Designation: A 354 – 00a

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

This standard is issued under the fixed designation A 354; 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 Department of Defense.

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 minimum 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 A 193/A 193M.

1.2 Two levels of bolting strength 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 A 490. Alloy steel bolts, studs, and other externally threaded fasteners (that is, heavy hex-structural bolts over 1½ in., hex bolts, anchor bolts, and countersunk bolts) exhibiting similar mechanical properties to bolts conforming to Specification A 490 shall be covered by Grade BD of this specification.

When bolts of Grade BD of this specification are considered for pretentioned applications in excess of 50 % of the bolt tensile strength, the additional requirements of head size, maximum tensile strength, nut size and strength, washer hardness, tests, and inspections contained in Specification A 490 should be carefully considered.

1.3 Nuts are covered in Specification A 563. 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 A 563, Table 3) greater than the specified grade and style of nut are suitable.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware[3]

A 193/A193M Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service[4]

A 490 Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength[5]

A 563 Specification for Carbon and Alloy Steel Nuts[5]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[6]

B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel[7]

D 3951 Practice for Commercial Packaging[8]

F 436 Specification for Hardened Steel Washers[5]

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets[5]

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series[5]

2.2 *ANSI/ASME Standards:*

[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] *Annual Book of ASTM Standards*, Vol 01.06.
[4] *Annual Book of ASTM Standards*, Vol 01.01.
[5] *Annual Book of ASTM Standards*, Vol 01.08.
[6] *Annual Book of ASTM Standards*, Vol 01.03.
[7] *Annual Book of ASTM Standards*, Vol 02.05.
[8] *Annual Book of ASTM Standards*, Vol 15.09.

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

B1.1 Unified Screw Threads[9]
B18.2.1 Square and Hex Bolts and Screws, Inch Series[9]
B18.24.1 Part Identifying Number (PIN) Code System[10]
2.3 *Military Standard:*
MIL-STD 105 Single Sampling Plan for Normal Inspection[11]

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),
3.1.5 Size and length,
3.1.6 Washers—Specify quantity and size (separate from bolts) (4.3),
3.1.7 *Zinc Coating*—When zinc-coated Grade BC fasteners are required, specify the zinc-coating process required, for example hot-dip, mechanically deposited, or no preference (see 4.4).
3.1.8 *Other Finishes*—Specify other protective finish, if required.
3.1.9 Specify if inspection at point of manufacture is required,
3.1.10 Specify if Certification (Section 14) is required, and
3.1.11 Specify additional testing (Section 9) or special requirements.
3.1.12 For establishment of a part identifying system, see ASME B18.24.1.

4. Materials and Manufacture

4.1 The steel shall be made by the open-hearth, electric-furnace, or basic-oxygen process.
4.2 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 machining. Heat treatment shall consist of quenching in a liquid medium (except Grade BD sizes 1½ in. and smaller shall be quenched in oil) from above the transformation temperature and then temperating by reheating to a temperature of not less than 800°F (427°C) for Grade BC and for Grade BD.
4.3 When used, suitable hardened washers shall be quenched and tempered (non-carburized) in accordance with Specification F 436.
4.4 *Zinc Coatings, Hot-Dip and Mechanically Deposited*:
4.4.1 When zinc-coated fasteners are required, the purchaser shall specify the zinc coating process, for example, hot-dip, mechanically deposited, or no preference.
4.4.2 When "hot-dip" is specified, the fasteners shall be zinc coated by the hot-dip process in accordance with the requirements of Class C of Specification A 153.
4.4.3 When mechanically deposited is specified, the fasteners shall be zinc-coated by the mechanical-deposition process in accordance with the requirements of Class 50 of Specification B 695.
4.4.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification A 153, Class C or a mechanically deposited zinc coating in accordance with Specification B 695, Class 50. 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.

NOTE 3—When the intended application requires that assembled tension exceeds 50 % of minimum bolt proof load, an anti-galling lubricant may be needed. Application of such a lubricant to nuts and a test of the lubricant efficiency are provided in Supplementary Requirement S1of Specification A 563 and should be specified when required.

4.5 Zinc-coated bolts and nuts shall be shipped in the same container unless specifically requested otherwise by the purchaser.

NOTE 4—Research conducted on bolts of similar material and manufacture indicates that hydrogen-stress cracking or stress cracking corrosion may occur on hot-dip galvanized Grade BD bolts.

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.

NOTE 5—Steel is considered to be alloy, by the American Iron and Steel Institute, when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 %; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

5.2 Product analysis may be made by the purchaser from finished material representing each lot of fasteners. The chemical composition thus determined shall conform to the requirements given in Table 1. 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

TABLE 1 Chemical Requirements

Element	Heat Analysis, %	Product Analysis, %
Carbon:		
For sizes through 1½ in.	0.30 to 0.53	0.28 to 0.55
For sizes larger than 1½ in.	0.35 to 0.53	0.33 to 0.55
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045

[9] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.
[10] Available from American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016–5990.
[11] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

with Test Methods A 751.

6. Mechanical Properties

6.1 Fasteners shall not exceed the maximum hardness specified in Table 2. Fasteners less than three diameters in length and studs less than four diameters in length shall have hardness values not less than the minimum nor more than the maximum hardness limits required in Table 2, as hardness is the only requirement.

6.2 Fasteners 1⅜ in. in diameter or less for Grade BC and 1¼ in. in diameter or less for Grade BD, other than those excepted in 6.1, shall be tested full size and shall conform to the tensile strength and either the proof load or the yield strength requirements in accordance with Table 3.

6.3 Fasteners larger than 1⅜ in. in diameter for Grade BC and fasteners larger than 1¼ in. in diameter for Grade BD, other than those excepted in 6.1, shall preferably be tested full size and when so tested, shall conform to the tensile strength and either the proof load or yield strength require-ments in accordance with Table 3 or Table 4. When equipment of sufficient capacity for full-size testing is not available, or when the length of the fastener makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements in accordance with Table 5. In the event that fasteners are tested by both full-size and by the machined test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

6.4 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.

7. Dimensions

7.1 *Bolts*—Unless otherwise specified, the bolts shall be Hex Head with dimensions conforming to the latest issue of ANSI/ASME B18.2.1.

7.2 *Studs*—Studs shall have dimensions conforming to those specified by the purchaser.

7.3 *Threads*:

7.3.1 Unless otherwise specified, threads shall be the Unified National Coarse Thread Series as specified in ANSI B1.1, and shall have Class 2 A tolerances.

7.3.2 When specified, threads shall be the Unified National Fine Thread Series, 8-Pitch Thread Series for sizes over 1 in. or 14-Pitch UNS on 1 in. size as specified in ANSI B1.1 and shall have Class 2A tolerances.

7.3.3 Unless otherwise specified, bolts and studs to be used with nuts or tapped holes that have been tapped oversize, in accordance with Specification A 563, shall have Class 2A threads before hot dip or mechanically deposited zinc coating. After zinc coating, the maximum limit of pitch and major diameter may exceed the Class 2A limit by the following amount:

Diameter, in.	Oversize Limit, in. (mm)[A]
¼	0.016
5⁄16, ⅜	0.017
7⁄16, ½	0.018
9⁄16 to ¾, incl	0.020
⅞	0.022
1.0 to 1¼, incl	0.024
1⅜, 1½	0.027
1¾ to 4.0, incl	0.050

[A] These values are the same as the overtapping required for zinc-coated nuts in Specification A 563.

7.3.4 The gaging limit for bolts shall be verified during manufacture or use by assembly of a nut tapped as nearly as practical to the amount oversize shown. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance, gage tolerance plus) is to be used. Assembly of the gage, or the nut described, must be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, are to be performed at the frequency and quality in accordance with Table 6.

8. Workmanship

8.1 Surface discontinuity limits shall be in accordance with Specification F 788/F 788M.

9. Number of Mechanical Tests

9.1 *Testing Responsibility*:

9.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 9.2 through 9.6.

9.1.2 When fasteners are furnished by a source other than the manufacturer, the responsible party as defined in 12.1 shall be responsible for ensuring that all tests have been performed and the fasteners comply with the requirements of this specification.

9.2 *Purpose of Lot Inspection*—The purpose of a lot inspection program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective it is essential that secondary processors, distributors, and purchasers maintain the identification and integrity of each lot until the product is installed.

9.3 *Lot Processing*—All fasteners shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each lot of fasteners from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

9.4 *Lot Definition*—A lot is a quantity of a uniquely identified fastener product of the same nominal size and length produced consecutively at the initial operation from a single mill heat of material and heat treatment lot and processed at

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
¼ to 2½	BD	311	363	33	39
Over 2½	BD	293	363	31	39

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		
			Tensile Strength, min, lbf[B]	Proof Load, min, lbf[C]	Yield Strength (0.2 % offset), min, lbf[D]	Tensile Strength, min, lbf[E]	Proof Load, min, lbf[F]	Yield Strength (0.2 % offset), min, lbf[G]
1	2	3	4	5	6	7	8	9
¼	20	0.0318	4 000	3 350	3 450	4 750	3 800	4 100
¼	28	0.0364	4 550	3 820	3 950	5 450	4 350	4 700
5⁄16	18	0.0524	6 550	5 500	5 700	7 850	6 300	6 800
5⁄16	24	0.0580	7 250	6 090	6 300	8 700	6 950	7 500
⅜	16	0.0775	9 700	8 150	8 450	11 650	9 300	10 075
⅜	24	0.0878	11 000	9 220	9 550	13 200	10 500	11 400
7⁄16	14	0.1063	13 300	11 150	11 600	15 950	12 750	13 850
7⁄16	20	0.1187	14 840	12 470	12 900	17 800	14 200	15 400
½	13	0.1419	17 750	14 900	15 450	21 300	17 050	18 500
½	20	0.1599	19 990	16 790	17 400	24 000	19 200	20 750
9⁄16	12	0.182	22 750	19 100	19 850	27 300	21 850	23 600
9⁄16	18	0.203	25 400	21 400	22 100	30 400	24 400	26 350
⅝	11	0.226	28 250	23 750	24 650	33 900	27 100	29 400
⅝	18	0.256	32 000	26 800	27 900	38 400	30 700	33 250
¾	10	0.334	41 750	35 050	36 400	50 100	40 100	43 400
¾	16	0.373	46 600	39 100	40 650	56 000	44 800	48 450
⅞	9	0.462	57 750	48 500	50 350	69 300	55 450	60 100
⅞	14	0.509	63 600	53 400	55 450	76 400	61 100	66 150
1	8	0.606	75 750	63 650	66 050	90 900	72 700	78 800
1	12	0.663	82 900	69 700	72 250	99 400	79 600	86 150
1	14 UNS	0.679	84 900	71 300	74 400	101 900	81 500	88 250
1⅛	7	0.763	95 400	80 100	83 150	114 450	91 550	99 200
1⅛	8	0.790	98 750	82 950	86 200	118 500	94 800	102 700
1⅛	12	0.856	107 000	89 800	93 300	128 400	102 700	111 250
1¼	7	0.969	121 150	101 750	105 600	145 350	116 300	126 000
1¼	8	1.000	125 000	105 000	109 000	150 000	120 000	130 000
1¼	12	1.073	134 100	112 600	116 950	161 000	128 800	139 450
1⅜	6	1.155	144 400	121 300	125 900	173 250	138 600	150 200
1⅜	8	1.233	154 150	129 450	134 400	185 000	148 000	160 300
1⅜	12	1.315	164 400	138 100	143 300	197 200	157 800	170 950
1½	6	1.405	175 650	147 550	153 150	210 750	168 600	182 500
1½	8	1.492	186 500	156 650	162 250	233 800	175 050	194 000
1½	12	1.581	197 600	166 000	172 300	237 200	189 700	205 500
1¾	5	1.90	237 500	199 500	207 100	285 000	228 000	247 000
1¾	8	2.08	260 000	218 400	226 700	312 000	249 600	270 000
2	4½	2.50	312 500	262 500	272 500	375 000	300 000	325 000
2	8	2.77	346 250	290 850	301 950	415 000	332 400	360 000
2¼	4½	3.25	406 250	341 250	354 250	487 000	390 000	422 500
2¼	8	3.56	445 000	373 800	388 050	534 000	422 200	462 800
2½	4	4.00	500 000	420 000	436 000	600 000	480 000	520 000
2½	8	4.44	550 000	466 200	483 950	666 000	532 800	577 200
2¾	4	4.93	566 950	468 350	488 050	690 200	517 650	566 950
2¾	8	5.43	624 450	515 850	537 550	750 200	570 150	624 450
3	4	5.97	686 550	567 150	591 050	835 800	626 850	686 550
3	8	6.51	748 650	618 450	644 500	911 400	683 550	748 650
3¼	4	7.10	816 500	674 500	702 900	994 000	745 500	816 500
3¼	8	7.69	884 350	730 550	761 300	1 076 600	807 650	884 350
3½	4	8.33	957 950	791 350	824 650	1 166 200	874 650	957 950
3½	8	8.96	1 030 400	851 200	887 050	1 254 400	940 800	1 030 400
3¾	4	9.66	1 110 900	917 700	956 350	1 352 400	1 014 300	1 110 900
3¾	8	10.34	1 199 100	983 300	1 023 650	1 447 600	1 085 700	1 189 100
4	4	11.08	1 274 200	1 052 600	1 096 900	1 551 200	1 163 400	1 274 200
4	8	11.81	1 358 200	1 122 000	1 169 200	1 653 400	1 240 050	1 358 150

[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 sizes ¼ to 2½ in., inclusive, and on 140 000 psi for sizes over 2½ to 4 in., inclusive.
[F] Based on 120 000 psi for sizes ¼ to 2½ in., inclusive, and on 105 000 psi for sizes over 2½ to 4 in., inclusive.
[G] Based on 130 000 psi for sizes ¼ to 2½ in., inclusive, and on 115 000 psi for sizes over 2½ to 4 in., inclusive.