



Designation: **A394 – 08<sup>ε1</sup> A394 – 08 (Reapproved 2015)**

## Standard Specification for Steel Transmission Tower Bolts, Zinc-Coated and Bare<sup>1</sup>

This standard is issued under the fixed designation A394; 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 ( $\epsilon$ ) 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.*

<sup>ε1</sup> NOTE—Table 1 was editorially revised in November 2011.

### 1. Scope\*

1.1 This specification covers the chemical and mechanical requirements of hexagon and square-head zinc-coated steel bolts and atmospheric corrosion-resistant bolts, in nominal thread diameters of 1/2, 5/8, 3/4, 7/8 and 1 in. for use in the construction of transmission towers, substations, and similar steel structures. The various types of bolts covered in this specification are:

- 1.1.1 *Type 0*—Hot-dip zinc-coated bolts made of low or medium carbon steel.
- 1.1.2 *Type 1*—Hot-dip zinc-coated bolts made of medium carbon steel, quenched and tempered.
- 1.1.3 *Type 2*—Withdrawn in 2005.
- 1.1.4 *Type 3*—Bare (uncoated), quenched and tempered bolts made of weathering steel.

1.2 **Annex A1** of this specification covers hot-dip zinc-coated steel ladder bolts, step bolts, and support-equipment bolts.

1.3 Nuts and washers that are supplied under this specification that are hot-dip zinc coated shall be in accordance with **4.4**.

1.4 Terms used in this specification are defined in Terminology **F1789**.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only. No other units of measurement are included in this standard.

1.6 The following safety hazards caveat pertains only to the test methods portion, Section **11**, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

- A563** Specification for Carbon and Alloy Steel Nuts
- D3951** Practice for Commercial Packaging
- F436** Specification for Hardened Steel Washers
- F606/F606M** Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets (Metric)
- F0606/F0606M** 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
- F2329** Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
- G101** Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

#### 2.2 ASME Standards:<sup>3</sup>

- B1.1** Unified Screw Threads
- B18.2.1** Square and Hex Bolts and Screws

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

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

### 3. Ordering Information

3.1 Orders for products under this specification shall include the following:

3.1.1 Quantity (number of bolts and accessories).

3.1.2 Name of products, including accessories such as **A563** nuts and **F436** washers when desired.

3.1.3 Dimensions, including nominal bolt diameter and length. For bolts other than transmission-tower bolts, complete dimensions are required (see **Annex A1**).

3.1.4 Type of bolt (for example, Type 0, 1, or 3).

3.1.4.1 When non-zinc-coated atmospheric corrosion-resistant steel is required, Type 3 bolts shall be specified by the purchaser.

3.1.5 ASTM designation and year of issue. When year of issue is not specified, bolts shall be furnished to the latest issue.

3.1.6 Additional requirements, if any, are to be specified on the purchase order:

3.1.6.1 Shear-strength testing (see **6.2.1** and **6.2.2**). Include type of test required.

3.1.6.2 Additional tests.

3.1.6.3 Inspection (see **12.1** and **12.2**).

3.1.6.4 Certification (see **14.1**).

3.1.6.5 Test reports (see **14.1**).

3.1.6.6 Other finishes, specify other protective finish, if required.

NOTE 1—Examples of ordering description:

(1) 1000 square-head transmission-tower bolts, ½ by 2 in. Type 1, hot-dip zinc coated, shear testing required, ASTM A394 – XX, with hot-dip zinc-coated hex nuts, Grade DH, ASTM **A563** – XX,

(2) 1000 transmission tower bolts, ½ by 2 in. Type 0, hot-dip zinc coated, ASTM A394 – XX, with hot-dip zinc-coated hex nuts, Grade A, ASTM **A563** – XX.

(3) 1000 transmission tower bolts, ½ by 2 in. Type 3, ASTM A394 – XX, with hex nuts, Grade DH3 weathering steel, ASTM **A563** – XX and with 2 circular washers, Type 3, ASTM **F436** – XX.

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

3.2 *Recommended Nuts:*

3.2.1 Unless otherwise specified, all nuts on these bolts shall be hex style and conform to the requirements of Specification **A563** as follows.

Bolt Type	Nut Grade	Finish
0	A	hot-dip zinc-coated
1	DH	hot-dip zinc-coated
3	DH3	plain

3.3 *Recommended Washers:*

3.3.1 Suitable washers for use with Type 0 are hot-dip zinc-coated carbon-steel washers with dimensions that are in accordance with Specification **F436**. Suitable washers for use with Type 1 bolts are hot-dip zinc-coated Type 1 hardened-steel washers that are in accordance with Specification **F436**. Suitable washers for use with Type 3 bolts are Type 3 hardened-steel washers that are in accordance with Specification **F436**.

### 4. Materials and Manufacture

4.1 Steel for the manufacture of bolts shall be made by any of the following processes: open-hearth, electric-furnace, or basic-oxygen.

4.2 *Heat Treatment:*

4.2.1 Type 1 bolts produced from medium carbon steel shall be quenched in a liquid medium from above the austenizing temperature. Type 1 bolts produced from medium carbon steel to which chromium, nickel, molybdenum, or boron were intentionally added shall be quenched only in oil from above the austenizing temperature.

4.2.2 Type 3 bolts shall be quenched only in oil from above the austenizing temperature.

4.2.3 Type 1 bolts, regardless of the steel used, and Type 3 bolts shall be tempered by reheating to not less than 800°F.

4.2.4 Cold-headed Type 0 bolts shall be stress relief annealed before zinc coating to remove cold work effects such that the hardness measured anywhere on the surface or through the cross-section shall meet the requirements in **6.1**.

4.3 Threads may be rolled or cut.

4.4 *Zinc Coatings, Hot Dip:*

4.4.1 Type 0 and Type 1 bolts shall be hot-dip zinc-coated accordance with the requirements of Specification **F2329**, except that the minimum average weight (thickness) of zinc coating shall be 1.65 oz/ft<sup>2</sup> (0.0028 in.) and the minimum weight of zinc coating on any one item shall be 1.50 oz/ft<sup>2</sup> (0.0025 in.).

4.4.2 Bolt threads shall not be cut, rolled, or otherwise finished after zinc coating.

4.4.3 Hot-dip zinc-coated nuts furnished under Specification **A563** shall be tapped after zinc coating.

4.4.4 Hot-dip zinc-coated nuts and washers supplied for use with bolts under this specification shall be zinc-coated in accordance with 4.4.1.

4.5 *Protection of Uncoated Surfaces*—When hot-dip zinc-coated nuts are ordered, the cutting oil or some other suitable substance shall be left on the uncoated surface to inhibit rusting during shipment and storage. It is recommended that the additional lubricant be clean and dry to the touch.

4.6 *Secondary Processing:*

4.6.1 If any processing which can affect the mechanical properties or performance of the bolts is performed after the initial testing, the bolts shall be retested for all specified mechanical properties and performance requirements affected by the reprocessing.

4.6.2 When the secondary processing is heat treatment, the bolts shall be tested for all specified mechanical properties. Hot-dip zinc-coated bolts shall be tested for all specified mechanical properties.

**5. Chemical Composition**

5.1 Type 0 and Type 1 bolts shall conform to the chemical composition requirements specified in Table 1.

5.2 Type 3 bolts shall conform to one of the chemical compositions specified in Table 2. The selection of the chemical composition A, B, C, D, E, or F shall be at the option of the bolt manufacturer. See Guide G101 for methods of estimating the atmospheric corrosion resistance of low alloy steels.

**6. Mechanical Properties**

6.1 *Tension Test*—Types 0, 1, and 3 bolts having a length equal to or more than 3 diameters shall be wedge tension tested as specified in 11.1 and shall conform to the tensile strength requirements in Table 3. Zinc-coated bolts shall be tested after coating. Bolts too short for full size testing or for other reasons not subject to tension tests, shall meet the following hardness requirements:

	Min	Max
Type 0—Rockwell B	80	100
Types 1 and 3—Rockwell C	25	34

6.2 *Shear Strength:*

6.2.1 When specified in the original inquiry and order, bolts, except as excluded in 6.2.2, shall be shear strength tested in accordance with 11.2 and shall meet the requirements given in Table 4.

6.2.2 Bolts with unthreaded body lengths shorter than two times the nominal bolt diameter, are subject to shear strength testing only upon agreement between the purchaser and supplier as to testing method and shear strength values.






**7. Dimensions**

7.1 Bolt threads, before zinc coating, shall be the unified coarse thread series and Class 2A tolerance as defined in the latest issue of ASME B1.1.

7.2 Unless otherwise specified, hex bolts shall be furnished. End bolts need not be chamfered or pointed. Bolts shall be full-size body in conformance with the latest issue of ASME B18.2.1, except as specified in 7.2.1 or 7.2.2.

7.2.1 Full-body length listed in Table 5 of this specification shall be the basis of manufacture and inspection.

**TABLE 1 Chemical Requirements and Head Markings**

Head Marking	Bolt Type	Element, %				
		Carbon	Manganese	Phosphorus	Sulfur	Boron
	0	0.55 max	...	0.048 max†	0.058 max	...
	0	0.55 max	...	0.048 max	0.058 max	...
	1	0.28/0.55	0.60 min	0.048 max†	0.058 max	...
	1	0.28/0.55	0.60 min	0.048 max	0.058 max	...
	3	...	...	...	See Table 2	...

† Editorially corrected in November 2011.

**TABLE 2 Chemical Requirements for Type 3 Heavy Hex Structural Bolts<sup>A</sup>**

Element	Composition, %					
	Type 3 Bolts <sup>A</sup>					
	A	B	C	D	E	F
<b>Carbon:</b>						
Heat Analysis	0.33–0.40	0.38–0.48	0.15–0.25	0.15–0.25	0.20–0.25	0.20–0.25
Product Analysis	0.31–0.42	0.36–0.50	0.14–0.26	0.14–0.26	0.18–0.27	0.19–0.26
<b>Manganese:</b>						
Heat Analysis	0.90–1.20	0.70–0.90	0.80–1.35	0.40–1.20	0.60–1.00	0.90–1.20
Product Analysis	0.86–1.24	0.67–0.93	0.76–1.39	0.36–1.24	0.56–1.04	0.86–1.24
<b>Phosphorus:</b>						
Heat Analysis	0.035 max	0.06–0.125	0.035 max	0.035 max	0.035 max	0.035 max
Product Analysis	0.040 max	0.06–1.25	0.040 max	0.040 max	0.040 max	0.040 max
<b>Sulfur:</b>						
Heat Analysis	0.040 max	0.040 max	0.040 max	0.040 max	0.040 max	0.040 max
Product Analysis	0.045 max	0.045 max	0.045 max	0.045 max	0.045 max	0.045 max
<b>Silicon:</b>						
Heat Analysis	0.15–0.35	0.30–0.50	0.15–0.35	0.25–0.50	0.15–0.35	0.15–0.35
Product Analysis	0.13–0.37	0.25–0.55	0.13–0.37	0.20–0.55	0.13–0.37	0.13–0.37
<b>Copper:</b>						
Heat Analysis	0.25–0.45	0.20–0.40	0.20–0.50	0.30–0.50	0.30–0.60	0.20–0.40
Product Analysis	0.22–0.48	0.17–0.43	0.17–0.53	0.27–0.53	0.27–0.63	0.17–0.43
<b>Nickel:</b>						
Heat Analysis	0.25–0.45	0.50–0.80	0.25–0.50	0.50–0.80	0.30–0.60	0.20–0.40
Product Analysis	0.22–0.48	0.47–0.83	0.22–0.53	0.47–0.83	0.27–0.63	0.17–0.43
<b>Chromium:</b>						
Heat Analysis	0.45–0.65	0.50–0.75	0.30–0.50	0.50–1.00	0.60–0.90	0.45–0.65
Product Analysis	0.42–0.68	0.47–0.83	0.27–0.53	0.45–1.05	0.55–0.95	0.42–0.68
<b>Vanadium:</b>						
Heat Analysis	<i>B</i>	<i>B</i>	0.020 min	<i>B</i>	<i>B</i>	<i>B</i>
Product Analysis	<i>B</i>	<i>B</i>	0.010 min	<i>B</i>	<i>B</i>	<i>B</i>
<b>Molybdenum:</b>						
Heat Analysis	<i>B</i>	0.06 max	<i>B</i>	0.10 max	<i>B</i>	<i>B</i>
Product Analysis	<i>B</i>	0.07 max	<i>B</i>	0.11 max	<i>B</i>	<i>B</i>
<b>Titanium:</b>						
Heat Analysis	<i>B</i>	<i>B</i>	<i>B</i>	0.05 max	<i>B</i>	<i>B</i>
Product Analysis	<i>B</i>	<i>B</i>	<i>B</i>	0.06 max	<i>B</i>	<i>B</i>

<sup>A</sup> A, B, C, D, E, and F are classes of material used for Type 3 bolts. Selection of a class shall be at the option of the bolt manufacturer.

<sup>B</sup> These elements are not specified or required.

**TABLE 3 Tensile Strength<sup>A</sup>**

Nominal Size, in.	Minimum Tensile Load, lbf	
	Type 0 <sup>B</sup>	Types 1 and 3 <sup>C</sup>
1/2	10 500	17 050
5/8	16 700	27 100
3/4	24 700	40 100
7/8	34 200	55 450
1	44 850	72 700

<sup>A</sup> Tensile strength based on the thread stress area,  $A_s$ , is calculated as follows:

$$A_s = 0.7854 [D - (0.9743/N)]^2$$

where:

$D$  = nominal diameter, and

$N$  = threads per inch.

<sup>B</sup> Based on 74 000 psi unit tensile strength.

<sup>C</sup> Based on 120 000 psi unit tensile strength.

7.2.2 On rolled thread bolts, the distance from the top of the extrusion angle to be the first fully formed thread shall not exceed 3.5 thread pitches in length.

### 7.3 Threads:

7.3.1 *Uncoated*—There shall be the Unified Coarse Thread Series as specified in ASME B1.1, and shall have Class 2A tolerances.

7.3.2 *Coated*—Unless otherwise specified, zinc-coated bolts to be used with zinc-coated nuts or tapped holes that are tapped oversize, in accordance with Specification A563, shall have Class 2A threads before hot-dip zinc-coating. After zinc-coating, the maximum limits of pitch and major diameter shall not exceed the Class 2A limit by more than the following amounts: