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.

Designation: A781/A781M – 20

Standard Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use[1]

This standard is issued under the fixed designation A781/A781M; 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.

1. Scope*

1.1 This specification covers a group of requirements that are mandatory requirements of the following steel casting specifications issued by ASTM. If the product specification specifies different requirements, the product specification shall prevail.

ASTM Designation	Title of Specification
A27/A27M	Steel Castings, Carbon, for General Application
A128/A128M	Steel Castings, Austenitic Manganese
A148/A148M	Steel Castings, High Strength, for Structural Purposes
A297/A297M	Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
A447/A447M	Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
A494/A494M	Castings, Nickel and Nickel Alloy
A560/A560M	Castings, Chromium-Nickel Alloy
A743/A743M	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
A744/A744M	Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
A747/A747M	Steel Castings, Stainless, Precipitation Hardening
A890/A890M	Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
A915/A915M	Steel Castings, Carbon and Alloy, Chemical Requirements Similar to Standard Wrought Grades
A958/A958M	Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similiar to Standard Wrought Grades
A1002	Castings, Nickel-Aluminum Ordered Alloy

1.2 This specification also covers a group of supplementary requirements that 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 The requirements of the individual material specification and this general specification shall prevail in the sequence named.

1.4 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.

1.5 *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:*[2]

A27/A27M Specification for Steel Castings, Carbon, for General Application

A128/A128M Specification for Steel Castings, Austenitic Manganese

A148/A148M Specification for Steel Castings, High Strength, for Structural Purposes

A297/A297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

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

A447/A447M Specification for Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service

A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

A494/A494M Specification for Castings, Nickel and Nickel Alloy

A560/A560M Specification for Castings, Chromium-Nickel Alloy

[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 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**

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A609/A609M Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
A744/A744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
A747/A747M Specification for Steel Castings, Stainless, Precipitation Hardening
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
A890/A890M Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
A915/A915M Specification for Steel Castings, Carbon, and Alloy, Chemical Requirements Similar to Standard Wrought Grades
A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
A958/A958M Specification for Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades
A967/A967M Specification for Chemical Passivation Treatments for Stainless Steel Parts
A991/A991M Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products
A1002 Specification for Castings, Nickel-Aluminum Ordered Alloy
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
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 *SAE Standard:*[3]

AMS 2750 Pyrometry

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions in Test Methods and Definitions A370, Test Methods, Practices, and Terminology A751, Terminology A941, and Test Methods A1058 are applicable to this specification and to those listed in 1.1.

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

3.1.3 *test specimen, n*—the part that will be acted upon in a 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 specified in the individual specification.

4.2 *Heat Treatment:*

4.2.1 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 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 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.

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

4.2.4 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, Practices, and Terminology A751.

[3] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

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

Element	Range, %[A]	Tolerances[B,C] Over Maximum or Under Minimum Limit, %
C	up to 0.65	0.03 × % C_L + 0.02
	above 0.65	0.04
Mn	up to 1	0.08 × % Mn_L + 0.01
	above 1	0.09
Si	up to 0.60	0.22 × % Si_L – 0.01
	above 0.60	0.15
P	all	0.13 × % P_L + 0.005
S	all	0.36 × % S_L + 0.001
Ni	up to 2	0.10 × % Ni_L + 0.03
	above 2	0.25
Cr	up to 2	0.07 × % Cr_L + 0.04
	above 2	0.18
Mo	up to 0.6	0.04 × % Mo_L + 0.03
	above 0.6	0.06
V	up to 0.25	0.23 × % V_L + 0.004
	above 0.25	0.06
W	up to 0.10	0.08 × % W_L + 0.02
	above 0.10	0.02
Cu	up to 0.15	0.18 × % Cu_L + 0.02
	above 0.15	0.05
Al	up to 0.10	0.08 × % Al_L + 0.02
	above 0.10	0.03

[A] The range denotes the composition limits up to which 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 footnote C.
[C] To illustrate the computation of the tolerance, consider the manganese maximum of 0.70 for a 0.30 carbon grade 65-35 in Specification A27/A27M. The maximum permissible deviation is (0.08 × 0.70 + 0.01) = 0.066. Therefore, the highest acceptable product analysis is 0.766. Similarly, for a 0.20 carbon grade 70-40 in Specification A27/A27M, the maximum manganese content is 1.40; thus, the highest acceptable product analysis is (1.40 + 0.09) = 1.49.

5.2 *Heat Analysis*—An analysis of each heat shall be made by the manufacturer to determine the percentages of the elements specified in the individual specification for the grade being poured. 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 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. Samples for carbon analysis shall be taken no closer than ¼ in. [6 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 and stainless steel castings may vary from the specified limits by the amounts shown in Table 1 and Table 2, respectively. The product analysis tolerances of Tables 1 and 2 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 S13 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 supplied material such that the material conforms to the requirements of a different grade.

6. Mechanical Test Requirements

NOTE 1—The tension testing requirements of this specification are intended only to characterize the tensile properties of the heat for determination of conformance to the requirements of the applicable product specification. Such testing procedures are not intended to define the upper or lower limits of tensile properties at all possible test locations within a heat. It is well known and documented that tensile properties will vary within a heat or individual casting as a function of chemical composition, processing, testing procedure, and other factors.[4] It is, therefore, incumbent on designers and engineers to use sound engineering judgement when using tension test results.

6.1 The individual product specifications vary as to whether mechanical tests are required; for this reason, and to determine specific test requirements, the individual product specification should be reviewed.

6.2 Unless otherwise specified by the purchaser, when mechanical properties are required by the product specification, test coupons may be cast integrally with the castings, or as separate blocks, in accordance with Specification A1067/A1067M, Fig. 1, Fig. 2, or Fig. 4, except when Supplementary Requirement S15 is specified. The test coupon in Specification A1067/A1067M, Fig. 4 may be employed only for austenitic stainless steel and nickel-base alloy castings with cross sections less than 2½ in. [65 mm].

6.3 Test specimens may be cut from heat-treated castings, at the producer's or the purchaser's option, instead of from separately cast test coupons.

6.4 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.

6.5 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.

6.6 The specimens may be cast to shape or machined from coupons to dimensions in accordance with Test Methods and Definitions A370.

6.7 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

[4] Information on the relationship of mechanical properties determined on test coupons obtained as specified in 6.2 with those obtained from the casting may be found in *The Steel Casting Handbook*, Fifth Edition, Steel Founders' Society of America, pp.15–35 through 15–43, 1980.

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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			
	over 0.20 to 0.60, incl	0.02	Cobalt	over 0.05 to 0.50, incl	0.01[A]
	over 0.60 to 1.20, incl	0.03		over 0.50 to 2.00, incl	0.02
				over 2.00 to 5.00, incl	0.05
Manganese	to 1.00, incl	0.03			
	over 1.00 to 3.00, incl	0.04	Columbium plus tantalum	to 1.50, incl	0.05
	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
				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			
	over 10.00 to 15.00, incl	0.15	Nitrogen	to 0.02, incl	0.005
	over 15.00 to 20.00, incl	0.20		over 0.02 to 0.19, incl	0.01
	over 20.00 to 30.00, incl	0.25		over 0.19 to 0.25, incl	0.02
				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	Tungsten	to 1.00, incl	0.03
	over 10.00 to 20.00, incl	0.15		over 1.00 to 2.00, incl	0.05
	over 20.00 to 30.00, incl	0.20			
			Vanadium	to 0.50, incl	0.03
Molybdenum	over 0.20 to 0.60, incl	0.03		over 0.50 to 1.50, incl	0.05
	over 0.60 to 2.00, 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.

0.5 ksi [5 MPa] for yield and tensile strength and to the nearest 1 % for elongation and reduction of area. In the special case of rounding the number "5" when no additional numbers other than "0" follow the "5," rounding shall be done in the direction of the specification limits if following Practice E29 would cause rejection of material.

7. Workmanship, Finish, and Appearance

7.1 All castings shall be made in a workmanlike manner and shall conform to the dimensions on drawings furnished by the purchaser before manufacture is started. If the pattern is supplied by the purchaser, the dimensions of the casting shall be as predicated by the pattern.

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. 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.

8.2 When additional inspection is desired, Supplementary Requirement S1, S2, S3, S4, or S5 may be specified.

8.3 Rejectable indications shall not be peened, plugged, or impregnated.

9. Repair

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

10. Inspection

10.1 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.

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All tests and inspections, with the exception of product analysis (5.3), shall be made at the place of manufacture unless otherwise agreed.

11. Rejection

11.1 Subsequent to acceptance at the manufacturer's works, material that is found to be unacceptable as determined by requirements specified in the order may be rejected by the purchaser. The manufacturer should be notified of such rejection. If the manufacturer is dissatisfied with the results of any tests performed by the purchaser, they may make claim for a rehearing.

12. Retesting

12.1 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.

12.2 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. Testing after reheat treatment shall consist of the full number of specimens taken from locations complying with the specification or order.

NOTE 2—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.

13. Keywords

13.1 castings; common requirements; steel and alloy

SUPPLEMENTARY REQUIREMENTS

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

S1. Magnetic Particle Examination

S1.1 Castings shall be examined for surface and near-surface discontinuities by magnetic particle examination. The examination shall be in accordance with Guide E709. Extent of examination and the basis for acceptance shall be agreed upon between the manufacturer and purchaser.

S2. Radiographic Examination

S2.1 Castings shall be examined for internal defects by means of X-rays or gamma rays. The procedure shall be in accordance with Guide E94/E94M, and types and degrees of discontinuities considered shall be judged by Reference Radiographs E446, E186, or E280. Extent of examination and basis for acceptance shall be agreed upon between the manufacturer and purchaser.

S3. Liquid Penetrant Examination

S3.1 Castings shall be examined for surface discontinuities by means of liquid penetrant examination. The examination shall be in accordance with Practice E165/E165M. Areas to be inspected, methods and types of liquid penetrants to be used, developing procedure, and basis for acceptance shall be agreed upon between the manufacturer and purchaser.

S4. Ultrasonic Examination

S4.1 Castings shall be examined for internal defects by means of ultrasonic examination. The examination procedure shall be in accordance with Practice A609/A609M. Extent of examination, methods of testing, and basis for acceptance shall be agreed upon between the manufacturer and purchaser.

S5. Examination of Weld Preparation

S5.1 Magnetic particle or liquid penetrant examination of cavities prepared for welding shall be performed to verify removal of those discontinuities found unacceptable by the examination method specified for the casting. Unless other degrees of shrinkage or types of discontinuities found in the cavities are specified, Type II, Internal Shrinkage, of Reference Photographs E125, of Degree 2 in sections up to 2 in. [50.8 mm] thick, and of Degree 3 in sections over 2 in. thick shall be acceptable.

S6. Certification

S6.1 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 date) and was found to meet the requirements.

S6.2 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.

S7. Prior Approval of Major Weld Repairs

S7.1 Major weld repairs, as defined and agreed upon between the manufacturer and purchaser, shall be subject to the prior approval of the purchaser.

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S8. Marking

S8.1 The manufacturer's name or identification mark and the pattern number shall be cast or stamped on all castings. When further specified, the heat numbers or serial numbers shall be marked on individual castings.

S9. Charpy Impact Test

S9.1 Charpy impact test properties shall be determined by testing a set of three Charpy V-notch specimens made from each heat at a test temperature agreed upon by the manufacturer and purchaser. The material from which the test specimens are prepared shall be cast in accordance with 6.2. The acceptance requirements shall be either energy absorbed, lateral expansion, or percent shear area, or all three, and shall be that agreed upon between the manufacturer and purchaser. Test specimens shall be prepared as Type A and tested in accordance with Test Methods and Definitions A370, or the test track specified by the purchaser when referencing Test Methods A1058.

S9.2 *Absorbed Energy*—Average energy value of three specimens shall be not less than specified, with not more than one value permitted to fall below the minimum specified and no value permitted below the minimum specified for a single specimen.

S9.3 *Lateral Expansion*—Lateral expansion value shall be agreed upon between the manufacturer and purchaser.

S9.4 *Percent Shear Area*—Percent shear area shall be agreed upon between the manufacturer and purchaser.

S10. Hardness Test

S10.1 Hardness measurements at specified locations on the castings shall be made in accordance with Test Methods and Definitions A370, or the test track specified by the purchaser when referencing Test Methods A1058, and reported.

S11. Specified Ferrite Content Range

S11.1 The chemical composition of the heat shall be controlled such that the ferrite content, as determined by the chemical composition procedure of Practice A800/A800M, shall be in conformance with the specified ferrite content range.

S11.2 The specified ferrite content range shall be as agreed upon between the manufacturer and the purchaser. The minimum specified ferrite content range shall be 10 %, with the minimum ferrite content being no lower than the percent necessary to achieve the minimum mechanical properties required for the alloy.

S11.3 Should the purchaser wish to have the ferrite content determined by either magnetic response or metallographic methods, the purchaser should impose Supplementary Requirement S1 or S2 of Practice A800/A800M.

S12. Test Report

S12.1 The manufacturer shall supply a test report to the purchaser giving the results of all tests performed, including chemical analysis.

S13. Unspecified Elements

S13.1 Chemical analysis and limits for elements not specified for the grade ordered shall be as agreed upon between the manufacturer and purchaser.

S14. Tension Test from Castings

S14.1 In addition to the tension test required by the material specification, test material shall be cut from the casting. The mechanical properties and location for the test material shall be agreed upon by the manufacturer and purchaser.

S15. Alternate Mechanical Test Coupons and Specimen Locations for Castings

S15.1 Test coupons may be cast integrally with the castings or separately. Separately cast coupons shall be heat treated together with the castings they represent.

S15.2 In the following, the casting thickness, T, is the maximum thickness of the casting exclusive of padding added for directional solidification, flanges, appendages, and sections designated by the designer as noncritical. The order, inquiry, and drawing shall designate what the test dimension, T, is for the casting.

S15.3 One of the following shall apply:

S15.3.1 The longitudinal centerline of the test specimen shall be taken at least ¼ T from the T dimension surface and all of the gage length must be at least 1 T from any other heat-treated surface, exclusive of the surface opposite the T dimension surface. (See Specification A1067/A1067M, Fig. 5 (a).) For cylindrical castings, the longitudinal centerline of the specimens shall be taken at least ¼ T from the outside or inside and all of the gage length must be at least T from the as-heat-treated end. (See Specification A1067/A1067M Fig. 5 (b).) For ferritic and martensitic castings, partial severing of test coupons prior to final heat treatment is permitted.

S15.3.2 Where separately cast test coupons are used, the dimension shall not be less than 3 T by 3 T by T, and each specimen shall meet the requirements of S15.3.1, except that when T exceeds 5 in. [125 mm], the dimension may be 15 by 15 by 5 in. [375 by 375 by 125 mm], by agreement between the manufacturer and the purchaser. The test coupon shall be of the same heat of steel and shall receive substantially the same casting practices as the production casting it represents. Centrifugal castings may be represented by statically cast coupons. (See Specification A1067/A1067M, Fig. 6.)

S15.3.3 When agreed upon by the manufacturer and the purchaser, castings that are cast or machined to essentially the finished configuration prior to heat treatment shall have test specimens removed from a prolongation or other stock on the casting at a location below the nearest heat-treated surface indicated on the order. The specimen location shall be at a distance below the nearest heat-treated surface equivalent to at least the greatest distance that the indicated high-tensile-stress surface will be from the nearest heat-treated surface and a minimum of twice this distance from a second heat-treated surface, except that the test specimens shall be no nearer than ¾ in. [19 mm] to a heat-treated surface and 1½ in. [38 mm] from a second heat-treated surface. (See Specification A1067/A1067M, Fig. 7.)

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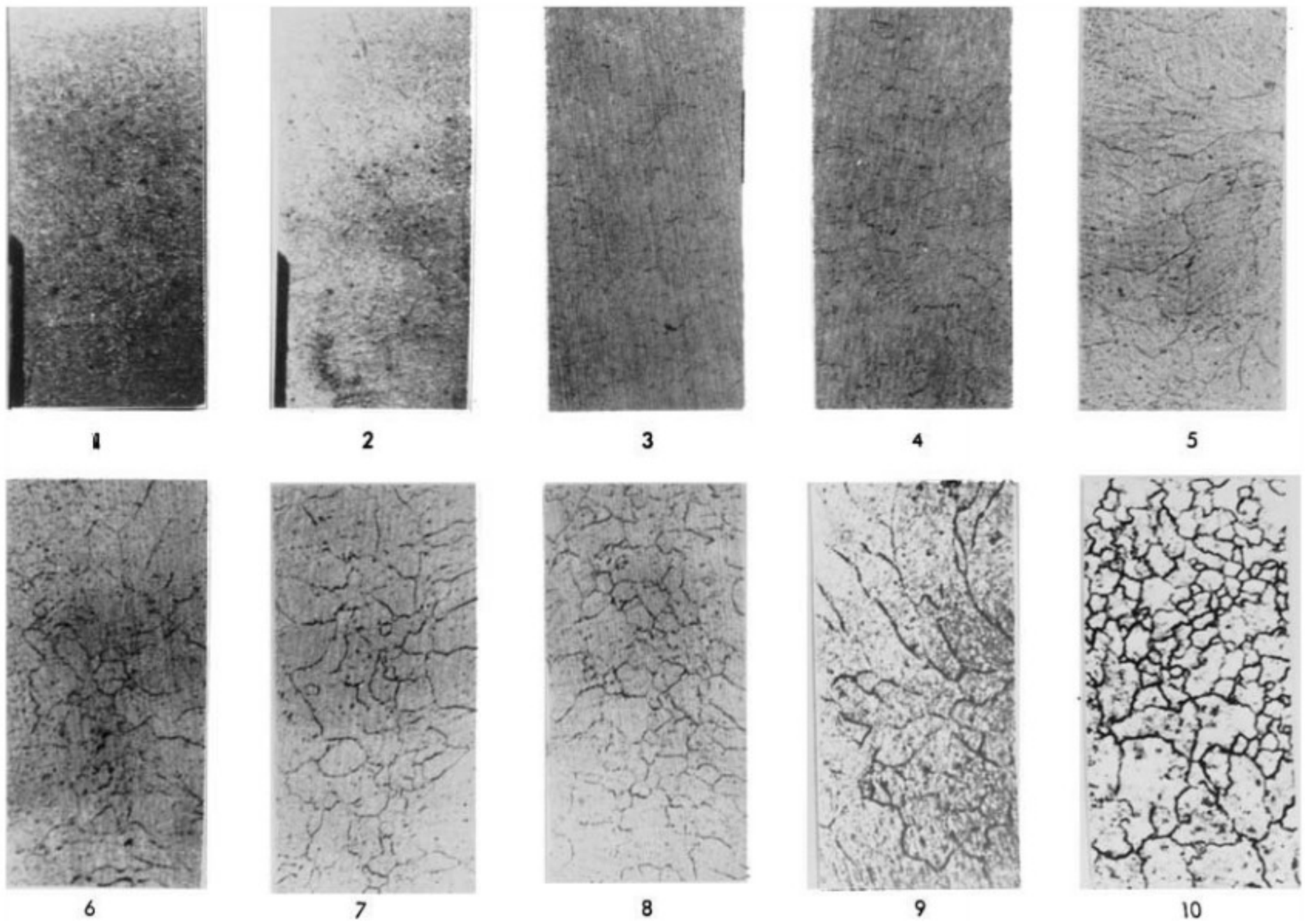

NOTE 1—The ten levels of severity of intergranular network structures shown are indicative of the presence of aluminum nitride precipitation in the primary austenitic grain boundaries.

FIG. S17.1 Reference Photographs of Macroetched Cast Steel

S15.3.4 Where specimens are to be removed from the body of quenched and tempered castings, either the requirements of S15.3.1 shall be met or a steel thermal buffer pad or thermal insulation or other thermal barriers shall be used during heat treatment. Steel thermal buffer pads shall be a minimum of *T* by *T* by 3 *T* in length and shall be joined to the casting surface by a partial penetration weld completely sealing the buffered surface. Test specimens shall be removed from the casting in a location adjacent to the center third of the buffer pad. They shall be located at a minimum distance of ½ in. [13 mm] from the buffered surface and ¼ *T* from other heat-treated surfaces (see Specification A1067/A1067M, Fig. 8). When thermal insulation is used, it shall be applied adjacent to the casting surface where the test specimens are to be removed. The producer shall demonstrate that the cooling rate of the test specimen location is no faster than that of specimens taken by the method described in S15.3.1.

S16. Weld Repair Charts

S16.1 Major weld repairs shall be documented by means of sketches or photographs, or both, showing the location and major dimensions of cavities prepared for welding. Documentation shall be submitted to the purchaser at the completion of the order.

S16.2 Unless other criteria are agreed upon between the manufacturer and the purchaser, weld repairs made to correct leakage on hydrostatic testing, or weld repairs for which the depth of the cavity required for welding exceeds 40 % of the actual wall thickness, or weld repairs for which the area of the cavity required for welding shall be documented:

(1) Exceeds approximately 10 in.^{2} [65 cm^2] for castings weighing up to 10 000 lb (4.5 tons);

(2) Exceeds approximately 20 in.^{2} [130 cm^2] for castings weighing from 10 000 lb to 30 000 lb (4.5 to 13.5 tons);

(3) Exceeds approximately 30 in.^{2} [200 cm^2] for pieces weighing more than 30 000 lb (13.5 tons).

S17. Macroetch Test

S17.1 Apply Supplementary Requirement S13 for the spectrographic determination and reporting of the total residual aluminum content of all heats of ferritic and martensitic steels subjected to this macroetch test.

S17.2 When the heat analysis indicates a total residual aluminum content in excess of 0.08 %, the manufacturer shall etch a cross section of the casting with the heaviest section for which this supplementary requirement is invoked, or a coupon attached to that heaviest section or an area directly under a riser (see Note S17.1). Cross sections from a separately cast test block from the same heat and of a thickness representative of the heaviest section of castings purchased under this supplementary requirement may also be used for macroetch testing. The etching shall be performed on the selected section after its heat treatment, that is, after heat treatment as defined in the product specification.

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NOTE S17.1—High-strength martensitic castings, in particular, may be damaged beyond use if the etch is applied directly to the casting.

S17.3 The preparation of the surface and the macroetching procedure with Solution No. 1 (1:1 HCI) of Table 5 in Practice E340 shall be followed. The resulting etched surface shall be compared and rated with the reference photographs in Fig. S17.1 depicting ten levels of severity of intergranular network structures indicative of the presence of aluminum nitride or other constituents prone toward precipitating at grain boundaries during solidification and subsequent cooling. Fig. S17.1 relates the severity levels shown in these photographs, with specific delineation widths and percent of boundary outlining in the etched structures.

S17.4 Castings represented by etched structures exhibiting a network rating in excess of Severity Level 4 shall be considered unacceptable until further evaluations are completed. The acceptability of individual castings may be determined by etching sections of each casting to ascertain the network severity level. Disposition of unacceptable castings shall be a matter of agreement between the manufacturer and purchaser. Those castings exhibiting etched severity levels greater than four may be evaluated further by any of the following agreed-upon methods:

S17.4.1 Fracture testing to determine the amount of "rock candy" structure.

S17.4.2 Mechanical testing (for example, bend, tensile) to determine the ductility characteristics.

S17.4.3 Weld testing to determine crack susceptibility in the heat-affected zone of a circular groove welded with cellulose-coated electrodes.

S17.5 Alternatively, by agreement, it is permissible to subject castings from an unacceptable heat to a high-temperature homogenizing cycle prior to the normal production heat treatment and subsequently macroetch test each casting.

S17.6 Heavy section castings (see Note S17.2) whose configurations are amenable to the attachment of test coupons representative of the section thickness involved and from which standard 0.505-in. [12.827-mm] diameter tension specimens may be machined are exempt from this macroetch test if the results of the tension test on the coupon after heat treatment of the casting meet the minimum requirements specified for the grade of steel involved.

NOTE S17.2—For purposes of this supplementary requirement, a heavy section casting is defined as one having a wall thickness of 1½ in. [37 mm] or greater, in combination with a casting weight of at least 1000 lb [455 kg].

S18. Hot Isostatic Pressing (HIPing)

S18.1 Castings shall be processed by hot isostatic pressing (HIPing) according to Practice A1080/A1080M. Unless specified by the purchaser in the purchase order or contract, the HIPing time, temperature, pressure, and other parameters shall be at the discretion of the producer.

S19. Cleaning of Stainless Steels

S19.1 Final cleaning of the casting surfaces shall be performed in accordance with one of the cleaning methods in Practice A380/A380M or Specification A967/A967M as agreed upon between the purchaser and the supplier. Acceptance testing shall be subject to agreement between the purchaser and supplier.

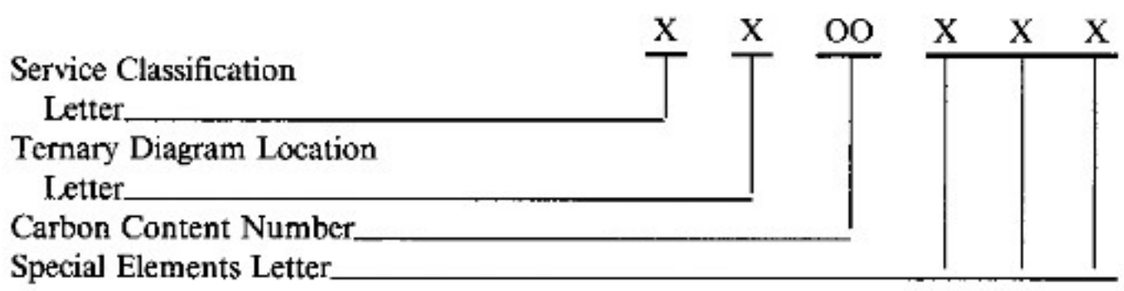
APPENDIXES

(Nonmandatory Information)

X1. ALLOY DESIGNATIONS FOR CAST STAINLESS STEELS

X1.1 Cast stainless steels are usually specified on the basis of composition using the alloy designation system established by the Alloy Casting Institute (ACI). The ACI designations, for example, CF8M, have been adopted by ASTM and are preferred for cast alloys over the designations used by the American Iron and Steel Institute for similar wrought steels.

X1.2 This nomenclature system has served successfully to accommodate changes in old alloys and to designate new ones.



X1.2.1 *Service Classification Letter*—The first letter of the cast stainless steel designation system identifies the intended service application of the alloy. The letter C indicates corrosion-resistant service, and the letter H indicates the heat-resistant service at and above 1200 °F [649 °C].

X1.2.2 *Ternary Diagram Location Letter*—The second letter indicates the approximate location of the nickel and chromium contents of the alloy grade on the FeCrNi ternary diagram shown in Fig. X1.1.

X1.2.3 *Carbon Content Number*—For C service classifications, this single or dual-digit numeral represents the maximum carbon content in units of 0.01 %. For H service classifications, this number represents the midpoint of the range of carbon content in terms of 0.01 % with a ±0.05 % limit.

X1.2.4 *Special Elements Letter*—Additional letters following the numeral represent special chemical elements in the alloy grade, such as M for molybdenum, C for columbium (Nb for niobium), Mn for manganese, S for silicon, N for nitrogen, Cu for copper, and W for tungsten. There are two exceptions;

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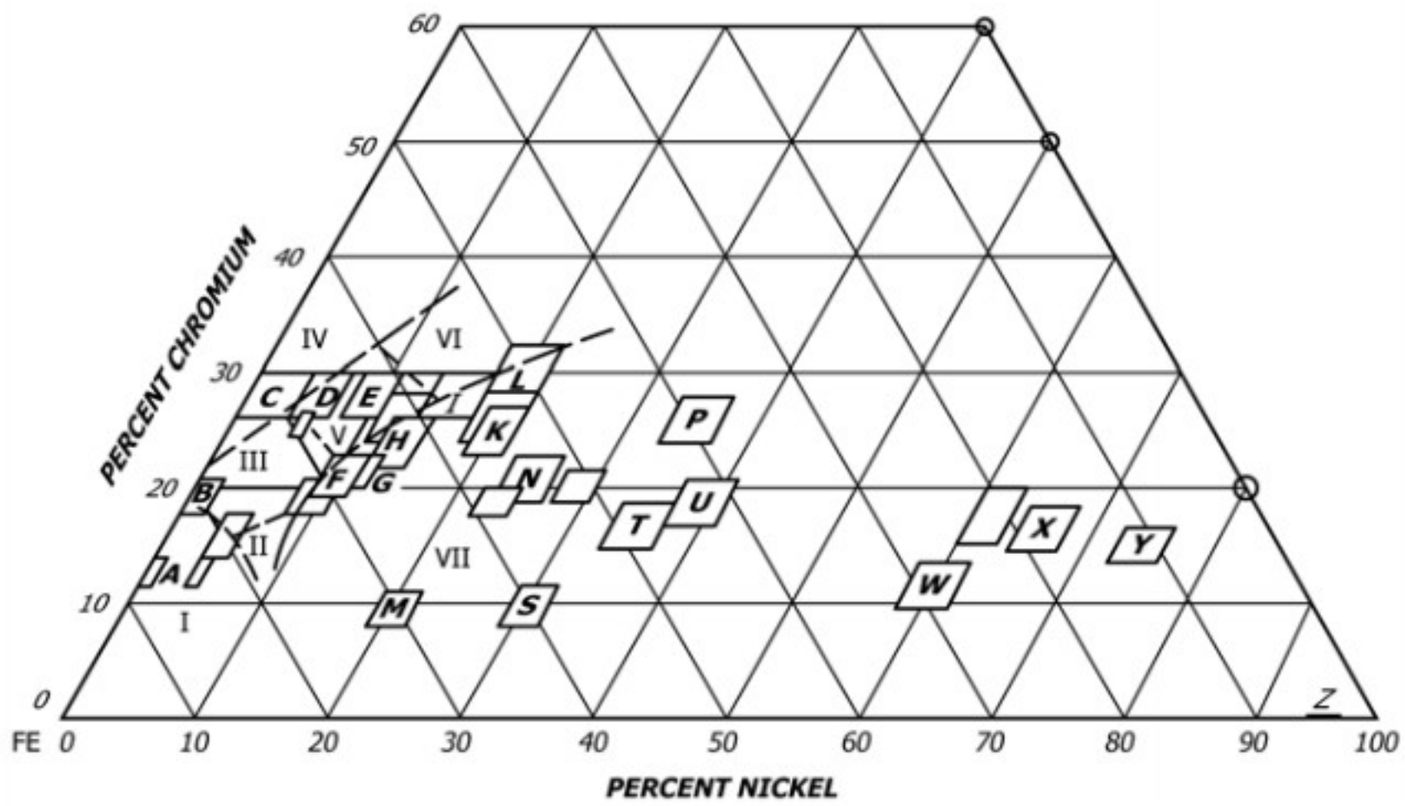

NOTE 1—The approximate areas of microstructures to be expected at room temperature are indicated as follows:
I—Martensite
II—Martensite and untransformed austenite
III—Ferrite plus martensite and untransformed austenite
IV—Ferrite
V—Ferrite plus austenite
VI—Ferrite plus austenite plus sigma
VII—Austenite
NOTE 2—Carbides also may be present depending on carbon content and thermal history.

FIG. X1.1 Letters Assigned to Chromium and Nickel Ranges in ACI Designation System

the letter A indicates "Controlled Ferrite," and the letter F indicates "Free Machining."

X1.3 In Fig. X1.1, unlettered Ni-Cr ranges are associated with the nearest lettered location. They may be the result of differences between corrosion and heat-resistant types, or because of the influence of additional elements, for example, the precipitation hardening grades CB-7Cu-1 and CB-7Cu-2.

X2. WROUGHT ALLOYS SIMILAR TO CASTING ALLOYS IN SPECIFICATIONS A494/A494M, A743/A743M, A744/A744M, A747/A747M, AND A890/A890M

X2.1 Table X2.1 is provided for the user of the above-listed specifications as an aid in selecting cast alloys that are similar in chemical composition to wrought alloys. It is not intended to imply that the cast alloy would have the same mechanical, physical, or corrosion properties as the indicated wrought alloy.

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TABLE X2.1 Similar Alloys

Nominal Composition	ASTM Casting Specification	Casting Grade Designation	UNS Number	Similar Wrought Alloy	UNS Number
11Cr-7Ni	A743/A743M	CA6N	J91650	. . .	. . .
13Cr-4Ni	A743/A743M	CA6NM	J91540	F-6NM[A]	S41500
13Cr	A743/A743M	CA15	J91150	410[B]	S41000
13Cr	A743/A743M	CA40	J91151	. . .	. . .
12Cr-Mo-V-W	A743/A743M	CA28MWV	J91422	422[B]	S42200
13Cr-Mo	A743/A743M	CA15M	J91153	420[B]	S42000
13Cr-S	A743/A743M	CA40F	J91154	420F[B]	S42020
19Cr-1Ni	A743/A743M	CB30	J91803	442[B]	S44200
16Cr-4Ni-4Cu	A747/A747M	CB7Cu-1	J92180	17-4[C]	S17400
15Cr-5Ni-3Cu	A747/A747M	CB7Cu-2	J92110	15-5[C]	S15500
27Cr	A743/A743M	CC50	J92615	446[B]	S44600
25Cr-5Ni-3Cu-2Mo-N	A890/A890M	1B & CD4MCuN	J93372	255[C]	S32550
25Cr-6Ni-2Cu-3Mo-N	A890/A890M	1C & CD3MCuN	J93373	255[C]	S32550
24Cr-10Ni-3Mo-N	A890/A890M	2A & CE8MN	J93345	. . .	. . .
25Cr-5Ni-2Mo-N	A890/A890M	3A & CD6MN	J93371	. . .	. . .
22Cr-5Ni-3Mo-N	A890/A890M	4A & CD3MN	J92205	2205[C]	S39205
25Cr-7Ni-4Mo-N	A890/A890M	5A & CE3MN	J93404	. . .	. . .
25Cr-7Ni-Mo-N	A890/A890M	6A & CD3MCuWN	J93380	Zeron 100[D]	S32760
28Cr-9Ni	A743/A743M	CE30	J93423	. . .	. . .
18Cr-8Ni	A743/A743M, A744/A744M	CF3	J92500	304L[B]	S30403
16Cr-12Ni-2Mo	A743/A743M, A744/A744M	CF3M	J92800	316L[B]	S31603
16Cr-12Ni-2Mo-N	A743/A743M	CF3MN	J92804	316LN[B]	S31653
18Cr-8Ni	A743/A743M, A744/A744M	CF8	J92600	304[B]	S30400
18Cr-10Ni-Cb	A743/A743M, A744/A744M	CF8C	J92710	347[B]	S34700
16Cr-12Ni-2Mo	A743/A743M, A744/A744M	CF8M	J92900	316[B]	S31600
18Cr-8Ni-4Si-N	A743/A743M	CF10SMnN	J92972	Nitronic[E] 60	S21800
18Cr-8Ni-S	A743/A743M	CF16F	J92701	303Se[B]	S30300
18Cr-8Ni	A743/A743M	CF20	J92602	302[B]	S30200
22Cr-13Ni-5Mn	A743/A743M	CG6MMN	J93790	Nitronic[E] 50	S20910
18Cr-13Ni-3Mo	A743/A743M, A744/A744M	CG8M	J93000	317[B]	S31700
21Cr-11Ni	A743/A743M	CG12	J93001	308[B]	S30800
23Cr-12Ni	A743/A743M	CH20	J93402	309[B]	S30900
20Cr-18Ni-6Mo-Cu-N	A743/A743M, A744/A744M	CK3MCuN	J93254	254 SMO[F]	S31254
25Cr-20Ni	A743/A743M	CK20	J94202	310[B]	S31000
24Ni-21Cr-6Mo-N	A743/A743M, A744/A744M	CN3MN	J94651	AL-6XN[G]	N08367
29Ni-20Cr-3Cu-2Mo	A743/A743M, A744/A744M	CN7M	N08007	Alloy 20[C]	N08020
24Ni-19Cr-3Mo-2Cu	A743/A743M, A744/A744M	CN7MS	J94650	. . .	. . .
41Ni-22Cr-3mO-fE	A494/A494M	CU5MCuC	N08826	825	N28820
61Ni-16Mo-16Cr	A494/A494M	CW2M	N26455	C4[C]	N06455
59Ni-18Mo-18Cr	A494/A494M	CW6M	N30107	. . .	. . .
60Ni-22Cr-9Mo-3.5Cb	A494/A494M	CW6MC	N26625	625[C]	N06625
55Ni-17Mo-16Cr-4W	A494/A494M	CW12MW	N30002	C[C]	N10002
57Ni-13Mo-21Cr	A494/A494M	CX2MW	N26022	C22[H]	N06022
74Ni-12Cr-4Bi-4Sn	A494/A494M	CY5SnBiM	N26055	. . .	. . .
72Ni-15Cr-8Fe	A494/A494M	CY40	N06040	600[C]	N06600
95Ni	A494/A494M	CZ100	N02100	200[C]	N02200
63Ni-29Cu-4Si	A494/A494M	M25S	N24025	. . .	. . .
63Ni-29Cu-2Cb	A494/A494M	M30C	N24130	. . .	. . .
63Ni-29Cu-Si	A494/A494M	M30H	N24030	. . .	. . .
67Ni-30Cu	A494/A494M	M-35-1	N24135	400[C]	N04400
67Ni-30Cu	A494/A494M	M-35-2	N04020	400[C]	N04400
65Ni-28Mo-2Fe	A494/A494M	N7M	N30007	B2[C]	N10665
62Ni-28Mo-5Fe	A494/A494M	N12MV	N30012	B[C]	N10001

[A] ASTM designation.
[B] Common description, formerly used by AISI.
[C] Common name used by two or more producers; not a trademark.
[D] Proprietary trademark: WEIR Materials.
[E] Proprietary trademark: AK Steel Corporation.
[F] Proprietary trademark: Avesta Sheffield AB.
[G] Proprietary trademark: Allegheny Ludlum Corporation.
[H] Proprietary trademark: Haynes International.

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X3. ADDITION OF NEW GRADES TO PRODUCT SPECIFICATIONS COVERED BY A781/A781M

X3.1 Where grades are already included in other A01.18 standards, they may be added to other A01.18 standards. In this case, the information described in X3.2 and X3.3 is not required.

X3.2 For grades not already included in A01.18 standards, the following data should be provided from a minimum of ten production heats. This data should include:

X3.2.1 Chemical composition.

X3.2.2 Mechanical properties as applicable to the product specification being cited. These may include but are not limited to the following:

X3.2.2.1 Ultimate tensile strength,

X3.2.2.2 Yield strength,

X3.2.2.3 Reduction in area,

X3.2.2.4 Elongation, and

X3.2.2.5 Impact properties (Charpy V).

X3.3 The test coupon size from which the test pieces are removed should be stated for each test.

X3.3.1 Heat treatment requirements.

X3.3.2 Weld procedure (welding should be carried out using commercially available consumables).

X3.4 The inclusion of the proposed material should be supported by written request from at least one purchaser or user indicating the need for the new grade.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A781/A781M – 18c) that may impact the use of this standard. (Approved Jul. 1, 2020.)

(1) Added AMS 2750 to Section 2 and 4.2.1.

(2) Added statement that 4.2.2 only applies to heat treatments in furnaces surveyed to Test Method A991/A991M.

(3) Added new subsection 4.2.3 and renumbered subsequent subsections.

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