



# Standard Specification for High Strength Steel Castings in Heavy Sections<sup>1</sup>

This standard is issued under the fixed designation A1001; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers cast alloy steels in the normalized and tempered or quenched and tempered condition, in section sizes through 37 in. (940 mm), suitable for high strain gradient conditions such as those encountered in hooks, shackles, support frames, and other lifting devices. The classes of steel in this specification are weldable only with qualified procedures.

1.2 Section range and class selection will depend on design and service conditions. Users should note that this specification contemplates mechanical property gradients.

1.3 The values stated in 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 non-conformities with the specification. Inch-pound units are applicable for material ordered to this Specification and SI units for material ordered to this Specification.

1.4 If, by agreement, castings are to be supplied in a partially completed condition, that is, all of the provisions of the product specification have not been filled, then the material marking (see Section 15) and certification (see Section 14) are to reflect the extent to which the product specification requirements have been met.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

**A370** Test Methods and Definitions for Mechanical Testing of Steel Products

**A609/A609M** Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

**E94** Guide for Radiographic Examination

**E165** Practice for Liquid Penetrant Examination for General Industry

**E709** Guide for Magnetic Particle Testing

**E1019** Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques

**E1447** Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

**E1806** Practice for Sampling Steel and Iron for Determination of Chemical Composition

2.2 *Manufacturers Standardization of the Value and Fittings Industry Standards:*

**MSS SP-55** Quality Standard for Steel Castings – Visual Method<sup>3</sup>

## 3. General Conditions for Delivery

3.1 Materials furnished to this Specification shall conform to the applicable requirements of Specification **A703/A703M**, including the supplementary requirements that are indicated on the purchase order.

3.2 Terminology and test methods shall be in accordance with Test Methods and Definitions **A370**.

3.3 In the case of conflict between requirements of this specification and referenced specifications, the former shall prevail.

## 4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements to be considered include, but are not limited to, the following:

4.1.1 A description of the casting by pattern number or a fully dimensional and toleranced drawing,

4.1.2 ASTM designation and year of issue,

4.1.3 Section range and class of steel (see **Table 1**),

<sup>3</sup> Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602.

**TABLE 1 Required Mechanical Properties**

Section Range	Class	Chemistry Grade <sup>A</sup>	Tensile Strength		Yield Strength, min ksi (MPa) at 0.2 % Offset		Elongation, 2 in (50 mm) or 4d, min, %		Reduction of Area, min %		Charpy V-Notch, Min Average, ft-lb (J)	
			T/8 <sup>B</sup>	3T/8 <sup>B</sup>	T/8 <sup>B</sup>	3T/8 <sup>B</sup>	T/8 <sup>B</sup>	3T/8 <sup>B</sup>	T/8 <sup>B</sup>	3T/8 <sup>B</sup>	T/8 <sup>B</sup>	3T/8 <sup>B</sup>
1	A	I, II	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
1	B	I	105 (725)	95 (655)	85 (585)	76 (525)	15	11	30	22	25 (34)	15 (20)
1	C	I	90 (620)	80 (550)	70 (485)	63 (435)	17	13	34	26	25 (34)	15 (20)
2	A	I	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
2	B	I	105 (725)	95 (655)	85 (585)	76 (525)	16	12	32	24	25 (34)	15 (20)
2	C	I	90 (620)	80 (550)	70 (485)	63 (435)	18	14	36	28	25 (34)	15 (20)
3	A	I, III	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
3	B	I	105 (725)	95 (655)	85 (585)	76 (525)	17	13	34	26	25 (34)	15 (20)
3	C	I	90 (620)	80 (550)	70 (485)	63 (435)	19	16	38	32	25 (34)	15 (20)
4	A	I, II	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
4	B	I	105 (725)	95 (655)	85 (585)	76 (525)	19	16	38	32	25 (34)	15 (20)
4	C	I	90 (620)	80 (550)	70 (485)	63 (435)	21	18	42	36	25 (34)	15 (20)
5	A	I, II	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
5	B	I	105 (725)	95 (655)	85 (585)	76 (525)	19	16	38	32	25 (34)	15 (20)
5	C	I	90 (620)	80 (550)	70 (485)	63 (435)	21	18	42	36	25 (34)	15 (20)
6	A	I	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
6	B	I	105 (725)	95 (655)	85 (585)	76 (525)	19	16	38	32	25 (34)	15 (20)
6	C	I	90 (620)	80 (550)	70 (485)	63 (435)	21	18	42	36	25 (34)	15 (20)
7	A	I	110 (760)	100 (690)	90 (620)	80 (550)	18	15	36	30	25 (34)	15 (20)
7	B	I	105 (725)	95 (655)	85 (585)	76 (525)	19	16	38	32	25 (34)	15 (20)
7	C	I	90 (620)	80 (550)	70 (485)	63 (435)	21	18	42	36	25 (34)	15 (20)

<sup>A</sup> See 7.1. Chemistry other than these listed can be used if properties are met.

<sup>B</sup> See Fig. 1

4.1.4 Definition of inspection methods, extent of examination, frequency, casting quality zones, and acceptance criteria (see Section 11).

4.1.5 Product marking locations (see Section 15),

4.1.6 Certification report options (see Section 14),

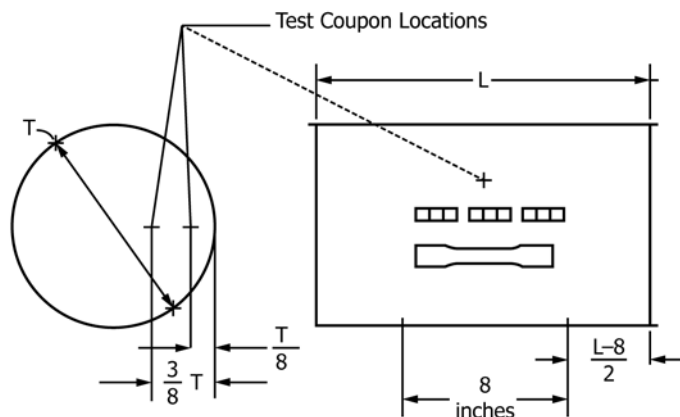
4.1.7 Options in the specification (see 1.4 and 11.6), and

4.1.8 The supplementary requirements desired.

## 5. Test Block Requirements

5.1 The supplier shall produce a minimum of one test block for each heat.

5.2 Test block configuration shall be in accordance with Fig. 1. A standard draft angle is permitted over the length “L” of the test block provided the minimum cylinder diameter is greater than “T” given in Table 2.



**FIG. 1 Test Block Configuration**

**TABLE 2 Section Range Definition and Test Block Dimensions**

Section Range	Section Size, in (mm)		Test Block Dimensions, in (mm) <sup>A</sup>	
	Over	Not Over	T	L
1	3 (76)	5 (127)	4 (102)	8 (203)
2	5 (127)	7 (178)	6 (152)	8 (203)
3	7 (178)	11 (279)	9 (229)	9 (229)
4	11 (279)	15 (381)	13 (330)	13 (330)
5	15 (381)	21 (533)	18 (457)	18 (457)
6	21 (533)	29 (737)	25 (635)	25 (635)
7	29 (737)	37 (940)	33 (813)	33 (813)

<sup>A</sup> See Fig. 1.

5.3 Test block size shall be in accordance with Table 2 for specified section range. The section range selection made by the purchaser (see 4.1.3) should consider casting section size and geometry, service conditions, mechanical property correlations developed by the supplier, or other important factors.

5.4 Tension and Charpy impact tests shall be performed on specimens taken from both the 1/8T and 3/8T locations and shall be oriented within the 8-in. (203-mm) midsection as shown in Fig. 1.

5.5 Oxygen and nitrogen gas content tests shall be performed on specimens taken from the 3/8T location and shall be within the 8 in. (203 mm) midsection as shown in Fig. 1.

## 6. Materials and Manufacture

6.1 The steel shall be made by electric furnace process with methods to conform to the maximum gas levels given in Table 3. These methods may include a special refining process such as argon-oxygen-decarburization (AOD).

6.2 Heat treatment procedure shall be reported to the purchaser by the supplier for the specified section range, class, and grade.

6.2.1 Multiple austenitizing is permitted.

**TABLE 3 Maximum Gas Content Levels**

Section Range	Nitrogen, ppm	Oxygen, ppm	Oxygen Analysis Tolerance, ppm	Oxygen Analysis Limit, ppm <sup>A</sup>
1	110	100	30	130
2	110	100	30	130
3	100	90	27	117
4	100	90	27	117
5	90	80	24	104
6	80	70	21	91
7	70	60	18	78

<sup>A</sup>Specification compliance level is average value of three determinations, see 10.3

6.2.2 Multiple tempering is permitted. The minimum final tempering temperature shall not be less than 1100°F (593°C). Post weld heat treatment shall not be less than 1050°F (566°C).

6.3 Test block(s) may be heat treated separately from the castings they represent.

6.3.1 Test block(s) shall be heat treated in the same production heat treat equipment, in the same facility, and to the same procedure as the castings to be produced. Test block(s) are excluded from post weld heat treatment (see 12.2.9).

6.3.2 The test block(s) tempering temperature shall be within  $\pm 25^{\circ}\text{F}$  ( $14^{\circ}\text{C}$ ) of the casting tempering temperature.

6.4 Heat treatment charts showing time and temperature shall be prepared and held available for inspection by the purchaser.

## 7. Chemical Composition

7.1 Supplier shall select the casting chemistry Grade from Table 1 for the section range, and class specified by the purchaser.

7.1.1 Chemical composition shall conform to Table 4 for Grades II and III.

7.1.2 Grade I designates the use of an alternate chemistry selected by the supplier. Alternate chemistries shall conform to the allowable element ranges and limits given in Table 5.

**TABLE 4 Chemical Grade Composition (Maximum Percent Unless Range is Given)**

Element:	Grade		
	I	II	III
See Table 5	See Table 5	...	...
Carbon	...	0.20 to 0.28	0.20 to 0.28
Manganese	...	1.00 to 1.40	1.00 to 1.40
Phosphorus	...	0.02	0.03
Sulfur	...	0.015	0.025
Silicon	...	0.30 to 0.60	0.30 to 0.60
Nickel	...	1.00 to 1.30	1.00 to 1.30
Chromium	...	0.80 to 1.20	0.80 to 1.20
Molybdenum	...	0.60 to 0.85	0.60 to 0.85
Aluminum	...	0.03	0.07
Residual Elements:	See Table 5		
Zirconium	...	A	A
Copper	...	A	A
Titanium	...	A	A
Tungsten	...	A	A
Vanadium	...	A	A
Columbium	...	A	A
Boron	...	A	A
Total Content of Residual Elements	...	0.60	0.60

<sup>A</sup> Reported for Information Only

**TABLE 5 Element Tolerance Ranges and Maximum Limits for Alternate Chemistries**

Element	Average of Declared Range, (%)	Maximum Range (%)	Maximum Limit (%)
Carbon	All	0.08	0.35
Manganese	<1.00	0.30	...
	$\geq 1.00$	0.40	...
Phosphorus	All	...	0.02
Sulfur	All	...	0.015
Nickel	<1.50	0.30	...
	$\geq 1.50$	0.50	...
Chromium	<1.50	0.40	...
	$\geq 1.50$	0.50	...
Molybdenum	All	0.25	...
Aluminum	All	0.04	0.06
Vanadium	All	0.10	...
Copper <sup>A</sup>	...	...	...
Titanium <sup>A</sup>	...	...	...
Columbium <sup>A</sup>	...	...	...
Zirconium <sup>A</sup>	...	...	...
Nitrogen <sup>A</sup>	...	...	...

<sup>A</sup> Reported for information only.

7.2 A product analysis shall be made for specification conformance. The product analysis shall be performed on a specimen taken from the test block(s) in Section 5 and shall be from the 3/8T location and shall be within the 8 in. (203 mm) midsection as shown in Fig. 1. The supplier shall perform the product analysis in addition to any other process control analysis.

7.3 Retests for conformance are permitted in accordance with Section 13.

## 8. Tension Test

8.1 Tension tests shall be performed on test specimens taken from test block(s) as determined in Section 5.

8.1.1 One tension test specimen is required at each of the 1/8T and 3/8T locations and shall be oriented within the 8 in. (203 mm) midsection as shown in Fig. 1.

8.1.2 Tension test specimens shall be machined to the form and dimension shown in Fig. 4 of Test Methods and Definitions A370 and tested in accordance with those test methods.

8.2 Mechanical properties shall conform to the requirements given in Table 1.

8.3 Retests for conformance are permitted in accordance with Section 13.

## 9. Charpy Impact Test

9.1 Charpy impact tests shall be performed on test specimens taken from test block(s) as determined in Section 5. One set of Charpy impact test specimens is required at each of the 1/8T and 3/8T locations and shall be oriented within the 8 in. (203 mm) midsection as shown in Fig. 1.

9.2 Charpy impact tests shall be performed in accordance with A703/A703M S8.1 at  $-40^{\circ}\text{F}$  ( $-40^{\circ}\text{C}$ ) temperature.

9.3 Acceptance criteria shall be in accordance with A703/A703M S8.2 method and conform to the average absorbed energy values given in Table 1.

9.4 Minimum single specimen value shall not be less than 5 ft-lbs (7 J) below the average absorbed energy values given in Table 1.

9.5 Retests for conformance are permitted in accordance with Section 13.

## 10. Gas Content Requirements

10.1 Oxygen and nitrogen gas content tests shall be performed on test specimens taken from the test block(s) as determined in Section 5. Gas content tests shall be performed on specimens taken from the 3/8T location and shall be within the 8 in. (203 mm) midsection as shown in Fig. 1.

10.2 Hydrogen gas content tests shall be performed on ladle specimens for section ranges 4 – 7 and results reported. A carrier gas infusion method may be used with samplers and instrumentation in accordance with Practice E1806 and Test Method E1447 respectively.

10.3 Oxygen and nitrogen gas content tests shall be performed in accordance with Test Methods E1019. Oxygen content for specification compliance shall be taken as the average value of three determinations.

10.4 Oxygen and nitrogen gas content requirements of steel used for the castings shall conform to the requirements given in Table 3.

10.5 Retests for conformance are permitted in accordance with Section 13.

## 11. Quality

11.1 The purchaser shall establish casting quality zones that include, at a minimum, a shell and a core depth zone (See Fig. 2).

11.2 Non-destructive examination for specification conformance shall be of the final heat treated condition.

11.3 Casting shell zone surface shall be visually examined and graded in accordance with MSS SP-55. Acceptance criteria shall be as specified in the purchase order.

11.4 Casting shell zone surface shall be examined for discontinuities by magnetic particle or liquid penetrant inspection, or both, in accordance with Practice E709 and Test Method E165 respectively. Personnel performing the examination shall have at least ASNT Level II qualification in the inspection method used and shall be qualified by persons having ASNT Level III qualification. Inspection method, extent

of examination, frequency, and acceptance criteria shall be as specified in the purchase order.

11.5 Casting shell and core zones shall be examined for internal defects by ultrasonic or radiographic inspection, or both, in accordance with Practice A609/A609M and Guide E94 respectively. Personnel performing the examination shall have at least ASNT Level II qualification in the inspection method used and shall be qualified by persons having ASNT Level III qualification. Inspection method, extent of examination, frequency, and acceptance criteria for each zone shall be as specified in the purchase order.

11.6 Purchaser may select representative castings from each heat for destructive examination of internal defects in accordance with terms of Specification A703/A703M S2 and the acceptance criteria specified in the purchase order.

## 12. Repair Methods

12.1 *Grinding*—Indications rejected under Section 11 may be removed by grinding, consistent with the following:

12.1.1 Grinding shall not reduce final section thickness below the minimum permitted by the design drawing. Grinding shall be smoothly fared into the surrounding surface.

12.1.2 Grinding surface area shall be re-examined and evaluated in accordance with 11.4.

12.2 *Welding*—Indications rejected under Section 11 may be removed and repair welded, consistent with the following:

12.2.1 Indication removal may be accomplished by grinding or use of thermal methods. High temperature methods may require pre-heat in accordance with the weld procedure.

12.2.2 Weld repair to be made on castings in which the depth of any cavity prepared for welding is more than the lesser of T/5 or 2 in. (51 mm) shall be approved by the purchaser prior to welding. “T” is the test block diameter as shown in Fig. 1 and given in Table 2.

12.2.3 Weld repair to be made on castings in which the open surface of any cavity prepared for welding is greater than the lesser of T in.<sup>2</sup> or 10 in.<sup>2</sup> (64 cm<sup>2</sup>) shall be approved by the purchaser prior to welding. “T” is the test block diameter as shown in Fig. 1 and given in Table 2.

12.2.4 Weld repair charts for weld repairs requiring purchaser approval shall be provided in accordance with Specification A703/A703M S20.1.

12.2.5 Weld repair cavities shall be examined and evaluated in accordance with 11.4.

12.2.6 Repairs shall be made using procedures and welders qualified under Section IX of the ASME Boiler and Pressure Vessel Code.<sup>4</sup>

12.2.7 The entire casting should be raised to temperature when pre- and postweld heat treatment is required by the weld procedure. Use of localized pre- and postweld heat treatment shall be in accordance with procedure approved by the purchaser.

12.2.8 Finished weld repairs shall be examined and evaluated in accordance with 11.4 and 11.5.

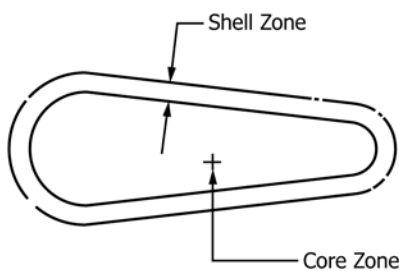


FIG. 2 Quality Zones

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

12.2.9 After repair welding, all heat treated castings shall be post-weld heat treated below the final tempering temperature. The post-weld heat treatment temperature shall be no more than 50°F (28°C) below the final tempering temperature.

### 13. Retests

13.1 Reheat treatment in accordance with 6.2 and 6.3 is permitted before retesting.

13.2 If mechanical property, Charpy impact, or oxygen gas content certification test fails to conform to requirements of this specification, two additional specimens from the same test block shall be tested. Retest specimens shall be taken from the appropriate 1/8T and 3/8T locations and shall be oriented within the 8 in. (203 mm) midsection as shown in Fig. 1. Both test results shall conform to applicable requirements of this specification.

13.3 If nitrogen gas content certification test fails to conform to requirements of this specification, an aluminum nitride test shall be conducted in accordance with Specification A703/A703M S23.3. Severity level greater than four shall be cause for casting rejection. Retest specimen shall be taken from the 3/8T location and shall be within the 8 in. (203 mm) midsection as shown in Fig. 1.

### 14. Certification

14.1 Supplier shall furnish to the purchaser certification report complete with options specified in the order.

14.2 Certification report shall include the following:

14.2.1 Purchase order number,

14.2.2 Casting component number(s),

14.2.3 Material specification number, year-date, and the section range, class, and grade symbols (see 15.1),

14.2.4 Heat number(s),

14.2.5 Results of chemical composition conformance test (see Section 7),

14.2.6 Results of mechanical properties conformance test (see Section 8),

14.2.7 Results of Charpy impact conformance test (see Section 9),

14.2.8 Results of gas content conformance test (see Section 10).

14.2.9 Results of non-destructive examinations (see Section 11 and 12.2.8),

14.3 Certification report may include the following:

14.3.1 Weld repair charts (see 12.2.4),

14.3.2 Heat treatment procedure (see 6.2),

14.3.3 Heat treatment time and temperature charts (see 6.4),

14.3.4 Extent to which the casting is incomplete (see 1.4 and 15.5), and

14.3.5 Results of supplementary requirements testing.

### 15. Product Marking

15.1 Castings shall be marked for material identification with the section range, class, and grade symbols. For example: 3-A-III.

15.2 Heat numbers or serial numbers that are traceable to heat numbers shall be marked on all castings.

15.3 Castings shall be marked with the manufacturer's identification or symbol.

15.4 Marking location shall be shown on the purchaser's casting drawing.

15.5 Castings furnished partially complete shall include the suffix Y following the section range, class, and grade designation specified in 15.1.

### 16. Keywords

16.1 aluminum nitride; AOD; heavy section; hydrogen gas; nitrogen gas; oxygen gas

## SUPPLEMENTARY REQUIREMENTS

### S1. Property Gradient Report

S1.1 Tensile and Charpy property values shall be determined from the surface to the center of the test block at 1-in. (25-mm) increments.

S1.2 The tensile and Charpy property values shall be reported to the purchaser.

S1.3 The macrohardness survey shall be made at ¼-in. (6-mm) increments from the surface to the center of the test block and reported to the purchaser.

### S2. Hydrogen Gas Content

S2.1 Hydrogen gas content shall be controlled with gas level and test method specified in the purchaser order.



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