



# Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength<sup>1</sup>

This standard is issued under the fixed designation A325; 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.*

## 1. Scope\*

1.1 This specification<sup>2</sup> covers two types of quenched and tempered steel heavy hex structural bolts having a minimum tensile strength of 120 ksi for sizes 1.0 in. and less and 105 ksi for sizes over 1.0 to 1½ in., inclusive.

1.2 The bolts are intended for use in structural connections. These connections are comparable to those covered under the requirements of the Specification for Structural Joints Using High-Strength Bolts, approved by the Research Council on Structural Connections; endorsed by the American Institute of Steel Construction and by the Industrial Fastener Institute.

1.3 The bolts are furnished in sizes ½ to 1½ in., inclusive. They are designated by type, denoting chemical composition as follows:

Type	Description
Type 1	Medium carbon, carbon boron, or medium carbon alloy steel.
Type 2	Withdrawn in November 1991.
Type 3	Weathering steel.

NOTE 1—Bolts for general applications, including anchor bolts, are covered by Specification A449. Also refer to Specification A449 for quenched and tempered steel bolts and studs with diameters greater than 1½ in. but with similar mechanical properties.

1.4 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 2—A complete metric companion to Specification A325 has been developed, Specification A325M; therefore, no metric equivalents are presented in this specification.

1.5 This specification is applicable to heavy hex structural bolts only. For bolts of other configurations and thread lengths with similar mechanical properties, see Specification A449.

<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 ASME Boiler and Pressure Vessel Code applications see related Specification SA-325 in Section II of that Code.

1.6 Terms used in this specification are defined in Terminology F1789.

1.7 The following safety hazard caveat pertains only to the test methods portion, Section 10, 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>3</sup>

- A194/A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- A325M Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength (Metric)
- A449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
- 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
- D3951 Practice for Commercial Packaging
- F436 Specification for Hardened Steel Washers
- F606 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
- F959 Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners

<sup>3</sup> 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

- [F1136 Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners](#)
- [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>4</sup>

**B 1.1 Unified Screw Threads**

**B 18.2.6 Fasteners for Use in Structural Applications**

**B 18.24 Part Identification Number (PIN) Code System Standard for B18 Fastener Products**

2.3 *RCSC Standard:*<sup>5</sup>

**Specification for Structural Joints Using High-Strength Bolts**

**3. Ordering Information**

3.1 Orders for heavy hex structural bolts under this specification shall include the following:

- 3.1.1 Quantity (number of pieces of bolts and accessories).
- 3.1.2 Size, including nominal bolt diameter, thread pitch, and bolt length.
- 3.1.3 Name of product, heavy hex structural bolts.
- 3.1.4 When bolts threaded full length are required, Supplementary Requirement S1 shall be specified.
- 3.1.5 Type of bolt: Type 1 or 3. When type is not specified, either Type 1 or Type 3 shall be furnished at the supplier's option.

3.1.6 ASTM designation and year of issue.

3.1.7 Other components such as nuts, washers, and compressible washer-type direct-tension indicators, if required.

3.1.7.1 When such other components are specified to be furnished, also state "Nuts, washers, and direct tension indicators, or combination thereof, shall be furnished by lot number."

3.1.8 *Zinc Coating*—Specify the zinc coating process required, for example, hot dip, mechanically deposited, Zinc/Aluminum Corrosion Protective Coating or no preference (see 4.3).

3.1.9 *Other Finishes*—Specify other protective finish, if required.

3.1.10 Test reports, if required (see Section 13).

3.1.11 Supplementary or special requirements, if required.

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

NOTE 3—A typical ordering description follows: 1000 pieces 1 $\frac{1}{8}$ -7 UNC in. dia  $\times$  4 in. long heavy hex structural bolt, *Type 1 ASTM A325-02*, each with one hardened washer, ASTM F436 Type 1, and one heavy hex nut, ASTM A563 Grade DH. Each component hot-dip zinc-coated. Nuts lubricated.

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>5</sup> Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 700, Chicago, IL 60601-2001, <http://www.aisc.org>.

3.2 *Recommended Nuts:*

3.2.1 Nuts conforming to the requirements of Specification A563 are the recommended nuts for use with Specification A325 heavy hex structural bolts. The nuts shall be of the class and have a surface finish for each type of bolt as follows:

Bolt Type and Finish	Nut Class and Finish
1, plain (noncoated)	A563-C, C3, D, DH, DH3, plain
1, zinc coated	A563-DH, zinc coated
1, coated in accordance with Specification F1136, Grade 3	A563-DH coated in accordance with Specification F1136, Grade 5
3, plain	A563-C3, DH3, plain

3.2.2 Alternatively, nuts conforming to Specification A194/A194M Gr. 2H are considered a suitable substitute for use with Specification A325 Type 1 heavy hex structural bolts.

3.2.3 When Specification A194/A194M Gr. 2H zinc-coated nuts are supplied, the zinc coating, overtapping, lubrication, and rotational capacity testing shall be in accordance with Specification A563.

3.3 *Recommended Washers:*

3.3.1 Washers conforming to Specification F436 are the recommended washers for use with Specification A325 heavy hex structural bolts. The washers shall have a surface finish for each type of bolt as follows:

Bolt Type and Finish	Washer Finish
1, plain (uncoated)	plain (uncoated)
1, zinc coated	zinc coated
1, coated in accordance with Specification F1136, Grade 3	coated in accordance with Specification F1136, Grade 3
3, plain	weathering steel, plain

3.4 *Other Accessories:*

3.4.1 When compressible washer type direct tension indicators are specified to be used with these bolts, they shall conform to Specification F959, Type 325.

**4. Materials and Manufacture**

4.1 *Heat Treatment:*

4.1.1 Type 1 bolts produced from medium carbon steel shall be quenched in a liquid medium from the austenitizing 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 the austenitizing temperature.

4.1.2 Type 3 bolts shall be quenched only in oil from the austenitizing temperature.

4.1.3 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 *Threading*—Threads shall be cut or rolled.

4.3 *Zinc Coatings, Hot-Dip and Mechanically Deposited, Zinc/Aluminum Corrosion Protective Coating:*

4.3.1 When zinc-coated fasteners are required, the purchaser shall specify the zinc coating process, for example, hot

dip, mechanically deposited, Zinc/Aluminum Corrosion Protective Coating, or no preference.

4.3.2 When hot-dip is specified, the fasteners shall be zinc-coated by the hot-dip process and the coating shall conform to the coating weight/thickness and performance requirements of Specification **F2329**.

4.3.3 When mechanically deposited is specified, the fasteners shall be zinc-coated by the mechanical deposition process and the coating shall conform to the coating weight/thickness and performance requirements of Class 55 of Specification **B695**.

4.3.4 When Zinc/Aluminum Corrosion Protective Coating is specified, the coating shall conform to the coating weight/thickness and performance requirements of Grade 3 of Specification **F1136**.

4.3.5 When no preference is specified, the supplier shall furnish either a hot-dip zinc coating in accordance with Specification **F2329**, a mechanically deposited zinc coating in accordance with Specification **B695**, Class 55, or a Zinc/Aluminum Corrosion Protective Coating in accordance with Specification **F1136**, Grade 3. 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 *Lubrication*—When zinc-coated nuts are ordered with the bolts, the nuts shall be lubricated in accordance with Specification **A563**, Supplementary Requirement S1, to minimize galling.

#### 4.5 *Secondary Processing*:

4.5.1 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.

4.5.2 When the secondary process 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 and rotational capacity. If zinc-coated nuts are relubricated after the initial rotational capacity tests, the assemblies shall be retested for rotational capacity.

## 5. Chemical Composition

5.1 Type 1 bolts shall be plain carbon steel, carbon boron steel, alloy steel or alloy boron steel at the manufacturer's option, conforming to the chemical composition specified in **Table 1**.

5.2 Type 3 bolts shall be weathering steel and 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.

5.3 Product analyses made on finished bolts representing each lot shall conform to the product analysis requirements specified in **Tables 1 and 2**, as applicable.

**TABLE 1 Chemical Requirements for Type 1 Bolts**

Element	Carbon Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058
Silicon	0.15–0.30	0.13–0.32

  

Element	Carbon Boron Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058
Silicon	0.10–0.30	0.08–0.32
Boron	0.0005–0.003	0.0005–0.003

  

Element	Alloy Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Silicon	0.15–0.35	0.13–0.37
Alloying Elements	<sup>A</sup>	<sup>A</sup>

  

Element	Alloy Boron Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Silicon	0.15–0.35	0.13–0.37
Boron	0.0005–0.003	0.0005–0.003
Alloying Elements	<sup>A</sup>	<sup>A</sup>

<sup>A</sup> Steel, as defined by the American Iron and Steel Institute, shall be considered to be alloy 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.

5.4 Heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for bolts.

5.5 Compliance with **5.4** shall be based on certification that heats of steel having any of the listed elements intentionally added were not used to produce the bolts.

5.6 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology **A751**.

## 6. Mechanical Properties

6.1 *Hardness*—The bolts shall conform to the hardness specified in **Table 3**.

### 6.2 *Tensile Properties*:

6.2.1 Except as permitted in **6.2.1.1** for long bolts and **6.2.1.2** for short bolts, sizes 1.00 in. and smaller having a nominal length of  $2\frac{1}{4}D$  and longer, and sizes larger than 1.00

**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	0.06–0.12	0.035 max	0.035 max	0.035 max	0.035 max
Product analysis	0.040 max	0.06–0.125	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	<sup>B</sup>	<sup>B</sup>	0.020 min	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>
Product analysis	<sup>B</sup>	<sup>B</sup>	0.010 min	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>
<b>Molybdenum:</b>						
Heat analysis	<sup>B</sup>	0.06 max	<sup>B</sup>	0.10 max	<sup>B</sup>	<sup>B</sup>
Product analysis	<sup>B</sup>	0.07 max	<sup>B</sup>	0.11 max	<sup>B</sup>	<sup>B</sup>
<b>Titanium:</b>						
Heat analysis	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>	0.05 max	<sup>B</sup>	<sup>B</sup>
Product analysis	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>	0.06 max	<sup>B</sup>	<sup>B</sup>

<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 Hardness Requirements for Bolts**

Bolt Size in.	Nominal Length in.	Brinell		Rockwell C	
		Min	Max	Min	Max
½ to 1, incl	Less than 2D	253	319	25	34
	2D and over	...	319	...	34
1 ⅛ to 1 ½, incl	Less than 3D	223	286	19	30
	3D and over	...	286	...	30

D = Nominal diameter or thread size.

in. having a nominal length of 3D and longer, shall be wedge tested full size and shall conform to the minimum wedge tensile load and proof load or alternative proof load specified in Table 4. The load achieved during proof load testing shall be equal to or greater than the specified proof load.

6.2.1.1 When the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 5. When bolts are tested by both full-size and machined specimen methods, the full-size test shall take precedence.

6.2.1.2 Sizes 1.00 in. and smaller having a nominal length shorter than 2¼D down to 2D, inclusive, that cannot be wedge tensile tested shall be axially tension tested full size and shall conform to the minimum tensile load and proof load or alternate proof load specified in Table 4. Sizes 1.00 in. and smaller having a nominal length shorter than 2D and sizes larger than 1.00 in. with nominal lengths shorter than 3D that cannot be axially tensile tested shall be qualified on the basis of hardness.

6.2.2 For bolts on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event of low hardness readings.

### 6.3 Rotational Capacity Test: