Designation: A194/A194M – 24

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 M12 through M100 nominal. It also covers austenitic stainless steel nuts in the size range ¼ in. and M12 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

B766 Specification for Electrodeposited Coatings of Cadmium

E112 Test Methods for Determining Average Grain Size

E566 Practice for Electromagnetic (Eddy Current/Magnetic Induction) 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

[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.

Current edition approved May 1, 2024. Published June 2024. Originally approved in 1936. Last previous edition approved in 2023 as A194/A194M – 23. DOI: 10.1520/A0194_A0194M-24.

[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 www.astm.org/contact. 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**

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
B18.2.6M Metric Fasteners for Use in Structural Applications

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, 43, 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.

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, ASME B 18.2.6M or ASME B 18.2.4.6M for metric nuts.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

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.

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

Grade	Description and UNS Designation	Carbon	Manganese	Phosphorus	Sulfur[E]	Silicon	Chromium	Nickel	Molybdenum	Titanium	Niobium[H]	Nitrogen	Copper	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	(501) S50100	0.10 min	1.00	0.040	0.030	1.00	4.0–6.0	. . .	0.40–0.65	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6	(410) S41000	0.08–0.15	1.00	0.040	0.030	1.00	11.5–13.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6F	(416) S41600	0.15	1.25	0.060	0.15 min	1.00	12.0–14.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6F	(416Se) S41623	0.15	1.25	0.060	0.060	1.00	12.0–14.0	. . .	. . .	. . .	. . .	. . .	. . .	0.15 min	. . .	. . .
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	. . .	. . .	. . .	. . .	. . .	. . .	. . .
43	Nickel-Chromium Molybdenum	0.38–0.43	0.60–0.85	0.035	0.04	0.15–0.35	0.70–0.90	1.65–2.0	0.20–0.30	. . .	. . .	. . .	. . .	. . .	. . .	. . .
8, 8A	(304) S30400	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
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	(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	. . .	. . .	. . .	. . .
8CLNCuB, 8CLNCuBA	S34752[J]	0.005-0.020	2.00	0.035	0.010	0.60	17.0–19.0	10.0–13.0	0.20–1.20	. . .	0.20–0.50, 15 x carbon content, min	0.06–0.12	2.50–3.50	. . .	. . .	. . .
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	. . .	. . .	. . .	. . .	. . .	. . .	. . .
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	(303) S30300	0.15	2.00	0.20	0.15 min	1.00	17.0–19.0	8.0–10.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
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	(305) S30500	0.12	2.00	0.045	0.030	1.00	17.0–19.0	11.0–13.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
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	(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	(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	. . .	. . .	. . .	. . .

TABLE 1 *Continued*

Grade	Description and UNS Designation	Carbon	Manganese	Phosphorus	Sulfur[E]	Silicon	Chromium	Nickel	Molybdenum	Titanium	Niobium[H]	Nitrogen	Copper	Selenium	Vanadium	Aluminum
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			0.10–0.30	
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	(254) S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	. . .	. . .	0.18–0.25	0.50–1.00	. . .	. . .	. . .
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	(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	. . .	. . .	. . .
16	Chromium Molybdenum 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[B]

[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] Typical steel compositions used for this grade include 4140, 4142, 4145, 4140H, 4142H, and 4145H.
[H] Niobium (Nb) and Columbium (Cb) 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.
[J] Boron content shall be in the range 0.001–0.005.

TABLE 2 Hardness Requirements[A]

Grade and Type	Completed Nuts			Sample Nut after Treatment as in 8.1.5	
	Brinell Hardness	Rockwell Hardness		Brinell Hardness, min	Rockwell Hardness B Scale, min
		C Scale	B Scale		
1	121 min	...	70 min	121	70
2	159 to 352	...	84 min	159	84
2H to 1½ in. or M36, incl	248 to 327	24 to 35	...	179	89
2H over 1½ in. or M36	212 to 327	35 max	95 min	147	79
2HM and 7M	159 to 235	...	84 to 99	159	84
3, 7, 16, 43	248 to 327	24 to 35	...	201	94
6 and 6F	228 to 271	20 to 28	...	...	...
8, 8C, 8CLN, 8CLNCuB, 8M, 8T, 8F, 8P, 8N, 8MN, 8LN, 8MLN, 8MLCuN, 8ML4CuN, and 9C	126 to 300	32 max	60 min	...	...
8A, 8CA, 8CLNA, 8CLNCuBA, 8MA, 8TA, 8FA, 8PA, 8NA, 8MNA, 8LNA, 8MLNA, 8MLCuNA, 8ML4CuNA, and 9CA	126 to 192	...	60 to 90	...	...
8R, 8RA, 8S, and 8SA	183 to 271	25 max	88 min	...	...

[A] Where ellipses (...) appear in this table there is no requirement.

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, 43, 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]
43	1100 [595]
16	1200 [650]

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

6.5 For Grade 2HM and 7M nuts, a final stress relief shall be performed, after all machining, cutting, and forming operations, at a minimum temperature of 50°F (28°C) below the original tempering temperature. A tempering operation may be substituted for this post-machining/cutting/forming stress relief. Surface preparation for hardness testing or nondestructive evaluation is permitted.

6.5.1 In the case where the original temper was performed via induction heat treatment at a temperature above 1300°F (705°C) but the post-machining/cutting/forming stress relief will be performed in a standard furnace, the minimum stress relief temperature shall be 1200°F (650°C).

NOTE 1—A specific minimum stress relief temperature is given in 6.5.1 because no correlation can be drawn between the original tempering temperature utilizing induction and the stress relieving temperature in a standard furnace.

6.6 Grades 8, 8C, 8CLN, 8CLNCuB, 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.

6.7 Grades 8A, 8CA, 8CLNA, 8CLNCuBA, 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:*

8.1.1.1 All nuts shall meet the hardness requirements specified in Table 2.

8.1.1.2 Sample nuts of Grades 1, 2, 2H, 2HM, 3, 7, 7M, 43, and 16 which have been given the treatment described in 8.1.5 shall meet the minimum hardness specified in Table 2.

TABLE 3 Proof Load Using Threaded Mandrel — Inch Series

NOTE 1—Proof loads are not design loads.

Nominal Size, in.	Threads per Inch	Stress Area in.^{2}	Proof Load, lbf[A]					
			Grade 1		Grades 2, 2HM, 6, 6F, 7M		Grades 2H, 3, 7, 16, 43	
			Heavy Hex[B]	Hex[C]	Heavy Hex[D]	Hex[E]	Heavy Hex[F]	Hex[G]
¼	20	0.0316	4 130	3 820	4 770	4 300	5 570	4 770
5⁄16	18	0.0524	6 810	6 290	7 860	7 070	9 170	7 860
⅜	16	0.0774	10 080	9 300	11 620	10 460	13 560	11 620
7⁄16	14	0.1063	13 820	12 760	15 940	14 350	18 600	15 940
½	13	0.1419	18 450	17 030	21 280	19 160	24 830	21 280
9⁄16	12	0.182	23 660	21 840	27 300	24 570	31 850	27 300
⅝	11	0.226	29 380	27 120	33 900	30 510	39 550	33 900
¾	10	0.334	43 420	40 080	50 100	45 090	58 450	50 100
⅞	9	0.462	60 060	55 440	69 300	62 370	80 850	69 300
1	8	0.606	78 780	72 720	90 900	81 810	106 000	90 900
1⅛	8	0.790	102 700	94 800	118 500	106 700	138 200	118 500
1¼	8	1.000	130 000	120 000	150 000	135 000	175 000	150 000
1⅜	8	1.233	160 200	148 000	185 000	166 500	215 800	185 000
1½	8	1.492	194 000	170 040	223 800	201 400	261 100	223 800

			All Types of Grade 8, Grades 9C and 9CA	
			Heavy Hex[H]	Hex[I]
¼	20	0.0316	2 540	2 380
5⁄16	18	0.0524	4 190	3 930
⅜	16	0.0774	6 200	5 810
7⁄16	14	0.1063	8 500	7 970
½	13	0.1419	11 350	10 640
9⁄16	12	0.182	14 560	13 650
⅝	11	0.226	18 080	16 950
¾	10	0.334	26 720	25 050
⅞	9	0.462	36 960	34 650
1	8	0.606	48 480	45 450
1⅛	8	0.790	63 200	59 250
1¼	8	1.000	80 000	75 000
1⅜	8	1.233	98 640	92 450
1½	8	1.492	119 360	111 900

[A] See limit for proof load test in 8.2.2.1. The proof load for jam nuts shall be 46 % of the tabulated load.
[B] Based on proof stress of 130 000 psi.
[C] Based on proof stress of 120 000 psi.
[D] Based on proof stress of 150 000 psi.
[E] Based on proof stress of 135 000 psi.
[F] Based on proof stress of 175 000 psi.
[G] Based on proof stress of 150 000 psi.
[H] Based on proof stress of 80 000 psi.
[I] Based on proof stress of 75 000 psi.

8.1.2 *Number of Tests*—(Grades 1, 2, 2H, 3, 7, 43, and 16 and all types of Grade 6):

8.1.2.1 Tests on the number of sample nuts in accordance with the following table shall be performed by the manufacturer following all production heat treatments:

Lot Size	Samples
Up to 800	1
801 to 8000	2
8001 to 22 000	3
Over 22 000	5

8.1.2.2 In addition, a hardness test shall be performed by the manufacturer in accordance with 8.1.5 on one sample nut selected from each nominal diameter and series from each grade and heat number following completion of all production heat treatments.

8.1.3 *Number of Tests, Grades 2HM and 7M:*

8.1.3.1 Each nut shall be tested in accordance with either Specification A962/A962M or with Test Methods F606/F606M to ensure product conformance. The use of 100 % electromagnetic testing for hardness as an alternative to 100 % indentation hardness testing is permissible when qualified by sampling using indentation hardness testing. Each lot tested for hardness electromagnetically shall be 100 % examined in accordance with Practice E566. Following electromagnetic testing for hardness, a random sample of a minimum of 100 pieces in each purchase lot (as defined in 3.1.3) shall be tested by indentation hardness methods. All samples must meet hardness requirements to permit acceptance of the lot. If any one sample is outside of the specified maximum or minimum hardness, the lot shall be rejected and either reprocessed and resampled, or tested 100 % by indentation hardness methods.

8.1.3.2 In addition, 8.1.2.2 shall be met.

8.1.4 *Number of Tests, All Types of Grade 8*—Tests on the number of sample nuts in accordance with 8.1.2.1 shall be performed by the manufacturer.

8.1.5 *Test 2*—In addition to the testing required by 8.1.2.1 the manufacturer shall also perform hardness tests on sample

TABLE 4 Proof Load Using Threaded Mandrel — Metric

NOTE 1—Proof loads are not design loads.

Nominal Size, mm	Threads Pitch	Stress Area mm^2	Proof Load, kN[A]					
			Grade 1		Grades 2, 2HM, 6, 6F, 7M		Grades 2H, 3, 7, 16, 43	
			Heavy Hex[B]	Hex[C]	Heavy Hex[D]	Hex[E]	Heavy Hex[F]	Hex[G]
M12	1.75	84.3	75.5	69.5	87.3	78.4	101.6	87.3
M14	2.0	115.0	102.9	94.9	119.0	107.0	138.6	119.0
M16	2.0	157.0	140.5	129.5	162.5	146.0	189.2	162.5
M20	2.5	245.0	219.3	202.1	253.6	227.8	295.2	253.6
M22	2.5	303.0	271.2	249.9	313.6	281.8	365.1	313.6
M24	3.0	353.0	315.9	291.2	365.4	328.3	425.4	365.4
M27	3.0	459.0	411.0	378.7	475.1	426.9	553.4	475.1
M30	3.5	561.0	502.1	462.8	580.6	521.7	676.0	580.6
M36	4.0	817.0	731.2	674.0	845.6	759.8	984.5	845.6

Nominal Size, mm	Thread Pitch	All Types of Grade 8, and Grades 9C and 9CA		Hex[I]
		Stress Area, mm^2	Heavy Hex[H]	
M12	1.75	84.3	46.4	43.4
M14	2.0	115.0	63.3	59.2
M16	2.0	157.0	86.4	80.9
M20	2.5	245.0	134.8	126.2
M22	2.5	303.0	166.7	156.0
M24	3.0	353.0	194.2	181.8
M27	3.0	459.0	252.5	236.4
M30	3.5	561.0	308.6	288.9
M36	4.0	817.0	449.4	420.8

[A] See limit for proof load test in 8.2.2.1. The proof load for jam nuts shall be 46 % of the tabulated load.
[B] Based on proof stress of 895 MPa.
[C] Based on proof stress of 825 MPa.
[D] Based on proof stress of 1035 MPa.
[E] Based on proof stress of 930 MPa.
[F] Based on proof stress of 1205 MPa.
[G] Based on proof stress of 1035 MPa.
[H] Based on proof stress of 550 MPa.
[I] Based on proof stress of 515 MPa.

nuts after the following test heat treatment. After completion of all production heat treatments heat the specimen nuts to the temperatures indicated below for 24 h, then slow cool. Test at room temperature.

Grade[A]	Temperature, °F [°C]
1	850 [455]
2, 2H, 2HM	1000 [540]
3, 7, 7M, 43	1100 [590]
16	1200 [650]

[A] Nuts intended to be coated with zinc or cadmium (marked in accordance with the requirements of Supplementary Requirement S8) are not subjected to the requirements of 8.1.5 (See Appendix X2).

8.1.5.1 *Special Requirement, Grades 2HM and 7M*—Preparation of Grades 2HM and 7M nuts for hardness test and the hardness test itself shall be performed with consideration to (*1*) protect legibility of markings; (*2*) minimize exterior dimensional changes; and (*3*) maintain thread fit.

8.2 *Proof Load Test:*

8.2.1 *Requirements*—The nuts listed in Table 3 and Table 4 shall be capable of withstanding the proof loads specified therein. Grades and geometries listed in S1 and S4 are required when specified in the purchase order or contract. Custom proof load test values may be specified by the purchase order or contract per S9. Parts which are not proof load tested to the requirements of Table 3, Table 4, S1, S4, or S9 shall be cross sectional hardness tested per Annex A3 of Test Methods and Definitions A370.

8.2.2 *Number of Tests:*

8.2.2.1 The manufacturer shall test the number of nuts specified in 8.1.2.1 following all production heat treatments. Proof Load tests prevail over hardness tests in the event a conflict exists relative to minimum strength.

8.2.3 *Test Method*—The test shall be run using a threaded mandrel or a test bolt in accordance with Specification A962/A962M.

8.3 *Cone Proof Load Test:*

8.3.1 *Requirements*—This test shall be performed only when visible surface discontinuities become a matter of issue between the manufacturer and the purchaser. Nuts in the size range ¼ to 1½ in. inclusive and M12 to M36 inclusive shall be proof load tested. Nuts not in this size range and all types of Grade 8 nuts are not subject to this test. Nuts manufactured to dimensions and configurations other than those covered by Specification A962/A962M, ASME B 1.1, ASME B 1.13M, ASME B 18.2.2, ASME B 18.2.6M, or ASME B 18.2.4.6M are not subject to the cone proof load test. The cone proof load applied shall be determined in accordance with the Cone Proof Load requirements in Specification A962/A962M (tables or

formulae or both) based upon the proof stresses shown in Table 5 and Table 6 of Specification A194/A194M.

8.3.2 *Number of Tests*—The manufacturer shall sample and test the number of nuts specified in 8.1.2.1. The lot shall be considered acceptable if the sample nut(s) withstand(s) application of the cone proof load without failure.

9. Dimensions

9.1 Unless otherwise specified, nuts shall be hexagonal in shape, and in accordance with the dimensions for the hex or heavy hex series, as required, in ASME B 18.2.2 (for inch nuts), ASME B 18.2.6M or ASME B 18.2.4.6M (for metric nuts).

9.2 Unless otherwise specified, threads shall be in accordance with ASME B 1.1 or ASME B 1.13M, and shall be gauged in accordance with ASME B 1.2 and ASME B 1.13M as described in 9.2.1 and 9.2.2.

9.2.1 Inch nuts up to and including 1 in. nominal size shall be UNC Series Class 2B fit. All metric nuts shall be coarse thread series tolerance 6H.

9.2.2 Inch nuts over 1 in. nominal size shall be either UNC Series Class 2B fit or 8 UN Series Class 2B fit. Unless otherwise specified, the 8 UN series shall be furnished.

NOTE 2—Modification of thread dimensions may result in loss of load carrying ability.

NOTE 3—In an effort to support international standardization, a number of metric ASME dimensional standards have been withdrawn. ASME B 18.2.4.6M was withdrawn because the content had been incorporated into ASME B 18.2.6M. However, B18.2.6M applies to heavy hex configurations for sizes M12 through M36 only. Larger sizes are still often produced to the requirements of ASME B 18.2.4.6M.

10. Workmanship, Finish, and Appearance

10.1 Nuts shall be free of defects and shall be good commercial finish.

10.2 If visible surface imperfections in size ¼ through 1½ in. and M12 through M36 and in any grade other than Grade 8 become a matter of issue between the manufacturer and the purchaser, the cone proof load test described in 8.3 shall be employed.

10.3 If a scale-free bright finish is required, this shall be specified on the purchase order.

11. Retests

11.1 Provisions for retests by the purchaser and his representative are specified in Supplementary Requirement S2.

12. Certification

12.1 In addition to the requirements of Specification A962/A962M, the certification shall include the results of the chemical analysis, macroetch examination (Carbon and Alloy Steels Only), mechanical tests, and the minimum tempering temperature for nuts of Grades 2H, 2HM, 3, 6, 6F, 7, 7M, and 43.

13. Product Marking

13.1 In addition to the requirements of Specification A962/A962M, nuts shall be legibly marked on one face with marking representing the grade, type, and applicable manufacturing process shown in Table 7. Marking of wrench flats or bearing surfaces is not permitted unless agreed upon between manufacturer and purchaser.

14. Keywords

14.1 bolting; chemical analysis; coated; marking on bolting components; nuts; plated

TABLE 5 Proof Stress Using 120° Hardened Steel Cone — Inch

Type	Proof Stress – psi, Minimum		
	Grade 1	Grades 2, 2HM, 6, 6F & 7M	Grades 2H 3, 7, 43, & 16
Hex	120 000	135 000	150 000
Heavy Hex	130 000	150 000	175 000

TABLE 6 Proof Stress Using 120° Hardened Steel Cone — Metric

Type	Proof Stress – MPa, Minimum		
	Grade 1	Grades 2, 2HM, 6, 6F & 7M	Grades 2H 3, 7, 43, & 16
Hex	825	930	1035
Heavy Hex	895	1035	1205

TABLE 7 Marking of Nuts[A]

Grade and Type	Nuts Hot-Forged or Cold-Punched	Nuts Machined from Bar Stock	Nuts Manufactured in Accordance with 6.7
1	1	1B	...
2	2	2B	...
2H[B]	2H	2HB	...
2HM[B,C]	2HM	2HMB	...
3	3	3B	...
6	6	6B	...
6F	6F	6FB	...
7	7	7B	...
7L[D]	7L	7BL	...
7M[B,C]	7M	7MB	...
7ML[B,D]	7ML	7MLB	
43	43	43B	...
43L[D]	43L	43LB	...
8	8	8B	8A
8C	8C	8CB	8CA
8CLNCuB	8CLNCuB	8CLNCuBB	8CLNCuBA
8CLN	8CLN	8CLNB	8CLNA
8M	8M	8MB	8MA
8T	8T	8TB	8TA
8F	8F	8FB	8FA
8P	8P	8PB	8PA
8N	8N	8NB	8NA
8MN	8MN	8MNB	8MNA
8R	8R	8RB	8RA
8S	8S	8SB	8SA
8LN	8LN	8LNB	8LNA
8MLN	8MLN	8MLNB	8MLNA
8MLCuN	8MLCuN	8MLCuNB	8MLCuNA
8ML4CuN	8ML4CuN	8ML4CuNB	8ML4CuNA
9C	9C	9CB	9CA
16	16	16B	

[A]Where ellipses (...) appear in this table there is no requirement.
[B]The letters H and M indicate heat-treated nuts (see Section 6).
[C]An underline as a marking requirement for grades 2HM and 7M has been removed but is permitted.
[D]See Supplementary Requirement S3.

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall be applied only when specified by the purchaser in the inquiry, contract, or order. Details of these supplementary requirements shall be agreed upon in writing by the manufacturer and purchaser. Supplementary requirements shall in no way negate any requirement of the specification itself.

S1. Strain-Hardened Austenitic Steel Nuts

S1.1 Strain hardened Grades 8, 8C, 8T, 8M, 8F, 8P, 8N, or 8MN nuts may be specified. When Supplementary Requirement S1 is invoked in the order, nuts shall be machined from cold drawn bars or shall be cold forged to shape. No subsequent heat treatment shall be performed on the nuts. Nuts made in accordance with this requirement shall be proof load tested in accordance with 8.2.2.1 and shall withstand the proof load specified in Table S1.1 and Table S1.2. The hardness limits of Table 2 do not apply to strain hardened nuts. Nuts made in

TABLE S1.1 Proof Load Testing of Strain Hardened Nuts Using Threaded Mandrel — Inch Series

NOTE 1—Proof loads are not design loads.

Nominal Size, in.	Threads per in.	Stress Area, in.^{2}	Proof Load, lbf[A] All Types of Grade 8 (strain hardened) Heavy Hex[C]	Proof Load, lbf[A] All Types of Grade 8 (strain hardened) Hex[B]
¼	20	0.0316	3 950	3 480
5/16	18	0.0523	6 550	5 760
⅜	16	0.0774	9 675	8 510
7/16	14	0.1063	13 290	11 690
½	13	0.1419	17 740	15 610
9/16	12	0.182	22 750	20 020
⅝	11	0.226	28 250	24 860
¾	10	0.334	41 750	36 740
⅞	9	0.462	53 130	46 200
1	8	0.606	69 690	60 600
1⅛	8	0.790	82 950	75 050
1¼	8	1.000	105 000	95 000
1⅜	8	1.233	123 300	110 970
1½	8	1.492	149 200	134 280

[A] The proof load for jam nuts shall be 46 % of the tabulated value.
[B] Based on proof stress of 110 000 psi up to ¾ in.; 100 000 psi ⅞ to 1 in.; 95 000 psi 1⅛ to 1¼ in.; 90 000 psi 1⅜ to 1½ in.
[C] Based on proof stress of 125 000 psi up to ¾ in.; 115 000 psi ⅞ to 1 in.; 105 000 psi 1⅛ to 1¼ in.; 100 000 psi 1⅜ to 1½ in.

TABLE S1.2 Proof Load Testing of Strain Hardened Nuts Using Threaded Mandrel—Metric

NOTE 1—Proof loads are not design loads.

Nominal Size, mm	Thread Pitch	Stress Area, mm^2	Proof Load, kN[A] All Types of Grade 8 (strain hardened) Heavy Hex[C]	Proof Load, kN[A] All Types of Grade 8 (strain hardened) Hex[B]
M12	1.75	84.3	72.5	64.1
M14	2.0	115.0	98.9	87.4
M16	2.0	157.0	135.0	119.3
M20	2.5	245.0	210.9	186.2
M22	2.5	303.0	240.9	209.0
M24	3.0	353.0	280.6	243.5
M27	3.0	459.0	332.7	300.6
M30	3.5	561.0	406.7	367.5
M36	4.0	817.0	563.7	506.5

[A] The proof load for jam nuts shall be 46 % of the tabulated value.
[B] Based on proof stress of 760 MPa up to M20 mm; 690 MPa M22 to M24 mm; 655 MPa M27 to M30; and 620 MPa for M36.
[C] Based on proof stress of 860 MPa up to M20 mm; 795 MPa M22 to M24 mm; 725 MPa M27 to M30 mm; and 690 MPa for M36.

accordance with this requirement shall be marked with the Grade symbol underlined.

S2. Retests by Purchaser's Representative

S2.1 The purchaser's representative may select two nuts per keg (200-lb unit [90-kg]) for sizes ⅝ in. and M16 and smaller, one nut per keg for sizes over ⅝ in. and M16 up to and including 1½ in. and M36, and one nut per every two kegs for sizes larger than 1½ in. and M36, which shall be subjected to the tests specified in Section 8.

S3. Low-Temperature Requirements for Grade 7, Grade 7M, and Grade 43 Nuts

S3.1 When low-temperature requirements are specified for Grade 7 nuts, the Charpy test procedures and requirements as defined in Specification A320/A320M for Grade L7 shall apply. When low-temperature requirements are specified for Grade 7M nuts, the Charpy test procedures and requirements as defined in Specification A320/A320M for Grade L7M shall apply. When low-temperature requirements are specified for Grade 43 nuts, the Charpy test procedures and requirements as defined in Specification A320/A320M for Grade L43 shall apply. Charpy specimens may be taken from a sample nut, nut blank, or may be taken from separate test samples of the same heat processed through heat treatment with the nuts for which the test is to apply. Impact testing is not required when the bar stock or nut is smaller than ⅝ in. [16 mm] in diameter.

S3.2 An "L" shall be added to the marking, as shown in Table 7, for nuts so tested.

S4. Proof Load Tests of Large Nuts

S4.1 Proof load testing of nuts requiring proof loads of over 160 000 lbf or 705 kN is required. Testing shall be performed in accordance with 8.2 to the loads required in Table S4.1 and Table S4.2. The maximum load will be based entirely on the equipment available.

TABLE S4.1 Proof Load for Large Heavy Hex Nuts — Inch[A]

Nominal Size, in.	Threads per in.	Stress Area, in.^{2}	Proof Load, lbf[B]		
			Grade 1 Heavy Hex	Grades 2, 2HM, 6, 6F, 7M Heavy Hex	Grades 2H, 3, 7, 43, 16 Heavy Hex
1⅝	8	1.78	231 400	267 000	311 500
1¾	8	2.08	270 400	312 000	364 000
1⅞	8	2.41	313 300	361 500	421 800
2	8	2.77	360 100	415 500	484 800
2¼	8	3.56	462 800	534 000	623 000
2½	8	4.44	577 200	666 000	777 000
2¾	8	5.43	705 900	814 500	950 250

[A] ASME B18.2.2 in the size range over 1½ in. provides dimensions only for heavy hex nuts. Refer to 8.3.1.
[B] Proof loads for nuts of larger dimensions or other thread series may be calculated by multiplying the thread stress area times the proof stress in the notes to Table 3 or Table S1.1. The proof load for jam nuts shall be 46 % of the tabulated load.

TABLE S4.2 Proof Load for Large Heavy Hex Nuts — Metric[A]

Nominal Size, mm	Thread Pitch	Stress Area, mm^2	Proof Load, kN[B]		
			Grade 1 Heavy Hex	Grades 2, 2HM, 6, 6F, 7M Heavy Hex	Grades 2H, 3, 7, 43, 16 Heavy Hex
M42	4.5	1120	1002.4	1159.2	1349.6
M48	5	1470	1315.7	1521.4	1771.4
M56	5.5	2030	1816.9	2101.0	2446.2
M64	6	2680	2398.6	2773.8	3229.4
M72	6	3460	3096.7	3581.1	4169.3

[A] ASME B 18.2.4.6M in the size range over M36 provides dimensions only for heavy hex nuts. Refer to 8.3.1.
[B] Proof loads for nuts of larger dimensions or other thread series may be calculated by multiplying the thread stress area times the proof stress in the notes to Table 4 or Table S1.2. The proof load for jam nuts shall be 46 % of the tabulated load.

S5. Control of Product by Heat Number

S5.1 When control of nuts by actual heat analysis is required and this supplementary requirement is specified, the manufacturer shall identify the completed nuts in each shipment by the actual heat number. When this supplementary requirement is specified, a certificate including the results of the actual production tests of each test lot together with the heat chemical analysis shall be furnished by the manufacturer.

S6. Grain Size Requirements for Non H Grade Austenitic Steels Used Above 1000 °F

S6.1 For design metal temperatures above 1000 °F [540 °C], the material shall have a grain size of No. 7 or coarser as determined in accordance with Test Methods E112. The grain size so determined shall be reported on the Certificate of Test.

S7. Coating on Nuts

S7.1 It is the purchaser's responsibility to specify in the purchase order all information required by the coating facility. Examples of such information may include but are not limited to the following:

S7.1.1 Reference to the appropriate coating specification and type, thickness, location, modification to dimensions, and hydrogen embrittlement relief.

NOTE S7.1—Modification of thread dimensions may result in loss of load carrying ability.

S7.1.2 Reference to Specifications A153/A153M, B633, B695, B696, B766, F1941/F1941M, F2329/F2329M, or Test Method F1940, or other standards.

S8. Marking Coated Nuts

S8.1 Nuts coated with zinc shall have ZN marked after the grade symbol. Nuts coated with cadmium shall have CD marked after the grade symbol.

NOTE S8.1—As an example, the marking for zinc-coated 2H bolting components will now be 2HZN rather than 2H*.

S9. Proof Load Testing

S9.1 Proof load tests of nuts made to dimensions, thread pitch, and configurations other than those covered in Table 3 or Table 4 shall be made using loads agreed upon between the manufacturer and the purchaser.

S10. 100 % Hardness Testing of Grade 2HM and 7M

S10.1 Each nut shall be tested for hardness by indentation method and shall meet the requirements specified in Table 2.

APPENDIXES

(Nonmandatory Information)

X1. STRAIN HARDENING OF AUSTENITIC STEELS

X1.1 Strain hardening is the increase in strength and hardness that results from plastic deformation below the recrystallization temperature (cold work). This effect is produced in austenitic stainless steels by reducing oversized bars to the desired final size by cold drawing or other process. The degree of strain hardening achievable in any alloy is limited by its strain hardening characteristics. In addition, the amount of strain hardening that can be produced is further limited by the variables of the process, such as the total amount of cross-section reduction, die angle and bar size. In large diameter bars, for example, plastic deformation will occur principally in the outer regions of the bar, so that the increased strength and hardness due to strain hardening is achieved predominantly near the surface of the bar. That is, the smaller the bar, the greater the penetration of strain hardening. Thus, the mechanical properties of a given strain hardened bolting component are dependent not just on the alloy, but also on the size of bar from which it is machined.

X2. COATINGS AND APPLICATION LIMITS

X2.1 Use of coated bolting components at temperatures above approximately one-half the melting point (Fahrenheit or Celsius) of the coating is not recommended unless consideration is given to the potential for liquid and solid metal embrittlement, or both. The melting point of elemental zinc is approximately 780 °F [415 °C]. Therefore, application of zinc coated bolting components should be limited to temperatures less than 390 °F [210 °C]. The melting point of cadmium is approximately 600 °F [320 °C]. Therefore, application of cadmium coated bolting components should be limited to temperatures less than 300 °F [160 °C].

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A194/A194M – 23) that may impact the use of this standard. (Approved May 1, 2024.)

(1) Changed nitrogen range for Grade 8MLCuN/8MLCuNA in Table 1.
(2) Modified Section 9 to allow for other nut configurations.
(3) Added Note 3 for further guidance regarding metric dimensional specifications.
(4) Included references to ASME B 18.2.6M where applicable.

Committee A01 has identified the location of selected changes to this standard since the last issue (A194/A194M – 22a) that may impact the use of this standard. (Approved May 1, 2023.)

(1) Reworded 8.2.1 to clarify cross sectional hardness testing requirements.