



Designation: A354 – 17^{ε2}

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.

^{ε1} NOTE—Table 4 was editorially corrected in November 2017.

^{ε2} NOTE—13.1.5 was editorially corrected in November 2018.

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 1½ in. in diameter are covered in Specification F3125/F3125M. For fastener diameter sizes above 1½ 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 ⁴
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

⁴ 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 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,

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.

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

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 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

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

^ASee 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