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Standard Specification for High-Strength Bolts for Structural Steel Joints [Metric]¹

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This specification has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification² covers requirements of various types of quenched and tempered steel bolts in nominal thread diameters M16 to M36 inclusive, commonly known as "high-strength structural bolts," intended for use in structural joints that are comparable to those made under the Specifications for Structural Joints Using ASTM A 325 or A 490 Bolts,³ issued by the Research Council on Structural Connections of the Engineering Foundation. Types of bolts covered in this specification are:

1.1.1 *Type 1*—Bolts made of medium-carbon steel.

1.1.2 *Type 2*—Bolts made from what is generally described as low-carbon martensite steel.

1.1.3 *Type 3*—Bolts made of steel having atmospheric corrosion resistance and weathering characteristics comparable to that of the steel covered in Specifications A 588/A 588M, A 242/A 242M, 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 5.3). When properly exposed to the atmosphere, these steels can be used bare (uncoated) for many applications.

1.2 This specification provides that heavy hex structural bolts shall be furnished unless other dimensional requirements are stipulated in the purchase inquiry and order.

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

Bolt Type and Finish	Nut Class and Finish
1 and 2, plain (noncoated)	8S or 8S3, plain
1 and 2, zinc-coated	10S, zinc-coated
3, plain	8S3, plain

1.4 Unless otherwise specified, all washers used on these bolts shall conform to the requirements of Specification F 436M and shall be of a surface finish for each type of bolt as follows:

Bolt Type and Finish

1 and 2, plain (uncoated)
1 and 2, zinc-coated
3, plain

Washer Finish

plain (uncoated)
zinc-coated
weathering steel, plain

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

1.5 Zinc-coated bolts and nuts shall be shipped in the same container.

2. Referenced Documents

2.1 ASTM Standards:

A 242/A 242M Specification for High-Strength Low-Alloy Structural Steel⁴

A 325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength⁵

A 490 Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength⁵

A 563M Specification for Carbon and Alloy Steel Nuts [Metric]⁵

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] Thick⁴

A 709/A 709M Specification for Structural Steel for Bridges⁴

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products⁶

D 3951 Practice for Commercial Packaging⁷

F 436M Specification for Hardened Steel Washers [Metric]⁵

F 568 Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners⁵

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets⁵

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series⁵

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels⁸

2.2 ANSI Standards:⁹

⁴ Annual Book of ASTM Standards, Vol 01.04.

⁵ Annual Book of ASTM Standards, Vol 15.08.

⁶ Annual Book of ASTM Standards, Vols 01.01 through 01.05.

⁷ Annual Book of ASTM Standards, Vol 15.09.

⁸ Annual Book of ASTM Standards, Vol 03.02.

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

¹ This specification is under the jurisdiction of ASTM Committee F-16 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 Published by American Institute of Steel Construction, Wrigley Building, 400 N. Michigan Ave., Chicago, IL 60611.

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ANSI B1.13M Metric Screw Threads

ANSI B18.2.3.7M Metric Heavy Hex Structural Bolts

ANSI B18.2.4.6M Metric Heavy Hex Nuts

2.3 *Military Standard*¹⁰

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

3. Ordering Information

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

3.1.1 Quantity (number of pieces of bolts and accessories).

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

3.1.3 *Zinc Coating*—Specify the zinc-coating process required, for example, hot-dip, mechanically deposited, or no preference (see 4.1).

3.1.4 *Other Finishes*—Specify other protective finish if required.

3.1.5 Dimensions including nominal bolt diameter, thread pitch, and length. For bolts of dimensional requirements other than heavy hex structural bolts (see 1.2), it is normally necessary to specify grip length.

3.1.6 Type of bolt (that is, Type 1, 2, or 3).

3.1.6.1 When the bolt type is not specified, either Type 1 or Type 2 may be supplied at the option of the manufacturer. Type 3 bolts may be supplied by the manufacturer if agreed upon by the purchaser.

3.1.6.2 Where elevated temperature applications are involved, Type 1 bolts shall be specified by the purchaser.

3.1.6.3 When atmospheric corrosion resistance is required, Type 3 bolts shall be specified by the purchaser.

3.1.6.4 When zinc-coated high-strength structural bolts are specified, the bolts shall be either Types 1 or 2, at the manufacturer's option, unless otherwise ordered by the purchaser.

3.1.7 ASTM designation and year of issue.

3.1.8 Any special requirements.

NOTE 2—Two examples of ordering descriptions follow: (1) 1000 pieces, heavy hex structural bolts, each with one hardened washer and one heavy hex nut, hot-dip zinc-coated, M24 × 3 × 100, ASTM A 325M – XX. (2) 1000 pieces, heavy hex structural bolts, no nuts or washers, M20 × 2.5 × 80 Type 3, ASTM A 325M – XX.

3.2 *Government Provisioning*—Government procurement and design selection criteria shall be specified in accordance with ANSI (or ANSI/ASME) B18.2.3.7M or B18.2.4.6M, as appropriate.

4. Materials and Manufacture

4.1 Steel for bolts, and the heading, threading, heat treatment and zinc-coating of bolts shall be in accordance with requirements specified for classes 8.8 and 8.8.3 bolts in Specification F 568.

5. Chemical Composition

5.1 Type 1 bolts shall conform to the chemical composition requirements specified for medium carbon steel class 8.8 bolts in Specification F 568.

5.2 Type 2 bolts shall conform to the chemical composition requirements specified for low-carbon martensite steel class 8.8 bolts in Specification F 568.

5.3 Type 3 bolts shall conform to the chemical composition requirements specified for Class 8.8.3 bolts in Specification F 568. See Guide G 101 for methods of estimating the atmospheric corrosion resistance of low alloy steels.

5.4 Chemical analyses shall be performed in accordance with Test Methods A 751.

6. Mechanical Properties

6.1 Bolts shall meet the mechanical requirements specified for classes 8.8 and 8.8.3 bolts in Specification F 568. For information purposes only, the mechanical properties of bolts are given in Appendix X1.

6.2 In addition, when zinc-coated bolts and nuts are supplied, the bolt/nut assembly shall be tested full size in an assembled joint as specified in 9.2. After initial tightening, the nut shall be capable of being turned through the following rotation with respect to the bolt without producing bolt or nut failure:

Bolt Length ⁴	Nut Rotation, °
Up to and incl 4D	300
Over 4D to 8D	360
Over 8D	420

⁴ D is nominal bolt diameter.

7. Dimensions

7.1 Bolts with hex heads shall be full-body bolts conforming to the dimensions for heavy hex structural bolts specified in ANSI B18.2.3.7M.

7.2 Threads shall be Metric Coarse Thread Series as specified in ANSI B1.13M, and shall have grade 6g tolerances.

7.3 Unless otherwise specified, zinc-coated bolts, to be used with zinc-coated nuts which have been tapped oversize in accordance with Specification A 563M shall have grade 6g threads before hot dip or mechanically deposited zinc-coating. After zinc-coating the maximum limits of pitch diameter and major diameter may exceed grade 6g limits by the following amount:

Nominal Bolt Diameter	Oversize Limit, mm
M16	0.42
M20	0.53
M22	0.53
M24	0.64
M27	0.64
M30	0.75
M36	0.86

7.4 The acceptability of assemblage of zinc-coated bolts shall be verified during manufacture or use by assembly with a nut tapped as nearly as practical to the oversize limit shown above. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance, gage tolerance plus) shall be used. Assembly of the gage, or the nut described above, shall be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, shall be performed at the frequency and acceptability specified in Table 1.

¹⁰ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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TABLE 1 Sample Sizes and Acceptance Numbers for Inspection of Hot Dip or Mechanically Deposited Zinc-Coated Threads

Lot Size	Sample Size ^{A,B}	Acceptance Number ^A
2 to 90	13	1
91 to 150	20	2
151 to 280	32	3
281 to 500	50	5
501 to 1 200	80	7
1 201 to 3 200	125	10
3 201 to 10 000	200	14
10 001 and over	315	21

^A Sample sizes of acceptance numbers are extracted from "Single Sampling Plan for Normal Inspection" Table II-A, MIL-STD-105.

^B Inspect all bolts in the lot if the lot size is less than the sample size.

8. Workmanship

8.1 Surface discontinuity limits shall be in accordance with Specification F 788/F 788M.

9. Test Methods

9.1 Tests shall be conducted in accordance with Test Methods F 606.

9.2 The zinc-coated bolt shall be placed in a steel joint and assembled with a zinc-coated washer and a zinc-coated nut. The joint shall be one or more flat structural steel plates with a total thickness, including the washer, such that three to five full threads of the bolt are located between the bearing surfaces of the bolt head and nut. The hole in the joint shall have the same nominal diameter as the hole in the washer. The initial tightening of the nut shall produce a load in the bolt not less than 10 % of the specified proof load (Appendix X1). After this initial tightening, the nut position shall be marked, and this marking shall serve as the base from which the rotation requirements of 6.2 shall be measured. During nut rotation the bolt head shall be restrained from turning.

10. Quality Assurance of Mechanical Requirements

10.1 The manufacturer shall make sample inspections of every lot of bolts to ensure that properties of bolts are in conformance with the requirements of this specification. All bolts shall be inspection tested prior to shipment in accordance with one of the two quality assurance procedures described in 10.2 and 10.3, respectively. The manufacturer shall have the option of which procedure will be followed when furnishing bolts to any single purchase order.

10.1.1 The purpose of a lot inspection testing program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective it is essential that following delivery the purchaser continue to maintain the identification and integrity of each lot until the product is installed in its service application.

10.2 Production Lot Method:

10.2.1 All bolts shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer shall identify and maintain the integrity of each production lot of bolts from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

10.2.2 A production lot, for purposes of assigning an identification number and from which test samples shall be

selected, shall consist of all bolts processed essentially together through all operations to the shipping container that are of the same nominal diameter, the same nominal length, and produced from the same mill heat of steel.

10.2.3 The manufacturer shall make tests for proof load, tensile strength (wedge test), and hardness of each lot of bolts. Alternatively, in accordance with 6.1, tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

10.2.4 From each production lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Production Lot	Number of Specimens
800 and less	1
801 to 8 000	2
8 001 to 35 000	3
35 001 to 150 000	8
150 001 and over	13

10.2.5 If any test specimen shows defective machining it may be discarded and another specimen substituted.

10.2.6 Bolts shall be packed in shipping containers as soon as practicable following final processing. Shipping containers shall be marked with the lot identification number.

10.2.7 A copy of the inspection test report for each production lot from which bolts are supplied to fill the requirements of a shipment shall be furnished to the purchaser when specified in the order. Individual heats of steel need not be identified on the test report.

10.3 Shipping Lot Method:

10.3.1 In-process inspection during all manufacturing operations and treatments and storage of manufactured bolts shall be in accordance with the practices of the individual manufacturer.

10.3.2 Before packing bolts for shipment, the manufacturer shall make tests of sample bolts taken at random from each shipping lot. A shipping lot, for purposes of selecting test samples, is defined as that quantity of bolts of the same nominal diameter and same nominal length necessary to fill the requirements of a single purchase order.

10.3.3 The manufacturer shall make tests for proof load, tensile strength (wedge test), and hardness of each lot of bolts. Alternatively, in accordance with 6.1, tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

10.3.4 From each shipping lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Shipping Lot	Number of Specimens
150 and less	1
151 to 280	2
281 to 500	3
501 to 1 200	5
1 201 to 3 200	8
3 201 to 10 000	13
10 001 and over	20

10.3.5 If any test specimen shows defective machining it may be discarded and another specimen substituted.

10.3.6 A copy of the inspection test report for each shipping lot shall be furnished to the purchaser when specified in the order. Individual heats of steel are not identified in the finished product.

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11. Visual Inspection for Head Bursts

11.1 A burst is an open break in the metal (material). Bursts can occur on the flats or corners of the heads of bolts.

11.2 A defective bolt, for the purposes of the visual inspection for bursts, shall be any bolt that contains a burst in the flat of the head which extends into the top crown surface of the head (chamfer circle) or the underhead bearing surface. In addition, bursts occurring at the intersection of two wrenching flats shall not reduce the width across corners below the specified minimum.

11.3 A lot, for the purposes of visual inspection, shall consist of all bolts of one type having the same nominal diameter and length offered for inspection at one time. No lot shall contain more than 10 000 pieces.

11.4 From each lot of bolts, a representative sample shall be picked at random and visually inspected for bursts. The sample size shall be as shown in Table 2. If the number of defective bolts found during inspection by the manufacturer is greater than the acceptance number given in Table 2 for the sample size, all bolts in the lot shall be visually inspected and all defective bolts shall be removed and destroyed. If the number of defective bolts found during inspection by the purchaser is greater than the acceptance number given in Table 2 for the sample size, the lot shall be subject to rejection.

12. Inspection

12.1 If the inspection described in 12.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

12.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection shall be made and shall be so conducted as not to interfere unnecessarily with the operation of the works.

13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

14. Certification

14.1 When specified on the order, the manufacturer shall furnish the test reports described in 10.2.7 and 10.3.6

TABLE 2 Sample Sizes and Acceptance Numbers for Inspection of Bursts

Lot Size	Sample Size ^{A,B}	Acceptance Number ^A
1 to 150	5	0
151 to 500	20	1
501 to 1 200	32	2
1 201 to 3 200	50	3
3 201 to 10 000	80	5

^A Sample sizes and acceptance numbers are extracted from "Single Sampling Plan for Normal Inspection" Table IIA, MIL-STD-105.

^B Inspect all bolts in the lot if the lot size is less than the sample size.

depending on whether the bolts are furnished by the production lot or shipping lot method.

15. Responsibility

15.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser and certifies that the fastener was manufactured, sampled, tested and inspected in accordance with this specification and meets all of its requirements.

16. Product Marking

16.1 All bolts, Types 1, 2, and 3, shall be marked A 325M, and shall also be marked with a symbol identifying the manufacturer or private label distributor, as appropriate.

16.2 In addition, Type 1 bolts shall be marked 8S; Type 2 bolts shall be marked 8S with this marking underlined; and Type 3 bolts shall be marked 8S3.

16.3 At the manufacturer's option, Type 3 bolts may have other distinguishing marks to indicate the bolt is atmospheric corrosion resistant and of a weathering type.

16.4 All markings shall be located on the top of the bolt head with the base of the property class numerals positioned toward the closest periphery of the head. Markings may be either raised or depressed at the option of the manufacturer.

16.5 Type and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and, when on the same level, shall be separated by at least two spaces.

17. Packaging and Package Marking**17.1 Packaging:**

17.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

17.1.2 When zinc coated nuts are included on the same order as zinc coated bolts, the bolts and nuts shall be shipped in the same container.

17.1.3 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

17.2 Package Marking:

17.2.1 Each shipping unit shall include or be plainly marked with the following information:

17.2.1.1 ASTM designation and type,

17.2.1.2 Size,

17.2.1.3 Name and brand or trademark of the manufacturer,

17.2.1.4 Number of pieces,

17.2.1.5 Lot number,

17.2.1.6 Purchase order number, and

17.2.1.7 Country of origin.

18. Keywords

18.1 bolts; carbon steel; metric; steel; structural; weathering steel



APPENDIX

(Nonmandatory Information)

X1. MECHANICAL PROPERTIES, FULL-SIZE BOLTS

TABLE X1.1 Mechanical Properties—Full-Size Bolts

Nominal Bolt Diameter and Thread Pitch	Stress Area, mm ²	Proof Load Length Measurement Method, kN	Proof Load Yield Strength Method, kN	Tensile Strength, min, kN	Hardness			
					Rockwell		Vickers	
					min	max	min	max
M16 x 2	157	94.2	104	130				
M20 x 2.5	245	147	162	203				
M22 x 2.5	303	182	200	251	C23	C34	255	336
M24 x 3	353	212	233	293				
M27 x 3	459	275	303	381				
M30 x 3.5	561	337	370	466				
M36 x 4	817	490	539	678				

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