Designation: ~~F468 – 22~~ F468 – 23

Standard Specification for Nonferrous Bolts, Hex Cap Screws, Socket Head Cap Screws, and Studs for General Use[1]

This standard is issued under the fixed designation F468; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers the requirements for commercial wrought nonferrous bolts, hex cap screws, and studs 0.250 to 1.500 ~~in. and~~ in., socket head cap screws (including socket head cap, button head and flat countersunk head configurations) with nominal thread 0.06 (size 0) through 1.500 in. and low head socket cap screws with nominal thread 0.112 (size 4) through 0.625 (⅝) in. inclusive in diameter manufactured from a number of alloys in common use and intended for general service applications.

1.2 Applicable nuts for use with bolts, cap screws, and studs covered by this specification are covered by Specification F467.

1.2.1 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—A complete metric companion to Specification F468 has been developed—F468M; therefore no metric equivalents are presented in this specification.

1.3 *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]

B154 Test Method for Mercurous Nitrate Test for Copper Alloys
B193 Test Method for Resistivity of Electrical Conductor Materials
B211/B211M Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
B565 Test Method for Shear Testing of Aluminum and Aluminum-Alloy Rivets and Cold-Heading Wire and Rods
B574 Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Molybdenum-Chromium-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Rod
D3951 Practice for Commercial Packaging
E8/E8M Test Methods for Tension Testing of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials

[1] This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.04 on Nonferrous Fasteners.
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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**

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys (Withdrawn 2017)[3]
E38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys (Withdrawn 1989)[3]
E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry (Withdrawn 2022)[3]
E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)[3]
E55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition
E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)[3]
E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys (Withdrawn 2010)[3]
E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)[3]
E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
E101 Test Method for Spectrographic Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique (Withdrawn 1996)[3]
E120 Test Methods for Chemical Analysis of Titanium and Titanium Alloys (Withdrawn 2003)[3]
E165/E165M Practice for Liquid Penetrant Testing for General Industry
E227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique (Withdrawn 2002)[3]
E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
E478 Test Methods for Chemical Analysis of Copper Alloys
E1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion
F467 Specification for Nonferrous Nuts for General Use
F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
F788 Specification for Surface Discontinuities of Bolts, Screws, Studs, and Rivets, Inch and Metric Series
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

2.2 *ASME Standards:*[4]

ASME B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.3 Screw Thread Gaging System for Dimensional Acceptability – Inch Screw Threads (IN, UNR, and UNJ)
ASME B18.2.1 Square and Hex Bolts and Screws, Including Hex Cap Screws
ASME B18.3 Socket Head Cap, Shoulder, and Set Screws – Inch Series
ASME H35.1 Alloy and Temper Designation Systems for Aluminum

2.3 *Federal Specifications:*[5]

QQ-N-286 Nickel-Copper-Aluminum Alloy, Wrought (UNS N05500)

3. Ordering Information

3.1 Orders for fasteners under this specification shall include the following information:

3.1.1 Quantity (number of pieces of each item and size),

3.1.2 Name of item. For silicon bronze alloy 651, state if hex cap screw dimensions or roll thread body diameter are required (see 7.1.2);

3.1.3 Size (nominal diameter, threads per inch, thread pitch, thread class, and length);

3.1.4 Alloy number (Table 1). For Ti5, state Class A or Class B (Table 1, 6.5, and 6.5.1);

3.1.5 Stress relieving, if required (see 4.2.3);

3.1.6 Source inspection, if required (see Section 13);

3.1.7 Certificate of compliance, conformance, or test reports, if required (see Section 15);

3.1.8 Additional requirements, if any, to be specified on the purchase order (see 4.2.1, 4.2.4, 7.3.1, 8.2, 10.1, and 11.1);

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.
[5] DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 http://quicksearch.dla.mil/

TABLE 1 Chemical Requirements

Composition, % maximum except as shown, ellipses indicate no requirement for listed element													
UNS Designation Number	Copper and Copper-Base Alloys[A]												
	Alloy	General Name	Aluminum	Copper	Iron	Manganese	Nickel[B]	Phosphorus	Silicon	Zinc	Lead	Tin	Arsenic
C11000	110	ETP copper	. . .	99.9 min[C]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
C26000	260	cartridge brass 70 %	. . .	68.5–71.5[D]	0.05	. . .	. . .	. . .	. . .	balance	0.07	. . .	. . .
C27000	270	yellow brass 65 %	. . .	63.0–68.5[D]	0.07	. . .	. . .	. . .	. . .	balance	0.09	. . .	. . .
C46200	462	naval brass 63 – 1/2 %	. . .	62.0–65.0[E]	0.10	. . .	. . .	. . .	. . .	balance	0.20	0.5–1.0	. . .
C46400	464	naval brass	. . .	59.0–62.0[E]	0.10	. . .	. . .	. . .	. . .	balance	0.20	0.5–1.0	. . .
C51000	510	phosphor bronze 5 %[A]	. . .	balance[F]	0.10	. . .	. . .	0.03–0.35	. . .	0.30	0.05	4.2–5.8	. . .
C61300	613	aluminum bronze	6.0–7.5	balance[G]	2.00–3.00	0.20	0.15	0.015	0.10	0.10	0.01	0.20–0.50	. . .
C61400	614	aluminum bronze[D]	6.0–8.0	balance[C,F]	1.50–3.50	1.00	. . .	0.015	. . .	0.20	0.01	. . .	. . .
C63000	630	aluminum bronze	9.0–11.0	balance[C,F]	2.00–4.00	1.50	4.0–5.5	. . .	0.25	0.30	. . .	0.20	. . .
C64200	642	aluminum bronze	6.3–7.6	balance[C,F]	0.30	0.10	0.25	. . .	1.5–2.2[H]	0.50	0.05	0.20	0.09
C65100	651	silicon bronze low[B]	. . .	balance[C,F]	0.80	0.70	. . .	. . .	0.8–2.0	1.5	0.05	. . .	. . .
C65500	655	silicon bronze high[A]	. . .	balance[C,F]	0.80	0.05–1.30	0.6	. . .	2.8–3.8	1.5	0.05	. . .	. . .
C66100	661	silicon bronze	...	balance[C,F]	0.25	1.50	. . .	. . .	2.8–3.5	1.5	0.20–0.8	. . .	. . .
C67500	675	manganese bronze[A]	0.25 max	57.0–60.0[C,F]	0.80–2.0	0.05–0.50	. . .	. . .	. . .	balance	0.20	0.5–1.5	. . .
C71000	710	copper-nickel 20 %	. . .	balance[C,F]	1.0	1.00	19.0–23.0	. . .	. . .	1.00	0.05	. . .	. . .
C71500	715	copper-nickel 30 %	. . .	balance[C,F]	0.40–1.0	1.00	29.0–33.0	. . .	. . .	1.00	0.05	. . .	. . .

[A]Elements shown as balance shall be arithmetically computed by deducting the sum of the other named elements from 100.
[B]Cobalt is to be counted as nickel.
[C]Silver is to be counted as copper
[D]Minimum content of copper plus all other elements with specified limits shall be ~~99.7%.~~99.7 %.
[E] Minimum content of copper plus all other elements with specified limits shall be ~~99.6%~~99.6 %
[F] Minimum content of copper plus all other elements with specified limits shall be 99.5 %
[G]Per UNS C61300: copper (including silver) plus specified elements = 99.8 min; this standard requires copper plus silver = 88.5–91.5
[H]This standard allows for an alloy with max 2.6 % silicon provided the sum of all the elements other than copper, silicon, and iron does not exceed 0.30 %.

TABLE 1 *Continued*

Nickel and Nickel-Base Alloys[A]																	
UNS Designation Number	Alloy	General Name	Aluminum	Carbon,	Chromium	Copper	Iron	Manganese	Nickel	Phosphorus	Silicon	Titanium	Cobalt	Molybdenum	Sulfur	Vanadium	Tungsten	Niobium
N10001	335	Ni-Mo Alloy Solid Solution Strengthened	. . .	0.12	1.0	. . .	6.0	1.0	balance	0.040	1.00	. . .	2.50	26.0–33.0	0.030	0.60	. . .	. . .
N10276	276	Ni-Mo-Cr Alloy SSS	. . .	0.02	14.5–16.5	. . .	4.0–7.0	1.00	balance	0.030	0.08	. . .	2.50	15.0–17.0	0.030	0.35	3.0–4.5	. . .
N04400	400	Ni-Cu Alloy SSS	. . .	0.3	. . .	balance	2.5	2.0	63.0–70.0	. . .	0.5	. . .		. . .	0.024	. . .	. . .	. . .
N04405	405	Ni-Cu Alloy SSS	. . .	0.3	. . .	balance	2.5	2.0	63.0–70.0	. . .	0.5	. . .		. . .	0.025–0.060	. . .	. . .	. . .
N05500	500	Ni-Cu Alloy Precipitation Hardenable	2.30–3.15	0.25	. . .	balance	2.0	1.5	63.0–70.0	...	0.5	0.35–0.85		. . .	0.01	. . .	. . .	. . .
N06059	59	Low Carbon Ni-Cr-Mo Alloy	0.1–0.4	0.010	22.0–24.0	0.5	1.5	0.5	balance	0.015	0.10	. .	0.3	15.0–16.5	0.010	. . .	. . .	. . .
N06625	625[B]	Ni-Cr-Mo-Cb (Nb) Alloy SSS	0.40	0.10	20.0–23.0	. . .	5.0	0.50	balance	0.015	0.50	0.40	1.00	8.0–10.0	0.015	. . .	. . .	3.15–4.15

TABLE 3.1.4 *Continued*

TABLE 1 *Continued*

Nickel and Nickel-Base Alloys[A]

UNS Designation Number	Alloy	General Name	Aluminum	Carbon,	Chromium	Copper	Iron	Manganese	Nickel	Phosphorus	Silicon	Titanium	Cobalt	Molybdenum	Sulfur	Vanadium	Tungsten	Niobium
N06686	686	Ni-Cr-Mo-W Alloy	. . .	0.010	19.0–23.0	. . .	5.0	0.75	balance	0.04	0.08	0.02–0.25		15.0–17.0	0.02	. . .	3.0–4.4	. . .

[A] Elements shown as balance shall be arithmetically computed by deducting the sum of the other named elements from 100.
[B] See 4.1.3.

TABLE 1 *Continued*

Composition, %

Aluminum-Base Alloys[A,B]

UNS Designation Number	Alloy	General Name	Aluminum	Chromium	Copper	Iron	Manganese	Silicon	Titanium	Zinc	Magnesium	Other Elements	
												Each	Total
A92024	2024	Aluminum 2024	balance	0.10 max	3.8–4.9	0.50	0.30–0.9	0.50	0.15[C]	0.25	1.2–1.8	0.05	0.15
A96061	6061	Aluminum 6061	balance	0.04–0.35	0.15–0.40	0.7	0.15	0.40–0.8	0.15	0.25	0.8–1.2	0.05	0.15
A97075	7075	Aluminum 7075	balance	0.18–0.28	1.2–2.0	0.50	0.30	0.40	0.20[D]	5.1–6.1	2.1–2.9	0.05	0.15

[A] Analysis shall regularly be made only for the elements specified in this table. If, however, the presence of other elements is suspected or indicated in amounts greater than the specified limits, further analysis shall be made to determine that these elements are not present in excess of the specified limits.
[B] Elements shown as balance shall be arithmetically computed by deducting the sum of the other named elements from 100.
[C] Titanium + zirconium 0.20 %, max for extruded and forged products only, when agreed upon.
[D] Titanium + zirconium 0.25 %, max for extruded and forged products only, when agreed upon.

TABLE 1 *Continued*

Titanium and Titanium-Base Alloys[A]

UNS Designation Number	Alloy	General Name	Aluminum	Carbon	Iron	Titanium	Hydrogen	Nitrogen	Oxygen	Palladium	Vanadium	Chromium	Molybdenum	Zirconium	Tin	Silicon	Residuals[B]	
																	each	total
R50250	1	Titanium, Unalloyed Gr 1	. . .	0.10	0.20	balance	0.015	0.03	0.18	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
R50400	2	Titanium, Unalloyed Gr 2	. . .	0.10	0.30	balance	0.015	0.03	0.25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
R50700	4	Titanium, Unalloyed Gr 4	. . .	0.10	0.50	balance	0.015	0.05	0.40	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.1	0.4
R56400	5[C]	Titanium Alloy Gr 5[C]	5.5–6.75	0.10	0.40	balance	0.015	0.05	0.20	. . .	3.5–4.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .
R56401	23	Titanium Alloy 6Al-4V ELI	5.5–6.5	0.08	0.25	balance	0.012	0.05	0.13	. . .	3.5–4.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .
R52400	7	Titanium, Low Alloyed Gr 7	. . .	0.10	0.30	balance	0.015	0.03	0.25	0.12–0.25[D]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
R58640	19	Titanium Alloy Beta C	3.0–4.0	0.05	0.30	balance	0.0200	0.03	0.12		7.5–8.5	5.5–6.5	3.5–4.5	3.5–4.5	. . .	. . .	0.15	0.4

TABLE 3.1.4 *Continued*

TABLE 1 *Continued*

Titanium and Titanium-Base Alloys[A]

UNS Designation Number	Alloy	General Name	Aluminum	Carb-on	Iron	Titanium	Hydrogen	Nitrogen	Oxygen	Palladium	Vanadium	Chromium	Molybdenum	Zirconium	Tin	Silicon	Residuals[B]	
																	each	total
R55111	32	Titanium Alloy 5Al-1Sn-1V-1Zr	4.5–5.5	0.08	0.25	balance	0.015	0.03	0.11	. . .	0.6–1.4	. . .	0.6–1.2	0.6–1.4	0.6–1.4	0.06–0.14	. . .	. . .

[A] Elements shown as balance shall be arithmetically computed by deducting the sum of the other named elements from 100.
[B] A residual is an element present in a metal or an alloy in small quantities inherent to the manufacturing process but not added intentionally. Residual elements need not be reported unless a report is specifically required by the purchaser.
[C] Identical chemical requirements apply to both Class A and B as defined in Table 2 and 6.5.
[D] This standard allows for ~~0.10%~~0.10 % max ruthenium and 0.10 % max palladium, or both, to be added to Grade 19 for enhanced corrosion resistance as negotiated between purchaser and vendor. Chemical analysis is not required unless specifically required by the purchaser.

3.1.9 Supplementary Requirements, if any; and

3.1.10 ASTM designation and ~~date~~year of issue.

NOTE 2—*Example*
10 000 pieces, Hex Cap Screw, 0.250 in.-20 × 3.00 in., Alloy 270. Furnish Certificate of Compliance, Supplementary Requirement S1, ASTM F 468-XX.

4. Materials and Manufacture

4.1 *Materials:*

4.1.1 The bolts, cap screws, socket head cap screws and studs shall be manufactured from material having a chemical composition conforming to the requirements in Table 1, except as provided in Supplementary Requirement S5, and capable of developing the required mechanical properties for the specified alloy in the finished fastener. See Specification B574 for nickel alloys.

4.1.2 The starting condition of the raw material shall be at the discretion of the fastener manufacturer except as provided in 4.1.3 and Supplementary Requirement S5, but shall be such that the finished products conform to all of the specified requirements.

4.1.3 Alloy 625 material shall be refined using the electroslag remelting process (ESR), or the vacuum arc remelting process (VAR).

4.2 *Manufacture:*

4.2.1 *Forming*—Unless otherwise specified, the fasteners shall be cold formed, hot formed, or machined from suitable material, at the option of the manufacturer.

4.2.2 *Condition*—Except as provided in 4.2.3 and Supplementary Requirement S5, the fasteners shall be furnished in the following conditions:

Alloy	Condition
Copper (all alloys)	As formed or stress relieved at manufacturer's option
Nickel alloys:	
400 and 405	As formed or stress relieved at manufacturer's option
500	Solution annealed and aged
625	Annealed
Aluminum alloys:	
2024-T4	Solution treated and naturally aged
6061-T6	Solution treated and artificially aged
7075-T73	Solution treated and stabilized
Titanium	As formed

4.2.3 *Stress Relieving*—When required, stress relieving shall be specified by the purchaser for nickel alloys 400 and 405 and all copper alloys.

4.2.4 *Threads*—Unless otherwise specified, the threads shall be rolled or cut at the option of the manufacturer.

4.2.4.1 Bolts, cap screws and studs shall be rolled or cut at the option of the manufacturer.

4.2.4.2 Socket head cap screws and flat countersunk head cap screws in sizes up to 1.00 in. inclusive and product lengths up to 6.00 in. inclusive shall have threads formed by rolling, except by special arrangement with the purchaser. Larger products may be rolled or cut at the option of the manufacturer.

4.2.4.3 Button and low head cap screws shall have threads formed by rolling.

5. Chemical Composition

5.1 *Chemical Composition*—The fasteners shall conform to the requirements as to chemical composition prescribed in Table 1 for the specified alloy, except as provided in Supplementary Requirement S5 when specified by the purchaser.

5.2 *Product Analysis:*

5.2.1 Product analyses may be made by the purchaser from finished products representing each lot. The chemical composition thus determined shall conform to the requirements in Table 1~~.~~, except as provided in Supplementary Requirement S5 when specified by the purchaser.

5.2.2 In the event of disagreement, a referee chemical analysis of samples from each lot shall be made in accordance with 10.1 and 11.1.

6. Mechanical Properties

6.1 The fasteners shall be tested in accordance with the mechanical testing requirements for the applicable type, length of product, and minimum tensile strength and shall meet the mechanical properties in Table 2 and Table 3 for the specified alloy except for ~~button~~ button, low and flat countersunk head cap screws, which shall meet ~~80%~~80 % of the listed tensile values. This requirement applies to full size testing only.

6.2 Fasteners having a length equal to or longer than the "minimum length of product requiring tension testing" as specified in Test Methods F606/F606M and a breaking load of 120 000 lbf or less shall be tested full size and shall meet the full-size tensile (minimum and maximum) and yield strength properties in Table 2 for the specified alloy.

6.3 Fasteners having a length equal to or longer than the "minimum length of product requiring tension testing" as specified in Test Methods F606/F606M and a breaking load exceeding 120 000 lbf shall preferably be tested full size and shall meet the full-size tensile (minimum and maximum) and yield strength properties in Table 2. When equipment of sufficient capacity for such tests is not available, or if excessive length of the bolts or stud makes full-size testing impractical, standard round specimens shall be used which shall meet the "machined specimen tests" tensile properties in Table 2. In the event of a discrepancy between full-size and machined specimen tension tests, full-size tests shall be used as the referee method to determine acceptance.

6.4 For all alloys except aluminum and titanium, fasteners that are too short (lengths less than that specified in Test Methods F606/F606M as the "minimum length of product requiring tension testing"), that have insufficient threads for tension testing (see 10.2), or that have drilled or undersized heads weaker than the thread section, are not subject to tension tests but shall conform to the minimum and maximum hardness in Table 2. Hardness tests are not applicable to aluminum and titanium alloys. When required for aluminum alloys, a shear test shall be performed in accordance with 10.2.2 and 11.2.2. Test results shall conform to the following minimum shear strength requirements: 37 ksi for 2024-T4; 25 ksi for 6061-T6; and 41 ksi for 7075-T73.

6.5 Full-size bolts and cap screws subject to tension tests shall be tested using a wedge under the head. Wedge angles shall be as follows, except for Ti5 Class B which shall use wedge angles as defined in 6.5.1. The wedge shall be 10° for bolts and cap screws of 0.750-in. nominal diameter and less, and 6° for bolts and cap screws over 0.750 in. in diameter. For bolts and cap screws threaded essentially to the head, the wedge angle shall be 6° for sizes 0.750 in. in nominal diameter and less and 4° for sizes over 0.750 in. in diameter.

6.5.1 Ti5 Class B wedge angles shall be 6° for bolts and cap screws of 0.750 in. nominal diameter and less and 4° for bolts and cap screws over 0.750 in. in diameter. For bolts and cap screws threaded essentially to the head, the wedge angle shall be 4° for bolts and cap screws of 0.750 in. nominal diameter and less and 2° for bolts and cap screws over 0.750 in. in diameter.

6.5.2 ~~Flat countersunk head cap screws and button~~ Button, low and flat countersunk head cap screws shall be axially tensile tested.

6.6 Where both tension and hardness tests are performed, the tension test results shall take precedence for acceptance purposes.

7. Dimensions

7.1 *Bolt, Hex, and Socket Head Cap Screws:*