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# Standard Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service<sup>1</sup>

This standard is issued under the fixed designation A 990; 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 ( $\epsilon$ ) 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 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. 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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

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:<sup>2</sup>

- A 351/A 351M Specification for Castings, Austenitic, for Pressure-Containing Parts
- 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 494/A 494M Specification for Castings, Nickel and Nickel Alloy
- A 703/A 703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts
- A 743/A 743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
- A 744/A 744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
- A 802/A 802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination
- A 903/A 903M Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
- A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
- A 985/A 985M Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts
- E 94 Guide for Radiographic Examination
- E 165 Test Method for Liquid Penetrant Examination
- E 186 Reference Radiographs for Heavy-Walled (2 to 412-in. [51 to 114-mm]) Steel Castings
- E 272 Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings
- E 280 Reference Radiographs for Heavy-Walled (412 to 12-in. [114 to 305-mm]) Steel Castings
- E 446 Reference Radiographs for Steel Castings Up to 2 in. [51 mm] in Thickness

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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.

**2.2 AWS Standards:**<sup>3</sup>

- 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, Specification for Nickel and Nickel Alloy Electrodes for Shielded Metal Arc Welding
- AWS A5.14, Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods

**2.3 ASME/ANSI Standard:**<sup>4</sup>

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

**3. Terminology**

3.1 *Definitions*— The definitions in Test Methods and Definitions A 370 and Terminology A 941 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 A 703/A 703M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 703/A 703M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 703/A 703M, this specification shall prevail.

4.2 Investment Castings – Material furnished to this specification shall conform to the requirements of Specification A 985/A 985M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 985/A 985M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 985/A 985M, Specification A 985/A 985M 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 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:

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

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>. A0†

**TABLE 1 Chemical Requirements**

Element, % (max, except where range is given)	Grade		
	CW-2M	CN3MCu	M35-1
C	0.020	0.030	0.35
Mn	1.00	1.50	1.50
Si	0.80	1.00	1.25
P	0.030	0.030	0.030
S	0.015	0.015	0.015
Mo	15.0-17.5	2.0-3.0	...
Fe	2.00	balance	3.5
Ni	balance	27.5-30.5	Balance
Cr	15.0-17.5	19.0-22.0	...
Cu	...	3.0-3.5	26.0-33.0
W	1.00	...	...

**TABLE 2 Nondestructive Examination Requirements**

Maximum Casting Thickness	Class	Visual Examination, Practice A 802/A 802M Minimum Acceptance Level	Radiographic Examination, Guide E 94 Number of Castings Severity Level per Table 6	Liquid Penetrant Examination, Test Method E 165	
				Coverage	Minimum Acceptance Level per Specification A 903/A 903M
less than 5/8 in. (15.9 mm)	A	Level I	100 %	All accessible surfaces	Level I
	B	Level II	100 %	All accessible wetted surfaces	Level II
	C	Level II	Initial casting off pattern	Weld repairs	Level II
	D	Level II	Initial casting off pattern	NA	NA
5/8 to 1 in. (15.9 to 25.4 mm)	A	Level I	100 %	All accessible surfaces	Level II
	B	Level II	100 %	All accessible wetted surfaces	Level III
	C	Level II	Initial casting off pattern	Weld repairs	Level III
	D	Level II	Initial casting off pattern	NA	NA
Over 1 to 2 in. (25.4 to 50.8 mm)	A	Level I	100 %	All accessible surfaces	Level III
	B	Level II	100 %	All accessible wetted surfaces	Level IV
	C	Level II	Initial casting off pattern	Weld repairs	Level IV
	D	Level II	Initial casting off pattern	NA	NA
Over 2 to 4 1/2 in. (50.8 to 114 mm)	A	Level II	100 %	All accessible 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)	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

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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.

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## 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.

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.

**TABLE 3 Tensile Requirements**

	Grade		
	CW-2M	CN3MCu	M35-1
Tensile strength, min, psi (MPa)	72 000 (495)	62 000 (425)	65 000 (450)
0.2 % offset yield strength, min, psi (MPa)	40 000 (275)	25 000 (170)	25 000 (170)
Elongation in 2 in. (50 mm), min, % <sup>A</sup>	20.0	35.0	25.0

<sup>A</sup>When ICI test bars are used in tensile testing as provided for in Specification A 985/A 985M, the gage length to reduced section diameter ratio shall be 4 to 1.

**TABLE 4 Heat Treat Requirements**

Grade	Heat Treatment
CW-2M	Heat to 2250° ± 25°F (1232° ± 14°C) for a min of 1 h at temperature/1 in. (25 mm) of thickness. Quench in water. <sup>A</sup>
CN3MCu	Heat to 2050°F (1120°C) min for a min of 1 h at temperature/1 in. (25 mm) of thickness. Quench in water. <sup>A</sup>
M35-1	As-cast

<sup>A</sup> Quench in water or rapid cool by other means as agreed upon by the manufacturer and purchaser.

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 A 488/A 488M.

### 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 A 802/A 802M. 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.

10.3.2 The extent of coverage shall be agreed upon between the manufacturer and purchaser. Where applicable, the minimum coverage shall comply with ASME/ANSI B 16.34.

10.3.3 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

10.3.4 All castings that are radiographed and found acceptable shall be marked permanently RT.

~~10.3.5 For Classes C and D, if a rejectable indication is found, that first casting shall be scrapped or repaired and the second casting radiographed. If the second casting passes, then no additional radiography beyond the normal amount is required. If that second casting fails, all remaining castings shall be radiographed in only the rejectable areas found on the first and second castings.~~

10.3.5 For Classes C and D, if a rejectable indication is found, that first casting shall be scrapped or repaired and the second casting radiographed. If the second casting passes, then no additional radiography beyond the normal amount is required. If that second casting fails, all remaining castings shall be radiographed in only the rejectable areas found on the first and second castings. After changes are made to the gating or risering of a pattern, and the subsequent castings produce no rejectable radiographic indications, then no additional radiography beyond the sampling rate agreed upon by the purchaser and the producer shall be required.

### 10.4 Liquid Penetrant Examination :

10.4.1 All Class A, B, and C castings shall be liquid penetrant (LP) tested in accordance with Table 2 after the final specified heat treatment.

10.4.2 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

10.4.3 When welding is performed after the liquid penetrant examination, the repair weld and at least 1/4 in. (6 mm) of the surrounding material shall be LP tested in accordance with Table 2.

## 11. Repair by Welding

11.1 All weld repairs shall be made with welders and procedures qualified in accordance with Practice A 488/A 488M. Only the filler material grades specified in Table 5 shall be used.