Designation: F 568M – 04

METRIC

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

This standard is issued under the fixed designation F 568M; 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 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 898-1. 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/A 588M. 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:* [2]

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

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

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

A 325M Specification for Structural Bolts, Steel, Heat Treated 830 Mpa Minimum Tensile Strength [Metric]

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

A 449 Specification for Quenched and Tempered Steel Bolts and Studs

A 490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

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

A 574 Specification for Alloy Steel Socket-Head Cap Screws

[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 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.**

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 15.
[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.

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.

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.

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] Thick
A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
D 3951 Practice for Commercial Packaging
F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets
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 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Requirements
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *ISO Standard:*[3]
ISO 898-1, Mechanical Properties of Fasteners, Part I, Bolts, Screws, and Studs

2.3 *ASME Standards:*[3]
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
B 18.5.2.2M Metric Round Head Square Neck Bolts

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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 (see Section 7),
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 Tables 3 and 4, or proof load testing, see Tables 5 and 6; stud marking, see 15.2.3; additional testing, see Section 9).
3.1.9 Test reports if required, see Section 14.

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

TABLE 4 Mechanical Testing Requirements for Bolts, Screws, and Studs [A]

Item	Product	Property Class	Specified Min Tensile Strength of Product (See Table 5) kN	Length of Product[B]	Product Hardness		Surface Hardness[C]	Tests Conducted Using Full-Size Products			Tests Conducted Using Machined Test Specimens			
					Max	Min	Max	Proof Load	Wedge Tensile Strength[D]	Axial Tensile Strength	Yield Strength	Tensile Strength	Elongation	Reduction of Area
1	short length bolts and screws	all	all	less than *x*	●	●	●	...	...	...	...	...	...	...
2	special head bolts and screws[E]	all	all	all	●	●	●	...	...	...	...	...	...	...
3	bolts and screws with hex or hex flange heads except items 1 and 2	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	●	...	...	...	...	...
				over 8D or 200 mm, whichever is greater through and incl 300 mm	●	...	●	○	●	...	...	...	...	...
				over 300 mm	●	...	●	○	A	...	B	B	B	B
			over 450	*x* and longer	●	...	●	○	A	...	B	B	B	B
4	all bolts and screws except items 1, 2, and 3	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	...	●	...	...	...	...
				over 8D or 200 mm, whichever is greater	●	...	●	○	...	A	B	B	B	B
			over 450	*x* and longer	●	...	●	○	...	A	B	B	B	B
5	short length studs	all	all	less than *x*	●	●	●	...	...	...	...	...	...	...
6	all studs except item 5	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	●	...	...	...	...	...
				over 8D or 200 mm, whichever is greater	●	...	●	○	A	...	B	B	B	B
			over 450	*x* and longer	●	...	●	○	A	...	B	B	B	B
Tests to be conducted in accordance with the following paragraph of Method F 606M:					3.1			3.2.1	3.5	3.4	3.6			

[A] ● denotes a mandatory test. For each product all mandatory tests (●) shall be performed. In addition, either all tests denoted A (which apply to full-size products) or all tests denoted B (which apply to machined test specimens) shall be performed. ○ denotes tests to be performed when specifically required in the original inquiry and purchase order. In case arbitration is necessary, A tests and proof load test shall be performed. Leaders (. . .) indicate tests that are not required.

[B] D equals nominal diameter of product. *x* equals the minimum length of product subject to tensile testing. Values of *x* are as follows:

Nominal Product Diameter	*x*, mm
M5	12
M6	14
M8	20
M10	25
M12	30
M14	35
M16	40
M20	45
M24 and larger	3D

[C] Surface hardness requirements apply only to Property Classes 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9.

[D] Tensile test wedge angles are specified in Table 6.

[E] Special head bolts and screws are those with special configurations or with drilled heads which are weaker than the threaded section.

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 ten 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.