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Standard Specification for Alloy Steel Socket-Head Cap Screws [Metric]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 the requirements for quenched and tempered alloy steel hexagon socket-head cap screws, 1.6 mm through 48 mm in diameter having a minimum ultimate tensile strength of 1220 MPa.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—This specification is the metric companion of Specification A574.

1.3 The following hazard caveat pertains only to the test method portions, sections 5.1, 5.6, 8, and 12, 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.*

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
- F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets (Metric)
- 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
- F1789 Terminology for F16 Mechanical Fasteners

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

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

2.2 ASME Standards:³

B18.3.1M Metric Socket Head Cap Screws

B18.12 Glossary of Terms for Mechanical Fasteners

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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*—The definition of terms used in this specification shall be as specified in Terminology F1789, ASME B18.12, or the applicable referenced standards, unless otherwise defined herein. In the event that there are differences for a given term ASTM definitions shall be used.

4. Ordering Information

4.1 Orders for socket head cap screws under this specification shall include the following information:

4.1.1 ASTM designation and year of issue.

4.1.2 Name of the screw (SHCS).

4.1.3 Quantity (number of pieces by size).

4.1.4 Dimensions, including nominal thread designation, thread, pitch, and nominal screw length (millimeters).

4.2 Orders for socket head cap screws shall include the following optional requirements if specified by the purchaser:

4.2.1 Inspection at point of manufacture.

4.2.2 Coating, if a protective finish other than those, which are described in 5.5, is required, it must be specified (see 5.6).

4.2.3 Certified test reports, as required (see Section 15).

4.2.4 Additional testing (see 12.1).

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.

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

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

- 4.2.5 Special packaging (see 18.1.2).
- 4.2.6 Supplementary requirements (see S1).
- 4.2.7 Special requirements.
- 4.2.8 For establishment of a part identifying system see ASME B18.24.

5. Materials and Manufacture

5.1 The screws shall be fabricated from alloy steel made to a fine grain practice. In the event of controversy over grain size, referee tests on finished screws conducted in accordance with Test Methods E112 shall prevail.

5.2 Screws in sizes through M20, and with lengths through ten times the nominal product size or 150 mm, whichever is shorter, shall be cold headed, except that when specified by the purchaser the screws shall be hot headed. Larger sizes and longer lengths shall be cold or hot headed at the option of the manufacturer, unless otherwise specified by the purchaser. Screws M42 and larger shall be permitted to be machined. Sockets shall be forged or machined at the option of the manufacturer.

5.3 Screws in sizes through M24, and product lengths through 150 mm inclusive, shall be roll threaded, unless otherwise specified by the purchaser. Larger products shall be rolled, cut, or ground at the option of the manufacturer.

5.4 Screws shall be heat treated by quenching in oil from above the transformation temperature and then tempered by reheating to at least 380°C to achieve the mechanical properties specified in Section 7 and Table 1.

5.4.1 When specified by the purchaser, the minimum tempering temperature shall be verified by subjecting screws to 370°C for 30 minutes at temperature. The mean cross section hardness of three readings on the screw before and after retempering shall not differ by more than 20 points Vickers (DPH).

5.5 *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.

5.6 Protective Coatings:

5.6.1 When a protective finish other than as specified in 5.5 is required, it shall be specified on the purchase order with the applicable finish specification.

5.6.2 When protective or decorative coatings are applied to the screws, precautions specified by the coating requirements to minimize internal hydrogen embrittlement shall be exercised. Additional precautions such as the requirements in Test Method F1940 and Test Methods F606M shall be by agreement with the purchaser.

6. Chemical Composition

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

6.2 One or more of the following alloying elements: chromium, nickel, molybdenum, or vanadium shall be present in the steel in sufficient quantity to ensure 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).

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

6.4 Steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

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

7. Mechanical Properties

7.1 Socket head cap screws shall be tested in accordance with the mechanical testing requirements specified in Table 3, and shall meet the mechanical requirements in Table 1 and Table 4.

7.2 The screws that are tested for wedge tensile strength shall utilize a wedge of the angle specified in Table 5 under the head. To meet the requirements of the wedge test, there must be a tensile failure in the body or thread section. For the purpose of this test, failure means separation into two pieces. Screws threaded to the head shall pass the requirements for this test if the fracture that caused failure originated in the thread area, even though it may have propagated into the fillet area or the head before separation.

8. Metallurgical Requirement

8.1 Carburization or Decarburization:

8.1.1 There shall be no evidence of carburization or total decarburization on the surfaces of the heat-treated screws when measured in accordance with Test Method F2328M (Class 4 Product).

TABLE 1 Mechanical Requirements

Property Class	12.9 ^A
Full-size screws:	
Tensile or wedge strength, min, MPa	1220
Proof load (stress), min, MPa	970
Machined test specimen:	
Yield strength at 0.2 % offset, min, MPa	1100
Tensile strength, min, MPa	1220
Elongation in 5D, min, %	10 ^A
Reduction of area, min, %	35
Product hardness:	
Rockwell	38 to 44 HRC
Vickers	372 to 434 DPH

^A Elongation is 2 percentage points higher than property class 12.9.

TABLE 2 Chemical Requirements

Element	Composition, %	
	Heat Analysis	Product Analysis
Carbon	0.33 to 0.48	0.31 to 0.50
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Alloying elements	See 6.2	

TABLE 3 Mechanical Testing Requirements

Item	Description	Tensile Load, min, kN	Product Length	Hardness, max	Hardness, min	Decarb/Carburization	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	Reduction of Area
1	All short lengths	...	≤3D ^A	<i>B</i>	<i>B</i>	<i>B</i>	...	...	...	...	...	...	...
2	Smaller SHCS	≤1200	3D to 300 mm	<i>B</i>	...	<i>B</i>	Z ^C	X ^C	...	...	...	...	...
3	Smaller SHCS	≤1200	Over 300 mm	<i>B</i>	...	<i>B</i>	Z ^C	X ^C	...	Y ^C	Y ^C	Y ^C	Y ^C
4	Larger SHCS	≥1200	>3D	<i>B</i>	...	<i>B</i>	Z ^C	...	X ^C	Y ^C	Y ^C	Y ^C	Y ^C

^A *D* denotes nominal diameter of product.

^B Denotes mandatory test.

^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 test denoted Z shall be conducted when purchaser requests the test in inquiry and order.

TABLE 4 Minimum Ultimate Tensile Loads

NOTE—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	1.55	1.23
M2 × 0.4	2.07	2.53	2.01
M2.5 × 0.45	3.39	4.14	3.2
M3 × 0.5	5.03	6.14	4.88
M4 × 0.7	8.78	10.7	8.52
M5 × 0.8	14.2	17.3	13.8
M6 × 1	20.1	24.5	19.5
M8 × 1.25	36.6	44.6	35.5
M10 × 1.5	58.0	70.8	56.3
M12 × 1.75	84.3	103	81.8
M14 × 2	115	140	112
M16 × 2	157	192	152
M20 × 2.5	245	299	238
M24 × 3	353	431	342
M30 × 3.5	561	684	544
M36 × 4	817	997	792
M42 × 4.5	1120	1370	1090
M48 × 5	1470	1790	1430

TABLE 5 Wedge Test Angle

Product	Diameter, mm	degree
Socket-head cap screws threaded 2D and closer to underside of head	through 20	6
	over 20 to 36	4
All other socket-head cap screws	through 12	10
	over 12 to 16	8
	over 16 to 36	6

8.1.2 The depth of partial decarburization shall be limited to the values in Test Method **F2328M** (Class 4 Product) when measured as described therein.

9. Dimensions

9.1 Unless otherwise specified, the product shall conform to the requirements of ASME **B18.3.1M**.

10. Workmanship, Finish and Appearance

10.1 *Surface Discontinuities*—The surface discontinuities for these products shall conform to Specification **F788/F788M** and the additional limitations specified herein.

10.2 Forging Cracks:

10.2.1 Forging cracks that connect the socket to the periphery of the head as shown in **Fig. 1** are not permissible.

10.2.2 Forging cracks originating on the periphery of the head and with a traverse indicating a potential to intersect on the top of the socket head as shown in **Fig. 1** are not permissible.

10.2.3 Other forging cracks are permissible provided those that are located in the bearing area, fillet, and top surfaces do not have a depth exceeding 0.03D or 0.13 mm, whichever is greater. For peripheral discontinuities, the maximum depth shall be 0.06D or 1.6 mm, whichever is greater (see **Fig. 1**).

10.2.4 Forging cracks located in the socket wall within 0.1 times the actual key engagement (*T*) from the bottom of the socket are not permissible. Discontinuities located elsewhere in the socket shall not have a length exceeding 0.25*T*, or a maximum depth of 0.03D or 0.13 mm, whichever is greater (see **Fig. 2**).

10.3 Seams in the shank shall not exceed a depth of 0.03D or 0.13 mm, whichever is greater.

10.4 *Thread Discontinuities*—Threads shall have no laps at the root or on the flanks located below the pitch line, as shown in **Fig. 3**, when inspected in accordance with Specification **F788/F788M**, S1.2. Laps are permitted at the thread crest (**Fig. 3C**) that do not exceed 25 % of the basic thread height, and on the thread flanks above the pitch diameter. Longitudinal seams rolled beneath the root of the thread and across the crests of the threads are acceptable within the limits of **10.3**.

11. Sampling and Number of Tests

11.1 Guide **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.

12. Test Methods

12.1 Testing, to demonstrate that the requirements in **5.4.1**, Section **7**, or any additional mechanical tests that are required by the purchaser have been met, shall be in accordance with Test Methods **F606M** at room temperature.

12.2 The inspection and evaluation of surface discontinuities shall be in accordance with the requirements in Specification **F788/F788M**.

12.3 Decarburization and carburization tests shall be conducted in accordance with Test Method **F2328M**, Class 4.