Designation: A 487/A 487M – 93 (Reapproved 2007)

Standard Specification for Steel Castings Suitable for Pressure Service[1]

This standard is issued under the fixed designation A 487/A 487M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] 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 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 are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. Inch-pound units are applicable for material ordered to Specification A 487 and SI units for material ordered to Specification A 487M.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

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 703/A 703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts

E 165 Test Method for Liquid Penetrant Examination

E 709 Guide for Magnetic Particle Examination

2.2 *American Society of Mechanical Engineers:*

ASME Boiler and Pressure Vessel Code, Section IX [4]

2.3 *Manufacturers Standardization Society of the Valve and Fittings Industry Standards:*[5]

SP-55 Quality Standard for Steel Castings-Visual Method

3. General Conditions for Delivery

3.1 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. 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.

[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 ASME Boiler and Pressure Vessel Code applications see related Specifications SA-487 in Section II of that code.

[3] 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.

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

[5] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, http://www.mss-hq.com.

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TABLE 1 Heat Treat Requirement

Grade	Class	Austenitizing Temperature, min, °F [°C]	Media[A]	Quenching Cool Below °F [°C]	Tempering Temperature, °F [°C][B]
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 (J31200)	A	1600 [870][C]	A	600 [315]	1100 [595]
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][DE]
CA15	D	1750 [955]	A or L	400 [205]	1150 [260][DE]
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 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.

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. Product analysis tolerance shall conform to the product analysis tolerance shown in Specification A 703/A 703M. Product analysis tolerances for stainless grades are not presently applicable pending development of these limits.

7. *Tensile Requirements* Tensile Requirements

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

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 A 488/A 488M.

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TABLE 2 Chemical Requirements (Maximum Percent Unless Range is Given)

Grade	1.	2.	4.	6.	7.	8.	9.	10.	11.	12.
Class Type	ABC Vanadium	ABC Manganese-Molyb-denum	ABCDE Nickel-Chromium-Molybdenum	AB Manganese Nickel-Chromium-Molybdenum	A Nickel-Chromium-Molybdenum-Vanadium[A]	ABC Chromium-Molyb-denum	ABCDE Chromium-Molyb-denum	AB Nickel-Chromium-Molybde-num	AB Nickel-Chromium-Molybdenum	AB Nickel-Chromium-Molybdenum
Carbon	0.30	0.30	0.30	0.05–0.38	0.05–0.20	0.05–0.20	0.05–0.33	0.30	0.05–0.20	0.05–0.20
Manganese	1.00	1.00–1.40	1.00	1.30–1.70	0.60–1.00	0.50–0.90	0.60–1.00	0.60 to 1.00	0.50–0.80	0.40–0.70
Phosphorus	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60
Nickel	. . .	. . .	0.40–0.80	0.40–0.80	0.70–1.00	. . .	. . .	1.40–2.00	0.70–1.10	0.60–1.00
Chromium	. . .	. . .	0.40–0.80	0.40–0.80	0.40–0.80	2.00–2.75	0.75–1.10	0.55–0.90	0.50–0.80	0.50–0.90
Molybdenum	. . .	0.10–0.30	0.15–0.30	0.30–0.40	0.40–0.60	0.90–1.10	0.15–0.30	0.20–0.40	0.45–0.65	0.90–1.20
Vanadium	0.04–0.12	. . .	. . .	. . .	0.03–0.10	. . .	. . .	. . .	. . .	. . .
Boron	. . .	. . .	. . .	. . .	0.002–0.006	. . .	. . .	. . .	. . .	. . .
Copper	. . .	. . .	. . .	. . .	0.15–0.50	. . .	. . .	. . .	. . .	. . .
Residual Elements:										
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel	0.50	0.50	. . .	. . .	. . .	. . .	0.50	. . .	. . .	. . .
Chromium	0.35	0.35	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mo + W	0.25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Tungsten	. . .	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vanadium	. . .	0.03	0.03	0.03	. . .	0.03	0.03	0.03	0.03	0.03
Total content of residual elements	1.00	1.00	0.60	0.60	0.60	0.60	1.00	0.60	0.50	0.50

Grade	13.	14.	16	CA15	CA15M	CA6NM
Class Type	AB Nickel-Molybdenum	A Nickel-Molybdenum	A Low Carbon Manganese-Nickel (J31200)	ABCD Martensitic Chromium	A Martensitic Chromium	AB Martensitic Chromium Nickel
Carbon	0.30	0.55	0.12[B]	0.15	0.15	0.06
Manganese	0.80–1.10	0.80–1.10	2.10[B]	1.00	1.00	1.00
Phosphorus	0.04	0.04	0.02	0.040	0.040	0.04
Sulfur	0.045	0.045	0.02	0.040	0.040	0.03
Silicon	0.60	0.60	0.50	1.50	0.65	1.00
Nickel	1.40–1.75	1.40–1.75	1.00–1.40	1.00	1.0	3.5–4.5
Chromium	. . .	. . .	. . .	11.5–14.0	11.5–14.0	11.5–14.0
Molybdenum	0.20–0.30	0.20–0.30	. . .	0.50	0.15–1.0	0.4–1.0
Boron	. . .	. . .	. . .	. . .	. . .	. . .
Copper	. . .	. . .	. . .	. . .	. . .	. . .
Residual Elements						
Copper	0.50	0.50	0.20	0.50	0.50	0.50
Nickel	. . .	. . .	. . .	. . .	. . .	. . .
Chromium	0.40	0.40	0.20	. . .	. . .	. . .
Molybdenum	. . .	. . .	0.10	. . .	. . .	. . .
Tungsten	0.10	0.10	0.10	0.10	0.10	0.10
Vanadium	0.03	0.03	0.02	0.05	0.05	0.05
Total content of residual elements	0.75	0.75	0.50	0.50	0.50	0.50

[A] Proprietary steel composition.
[B] 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 %.

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 postweld 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 the weld repair by radiography when Supplementary Requirement S 5 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.

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TABLE 3 Required Mechanical Properties

Previous Designation	Grade	Class	Tensile Strength,[A] min, ksi [MPa]	Yield Strength, min, ksi [MPa], at 0.2 % Offset	Elongation, 2 in. [50 mm] or 4*d*, min, %	Reduction of Area, min %	Hardness max, HRC [HB]	Max Thickness, in. [mm]
1N	1	A	85 [585]–110 [760]	55 [380]	22	40		
1Q		B	90 [620]–115 [795]	65 [450]	22	45		
	1							
	1	C	90 [620]	65 [450]	22	45	22 [235]	
2N	2	A	85 [585]–110 [760]	53 [365]	22	35		
2Q	2	B	90 [620]–115 [795]	65 [450]	22	40		
	2	C	90 [620]	65 [450]	22	40	22 [235]	
4N	4	A	90 [620]–115 [795]	60 [415]	18	40		
4Q	4	B	105 [725]–130 [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]
8N	8	A	85 [585]–110 [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 [484]–95 [655]	40 [275]	20	35		
11Q	11	B	105 [725]–130 [895]	85 [585]	17	35		
12N	12	A	70 [485]–95 [655]	40 [275]	20	35		
12Q	12	B	105 [725]–130 [895]	85 [585]	17	35		
13N	13	A	90 [620]–115 [795]	60 [415]	18	35		
13Q	13	B	105 [725]–130 [895]	85 [585]	17	35		
14Q	14	A	120 [825]–145 [1000]	95 [655]	14	30		
16N	16 (J31200)	A	70 [485]–95 [655]	40 [275]	22	35		
CA15A	CA15	A	140 [965]–170 [1170]	110 [760]–130 [895]	10	25		
CA15	CA15	B	90 [620]–115 [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 [620]–115 [795]	65 [450]	18	30		
CA6NM	CA6NM	A	110 [760]–135 [930]	80 [550]	15	35		
CA6NM	CA6NM	B	100 [690]	75 [515]	17	35	23 [255][B]	

[A] Minimum ksi, unless range is given.
[B] Test Methods and Definitions A 370, Table 3a does not apply to CA6NM. The conversion given is based on CA6NM test coupons. (For example, see ASTM STP 756.[8])

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 cm^2].

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

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TABLE 4 Minimum Pre-Heat and Post Weld Heat Treat Requirements

Grade	Class	Minimum Pre-Heat 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 (J31200)	A	50 [10]	1100 [595][A] minimum
CA15	A	400 [205]	1750 [955] air cool or liquid quench below 400°F [205°C] temper at 900°F [480°C] 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.

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 Specification A 703/A 703M. Those which are ordinarily considered suitable for use with this specification are given below. Others enumerated in Specification A 703/A 703M

S1. Unspecified Elements

S4. Magnetic Particle Inspection

S5. Radiographic Inspection

S8. Charpy Impact Test

S8.1 In addition to the requirements listed in S 8of Specification A 703/A 703M, the following specific requirements apply to this specification:

S8.1.1 When S 8 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 S 8.1.3 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 S 8.1.1, 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°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 Practice E 709 or Practice E 165.

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