Designation: B472 – 10 (Reapproved 2015)

Standard Specification for Nickel Alloy Billets and Bars for Reforging[1]

This standard is issued under the fixed designation B472; 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 UNS N06002, UNS N06030, UNS N06035, UNS N06022, UNS N06200, UNS N10362, UNS N06230, UNS N06600, UNS N06617, UNS N06625, UNS N08020, UNS N08026, UNS N08024, UNS N08120, UNS N08926, UNS N08367, UNS N10242, UNS N10276, UNS N10665, UNS N10675, UNS N12160, UNS R20033, UNS N06059, UNS N06686, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R30556[2] billets and bars for reforging.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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 become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *billets and bars, n*—terms billets and bars as used in this specification shall be understood as billets and bars for reforging.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 Quantity (weight or number of pieces),

4.1.2 Name of material or UNS number,

4.1.3 Form (bar or billet),

4.1.4 Dimensions,

4.1.5 ASTM designation and year of issue,

4.1.6 Inspection (12.1),

4.1.7 Certification—State if certification or a report of test results is required (Section 14),

4.1.8 Supplementary requirements, if any, and

4.1.9 If possible, the intended end use.

NOTE 1—A typical ordering description is as follows: 10 000 lb (4536 kg), UNS N08020, forging bar, 4¼ in. (107.95 mm) round, Specification B472.

5. Materials and Manufacture

5.1 The products shall be hot worked from ingots by rolling, forging, extruding, hammering, or pressing.

5.2 The products may be conditioned by chipping, grinding, or machining to remove injurious surface defects provided the depth of conditioning does not exceed that which will affect the surface condition or dimensions of the article to be forged from the bar or billet.

6. Chemical Composition

6.1 The material shall conform to the requirements as to chemical composition prescribed in Table 1.

[1] This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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[2] New designation established in accordance with ASTM E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[3] 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 Requirements

Element	Composition, %					
	UNS N08026	UNS N08020	UNS N08024	UNS N08367	UNS N08926	UNS R20033
Carbon, max	0.03	0.07	0.03	0.030	0.020	0.015
Manganese, max	1.00	2.00	1.00	2.00	2.00	2.0
Phosphorus, max	0.03	0.045	0.035	0.040	0.03	0.02
Sulfur, max	0.03	0.035	0.035	0.030	0.01	0.01
Silicon, max	0.50	1.00	0.50	1.00	0.50	0.50
Nickel	33.00–37.20	32.00–38.00	35.00–40.00	23.50–25.50	24.00–26.00	30.0–33.0
Chromium	22.00–26.00	19.00–21.00	22.50–25.00	20.00–22.00	19.00–21.00	31.0–35.0
Molybdenum	5.00–6.70	2.00–3.00	3.50–5.00	6.00–7.00	6.0–7.0	0.50–2.0
Copper	2.00–4.00	3.00–4.00	0.50–1.50	0.75 max	0.5–1.5	0.30–1.20
Columbium (Nb) + tantalum	...	8 × carbon–1.00	0.15–0.35	...	...	...
Nitrogen	0.10–0.16	...	...	0.18–0.25	0.15–0.25	0.35–0.60
Iron[A]	remainder	remainder	remainder	remainder	balance	balance

Element	Composition, %								
	UNS N06030	UNS N06022	UNS N06200	UNS N10362	UNS N10276	UNS N10665	UNS N10675	UNS N06002	UNS N06230
Carbon, max	0.03	0.015	0.010	0.010	0.010	0.02	0.01	0.05-0.15	0.05-0.15
Manganese, max	1.5	0.50	0.50	0.60	1.0	1.0	3.0	1.00	0.30-1.00
Phosphorous, max	0.04	0.02	0.025	0.025	0.04	0.04	0.030	0.04	0.030
Sulfur, max	0.02	0.02	0.010	0.010	0.03	0.03	0.010	0.03	0.015
Silicon, max	0.8	0.08	0.08	0.08	0.08	0.10	0.10	1.00	0.25-0.75
Nickel	remainder	remainder	remainder	remainder	remainder	remainder	65.0 min	remainder[A]	remainder[A]
Chromium	28.0-31.5	20.0-22.5	22.0-24.0	13.8-15.6	14.5-16.5	1.0 max	1.0-3.0	20.5-23.0	20.0-24.0
Molybdenum	4.0-6.0	12.5-14.5	15.0-17.0	21.5-23.0	15.0-17.0	26.0-30.0	27.0-32.0	8.0-10.0	1.0-3.00
Copper	1.0-2.4	...	1.3-1.9	.....	...	...	0.20	...	...
Columbium (Nb) + tantalum	0.30-1.50	...	...	...	...	...	...	...	...
Iron	13.0-17.0	2.0-6.0	3.0 max	1.25 max	4.0-7.0	2.0 max	1.0-3.0	17.0-20.0	3.0 max
Cobalt, max	5.0	2.5	2.0	...	2.5	1.0	3.0	0.5-2.5	5.0
Tungsten	1.5-4.0	2.5-3.5	...	...	3.0-4.5	...	3.0 max	0.2-1.0	13.0-15.0
Vanadium, max	...	0.35	...	...	0.35	...	0.20	...	...
Titanium, max	...	...	...	...	...	...	0.2	...	...
Zirconium, max	...	...	...	...	...	...	0.10	...	...
Columbium (Nb)	...	...	...	...	...	...	0.20 max	...	...
Tantalum	...	...	...	...	...	...	0.20 max		
Nickel + Molybdenum	...	...	...	...	...	...	94.0-98.0	...	...
Aluminum, max	...	...	0.50	0.50	...	...	0.50	...	0.20-0.50
Lanthanum	...	...	...	...	...	...	...	...	0.005-0.050
Boron	...	...	...	...	...	...	...	...	0.015 max

Element	Composition, %							
	UNS N12160	UNS R30556	UNS N06625	UNS N06600	UNS N10242	UNS N08120	UNS N06617	UNS N06035
Carbon	0.15 max	0.05-0.15	0.10 max	0.15 max	0.03	0.02-0.10	0.05-0.15	0.050 max
Manganese	1.5 max	0.50-2.00	0.50 max	1.0 max	0.80 max	1.5 max	1.0 max	0.50 max
Phosphorous	0.030 max	0.04 max	0.015 max	...	0.030 max	0.040 max	...	0.030 max
Sulfur	0.015 max	0.015 max	0.015 max	0.015 max	0.015 max	0.03 max	0.015 max	0.015 max
Silicon	2.4-3.0	0.20-0.80	0.50 max	0.50 max	0.80 max	1.0 max	1.0 max	0.60 max
Nickel	remainder[A]	19.0-22.5	58.0 min[A]	72.0 min[A]	remainder[A]	35.0-39.0	44.5 min[A]	remainder[A]
Chromium	26.0-30.0	21.0-23.0	20.0-23.0	14.0-17.0	7.0-9.0	23.0-27.0	20.0-24.0	32.25-34.25
Molybdenum	1.0 max	2.5-4.0	8.0-10.0	...	24.0-26.0	2.50 max	8.0-10.0	7.60-9.00
Copper	...	...	...	0.5 max	...	0.50 max	0.5 max	0.30 max
Columbium (Nb) + tantalum	...	...	3.15-4.15	...	...	0.4-0.9	...	...
Nitrogen	...	0.10-0.30	...	...	...	0.15-0.30	...	...
Iron	3.5 max	remainder[A]	5.0 max	6.0-10.0	2.0 max	remainder[A]	3.0 max	2.00 max
Cobalt, max	27.0-33.0	16.0-21.0	...	...	1.00 max	3.0	10.0 min-15.0 max	1.00
Tungsten	1.0 max	2.0-3.5	...	...	...	2.50 max	...	0.60 max
Vanadium, max	...	...	...	...	...	...	...	0.20
Titanium	0.20-0.80	...	0.4 max	...	...	0.20 max	0.6 max	...
Zirconium	...	0.001-0.10	...	...	...	...	...	...
Columbium	1.0 max	0.30 max	...	...	...	...	...	...
Tantalum	...	0.30-1.25	...	...	...	...	...	...
Aluminum, max	...	0.10-0.50	0.4	...	0.50	0.40	0.8-1.5	0.40 max
Lanthanum	...	0.005-0.10	...	...	...	...	...	...
Boron	...	0.02 max	...	...	0.006 max	0.010 max	0.006 max	...

Element	Composition, %					
	UNS N06059	UNS N06686	UNS N08031	UNS N06045	UNS N06025	UNS N10629
Carbon, max	0.010	0.010	0.015	0.05-0.12	0.15-0.25	0.01

TABLE 1 *Continued*

	Composition, %					
Manganese, max	0.5	0.75	2.0	1.0	0.15	1.5
Phosphorous, max	0.015	0.04	0.020	0.02	0.02	0.040
Sulfur, max	0.010	0.02	0.010	0.010	0.010	0.010
Silicon, max	0.10	0.08	0.3	2.5-3.0	0.5	0.05
Nickel	Remainder[A]	Remainder[A]	30.0-32.0	45.0 min	Remainder[A]	Remainder[A]
Chromium	22.0-24.0	19.0-23.0	26.0-28.0	26.0-29.0	24.0-26.0	0.5-1.5
Molybdenum	15.0-16.5	15.0-17.0	6.0-7.0	...	...	26.0-30.0
Copper	0.50 max	...	1.0-1.4	0.3 max	0.1 max	0.5
Yttrium	...	...	...	...	0.05-0.12	...
Nitrogen	...		0.15-0.25	...		...
Iron	1.5 max	5.0 max	Remainder[A]	21.0–25.0	8.0–11.0	1.0-6.0
Cobalt, max	0.3	...	...	...	...	2.5
Tungsten	...	3.0–4.4	...	...	...	...
Vanadium, max	...	...	...	...	...	...
Titanium, max	...	0.02–0.25	...	...	0.1-0.2	...
Zirconium, max	...	...	...	...	0.01-0.10	...
Columbium (Nb)	...	...	...	...	...	...
Tantalum	...	...	...	...	...	...
Cerium	...	...	...	0.03-0.09	...	...
Aluminum, max	0.1-0.4	...	...	...	1.8-2.4	0.1–0.5

[A] See 11.1.

TABLE 2 Permissible Variations in Size of Hot-Rolled Round Bars

Specified Size, in. (mm)	Permissible Variations from Specified Size, in. (mm)		Out-of-Round,[A] in. (mm)
	Over	Under	
Over 7/16 (11.11) to 5/8 (15.88), incl	0.007 (0.18)	0.007 (0.18)	0.010 (0.25)
Over 5/8 (15.88) to 7/8 (22.22), incl	0.008 (0.20)	0.008 (0.20)	0.012 (0.30)
Over 7/8 (22.22) to 1 (25.40), incl	0.009 (0.23)	0.009 (0.23)	0.013 (0.33)
Over 1 (25.40) to 1 1/8 (28.58), incl	0.010 (0.25)	0.010 (0.25)	0.015 (0.38)
Over 1 1/8 (28.58) to 1 1/4 (31.75), incl	0.011 (0.28)	0.011 (0.28)	0.016 (0.41)
Over 1 1/4 (31.75) to 1 3/8 (34.92), incl	0.012 (0.30)	0.012 (0.30)	0.018 (0.46)
Over 3/8 (34.92) to 1 1/2 (38.10), incl	0.014 (0.36)	0.014 (0.36)	0.021 (0.53)
Over 1 1/2 (38.10) to 2 (50.80), incl	1/64 (0.40)	1/64 (0.40)	0.023 (0.58)
Over 2 (50.80) to 2 1/2 (63.50), incl	1/32 (0.79)	0	0.023 (0.58)
Over 2 1/2 (63.50) to 3 1/2 (88.90), incl	3/64 (1.19)	0	0.035 (0.89)
Over 3 1/2 (88.90) to 4 1/2 (114.30), incl	1/16 (1.59)	0	0.046 (1.17)
Over 4 1/2 (114.30) to 5 1/2 (139.70), incl	5/64 (1.98)	0	0.058 (1.47)
Over 5 1/2 (139.70) to 6 1/2 (165.10), incl	1/8 (3.18)	0	0.070 (1.78)
Over 6 1/2 (165.10) to 8 (203.20), incl	5/32 (3.97)	0	0.085 (2.18)

[A] Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section.

6.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the requirements specified in Table 1 subject to the permissible tolerances in Specification B880.

7. Dimensions and Permissible Variations

7.1 Billets shall conform to the shapes and dimensions specified by the purchaser within a permissible variation of ±5 %.

7.2 Bars shall conform to the shape and dimensions specified by the purchaser within the permissible variations prescribed in Table 2.

8. Workmanship, Finish, and Appearance

8.1 The material shall be uniform in quality and free of injurious defects.

9. Sampling

9.1 *Lot*—A lot for chemical analysis shall consist of one heat.

9.2 *Test Material Selection:*

9.2.1 *Chemical Analysis*—Representative samples shall be taken during pouring or subsequent processing.

10. Number of Tests

10.1 *Chemical Analysis*—One test per heat.

11. Test Methods

11.1 The chemical composition of the material as enumerated in this specification shall, in case of disagreement, be determined in accordance with the following methods:

Test	ASTM Designations
Chemical analysis	E1473[A]

[A] Iron or nickel shall be determined arithmetically by difference.

12. Inspection

12.1 If specified, source inspection of the material by the purchaser at the manufacturer's plant shall be made as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

14. Certification

14.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Keywords

15.1 bar; billet; UNS N06002; UNS N06030; UNS N06035; UNS N06022; UNS N06200; UNS N06230; UNS N10362; UNS N06600; UNS N06617; UNS N06625; UNS N08020; UNS N08024; UNS N08026; UNS N01820; UNS N08367; UNS N08926; UNS N10242; UNS N10276; UNS N10665; UNS N10675; UNS N12160; UNS R20033; UNS R30556; UNS N06059; UNS N06686; UNS N10629; UNS N08031; UNS N06045; UNS N06025

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall be applied only when specified by the purchaser in the inquiry, contract, or order.

S1. Corrosion Tests for UNS N08020

S1.1 One intergranular corrosion test per heat shall be performed by the manufacturer on a sensitized specimen and tested in accordance with Practices A262. When this supplementary requirement is specified, the specific practice (Practice B or Practice E) shall also be specified. If Practice B is specified, the specimen must pass with a rate of less than 0.002 in./month (ipm).

S1.1.1 The specimen shall be stabilized by annealing at a temperature of 1700 to 1750°F (927 to 954°C) and quenching in water or rapidly cooling by other means. The specimen shall then be sensitized for 1 h at 1250°F (677°C) before being subjected to corrosion testing.

S1.1.2 If any specimen selected to represent any heat fails to meet the test requirement, the material represented by such specimen may be reheat-treated and resubmitted for test.