Designation: A 325M – 04

METRIC

An American National Standard

Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength [Metric][1]

This standard is issued under the fixed designation A 325M; 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 Department of Defense.

1. Scope*

1.1 This specification[2] covers two types of quenched and tempered, steel, metric heavy hex structural bolts having a minimum tensile strength of 830 MPa (Note 1).

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 ASTM A 325 or A 490 bolts, approved by the Research Council on Structural Connections; endorsed by the American Institute of Steel Construction and by the Industrial Fastener Institute.[3]

1.3 The bolts are furnished in sizes M12 to M136 inclusive. They are designated by type denoting chemical composition as follows:

1.3.1 *Type 1*—Medium-carbon, carbon boron, medium carbon alloy, or alloy boron steel.

1.3.2 *Type 2*—Withdrawn in 2003.

1.3.3 *Type 3*—Weathering Steel.

1.4 This specification is applicable to metric heavy hex, structural bolts only.

1.5 Terms used in this specification are defined in Specification F 1789.

1.6 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, 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 requirements prior to use.*

NOTE 1—This specification is the metric companion to the inch pound Specification A 325.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

A 153 Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware

A 490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric]

A 563M Specification for Carbon and Alloy Steel Nuts [Metric]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

B 695 Specification of Coatings of Zinc Mechanically Deposited on Iron and Steel

D 3951 Practice for Commercial Packaging

F 436M Specification for Hardened Steel Washers [Metric]

F 606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric]

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

F 959M Specification for Compressible Washer-Type Direct Tension Indicators for Use with Structural Fasteners [Metric]

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F 1789 Terminology for F16 Mechanical Fasteners

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

2.2 *ASME Standards:*

B 1.13M Metric Screw Threads[5]

[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-325M in Section II of that Code.

[3] Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

[4] 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.

[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

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

B 18.2.3.7M Metric Heavy Hex Structural Bolts[5]

B 18.18.3M Inspection and Quality Assurance for Special Purpose Fasteners[5]

B 18.24.1 Part Identifying Number (PIN) Code System[5]

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 Type 3. When the 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.

3.1.8 *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 13).

3.1.11 Supplementary or special requirements, if required.

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

NOTE 2—A typical ordering description follows: 1000 pieces, M24×3×100, heavy hex structural bolts, Type 1 ASTM A 325M - 03, each with one hardened washer and one heavy hex nut, mechanically deposited zinc coating (see 3.1.8 for any special requirements).

3.2 *Recommended Nuts*:

3.2.1 Nuts conforming to the requirements of Specification A 563M are the recommended nuts for use with A 325M metric 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 Specification
1, plain (noncoated)	A 563M—8S or 8S3, plain
1, zinc-coated	A 563M—10S, zinc-coated
3, plain	A 563M—8S3, plain

3.3 *Recommended Washers*:

3.3.1 Washers conforming to Specification F 436M are the recommended washers for use with Specification A 325M Metric 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
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 the requirements in Specification F 959M Type 8.8.

4. Materials and Manufacture

4.1 *Heat Treatment*:

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	A	A
	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	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.

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

4.1.2 Type 1 bolts produced from carbon steel to which chromium, nickel, molybdenum, or boron were intentionally added shall be quenched only in oil from the austenitizing temperature.

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

4.1.4 Type 1 bolts, regardless of the steel used, and Type 3 bolts, shall be tempered by reheating to not less than 427°C.

4.2 *Threading*—Threads shall 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.

TABLE 2 Chemical Requirements for Type 3 Heavy Hex Structural Bolts[A]

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	0.035 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
Sulfur:						
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
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	[B]	[B]	0.020 min	[B]	[B]	[B]
Product analysis	[B]	[B]	0.010 min	[B]	[B]	[B]
Molybdenum:						
Heat analysis	[B]	0.06 max	[B]	0.10 max	[B]	[B]
Product analysis	[B]	0.07 max	[B]	0.11 max	[B]	[B]
Titanium:						
Heat analysis	[B]	[B]	[B]	0.05 max	[B]	[B]
Product analysis	[B]	[B]	[B]	0.06 max	[B]	[B]

[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.
[B] These elements are not specified or required.

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 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 695.

4.3.4 When no preference is specified, the supplier shall 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. 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 563M, 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. See 10.2, Note 4.

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 G 101 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 Table 1 or Table 2, as applicable.

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 A 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 Except as permitted in 6.2.2 for long bolts, and 6.2.3 for short bolts, sizes M24 and smaller having a length of 2-¼ D and longer; and sizes larger than M24 having a 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.

6.2.2 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 tent shall take precedence.

TABLE 3 Hardness Requirements for Bolts

Bolt Size, mm	Bolt Length, mm	Brinell		Rockwell C	
		Min	Max	Min	Max
M12 to M24, incl	Less than 2*D* [A]	253	319	25	34
	2*D* and over	. . .	319	. . .	34
M25 to M36, incl	Less than 3*D* [A]	223	286	19	30
	3*D* and over	. . .	286	. . .	30

[A] Sizes M24 and smaller having a length shorter than 2*D* and sizes larger than M24 having a length shorter than 3*D* are subject only to minimum and maximum hardness.

D = Nominal diameter or thread size.

TABLE 4 Tensile Load and Proof Load Requirements for Full-Size Bolts

Nominal Diameter and Thread Pitch	Stress Area,[A] mm	Tensile Load,[B] min,	Proof Load,[B] Length Measurement Method	Alternative Proof Load,[B] Yield Strength Method
Column 1	Column 2	Column 3	Column 4	Column 5
M12 × 1.75	84.3	70	50.6	55.6
M16 × 2	157	130	94.2	104
M20 × 2.5	245	203	147	162
M22 × 2.5	303	251	182	200
M24 × 3	353	293	212	233
M27 × 3	459	381	275	303
M30 × 3.5	561	466	337	370
M36 × 4	817	678	490	539

[A] Stress Area, $mm^2 = 0.7854\ (D - 0.9382P)^2$
where:
D = nominal bolt diameter, mm, and
P = thread pitch, mm.

[B] Loads tabulated are based on the following:

Column 3	Column 4	Column 5
830 MPa	600 MPa	660 MPa

TABLE 5 Tensile Strength Requirements for Specimens Machined from Bolts

Nominal Diameter, mm	Tensile Strength, min, MPa	Yield Strength, min, MPa	Elongation in 4D, min, %	Reduction of Area, min, %
M12 to M36 incl	830	660	14	35

6.2.3 Sizes M24 and smaller having a length shorter than 2-¼ D down to 2D inclusive, which 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 M24 and smaller having a length shorter than 2D, which cannot be axially tensile tested shall be qualified on the basis of hardness.

6.2.4 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*:

6.3.1 *Definition*—The rotational capacity test is intended to evaluate the presence of a lubricant, the efficiency of the lubricant, and the compatibility of assemblies as represented by the components selected for testing.

6.3.2 *Requirement*—Zinc-coated bolts, zinc-coated washers and zinc-coated and lubricated nuts tested full size in an assembled joint or tension measuring device, in accordance with 10.2, shall not show signs of failure when subjected to the nut rotation in Table 6. The test shall be performed by the responsible party (see Section 14) prior to shipment after zinc coating and lubrication of nuts. See 10.2, Note 4.

TABLE 6 Rotational Capacity Test for Zinc-Coated Bolts

Nominal Bolt Length, mm	Nut Rotation, degrees (turn), min
2D and shorter	180 (½)
Over 2D to 3D incl	240 (⅔)
Over 3D to 4D incl	300 (⅞)
Over 4D to 8D incl	360 (1)
Over 8D	420 (1-⅛)