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Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service[1]

This standard is issued under the fixed designation A352/A352M; 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 specification[2] covers steel castings for valves, flanges, fittings, and other pressure-containing parts intended primarily for low-temperature service.

1.2 Several grades of ferritic steels and one grade of martensitic steel are covered. Selection of analysis will depend on design and service conditions (Note 1). The temperature shown is the lowest temperature at which the material ordinarily is required to meet the impact requirements of this specification (see Supplementary Requirement S51, Impact Test Temperatures). Users should note that hardenability of some of the grades mentioned may restrict the maximum size at which the required mechanical properties are obtainable (see Appendix X1).

Grade	Usual Minimum Testing Temperatures, °F [°C]
LCA	–25 [–32]
LCB	–50 [–46]
LCC	–50 [–46]
LC1	–75 [–59]
LC2	–100 [–73]
~~LC2-1~~	~~–100 [–73]~~
LC2-1	–100 [–73]
LC3	–150 [–101]
LC4	–175 [–115]
LC9	–320 [–196]
CA6NM	–100 [–73]

NOTE 1—This specification covers the low-temperature requirements particularly pertinent for ferritic and martensitic steels. Certain grades of austenitic steel castings furnished in accordance with Specification A351/A351M have been found suitable for low-temperature service down to –300 °F [–184 °C] and others down to –425 °F [–254 °C]. These grades may be used when impact tested in accordance with Specification A352/A352M with energy levels and temperatures of test mutually agreed upon between the purchaser and the manufacturer. As a guide to the selection of energy levels and testing temperatures, Appendix X1 should be consulted.

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

[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 Specification SA-352, in Section II of that Code.

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

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 A352 and SI units for material ordered to Specification A352M.

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]

A351/A351M Specification for Castings, Austenitic, for Pressure-Containing Parts
A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
A703/A703M Specification for Steel 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 *Manufacturers Standardization Society of the Valve and Fittings Industry Standard:*[4]

SP-55 Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components (Visual Method)

3. General Conditions for Delivery

3.1 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. 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 Grade of steel,

4.1.3 Options in the specification, and

4.1.4 The supplementary requirements desired, including the standards of acceptance.

5. Heat Treatment

5.1 All castings shall receive a heat treatment proper to their design and chemical composition. It should be recognized that liquid quenching of the ferritic grades is normally required to meet the mechanical properties of heavier sections and will greatly enhance the low-temperature properties of thinner sections.

5.2 Ferritic castings shall be furnished in the normalized and tempered or liquid quenched and tempered condition, except for Grade LC9, which shall be liquid quenched and tempered. Castings shall be tempered at a minimum of 1100 °F [590 °C], except Grade LC4, which shall be 1050 °F [565 °C], and Grade LC9, which shall be tempered in the range of 1050 to 1175 °F [565 to 635 °C], followed by cooling in air or liquid.

5.3 CA6NM castings shall be heat treated by heating to 1850 °F [1010 °C] minimum, and air cooling to 200 °F [95 °C] maximum before any optional intermediate temper, but shall cool to 100 °F [40 °C] maximum before the final temper, which shall be between 1050 and 1150 °F [565 and 620 °C].

5.4 Castings shall be allowed to cool below the transformation range directly after pouring and solidification before they are reheated for normalizing or liquid quenching.

[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 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602.

5.5 *Temperature Control*—Furnace temperature for heat treating shall be controlled by use of pyrometers.

6. Chemical Composition

6.1 The steel shall conform to the chemical composition requirements for the grade ordered, as specified in Table 1.

7. Mechanical Requirements

7.1 *Tension Test:*

7.1.1 Tensile properties of steel used for the castings shall conform to the requirements specified in Table 2.

7.2 *Impact Test:*

7.2.1 The notched bar impact properties of the material shall be determined by testing a set of three Charpy V-notch impact specimens for each heat at one of the standard test temperatures shown in Table 2, depending on the intended service temperature (see Appendix X1). The average energy value of the three specimens shall not be less than specified in Table 2, with not more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

8. Quality

8.1 The surface of the casting shall be examined visually and shall be free of adhering sand, scale, cracks, and hot tears. 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 temperature are used in the removal of discontinuities, castings shall be preheated to at least the minimum temperatures in Table 3.

8.2 When additional inspection is desired, Supplementary Requirements S4, S5, and S10 may be ordered.

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

9. Repair by Welding

9.1 Repairs shall be made using procedures and welders in accordance with Practice A488/A488M.

9.2 Welding of Grade LC9 shall be accomplished using nonmagnetic filler material of AWS classification ENiCrFe-2, and shall require liquid penetrant inspection of the weld (Supplementary Requirement S6) when magnetic particle inspection (Supplementary Requirement S4) is specified for the casting.

9.3 Weld repairs shall be inspected to the same quality standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S4 specified, weld repairs shall be inspected by magnetic particle examination to the same standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S5 specified, weld repairs on castings that have leaked on hydrostatic tests, or on castings in which the depth of any cavity prepared for repair welding exceeds 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller, or on castings in which any cavity prepared for welding is greater than approximately 10 in.^{2} [65 cm^2] shall be radiographed to the same standards that are used to inspect the castings.

9.4 Castings containing any repair weld that exceeds 20 % of the wall thickness, or 1 in. [25 mm], whichever is smaller, or that exceeds approximately 10 in.^{2} [65 cm^2] in area, or that was made to correct hydrostatic test defects shall be stress relieved or heat treated after welding. This mandatory stress relief or heat treatment shall be in accordance with the procedure qualification used. When stress relief is required for Grade LC9, cooling shall be in still air.

10. Product Marking

10.1 All marking shall be on a raised pad using low-stress stamps.

TABLE 1 Chemical Requirements[A,B]

Material Grade UNS Type	Composition, %									
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Vanadium
LCA[C] J02504 Carbon Steel	0.25	0.70	0.04	0.045	0.60	0.50[D]	0.50[D]	0.20	0.30	0.03[D]
LCB[C] J03003 Carbon Steel	0.30	1.00	0.04	0.045	0.60	0.50[D]	0.50[D]	0.20[D]	0.30[D]	0.03[D]
LCC[C] J02505 C-Mn Steel	0.25	1.20	0.04	0.045	0.60	0.50[D]	0.50[D]	0.20[D]	0.30[D]	0.03[D]
~~LC1~~ ~~J12522~~ ~~C-Mo Steel~~	~~0.25~~	~~0.50 – 0.80~~	~~0.04~~	~~0.045~~	~~0.60~~	~~. . .~~	~~. . .~~	~~0.45 – 0.65~~	~~. . .~~	~~. . .~~
LC1 J12522 C-Mo Steel	0.25	0.50–0.80	0.04	0.045	0.60	. . .	. . .	0.45–0.65	. . .	. . .
~~LC2~~ ~~J22500~~ ~~2.5Ni Steel~~	~~0.25~~	~~0.50 – 0.80~~	~~0.04~~	~~0.045~~	~~0.60~~	~~2.00 – 3.00~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~
LC2 J22500 2.5Ni Steel	0.25	0.50–0.80	0.04	0.045	0.60	2.00–3.00	. . .	. . .	. . .	. . .
~~LC2-1~~ ~~J42215~~ ~~Ni-Cr-Mo Steel~~	~~0.22~~	~~0.55 – 0.75~~	~~0.04~~	~~0.045~~	~~0.50~~	~~2.50 – 3.50~~	~~1.35 – 1.85~~	~~0.30 – 0.60~~	~~. . .~~	~~. . .~~
LC2-1 J42215 Ni-Cr-Mo Steel	0.22	0.55–0.75	0.04	0.045	0.50	2.50–3.50	1.35–1.85	0.30–0.60	. . .	. . .
~~LC3~~ ~~J31550~~ ~~3.5Ni Steel~~	~~0.15~~	~~0.50 – 0.80~~	~~0.04~~	~~0.045~~	~~0.60~~	~~3.00 – 4.00~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~
LC3 J31550 3.5Ni Steel	0.15	0.50–0.80	0.04	0.045	0.60	3.00–4.00	. . .	. . .	. . .	. . .
~~LC4~~ ~~J41500~~ ~~4.5Ni Steel~~	~~0.15~~	~~0.50 – 0.80~~	~~0.04~~	~~0.045~~	~~0.60~~	~~4.00 – 5.00~~	~~. . .~~	~~. . .~~	~~. . .~~	~~. . .~~
LC4 J41500 4.5Ni Steel	0.15	0.50–0.80	0.04	0.045	0.60	4.00–5.00	. . .	. . .	. . .	. . .
~~LC9~~ ~~J31300~~ ~~9Ni Steel~~	~~0.13~~	~~0.90~~	~~0.04~~	~~0.045~~	~~0.45~~	~~8.50 – 10.0~~	~~0.50~~	~~0.20~~	~~0.30~~	~~0.03~~
LC9 J31300 9Ni Steel	0.13	0.90	0.04	0.045	0.45	8.50–10.0	0.50	0.20	0.30	0.03
~~CA6NM~~ ~~J91540~~ ~~12.5Cr-Ni-Mo Steel~~	~~0.06~~	~~1.00~~	~~0.04~~	~~0.03~~	~~1.00~~	~~3.5 – 4.5~~	~~11.5 – 14.0~~	~~0.4 – 1.0~~	~~. . .~~	~~. . .~~

CA6NM J91540 12.5Cr-Ni-Mo Steel	0.06	1.00	0.04	0.03	1.00	3.5–4.5	11.5–14.0	0.4–1.0	. . .	. . .

[A] All values are maximums unless a range is provided.
[B] Where ". . ." appears in this table, there is no requirement, and the element need not be analyzed for or reported.
[C] 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 1.10 % for LCA, 1.28 % for LCB, and 1.40 % for LCC.
[D] Specified Residual Elements—The total content of these elements is 1.00 % maximum.

TABLE 2 Mechanical Property Requirements

Material Grade	Tensile Requirements[A,B]				Impact Requirements Charpy V-Notch[B,E]		
	Tensile Strength, ksi [MPa]	Yield Strength,[C] ksi [MPa]	Elongation in 2 in. [50 mm], %[D]	Reduction of Area, %	Minimum energy value for two specimens and minimum average of three specimens, ft·lbf [J]	Minimum energy value for single specimen, ft·lbf [J]	Testing Temperature, °F [°C]
~~LCA~~ ~~J02504~~ ~~Carbon Steel~~	~~60.0 – 85.0~~ ~~[415 – 585]~~	~~30.0 [205]~~	~~24~~	~~35~~	~~13 [18]~~	~~10 [14]~~	~~–25 [–32]~~
LCA J02504 Carbon Steel	60.0–85.0 [415–585]	30.0 [205]	24	35	13 [18]	10 [14]	–25 [–32]
~~LCB~~ ~~J03003~~ ~~Carbon Steel~~	~~65.0 – 90.0~~ ~~[450 – 620]~~	~~35.0 [240]~~	~~24~~	~~35~~	~~13 [18]~~	~~10 [14]~~	~~–50 [–46]~~
LCB J03003 Carbon Steel	65.0–90.0 [450–620]	35.0 [240]	24	35	13 [18]	10 [14]	–50 [–46]
~~LCC~~ ~~J02505~~ ~~C-Mn Steel~~	~~70.0 – 95.0~~ ~~[485 – 655]~~	~~40.0 [275]~~	~~22~~	~~35~~	~~15 [20]~~	~~12 [16]~~	~~–50 [–46]~~
LCC J02505 C-Mn Steel	70.0–95.0 [485–655]	40.0 [275]	22	35	15 [20]	12 [16]	–50 [–46]
~~LC1~~ ~~J12522~~ ~~C-Mo Steel~~	~~65.0 – 90.0~~ ~~[450 – 620]~~	~~35.0 [240]~~	~~24~~	~~35~~	~~13 [18]~~	~~10 [14]~~	~~–75 [–59]~~
LC1 J12522 C-Mo Steel	65.0–90.0 [450–620]	35.0 [240]	24	35	13 [18]	10 [14]	–75 [–59]
~~LC2~~ ~~J22500~~ ~~2.5Ni Steel~~	~~70.0 – 95.0~~ ~~[485 – 655]~~	~~40.0 [275]~~	~~24~~	~~35~~	~~15 [20]~~	~~12 [16]~~	~~–100 [–73]~~
LC2 J22500 2.5Ni Steel	70.0–95.0 [485–655]	40.0 [275]	24	35	15 [20]	12 [16]	–100 [–73]
~~LC2-1~~ ~~J42215~~ ~~Ni-Cr-Mo Steel~~	~~105.0 – 130.0~~ ~~[725 – 895]~~	~~80.0 [550]~~	~~18~~	~~30~~	~~30 [41]~~	~~25 [34]~~	~~–100 [–73]~~
LC2-1 J42215 Ni-Cr-Mo Steel	105.0–130.0 [725–895]	80.0 [550]	18	30	30 [41]	25 [34]	–100 [–73]
~~LC3~~ ~~J31550~~ ~~3.5Ni Steel~~	~~70.0 – 95.0~~ ~~[485 – 655]~~	~~40.0 [275]~~	~~24~~	~~35~~	~~15 [20]~~	~~12 [16]~~	~~–150 [–101]~~
LC3 J31550 3.5Ni Steel	70.0–95.0 [485–655]	40.0 [275]	24	35	15 [20]	12 [16]	–150 [–101]
~~LC4~~ ~~J41500~~ ~~4.5Ni Steel~~	~~70.0 – 95.0~~ ~~[485 – 655]~~	~~40.0 [275]~~	~~24~~	~~35~~	~~15 [20]~~	~~12 [16]~~	~~–175 [–115]~~

LC4 J41500 4.5Ni Steel	70.0–95.0 [485–655]	40.0 [275]	24	35	15 [20]	12 [16]	–175 [–115]
LC9 J31300 9Ni Steel	85.0 [585]	75.0 [515]	20	30	20 [27]	15 [20]	–320 [–196]
~~CA6NM~~ ~~J91540~~ ~~12.5Cr-Ni-Mo Steel~~	~~110.0 – 135.0~~ ~~[760 – 930]~~	~~80.0 [550]~~	~~15~~	~~35~~	~~20 [27]~~	~~15 [20]~~	~~–100 [–73]~~
CA6NM J91540 12.5Cr-Ni-Mo Steel	110.0–135.0 [760–930]	80.0 [550]	15	35	20 [27]	15 [20]	–100 [–73]

[A] All values are minimums unless a range is provided.
[B] See 1.2.
[C] Determine by either 0.2 % offset method or 0.5 % extension-under-load method.
[D] When ICI test bars are used in tensile testing as provided for in Specification A703/A703M, the gage length to reduced section diameter ratio shall be 4 to 1.
[E] See Appendix X1.