Designation: A 990 – 08

Standard Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service[1]

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 (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 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:* [2]

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

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

[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.

Current edition approved March 1, 2008. Published March 2008. Originally approved in 1998. Last previous edition approved in 2006 as A 990 – 06.

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

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

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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:*[4]
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.

[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		
	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	. . .	. . .

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:

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.

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:

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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 ⅝ 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
⅝ 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 ½ 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 ½ 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

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, %[A]	20.0	35.0	25.0

[A] 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.[A]
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.[A]
M35-1	As-cast

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

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 ⅜-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 ⅛ 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.

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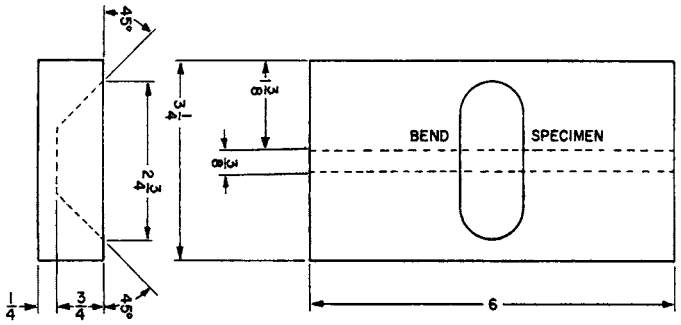
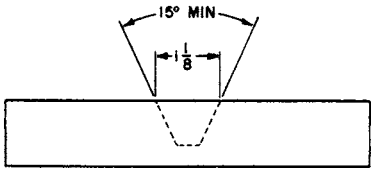
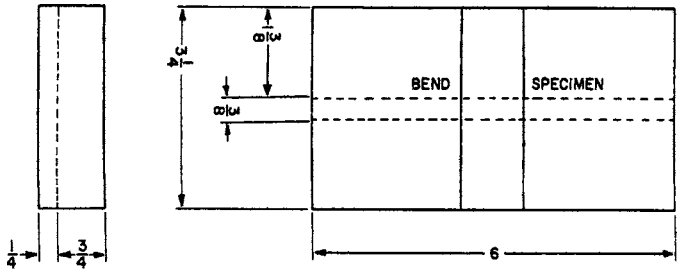


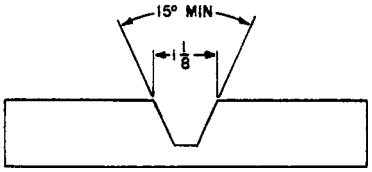


(a)

Metric Equivalents

in.	¼	⅜	¾	1 ⅛	2 ¾	3 ¼	6
[mm]	[5]	[10]	[20]	[30]	[70]	[85]	[155]





NOTE—May be used with the purchaser's approval when the molding process makes it impractical to cast the cavity into the test plate.

(b)

Metric Equivalents

in.	¼	⅜	¾	1 ⅛	3 ¼	6
[mm]	[5]	[10]	[20]	[30]	[85]	[155]

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

TABLE 5 Weld Filler Materials

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

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. 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 ¼ 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.

11.2 Major weld repairs are repairs required when a casting has leaked on hydrostatic test or when the depth of the cavity after preparation for repair exceeds 20 % of the actual wall thickness or 1 in. (25 mm), whichever is smaller, or when the extent of the welding exceeds approximately 10 $in.^2$(65 cm^2) or 5 % of the total surface area, whichever is smaller.

11.3 All weld repairs shall be subject to the same quality standards as are used to inspect the castings. Initial excavation of defects may be accomplished by any method including air-arc gouging, grinding, or machining; however, all visible traces of the air-arc process shall be removed by grinding or machining. All surfaces to be welded and at least 1 in. (25 mm) beyond shall be smooth and free of sand, scale, paint, oil, or other foreign matter. The cleaning may be accomplished by grinding or by machining followed by solvent washing.

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

12. Heat Treatment

12.1 All castings shall be solution heat treated as specified in Table 4.

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TABLE 6 Radiographic Severity Level Requirements

Nickel Base			Severity Level, Min Acceptance Level Reference Radiographs E 272								Reference Radiographs E 186	
			Shrinkage		Dross		Porosity		Inclusions		Chaplets	
Casting Thickness in Area of interest	Class	Type	Reference Radiograph	Source	Reference Radiograph	Source	Reference Radiograph	Source	Reference Radiograph	Source	Reference Radiograph	Source
1 in. (25 mm) and less	Class A	Feathery Spongy Linear	Cd 2 Cd 2 Ca 2	X-ray Gamma Gamma	Bb 1	X-ray	A3	X-ray	Ba 3	X-ray	None Acceptable	
	Class B, C and D	Feathery Spongy Linear	Cd 3 Cd 3 Ca 3	X-ray Gamma Gamma	Bb 2	X-ray	A4	X-ray	Ba 4	X-ray	None Acceptable	
Over 1 in. (25 mm)	Class A	Feathery Spongy Linear	Cd 3 Cd 3 Ca 3	X-ray Gamma Gamma	Bb 2	Gamma	A3	Gamma	Ba 3	Gamma	None Acceptable	
	Class B, C and D	Feathery Spongy Linear	Cd 4 Cd 4 Ca 4	X-ray Gamma Gamma	Bb 3	Gamma	A4	Gamma	Ba 4	Gamma	None Acceptable	

Iron-Nickel-Chromium							
Casting Thickness	Class	ASTM Standard	Shrinkage	Porosity	Inclusion	Hot Tear, Crack	Insert, Chaplet
Less than 1 in. (25 mm)	Class A	E 446	CA 2, CB 2, CC 2, CD 2	A 2	B 2	None	None
	Class B, C and D	E 446	CA 3, CB 3, CC 3, CD 3	A 3	B 3	None	None
1 to 2 in. (25 to 51 mm)	Class A	E 446	CA 2, CB 2, CC 2, CD 2	A 2	B 2	None	None
	Class B, C and D	E 446	CA 3, CB 3, CC 3, CD 3	A 3	B 3	None	None
Over 2 to 4½ in. (251 to 114 mm)	Class A	E 186	CA 3, CB 3, CC 3	A 3	B 3	None	None
	Class B, C and D	E 186	CA 4, CB 4, CC 4	A 4	B 4	None	None
Over 4½ in. (114 mm)	Class A	E 280	CA 3, CB 3, CC 3	A 3	B 3	None	None
	Class B, C and D	E 280	CA 4, CB 4, CC 4	A 4	B 4	None	None

12.2 Post-weld solution heat treatment is required for all major weld repairs, except on M35-1, which is used in the as-cast condition. Post-weld solution heat treatment of other weld repairs is not required provided an interpass temperature of 250°F (121°C) is not exceeded.

13. Workmanship, Finish, and Appearance

13.1 All surfaces shall be cleaned and free of scale. Final cleaning shall be accomplished by blasting with clean nonmetallic media not previously used on steel or iron parts, pickling, machining, or other approved methods approved by the purchaser.

13.2 The castings shall not be peened, plugged, or impregnated.

14. Product Marking

14.1 Castings shall be marked with the ASTM specification designation and grade symbol, for example, CW-2M. The manufacturer's name or identification mark, the pattern number or part number, and the heat number shall be cast or stamped on all castings except those of such small size as to make such marking impractical.

14.2 When the castings are too small to mark individually, a symbol traceable to the heat shall be placed on the castings and the required identification then placed on a tag affixed to the container in which these castings are shipped.

15. Keywords

15.1 casting; iron-nickel-chromium; nickel alloy; pressure retaining

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ANNEX

(Mandatory Information)

A1. ACCEPTANCE CRITERIA FOR INCLUSION OF NEW IRON-NICKEL-CHROMIUM AND NICKEL ALLOYS IN THIS SPECIFICATION

A1.1 Specifications A 351/A 351M, A 494/A 494M, A 743/A 743M, and A 744/A 744M contain alloys similar to those listed in this specification. The distinguishing requirements of this specification are as follows.

A1.1.1 One of four classes of alloys all with 0.015 % S max.

A1.1.1.1 Nickel base with 15 % Cr min, 8 % Mo min, and 0.020 % C max.

A1.1.1.2 Nickel base with 25–35 % Cu and 0.020 % C min.

A1.1.1.3 Nickel base with 25–35 % Mo and 0.020 % C max.

A1.1.1.4 Iron base, fully-austenitic, with 18 % Cr min, 17 % Ni min, 2–8 % Mo, and 0.030 % C max.

A1.1.2 AOD or VOD refined material, no revert except nickel base with 25 to 35 % Cu and 0.020 % C min.

A1.1.3 Weld bend test every heat in the as-welded condition.

A1.1.4 Levels of NDE with combinations of visual, LP, and radiography with acceptance criteria.

A1.1.5 Restricted heat treat requirements for improved corrosion resistance, solution heat treat after all major weld repairs. With 250°F (121°C) max interpass temperature, solution heat treat is not required for minor repairs.

A1.1.6 Specified weld filler material.

A1.2 To be considered for inclusion in this specification, the following data must be presented to Subcommittee A01.18.

A1.2.1 Demonstrate that all heats in the data package passed the weld bend test in the as-welded condition as directed in Section 9.

A1.2.2 The alloy shall fall within one of the four classes of materials listed in A1.1.1.1-A1.1.1.4 and meet the restricted compositional limits.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 990 - 06) that may impact the use of this standard (Approved March 1, 2008).

(1) Added "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," to 10.3.5.

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