



Designation: A 394 – 00

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

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*This standard has been approved for use by agencies of the Department of Defense.*

### 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  $\frac{1}{2}$ ,  $\frac{5}{8}$ ,  $\frac{3}{4}$ ,  $\frac{7}{8}$  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*—Zinc-coated bolts made of low or medium carbon steel.

1.1.2 *Type 1*—Zinc-coated bolts made of medium carbon steel, quenched and tempered.

1.1.3 *Type 2*—Zinc-coated bolts made from what is generally described as low-carbon martensite steel, quenched and tempered.

1.1.4 *Type 3*—Bare (uncoated), quenched and tempered bolts made of steel having atmospheric corrosion-resistance and weathering characteristics comparable to that of the steel covered in Specifications A 242/A 242M, A 588/A 588M, and A 709/A 709M. The atmospheric corrosion resistance of these steels is substantially better than that of carbon steel with or without copper addition (see 5.4). When properly exposed to the atmosphere, these steels can be used bare (uncoated) for many applications.

1.1.5 For applications requiring improved low-temperature characteristics, use of Types 1, 2, or 3 bolts is recommended.

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

1.3 Unless otherwise specified, all nuts used on these bolts shall be hex style and conform to the requirements of Specification A 563 as follows:

Bolt Type	Nut Grade	Finish
0	A	Zinc-coated
1 and 2	DH	Zinc-coated
3	DH3	Plain

1.4 Suitable washers for use with Type 0 are zinc-coated carbon-steel washers with dimensions that are in accordance

with Specification F 436. Suitable washers for use with Type 1 and Type 2 bolts are zinc-coated Type 1 hardened-steel washers that are in accordance with Specification F 436. Suitable washers for use with Type 3 bolts are Type 3 hardened-steel washers that are in accordance with Specification F 436.

1.5 Nuts and washers that are supplied under this specification that are zinc coated shall be in accordance with 4.4.

1.6 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 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles<sup>2</sup>

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware<sup>2</sup>

A 242/A 242M Specification for High-Strength Low-Alloy Structural Steel<sup>3</sup>

A 563 Specification for Carbon and Alloy Steel Nuts<sup>4</sup>

A 588/A 588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick<sup>3</sup>

A 709/A 709M Specification for Structural Steel for Bridges<sup>3</sup>

B 6 Specification for Zinc (Slab Zinc)<sup>5</sup>

B 244 Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments<sup>6</sup>

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals<sup>6</sup>

B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel<sup>6</sup>

D 3951 Practice for Commercial Packaging<sup>7</sup>

F 436 Specification for Hardened Steel Washers<sup>4</sup>

<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> Annual Book of ASTM Standards, Vol 01.06.

<sup>3</sup> Annual Book of ASTM Standards, Vol 01.04.

<sup>4</sup> Annual Book of ASTM Standards, Vol 01.08.

<sup>5</sup> Annual Book of ASTM Standards, Vol 02.04.

<sup>6</sup> Annual Book of ASTM Standards, Vol 02.05.

<sup>7</sup> Annual Book of ASTM Standards, Vol 15.09.

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

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets<sup>4</sup>

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series<sup>4</sup>

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels<sup>8</sup>

## 2.2 ANSI/ASME Standards:

B1.1 Unified Screw Threads<sup>9</sup>

B18.2.1 Square and Hex Bolts and Screws<sup>9</sup>

B 18.24.1 Part Identifying Number (PIN) Code System<sup>10</sup>

## 2.3 Military Standard:

MIL-STD-105 Single Sampling Plan for Normal Inspection<sup>11</sup>

## 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 A 563 nuts and F 436 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, 2, 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 For Type 0 and Type 1 bolts specify the zinc-coating process required, such as, “hot dip,” “mechanically deposited,” or “no preference.” Type 2 bolts shall have only mechanically-deposited zinc coatings.

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

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

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

3.1.7.2 Additional tests (see 10.2).

3.1.7.3 Inspection (see 12.1 and 12.2).

3.1.7.4 Certification (see 14.1).

3.1.7.5 Test reports (see 14.2).

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 A 394 – XX, with hot-dip zinc-coated hex nuts, Grade DH, ASTM A 563 – XX,

(2) 1000 transmission tower bolts, ½ by 2 in. Type 0, mechanically zinc coated, ASTM A 394 – XX, with mechanically zinc-coated hex nuts, Grade A, ASTM A 563 – XX.

(3) 1000 transmission tower bolts, ½ by 2 in. Type 3, Supplementary Requirement S2, ASTM A 394 – XX, with hex nuts, Grade DH3 weath-

ering steel, ASTM A 563 – XX and with 2 circular washers, Type 3, ASTM F 436 – XX.

3.1.8 For establishment of a part identifying system, see ASME B18.24.1.

## 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.

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

4.2 Types 1, 2 and 3 bolts shall be heat treated by quenching in a suitable liquid medium from above the austenitizing temperature and then tempering to the required finished hardness.

4.3 Slab zinc when used for coating shall be any grade of zinc conforming to Specification B 6.

4.4 *Zinc Coatings, Hot Dip and Mechanically Deposited.*

4.4.1 Type 0 and Type 1 bolts shall be zinc coated. The purchaser shall specify the zinc-coating process, that is “hot dip,” “mechanically deposited,” or “no preference.”

4.4.2 Type 2 bolts shall be zinc coated by the mechanical-deposition process.

4.4.3 When “hot dip” is specified, the bolts shall be zinc coated by the hot-dip process in accordance with the requirements of Class C of Specification A 153, except as specified in 4.4.6.

4.4.4 When “mechanically deposited” is specified, the bolts shall be zinc coated by the mechanical-deposition process in accordance with the requirements of Class 50 of Specification B 695, except as specified in 4.4.6.

4.4.5 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, except as specified in 4.4.6. 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.

4.4.6 The minimum average weight of a zinc coating shall be 1.65 oz/ft<sup>2</sup>. The minimum weight of a zinc coating on any one item shall be 1.50 oz/ft<sup>2</sup>.

4.4.7 Bolt threads shall not be cut, rolled, or otherwise finished after galvanizing.

4.4.8 Hot-dip zinc-coated nuts furnished under Specification A 563 shall be tapped after galvanizing.

## 5. Chemical Composition

5.1 Type 0 bolts shall conform to the chemical composition requirements specified for low-carbon steel bolts outlined in Table 1.

5.2 Type 1 bolts shall conform to the chemical composition requirements specified for medium carbon steel bolts in Table 1.

5.3 Type 2 bolts shall conform to the chemical composition requirements specified for low-carbon martensite steel bolts in Table 1.





<sup>8</sup> Annual Book of ASTM Standards, Vol 03.02.

<sup>9</sup> Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

<sup>10</sup> Available from American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

<sup>11</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 1 Chemical Requirements and Head Markings

Head Marking	Bolt Type	Element, %				
		Carbon	Manganese	Phosphorus	Sulphur	Boron
	0	0.55 max	...	0.048 max	0.058 max	...
	1	0.28/0.55	0.60 min	0.048 max	0.058 max	...
	2	0.15/0.25	0.74 min	0.048 max	0.058 max	0.0005 min
	3	...	See Table 2			

5.4 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 G 101 for methods of estimating the atmospheric corrosion resistance of low alloy steels.

5.5 Bolts are customarily furnished from stock and individual heats of steel cannot be identified.

6. Mechanical Properties

6.1 Tension Test—Types 0, 1, 2, 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, 2, 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.

TABLE 2 Chemical Requirements for Type 3 Bolts

Element Product Analysis	Type 3 Bolts Composition, % <sup>A</sup>					
	A	B	C	D	E	F
Carbon	0.31–0.42	0.36–0.50	0.14–0.26	0.14–0.26	0.18–0.27	0.19–0.26
Manganese	0.86–1.24	0.67–0.93	0.76–1.39	0.36–1.24	0.56–1.04	0.86–1.24
Phosphorus	0.045 max	0.06–0.125	0.040 max	0.045 max	0.045 max	0.045 max
Sulfur	0.055 max	0.055 max	0.045 max	0.055 max	0.045 max	0.045 max
Silicon	0.13–0.32	0.25–0.55	0.13–0.32	0.20–0.55	0.13–0.32	0.13–0.32
Copper	0.22–0.48	0.17–0.43	0.17–0.53	0.27–0.53	0.27–0.63	0.17–0.43
Nickel	0.22–0.48	0.47–0.83	0.22–0.53	0.47–0.83	0.27–0.63	0.17–0.43
Chromium	0.42–0.68	0.47–0.83	0.27–0.53	0.45–1.05	0.55–0.95	0.42–0.68
Vanadium	...	...	0.010 min	...	...	...
Molybdenum	...	0.07 max	...	0.11 max	...	...
Titanium	...	...	...	...	...	...

<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.

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

Nominal Size, in.	Minimum Load, lbf	
	Type 0, Tensile Strength, lbf <sup>B</sup>	Types 1, 2, and 3, Tensile Strength, lbf <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<sub>s</sub>, is calculated as follows:  
A<sub>s</sub> = 0.7854 [ D – (0.9743/N)]<sup>2</sup>

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. 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 ANSI/ASME B1.1. Threads may be rolled or cut.

7.2 Bolts shall be full-size body in conformance with the latest issue of ANSI/ASME B18.2.1, except that the full-body length listed in Table 5 shall be the basis of manufacture and inspection. Unless otherwise specified, hex bolts shall be furnished. Ends of bolts need not be chamfered or pointed.

7.3 Zinc-coated bolts must assemble with a nut tapped oversize as described in Specification A 563. In case of dispute, a calibrated go and not go thread-ring gage of the same diameter, thread class, and tolerance plus the amount of