

SPECIFICATION FOR STEEL CASTINGS SUITABLE FOR PRESSURE SERVICE



SA-487/SA-487M

(23)

(Identical with ASTM Specification A487/A487M-21 except no welding for Grade 17 per Table 4.)

Specification for Steel Castings Suitable for Pressure Service

1. Scope

1.1 This specification covers low-alloy steels and martensitic stainless steels in the normalized and tempered, or quenched and tempered, condition suitable for pressure-containing parts. The weldability of the classes in this specification varies from readily weldable to weldable only with adequate precautions, and the weldability of each class should be considered prior to assembly by fusion welding.

1.2 Selection will depend on design, mechanical, and service conditions. Users should note that hardenability of some of the grades mentioned may restrict the maximum size at which the required mechanical properties are obtained.

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 nonconformance with the standard.

1.3.1 Within the text, the SI units are shown in brackets.

1.4 *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:

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

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

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

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E709 Guide for Magnetic Particle Testing

2.2 *American Society of Mechanical Engineers:*

ASME Boiler and Pressure Vessel Code, Section IX

2.3 *Manufacturers Standardization Society of the Valve and Fittings Industry Standards:*

SP-55 Quality Standard for Steel Castings—Visual Method

3. General Conditions for Delivery

3.1 Except for investment castings, castings 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.

3.2 Investment castings 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.

4. Ordering Information

4.1 The inquiry and order should include or indicate the following:

4.1.1 A description of the casting by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

4.1.2 ASTM designation and year of issue,

4.1.3 Grade and class of steel,

4.1.4 Options in the specification, and

4.1.5 The supplementary requirements desired, including the standard of acceptance.

5. Heat Treatment

5.1 All castings shall receive a heat treatment indicated in Table 1. Preliminary heat treatment prior to final heat treatment, as well as multiple tempering, is permitted.

5.2 Heat treatment shall be performed after the castings have been allowed to cool below the transformation range.

5.3 The furnace temperature for heat treating shall be effectively controlled by use of recording-type pyrometers.

6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 2. Except for investment castings, product analysis tolerance shall conform to the product analysis tolerance shown in Specification A703/A703M. For investment castings, the product analysis tolerance shall conform to the product analysis tolerance shown in Specification A985/A985M.

7. Tensile Requirements

7.1 Tensile properties of steel used for the castings shall conform to the requirements prescribed in Table 3.

TABLE 1 Heat Treat Requirement

Grade	Class	Austenitizing Temperature, min, °F [°C]	Media ^A	Quenching Cool Below °F [°C]	Tempering Temperature, ^B °F [°C]
1	A	1600 [870]	A	450 [230]	1100 [595]
1	B	1600 [870]	L	500 [260]	1100 [595]
1	C	1600 [870]	A or L	500 [260]	1150 [620]
2	A	1600 [870]	A	450 [230]	1100 [595]
2	B	1600 [870]	L	500 [260]	1100 [595]
2	C	1600 [870]	A or L	500 [260]	1150 [620]
4	A	1600 [870]	A or L	500 [260]	1100 [595]
4	B	1600 [870]	L	500 [260]	1100 [595]
4	C	1600 [870]	A or L	500 [260]	1150 [620]
4	D	1600 [870]	L	500 [260]	1150 [620]
4	E	1600 [870]	L	500 [260]	1100 [595]
6	A	1550 [845]	A	500 [260]	1100 [595]
6	B	1550 [845]	L	500 [260]	1100 [595]
7	A	1650 [900]	L	600 [315]	1100 [595]
8	A	1750 [955]	A	500 [260]	1250 [675]
8	B	1750 [955]	L	500 [260]	1250 [675]
8	C	1750 [955]	L	500 [260]	1250 [675]
9	A	1600 [870]	A or L	500 [260]	1100 [595]
9	B	1600 [870]	L	500 [260]	1100 [595]
9	C	1600 [870]	A or L	500 [260]	1150 [620]
9	D	1600 [870]	L	500 [260]	1150 [620]
9	E	1600 [870]	L	500 [260]	1100 [595]
10	A	1550 [845]	A	500 [260]	1100 [595]
10	B	1550 [845]	L	500 [260]	1100 [595]
11	A	1650 [900]	A	600 [315]	1100 [595]
11	B	1650 [900]	L	600 [315]	1100 [595]
12	A	1750 [955]	A	600 [315]	1100 [595]
12	B	1750 [955]	L	400 [205]	1100 [595]
13	A	1550 [845]	A	500 [260]	1100 [595]
13	B	1550 [845]	L	500 [260]	1100 [595]
14	A	1550 [845]	L	500 [260]	1100 [595]
16	A	1600 [870] ^C	A	600 [315]	1100 [595]
17	A	1590 [865] ^C	L	500 [260]	1095 [590] ^{F,G}
CA15	A	1750 [955]	A or L	400 [205]	900 [480]
CA15	B	1750 [955]	A or L	400 [205]	1100 [595]
CA15	C	1750 [955]	A or L	400 [205]	1150 [620] ^{D,E}
CA15	D	1750 [955]	A or L	400 [205]	1150 [620] ^{D,E}
CA15M	A	1750 [955]	A or L	400 [205]	1100 [595]
CA6NM	A	1850 [1010]	A or L	200 [95]	1050–1150 [565–620]
CA6NM	B	1850 [1010]	A or L	200 [95]	1225–1275 [665–690] ^{E,F} 1050–1150 [565–620] ^G

^A A = air, L = liquid.

^B Minimum temperature unless a range is specified.

^C Double austenitize.

^D Double temper with the final temper at a lower temperature than the intermediate temper.

^E Air cool to below 200 °F [95 °C] after first temper.

^F Intermediate.

^G Final.

TABLE 2 Chemical Composition Requirements^{A,B}

Grade Class Type (UNS Number)	Element, %											
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Vanadium	Boron	Tungsten
1 ABC V (J13002)	0.30	1.00	0.035	0.035	0.80	0.50 ^D	0.35 ^D	^{C,D}	0.50 ^D	0.04–0.12	...	^{C,D}
2 ABC Mn-Mo (J13005)	0.30	1.00–1.40	0.035	0.035	0.80	0.50 ^D	0.35 ^D	0.10–0.30	0.50 ^D	0.03 ^D	...	0.10 ^D
4 ABCDE Ni-Cr-Mo (J13047)	0.30	1.00	0.035	0.035	0.80	0.40–0.80	0.40–0.80	0.15–0.30	0.50 ^E	0.03 ^E	...	0.10 ^E
6 AB Mn-Ni-Cr-Mo (J13855)	0.05–0.38	1.30–1.70	0.035	0.035	0.80	0.40–0.80	0.40–0.80	0.30–0.40	0.50 ^E	0.03 ^E	...	0.10 ^E
7 A Ni-Cr-Mo-V ^F (J13084)	0.05–0.20	0.60–1.00	0.035	0.035	0.80	0.70–1.00	0.40–0.80	0.40–0.60	0.15–0.50	0.03–0.10	0.002–0.006	0.10
8 ABC Cr-Mo (J22091)	0.05–0.20	0.50–0.90	0.035	0.035	0.80	...	2.00–2.75	0.90–1.10	0.50 ^E	0.03 ^E	...	0.10 ^E
9 ABCDE Cr-Mo (J13345)	0.05–0.33	0.60–1.00	0.035	0.035	0.80	0.50 ^D	0.75–1.10	0.15–0.30	0.50 ^D	0.03 ^D	...	0.10 ^D
10 AB Ni-Cr-Mo (J23015)	0.30	0.60–1.00	0.035	0.035	0.80	1.40–2.00	0.55–0.90	0.20–0.40	0.50 ^E	0.03 ^E	...	0.10 ^E
11 AB Ni-Cr-Mo (J12082)	0.05–0.20	0.50–0.80	0.035	0.035	0.60	0.70–1.10	0.50–0.80	0.45–0.65	0.50 ^G	0.03 ^G	...	0.10 ^G
12 AB Ni-Cr-Mo (J22000)	0.05–0.20	0.40–0.70	0.035	0.035	0.60	0.60–1.00	0.50–0.90	0.90–1.20	0.50 ^G	0.03 ^G	...	0.10 ^G
13 AB Ni-Mo (J13080)	0.30	0.80–1.10	0.035	0.035	0.60	1.40–1.75	0.40 ^H	0.20–0.30	0.50 ^H	0.03 ^H	...	0.10 ^H

TABLE 2 Continued

Grade Class Type (UNS Number)	Element, %											
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Vanadium	Boron	Tungsten
14 A Ni-Mo (J15580)	0.55	0.80–1.10	0.035	0.035	0.60	1.40–1.75	0.40 ^H	0.20–0.30	0.50 ^H	0.03 ^H	...	0.10 ^H
16 A Low C-Mn-Ni (J31200)	0.12 ^I	2.10 ^I	0.02	0.02	0.50	1.00–1.40	0.20 ^G	0.10 ^G	0.20 ^G	0.02 ^G	...	0.10 ^G
17 A Ni-Cr-Mo	0.05–0.20	0.55–0.70	0.01	0.005	0.20–0.50	3.0–3.80	1.35–1.60	0.35–0.60	0.20	0.03
CA15 ABCD Martensitic Cr (J91150)	0.15	1.00	0.035	0.035	1.50	1.00	11.5–14.0	0.50	0.50 ^G	0.05 ^G	...	0.10 ^G
CA15M A Martensitic Cr (J91151)	0.15	1.00	0.035	0.035	0.65	1.00	11.5–14.0	0.15–1.0	0.50 ^G	0.05 ^G	...	0.10 ^G
CA6NM AB Martensitic Cr-Ni (J91540)	0.06	1.00	0.035	0.03	1.00	3.5–4.5	11.5–14.0	0.4–1.0	0.50 ^G	0.05 ^G	...	0.10 ^G

^A All values are maximums unless a range is provided.

^B Where ellipses (...) appear in this table, there is no requirement and the element need not be analyzed for or reported.

^C The Mo + W content shall not exceed 0.25 %.

^D Specified Residual Elements—the total content of these elements is 1.00 % maximum.

^E Specified Residual Elements—the total content of these elements is 0.60 % maximum.

^F Proprietary steel composition.

^G Specified Residual Elements—the total content of these elements is 0.50 % maximum.

^H Specified Residual Elements—the total content of these elements is 0.75 % maximum.

^I For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % manganese above the specified maximum will be permitted up to a maximum of 2.30 %.

TABLE 3 Required Mechanical Properties

Previous Designation	Grade	Class	Tensile Strength, ^A ksi [MPa]	Yield Strength, ^A ksi [MPa], at 0.2 % Offset	Elongation, ^A 2 in. [50 mm] or 4d, %	Reduction of Area, ^A %	Maximum Hardness, HRC [HB]	Thickness, in. [mm]
1N	1	A	85–110 [585–760]	55 [380]	22	40		
1Q	1	B	90–115 [620–795]	65 [450]	22	45		
	1	C	90 [620]	65 [450]	22	45	22 [235]	
2N	2	A	85–110 [585–760]	53 [365]	22	35		
2Q	2	B	90–115 [620–795]	65 [450]	22	40		
	2	C	90 [620]	65 [450]	22	40	22 [235]	
4N	4	A	90–115 [620–795]	60 [415]	18	40		
4Q	4	B	105–130 [725–895]	85 [585]	17	35		
	4	C	90 [620]	60 [415]	18	35	22 [235]	
	4	D	100 [690]	75 [515]	17	35	22 [235]	
4QA	4	E	115 [795]	95 [655]	15	35		
6N	6	A	115 [795]	80 [550]	18	30		
6Q	6	B	120 [825]	95 [655]	12	25		
7Q	7	A	115 [795]	100 [690]	15	30		2.5 [63.5] max
8N	8	A	85–110 [585–760]	55 [380]	20	35		
8Q	8	B	105 [725]	85 [585]	17	30		
	8	C	100 [690]	75 [515]	17	35	22 [235]	
9N	9	A	90 [620]	60 [415]	18	35		
9Q	9	B	105 [725]	85 [585]	16	35		
	9	C	90 [620]	60 [415]	18	35	22 [235]	
	9	D	100 [690]	75 [515]	17	35	22 [235]	
	9	E	115 [795]	95 [655]	15	35		
10N	10	A	100 [690]	70 [485]	18	35		
10Q	10	B	125 [860]	100 [690]	15	35		
11N	11	A	70–95 [484–655]	40 [275]	20	35		
11Q	11	B	105–130 [725–895]	85 [585]	17	35		
12N	12	A	70–95 [485–655]	40 [275]	20	35		
12Q	12	B	105–130 [725–895]	85 [585]	17	35		
13N	13	A	90–115 [620–795]	60 [415]	18	35		
13Q	13	B	105–130 [725–895]	85 [585]	17	35		
14Q	14	A	120–145 [825–1000]	95 [655]	14	30		
16N	16	A	70–95 [485–655]	40 [275]	22	35		
	17	A	113 [780]	97 [670]	15	30		up to 6.0 [150], incl.
	17	A	110 [760]	94 [650]	15	30		over 6.0 [150] to 8.0 [200], incl.
	17	A	106 [730]	91 [625]	15	30		over 8.0 [200] to 12.0 [300], incl.
	17	A	102 [705]	88 [605]	15	30		over 12.0 [300] to 14.0 [360], incl.
CA15A	CA15	A	140–170 [965–1170]	110–130 [760–895]	10	25		
CA15	CA15	B	90–115 [620–795]	65 [450]	18	30		
	CA15	C	90 [620]	60 [415]	18	35	22 [235]	
	CA15	D	100 [690]	75 [515]	17	35	22 [235]	
CA15M	CA15M	A	90–115 [620–795]	65 [450]	18	30		
CA6NM	CA6NM	A	110–135 [760–930]	80 [550]	15	35		
CA6NM	CA6NM	B	100 [690]	75 [515]	17	35	23 [255] ^B	

^A Minimum value, unless a range is provided.

^B Test Methods and Definitions A370, Table 2 does not apply to CA6NM. The conversion given is based on CA6NM test coupons. (For example, see ASTM STP 756.)

8. Quality

8.1 The surface of the casting shall be free of adhering sand, scale, cracks, and hot tears as determined by visual examination. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Visual Method SP-55 or other visual standards may be used to define acceptable surface discontinuities and finish. Unacceptable visual surface discontinuities shall be removed and their removal verified by visual examination of the resultant cavities. When methods involving high temperatures are used in the removal and repair of discontinuities, the casting shall be preheated to at least the minimum temperature in Table 4.

8.2 The castings shall not be peened, plugged, or impregnated to stop leaks.

9. Repair By Welding

9.1 For castings other than those intended for use under ASME Boiler and Pressure Vessel Code, repairs shall be made using procedures and welders qualified under Practice A488/A488M.

9.2 On castings intended for use under the ASME Boiler and Pressure Vessel Code, repairs shall be made by procedures and welders qualified under Section IX of that code.

9.3 After repair welding, all castings shall be post-weld heat treated in accordance with Table 4 or reheat treated in accordance with Table 1.

9.4 Weld repairs shall be inspected using the same quality standards as are used to inspect the castings. Re-examination of

TABLE 4 Minimum Preheat and Post-Weld Heat Treat Requirements

Grade	Class	Minimum Preheat Temperature, °F [°C]	Post-Weld Heat Treat, °F [°C]
1	A, B	200 [95]	1100 [595] ^A minimum
1	C	200 [95]	1150 [620] ^A minimum
2	A, B	200 [95]	1100 [595] ^A minimum
2	C	200 [95]	1150 [620] ^A minimum
4	A, B, E	200 [95]	1100 [595] ^A minimum
4	C, D	200 [95]	1150 [620] ^A minimum
6	A, B	300 [150]	1100 [595] ^A minimum
7	A	300 [150]	1100 [595] ^A minimum
8	A, B, C	300 [150]	1250 [675] ^A minimum
9	A, B, E	300 [150]	1100 [595] ^A minimum
9	C, D	300 [150]	1150 [620] ^A minimum
10	A, B	300 [150]	1100 [595] ^A minimum
11	A, B	300 [150]	1100 [595] ^A minimum
12	A, B	300 [150]	1100 [595] ^A minimum
13	A, B	400 [205]	1100 [595] ^A minimum
14	A	400 [205]	1100 [595] ^A minimum
16	A	50 [10]	1100 [595] ^A minimum
17	A	...	No welding
CA15	A	400 [205]	1750 [955] air cool or liquid quench below 400 [205] temper at 900 [480] minimum
CA15	B	400 [205]	1100 [595] ^A minimum
CA15	C, D	400 [205]	1150 [620] ^A minimum
CA15M	A	400 [205]	1100 [595] ^A minimum
CA6NM	A	50 [10]	Final temper between 1050 [565] and 1150 [620]
CA6NM	B	50 [10]	Intermediate PWHT between 1225 [665] and 1275 [690] Final temper PWHT 1050 [565] and 1150 [620] ^B

^A Post-weld heat treat temperature must be at or below the final tempering temperature.

^B The intermediate and final PWHT temperatures shall be the same as the intermediate and final tempering temperatures, respectively, as the original heat treatment of the castings. Cool to below 200 °F [95 °C] between the intermediate and final PWHT.

the weld repair by radiography when Supplementary Requirement S5 has been specified will not be necessary when an applicable surface inspection method was used to locate the discontinuity except for the following:

9.4.1 Weld repairs on castings which have leaked on hydrostatic test.

9.4.2 Weld repairs on castings in which the depth of any cavity prepared for repair welding is more than 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller.

9.4.3 Weld repairs on castings in which any cavity prepared for welding is greater than approximately 10 in.² [65 cm²].

10. Product Marking

10.1 Castings shall be marked for material identification with the grade and class symbols (1-A, 4-C, CA15-A).

11. Keywords

11.1 alloy steel; martensitic stainless steel; pressure-containing parts; stainless steel; steel castings

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not apply unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specifications A703/A703M and A985/A985M. Those which are ordinarily considered suitable for use with this specification are given below. Others enumerated in Specifications A703/A703M and A985/A985M may be used with this specification upon agreement between the manufacturer and purchaser.

S1. Unspecified Elements**S4. Magnetic Particle Inspection****S5. Radiographic Inspection****S8. Charpy Impact Test**

S8.1 In addition to the requirements listed in S8 of Specifications A703/A703M and A985/A985M, the following specific requirements apply to this specification:

S8.1.1 When S8 is specified for Grades 1B, 2B, 4B, 6B, 7A, 8B, 9B, or 10B, impact properties shall be determined by performing a Charpy V-notch impact test at -50°F [-46°C] with a specific minimum average value of 15 ft-lb [20 J] and a specified minimum single value of 10 ft-lb [14 J]. Other temperatures may be used upon agreement between the manufacturer and the purchaser, in which case S8.1.3 shall apply. Other higher specified minimum average and single values may be used upon agreement between the manufacturer and the purchaser.

S8.1.2 Impact requirements for grades other than 1B, 2B, 4B, 6B, 7A, 8B, 9B, and 10B shall be agreed upon between the manufacturer and the purchaser.

S8.1.3 When an impact test temperature other than -50°F [-46°C] is used for those grades listed in S8.1.1, the lowest test temperature at which the material meets the impact requirements shall be stamped with low-stress stamps immediately ahead of the material symbol on the raised pad (for example, 25 10B for $+25^{\circ}\text{F}$ [-4°C] and 025 10B for -25°F [-32°C]).

S10. Examination of Weld Preparation

S10.1 The method of performing the magnetic particle or liquid penetrant test shall be in accordance with Guide E709 or Practice E165/E165M.

S26. Alternate Tension Test Coupons and Specimen Locations for Castings**S27. Hot Isostatic Pressing (HIPing)**