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METRIC

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Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners[1]

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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 chemical and mechanical requirements for nine property classes of carbon and alloy steel externally threaded metric fasteners in nominal thread diameters M1.6 through M100 suited for use in general engineering applications.

1.2 This specification does not cover dimensional requirements for fasteners of any property class. When referencing this specification for procurement purposes, it is mandatory that size, type, style, and any special dimensions of the product be additionally specified.

1.2.1 In case of any conflict in requirements, the requirements of the individual product specification shall take precedence over those of this general specification.

1.2.2 The purchaser may specify additional requirements which do not negate any of the provisions of this general specification or of the individual product specification. Such additional requirements, the acceptance of which are subject to negotiation with the supplier, must be included in the order information (see Section 3).

1.3 Requirements for seven of the nine property classes, 4.6, 4.8, 5.8, 8.8, 9.8, 10.9, and 12.9, are essentially identical with requirements given for these classes in ISO 898/I. The other two, 8.8.3 and 10.9.3, are not recognized in ISO standards.

1.4 Classes 8.8.3 and 10.9.3 bolts, screws, and studs have atmospheric corrosion resistance and weathering characteristics comparable to those of the steels covered in Specification A 588. 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.

1.5 When agreed on by the purchaser, Class 5.8 fasteners may be supplied when either Classes 4.6 or 4.8 are ordered; Class 4.8 may be supplied when Class 4.6 is ordered; Class 8.8.3 may be supplied when Class 8.8 is ordered; and Class 10.9.3 may be supplied when Class 10.9 is ordered.

1.6 The product size range for which each property class is applicable is given in Table 1 and Table 2 on chemical composition requirements, and the mechanical requirements table (see Table 3).

1.7 Appendix X1 gives conversion guidance to assist designers and purchasers in the selection of a suitable property class.

1.8 Appendix X2 explains the significance of the property class designation numerals.

2. Referenced Documents

2.1 *ASTM Standards:*

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware[2]

A 307 Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength[3]

A 325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength[3]

A 325M Specification for High-Strength Bolts for Structural Steel Joints [Metric][3]

A 354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners[3]

A 449 Specification for Quenched and Tempered Steel Bolts and Studs[3]

A 490 Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength[3]

A 490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric][3]

A 574 Specification for Alloy Steel Socket-Head Cap Screws[3]

A 588/A588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick[4]

A 751 Test Methods, Practices, and Terminology for

[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] *Annual Book of ASTM Standards*, Vol 01.06.

[3] *Annual Book of ASTM Standards*, Vol 15.08.

[4] *Annual Book of ASTM Standards*, Vol 01.04.

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

TABLE 1 Chemical Composition Requirements

Property Class	Nominal Product Diameter, mm	Material and Treatment	Product Analysis Element (% by weight)						Tempering Temperature, °C
			C		Mn	B	P	S	
			Min	Max	Min	Min	Max	Max	Min
4.6	M5–M100	low or medium carbon steel	...	0.55	...	...	0.048	0.058	...
4.8	M1.6–M16	low or medium carbon steel, partially or fully annealed as required	...	0.55	...	...	0.048	0.058	...
5.8	M5–M24	low or medium carbon steel, cold worked	0.13	0.55	...	...	0.048	0.058[A]	...
8.8	M20–M80	medium carbon steel, product is quenched and tempered[B]	0.25	0.55	...	...	0.048	0.058[C]	425
8.8	M20–M36	low carbon martensite steel, product is quenched and tempered[D]	0.15	0.40	0.74	0.0005	0.048	0.058	425
8.8.3	M20–M36	atmospheric corrosion resistant steel, product is quenched and tempered				see Table 2			425
9.8	M1.6–M16	medium carbon steel, product is quenched and tempered	0.25	0.55	...	...	0.048	0.058	425
9.8	M1.6–M16	low carbon martensite steel, product is quenched and tempered[D]	0.15	0.40	0.74	0.0005	0.048	0.058	425
10.9	M5–M20	medium carbon steel, product is quenched and tempered[E,F]	0.25	0.55	...	...	0.048	0.058	425
10.9	M5–M100	medium carbon alloy steel, product is quenched and tempered[E]	0.20	0.55	...	...	0.040	0.045	425
10.9	M5–M36	low carbon martensite steel, product is quenched and tempered[E,F]	0.15	0.40	0.74	0.0005	0.048	0.058	340
10.9.3	M16–M36	atmospheric corrosion resistant steel, product is quenched and tempered[E]				see Table 2			425
12.9	M1.6–M100	alloy steel, product is quenched and tempered[E,G]	0.31	0.65	...	...	0.045	0.045	380

[A] For studs only, sulfur content may be 0.33 %, max.
[B] At the manufacturer's option, medium-carbon-alloy steel may be used for nominal thread diameters over M24.
[C] For studs only, sulfur content may be 0.13 %, max.
[D] Products made using this material shall be specially identified as specified in Section 12.
[E] Steel for Classes 10.9, 10.9.3, and 12.9 products shall be fine grain and have a hardenability that will achieve a structure of approximately 90 % martensite at the center of a transverse section one diameter from the threaded end of the product after oil quenching.
[F] Carbon steel may be used at the option of the manufacturer for products of nominal thread diameters M12 and smaller. When approved by the purchaser, carbon steel may be used for products of diameters larger than M12 through M20, inclusive.
[G] Alloy steel shall be used. Steel is considered to be alloy by the American Iron and Steel Institute 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.

Chemical Analysis of Steel Products[5]
B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel[6]
D 3951 Practice for Commercial Packaging[7]
F 606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric][3]
F 788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series[3]
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels[8]

2.2 *ISO Standard:*[9]
ISO 898/I, Mechanical Properties of Fasteners, Part I, Bolts, Screws, and Studs

2.3 *ANSI Standards:*[9]
B 18.2.3.1M Metric Hex Cap Screws
B 18.2.3.2M Metric Formed Hex Screws
B 18.2.3.3M Metric Heavy Hex Screws
B 18.2.3.4M Metric Hex Flange Screws
B 18.2.3.5M Metric Hex Bolts
B 18.2.3.6M Metric Heavy Hex Bolts
B 18.5.2.1M Metric Round Head Short Square Neck Bolts

2.4 *ANSI/ASME Standard:*[9]
B18.5.2.2M Metric Round Head Square Neck Bolts

3. Ordering Information

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

3.1.1 Quantity (number of pieces),

3.1.2 Name of product (that is, type and style of bolt, screw, or stud),

3.1.3 Dimensions, including nominal thread diameter, thread pitch, and length,

3.1.4 Property class,

3.1.5 *Zinc Coating*—Specify the zinc coating process required, for example, hot dip, mechanically deposited, or no preference (see 4.5),

3.1.6 *Other Finishes*—Specify other protective finish, if required,

3.1.7 ASTM designation and year of issue, and

3.1.8 Any special requirements (for example, mechanical requirements, see Table 3, or proof load testing, see Table 4; stud marking, see 12.2.3; additional testing, see 8.3).

3.2 *Government Provisioning*—Government procurement and design selection criteria shall be specified in accordance with ANSI (or ANSI/ASME) B18.2.3.1M, B18.2.3.2M, B18.2.3.3M, B18.2.3.4M, B18.2.3.5M, B18.2.3.6M, B18.5.2.1M, or B18.5.2.2M, as appropriate.

4. Materials and Manufacture

4.1 Steel for bolts, screws, and studs shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

4.2 *Heading Practice*:

4.2.1 Methods other than upsetting or extrusion, or both, are permitted only by special agreement between purchaser and producer.

[5] *Annual Book of ASTM Standards*, Vol 01.03.
[6] *Annual Book of ASTM Standards*, Vol 02.05.
[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, New York, NY 10036.

TABLE 2 Chemical Composition Requirements for Classes 8.8.3 and 10.9.3

Element	Composition, %[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 types of material used for Property Classes 8.8.3 and 10.9.3 bolts, screws, and studs. Selection of a composition shall be at the option of the product manufacturer except that sizes M20 and larger shall conform to Composition A or B only.

4.2.2 Class 4.6 may be hot or cold headed at the option of the manufacturer.

4.2.3 Classes 4.8, 5.8, 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9 bolts and screws in nominal thread diameters up to M20 inclusive with lengths up to 10 times the nominal product size or 150 mm, whichever is shorter, shall be cold headed, except that they may be hot headed by special agreement with the purchaser. Larger diameters and longer lengths may be cold or hot headed at the option of the manufacturer.

4.3 *Threading Practice*:

4.3.1 Threads on Class 4.6 bolts and screws and on all classes of studs may be cut, rolled, or ground at the option of the manufacturer.

4.3.2 Threads on Classes 4.8, 5.8, 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9 bolts and screws in nominal thread diameters up to M20 inclusive, and product lengths up to 150 mm inclusive, shall be roll threaded, except by special agreement with the purchaser. Threads of these classes on bolts and screws larger than M20 or longer than 150 mm or both, may be rolled, cut, or ground at the option of the manufacturer.

4.4 *Heat Treatment*:

4.4.1 Class 4.6 bolts and screws and Classes 4.6, 4.8, and 5.8 studs need not be heat treated.

4.4.2 Classes 4.8 and 5.8 bolts and screws shall be stress relieved if necessary to assure the soundness of the head to shank junction. When stress relieving is specified by the purchaser, Class 5.8 bolts and screws shall be stress relieved at a minimum stress-relief temperature of 470°C. Where higher stress-relief temperatures are necessary to relieve stresses in severely upset heads, mechanical requirements shall be agreed upon between the purchaser and producer.

4.4.3 Classes 8.8, 8.8.3, and 9.8 bolts, screws, and studs shall be heat treated by quenching in a liquid medium from above the transformation temperature and reheating to the tempering temperature given in Table 1.

4.4.4 Classes 10.9, 10.9.3, and 12.9 bolts, screws, and studs shall be heat treated by quenching in oil from above the transformation temperature and reheating to the tempering temperature given in Table 1.

4.4.5 *Tempering-Temperature-Audit Test*—This test is a means for checking whether products were tempered at the specified temperature. The hardness (mean hardness of three hardness readings) of a bolt, screw, or stud as manufactured shall be measured. The product shall then be retempered for a minimum of 30 min per 25 mm of nominal diameter, but not less than 30 min, at a temperature 10°C less than the minimum tempering temperature specified for the property class and material in Table 1. The hardness of the retempered product shall then be measured. The difference between the hardness of the product before and after retempering shall not exceed 20 HV points.

4.5 *Zinc Coatings, Hot-Dip, and Mechanically Deposited*:

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

TABLE 3 Mechanical Requirements for Bolts, Screws, and Studs

Property Class	Nominal Diameter of Product	Full Size Bolts, Screws, and Studs			Machined Test Specimens of Bolts, Screws, and Studs				Surface Hardness	Product Hardness			
		Proof Load[A]		Tensile Strength, MPa[A]	Yield Strength, MPa[B]	Tensile Strength, MPa	Elongation, %	Reduction of Area, %	Rockwell 30N	Rockwell		Vickers	
		Length Measurement Method, MPa	Yield Strength Method, MPa	Min	Min	Min	Min	Min	Max	Min	Max	Min	Max
4.6	M5–M100	225	240	400	240[C]	400	22	35	...	B67	B95	120	220
4.8	M1.6–M16	310	340	420	340	420	14	35	...	B71	B95	130	220
5.8	M5–M24[D]	380	420	520	420	520	10	35	...	B82	B95	160	220
8.8	M20–M80	600	660	830	660	830	12	35	53	C23	C34	255	336
8.8.3	M20–M36	600	660	830	660	830	12	35	53	C23	C34	255	336
9.8	M1.6–M16	650	720	900	720	900	10	35	56	C27	C36	280	360
10.9	M5–M100	830	940	1040	940	1040	9	35	59	C33	C39	327	382
10.9.3	M16–M36	830	940	1040	940	1040	9	35	59	C33	C39	327	382
12.9[E]	M1.6–M100	970	1100	1220	1100	1220	8	35	63	C38	C44	372	434

[A] Proof load and tensile strength values for full size products of each property class are given in Table 5.
[B] Yield strength is stress at which a permanent set of 0.2 % of gage length occurs.
[C] Yield point shall apply instead of yield strength at 0.2 % offset for Class 4.6 products.
[D] Class 5.8 applies only to bolts and screws with lengths 150 mm and shorter and to studs of all lengths.
[E] Caution is advised when considering the use of Class 12.9 bolts, screws, and studs. Capability of the bolt manufacturer, as well as the anticipated in-use environment, should be considered. High-strength products of Class 12.9 require rigid control of heat-treating operations and careful monitoring of as-quenched hardness, surface discontinuities, depth of partial decarburization, and freedom from carburization. Some environments may cause stress corrosion cracking of nonplated as well as electroplated products.

dip, mechanically deposited, or no preference.

4.5.2 When hot-dip is specified, the fasteners shall be zinc coated by the hot-dip process in accordance with the requirements of Class C of Specification A 153.

4.5.3 When mechanically deposited is specified, the fasteners shall be zinc coated by the mechanical deposition process in accordance with the requirements of Class 50 of Specification B 695.

4.5.4 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. All components of mating fasteners (for example, bolts, nuts, and washers) shall be coated by the same zinc coating process, and the suppliers option is limited to one process per item with no mixed processes in a lot.

4.6 Bolts, screws, and studs of Classes 10.9 and 12.9 should not be hot-dip zinc-coated.

NOTE 1—Research conducted on bolts with properties equivalent to Class 10.9 indicated that hydrogen-stress corrosion cracking may occur in hot-dip zinc-coated fasteners of Classes 10.9 and 12.9.

5. Chemical Composition

5.1 For all classes except 8.8.3 and 10.9.3, the bolts, screws, and studs shall conform to the chemical composition specified in Table 1.

5.2 *Classes 8.8.3 and 10.9.3*:

5.2.1 Sizes M20 and smaller shall conform to any one of the compositions (A, B, C, D, E, or F) specified in Table 2, at the suppliers option.

5.2.2 Sizes larger than M20 shall conform to Compositions A or B specified in Table 2, at the suppliers option.

5.2.3 See Guide G 101 for methods of estimation corrosion resistance of low alloy steels.

5.3 Material analyses may be made by the purchaser from finished products representing each lot. The chemical composition thus determined shall conform to the requirements specified for the product analysis in Table 1 and Table 2.

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

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

6. Mechanical Properties

6.1 Bolts, screws, and studs shall be tested in accordance with the mechanical testing requirements for the applicable type, property class, size, and length of product as specified in Table 4, and shall meet the mechanical requirements specified for that product in Tables 3-5.

6.2 For products on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence over low readings of hardness tests.

7. Workmanship

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

8. Number of Tests and Retests

8.1 The requirements of this specification shall be met in continuous mass production for stock; the manufacturer shall inspect to ensure that the product conforms to the specified requirements. Additional tests of individual shipments of product are not ordinarily required. Individual heats of steel are not identified in the finished product.

8.2 When specified in the order, the manufacturer shall furnish a test report certified to be the last completed set of mechanical tests for each stock size in each shipment.