Designation: F2882/F2882M – 17

Standard Specification for Screws, Alloy Steel, Heat Treated, 170 ksi and 1170 MPa Minimum Tensile Strength (Inch and Metric)[1]

This standard is issued under the fixed designation F2882/F2882M; 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.

1. Scope

1.1 This specification covers the requirements for quenched and tempered alloy steel screws 0.060 through 1½ in. and 1.6 through 48 mm in diameter having a minimum ultimate tensile strength of 170 KSI or 1170 MPa.

1.2 The values are stated in inch-pound units for inch fasteners and SI metric units for metric fasteners. The values stated in each system may not be exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in nonconformance to the standard.

1.3 *The following hazard caveat pertains only to the test method 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 limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

E112 Test Methods for Determining Average Grain Size

F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

F788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F1940 Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners

F2282 Specification for Quality Assurance Requirements for Carbon and Alloy Steel Wire, Rods, and Bars for Mechanical Fasteners

F2328 Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts

F2328M Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws, Studs, and Nuts (Metric)

2.2 *ASME Standards:*[3]

B18.2.1 Square and Hex Bolts and Screws

B18.2.3.3M Metric Heavy Hex Screws

B18.2.3.4M Metric Hex Flange Screws

B18.2.3.5M Metric Hex Bolts

B18.2.3.9M Metric Heavy Hex Hex Flange Screws

B18.2.5 12 Point Flange Screws

B18.2.5M Metric 12 Point Flange Screws

B18.2.7.1M Metric 12 Spline Flange Screws

B18.3 Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys (Inch Series)

B18.3.1M Socket Head Cap Screws (Metric Series)

B18.24 Part Identifying Number (PIN) Code System Standard for B18 Fastener Products

3. Ordering Information

3.1 Orders for high strength screws under this specification shall include the following information:

3.1.1 Quantity (number of screws),

3.1.2 Nominal dimensions, including diameter, thread designation, thread, pitch, and nominal screw length,

3.1.3 Name of the screw including specification,

[1] This test method 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.

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

3.1.3.1 ASME B18.2.1, Square and Hex Bolts and Screws,
3.1.3.2 ASME B18.2.5, 12 Point Flange Screws,
3.1.3.3 ASME B18.3, Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys (Inch Series),
3.1.3.4 ASME B18.2.3.3M, Metric Heavy Hex Screws,
3.1.3.5 ASME B18.2.3.4M, Metric Hex Flange Screws,
3.1.3.6 ASME B18.2.3.5M, Metric Hex Bolts,
3.1.3.7 ASME B18.2.3.9M, Metric Heavy Hex Flange Screws,
3.1.3.8 ASME B18.2.5M, Metric 12 Point Flange Screws,
3.1.3.9 ASME B18.2.7.1M, Metric 12-Spline Flange Screws,
3.1.3.10 ASME B18.3.1M, Socket Head Cap Screws (Metric Series),
3.1.4 ASTM designation and year of issue.

3.2 Orders for high strength screws may include the following optional requirements:
3.2.1 Inspection at point of manufacture.
3.2.2 Coating, if required (see 4.6).
3.2.3 Additional Testing (see 11.1).
3.2.4 Special Packaging (see 14.1.2).
3.2.5 Supplementary Requirement (see S1).
3.2.6 Special Requirements.
3.2.7 For establishment of a part identifying system, see ASME B18.24.

4. Materials and Manufacture

4.1 The screws shall be fabricated from steel made to fine grain practice and shall have an austenitic grain size of 5 or finer. In the event of controversy over grain size, referee tests on finished screws conducted in accordance with Test Methods E112 shall prevail.

4.2 High strength screws shall be heat treated by quenching in oil from above the transformation temperature and then tempered by reheating to at least 797°F or 425°C to achieve the mechanical properties specified in Section 6 and Table 1.

4.2.1 The minimum tempering temperature may be verified by submitting screws to 777°F or 415°C for 30 min at temperature. The mean cross-section hardness of three readings on the screw before and after retempering shall not differ by more than 2 points HRC.

TABLE 1 Mechanical Requirements

	Grade 170	Property Class 11.9
Full-size screws:		
Tensile or wedge strength, min,	170 KSI[A]	1170 MPa
Proof load (stress), min,	135 KSI	930 MPa
Machined test specimen:		
Yield strength at 0.2 % offset, min,	153 KSI	1055 MPa
Tensile strength, min, KSI	170 KSI	1170 MPa
Elongation in 5D, min, %	10	10
Reduction of area, min, %	35	35
Product hardness:		
Rockwell	37 to 42 HRC	37 to 42 HRC
Vickers	372 to 434 DPH	372 to 434 DPH

[A] Not applicable to fasteners with reduced loadability due to head configuration such as flat countersunk or button head screws. See Table 4 or Table 5 for full-size tensile requirements.

4.3 Re-heat-treatment of screws for the purpose of carbon restoration is not permitted except for set screws.

4.4 Unless otherwise specified, threads of screws shall be rolled for diameters through 0.625 in. or M20 and for screw lengths through 6 in. or 150 mm. For diameters and lengths other than this, threads may be rolled, cut, or ground with the exception of socket set screws. Set screws with thread diameters up to and including #5 or M 3.5, and all other diameters with lengths less than seven thread pitches may be rolled, cut, or ground. Thread diameters #6 or M4 and larger with a minimum of seven thread pitches in length shall be rolled.

4.5 *Standard Finishes*—Unless otherwise specified, the screws shall be furnished with one of the following "standard surfaces as manufactured," at the option of the manufacturer; *(1)* bright uncoated, *(2)* thermal black oxide, or *(3)* chemical black oxide. Hydrogen embrittlement tests shall not be required for screws furnished in these conditions.

4.6 *Protective Coatings:*
4.6.1 When a protective finish other than as specified in 4.5 is required, it shall be specified on the purchase order with the applicable finish specification.
4.6.2 When protective or decorative coatings are applied to the screws, precautions specified by the coating requirements to minimize internal hydrogen embrittlement shall be exercised. When specified in the purchase order, testing shall be conducted in accordance with Test Methods F606/F606M or F1940. In the event that hardness reductions occur in test specimens due to coating curing times and temperatures, testing shall be conducted alternatively in accordance with Test Method F1624.

5. Chemical Composition

5.1 The screws shall be alloy steel conforming to the chemical composition specified in Table 2 and the requirements in Specification F2282. See Supplementary Requirement S1 when additional alloy steel grades are required.

5.2 One or more of the following alloying elements: chromium, nickel, molybdenum, or vanadium shall be present in sufficient quantity to ensure that the specified strength properties are met after oil quenching and tempering. As a guide for selecting material, an alloy steel should be capable of meeting the specified mechanical requirements if the "as oil quenched" core hardness one diameter from the point is equal to or exceeds 25 HRC + (55 × carbon content).

5.3 When product analyses are made by the purchaser from finished screws representing each lot, the chemical composition shall conform to the requirements for product analysis in Table 2.

TABLE 2 Chemical Requirements

Element	Composition, %	
	Heat Analysis	Product Analysis
Carbon	0.33 to 0.48	0.31 to 0.50
Manganese, max	1.25	1.25
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Alloying elements	See 5.2	

5.4 Steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for cold headed parts.

5.5 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A751.

6. Mechanical Properties

6.1 Screws shall be tested in accordance with mechanical testing requirements specified in Table 3, and shall meet the mechanical requirements in Table 1, and either Table 4, Table 5 or Table 6.

6.2 The screws that are tested for wedge tensile strength shall utilize a wedge of the angle specified in Table 7.

6.3 The hardness limits shall be met anywhere on the cross section through the threads, one diameter from the screw point.

6.4 Mechanical properties shall be determined using Test Methods F606/F606M.

7. Dimensions

7.1 Unless otherwise specified, the product shall conform to the dimensional specification detailed in the purchase order.

8. Workmanship, Finish, and Appearance

8.1 There shall be no evidence of carburization or gross decarburization on the surfaces of the heat-treated screws when measured in accordance with F2328 for inch products and F2328M for metric products.

8.2 The depth of partial decarburization shall be limited to F2328 Class 3 for inch products or F2328M Class 4 for metric products.

8.3 The surface discontinuities for these products shall conform to Specification F788/F788M.

9. Sampling and Number of Tests

9.1 Practice F1470 shall be used to determine the necessary sampling plan and the number of tests that must be performed to demonstrate that all of the requirements of this standard are met for each lot.

10. Test Methods

10.1 Conduct tests for proof load, wedge tensile, and ultimate tensile strength in accordance with Test Method F606/F606M.

10.2 Decarburization and carburization tests shall be conducted in accordance with Test Method F2328 for inch products and F2328M for metric products.

10.3 Surface discontinuities including thread lap inspection shall be conducted in accordance with Standard F788/F788M.

11. Inspection

11.1 If the additional tests described in 11.2 are required by the purchaser, it shall be specified in the inquiry, order, or contract.

11.2 The inspector representing the purchaser, upon reasonable notice, 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 and inspection required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. Product Marking

12.1 All screws with nominal diameters of 0.2 in. or 5 mm and larger shall be permanently marked to identify the material grade, "170" for inch series or "11.9" for metric and the manufacturer's or private label distributor's identification symbol.

12.2 Material grade and manufacturer's or private label distributor's identification shall be separate and distinct. Marks shall preferably be in different locations and, when on the same level, shall be separated by a distinctive mark such as a forward or backward slash, colon, dash, dot, or space.

TABLE 3 Mechanical Testing Requirements

Item	Nom. Dia.	Product Length	Hardness, max	Hardness, min	Test Conducted Using Full Size Product			Test Conducted Using Machined Test Specimen			
					Proof Load	Wedge Tensile Strength	Axial Tensile Strength	Yield Strength at 0.2% Offset	Tensile Strength	Elongation	% Red. of Area
1	All short lengths	Less than 3D[A]	B	B	...	...	...	...	...	...	...
2	≤1.0 in. or M24	Over 3D[A]	B	...	Z[C]	B	...	...	...	...	...
3	>1.0 in. or M24 and ≤ M36	Over 3D[A]	B	...	Z[C]	X[C]	...	Y[C]	Y[C]	Y[C]	Y[C]
4	> M36	Over 3D[A]	B	...	Z[C]	...	X[C]	Y[C]	Y[C]	Y[C]	Y[C]
5[D]	...	Over 3D[A]	B	...	...	...	X[C]	...	...	...	...

[A] D denotes nominal diameter of product.
[B] B Denotes mandatory test.
[C] C Either all tests denoted by X or all tests denoted by Y shall be performed. In case of arbitration full-size tests, denoted X, shall be decisive. Proof load test denoted Z shall be conducted when purchaser requests the test in inquiry and order.
[D] Item 5 would include socket set screws and screws with reduced loadability due to head configuration such as flat countersunk or button head screws.

TABLE 4 Tensile Requirements for Coarse Thread Screws-Inch Series

Screw Dia (*D*), in.	Threads, in.	Tensile Load, min, lbf	Stress Area, in.^{2A}	Proof Load (Length Measurement Method), min, lbf	Button and Countersunk Heads, Tensile Load, min lbf^{B}
0.073	64	447	0.00263	355	358
0.086	56	629	0.00370	500	503
0.099	48	828	0.00487	657	662
0.112	40	1 029	0.00604	815	821
0.125	40	1 351	0.00796	1,075	1 083
0.138	32	1 549	0.00909	1,227	1 236
0.164	32	2 380	0.0140	1 890	1 904
0.190	24	2 975	0.0175	2 363	2 380
0.250	20	5 412	0.0318	4 293	4 330
0.3125	18	8 916	0.0524	7 074	7 130
0.375	16	13 128	0.0775	10 463	10 540
0.4375	14	18 039	0.1063	14 351	14 430
0.500	13	24 083	0.1419	19 157	19 270
0.625	11	38 400	0.226	30 500	30 720
0.750	10	56 800	0.334	45 100	45 440
0.875	9	78 500	0.462	62 400	62 800
1.000	8	103 000	0.606	81 800	82 400
1.125	7	129 000	0.763	103 000	103 200
1.250	7	165 000	0.969	131 000	132 000
1.375	6	196 000	1.155	156 000	156 800
1.500	6	239 000	1.405	190 000	191 200

^{A} Stress areas based on Handbook H-28 (U.S. Department of Commerce) as follows:

$$A_s = 0.7854[D - (0.9743/n)]^2$$

where:

A_s = stress area,
D = nominal screw size, and
n = threads/in.

^{B} Because of the reduced loadability due to the head critical configuration of these parts, the full size tensile loads are based on 80% of the minimum heat treated material strength (170 KSI) and the stress areas.

13. Responsibility

13.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

14. Packaging and Package Marking

14.1 *Packaging:*

14.1.1 Unless otherwise specified, product shall be packaged according to the manufacturer's practice to prevent damage before and during shipment.

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

14.2 *Package Marking:*

14.2.1 Unless otherwise agreed between the purchaser and supplier, the container shall be marked to permit identification of the lot. Each shipping unit shall also include or be plainly marked with the following information:

14.2.1.1 ASTM designation,
14.2.1.2 Size,
14.2.1.3 Name and brand or trademark of the manufacturer,
14.2.1.4 Number of pieces,
14.2.1.5 Purchase order number, and
14.2.1.6 Country of origin.

15. Keywords

15.1 alloy steel; bolts; screws

TABLE 5 Tensile Requirements for Fine Thread Screws- Inch Series

Screw Dia (*D*), in.	Threads, in.	Tensile Load, min, lbf	Stress Area, in.[2A]	Proof Load (Length Measurement Method), min, lbf	Button and Countersunk Heads, Tensile Load, min lbf[B]
0.060	80	306	0.00180	243	245
0.073	72	472	0.00278	375	378
0.086	64	670	0.00394	532	536
0.099	56	889	0.00523	706	711
0.112	48	1124	0.00661	892	899
0.125	44	1407	0.00830	1 119	1129
0.138	40	1728	0.01015	1 369	1380
0.164	36	2503	0.01474	1 986	2005
0.190	32	3400	0.0200	2 700	2720
0.250	28	6139	0.0364	4 918	4950
0.3125	24	9822	0.0580	7 830	7888
0.375	24	14922	0.0878	11 861	11 941
0.4375	20	20211	0.1187	16 007	16 841
0.500	20	27200	0.1599	21 600	21 746
0.625	18	43 500	0.256	34 600	34 800
0.750	16	63 400	0.373	50 400	50 730
0.875	14	86 500	0.509	68 700	69 200
1.000	12	113 000	0.663	89 500	90 200
1.125	12	146 000	0.856	116 000	116 400
1.250	12	182 000	1.073	145 000	145 900
1.375	12	224 000	1.315	178 000	178 840
1.500	12	269 000	1.581	213 000	215 000

[A] Stress areas based on Handbook H-28 (U.S. Department of Commerce) as follows:

$$A_s = 0.7854[D - (0.9743/n)]^2$$

where:

A_s = stress area,
D = nominal screw size, and
n = threads/in.

[B] Because of the reduced loadability due to the head critical configuration of these parts, the full size tensile loads are based on 80% of the minimum heat treated material strength (170 KSI) and the stress areas.

TABLE 6 Tensile Requirements for Metric Screws

NOTE 1—All values are rounded to 3 significant digits.

Thread Size	Stress Area, mm^2	Tensile Load, min, kN	Proof Load, kN
M1.6 × 0.35	1.27	1.46	1.19
M2 × 0.4	2.07	2.39	1.94
M2.5 × 0.45	3.39	3.91	3.09
M3 × 0.5	5.03	5.80	4.71
M4 × 0.7	8.78	10.1	8.22
M5 × 0.8	14.2	16.3	13.3
M6 × 1	20.1	23.1	18.8
M8 × 1.25	36.6	42.1	34.2
M10 × 1.5	58.0	66.9	54.3
M12 × 1.75	84.3	97	78.9
M14 × 2	115	132	108
M16 × 2	157	181	147
M20 × 2.5	245	282	230
M24 × 3	353	407	330
M30 × 3.5	561	646	525
M36 × 4	817	942	764
M42 × 4.5	1120	1290	1050
M48 × 5	1470	1690	1380

TABLE 7 Wedge Test Angles

Screw Dia (*D*), in. and mm	Wedge Angle, Deg	
	Body Lengths 2*D* or Less or Threaded to the Head	Body Lengths Greater than 2*D*
0.112 – 0.500 in. or up through 12 mm, inclusive	6	10
0.625 – 0.750 in. or 13–16 mm , inclusive	6	8
0.875 – 1.500 in. or 20–36 mm, inclusive	4	6

SUPPLEMENTARY REQUIREMENTS

The following Supplementary Requirement shall apply only when specified by the purchaser in the contract or purchase order. Supplementary requirements shall in no way negate any requirement of the specification itself.

S1. Specific Grade Chemical Compositions

S1.1 When Supplementary Requirement S1 is specified on the order, the chemical composition shall conform to one of the compositions in Table S1.1 at the option of the supplier, unless a specific composition (Grade) has been specified on the purchase order.

TABLE S1.1 Chemical Composition

Grade Designation	4037	4042	4137	4140	4142	4145	4340	8740	5137M	51B37M
UNS Number	G40370	G40420	G41370	G41400	G41420	G41450	G43400	G87400	. . .	. . .
Carbon:										
Heat Analysis	0.35–0.40	0.40–0.45	0.35–0.40	0.38–0.43	0.40–0.45	0.43–0.48	0.38–0.43	0.38–0.43	0.35–0.40	0.33–0.40
Product Analysis	0.33–0.42	0.38–0.47	0.33–0.42	0.36–0.45	0.38–0.47	0.41–0.50	0.36–0.45	0.36–0.45	0.33–0.42	0.31–0.42
Manganese:										
Heat Analysis	0.70–0.90	0.70–0.90	0.70–0.90	0.75–1.00	0.75–1.00	0.75–1.00	0.60–0.80	0.75–1.00	0.30–0.50	0.30–0.50
Product Analysis	0.67–0.93	0.67–0.93	0.67–0.93	0.71–1.04	0.71–1.04	0.71–1.04	0.57–0.83	0.71–1.04	0.27–0.53	0.27–0.53
Phosphorus, max.:										
Heat Analysis	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Product Analysis	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Sulfur, max.:										
Heat Analysis	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Product Analysis	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon:										
Heat Analysis	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35	0.15–0.35
Product Analysis	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37	0.13–0.37
Nickel:										
Heat Analysis	[A]	[A]	[A]	[A]	[A]	[A]	1.65–2.00	0.40–0.70	[A]	[A]
Product Analysis	. . .	. . .	. . .	. . .	. . .	. . .	1.65–2.05	0.37–0.73	. . .	. . .
Chromium:										
Heat Analysis	[A]	[A]	0.80–1.10	0.80–1.10	0.80–1.10	0.80–1.10	0.70–0.90	0.40–0.60	0.90–1.20	0.95–1.25
Product Analysis	. . .	. . .	0.75–1.15	0.75–1.15	0.75–1.15	0.75–1.15	0.67–0.93	0.37–0.63	0.85–1.25	0.90–1.30
Molybdenum:										
Heat Analysis	0.20–0.30	0.20–0.30	0.15–0.25	0.15–0.25	0.15–0.25	0.15–0.25	0.20–0.30	0.20–0.30	[A]	[A]
Product Analysis	0.18–0.32	0.18–0.32	0.13–0.27	0.13–0.27	0.13–0.27	0.13–0.27	0.18–0.32	0.18–0.32	. . .	. . .
Boron:										
Heat Analysis	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	0.0005–0.003
Product Analysis	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	[B]

[A] Elements shown with an "A" are not applicable to that grade designation.
[B] Boron is not subject to product analysis.