Designation: A354 – 17ε2

Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners[1]

This standard is issued under the fixed designation A354; 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.

ε[1] NOTE—Table 4 was editorially corrected in November 2017.
ε[2] NOTE—13.1.5 was editorially corrected in November 2018.

1. Scope*

1.1 This specification[2] covers the chemical and mechanical requirements of quenched and tempered alloy steel bolts, studs, and other externally threaded fasteners 4 in. and under in diameter for application at normal atmospheric temperatures, where high strength is required and for limited application at elevated temperature (Note 1). Any alloy steel capable of meeting the mechanical and chemical properties set forth in this specification may be used.

NOTE 1—For bolts, studs, or other externally threaded fasteners, to be used at elevated temperatures, refer to Specification A193/A193M.

1.2 Two strength levels are covered, designated Grades BC and BD. Selection will depend upon design and the stresses and service for which the product is to be used.

NOTE 2—Quenched and tempered alloy steel bolts for structural steel joints up through 1½ in. in diameter are covered in Specification F3125/F3125M. For fastener diameter sizes above 1 ½ in., Grade BC may be considered for structural steel bolting where tensile strength above 120 ksi is necessary and Grade BD may be considered for structural steel bolting where tensile strength above 150 ksi is necessary. In this event, additional requirements of Specification F3125/F3125M, such as head size, lubricant, and magnetic particle inspection, should be carefully considered.

1.3 Nuts are covered in Specification A563. Unless otherwise specified, the grade and style of nut for each grade of fastener shall be as follows:

Grade of Fastener and Surface Finish	Nut Grade and Style[A]
BC, plain (or with a coating of insufficient thickness to require over-tapped nuts)	C, heavy hex
BC, zinc-coated (or with a coating thickness requiring over-tapped nuts)	DH, heavy hex
BD, all finishes	DH, heavy hex

[A] Nuts of other grades and styles having specified proof load stresses (Specification A563, Table 3) greater than the specified grade and style of nut are suitable.

1.4 Optional supplementary requirements are provided at the end of this standard.

1.5 Terms used in this specification are defined in Terminology F1789 unless otherwise defined herein.

1.6 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *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]

A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

A563 Specification for Carbon and Alloy Steel Nuts

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

[1] This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets and Washers.

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[2] For *ASME Boiler and Pressure Vessel Code* applications see related Specification SA-354 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**

E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
E709 Guide for Magnetic Particle Testing
E1268 Practice for Assessing the Degree of Banding or Orientation of Microstructures
E1417/E1417M Practice for Liquid Penetrant Testing
E1444/E1444M Practice for Magnetic Particle Testing
E2884 Guide for Eddy Current Testing of Electrically Conducting Materials Using Conformable Sensor Arrays
F436/F436M Specification for Hardened Steel Washers Inch and Metric Dimensions
F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
F788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
F1789 Terminology for F16 Mechanical Fasteners
F2328 Test Method for Determining Decarburization and Carburization in Hardened and Tempered, Threaded, Steel Bolts, Screws, Studs, and Nuts
F2329/F2329M Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
F3125/F3125M Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

2.2 *ASME Standards:*[4]
B1.1 Unified Screw Threads
B18.2.1 Square and Hex Bolts and Screws, Inch Series
B18.24 Part Identifying Number (PIN) Code System Standard for B18 Fastener Products

2.3 *ISO Publication*[5]
ISO TR 20491 Fundamentals of Hydrogen Embrittlement in Steel Fasteners[6]

3. Ordering Information

3.1 Orders for bolts and studs (including nuts and accessories) under this specification shall include the following:

3.1.1 ASTM designation and year of issue,

3.1.2 Name of product (that is, bolt or stud),

3.1.3 Grade (that is, BC or BD),

3.1.4 Quantities (number of pieces by size, including nuts, and washers),

3.1.5 Size, including nominal bolt diameter and bolt length, and thread pitch if other than standard,

3.1.6 *Zinc Coating*—When zinc-coated fasteners are required, specify the zinc-coating process required, for example hot-dip, mechanically deposited, or no preference (see 4.3).

3.1.7 *Other Finishes*—Specify other protective finish, if required.

3.1.8 Specify if inspection at point of manufacture is required,

3.1.9 Specify if Test Reports (Section 17) are required,

3.1.10 Specify additional testing (Section 12) or special requirements, and

3.1.11 Any supplementary requirements.

3.1.12 For establishment of a part identifying system, see ASME B18.24.

4. Materials and Manufacture

4.1 All fasteners shall be heat-treated. At the option of the manufacturer, heat treatment may be performed on the raw material, during the manufacturing operations, or after final forming or machining. Heat treatment shall consist of quenching in a liquid medium from above the austenite transformation temperature and then tempering by reheating to a temperature of not less than 800°F. When heat treatment is performed after threading for headed fasteners or double end studs, the fasteners shall be quenched in oil.

NOTE 3—The manufacturer should ensure that the austenite transformation temperature has been exceeded and sufficient time allowed to achieve adequate transformation to martensite throughout the fastener during quenching. This requirement is especially critical for sizes above 1½ in. as they require more time for heat transfer from the center. This microstructure helps to ensure uniform mechanical properties, specifically hardness, strength and toughness, are achieved throughout the fastener.

4.2 Washers for bolts supplied to this standard shall be in accordance with Specification F436/F436M. Nuts for bolts supplied to this standard shall be in accordance with Specification A563.

4.3 *Zinc Coatings, Hot-Dip and Mechanically Deposited Requiring Over-tapped Nuts:*

4.3.1 When zinc-coated fasteners are required, the purchaser shall specify the zinc coating process, for example, hot-dip, mechanically deposited, or no preference.

4.3.2 When "hot-dip" is specified, the threaded components (bolts and nuts) shall be zinc coated by the hot-dip process in accordance with the requirements of Specification F2329/F2329M.

4.3.3 When "mechanically deposited" is specified, the threaded components (bolts and nuts) shall be zinc-coated by the mechanical-deposition process in accordance with the requirements of Class 55 of Specification B695.

4.3.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F2329/F2329M, or a mechanically deposited zinc coating in accordance with Specification B695, Class 55. Threaded components (bolts and nuts) shall be coated by the same zinc-coating process and the supplier's option is limited to one process per item with no mixed processes in a lot.

4.3.5 Unless otherwise specified, when zinc-coated washers are required, the washers shall be hot-dip zinc coated in

[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), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[6] Pending approval.

accordance with Specification F2329/F2329M, or mechanically deposited zinc-coated in accordance with Specification B695, Class 55. The coating process for the washers need not be the same as that for the threaded components (bolts and nuts).

NOTE 4—See ISO TR 20491[6], "Fundamentals of Hydrogen Embrittlement in Steel Fasteners", listed in 2.3, in regard to the susceptibility of high hardness, electroplated zinc coated materials to hydrogen embrittlement.

4.4 *Other Coatings:*

4.4.1 When other coatings are required, the purchaser shall specify the coating specification, including the classification codes or grade numbers to identify the coating material, thickness, supplemental treatments, or other requirements to define the coating. The fasteners shall be coated in accordance with and conform to the specified coating specification.

4.4.2 When a specification does not apply, the purchaser shall specify the desired coating, coating thickness, supplementary treatments, or other requirements to define the coating.

5. Chemical Composition

5.1 All fasteners shall be made from alloy steel conforming to the chemical composition requirements in accordance with Table 1. The steel shall contain sufficient alloying elements to qualify it as an alloy steel.

5.2 Product analysis may be made by the purchaser from finished material representing each lot of fasteners. Choice of alloy steel composition necessary to ensure meeting the specified mechanical requirements shall be made by the manufacturer and shall be reported to the purchaser for information purposes only.

5.3 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

5.4 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A751.

TABLE 1 Chemical Requirements

Alloy Steel for Sizes through 4 in. for Grade BC and through 2 ¼ in. for Grade BD		
Element	Heat Analysis, %	Product Analysis, %
Carbon:	0.30 to 0.53	0.28 to 0.55
Manganese, min	0.600	0.570
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Boron, max	0.003	0.003
Alloying Elements	[A]	[A]

Alloy Steel for Grade BD Sizes over 2 ¼ in. through 4 in.		
Element	Heat Analysis, %	Product Analysis, %
Carbon	0.35-0.53	0.33-0.55
Nickel, min	0.400	0.380
Chromium, min	0.400	0.380
Molybdenum, min	0.150	0.150
Manganese, min	0.600	0.570
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Boron, max	0.003	0.003
Other Alloying Elements	[A]	[A]

[A] See Terminology F1789 for alloy steel definition.

6. Mechanical Properties

6.1 *Tensile Properties:*

6.1.1 Except as permitted in 6.1.2 and 6.1.3, diameters of headed fasteners 1 in. and smaller having a nominal length of 2 ¼ D and longer, and diameters over 1 in. having a nominal length of 3D and longer, shall be wedge tested full size to Test Method F606/F606M and shall conform to the tensile load and proof load in Table 3.

6.1.2 Headed fasteners with diameters 1 in. and smaller having a nominal length shorter than 2 ¼ D down to 2D, inclusive, that cannot be wedge tensile tested, shall be axially tension tested full size to Test Method F606/F606M and shall conform to the tensile load and proof load in Table 3.

6.1.3 Headed fasteners with diameters 1 in. and smaller having a nominal length shorter than 2D and diameters larger than 1 in. with nominal lengths shorter than 3D that cannot be axially tensile tested shall be accepted on the basis of hardness in Table 2.

6.1.4 Studs with nominal lengths of 5D and longer shall be axially tension tested full size and shall conform to the tensile load and proof load in Table 3. Studs with nominal lengths less than 5D shall be qualified on the basis of hardness in Table 2.

6.1.5 Fracture on full-size tests shall be in the threads of the fastener without fracture at the junction of the head and body.

6.1.6 When the sizes of the fastener makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements in Table 4. When bolts are tested by both full-size and machined specimen methods, the full-size test shall take precedence.

6.2 *Hardness*—Fasteners shall conform to the hardness in Table 2. Fasteners over 2¼ in. in nominal diameter shall conform to the cross sectional hardness requirements in Section 9.

6.3 For fasteners on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event that there is controversy over low readings of hardness tests, except as stated in 9.1.1.

7. Carburization/Decarburization

7.1 *Requirements:*

7.1.1 *Carburization*—The bolts shall show no evidence of a carburized surface when evaluated in accordance with Test Method F2328.

7.1.2 *Decarburization*—Hardness value differences shall not exceed the requirements set forth for decarburization in Test Method F2328. Grade BC shall meet the requirements of Class 1 and Grade BD shall meet the requirements of Class 2, regardless of size.

TABLE 2 Hardness Requirements for Full-Size Fasteners

Size, in.	Grade	Hardness			
		Brinell		Rockwell C	
		Minimum	Maximum	Minimum	Maximum
¼ to 2½	BC	255	331	26	36
Over 2½	BC	235	311	22	33
All sizes	BD	311	352	33	38

TABLE 3 Tensile Requirements for All Full-Size Fasteners—Inch-Pound Units

Bolt Size, in.	Threads per inch	Stress Area,[A] in.^{2}	Grade BC			Grade BD			
			Ultimate Tensile Load, min, lbf[B]	Proof Load, lbf[C]	Yield Strength (0.2 % offset), min, lbf[D]	Ultimate Tensile Load, min, lb[E]	Ultimate Tensile Load, max, lbf[F]	Proof Load, lbf[G]	Yield Strength (0.2 % offset), min, lbf[H]
1	2	3	4	5	6	7	8	9	10
¼	20	0.0318	4 000	3 350	3 450	4 750	5 500	3 800	4 100
¼	28	0.0364	4 550	3 820	3 950	5 450	6 300	4 350	4 700
5⁄16	18	0.0524	6 550	5 500	5 700	7 850	9 050	6 300	6 800
5⁄16	24	0.0580	7 250	6 090	6 300	8 700	10 000	6 950	7 500
⅜	16	0.0775	9 700	8 150	8 450	11 650	13 400	9 300	10 075
⅜	24	0.0878	11 000	9 220	9 550	13 200	15 200	10 500	11 400
7⁄16	14	0.1063	13 300	11 150	11 600	15 950	18 400	12 750	13 850
7⁄16	20	0.1187	14 840	12 470	12 900	17 800	20 550	14 200	15 400
½	13	0.1419	17 750	14 900	15 450	21 300	24 550	17 050	18 500
½	20	0.1599	19 990	16 790	17 400	24 000	27 650	19 200	20 750
9⁄16	12	0.182	22 750	19 100	19 850	27 300	31 500	21 850	23 600
9⁄16	18	0.203	25 400	21 400	22 100	30 400	35 100	24 400	26 350
⅝	11	0.226	28 250	23 750	24 650	33 900	39 100	27 100	29 400
⅝	18	0.256	32 000	26 800	27 900	38 400	44 300	30 700	33 250
¾	10	0.334	41 750	35 050	36 400	50 100	57 800	40 100	43 400
¾	16	0.373	46 600	39 100	40 650	56 000	64 550	44 800	48 450
⅞	9	0.462	57 750	48 500	50 350	69 300	79 950	55 450	60 100
⅞	14	0.509	63 600	53 400	55 450	76 400	88 000	61 100	66 150
1	8	0.606	75 750	63 650	66 050	90 900	104 850	72 700	78 800
1	12	0.663	82 900	69 700	72 250	99 400	114 700	79 600	86 150
1	14 UNS	0.679	84 900	71 300	74 400	101 900	117 500	81 500	88 250
1⅛	7	0.763	95 400	80 100	83 150	114 450	132 000	91 550	99 200
1⅛	8	0.790	98 750	82 950	86 200	118 500	136 700	94 800	102 700
1⅛	12	0.856	107 000	89 800	93 300	128 400	148 000	102 700	111 250
1¼	7	0.969	121 150	101 750	105 600	145 350	167 650	116 300	126 000
1¼	8	1.000	125 000	105 000	109 000	150 000	173 000	120 000	130 000
1¼	12	1.073	134 100	112 600	116 950	161 000	185 600	128 800	139 450
1⅜	6	1.155	144 400	121 300	125 900	173 250	199 850	138 600	150 200
1⅜	8	1.233	154 150	129 450	134 400	185 000	213 300	148 000	160 300
1⅜	12	1.315	164 400	138 100	143 300	197 200	227 500	157 800	170 950
1½	6	1.405	175 650	147 550	153 150	210 750	243 100	168 600	182 500
1½	8	1.492	186 500	156 650	162 250	233 800	258 100	175 050	194 000
1½	12	1.581	197 600	166 000	172 300	237 200	273 500	189 700	205 500
1¾	5	1.90	237 500	199 500	207 100	285 000	328 700	228 000	247 000
1¾	8	2.08	260 000	218 400	226 700	312 000	359 800	249 600	270 000
2	4½	2.50	312 500	262 500	272 500	375 000	432 500	300 000	325 000
2	8	2.77	346 250	290 850	301 950	415 000	480 000	332 400	360 000
2¼	4½	3.25	406 250	341 250	354 250	487 000	562 250	390 000	422 500
2¼	8	3.56	445 000	373 800	388 050	534 000	616 000	422 200	462 800
2½	4	4.00	500 000	420 000	436 000	600 000	692 000	480 000	520 000
2½	8	4.44	550 000	466 200	483 950	666 000	768 100	532 800	577 200
2¾	4	4.93	566 950	468 350	488 050	739 500	853 000	591 600	640 900
2¾	8	5.43	624 450	515 850	537 550	814 500	939 400	651 600	705 900
3	4	5.97	686 550	567 150	591 050	895 500	1 032 800	716 400	776 100
3	8	6.51	748 650	618 450	644 500	976 500	1 126 200	781 200	846 300
3¼	4	7.10	816 500	674 500	702 900	1 065 000	1 228 300	852 000	923 000
3¼	8	7.69	884 350	730 550	761 300	1 153 500	1 330 400	922 800	999 700
3½	4	8.33	957 950	791 350	824 650	1 249 500	1 441 100	999 600	1 082 900
3½	8	8.96	1 030 400	851 200	887 050	1 344 000	1 550 100	1 075 200	1 164 800
3¾	4	9.66	1 110 900	917 700	956 350	1 449 000	1 671 200	1 159 200	1 255 800
3¾	8	10.34	1 199 100	983 300	1 023 650	1 551 000	1 788 800	1 240 800	1 344 200
4	4	11.08	1 274 200	1 052 600	1 096 900	1 662 000	1 916 800	1 329 600	1 440 400
4	8	11.81	1 358 200	1 122 000	1 169 200	1 771 500	2 043 100	1 417 200	1 535 300

[A] Stress Area, in.^{2} = 0.7854 [D – 0.9743/ n] ^{2} where D = nominal diameter, in., and n = threads/in.
[B] Based on 125 000 psi for sizes ¼ to 2½ in., inclusive, and on 115 000 psi for sizes over 2½ to 4 in., inclusive.
[C] Based on 105 000 psi for sizes ¼ to 2½ in., inclusive, and on 95 000 psi for sizes over 2½ to 4 in., inclusive.
[D] Based on 109 000 psi for sizes ¼ to 2½ in., inclusive, and on 99 000 psi for sizes over 2½ to 4 in., inclusive.
[E] Based on 150 000 psi for all sizes.
[F] Based on 173 00 psi for all sizes.
[G] Based on 120 000 psi for all sizes.
[H] Based on 130 000 psi for all sizes.