



Designation: A990-10a **Designation: A990 – 11**

Standard Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service¹

This standard is issued under the fixed designation A990; 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 iron-nickel-chromium and nickel alloy castings specially processed with restricted melt practices, weldability testing, and nondestructive examination (NDE) requirements.

1.2 A number of grades of iron-nickel-chromium and nickel alloy castings are included in this specification. Since these grades possess varying degrees of suitability for service in corrosive environments, it is the responsibility of the purchaser to determine which grade shall be furnished. Selection will depend on design and service conditions, mechanical properties, and corrosion-resistant characteristics.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 non-conformance with the standard.

1.3.1 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order or contract specifies the applicable M specification designation (SI units), the inch-pound units shall apply. Within the text, the SI units are shown in brackets or parentheses.

1.4 *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

A351/A351M Specification for Castings, Austenitic, for Pressure-Containing Parts

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

A494/A494M Specification for Castings, Nickel and Nickel Alloy

A703/A703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts

A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application

A744/A744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service

A802/A802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination

A903/A903M Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A985/A985M Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts

E94 Guide for Radiographic Examination

E165 Practice for Liquid Penetrant Examination for General Industry

E186 Reference Radiographs for Heavy-Walled (2 to 412-in. (50.8 to 114-mm)) Steel Castings

E272 Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings

E280 Reference Radiographs for Heavy-Walled (412 to 12-in. (114 to 305-mm)) Steel Castings

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.

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

E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

2.2 AWS Standards:³

AWS A5.4, Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding

AWS A5.9, Specification for Bare Stainless Steel Welding Electrodes and Rods

AWS A5.11/A5.11M, Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding

AWS A5.14/A5.14M, Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods

2.3 ASME/ANSI Standard:⁴

ASME/ANSI B16.34, Valves-Flanged, Threaded, and Welding End

3. Terminology

3.1 *Definitions*—The definitions in Test Methods and Definitions A370 and Terminology A941 are applicable to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accessible surface, n*—surface that can be welded on without cutting access holes in the casting.

3.2.2 *refined ingot, n*—metal processed by argon-oxygen-decarburization (AOD) or vacuum-oxygen-decarburization (VOD) and cast to a size and shape suitable for remelting.

3.2.3 *revert, n*—gates, risers, and castings. Also includes scrapped machinery and fabricated items, chips, and turnings.

4. General Conditions for Delivery

4.1 Other than investment castings, material furnished to this specification shall conform to the requirements of Specification A703/A703M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A703/A703M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A703/A703M, this specification shall prevail.

4.2 Investment Castings – Material furnished to this specification shall conform to the requirements of Specification A985/A985M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A985/A985M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A985/A985M, Specification A985/A985M shall prevail.

5. Ordering Information

5.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered to this

³ Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

TABLE 1 Chemical Requirements

Element, % (max, except where range is given)	Grade					
	CK3MCuN	CW-2M	CN3MCu	M35-1	CW2MC	N2M
C	0.025	0.020	0.030	0.35	0.020	0.020
Mn		1.00	1.50	1.50	1.00	1.00
Mn	1.20	1.00	1.50	1.50	1.00	1.00
Si		0.80	1.00	1.25	0.45	0.80
Si	0.75	0.80	1.00	1.25	0.45	0.80
P		0.030	0.030	0.030	0.015	0.030
P	0.020	0.030	0.030	0.030	0.015	0.030
S		0.015	0.015	0.015	0.015	0.015
S	0.010	0.015	0.015	0.015	0.015	0.015
Mo		15.0-17.5	2.0-3.0	...	8.0-10.0	30.0-33.0
Mo	6.0-7.0	15.0-17.5	2.0-3.0	...	8.0-10.0	30.0-33.0
Fe		2.00	balance	3.5	5.0	3.00
Fe	balance	2.00	balance	3.5	5.0	3.00
Ni		balance	27.5-30.5	Balance	Balance	Balance
Ni	17.5-19.5	balance	27.5-30.5	Balance	Balance	Balance
Cr		15.0-17.5	19.0-22.0	...	20.0-23.0	1.00
Cr	19.5-20.5	15.0-17.5	19.0-22.0	...	20.0-23.0	1.00
N	0.18-0.24					
Cu		...	3.0-3.5	26.0-33.0	0.50	0.20
Cu	0.50-1.00	...	3.0-3.5	26.0-33.0	0.50	0.20
W		1.00	...	...	0.50	0.20
V		...	...	...	0.20	0.20
V		...	...	...	0.20	0.20
Cb		...	...	...	3.1-4.5	...

specification. Such requirements may include, but are not limited to, the following:

- 5.1.1 Quantity.
- 5.1.2 Grade designation (Table 1).
- 5.1.3 Description of the casting by pattern number or drawing. Dimensional tolerances should be included on the casting drawing.
- 5.1.4 Nondestructive inspection class required (Table 2). Class D will be supplied unless otherwise specified.
- 5.1.5 Wetted surfaces (Table 2).
- 5.2 The purchaser shall specify any supplementary requirements desired, including standards of acceptance, required to describe adequately the desired material.

6. Process and Manufacture

- 6.1 Alloys, except for nickel base, 25 to 35 % Cu alloys, shall be made by one of the two following processes:
 - 6.1.1 Electric arc or induction furnace melting followed by AOD or VOD refining, or
 - 6.1.2 Electric induction furnace melting of refined ingot.
- 6.2 Nickel base alloys with 25 to 35 % Cu shall be made by 6.1.1 or 6.1.2 or by electric furnace.
- 6.3 Additions of up to 5 % are permitted for compositional adjustments and deoxidation.
- 6.4 Revert shall not be used.

7. Chemical Composition

7.1 These alloys shall conform to the chemical composition requirements prescribed in Table 1. An analysis of every heat is required.

8. Tensile Properties

8.1 One tension test shall be made from each heat. Test results shall conform to the tensile requirements specified in Table 3. The bar shall be solution heat treated per the requirements of Table 4 in production furnaces to the same procedure as the castings it represents. If the casting grade does not require heat treatment, the bar used for the test specimen shall not be heat treated.

9. Weldability Qualification

9.1 Each heat shall be qualified by weldability testing.

TABLE 2 Nondestructive Examination Requirements

Maximum Casting Thickness	Class	Visual Examination, Practice A802/A802M Minimum Acceptance Level	Radiographic Examination, Guide E94 Number of Castings Severity Level per Table 6	Liquid Penetrant Examination, Test Method E165	
				Coverage	Minimum Acceptance Level per Specification A903/A903M
less than 5/8 in. (15.9 mm) less than 5/8 in. (15.9 mm)	A	Level I	100 %	All accessible surfaces	Level I
	A	Level I	100 %	All accessible surfaces	Level II
	B	Level II	100 %	All accessible wetted surfaces	Level II
	C	Level II	Initial casting off pattern	Weld repairs	Level II
5/8 to 1 in. (15.9 to 25.4 mm) 5/8 to 1 in. (15.9 to 25.4 mm)	D	Level II	Initial casting off pattern	NA	NA
	A	Level I	100 %	All accessible surfaces	Level II
	A	Level I	100 %	All accessible surfaces	Level III
	B	Level II	100 %	All accessible wetted surfaces	Level III
Over 1 to 2 in. (25.4 to 50.8 mm) Over 1 to 2 in. (25.4 to 50.8 mm)	C	Level II	Initial casting off pattern	Weld repairs	Level III
	D	Level II	Initial casting off pattern	NA	NA
	A	Level I	100 %	All accessible surfaces	Level III
	A	Level I	100 %	All accessible surfaces	Level IV
Over 2 to 4 1/2 in. (50.8 to 114 mm)	B	Level II	100 %	All accessible wetted surfaces	Level IV
	B	Level II	100 %	All accessible wetted surfaces	Level IV
	C	Level III	Initial casting off pattern	Weld repairs	Level V
	D	Level III	Initial casting off pattern	NA	NA
Over 4 1/2 in. (114 mm)	D	Level II	Initial casting off pattern	NA	NA
	A	Level III	100 %	All accessible surfaces	Level V
	B	Level III	100 %	All accessible wetted surfaces	Level V
	C	Level IV	Initial casting off pattern	Weld repairs	Level V
	D	Level IV	Initial casting off pattern	NA	NA

TABLE 3 Tensile Requirements

	Grade					
	CK3MnCuN	GW-2M CW-2M	GN3MnCu CN3MnCu	M35-1 M35-1	GW2MG CW2MG	N2M N2M
Tensile strength, min, psi (MPa)		72 000 [495]	62 000 [425]	65 000 [450]	70 000 [485]	76 000 [525]
Tensile strength, min, psi [MPa]	80,000 [550]	72 000 [495]	62 000 [425]	65 000 [450]	70 000 [485]	76 000 [525]
0.2 % offset yield strength, min, psi (MPa)		40 000 [275]	25 000 [170]	25 000 [170]	40 000 [275]	40 000 [275]
0.2 % offset yield strength, min, psi [MPa]	38,000 [260]	40 000 [275]	25 000 [170]	25 000 [170]	40 000 [275]	40 000 [275]
Elongation in 2 in. (50 mm), min, % ^A	35.0	20.0	35.0	25.0	25.0	20.0
Elongation in 2 in. [50 mm], min, % ^A	35.0	20.0	35.0	25.0	25.0	20.0

^A When ICI test bars are used in tensile testing as provided for in Specification A985/A985M, the gage length to reduced section diameter ratio shall be 4 to 1.

TABLE 4 Heat Treat Requirements

Grade	Heat Treatment
CK3MnCuN	Heat to 2200 to 2265°F (1205 to 1240°C) for one hour at temperature/1 in. (25 mm) of thickness with a minimum of 4 hours. Quench in water. ^A
CW-2M	Heat to 2225 to 2300°F [1220 to 1260°C] for a minimum of 1 h at temperature/1 in. [25 mm] of thickness. Quench in water. ^A
CN3MnCu	Heat to 2050°F [1120°C] min for a min of 1 h at temperature/1 in. [25 mm] of thickness. Quench in water. ^A
M35-1	As-cast
CW2MG	Heat to 2175°F [1190°C] min for a min of 2 h at temperature or a min of 1 h/1 in. [25 mm] of thickness whichever is greater. Quench in water. ^A
N2M	Heat to 2080°F [1140°C] min for a min of 2 h at temperature + 1 h/1 in. [25 mm] of thickness. Quench in water. ^A

^A Quench in water or rapid cool by other means as agreed upon by the manufacturer and purchaser.

9.2 Sampling:

9.2.1 The weldability test plate shall be cast in accordance with Fig. 1.

9.2.2 For heats produced under 6.1.1, at least one weldability test plate shall be cast from each heat.

9.2.3 For heats produced under 6.1.2, at least one weldability test plate shall be cast from the first heat in an uninterrupted series of heats, made in the same furnace from the same heat of refined ingot using the same melting procedure, and shall qualify all of the subsequent heats in that series made in the same shift.

9.3 Procedure:

9.3.1 The test plates required under 9.2 shall be processed and tested as follows:

9.3.1.1 Prior to welding, the test plate shall be solution heat treated according to the requirements of Table 4 in production furnaces to the same procedure as the castings it represents.

9.3.1.2 All forms of cold working, mechanical deformation, hammering, or peening, in excess of that required for normal cleaning is prohibited.

9.3.1.3 Fill the groove in the plate with weld deposit according to the procedure used in Section 11 and the filler material grade specified in Table 5.

9.3.1.4 For the purposes of the weldability test only, post weld heat treatment of the test plate is prohibited even if part of the procedure. Remove one 3/8-in. (10-mm) min thick bend coupon longitudinally from the center of the welded plate by machining, sawing, or abrasive cutting. Make a transverse side bend test of the welded joint in accordance with Practice A488/A488M.

9.4 Acceptance:

9.4.1 On the bent specimen, cracks or other open defects exceeding 1/8 in. (3.2 mm), measured in any direction on the convex surface shall be cause for rejection, except that cracks occurring on and limited to the corners while testing shall not be considered.

10. Nondestructive Examination

10.1 One of four different classes of nondestructive examination shall be imposed on castings ordered to this specification. Classes A, B, C, and D are defined in Table 2. Each class imposes specific requirements for three different NDE methods. Class D will be supplied unless otherwise specified.

10.2 *Visual Examination*—Each casting shall be examined visually in accordance with Practice A802/A802M. Fusion discontinuities, expansion discontinuities, and inserts are unacceptable. All other surface features must meet the acceptance criteria class in Table 2.

10.3 Radiographic Examination:

10.3.1 The number of castings to be examined radiographically and the acceptance criteria shall be in accordance with the specified class in Table 2 and Table 6.