Designation: ~~A194/A194M – 17~~ A194/A194M – 17a

Endorsed by
Manufacturers Standardization Society
of the Valve and Fittings Industry
Used in USNRC-RDT Standards

Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both[1]

This standard is issued under the fixed designation A194/A194M; 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 specification[2] covers a variety of carbon, alloy, and martensitic stainless steel nuts in the size range ¼ through 4 in. and metric M6 through M100 nominal. It also covers austenitic stainless steel nuts in the size range ¼ in. and M6 nominal and above. These nuts are intended for high-pressure or high-temperature service, or both. Grade substitutions without the purchaser's permission are not allowed.

1.2 Bars from which the nuts are made shall be hot-wrought. The material may be further processed by centerless grinding or by cold drawing. Austenitic stainless steel may be solution annealed or annealed and strain-hardened. When annealed and strain hardened austenitic stainless steel is ordered in accordance with Supplementary Requirement S1, the purchaser should take special care to ensure that 8.2.2, Supplementary Requirement S1, and Appendix X1 are thoroughly understood.

1.3 Supplementary requirements of an optional nature are provided. These shall apply only when specified in the inquiry, contract, and order.

1.4 This specification is expressed in both inch-pound units and in SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. 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 the standard. Within the text, the SI units are shown in brackets.

1.6 *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]

A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A276/A276M Specification for Stainless Steel Bars and Shapes
A320/A320M Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
A962/A962M Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range
B633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
B696 Specification for Coatings of Cadmium Mechanically Deposited

[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 A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-194 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**

B766 Specification for Electrodeposited Coatings of Cadmium
E112 Test Methods for Determining Average Grain Size
E566 Practice for Electromagnetic (Eddy Current) Sorting of Ferrous Metals
F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
F1940 Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners
F1941/F1941M Specification for Electrodeposited Coatings on Mechanical Fasteners, Inch and Metric
F2329/F2329M Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

2.2 *ASME Standards:*[4]
B 1.1 Unified Screw Threads
B 1.2 Gages and Gaging for Unified Inch Screw Threads
B 1.13M Metric Screw Threads
B 18.2.2 Square and Hex Nuts
B 18.2.4.6M Metric Heavy Hex Nuts

2.3 *ISO Standards:*[5]
4033 Hexagon High Nuts (Style 2) – Product A and B

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *Austenitic Grades*—All grades with a prefix of "8" or "9."

3.1.2 *Ferritic Grades*—Grades 1, 2, 2H, 2HM, 3, 6, 6F, 7, 7M, and 16.

3.1.3 *Lot*—Unless otherwise specified (see Discussion below), a lot is the quantity of nuts of a single nominal size and grade produced by the same manufacturing process.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.
[5] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

3.1.3.1 *Discussion*—

When Supplementary Requirement S5 is invoked on the purchase order, the following definitions of a lot shall apply:

3.1.3.2 *For Grade 8 Nuts*—The quantity of all the nuts of a single nominal diameter and grade made from the same heat of steel and made by the same manufacturing process.

3.1.3.3 *For All Other Grade Nuts*—(see 8.2 and 8.1.2.1)—All the nuts of a single nominal diameter and grade made from the same heat number and heat treated in the same batch if batch-type heat treating equipment is used or heat treated in the same continuous run of not more than 8 h under the same conditions if continuous-type heat treating equipment is used.

3.1.4 *Type:*

3.1.4.1 *For Grade 8 Nuts*—Variations within the grade designated by a letter and differentiated by chemistry and by manufacturing process.

3.1.4.2 *For Grade 6 Nuts*—Variations within the grade designated by the letter F as differentiated by chemical additions made for machineability.

3.1.5 *Series*—The dimensional relationship and geometry of the nuts as described in ASME B 18.2.2 for inch nuts and ISO 4033 for metric nuts sizes M6 through M10 and ASME B 18.2.4.6M for nuts sizes M12 through M100.

4. Ordering Information

4.1 The inquiry and order for bolting material and bolting components under this specification shall include the following as required to describe the items adequately:

4.1.1 Specification designation, year date, and grade, issue date and revision letter,
4.1.2 Quantity, number of pieces,
4.1.3 Dimensions (see Section 9),
4.1.4 Options in accordance with 8.2.2.1, 9.1, 9.2, 10.3, and 12, and
4.1.5 Supplementary Requirements, if any.

4.2 *Coatings*—Coatings are prohibited unless specified by the purchaser (see Supplementary Requirements S7 and S8). When coated nuts are ordered, the purchaser should take special care to ensure that Appendix X2 is thoroughly understood.

4.3 See Supplementary Requirement S3 for nuts to be used in low temperature applications (Specification A320/A320M).

4.4 *Proof Load Testing*—See Supplementary Requirement S9 for proof load testing of nuts manufactured to dimensions and configurations other than those covered in Tables 3 and 4.

5. Common Requirements

5.1 Bolting material and bolting components supplied to this specification shall conform to the requirements of Specification A962/A962M, of which nuts are considered bolting components, as are bolts, studs, screws, and washers intended for use in special service applications. These requirements include test methods, finish, thread dimensions, marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification A962/A962M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A962/A962M, this specification shall prevail.

6. Manufacture (Process)

6.1 Stainless steels for all types of Grade 6 and 8 nuts shall be made by one of the following processes:

6.1.1 Electric-furnace (with separate degassing and refining optional),

6.1.2 Vacuum induction furnace, or

6.1.3 Either of the above followed by electroslag remelting, or consumable-arc remelting.

6.2 The steel producer shall exercise adequate control to eliminate excessive unhomogeneity, nonmetallics, pipe, porosity, and other defects.

6.3 Grades 1 and 2 nuts shall be hot or cold forged, or shall be machined from hot-forged, hot-rolled, or cold-drawn bars.

6.3.1 All Grade 1 and 2 nuts shall be stress-relieved at a temperature of at least 1000 °F [538 °C] after forming or machining from bar with the following exceptions:

6.3.1.1 Nuts made by hot forging.

6.3.1.2 Nuts machined from hot-forged or hot-rolled bar.

6.3.1.3 Nuts machined from hot-forged/hot-rolled and cold-finished (max 10 % reduction in area) bar.

6.3.1.4 Nuts machined from cold-drawn and annealed (min 1000 °F [538 °C]) bar.

6.3.2 Grade 1 and 2 nuts made by hot forging or by machining from hot-forged or hot-rolled bars need not be stress relieved.

6.4 Grades 2H, 2HM, 3, 6, 6F, 7, 7M, and 16 nuts shall be hot- or cold-forged or shall be machined from hot-forged, hot-rolled, or cold-drawn bars and shall be heat treated to meet the required mechanical properties. These grades shall be uniformly reheated to the proper austenitizing temperature (a group thus reheated being known as a quenching charge) and quenched under substantially uniform conditions for each quenching charge and tempered as shown below. Grades 2H, 2HM, 3, 7, and 7M shall be liquid quenched. Grades 6 and 6F shall be quenched in liquid or inert gas. Grade 16 shall be heated to a temperature range from 1700 to 1750 °F (925 to 955 °C) and oil quenched.

Grade	Minimum Tempering Temperature, °F [°C]
2H	850 [455]
2HM	1150 [620]
3	1050 [565]
6 and 6F	1100 [595]
7	1100 [595]
7M	1150 [620]
16	1200 [650]

Nuts machined from bar heat treated in accordance with this specification need not be reheat-treated. For Grade 2HM and 7M nuts, a final stress relief shall be done at or above the minimum tempering temperature after all forming, machining, and tapping operations. This final stress relief may be the tempering operation.

6.4.1 Grade 6 and 6F nuts shall be tempered for a minimum of 1 h at the temperature.

6.5 Grades 8, 8C, 8CLN, 8M, 8T, 8F, 8P, 8N, 8MN, 8R, 8S, 8LN, 8MLN, 8MLCuN, 8ML4CuN, and 9C nuts shall be hot or cold forged, or shall be machined from hot-forged, hot-rolled or cold-drawn bars.

6.6 Grades 8A, 8CA, 8CLNA, 8MA, 8TA, 8FA, 8PA, 8NA, 8MNA, 8RA, 8SA, 8LNA, 8MLNA, 8MLCuNA, 8ML4CuNA, and 9CA nuts shall be hot- or cold-forged or shall be machined from hot-forged, hot-rolled, or cold-drawn bars and the nuts shall subsequently be carbide-solution treated by heating them for a sufficient time at a temperature to dissolve chromium carbides followed by cooling at a rate sufficient to prevent reprecipitation of the carbides.

7. Chemical Composition

7.1 Each alloy shall conform to the chemical composition requirements prescribed in Table 1.

8. Mechanical Requirements

8.1 *Hardness Test:*

8.1.1 *Requirements:*

TABLE 1 Chemical Requirements (Composition, percent)[A,B,C,D,I]

Grade ~~Symbol~~	~~Material~~	Description and UNS ~~Number~~ Designation	~~Carbon,~~Carbon %	Manga- ~~nese,~~nese %	Phospho- ~~rus,~~rus %	~~Sulfur,~~Sulfur %	~~Silicon,~~Silicon %	~~Chromium,~~ Chromium %	~~Nickel,~~Nickel %	Molyb- ~~denum,~~denum %	Tita- ~~nium,~~nium %	~~Colum-~~ Niobium ~~bium,[H]~~ %	~~Nitrogen,~~Nitrogen %	~~Other~~Copper ~~Elements,~~ %	Selenium	Vanadium	Aluminum
1	carbon		0.15 min	1.00	0.040	0.050	0.40	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2, 2HM, and 2H	carbon		0.40 min	1.00	0.040	0.050	0.40	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
~~3~~	~~Type 501~~		~~0.10 min~~	~~1.00~~	~~0.040~~	~~0.030~~	~~1.00~~	~~4.0–6.0~~	~~. . .~~	~~0.40–0.65~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
3	(501) S50100		0.10 min	1.00	0.040	0.030	1.00	4.0–6.0	. . .	0.40–0.65	. . .	. . .	. . .	. . .	. . .	. . .	. . .
~~6~~	~~Type 410~~	~~S41000~~	~~0.08–0.15~~	~~1.00~~	~~0.040~~	~~0.030~~	~~1.00~~	~~11.5–13.5~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
6	(410) S41000	0.08–0.15	1.00	0.040	0.030	1.00	11.5–13.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
~~6F~~	~~Type 416~~	~~S41600~~	~~0.15~~	~~1.25~~	~~0.060~~	~~0.15 min~~	~~1.00~~	~~12.0–14.0~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
6F	(416) S41600	0.15	1.25	0.060	0.15 min	1.00	12.0–14.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
~~6F~~	~~Type 416Se~~	~~S41623~~	~~0.15~~	~~1.25~~	~~0.060~~	~~0.060~~	~~1.00~~	~~12.0–14.0~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~		~~Selenium, 0.15 min~~			
6F	(416Se) S41623	0.15	1.25	0.060	0.060	1.00	12.0–14.0	. . .	. . .	. . .	. . .	. . .	. . .	0.15 min	. . .	. . .	
~~7[G], 7M[G]~~	~~Type 4140/ 4142/ 4145, 4140H, 4142H, 4145H~~		~~0.38–0.48~~	~~0.75–1.0~~	~~0.035~~	~~0.04~~	~~0.15–0.35~~	~~0.80–1.10~~	~~. . .~~	~~0.15–0.25~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
7[G], 7M[G]	Chromium-Molybdenum [G] –		0.38–0.48	0.75–1.0	0.035	0.04	0.15–0.35	0.80–1.10	. . .	0.15–0.25	. . .	. . .	. . .	. . .	. . .	. . .	. . .
~~8, 8A~~	~~Type 304~~	~~S30400~~	~~0.08~~	~~2.00~~	~~0.045~~	~~0.030~~	~~1.00~~	~~18.0–20.0~~	~~8.0–11.0~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
8, 8A	(304) S30400	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
~~8C, 8CA~~	~~Type 347~~	~~S34700~~	~~0.08~~	~~2.00~~	~~0.045~~	~~0.030~~	~~1.00~~	~~17.0–19.0~~	~~9.0–12.0~~	~~. . .~~	~~. . .~~	~~10 x carbon content, min 1.10~~	~~. . .~~	~~. . .~~			
8C, 8CA	(347) S34700	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	. . .	. . .	10 x carbon content, min 1.10	. . .	. . .	. . .	. . .	. . .	
~~8CLN, 8CLNA~~	~~Type 347LN~~	~~S34751~~	~~0.005-0.020~~	~~2.00~~	~~0.045~~	~~0.030~~	~~1.00~~	~~17.0–19.0~~	~~9.0–13.0~~	~~. . .~~	~~. . .~~	~~0.20–0.50, 15 x carbon content, min~~	~~0.06–0.10~~	~~. . .~~			
8CLN, 8CLNA	(347LN) S34751	0.005-0.020	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	. . .	. . .	0.20–0.50, 15 x carbon content, min	0.06–0.10	. . .	. . .	. . .	. . .	
~~8M, 8MA~~	~~Type 316~~	~~S31600~~	~~0.08~~	~~2.00~~	~~0.045~~	~~0.030~~	~~1.00~~	~~16.0–18.0~~	~~10.0–14.0~~	~~2.00–3.00~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~			
8M, 8MA	(316) S31600	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	

TABLE 1 *Continued*

Grade Symbol	Material	Description and UNS Number Designation	Carbon, %	Manganese, %	Phosphorus, %	Sulfur, %	Silicon, %	Chromium, Chromium %	Nickel, Nickel %	Molybdenum, %	Titanium, %	Columbium, Niobium [H], %	Nitrogen, Nitrogen %	Other Elements, %	Copper	Selenium	Vanadium	Aluminum
8T, 8TA	Type 321	S32100	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	. . .	5 x (C+N) min - 0.70 max	. . .	0.10	. . .				
8T, 8TA	(321) S32100	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	. . .	5 x (C+N) min - 0.70 max	. . .	0.10	. . .	. . .		. . .	. . .	
8F, 8FA	Type 303	S30300	0.15	2.00	0.20	0.15 min	1.00	17.0–19.0	8.0–10.0	. . .	. . .	. . .	. . .	. . .	. . .			
8F, 8FA	(303) S30300	0.15	2.00	0.20	0.15 min	1.00	17.0–19.0	8.0–10.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
8F, 8FA	Type 303Se	S30323	0.15	2.00	0.20	0.06	1.00	17.0–19.0	8.0–10.0	. . .	. . .	. . .		Selenium, 0.15 min				
8F, 8FA	(303Se) S30323	0.15	2.00	0.20	0.06	1.00	17.0–19.0	8.0–10.0	. . .	. . .	. . .		. . .	0.15 min	. . .	. . .		
8P, 8PA	Type 305	S30500	0.12	2.00	0.045	0.030	1.00	17.0–19.0	11.0–13.0	. . .	. . .	. . .	. . .	. . .				
8P, 8PA	(305) S30500	0.12	2.00	0.045	0.030	1.00	17.0–19.0	11.0–13.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		
8N, 8NA	Type 304N	S30451	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	0.10–0.16					
8N, 8NA	(304N) S30451	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	0.10–0.16	. . .	. . .	. . .	. . .		
8LN, 8LNA	Type 304LN	S30453	0.030	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	0.10–0.16					
8LN, 8LNA	(304LN) S30453	0.030	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	0.10–0.16	. . .	. . .	. . .	. . .		
8MN, 8MNA	Type 316N	S31651	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	. . .	. . .	0.10–0.16					
8MN, 8MNA	(316N) S31651	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	. . .	. . .	0.10–0.16	. . .	. . .	. . .	. . .		
8MLN, 8MLNA	Type 316LN	S31653	0.030	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	. . .	. . .	0.10–0.16					
8MLN, 8MLNA	(316LN) S31653	0.030	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	. . .	. . .	0.10–0.16	. . .	. . .	. . .	. . .		
8R, 8RA[F]	XM19	S20910	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	0.10–0.30	0.20–0.40	0.20–0.40				Vanadium, 0.10–0.30	
8R, 8RA[F]	(XM19) S20910	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	. . .	0.10–0.30	0.20–0.40				0.10–0.30		
8S, 8SA		(Nitronic 60) S21800	0.10	7.0–9.0	0.060	0.030	3.5–4.5	16.0–18.0	8.0–9.0	. . .	. . .	. . .	0.08–0.18	. . .	. . .	. . .	. . .	. . .
8MLCuN, 8MLCuNA	S31254	S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	. . .	. . .	0.18–0.22	0.50–1.00	Copper,			
8MLCuN, 8MLCuNA	(254) S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	. . .	. . .	0.18–0.22	0.50–1.00	. . .	. . .	. . .		
B8ML4CuN	S31730	S31730	0.030	2.00	0.040	0.010	1.00	17.0–19.0	15.0–16.5	3.0–4.0	. . .	. . .	0.045	Copper 4.0–5.0				
B8ML4CuN	(317) S31730	0.030	2.00	0.040	0.010	1.00	17.0–19.0	15.0–16.5	3.0–4.0	. . .	. . .	0.045	4.0–5.0	. . .	. . .	. . .		
9C, 9CA	N08367	N08367	0.030	2.00	0.040	0.030	1.00	20.0-22.0	23.5-25.5	6.0-7.0			0.18-0.25	Copper 0.75				
9C, 9CA	(AL-6XN) N08367	0.030	2.00	0.040	0.030	1.00	20.0-22.0	23.5- 25.5	6.0-7.0	. . .	. . .	0.18-0.25	0.75	. . .	. . .	. . .		

TABLE 1 *Continued*

Grade ~~Symbol~~	~~Material~~	Description and UNS ~~Number~~ Designation	~~Carbon,~~Carbon %	Manga-~~nese,~~nese %	Phospho-~~rus,~~rus %	~~Sulfur,~~Sulfur %	~~Silicon,~~Silicon %	~~Chromium,~~ Chromium %	~~Nickel,~~Nickel %	Molyb-denum %	Tita-~~nium,~~nium %	~~Colum-~~ Niobium ~~bium,~~[H] %	~~Nitrogen,~~Nitrogen %	~~Other~~Copper ~~Elements,~~ %	Selenium	Vanadium	Aluminum
~~16~~	~~Chromium Molyb-denum Vanadium~~		~~0.36–0.47~~	~~0.45–0.70~~	~~0.035~~	~~0.040~~	~~0.15–0.35~~	~~0.80–1.15~~	~~. . .~~	~~0.50–0.65~~	~~.~~	~~. . .~~	~~. . .~~	~~Vanadium, 0.25–0.35 Aluminum[B] 0.015~~			
16	Chromium Molyb-denum Vanadium		0.36–0.47	0.45–0.70	0.035	0.040	0.15–0.35	0.80–1.15	. . .	0.50–0.65	.	. . .	. . .	. . .	. . .	0.25–0.35	0.15

[A] The intentional addition of Bi, Se, Te, and Pb is not permitted except for Grades 6F, 8F, and 8FA, in which Se is specified and required.
[B] Total aluminum, soluble and insoluble.
[C] Maximum, unless minimum or range is indicated.
[D] Where ellipses (…) appear in this table there is no requirement and the element need not be determined or reported.
[E] Because of the degree to which sulfur segregates, product analysis for sulfur over 0.060 % max is not technologically appropriate.
[F] As described in Specification A276/A276M.
[G] ~~Grade 4 has been withdrawn. Grade 7 is an acceptable substitute for Grade 4.~~Typical steel compositions used for this grade include 4140, 4142, 4145, 4140H, 4142H, and 4145H.
[H] Columbium (Cb) and Niobium (Nb) are alternate names for element 41 in the Periodic Table of the Elements.
[I] Product Analysis–Individual determinations sometimes vary from the specified limits as shown in the tables. The several determinations of any individual element in a heat may not vary both above and below the specified range. Product variation limits are over for maximums, over or under for ranges, and under for minimums, unless otherwise indicated.