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Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service¹

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 specification² 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~~); (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 S22, 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]
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 of the 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]– 300°F [-184°C] and others down to -425°F [-254°C]– 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 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

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.

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.

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

~~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
E165 Practice for Liquid Penetrant Examination for General Industry
E709 Guide for Magnetic Particle Testing

2.2 ~~Manufacturers~~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~~ liquid quenched and tempered condition, except for Grade LC9, which shall be ~~liquid-quenched~~ liquid quenched and tempered. Castings shall be tempered at a minimum of ~~H00°F [590°C]~~; 1100 °F [590 °C], except Grade LC4, which shall be ~~H050°F [565°C]~~; 1050 °F [565 °C], and Grade LC9, which shall be tempered in the range of 1050 to ~~H75°F [635°C]~~; 635 °C], followed by cooling in air or liquid.

5.3 CA6NM castings shall be ~~heat-treated~~ heat treated by heating to ~~H850°F [1010°C]~~ 1850 °F [1010 °C] minimum, and air cooling to ~~200°F [95°C]~~ 200 °F [95 °C] maximum before any optional intermediate temper, but shall cool to ~~H00°F [40°C]~~ 100 °F [40 °C] maximum before the final temper, which shall be between 1050 and ~~H50°F [620°C]~~ 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.

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 requirements as to chemical composition 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 1](#).

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 1](#), depending on the intended service temperature (see [Appendix X1](#)). The average energy value of the three specimens shall not be less than specified, with not more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

~~7.2.2 The notched bar impact test shall be made in accordance with Test Methods and Definitions [A370](#).~~

~~7.2.3 Impact test specimens shall be machined to the form and dimensions shown in Test Methods and Definitions [A370](#), Fig. H.~~

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

⁴ Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602.



TABLE 1 Chemical, Tensile, and Impact Requirements

Type	Carbon Steel	Carbon Steel	Carbon-Manganese Steel	Carbon-Molybdenum Steel	2½ % Nickel Steel	Nickel-Chromium-Molybdenum Steel	3½ % Nickel Steel	4½ % Nickel Steel	9 % Nickel Steel	12½ % Chromium, Nickel-Molybdenum Steel
Grade	LCA	LCB ^A	LCC	LC1	LC2	LC2-1	LC3	LC4	LC9	CA6NM
UNS Number	J02504	J03003	J02505	J12522	J22500	J42215	J31550	J41500	J31300	J91540
Element, % (max, except where range is given)										
Carbon	0.25 ^A	0.30	0.25 ^A	0.25	0.25	0.22	0.15	0.15	0.13	0.06
Silicon	0.60	0.60	0.60	0.60	0.60	0.50	0.60	0.60	0.45	1.00
Manganese	0.70 ^A	1.00	1.20 ^A	0.50-0.80	0.50-0.80	0.55-0.75	0.50-0.80	0.50-0.80	0.90	1.00
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	0.03
Nickel	0.50 ^B	0.50 ^B	0.50 ^B	...	2.00-3.00	2.50-3.50	3.00-4.00	4.00-5.00	8.50-10.0	3.5-4.5
Chromium	0.50 ^B	0.50 ^B	0.50 ^B	...	...	1.35-1.85	...	...	0.50	11.5-14.0
Molybdenum	0.20	0.20 ^B	0.20 ^B	0.45-0.65	...	0.30-0.60	...	...	0.20	0.4-1.0
Copper	0.30	0.30 ^B	0.30 ^B	...	...	...	...	...	0.30	...
Vanadium	0.03 ^B	0.03 ^B	0.03 ^B	...	...	...	...	...	0.03	...
Tensile Requirements: ^C										
Tensile strength, ksi [MPa]	60.0-85.0 [415-585]	65.0-90.0 [450-620]	70.0-95.0 [485-655]	65.0-90.0 [450-620]	70.0-95.0 [485-655]	105.0-130.0 [725-895]	70.0-95.0 [485-655]	70.0-95.0 [485-655]	85.0 [585]	110.0-135.0 [760-930]
Yield strength, ^D min, ksi [MPa]	30.0 [205]	35.0 [240]	40.0 [275]	35.0 [240]	40.0 [275]	80.0 [550]	40.0 [275]	40.0 [275]	75.0 [515]	80.0 [550]
Elongation in 2 in. or 50 mm, min, % ^E	24	24	22	24	24	18	24	24	20	15
Reduction of area, min, %	35	35	35	35	35	30	35	35	30	35
Impact Requirements Charpy V-Notch ^{C,F}										
Energy value, ft-lbf [J], min value for two specimens and min avg of three specimens	13 [18]	13 [18]	15 [20]	13 [18]	15 [20]	30 [41]	15 [20]	15 [20]	20 [27]	20 [27]
Energy value, ft-lbf [J], min for single specimen	10 [14]	10 [14]	12 [16]	10 [14]	12 [16]	25 [34]	12 [16]	12 [16]	15 [20]	15 [20]
Testing temperature, °F [°C]	-25 [-32]	-50 [-46]	-50 [-46]	-75 [-59]	-100 [-73]	-100 [-73]	-150 [-101]	-175 [-115]	-320 [-196]	-100 [-73]

^A 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.

^B Specified Residual Elements—The total content of these elements is 1.00 % maximum.

^C See 1.2.

^D Determine by either 0.2 % offset method or 0.5 % extension-under-load method.

^E 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.

^F See Appendix X1.

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 2.

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

TABLE 2 Minimum Preheat Temperatures

Grade	Thickness, in. [mm]	Minimum Preheat Temperature, °F [°C]
LCA	all	50 [10]
LCB	all	50 [10]
LCC	all	50 [10]
LC1	over 5/8 [15.9]	250 [120]
	5/8 and under	50 [10]
LC2	all	300 [150]
LC2-1	all	300 [150]
LC3	all	300 [150]
LC4	all	300 [150]
CA6NM	all	50 [10]