

Designation: A354 – 17

Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners¹

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.

1. Scope*

1.1 This specification² 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 $1\frac{1}{2}$ in. in diameter are covered in Specification F3125/F3125M. For fastener diameter sizes above $1\frac{1}{2}$ 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:

	Nut Grade and
Grade of Fastener and Surface Finish	Style ^A
BC, plain (or with a coating of insufficient thick-	C, heavy hex
ness to require over-tapped nuts)	
BC, zinc-coated (or with a coating thickness re-	DH, heavy hex
quiring over-tapped nuts)	
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
- E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
- E709 Guide for Magnetic Particle Testing

¹This 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.

- 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 Publication⁵

ISO TR 20491 Fundamentals of Hydrogen Embrittlement in Steel Fasteners⁶

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 $1\frac{1}{2}$ 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 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).

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.

NOTE 4—See ISO TR 20491⁶, "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

6. Mechanical Properties

6.1 Tensile Properties:

Alloy Steel for Sizes through 4 in. for Grade BC and through 2 1/4 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	А	Α			
Alloy Steel for Grade B	D Sizes over 2 1/4 in. throu	ugh 4 in.			
Element	Heat	Product			
	Analysis, %	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	А	A			

^ASee Terminology F1789 for alloy steel definition.

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 ¹/₄ 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 $\frac{1}{4}$ 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 $2^{1}/_{4}$ 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.

8. Charpy Absorbed-Energy

8.1 Requirements:

TABLE 2 Hardness Requ	irements for	Full-Size	Fasteners
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		Hardness				
Size, in.	Grade	Bri	Brinell		Rockwell C	
		Minimum	Maximum	Minimum	Maximum	
1/4 to 21/2	BC	255	331	26	36	
Over 21/2	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	Threads	Stress		Grade BC			Grad	le BD	
Size,	per	Area, ^A	Liltimato		Viold	Liltimato	Liltimato		Viold
in.	inch	in. ²	Tanaila	Dreafload	Ctrongth	Tanaila	Tanaila	Proof	Ctrongth
			rensile	Proof Load,		rensile	rensile	Load,	Strength
			Load,	IDI	(0.2 % onset),	Load,	Load,	lbf ^G	(0.2 % offset),
			min, lbf ^ø		min, lbf ^D	min, lb ²	max, lbfr		min, lbf ^m
1	2	3	4	5	6	7	8	9	10
1/4	20	0.0318	4 000	3 350	3 450	4 750	5 500	3 800	4 100
1/4	20	0.0364	4 550	3 820	2 950	4750 5450	6 300	4 350	4 700
5/	20	0.0304	4 550	5 620	5 950	7 950	0 300	4 330	4 700
9/16	18	0.0524	0 000	5 500	5 700	7 850	9 050	6 300	0 800
9⁄16	24	0.0580	7 250	6 090	6 300	8 700	10 000	6 950	7 500
3/8	16	0.0775	9 700	8 150	8 450	11 650	13 400	9 300	10 075
3/8	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
1/2	13	0.1419	17 750	14 900	15 450	21 300	24 550	17 050	18 500
1/2	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
5%	11	0.226	28 250	23 750	24 650	33 900	39 100	27 100	29 400
56	19	0.256	22 000	26 800	27 000	28 400	44 200	20 700	23 250
-78	10	0.250	32 000	20 000	27 900	50 400	44 300 F7 800	30 7 00	33 230
9/4	10	0.334	41750	35 050	36 400	50 100	57 800	40 100	43 400
3/4	16	0.373	46 600	39 100	40 650	56 000	64 550	44 800	48 450
//8	9	0.462	57 750	48 500	50 350	69 300	79 950	55 450	60 100
7/8	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		0.679	84 900	71 300	74 400	101 900	117 500	81 500	88 250
114	7	0.079	04 900	20 100	74 400	114 450	122 000	01 550	00 200
1 1/8	7	0.703	95 400	80 100	03 150	114 450	132 000	91 550	99 200
1 1/8	8	0.790	98 750	82 950	86 200	118 500	136 700	94 800	102 700
11/8	12	0.856	107 000	89 800	93 300	128 400	148 000	102 /00	111 250
11/4	7	0.969	121 150	101 750	105 600	145 350	167 650	116 300	126 000
11/4	8	1.000	125 000	105 000	109 000	150 000	173 000	120 000	130 000
11/4	12	1.073	134 100	112 600	116 950	161 000	185 600	128 800	139 450
13⁄8	6	1.155	144 400	121 300	125 900	173 250	199 850	138 600	150 200
13/8	8	1.233	154 150	129 450	134 400	185 000	213 300	148 000	160 300
13/8	12	1.315	164 400	138 100	143 300	197 200	227 500	157 800	170 950
11/2	6	1 405	175 650	147 550	153 150	210 750	243 100	168 600	182 500
11/2	8	1 /02	186 500	156 650	162 250	233 800	258 100	175 050	10/ 000
1/2	10	1 501	107 600	166 000	172 200	200 000	272 500	190 700	205 500
1 72	12	1.001	197 000	100 000	172 300	237 200	273 500	109 700	205 500
1%4	5	1.90	237 500	199 500	207 100	285 000	328 700	228 000	247 000
19/4	8	2.08	260 000	218 400	226 700	312 000	359 800	249 600	270 000
2	41/2	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
21/4	41/2	3.25	406 250	341 250	354 250	487 000	562 250	390 000	422 500
21/4	8	3.56	445 000	373 800	388 050	534 000	616 000	422 200	462 800
21/2	4	4 00	500 000	420 000	436 000	600.000	692 000	480 000	520 000
21/2	•	4.00	550 000	466 200	492 050	666 000	769 100	522 800	577 200
2 72	0	4.44	500 000	400 200	403 950	720 500	700 100	552 600	640.000
2%4	4	4.93	500 950	408 350	488 050	739 500	853 000	591 600	640 900
23/4	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
31/4	4	7 10	816 500	674 500	702 900	1 065 000	1 228 300	852 000	923 000
31/4	8	7 69	884 350	730 550	761 300	1 153 500	1 330 400	922 800	999 700
Q1/4	1	8 22	957 950	701 250	824 650	1 240 500	1 441 100	990 600	1 082 000
0 /2 01/2	4 0	0.00 8 06	1 030 400	851 200	887 050	1 344 000	1 550 100	1 075 200	1 164 900
0.72	0	0.50	1 110 000	017 700	056 250	1 440 000	1 671 000	1 150 200	1 255 000
3%4 03/	4	9.00	1 100 100	917 700	1 000 050	1 449 000	1 700 000	1 040 000	
394	ō	10.34	1 199 100	903 300	1 023 030	1 551 000	1 / 00 000	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.

^a Stress Area, in.⁻ = 0.7854 [D - 0.9743 /ij⁻ where D = nonline traineter, in., and n - uncass/in. ^B Based on 125 000 psi for sizes 1/4 to 21/2 in., inclusive, and on 115 000 psi for sizes over 21/2 to 4 in., inclusive. ^C Based on 105 000 psi for sizes 1/4 to 21/2 in., inclusive, and on 95 000 psi for sizes over 21/2 to 4 in., inclusive. ^D Based on 109 000 psi for sizes 1/4 to 21/2 in., inclusive, and on 99 000 psi for sizes over 21/2 to 4 in., inclusive. ^E Based on 150 000 psi for all sizes.

^FBased 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.

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TABLE 4 Mechanical Requirements for Machined Specimens

Grade	Size, in.	Tensile Strength min, psi	Tensile Strength max, psi	Yield Strength (0.2 % offset), min, psi	Elonga- tion in 2 in. min, %	Reduc- tion of Area, min, %
BC	1/4 to 21/2, incl	125 000		109 000	16	50
BC	Over 21/2	115 000		99 000	16	45
BD	1/4 to 21/2, incl	150 000	173 000	130 000	14	40
BD	Over 21/2	140 000	173 000	115 000	14	40

8.1.1 Impact testing shall be performed on Grade BD fasteners with nominal diameters over 2 $\frac{1}{4}$ in. Such fasteners shall have a minimum absorbed-energy of 20 ft-lbf when tested at a temperature of $-4^{\circ}F$. (See 13.3.)

9. Cross Sectional Hardness

9.1 Requirements:

9.1.1 Grade BD fasteners with nominal diameters larger than 2 $\frac{1}{4}$ in. shall have equidistant hardness readings taken across the entire diameter of the fastener through the threaded section. Readings shall be no further apart than $\frac{1}{4}$ in. Hardness tests shall be conducted at a transverse section through the threads taken at a distance of approximately one diameter from the point end of the bolt or one end of the stud. No reading shall be outside the acceptable hardness range in Table 1, and no reading shall be greater than ± 3 HRC points from the average mid-radius hardness value.

10. Dimensions

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

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

10.3 Threads:

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

10.3.2 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 ASME B1.1 and shall have Class 2A tolerances.

10.3.3 Unless otherwise specified, bolts and studs to be used with nuts or tapped holes that have been tapped oversize, in accordance with Specification A563, 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 in accordance with Specification A563.

11. Workmanship

11.1 Surface discontinuity limits shall be in accordance with Specification F788/F788M.

12. Number of Tests

12.1 Testing Responsibility:

12.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 12.2 through 12.5.

12.1.2 When fasteners are furnished by a source other than the manufacturer, the responsible party as defined in 15.1 shall be responsible for ensuring that all tests have been performed and the fasteners comply with the requirements of this specification.

12.2 *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.

12.3 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.

12.4 *Number of Tests*—The minimum number of mechanical tests from each production lot shall be in accordance with Guide F1470.

12.4.1 For carburization and decarburization tests, not less than one sample unit per manufactured lot shall be tested in accordance with Test Method F2328.

12.4.2 Unless otherwise specified and when required, three full-size Type A test specimens shall be used for impact testing.

12.5 If any test specimen shows defective machining it may be discarded and another specimen substituted.

13. Test Methods

13.1 Hardness, Tensile Strength, Proof Load, and Yield Strength:

13.1.1 Test methods shall be conducted in accordance with Test Methods F606/F606M.

13.1.2 Proof load, rather than yield strength determination is preferred and shall be the arbitration method for fasteners $1\frac{1}{4}$ in. and under in diameter.

13.1.3 Hexagon bolts that are long enough to be wedge tested in accordance with 6.1.1 shall be tested using the wedge tension method.

13.1.4 Studs and bolts other than those in 13.1.3 shall be tested by the axial tension method or in accordance with 6.1.4 and 6.1.6.

13.1.5 The speed of testing determined with a free running crosshead shall be a maximum of $\frac{1}{8}$ in. for the bolt proof load (or yield strength) determination and a maximum of 1 in. for the tensile strength determination.

13.2 Carburization/Decarburization:

13.2.1 Tests shall be conducted in accordance with Test Method F2328.

13.3 Charpy Absorbed-Energy Test:

13.3.1 The test equipment and test method shall be in accordance with Test Methods E23. The test specimen shall be stabilized to a temperature of $-4^{\circ}F$ prior to test. Unless otherwise specified, test sample location shall be in accordance with Test methods F606/F606M as listed for tension testing of machine test specimens. The orientation shall be longitudinal with the notch perpendicular to the axis of the externally threaded fastener.

14. Inspection

14.1 If the inspection described in 14.2 is required by the purchaser, it shall be specified in the inquiry and contract or purchase order.

14.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as to not interfere unnecessarily with the operation of the works.

15. Responsibility

15.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

16. Rejection and Rehearing

16.1 Material that fails to conform to the requirements of this specification shall adhere to the disposition options specified in Practice F1470.

17. Certification

17.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party in accordance with Section 15, shall furnish the purchaser a test report which includes the following:

17.1.1 Product description, grade, quantity, ASTM Specification Number and issue date,

17.1.2 Alloy grade (AISI, SAE, UNS, etc.), heat analysis, heat number, and type of quench,

17.1.3 Results of hardness, carburization/decarburization, impact, cross sectional hardness, tensile, and proof load tests, as applicable,

17.1.4 Results of yield test, elongation and reduction area for machined specimen tests, as applicable,

17.1.5 Statement of compliance to Protective Coating Specification (if applicable),

17.1.6 Statement of compliance with the surface discontinuity requirements of Specification F788/F788M,

17.1.7 Statement of compliance dimensionally,

17.1.8 Report, describe, or illustrate manufacturer's markings and their location,

17.1.9 Lot number, purchase order number, and date shipped,

17.1.10 Country of origin, and

17.1.11 Title and signature of the individual assigned certification responsibility by the company officers, with complete mailing address.

17.2 Failure to include all the required information on the test report shall be cause for rejection.

18. Product Marking

18.1 *Manufacturers Identification* —All products shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.

18.2 Grade Identification:

18.2.1 All Grade BC products shall be marked "BC".

18.2.2 All Grade BD products shall be marked "BD".

18.3 Marking Location and Methods:

18.3.1 Bolts shall be marked on the top of the bolt head.

18.3.2 Where studs have both coarse and fine threads, all markings shall appear on the coarse thread end or, if preferred, the manufacturer's identification shall appear on the fine thread end and the grade marking on the coarse thread end.

18.3.3 Continuous thread studs may be marked on either end.

18.3.4 All markings may be raised or depressed at the manufacturer's option.

18.3.5 Grade and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and when on the same level shall be separated by at least two spaces.

18.4 *Product Marking Exemption*—Unless otherwise specified by the purchaser, all threaded rods 36 in. and longer shall be exempt from the marking requirements of this standard. Individual bars, rods, or bundles of bar stock or threaded rods shall be labeled or tagged with grade and manufacturer's name or mark, or both.

19. Packaging and Package Marking

19.1 Packaging:

19.1.1 Unless otherwise specified, packaging shall be in accordance manufacturer's practice.

19.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

19.2 Package Marking:

19.2.1 Each shipping unit shall include or be plainly marked with the following information:

19.2.1.1 ASTM designation and grade,

19.2.1.2 Size,

19.2.1.3 Name and brand or trademark of the manufacturer,

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19.2.1.4 Number of pieces,

19.2.1.5 Purchase order number, or other distinguishing information, when required by the customer, and

20. Keywords

20.1 alloy steel; bolts; steel; studs

19.2.1.6 Country of origin, when required by the customer.

SUPPLEMENTARY REQUIREMENTS

S1. Marking

S1.1 Studs that are continuously threaded with the same class of thread shall be marked on each end with the marking in accordance with Section 18.

S1.2 Marking small sizes (customarily less than 0.375 in.) may not be practical. Consult the producer for the minimum size that can be marked.

S2. Magnetic Particle Inspection for Longitudinal Discontinuities and Transverse Cracks

S2.1 *Requirements:*

S2.1.1 Each sample representative of the lot shall be magnetic particle inspected for longitudinal discontinuities and transverse cracks.

S2.1.2 The lot, as represented by the sample, shall be free from nonconforming bolts, as defined in Specification F788/ F788M, when inspected in accordance with S2.2.

S2.2 Inspection Procedure:

S2.2.1 The inspection sample shall be selected at random from each lot in accordance with Practice F1470 and examined for longitudinal discontinuities and transverse cracks.

S2.2.2 Magnetic particle inspection shall be conducted in accordance with Guide E709 or Practice E1444/E1444M. Guide E709 shall be used for referee purposes. If any noncon-

forming bolt is found during the manufacturer's examination of the lot selected in S2.2.1, the lot shall be 100% magnetic particle inspected, and all nonconforming bolts shall be removed and scrapped or destroyed.

S2.2.3 Eddy current or liquid penetrant inspection shall be an acceptable substitute for the 100% magnetic particle inspection when nonconforming bolts are found and 100 % inspection is required. Eddy current inspection shall be conducted in accordance with Guide E2884. Liquid penetrant inspection shall be conducted in accordance with Practice E1417/E1417M. On completion of the eddy current or liquid penetrant inspection, a random sample selected from each lot in accordance with Practice F1470 shall be re-examined by the magnetic particle method. In case of controversy, the magnetic particle test shall take precedence.

S2.2.4 Magnetic particle indications themselves shall not be cause for rejection. If in the opinion of the quality assurance representative the indications may be cause for rejection, a sample taken in accordance with Practice F1470 shall be examined by microscopic examination or removal by surface grinding to determine if the indicated discontinuities are within the specified limits.

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL INFORMATION ON MICROSTRUCTURE HOMOGENEITY ON FASTENERS LARGER THAN 2 $^{1}\!\!/\!\!4$ IN. NOMINAL DIAMETER

X1.1 Homogeneity of microstructure in a fastener is critical for achieving optimum product quality and performance. Achieving homogeneous microstructure in large diameters (sizes over 2-¹/₄ in.) is particularly challenging due to handling limitations and the time it takes for uniform heating and then cooling during quenching. Requirements aimed at assuring homogeneous microstructure and uniform hardness for sizes over 2-¹/₄ in were introduced in the 2017 revision. Notably requirements for the addition of nickel to the chemistry, Charpy testing, and a cross sectional hardness test were added.

X1.2 In the course of the 2017 revision of A354, the Subcommittee agreed that eliminating or limiting banding is desirable. Banding is non-homogeneity of chemistry and mi-

crostructure that can have deleterious effects on metallurgical and mechanical properties of the fastener. Banded microstructures are not uniformly heat treatable. Practice E1268 provides methods for evaluating banding by visual quantification and microhardness indentation. In a future revision of A354, the Subcommittee will consider adding acceptance criteria for banded microstructures based on Practice E1268 evaluation methods.

X1.3 This informative annex was added to (i) highlight the importance of microstructural homogeneity, and (ii) record the fact that future task group activity is planned to generate data for the possible addition of inspection procedures and acceptance criteria for banding.

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (A354-11) that may impact the use of this standard.

(1) Revised—Note 2.

(2) Revised— added "and washers" to 3.1.4.

(3) Revised—4.1- changed requirement from requiring Grade BD sizes $1\frac{1}{2}$ in and smaller to be quenched in oil to current statement in 4.1.

(4) *Revised*—4.3.2 and 4.3.3 clarified the components are bolts and nuts, and added 4.3.5 for requirement when zinc coated washers are specified.

(5) Revised—Table 1 to be based on grade and diameter size; added minimum nickel and minimum molybdenum to Grade BD sizes over $2\frac{1}{4}$ in. through 4 in; removed alloy steel definition in footnote "A" and directed users to Terminology F1789.

(6) *Revised*—6.1 changed tensile requirements to align with Specification F3125/F3125M requirements.

(7) Revised—6.1.4 regarding tensile properties for studs.

(8) *Revised*—Table 2 changed to hardness requirements for all sizes of Grade BD.

(9) *Revised*—Table 3 changed to include Ultimate Tensile Load, min column.

(10) Revised—Table 4 changed to require same tensile requirements for all Grade BD sizes.

(11) Added—Carb/Decarb requirements in Section 7.

(12) Added—Impact test requirements in Section 8.

(13) Added—cross sectional hardness test in Section 9.

(14) Added—12.4.2 to require minimum of 3 full size Type A test specimens for impact testing.

(15) Added—13.3.1 to require impact test method to be in compliance with Test Methods E23.

(16) Added—18.4 to exclude unthreaded bar stock and threaded rods 36 in. and long from product marking requirements.

(17) *Removed*—sentence in 18.2.2 referring to additional marking permission of 6 radial lines 60 degrees apart.

(18) Added—S2 for magnetic particle inspection supplementary requirement.

(19) Added—Appendix X1 nonmandatory appendix regarding microstructure homogeneity information.

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