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American Association
State Highway and
Transportation Officials
Standard AASHTO No.: M 164

Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength¹

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

1. Scope*

1.1 This specification² covers two types of quenched and tempered steel 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 covered under the requirements of the Specification for Structural Joints Using ASTM A 325 or A 490 Bolts, approved by the Research Council on Structural Connections of the Engineering Foundation.³

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Type 2	Withdrawn in November 1991.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. Atmospheric corrosion resistance and weathering characteristics are comparable to that of steels in Specifications A 242/A 242A 242M/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 5.2). When properly exposed to the atmosphere, these steels can be used bare (uncoated) for many applications.

NOTE 1—Bolts for general applications, including anchor bolts, are covered by Specification A 449/A 449. Also refer to Specification A 449/A 449 for quenched and tempered steel bolts and studs with diameters greater than 1½ in., but with similar mechanical properties.

NOTE 2—A complete metric companion to Specification A 325 has been developed—Specification A 325M; therefore no metric equivalents are presented in this specification.

1.4 The following safety hazards 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,*

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-325 in Section II of that Code.

³ Published by American Institute of Steel Construction, Wrigley Building, 400 N. Michigan Ave., Chicago, IL 60611.

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:

- A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware⁴
- A 194/A 194M Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service⁵
- A 242/A 242M Specification for High-Strength Low-Alloy Structural Steel⁶
- A 449 Specification for Quenched and Tempered Steel Bolts and Studs⁷
- A 490 Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength⁷
- A 563 Specification for Carbon and Alloy Steel Nuts⁷
- 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] Thick⁶
- A 709/A 709M Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges⁶
- A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products⁸
- B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel⁹
- D 3951 Practice for Commercial Packaging¹⁰
- F 436 Specification for Hardened Steel Washers⁷
- F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets⁷

⁴ Annual Book of ASTM Standards, Vol 01.06.

⁵ Annual Book of ASTM Standards, Vol 01.01.

⁶ Annual Book of ASTM Standards, Vol 01.04.

⁷ Annual Book of ASTM Standards, Vol 01.08.

⁸ Annual Book of ASTM Standards, Vol 01.03.

⁹ Annual Book of ASTM Standards, Vol 02.05.

¹⁰ Annual Book of ASTM Standards, Vol 15.09.

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

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series⁷

F 959 Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners⁷

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels¹¹

2.2 *ANSI/ASME Standards*:¹²

B 1.1 Unified Screw Threads

B 18.2.1 Square and Hex Bolts and Screws

B 18.18.3M Inspection and Quality Assurance for Special Purpose Fasteners

2.3 *Military Standard*:¹³

MIL-STD-105 Sampling Procedure and Tables for Inspection by Attributes

3. Ordering Information

3.1 Orders for 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 and length (see

3.1.3.1).

3.1.2.1 Bolts threaded full length, specify Supplementary Requirements S1.

3.1.3 Name of product.

3.1.3.1 Heavy Hex Structural Bolts are supplied unless otherwise specified. For bolts other than Heavy Hex Structural, dimensional requirements must be specified on the purchase inquiry and order. The thread length may not be changed except as provided in Supplementary Requirements S1.

3.1.4 Type of bolt, that is, Type 1 or 3.

3.1.5 ASTM designation and year of issue.

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

3.1.6.1 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”.

3.1.7 Accessories such as nuts and washers, when required.

3.1.8 *Zinc Coating*—Specify the zinc coating process required, for example, hot dip, mechanically deposited, 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 14).

3.1.11 Special requirements.

NOTE 3—A typical ordering description follows: 1000 pieces 1 in. dia × 4 in. long Heavy Hex Structural Bolt, *Type 1 ASTM A 325-XX*; each with one Hardened Washer, ASTM F 436 Type 1; and one Heavy Hex Nut, ASTM A 563 Grade DH. Each component hot dip zinc coated. Nuts lubricated.

3.2 *Recommended Nuts*:

3.2.1 Unless otherwise specified, all nuts used on these bolts shall conform to the requirements of Specifications A 194A 194/A 194M/A 194M or A 563, shall be heavy hex, and shall be of the class and surface finish for each type of bolt as follows:

¹¹ *Annual Book of ASTM Standards*, Vol 03.02.

¹² Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

¹³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[ASTM A325-00](https://standards.iteh.ai/catalog/standards/sist/319834b5-1cd1-4afd-b2fc-d1a5f2e29753/astm-a325-00)

<https://standards.iteh.ai/catalog/standards/sist/319834b5-1cd1-4afd-b2fc-d1a5f2e29753/astm-a325-00>

Bolt Type and Finish	Nut Class and Finish
1, plain (noncoated)	A 563-C, c 3, D, DH, DH3, plain
1, zinc coated	A 194-2, 2H, plain A 563-DH, zinc coated A 194-2H, zinc coated (see 3.2.2)
3, plain	A 563-C3, DH3, plain

3.2.2 When Specification A 194A 194/A 194M/A 194M Gr. 2H zinc coated nuts are supplied, the zinc coating, overtapping, lubrication, and rotational capacity testing shall be in accordance with Specification A 563A 563.

3.3 Unless otherwise specified, all washers used on these bolts shall conform to the requirements of Specifications F 436 or F 959F 436F 959 and shall be of 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
3, plain	weathering steel, plain

4. Materials and Manufacture

4.1 *Heat Treatment*—Bolts shall be heat treated by quenching in a liquid medium from above the austenitizing temperature and then tempering by reheating to a temperature of at least 800°F.

4.2 *Threading*—Threads of bolts may be cut or rolled.

4.3 *Zinc Coatings, Hot-dip and Mechanically Deposited:*

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 fasteners shall be zinc-coated by the hot-dip process and the coating shall conform to the coating weight/thickness and performance requirements of Class C of Specification A 153A 153.

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 50 of Specification B 695B 695.

4.3.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification A 153A 153, Class C, or a mechanically deposited zinc coating in accordance with Specification B 695B 695, Class 50. 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 A 563A 563, Supplementary Requirement S1, to minimize galling.

4.5 *Secondary Processing*—If heat treatment, zinc coating, lubrication, or other processing affecting properties is performed by a subcontractor, the fasteners shall be inspected after such processing by the party responsible for supplying the fasteners to the user or installer. Heat treated fasteners shall be

tested for all mechanical properties; hot dip zinc coated fasteners for all mechanical properties and rotational capacity; mechanically zinc coated fasteners for rotational capacity; and lubricated fasteners for rotational capacity.

5. Chemical Composition

5.1 Type 1 bolts shall be plain carbon steel, carbon/boron steel, or alloy steel, at the manufacturers 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 G 101G 101 for methods of estimating the atmospheric corrosion resistance of low alloy steels.

5.3 Product analyses may be made by the purchaser from finished material representing each lot of bolts. The chemical composition thus determined shall conform to the requirements specified in 5.1 or 5.2.

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

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
Boron	see 5.5 and 5.6	

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
Boron	see 5.5 and 5.6	
Alloying Elements	A	A

^A 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.

TABLE 2 Chemical Requirements for Type 3 Bolts

Element	Composition, %					
	Type 3 Bolts ^A					
	A	B	C	D	E	F
Carbon:						
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
Manganese:						
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
Phosphorus:						
Heat analysis	0.040 max	0.06–0.12	0.035 max	0.040 max	0.040 max	0.040 max
Product analysis	0.045 max	0.06–0.125	0.040 max	0.045 max	0.045 max	0.045 max
Sulfur:						
Heat analysis	0.050 max	0.050 max	0.040 max	0.050 max	0.040 max	0.040 max
Product analysis	0.055 max	0.055 max	0.045 max	0.055 max	0.045 max	0.045 max
Silicon:						
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
Copper:						
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
Nickel:						
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
Chromium:						
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
Vanadium:						
Heat analysis	...	...	0.020 min	...	...	...
Product analysis	...	...	0.010 min	...	...	...
Molybdenum:						
Heat analysis	...	0.06 max	...	0.10 max	...	...
Product analysis	...	0.07 max	...	0.11 max	...	...
Titanium:						
Heat analysis	...	...	...	0.05 max	...	...
Product analysis	...	...	...	...	...	...

^A 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.

5.5 For Type 1 bolts made from plain carbon steel or alloy steel, heats of steel to which boron has been intentionally added shall not be permitted.

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

5.7 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A 751A 751.

6. Mechanical Properties

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

6.2 Tensile Properties:

6.2.1 Bolts having a length of 3 times the diameter or longer (see 6.2.3) shall be tested full size and shall conform to the tensile strength and proof load or alternative proof load specified in Table 4.

6.2.2 Bolts having a length less than 3 times the diameter are not subject to tensile tests, except as permitted in 6.2.3.

TABLE 3 Hardness Requirements for Bolts

Bolt Size, in.	Bolt Length, in.	Brinell		Rockwell C	
		Min	Max	Min	Max
½ to 1, incl	Less than 3D ^A	253	319	25	34
	3D and over	–	319	–	34
1½ to 1½, incl	Less than 3D ^A	223	286	19	30
	3D and over	–	286	–	30

^A Bolts having a length less than 3 times the diameter are subject only to minimum/maximum hardness. Such lengths cannot be reasonably tensile tested. D = Nominal diameter or thread size.

6.2.3 Bolts having a length of 2 times the diameter or longer may be tested full size for tensile properties whenever test equipment is available. In such cases reference to “3 times the diameter” in Table 3, 6.2.1, and 6.2.2 shall be considered to be “2 times the diameter”.