Designation: A 494/A 494M – 04

Standard Specification for Castings, Nickel and Nickel Alloy[1]

This standard is issued under the fixed designation A 494/A 494M; 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 nickel, nickel-copper, nickel-copper-silicon, nickel-molybdenum, nickel-chromium, and nickel-molybdenum-chromium alloy castings for corrosion-resistant service.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. Inch-pound units are applicable for material ordered to Specification A 494 and SI units for material ordered to Specification A 494M.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 488/A 488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

A 732/A 732M Specification for Castings, Investment, Carbon and Low-Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures

A 781/A 781M Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use

E 8 Test Methods for Tension Testing of Metallic Materials

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[3]

E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys[3]

E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys[3]

E 354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

3. Terminology

3.1 *Definitions:*

3.1.1 *master heat*—a single furnace charge of refined alloy, which may either be poured directly into castings or into remelt alloy for individual melts.

3.1.2 *melts*—a single furnace charge poured into castings. When master heats are used to prepare melts, a melt analysis shall be reported.

4. General Conditions for Delivery

4.1 Material furnished to this specification shall conform to the requirements of Specification A 781/A 781M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 781/A 781M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 781/A 781M, this specification shall prevail.

5. Ordering Information

5.1 Orders for castings to this specification should include the following information:

5.1.1 Quantity, in pieces, and

5.1.2 Grade designation (Table 1) and class (Table 2).

5.2 The purchaser shall specify any of the following information required to describe adequately the desired material:

5.2.1 Heat-treat condition (see 6.1 and 6.2),

5.2.2 Repair welding (see Section 11)

5.2.3 Source inspection requirements, if any (see Specification A 781/A 781M),

5.2.4 Marking-for-identification requirements, if any (see 13.1), and

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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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] Withdrawn.

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

TABLE 1 Chemical Requirements

NOTE—Values are maximum unless otherwise indicated.

Grade	CZ100	M35-1[A]	M35-2	M30H	M25S	M30C[A]	N12MV	N7M	CY40	CW12MW	CW6M	CW2M	CW6MC	CY5SnBiM	CX2MW	CU5MCuC	CX2M
UNS Numbers	N02100	N24135	N04020	N24030	N24025	N24130	N30012	N30007	N06040	N30002	N30107	N26455	N26625	N26055	N26022	N08826	N26059
	Composition, %																
C, max	1.00	0.35	0.35	0.30	0.25	0.30	0.12	0.07	0.40	0.12	0.07	0.02	0.06	0.05	0.02	0.050 max	0.02
Mn, max	1.50	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.50	1.00	1.00	1.00	1.00	1.5	1.00	1.0 max	1.00
Si, max	2.00	1.25	2.00	2.7-3.7	3.5-4.5	1.0-2.0	1.00	1.00	3.00	1.00	1.00	0.80	1.00	0.5	0.80	1.0 max	0.50
P, max	0.03	0.03	0.03	0.03	0.03	0.03	0.040	0.040	0.03	0.040	0.040	0.03	0.015	0.03	0.025	0.030 max	0.020
S, max	0.03	0.03	0.03	0.03	0.03	0.03	0.030	0.030	0.03	0.030	0.030	0.03	0.015	0.03	0.025	0.030 max	0.020
Cu	1.25 max	26.0-33.0	26.0-33.0	27.0-33.0	27.0-33.0	26.0-33.0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.50-3.50	. . .
Mo	. . .	. . .	. . .	. . .	. . .	. . .	26.0-30.0	30.0-33.0	. . .	16.0-18.0	17.0-20.0	15.0-17.5	8.0-10.0	2.0-3.5	12.5-14.5	2.5-3.5	15.0-16.5
Fe	3.00 max	3.50 max	3.50 max	3.50 max	3.50 max	3.50 max	4.0-6.0	3.00 max	11.0 max	4.5-7.5	3.0 max	2.0 max	5.0 max	2.0 max	2.0-6.0	balance	1.50 max
Ni	95.00 min	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	38.0-44.0	balance
Cr	. . .	. . .	. . .	. . .	. . .	. . .	1.00	1.0	14.0-17.0	15.5-17.5	17.0-20.0	15.0-17.5	20.0-23.0	11.0-14.0	20.0-22.5	19.5-23.5	22.0-24.0
Cb (Nb)	. . .	0.5 max	0.5 max	. . .	. . .	1.0-3.0	. . .	. . .	. . .	. . .	. . .	. . .	3.15-4.50	. . .	. . .	0.60-1.20	. . .
W	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3.75-5.25	. . .	1.0 max	. . .	. . .	2.5-3.5	. . .	. . .
V	. . .	. . .	. . .	. . .	. . .	. . .	0.20-0.60	. . .	. . .	0.20-0.40	. . .	. . .	. . .	. . .	0.35 max	. . .	. . .
Bi	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3.0-5.0	. . .	. . .	. . .
Sn	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3.0-5.0	. . .	. . .	. . .

[A] Order M35-1 or M30C when weldability is required.

TABLE 2 Heat Treat Requirements

Grade	Heat Treatment
CZ100, M35-1, M35-2, CY40 Class 1, M30H, M30C, M25S Class 1, CY5SnBiM	As cast
M25S, Class 2[A]	Load into furnace at 600°F [315°C] maximum. Heat to 1600°F [870°C] and hold for 1 h plus an additional 30 min for each ½ in. [13 mm] of cross section over 1 in.[B] Cool to 1300°F [705°C][C] and hold at temperature for 30 min then quench in oil to room temperature.
M25S, Class 3	Load into furnace at 600°F [315°C] maximum. Heat slowly to 1100°F [605°C] and hold to develop maximum hardness. Furnace or air cool to room temperature.
N12MV, N7M	Heat to 2000°F [1095°C] minimum, hold for sufficient time to heat castings to temperature, quench in water or rapid cool by other means.
CW12MW, CW6M, CW6MC, CW2M	Heat to 2150°F [1175°C] minimum, hold for sufficient time to heat castings to temperature, quench in water or rapid cool by other means.
CY40, Class 2	Heat to 1900°F [1040°C] minimum, hold for sufficient time to heat castings to temperature, quench in water or rapid cool by other means.
CX2MW	Heat to 2200°F [1205°C] minimum, hold for sufficient time to heat castings to temperature, quench in water or rapid air cool by other means.
CU5MCuC	Heat to 2100°F [1150°C] minimum, hold for sufficient time to heat castings to temperature, quench in water. Stabilize at 1725–1815°F [940–990°C], hold for sufficient time to heat castings to temperature, quench in water or rapid cool by other means.
CX2M	Heat to 2100°F [1150°C] minimum, hold for sufficient time to heat castings to temperature, quench in water or rapid air cool by other means.

[A] M25S, while machinable in the "as-cast" condition, is capable of being solution treated for improved machinability. It may be subsequently age hardened to the hardness specified in Table 3 and finished machined or ground.
[B] For cross sections over 6 in. [125 mm], it may be necessary to increase the hold time if maximum softness is desired.
[C] For maximum softness and the least variation in hardness levels, castings should be transferred from an oven at 1600°F [870°C] to a second oven at 1300°F [705°C].

5.2.5 Supplementary requirements desired, including the standards of acceptance.

6. Heat Treatment

6.1 Castings shall be heat treated in accordance with the requirements in Table 2.

NOTE 1—Proper heat treatment of these alloys is usually necessary to enhance corrosion resistance and, in some cases, to meet mechanical properties. Minimum heat-treat temperatures are specified; however, it is sometimes necessary to heat treat at higher temperatures, hold for some minimum time at temperature, and then rapidly cool the castings in order to enhance the corrosion resistance and meet mechanical properties.

6.2 When Class 1 is specified, grades CY40 and M25S shall be supplied in the as-cast condition. When Class 2 is specified, grades CY40 and M25S shall be supplied in the solution-treated condition. When Class 3 is specified, grade M25S shall be supplied in the age-hardened condition.

7. Chemical Composition

7.1 These alloys shall conform to the chemical composition requirements prescribed in Table 1.

7.2 An analysis of each master heat shall be made by the manufacturer to determine the percentages of the elements specified in Table 1. The analysis shall be made from a representative sample taken during the pouring of the master heat. Chemical composition shall be reported to the purchaser or his representative.

7.3 Test Methods E 76 or Test Methods E 354 shall be used for referee purposes. Test Methods E 30 or Methods E 38 shall be used if Test Methods E 76 or Test Methods E 354 do not include a method for some element present in the material.

8. Tensile Properties

8.1 One tension test shall be made from each master heat except for grades M25S and CY5SnBiM when the master heat is used to pour the castings. One tension test shall be made from each melt except for grades M25S and CY5SnBiM. Test results shall conform to the tensile requirements specified in Table 3. Test bars shall be poured in special blocks from the same heat as the castings represented.

8.2 The bar from which the test specimen is taken shall be heat treated in production furnaces to the same procedure as the

TABLE 3 Mechanical Properties

	CZ100	M35-1	M35-2	M30H	M25S	M30C	N12MV	N7M	CY40	CW-12MW	CW6M	CW2M	CW6MC	CY5S-nBiM	CX2MW	CU5-MCuC	CX2M
Tensile strength, min, psi [MPa]	50 000 [345]	65 000 [450]	65 000 [450]	100 000 [690]	...	65 000 [450]	76 000 [525]	76 000 [525]	70 000 [485]	72 000 [495]	72 000 [495]	72 000 [495]	70 000 [485]	...	80 000 [550]	75 000 [520]	72 000 [495]
Yield strength, min, psi [MPa]	18 000 [125]	25 000 [170]	30 000 [205]	60 000 [415]	...	32 500 [225]	40 000 [275]	40 000 [275]	28 000 [195]	40 000 [275]	40 000 [275]	40 000 [275]	40 000 [275]	...	45 000 [310]	35 000 [240]	39 000 [270]
Elongation in 2 in. [50 mm],[A] min, %	10.0	25.0	25.0	10.0	...	25.0	6.0	20.0	30.0	4.0	25.0	20.0	25.0	...	30.0	20.0	40
Hardness HB	...	...	...	...	[B]	...	...	...	...	...	...	...	...	...	...	...	...

[A] When ICI test bars are used in tensile testing as provided for in Specification A 732/A 732M, the gage length to reduced section diameter ratio shall be 4 to 1.
[B] 300 HB minimum for the age hardened condition.