



Designation: **A990/A990M – 14a** A990/A990M – 18

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

This standard is issued under the fixed designation A990/A990M; 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 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~~ nonconformance 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~~ 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~~ safety, health, and health ~~environmental~~ environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:<sup>2</sup>

[A351/A351M](#) Specification for Castings, Austenitic, for Pressure-Containing Parts

[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

[A985/A985M](#) Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts

[E94/E94M](#) Guide for Radiographic Examination Using Industrial Radiographic Film

[E165/E165M](#) Practice for Liquid Penetrant Examination for General Industry

<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

- E186 Reference Radiographs for Heavy-Walled (2 to 4½ 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 (4½ to 12 in. (114 to 305 mm)) Steel Castings
- E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

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

- AWS ~~A5.4~~, A5.4 Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
- AWS ~~A5.9~~, A5.9 Specification for Bare Stainless Steel Welding Electrodes and Rods
- AWS ~~A5.11/A5.11M~~, A5.11/A5.11M Specification for Nickel and ~~Nickel Alloy~~ Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
- AWS ~~A5.14/A5.14M~~, A5.14/A5.14M Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods

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

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

### 3. Terminology

3.1 Definitions of Terms Specific to This Standard:

- 3.1.1 *accessible surface, n*—surface that can be welded on without cutting access holes in the casting.
- 3.1.2 *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.
- 3.1.3 *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—Investment Castings—Material—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.

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**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	1.20	1.00	1.50	1.50	1.00	1.00
Si	0.75	0.80	1.00	1.25	0.45	0.80
P	0.020	0.030	0.030	0.030	0.015	0.030
S	0.010	0.015	0.015	0.015	0.015	0.015
Mo	<del>6.0-7.0</del>	<del>15.0-17.5</del>	<del>2.0-3.0</del>	...	<del>8.0-10.0</del>	<del>30.0-33.0</del>
Mo	6.0-7.0	15.0-17.5	2.0-3.0	...	8.0-10.0	30.0-33.0
Fe	balance	2.00	balance	3.5	5.0	3.00
Ni	<del>17.5-19.5</del>	<del>balance</del>	<del>27.5-30.5</del>	<del>Balance</del>	<del>Balance</del>	<del>Balance</del>
Ni	17.5-19.5	balance	27.5-30.5	Balance	Balance	Balance
Cr	<del>19.5-20.5</del>	<del>15.0-17.5</del>	<del>19.0-22.0</del>	...	<del>20.0-23.0</del>	<del>1.00</del>
Cr	19.5-20.5	15.0-17.5	19.0-22.0	...	20.0-23.0	1.00
N	<del>0.18-0.24</del>	...	...	...	...	...
N	0.18-0.24	...	...	...	...	...
Cu	<del>0.50-1.00</del>	...	<del>3.0-3.5</del>	<del>26.0-33.0</del>	<del>0.50</del>	<del>0.20</del>
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
Co	...	...	...	...	<del>3.1-4.5</del>	...
Co	...	...	...	...	3.1-4.5	...

<sup>3</sup> Available from American Welding Society (AWS), 8669 NW 36 Street, #130, Miami, FL 33166-6672, <http://www.aws.org>.

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

## 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 describe 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.

**TABLE 2 Nondestructive Examination Requirements**

Maximum Casting Thickness	Class	Visual Examination, Practice A802/A802M Minimum Acceptance Level	Radiographic Examination, Guide E94	Liquid Penetrant Examination, Test Method E165	Class	Visual Examination
		Coverage	Number of Castings Severity Level per Table 6 Minimum Acceptance Level per Specification A903/A903M	Liquid Penetrant Examination, Practice E165/E165M		
less than 5/8 in. (15.9 mm)	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	
	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 III	
	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 IV	
	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	



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.

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.

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TABLE 3 Tensile Requirements

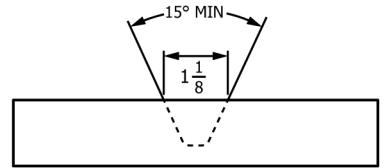
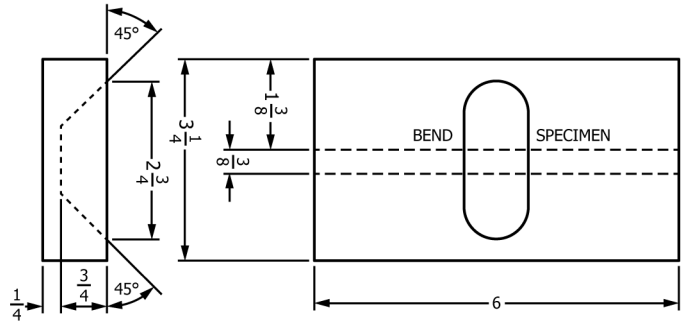
Table with 7 columns: Property, CK3MCuN, CW-2M, CN3MCu, M35-1, CW2MC, N2M. Rows include Tensile strength, 0.2 % offset yield strength, and Elongation in 2 in. [50 mm].

^ 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
CK3MCuN	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. <sup>A</sup>
CK3MCuN	Heat to 2200 to 2265 °F [1205 to 1240 °C] for 1 h at temperature/1 in. [25 mm] of thickness with a minimum of 4 h. Quench in water. <sup>A</sup>
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. <sup>A</sup>
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. <sup>A</sup>
GN3MCu	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>
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
GW2MG	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. <sup>A</sup>
CW2MC	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. <sup>A</sup>
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. <sup>A</sup>
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. <sup>A</sup>

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

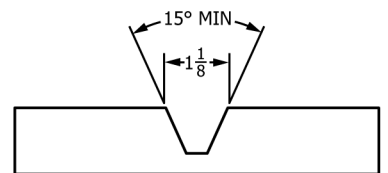
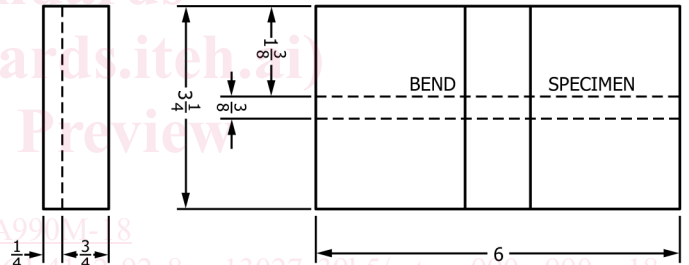


(a)

Metric Equivalents

in.	1/4	3/8	3/4	1 1/8	2 3/4	3 1/4	6
[mm]	[5]	[10]	[20]	[30]	[70]	[85]	[155]

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(b)

Metric Equivalents

in.	1/4	3/8	3/4	1 1/8	3 1/4	6
[mm]	[5]	[10]	[20]	[30]	[85]	[155]

FIG. 1 (a) Weldability Test Plate (b) Optional Weldability Test Plate Withwith a Machined Groove

### 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~~ ~~post-weld~~ heat treatment of the test plate is prohibited even if part of the procedure. Remove one  $\frac{3}{8}$ -in. (~~10-mm~~)[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  $\frac{1}{8}$  in. (~~3.2 mm~~)[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.

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-marked “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. 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—~~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  $\frac{1}{4}$  in. (~~6 mm~~)[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 A488/A488M. Only the filler material grades specified in Table 5 shall be used.

**TABLE 5 Weld Filler Materials**

Cast Grade	AWS A5.11/A5.11M and AWS A5.14/A5.14M Weld Filler Material
CK3MCuN	AWS A5.4 and AWS A5.9 NiCrMo-3
CW-2M	NiCrMo-7 or NiCrMo-10
CN3MCu	AWS A5.4 and AWS A5.9 320LR
M35-1	NiCu-7
CW2MC	NiCrMo-3
N2M	NiMo-7 or NiMo-10