



Designation: A703/A703M – 20a

Standard Specification for Steel Castings, General Requirements, for Pressure-Containing Parts¹

This standard is issued under the fixed designation A703/A703M; 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 a group of common requirements that, unless otherwise specified in an individual specification, shall apply to steel castings for pressure-containing parts under each of the following ASTM specifications:

Title of Specification	ASTM Designation
Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service	A216/A216M
Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service	A217/A217M
Castings, Austenitic, for Pressure-Containing Parts	A351/A351M
Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service	A352/A352M
Steel Castings, Alloy, Specially Heat-Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service	A389/A389M
Steel Castings Suitable for Pressure Service	A487/A487M
Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure-Retaining Parts for Corrosive Service	A990/A990M
Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts	A995/A995M

1.2 This specification also covers a group of supplementary requirements which may be applied to the above specifications as indicated therein. These are provided for use when additional testing or inspection is desired and apply only when specified individually by the purchaser in the order.

1.3 In case of conflict between the requirements of the individual specification and this general specification, the former shall prevail.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in

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-703/SA-703M in Section II of that Code.

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.

1.5 *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

- A216/A216M Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
- A217/A217M Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service
- A351/A351M Specification for Castings, Austenitic, for Pressure-Containing Parts
- A352/A352M Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A380/A380M Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A389/A389M Specification for Steel Castings, Alloy, Specially Heat Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service
- A487/A487M Specification for Steel Castings Suitable for Pressure Service
- A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
- A609/A609M Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof

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

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A800/A800M Practice for Estimating Ferrite Content of Stainless Steel Castings Containing Both Ferrite and Austenite

A802/A802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination

A903/A903M Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A967/A967M Specification for Chemical Passivation Treatments for Stainless Steel Parts

A990/A990M Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure-Retaining Parts for Corrosive Service

A991/A991M Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products

A995/A995M Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts

A1058 Test Methods for Mechanical Testing of Steel Products—Metric

A1067/A1067M Specification for Test Coupons for Steel Castings

A1080/A1080M Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E94/E94M Guide for Radiographic Examination Using Industrial Radiographic Film

E125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E186 Reference Radiographs for Heavy-Walled (2 to 4½ in. (50.8 to 114 mm)) Steel Castings

E208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

E280 Reference Radiographs for Heavy-Walled (4½ to 12 in. (114 to 305 mm)) Steel Castings

E340 Practice for Macroetching Metals and Alloys

E353 Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

E709 Guide for Magnetic Particle Testing

2.2 *ANSI Standard*.⁴

B16.5 Pipe Flanges and Flanged Fittings

2.3 *Standards of the Manufacturers Standardization Society of the Valve and Fitting Industry*.⁵

MSS SP 53 Quality Standard for Steel Castings and Forgings for Valves, Flanges, and Fittings and Other Piping Components (Magnetic Particle Exam Method)

MSS SP 54 Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components (Radiographic Examination Method)

2.4 *SAE Standard*.⁶

AMS 2750 Pyrometry

3. Terminology

3.1 *Definitions*:

3.1.1 The definitions in Test Methods and Definitions **A370**, Terminology **A941**, and Test Methods **A1058** are applicable to this specification and to those listed in 1.1.

3.1.2 *chaplet, n*—a chaplet is a metallic support placed in a mold cavity to maintain the spacing between a core and the mold.

3.1.3 *electronic data interchange (EDI), n*—the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

3.1.4 *heat, n*—all the molten metal poured from a single furnace or all the molten metal from two or more furnaces poured into a single ladle or casting prior to the replenishing of the furnace(s).

3.1.5 *internal chill, n*—an internal chill is a metallic device placed in a mold cavity to increase the rate of heat removal at that location.

3.1.6 *test coupon, n*—the part from which the test specimen will be extracted.

3.1.7 *test specimen, n*—the part that will be acted upon in a mechanical test.

4. Materials and Manufacture

4.1 *Melting Process*—The steel shall be made by open-hearth or electric-furnace process, with or without separate refining such as argon-oxygen-decarburization (AOD), unless otherwise designated by the individual specification.

4.2 *Heat Treatment*:

4.2.1 Ferritic and martensitic steel shall be cooled after pouring to provide substantially complete transformation of austenite prior to heat treatment to enhance mechanical properties.

4.2.2 Castings shall be heat treated in the working zone of a furnace that has been surveyed in accordance with Test Method **A991/A991M** or AMS 2750.

4.2.2.1 When using furnaces surveyed in accordance with Test Method **A991/A991M**, the following requirements apply for heat treatments above 2000 °F [1100 °C]. When castings are heat treated at temperatures above 2000 °F [1100 °C], then

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.org>.

⁶ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

the working zone shall have been established by a survey performed at not more than 25 °F [15 °C] below nor more than 200 °F [110 °C] above the minimum heat treatment temperature specified for the grade. If a minimum heat treatment temperature is not specified for the grade, then the survey temperature shall be not more than 50 °F [30 °C] below nor more than 175 °F [100 °C] above the furnace set point used.

4.2.2.2 When using furnaces surveyed in accordance with AMS 2750, there are no additional requirements beyond those stated in AMS 2750.

4.2.2.3 The maximum variation in measured temperature as determined by the difference between the highest temperature and the lowest temperature shall be as agreed between the purchaser and producer, except that during production heat treatment no portion of the furnace shall be below the minimum specified temperature nor above the maximum specified temperature for the grade being processed.

5. Chemical Composition

5.1 *Chemical Analysis*—Chemical analysis of materials covered by this specification shall be in accordance with Test Methods [A751](#).

5.2 *Heat Analysis*—An analysis of each heat shall be made by the manufacturer to determine the percentages of the elements specified. The analysis shall be made from a test sample preferably taken during the pouring of the heat. When drillings are used, they shall be taken not less than ¼ in. [6.4 mm] beneath the surface. The chemical composition thus determined shall be reported to the purchaser, or their representative, and shall conform to the requirements in the individual specification for the grade being poured.

5.3 *Product Analysis*—A product analysis may be made by the purchaser from material representing each heat, lot, or casting. The analysis shall be made on representative material. Due to the possibility of decarburization, samples for carbon analysis shall be taken no closer than ¼ in. [6.4 mm] to a cast surface, except that castings too thin for this shall be analyzed on representative material. The chemical composition thus determined shall meet the requirements specified in the applicable specification for the grade involved, or shall be subject to rejection by the purchaser, except that the chemical composition determined for carbon and low-alloy steel, stainless steel, and nickel and cobalt castings may vary from the specified limits by the amounts shown in [Table 1](#), [Table 2](#), and [Table 3](#), respectively. The product analysis tolerances of [Tables 1-3](#) are not applicable as acceptance criteria for heat analysis by the casting manufacturer. When comparing product and heat analysis for other than carbon and low-alloy steels and stainless steels, the reproducibility data R_2 , in Test Methods [E353](#) or [E354](#), as applicable, shall be taken into consideration.

5.4 *Unspecified Elements*—When chemical analysis for elements not specified for the grade ordered is desired, Supplementary Requirement S1 may be specified.

5.5 *Grade Substitution*—Grade substitution is not permitted. Grade substitution occurs when the material being supplied contains one or more elements that are not specified for the

TABLE 1 Product Analysis Tolerances – Carbon and Low-Alloy Steels

Element	Range ^A	Tolerances ^{B,C} over max or under min, Limit, %
Carbon (C)	up to 0.65 % above 0.65 %	$0.03 \times \% C_L + 0.02$ 0.04 %
Manganese (Mn)	up to 1 % above 1 %	$0.08 \times \% Mn_L + 0.01$ 0.09
Silicon (Si)	up to 0.60 % above 0.60 %	$0.22 \times \% Si_L - 0.01$ 0.15 %
Phosphorus (P)	all	$0.13 \times \% P_L + 0.005$
Sulfur (S)	all	$0.36 \times \% S_L + 0.001$
Nickel (Ni)	up to 2 % above 2 %	$0.10 \times \% Ni_L + 0.03$ 0.25 %
Chromium (Cr)	up to 2 % above 2 %	$0.07 \times \% Cr_L + 0.04$ 0.18 %
Molybdenum (Mo)	up to 0.6 % above 0.6 %	$0.04 \times \% Mo_L + 0.03$ 0.06 %
Vanadium (V)	up to 0.25 % above 0.25 %	$0.23 \times \% V_L + 0.004$ 0.06 %
Tungsten (W)	up to 0.10 % above 0.10 %	$0.08 \times \% W_L + 0.02$ 0.02 %
Copper (Cu)	up to 0.15 % above 0.15 %	$0.18 \times \% Cu_L + 0.02$ 0.05 %
Aluminum (Al)	up to 0.03 % 0.03 to 0.10 %, incl. above 0.10 %	0.01 % $0.08 \times \% Al + 0.02$ 0.03 %

^A The range denotes the composition limits up to which the tolerances are computed by the equation, and above which the tolerances are given by a constant.

^B The subscript_L for the elements in each equation indicates that the limits of the element specified by the applicable specification are to be inserted into the equation to calculate the tolerance for the upper limit and the lower limit, if applicable, respectively. Examples of computing tolerances are presented in the footnote C.

^C To compute the tolerances, consider the manganese limits 0.50 to 80 % of Grade WC4 of Specification [A217/A217M](#). In accordance with [Table 1](#), the maximum permissible deviation of a product analysis below the lower limit 0.50 is 0.05 % = $(0.08 \times 0.50 + 0.01)$. The lowest acceptable product analysis of Grade WC4, therefore, is 0.45 %. Similarly, the maximum permissible deviation above the upper limit of 0.80 % is 0.074 % = $(0.08 \times 0.80 + 0.01)$. The highest acceptable product analysis of Grade WC4, therefore, is 0.874. For Grade WCC of Specification [A216/A216M](#), the maximum manganese content is 1.40 % if the carbon content is 0.20 %. In this case, the highest acceptable product analysis is 1.49 = $(1.40 + 0.09)$.

supplied material such that the material conforms to the requirements of a different grade.

5.6 Where more than one ladle is poured into a single casting, the molten metal in each ladle must conform to the specified chemical requirements.

6. Mechanical Test Methods

6.1 All mechanical tests shall be conducted in accordance with Test Methods and Definitions [A370](#). When material is ordered to an M-suffix (SI units) standard, then in accordance with Test Methods [A1058](#).

6.2 Choice of testing track from the options listed in Test Methods [A1058](#) when material is ordered to an M-suffix (SI units) product standard should be identified by the purchaser in the ordering information. If the choice of test track is not specified in the order, then the default ASTM track shall be used as noted in Test Methods [A1058](#).

7. Tensile Requirements

7.1 One tension test shall be made from each heat, and shall conform to the tensile requirements specified. Test coupons

TABLE 2 Product Analysis Tolerances – Stainless Steels

Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit	Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Carbon	to 0.010, incl	0.002	Titanium	to 1.00, incl	0.05
	over 0.010 to 0.030, incl	0.005		over 1.00 to 3.00, incl	0.07
	over 0.030 to 0.20, incl	0.01	Cobalt	over 0.05 to 0.50, incl	0.01 ^A
	over 0.20 to 0.60, incl	0.02		over 0.50 to 2.00, incl	0.02
	over 0.60 to 1.20, incl	0.03	over 2.00 to 5.00, incl	0.05	
Manganese	to 1.00, incl	0.03	Columbium plus tantalum	to 1.50, incl	0.05
	over 1.00 to 3.00, incl	0.04			
	over 3.00 to 6.00, incl	0.05			
	over 6.00 to 10.00, incl	0.06			
	over 10.00 to 15.00, incl	0.10			
	over 15.00 to 20.00, incl	0.15	Tantalum	to 0.10, incl	0.02
Phosphorus	to 0.040, incl	0.005	Copper	to 0.50, incl	0.03
	over 0.040 to 0.20, incl	0.010		over 0.50 to 1.00, incl	0.05
		0.020	over 1.00 to 3.00, incl	0.10	
Sulfur	to 0.040, incl	0.005		over 3.00 to 5.00, incl	0.15
	over 0.040 to 0.20, incl	0.010		over 5.00 to 10.00, incl	0.20
	over 0.20 to 0.50, incl	0.020	Aluminum	to 0.15, incl	–0.005, +0.01
Silicon	to 1.00, incl	0.05		over 0.15 to 0.50, incl	0.05
	over 1.00 to 3.00, incl	0.10		over 0.50 to 2.00, incl	0.10
	over 3.00 to 6.00, incl	0.15			
Chromium	over 4.00 to 10.00, incl	0.10	Nitrogen	to 0.02, incl	0.005
	over 10.00 to 15.00, incl	0.15		over 0.02 to 0.19, incl	0.01
	over 15.00 to 20.00, incl	0.20		over 0.19 to 0.25, incl	0.02
	over 20.00 to 30.00, incl	0.25		over 0.25 to 0.35, incl	0.03
Nickel	to 1.00, incl	0.03	over 0.35 to 0.45, incl	0.04	
	over 1.00 to 5.00, incl	0.07	over 0.45 to 0.55, incl	0.05	
	over 5.00 to 10.00, incl	0.10	to 1.00, incl	0.03	
	over 10.000 to 20.00, incl	0.15	over 1.00 to 2.00, incl	0.05	
	over 20.00 to 30.00, incl	0.20			
Molybdenum	over 0.20 to 0.60, incl	0.03	Vanadium	to 0.50 incl	0.03
	over 0.60 to 2.00, incl	0.05		over 0.50 to 1.50, incl	0.05
	over 2.00 to 8.00, incl	0.10			
			Selenium	all	0.03

^A Product analysis limits for cobalt under 0.05 % have not been established, and the manufacturer should be consulted for those limits.

shall be cast from the same heat as the castings represented, except that for investment castings, the test coupons shall be cast in the same type of mold as the castings.⁷

7.2 The coupon from which the test specimen is taken shall be heat treated in production furnaces to the same procedure as the castings it represents.

7.3 Test specimens may be cut from heat-treated castings, at the producer's option, instead of from test coupons.

⁷ Information on the relationship of mechanical properties determined on test coupons obtained as specified in 7.1 and 7.4 with those obtained from the casting may be found in *The Steel Castings Handbook*, Fifth Edition, Steel Founders' Society of America, 1980, pp. 15–35 through 15–43.

7.4 *Investment Castings*—For investment castings, the coupons may be cast to shape or machined from coupons to dimensions in accordance with Test Methods and Definitions **A370** or the ICI coupon shown in Specification **A1067/A1067M**, Fig. 1.

7.5 *Other Castings*—Unless otherwise specified by the purchaser, test coupons may be cast integrally with the castings or separately in accordance with Specification **A1067/A1067M**, Figure 1, Figure 2, or Figure 4, except when Supplementary Requirement S26 is specified. The test coupon in Specification **A1067/A1067M**, Figure 4 shall be employed only for austenitic alloy castings with cross sections less than 2½ in. [63.5 mm]. Tension test specimens shall be prepared in

TABLE 3 Product Analysis Tolerances – Nickel and Cobalt Base Alloys

Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max	Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max	
Carbon	up to 0.02, incl	0.005	Aluminum	up to 0.10, incl	0.02	
	over 0.02 to 0.20, incl	0.01		over 0.10 to 0.50, incl	0.05	
	over 0.20 to 0.60, incl	0.02		over 0.50 to 2.00, incl	0.10	
	over 0.60 to 1.00, incl	0.03		over 2.00 to 5.00, incl	0.20	
Manganese	up to 1.00, incl	0.03	Boron	over 5.00 to 10.00, incl	0.25	
	over 1.00 to 3.00, incl	0.04		over 10.00 to 15.00, incl	0.30	
	over 3.00 to 6.00, incl	0.07		up to 0.01, incl	0.002	
	over 6.00 to 10.00, incl	0.10		over 0.01 to 0.05, incl	0.005	
Silicon	up to 0.05, incl	0.02	Iron	over 0.05 to 0.15, incl	0.010	
	over 0.05 to 0.25, incl	0.03		up to 0.20, incl	0.02	
	over 0.25 to 0.50, incl	0.04		over 0.20 to 0.75, incl	0.03	
	over 0.50 to 1.00, incl	0.05		over 0.75 to 2.50, incl	0.05	
Phosphorus	over 1.00 to 4.50, incl	0.10	Copper	over 2.50 to 5.00, incl	0.07	
	all	0.005		over 5.00 to 10.00, incl	0.10	
	Sulfur	up to 0.02, incl		0.003	over 10.00 to 15.00, incl	0.15
		over 0.02 to 0.06, incl		0.005	over 15.00 to 30.00, incl	0.30
Chromium		up to 5.00, incl	0.10	over 30.00 to 50.00, incl	0.45	
		over 5.00 to 15.00, incl	0.15	Vanadium	up to 0.20, incl	0.02
	over 15.00 to 25.00, incl	0.25	over 0.20 to 0.50, incl		0.03	
	over 25.00 to 35.00, incl	0.30	over 0.50 to 5.00, incl		0.04	
over 35.00 to 45.00, incl	0.40	over 5.00 to 10.00, incl	0.05			
Nickel	over 45.00 to 50.00, incl	0.50	Yttrium	over 10.00 to 20.00, incl	0.10	
	up to 1.00, incl	0.05		over 20.00 to 30.00, incl	0.15	
	over 1.00 to 5.00, incl	0.10		over 30.00 to 40.00, incl	0.20	
	over 5.00 to 10.00, incl	0.15		over 40.00 to 60.00, incl	0.30	
Cobalt	over 10.00 to 20.00, incl	0.20	Zirconium	over 60.00 to 80.00, incl	0.45	
	over 20.00 to 30.00, incl	0.25		over 80.00 to 99.00, incl	0.60	
	over 30.00 to 40.00, incl	0.30		Lanthanum	up to 0.50, incl	0.04
	over 40.00 to 60.00, incl	0.35			over 0.50 to 1.50, incl	0.05
over 60.00 to 80.00, incl	0.45	Cerium	up to 0.050, incl		0.005	
over 80.00 to 99.00, incl	0.60		over 0.050 to 0.10, incl		0.010	
up to 0.10, incl	0.01		over 0.10 to 0.20, incl	0.015		
over 0.10 to 0.20, incl	0.02		Hafnium	up to 0.10, incl	0.01	
over 0.20 to 1.00, incl	0.03	over 0.10 to 0.20, incl		0.02		
over 1.00 to 5.00, incl	0.05	Rhenium		up to 0.20, incl	0.01	
over 5.00 to 10.00, incl	0.10			up to 1.50, incl	0.05	
over 10.00 to 15.00, incl	0.15		over 1.50 to 3.00, incl	0.10		
over 15.00 to 20.00, incl	0.20		Platinum	over 3.00 to 5.00, incl	0.15	
over 20.00 to 25.00, incl	0.25	over 5.00 to 7.00, incl		0.20		
over 25.00 to 30.00, incl	0.30	Oxygen		up to 0.50, incl	0.03	
over 30.00 to 35.00, incl	0.35			Nitrogen	up to 0.010, incl	0.005
over 35.00 to 50.00, incl	0.50		up to 0.02, incl		0.005	
Molybdenum	up to 1.00, incl		0.03		over 0.02 to 0.19, incl	0.01
	over 1.00 to 3.00, incl	0.05	over 0.19 to 0.25, incl		0.02	
	over 3.00 to 5.00, incl	0.10	over 0.25 to 0.35, incl	0.03		
	over 5.00 to 20.00, incl	0.15	over 0.35 to 0.45, incl	0.04		
Tungsten	over 20.00 to 30.00, incl	0.25	over 0.45 to 0.60, incl	0.05		
	over 30.00 to 40.00, incl	0.35	Magnesium	up to 0.10, incl	0.01	
	up to 1.00, incl	0.04		Lead	up to 0.01, incl	0.002
	over 1.00 to 3.00, incl	0.10			Tin	up to 0.01, incl
over 3.00 to 5.00, incl	0.15	over 0.01 to 0.05, incl				0.005
over 5.00 to 10.00, incl	0.20	Zinc	up to 0.01, incl			0.002
over 10.00 to 20.00, incl	0.25		over 0.01 to 0.05, incl	0.005		
Niobium ⁴ and/or Tantalum	up to 1.50, incl		0.05	Zinc	up to 0.01, incl	0.002
	over 1.50 to 3.00, incl		0.10		over 0.01 to 0.05, incl	0.005
	over 3.00 to 5.00, incl	0.15				
	over 5.00 to 7.00, incl	0.20				
over 7.00 to 10.00, incl	0.25					
over 10.00 to 13.00, incl	0.30					

TABLE 3 *Continued*

Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max	Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max
Titanium	up to 0.10, incl	0.02			
	over 0.10 to 0.50, incl	0.03			
	over 0.50 to 1.00, incl	0.04			
	over 1.00 to 2.00, incl	0.05			
	over 2.00 to 3.50, incl	0.07			
	over 3.50 to 5.00, incl	0.10			
	over 5.00 to 10.00, incl	0.20			

^A Niobium (Nb) and Columbium (Cb) both designate element 41.

accordance with Test Methods and Definitions **A370** or Test Methods **A1058** as applicable.

7.6 To determine conformance with the tension test requirements, an observed value or calculated value shall be rounded off in accordance with Practice **E29** to the nearest 500 psi [5 MPa] for yield and tensile strength and to the nearest 1 % for elongation and reduction of area.

8. Repair by Welding

8.1 Repair by welding shall be in accordance with the requirements of individual specification using procedures and welders qualified in accordance with Practice **A488/A488M**.

9. Flanges

9.1 When a flange from a flanged casting is removed to make a weld end casting, discontinuities may be observed that would not have been detrimental in a flanged casting. The disposition of the casting shall be subject to agreement between the purchaser and manufacturer.

10. Quality

10.1 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. Practice **A802/A802M** 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.

10.2 The castings shall not be peened, plugged, or impregnated to stop leaks or disguise rejectable indications.

10.3 Internal chills and chaplets may be used in the manufacture of castings. However, the chills, chaplets, and affected cast material must be completely removed.

11. Hydrostatic Tests

11.1 Each casting shall be tested after machining to the hydrostatic shell test pressures prescribed in ANSI B16.5 for the applicable steel rating for which the casting is designed. Casting shall show no leaks. Castings ordered for working pressures other than those in the standard ANSI ratings, or those listed for which test pressures are not specified by ANSI B16.5, shall be tested at a pressure agreed upon between manufacturer and the purchaser.

11.2 It is realized that the foundry may be unable to perform the hydrostatic test prior to shipment, or that the purchaser may wish to defer testing until additional work or machining has been performed on the casting. Castings ordered in the rough state for final machining by the purchaser may be tested hydrostatically prior to shipment by the manufacturer at pressures to be agreed upon with the purchaser. However, the foundry is responsible for the satisfactory performance of the castings under the final test required in **11.1**.

12. Workmanship, Finish, and Appearance

12.1 All castings shall be made in a workmanlike manner and shall conform to the dimensions on drawings furnished by the purchaser. When the pattern is supplied by the purchaser, the dimensions of the casting shall be as predicated by the pattern unless otherwise agreed upon.

12.2 Machined welding ends shall be suitably protected against damage during shipping.

13. Retests

13.1 If a specimen is machined improperly or if flaws are revealed by machining or during testing, the specimen may be discarded and another substituted from the same heat.

13.2 If the results of the mechanical tests for any heat, lot, or casting do not conform to the requirements specified, castings may be reheat treated and retested. When castings are reheat treated, they may not be re-austenitized more than three times without the approval of the purchaser. Testing after reheat treatment shall consist of the full number of specimens taken from locations complying with the specification or order.

NOTE 1—Test Methods and Definitions **A370**, paragraph 4.4 and Test Methods **A1058**, paragraph 3.5 address retesting because of mechanical reasons such as failure of the test equipment. Test Methods and Definitions **A370**, paragraph 14.4.2 addresses retesting for reasons such as fracture outside of the middle half of the gauge length or at a punch mark.

14. Inspection

14.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with the applicable specification. Foundry inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections, with the exception of product analysis (**5.2**), shall be made at the place of manufacture unless otherwise agreed.

15. Rejection and Rehearing

15.1 Any rejection based on test reports shall be reported to the manufacturer within 30 days from the receipt of the test reports by the purchaser.

15.2 Material that shows unacceptable discontinuities as determined by the acceptance standards specified in the order subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified within 30 days after discovery of the rejectable condition.

15.3 Samples that represent rejected material shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

16. Certification

16.1 The manufacturer's certification shall be furnished to the purchaser stating that the material was manufactured, sampled, tested, and inspected in accordance with the material specification (including year of issue) and was found to meet the requirements. When the purchaser imposes the requirements of this specification, the manufacturer is responsible for compliance with the specification requirements during the production and processing of the casting by themselves and any of their subcontractors.

16.2 As applicable, the certification shall also include:

16.2.1 Material specification and grade,

16.2.2 Pattern number,

16.2.3 Heat number or serial number traceable to a heat number,

16.2.4 Chemical analysis of the heat,

16.2.5 Mechanical property results required by the specification and supplementary requirements specified in the purchase order,

16.2.6 Statement of satisfactory inspection, visual, and non-destructive testing specified in the purchase order,

16.2.7 Manufacturer's name, and

16.2.8 Additional purchase order requirements.

16.3 A signature is not required on the certification. However, the document shall clearly identify the organization submitting the certification. Notwithstanding the absence of a signature, the organization submitting the certification is responsible for its content.

16.4 A manufacturer's certification printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility, provided it conforms to any existing EDI agreement between the purchaser and the supplier.

17. Product Marking

17.1 Castings shall be marked for material identification with grade symbols (WCB, WC9, CF8M, and so forth). In addition, heat numbers, or serial numbers that are traceable to heat numbers, shall be marked on all pressure-containing castings individually weighing 50 lb [22.7 kg] or more. Pressure-containing castings weighing less than 50 lb [22.7 kg] shall be marked with either the heat number or a lot number that will identify the casting as to the month in which it was poured. Marking shall be in such position as not to injure the usefulness of the casting.

17.2 On castings for which impact property requirements are specified, stamped markings using low-stress stamps shall be on a raised pad when such pad can be made a part of the castings.

17.3 Castings shall be marked with the manufacturer's identification or symbol except when other provisions have been made between the manufacturer and purchaser.

18. Keywords

18.1 castings; general requirements; pressure containing; steel

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall be applied only when specified by the purchaser. Details of the supplementary requirements shall be agreed upon between the manufacturer and purchaser. The specified tests shall be performed by the manufacturer prior to shipment of the castings.

S1. Unspecified Elements

S1.1 Limits may be established for elements not specified for the grade ordered by agreement between the manufacturer and purchaser. The results of the analysis for the agreed-upon elements shall be reported.

S2. Destruction Tests

S2.1 Purchaser may select representative castings from each heat, and cut up and etch, or otherwise prepare, the sections for examination for internal defects. Should injurious defects be found that evidence unsound steel or faulty foundry technique, all the castings made from that particular pattern, heat, and heat

treatment charge may be rejected. All the rejected castings, including those cut up, shall be replaced by the manufacturer without charge.

S3. Bend Test

S3.1 One bend test shall be made from a test coupon from each heat in accordance with Test Methods and Definitions **A370**, and shall be machined to a 1 by ½-in. [25 by 13-mm] section with corners rounded to a radius not over ⅛ in. [1.6 mm]. When material is ordered to an M-suffix (SI units) product standard, the bend test requirements shall be in accordance with Test Methods **A1058**.