



Designation: **A487/A487M—20 A487/A487M – 21**

Standard Specification for Steel Castings Suitable for Pressure Service¹

This standard is issued under the fixed designation A487/A487M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification² 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:³

[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:⁴

[ASME Boiler and Pressure Vessel Code, Section IX](#)

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, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

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

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 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**. ~~Product~~ 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**. ~~Product analysis tolerances for stainless grades are not presently applicable pending development of these limits.~~

7. 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

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>.



TABLE 1 Heat Treat Requirement

Grade	Class	Austenitizing Temperature, min, °F [°C]	Media ^A	Quenching Cool Below °F [°C]	Tempering Temperature, ^B °F [°C] ²
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]
16	A	1600 [870] ^C	A	600 [315]	1100 [595]
17	ABCD	1590 [865]	L	500 [260]	1095 [590] ^{F,G}
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.

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.

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 (J13002)	ABC Manganese- Molybdenum (J13005)	ABCDE Nickel- Chromium- Molybdenum (J13047)	AB Manganese Nickel- Chromium- Molybdenum (J13855)	A Nickel- Chromium- Molybdenum- Vanadium ² (J12084)	ABC Chromium- Molybdenum (J22091)	ABCDE Chromium- Molybdenum (J13345)	AB Nickel- Chromium- Molybdenum (J23015)	AB Nickel- Chromium- Molybdenum (J12082)	AB Nickel- Chromium- Molybdenum (J22000)
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	0.60-1.00	0.50-0.80	0.40-0.70
Phosphorus	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
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

Class Type	AB Nickel- Molybdenum (J13080)	A Nickel- Molybdenum (J15580)	A Low Carbon Manganese- Nickel (J31200)	ABCD Nickel Chromium Molybdenum	ABCD Martensitic Chromium (J91150)	A Martensitic Chromium (J91151)	AB Martensitic Chromium Nickel (J91540)
Carbon	0.30	0.55	0.12 ^B	0.15-0.20	0.15	0.15	0.06
Manganese	0.80-1.10	0.80-1.10	2.10 ^B	0.55-0.70	1.00	1.00	1.00
Phosphorus	0.035	0.035	0.02	0.01	0.035	0.035	0.035
Sulfur	0.035	0.035	0.02	0.005	0.035	0.035	0.03
Silicon	0.60	0.60	0.50	0.20-0.50	1.50	0.65	1.00
Nickel	1.40-1.75	1.40-1.75	1.00-1.40	3.0-3.80	1.00	1.0	3.5-4.5
Chromium	...	...	...	1.35-1.60	11.5-14.0	11.5-14.0	11.5-14.0
Molybdenum	0.20-0.30	0.20-0.30	...	0.35-0.60	0.50	0.15-1.0	0.4-1.0
Boron	...	...	...	...	...	...	...
Copper	...	...	...	...	...	...	...
Residual Elements:							
—Copper	0.50	0.50	0.20	0.20	0.50	0.50	0.50
—Nickel	...	...	...	...	...	...	...
—Chromium	0.40	0.40	0.20	...	...	...	...
—Molybdenum	...	...	0.10	...	...	...	...



Class Type	AB Nickel-Molybdenum (J13080)	A Nickel-Molybdenum (J15580)	A Low-Carbon Manganese-Nickel (J31200)	ABCD Nickel-Chromium Molybdenum	ABCD Martensitic Chromium (J91150)	A Martensitic Chromium (J91151)	AB Martensitic Chromium-Nickel (J91540)
Tungsten	0.10	0.10	0.10	...	0.10	0.10	0.10
Vanadium	0.03	0.03	0.02	0.03	0.05	0.05	0.05
Total Content of Residual Elements	0.75	0.75	0.50	0.50	0.50	0.50	0.50

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	<u>C,D</u>	0.50 ^D	0.04–0.12	...	<u>C,D</u>
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

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TABLE 2 Continued

Grade Class Type (UNS Number)	Element, %											
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Vanadium	Boron	Tungsten
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
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%–0.01 % below the specified maximum carbon content, an increase of 0.04%–0.04 % manganese above the specified maximum will be permitted up to a maximum of 2.30%–2.30 %.



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 4d, 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	1	B	90 [620]–115 [795]	65 [450]	22	45		
	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	—	
	17	A	113 [780]	97 [670]	15	30	—	6.0 [150]
	17	B	110 [760]	94 [650]	15	30	—	8.0 [200]
	17	C	106 [730]	91 [625]	15	30	—	12.0 [300]
	17	D	102 [705]	88 [605]	15	30	—	14.0 [360]
GA15A	GA15	A	140 [965]–170 [1170]	110 [760]–130 [895]	10	25	—	
GA15	GA15	B	90 [620]–115 [795]	65 [450]	18	30	—	
—	GA15	C	90 [620]	60 [415]	18	35	22 [235]	
—	GA15	D	100 [690]	75 [515]	17	35	22 [235]	
GA15M	GA15M	A	90 [620]–115 [795]	65 [450]	18	30	—	
GA6NM	GA6NM	A	110 [760]–135 [930]	80 [550]	15	35	—	
GA6NM	GA6NM	B	100 [690]	75 [515]	17	35	23 [255] ^B	

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]	