COLD FINISHED BARS[A,B]

Note 1 — All grades quenched and tempered or normalized and tempered to Brinell 302 max. *before* cold finishing; and all grades stress relieved or annealed *after* cold finishing. Straightness tolerances are not applicable to bars having Brinell hardness exceeding 302.

		Straightness Tolerances, in. (Maximum Deviation) from Straightness in any 10-ft Portion of the Bar			
		Maximum of Carbon Range, 0.28% or Less		Maximum of Carbon Range Over 0.28% and All Grades Thermally Treated	
Size, in.	Length, ft	Rounds	Squares, Hexagons, and Octagons	Rounds	Squares, Hexagons, and Octagons
Less than 5/8	less than 15	1/8	3/16	3/16	1/4
Less than 5/8	15 and over	1/8	5/16	5/16	3/8
5/8 and over	less than 15	1/16	1/8	1/8	3/16
5/8 and over	15 and over	1/8	3/16	3/16	1/4

[A] The foregoing tolerances are based on the following method of measuring straightness: Departure from straightness is measured by placing the bar on a level table so that the arc or departure from straightness is horizontal, and the depth of the arc is measured with a feeler gage and a straightedge.

[B] It should be recognized that straightness is a perishable quality and may be altered by mishandling. The preservation of straightness in cold-finished bars requires the utmost care in subsequent handling. Specific straightness tolerances are sometimes required for carbon and alloy steels in which case the purchaser should inform the manufacturer of the straightness tolerances and the methods to be used in checking the straightness.

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A2. DIMENSIONAL TOLERANCES — SI UNITS

A2.1 Listed below are permissible variations in dimensions expressed in SI units of measurement.

TABLE A2.1
TOLERANCES IN SECTIONAL DIMENSIONS FOR ROUND AND SQUARE BARS AND ROUND-CORNERED SQUARE BARS

Size, mm	Tolerance from Specified Size, Over and Under, mm or %[A]	Out-of-Round, or Out-of-Square Section,[B] mm or %[A]
To 7, incl	0.13 mm	0.20 mm
Over 7 to 11, incl	0.15 mm	0.22 mm
Over 11 to 15, incl	0.18 mm	0.27 mm
Over 15 to 19, incl	0.20 mm	0.30 mm
Over 19 to 250, incl	1%	1.5%

[A] The tolerance shall be rounded to the nearest tenth of a millimetre after calculation.
[B] Out-of-round is the difference between the maximum and the minimum diameters of the bar, measured at the same cross section. Out-of-square is the difference in the two dimensions at the same cross section of a square bar between opposite faces.

TABLE A2.2
TOLERANCES IN CROSS SECTION FOR HOT-WROUGHT HEXAGONAL AND OCTAGONAL STEEL BARS

Specified Size Between Opposite Sides, mm	Tolerance from Specified Size, mm		Out of Hexagon or Out of Octagon, mm[A]
	Over	Under	
To 13, incl	0.18	0.18	0.3
Over 13 to 25, incl	0.25	0.25	0.4
Over 25 to 40, incl	0.55	0.35	0.6
Over 40 to 50, incl	0.8	0.40	0.8
Over 50 to 65, incl	1.2	0.40	1.2
Over 65 to 80, incl	1.6	0.40	1.6
Over 80 to 100, incl	2.0	0.40	2.0

[A] Out of hexagon or out of octagon is the greatest difference between any two dimensions at the cross section between opposite faces.

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TABLE A2.3
THICKNESS AND WIDTH TOLERANCES FOR HOT-WROUGHT SQUARE-EDGE AND ROUND-EDGE FLAT BARS[A,B]

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

[A] When a square is held against a face and an edge of a square edge flat bar, the edge shall not deviate by more than 3° or 5% of the thickness.
[B] Flats over 150 to 200 mm, incl in width are not available as hot-wrought bars in thickness 6 mm and under.

TABLE A2.4
THICKNESS, LENGTH, AND OUT-OF-SQUARE TOLERANCES FOR HOT-WROUGHT BAR SIZE ANGLES

Specified Length of Leg, mm[A,B]	Tolerances in Thickness for Thickness Given, Over and Under, mm			Tolerances for Length of Leg Over and Under, mm
	To 5, incl	Over 5 to 10, incl	Over 10	
To 50, incl	0.2	0.2	0.3	1
Over 50 to 75, excl	0.3	0.4	0.4	2

[A] The longer leg of an unequal angle determines the size for tolerance.
[B] Out of square tolerances in either direction is $1\frac{1}{2}°$ = 0.026 mm/mm.

TABLE A2.5
DIMENSIONAL TOLERANCES FOR HOT-WROUGHT BAR SIZE CHANNELS

Specified Size of Channel, mm	Tolerances in Size, Over and Under, mm				
	Depth of Section[A]	Width of Flanges[A]	Thickness of Web		Out of Square of Either Flange per mm of Flange Width,[B] mm
			To 5, incl	Over 5	
To 40, incl	1	1	0.2	0.4	0.03
Over 40 to 75, excl	2	2	0.4	0.5	0.03

[A] Measurements for depth of section and width of flanges are overall.
[B] For channels 16 mm and under in depth, out of square tolerance is 0.05 mm/mm.

TABLE A2.6
DIMENSIONAL TOLERANCES FOR HOT-WROUGHT BAR SIZE TEES

Specified Size of Tee,[A] mm	Tolerances in Size, mm						
	Width or Depth,[B]		Thickness of Flange		Thickness of Stem		Stem Out of Square[C]
	Over	Under	Over	Under	Over	Under	
To 30, incl	1	1	0.2	0.2	0.1	0.5	1
Over 30 to 50, incl	2	2	0.3	0.3	0.2	0.5	2
Over 50 to 75, excl	2	2	0.4	0.4	0.4	0.5	2

[A] The longer member of the unequal tee determines the size for tolerances.
[B] Measurements for width and depth are over all.
[C] Stem out of square is the tolerance from its true position of the center line of the stem measured at the point.

TABLE A2.7
PERMISSIBLE VARIATIONS IN DIMENSIONS FOR HALF-ROUNDS, OVALS, HALF-OVALS, AND OTHER SPECIAL BAR SIZE SECTIONS

Due to mill facilities, tolerances on half-rounds, ovals, and other special bar size sections vary among the manufacturers and such tolerances should be negotiated between the manufacturer and the purchaser.

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TABLE A2.8
LENGTH TOLERANCES FOR HOT-WROUGHT ROUNDS, SQUARES, HEXAGONS, OCTAGONS, FLATS, AND BAR SIZE SECTIONS

Specified Size of Rounds, Squares, Hexagons and Octagons, mm	Specified Size of Flats, mm		Tolerances over Specified Length, mm[A]				
	Thickness	Width	1500 to 3000, excl	3000 to 6000, excl	6000 to 9000, excl	9000 to 12 000, excl	12 000 to 18 000, excl
Hot Shearing							
To 25, incl	to 25, incl	to 75, incl	15	20	35	45	60
Over 25 to 50, incl	over 25	to 75, incl	15	25	40	50	65
	to 25, incl	over 75 to 150, incl	15	25	40	50	65
Over 50 to 125, incl	over 25	over 75 to 150, incl	25	40	45	60	70
Over 125 to 250, incl	. . .	. . .	50	65	70	75	85
Bar Size Sections	over 6 to 25, incl	over 150 to 200, incl	20	30	45	90	100
	over 25 to 75, incl	over 150 to 200, incl	30	45	50	90	100
	. . .	. . .	15	25	40	50	65
Hot Sawing							
50 to 125, incl	25 and over	75 and over	[B]	40	45	60	70
Over 125 to 250, incl	. . .	. . .	[B]	65	70	75	85

[A] No tolerance under.
[B] Smaller sizes and shorter lengths are not hot sawed.

TABLE A2.9
LENGTH TOLERANCES FOR RECUTTING OF BARS MEETING SPECIAL STRAIGHTNESS TOLERANCES

Sizes of Rounds, Squares, Hexagons, Octagons, Widths of Flats and Maximum Dimensions of Other Sections, mm	Tolerances over Specified Length, mm[A]	
	To 3700 mm, incl	Over 3700 mm
To 75, incl	6	8
Over 75 to 150, incl	8	11
Over 150 to 200, incl	11	14
Rounds over 200 to 250, incl	14	18

[A] No tolerance under.

TABLE A2.10
STRAIGHTNESS TOLERANCES FOR HOT-WROUGHT BARS AND BAR SIZE SECTIONS[A]

Standard tolerances	6 mm in any 1500 mm or (length in mm/250)[B]
Special tolerances	3 mm in any 1500 mm or (length in mm/500)[B]

[A] Because of warpage, straightness tolerances do not apply to bars if any subsequent heating operation or controlled cooling has been performed.
[B] Round to the nearest whole millimeter.

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TABLE A2.11
SIZE TOLERANCES FOR COLD-FINISHED CARBON STEEL BARS, COLD DRAWN OR TURNED AND POLISHED[A]

Size, mm	Tolerances from Specified Size, Under Only, mm			
	Maximum of Carbon Range 0.28 or Less	Maximum of Carbon Range Over 0.28 to 0.55, incl	Maximum of Carbon Range to 0.55%, incl Stress Relief or Annealed After Cold Finishing	Maximum of Carbon Range Over 0.55% or All Grades Quenched and Tempered or Normalized Before Cold Finishing
Rounds — Cold Drawn (to 100 mm in size) or Turned and Polished				
To 40, incl	0.05	0.08	0.10	0.13
Over 40 to 60, incl	0.08	0.10	0.13	0.15
Over 60 to 100, incl	0.10	0.13	0.15	0.18
Over 100 to 150, incl	0.13	0.15	0.18	0.20
Over 150 to 200, incl	0.15	0.18	0.20	0.23
Over 200 to 230, incl	0.18	0.20	0.23	0.25
Hexagons — Cold Drawn				
Up to 20, incl	0.05	0.08	0.10	0.15
Over 20 to 40, incl	0.08	0.10	0.13	0.18
Over 40 to 60, incl	0.10	0.13	0.15	0.20
Over 60 to 80, incl	0.13	0.15	0.18	0.23
Over 80 to 100, incl	0.13	0.15	. . .	
Squares— Cold Drawn[B]				
Up to 20, incl	0.05	0.10	0.13	0.18
Over 20 to 40, incl	0.08	0.13	0.15	0.20
Over 40 to 60, incl	0.10	0.15	0.18	0.23
Over 60 to 100, incl	0.15	0.20	0.23	0.28
Over 100 to 130, incl	0.25	. . .	. . .	. . .
Over 130 to 150, incl	0.36	. . .	. . .	. . .
Flats — Cold Drawn[B,C]				
To 20, incl	0.08	0.10	0.15	0.20
Over 20 to 40, incl	0.10	0.13	0.20	0.25
Over 40 to 80, incl	0.13	0.15	0.25	0.30
Over 80 to 100, incl	0.15	0.20	0.28	0.40
Over 100 to 150, incl	0.20	0.25	0.30	0.50
Over 150	0.33	0.38	. . .	. . .

[A] This table includes tolerances for bars that have been annealed, spheroidize annealed, normalized, normalized and tempered, or quenched and tempered before cold finishing. This table does not include tolerances for bars that are annealed, spheroidize annealed, normalized, normalized and tempered, or quenched and tempered after cold finishing; the producer should be consulted for tolerances for such bars.

[B] Tolerances may be ordered all plus, or distributed plus and minus with the sum equivalent to the tolerances listed.

[C] Width governs the tolerance for both width and thickness of flats, for example, when the maximum of carbon range is 0.28% or less for a flat 50 mm wide and 25 mm thick, the width tolerance is 0.13 mm and the thickness is the same, nearly, 0.13 mm.

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TABLE A2.12
SIZE TOLERANCES FOR COLD-FINISHED ROUND BARS, COLD DRAWN, GROUND AND POLISHED, OR TURNED, GROUND AND POLISHED

Size, mm		Tolerances from, Specified Size, Minus Only, mm
Cold Drawn, Ground, and Polished	Turned, Ground, and Polished	
To 40, incl	To 40, incl	0.03
Over 40 to 60, incl	Over 40 to 60, incl	0.04
Over 60 to 80, incl	Over 60 to 80, incl	0.05
Over 80 to 100, incl	Over 80 to 100, incl	0.08
. . .	Over 100 to 150, incl	0.10[A]
. . .	Over 150	0.13[A]

[A] For nonresulphurized steels (steels specified to maximum sulfur limits under 0.08%) or for steels thermally treated, the tolerance is increased by 0.03 mm.

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TABLE A2.13
SIZE TOLERANCES FOR COLD-FINISHED ALLOY STEEL BARS, COLD DRAWN OR TURNED AND POLISHED[A]

Size, mm	Tolerances from Specified Size, Under Only, mm			
	Maximum of Carbon Range 0.28 or less	Maximum of Carbon Range Over 0.28 to 0.55, incl	Maximum of Carbon Range to 0.55%, incl Stress Relief or Annealed After Cold Finishing	Maximum of Carbon Range Over 0.55% or All Grades Quenched and Tempered or Normalized Before Cold Finishing
Rounds — Cold Drawn (to 100 mm in size) or Turned and Polished				
To 25, incl, in coils	0.05	0.08	0.10	0.13
Cut Lengths				
To 40, incl	0.08	0.10	0.13	0.15
Over 40 to 60, incl	0.10	0.13	0.15	0.18
Over 60 to 100, incl	0.13	0.15	0.18	0.20
Over 100 to 150, incl	0.15	0.18	0.20	0.23
Over 150 to 200, incl	0.18	0.20	0.23	0.25
Over 200 to 230, incl	0.20	0.23	0.25	0.28
Hexagons — Cold Drawn				
Up to 20, incl	0.08	0.10	0.13	0.18
Over 20 to 40, incl	0.10	0.13	0.15	0.20
Over 40 to 60, incl	0.13	0.15	0.18	0.23
Over 60 to 80, incl	0.15	0.18	0.20	0.25
Over 80 to 100, incl	0.15	. . .	. . .	. . .
Squares — Cold Drawn				
Up to 20, incl	0.08	0.13	0.15	0.20
Over 20 to 40, incl	0.10	0.15	0.18	0.23
Over 40 to 60, incl	0.13	0.18	0.20	0.25
Over 60 to 100, incl	0.18	0.23	0.25	0.30
Over 100 to 130, incl	0.28	0.23	0.25	0.30
Flats — Cold Drawn[B]				
Width[B]				
To 20, incl	0.10	0.13	0.18	0.23
Over 20 to 40, incl	0.13	0.15	0.23	0.28
Over 40 to 80, incl	0.15	0.18	0.28	0.33
Over 80 to 100, incl	0.18	0.23	0.30	0.43
Over 100 to 150, incl	0.23	0.28	0.33	0.52
Over 150	0.36	. . .	. . .	. . .

[A] This table includes tolerances for bars that have been annealed, spheriodize annealed, normalized, normalized and tempered, or quenched and tempered before cold finishing. This table does not include tolerances for bars that are annealed, spheriodize annealed, normalized, normalized and tempered, or quenched and tempered after cold finishing; the producer should be consulted for tolerances for such bars.

[B] Width governs the tolerance for both width and thickness of flats. For example, when the maximum of carbon range is 0.28% or less for a flat 50 mm wide and 25 mm thick, the width tolerance is 0.13 mm and the thickness tolerance is the same, namely 0.13 mm.

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TABLE A2.14
STRAIGHTNESS TOLERANCES FOR COLD-FINISHED BARS[A,B]

Note — All grades quenched and tempered or normalized and tempered to Brinnell 302 maximum *before* cold finishing and all grades stress relieved or annealed *after* cold finishing. Straightness tolerances are not applicable to bars having Brinnell hardness exceeding 302.

		Straightness Tolerances, mm (Maximum Deviation) from Straightness in any 3000 mm Portion of the Bar			
		Maximum of Carbon Range, 0.28% or less		Maximum of Carbon Range over 0.28% and all Grades Thermally Treated	
Size, mm	Length, mm	Rounds	Squares, Hexagons, and Octagons	Rounds	Squares, Hexagons, and Octagons
Less than 16	Less than 4500	3	5	5	6
Less than 16	4500 and over	3	8	8	10
16 and over	Less than 4500	2	3	3	5
16 and over	4500 and over	3	5	5	6

[A] The foregoing tolerances are based on the following method of measuring straightness; departure from straightness is measured by placing the bar on a level table so that the arc or departure from straightness is horizontal, and the depth of the arc is measured with a feeler gage and a straightedge.

[B] It should be recognized that straightness is a perishable quality and may be altered by mishandling. The preservation of straightness in cold-finished bars requires the utmost care in subsequent handling. Specific straightness tolerances are sometimes required for carbon and alloy steels in which case the purchaser should inform the manufacturer of the straightness tolerances and the methods to be used in checking the straightness.

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