

# SPECIFICATION FOR STEEL CASTINGS, GENERAL REQUIREMENTS, FOR PRESSURE-CONTAINING PARTS



SA-703/SA-703M



(23)

(Identical with ASTM Specification A703/A703M-18a.)

# Specification for Steel Castings, General Requirements, for Pressure- Containing Parts

## 1. Scope

1.1 This specification 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

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:

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

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

A800/A800M Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof

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 Ferrous Alloys

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 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 Examination 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:*

B16.5 Pipe Flanges and Flanged Fittings

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

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)

### 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.

4.2.2.1 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.

4.2.2.2 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 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 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 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

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

Element	Range <sup>A</sup>	Tolerances <sup>B,C</sup> over max or under min, Limit, %
Carbon (C)	up to 0.65 % above 0.65 %	0.03 × % C <sub>L</sub> + 0.02 0.04 %
Manganese (Mn)	up to 1 % above 1 %	0.08 × % Mn <sub>L</sub> + 0.01 0.09
Silicon (Si)	up to 0.60 % above 0.60 %	0.22 × % Si <sub>L</sub> – 0.01 0.15 %
Phosphorus (P)	all	0.13 × % P <sub>L</sub> + 0.005
Sulfur (S)	all	0.36 × % S <sub>L</sub> + 0.001
Nickel (Ni)	up to 2 % above 2 %	0.10 × % Ni <sub>L</sub> + 0.03 0.25 %
Chromium (Cr)	up to 2 % above 2 %	0.07 × % Cr <sub>L</sub> + 0.04 0.18 %
Molybdenum (Mo)	up to 0.6 % above 0.6 %	0.04 × % Mo <sub>L</sub> + 0.03 0.06 %
Vanadium (V)	up to 0.25 % above 0.25 %	0.23 × % V <sub>L</sub> + 0.004 0.06 %
Tungsten (W)	up to 0.10 % above 0.10 %	0.08 × % W <sub>L</sub> + 0.02 0.02 %
Copper (Cu)	up to 0.15 % above 0.15 %	0.18 × % Cu <sub>L</sub> + 0.02 0.05 %
Aluminum (Al)	up to 0.03 % 0.03 to 0.10 %, incl. above 0.10 %	0.01 % 0.08 × % Al + 0.02 0.03 %

<sup>A</sup> 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.

<sup>B</sup> The subscript <sub>L</sub> 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.

<sup>C</sup> To compute the tolerances, consider the manganese limits 0.50 – 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 × 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 × 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).

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 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.

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 <sup>A</sup>	
	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	Tantalum	to 0.10, incl	0.02	
	over 15.00 to 20.00, incl	0.15				
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				
Silicon	to 1.00, incl	0.05	Aluminum	to 0.15, incl	−0.005, +0.01	
	over 1.00 to 3.00, incl	0.10		over 0.15 to 0.50, incl	0.05	
	over 3.00 to 6.00, incl	0.15		over 0.50 to 2.00, incl	0.10	
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	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			
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	

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

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.

7.4 *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, Fig. 1 and Table 1, with Fig. 2, or with Fig. 4, except when Supplementary Requirement S26 is specified. The test coupon in Specification A1067/A1067M, Fig. 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 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 1/2-in. [25 by 13-mm] section with corners rounded to a radius not over 1/16 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.

S3.2 The specimen shall withstand being bent longitudinally at room temperature through an angle of 90° about a pin, the diameter of which shall be the specimen thickness for carbon steels, and 1 in. [25 mm] for other steels. The specimen shall show no cracks on the outside of the bent portion of the specimen.

S3.3 Bend test specimens may be cut from heat-treated castings instead of from test specimens when agreed upon between manufacturer and purchaser.

S3.4 If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted from the same heat.

### S4. Magnetic Particle Inspection

S4.1 Castings shall be examined for surface and near-surface discontinuities by magnetic particle inspection. The examination shall be in accordance with Guide E709, and types and degrees of discontinuities considered shall be judged by Reference Photographs E125. Extent of examination, time of examination, and basis for acceptance shall be agreed upon between the manufacturer and purchaser. A specification which may be used as a basis for such agreement is MSS SP 53.

S4.2 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

### S5. Radiographic Inspection

S5.1 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. A specification that may be used as a basis for such agreement is MSS SP 54.

S5.2 Radiographic examination of castings may be performed before or after any heat treatment.

S5.3 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

### S6. Liquid Penetrant Inspection

S6.1 Castings shall be examined for surface discontinuities by means of liquid penetrant inspection. The examination shall be in accordance with Practice E165/E165M. Areas to be inspected, time of inspection, methods and types of liquid

penetrants to be used, developing procedure, and basis for acceptance shall be agreed upon between the manufacturer and purchaser. A specification that may be used as a basis for such agreement is Specification A903/A903M.

S6.2 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

### S7. Ultrasonic Inspection

S7.1 Castings shall be examined for internal defects by means of ultrasonic inspection. The inspection 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. A practice that may be used as a basis for such agreement is Practice A609/A609M.

S7.2 Ultrasonic examination of castings shall be performed after at least one heat treatment above the critical temperature range but need not be repeated after subsequent heat treatment.

S7.3 Personnel performing the examination shall be qualified in accordance with an acceptable written practice.

### S8. Charpy Impact Test

S8.1 Charpy impact test properties shall be determined on each heat from a set of three Charpy V-notch specimens made from a test coupon in accordance with Test Methods and Definitions A370 or Test Methods A1058, as applicable, and tested at a test temperature agreed upon by the manufacturer and purchaser. The acceptance requirements shall be either energy absorbed, lateral expansion, or percent shear area, or all three, and shall be those agreed upon by the manufacturer and purchaser. Test specimens shall be prepared as Type A and tested in accordance with Test Methods and Definitions A370 or Test Methods A1058, as applicable.

S8.2 *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.

S8.3 *Lateral Expansion*—Lateral expansion value shall be agreed upon by the manufacturer and purchaser.

S8.4 *Percent Shear Area*—Percent shear area shall be agreed upon by the manufacturer and purchaser.

### S9. Drop Weight Tests

S9.1 Drop weight test properties shall be determined from each heat by preparing and testing either Type P1, P2, or P3 specimens in accordance with Test Method E208. The crack starter weld shall be deposited on the surface of the specimen that was nearest to the casting surface. Each test shall consist of at least two specimens tested at a temperature agreed upon by the manufacturer and purchaser. Each specimen shall exhibit “no break” performance.

### S10. Examination of Weld Preparation

S10.1 Magnetic particle or liquid penetrant examination of cavities prepared for welding shall be performed to verify removal of those discontinuities found unacceptable by the inspection method specified for the casting. The method of

performing magnetic particle or liquid penetrant examination shall be in accordance with Guide E709 or Practice E165/E165M. 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 mm] thick and of Degree 3 in sections over 2 in. [50 mm] thick shall be acceptable.

### S11.

(This number not assigned to a supplementary requirement.)

### S12. Prior Approval of Major Weld Repairs

S12.1 Major weld repairs shall be subject to the prior approval of the purchaser.

### S13. Hardness Test

S13.1 A hardness test shall be made in accordance with Test Methods and Definitions A370 or Test Methods A1058, as applicable. The test location and the hardness requirements shall be agreed upon between the manufacturer and the purchaser.

### S14. Tension Test from Each Heat and Heat Treatment Charge

S14.1 One tension test shall be made for each heat and heat treatment charge.

### S15. Quench and Temper Heat Treatment

S15.1 The castings shall be quenched and tempered. Castings so treated shall be marked “QT.”

### S16.

(This number not assigned to a supplementary requirement.)

### S17. Tension Test from Castings

S17.1 In addition to the tensile test required in Section 6, test material shall be cut from heat-treated castings. The mechanical properties and location for the test material shall be agreed upon by the manufacturer and purchaser.

### S18. Tension Test for Castings Each Weighing 10 000 lb [4500 kg] or More

S18.1 Two tensile tests shall be made for each casting. The test specimens shall be prepared in accordance with Section 6. The location of the test specimens shall be agreed upon by the manufacturer and purchaser.

### S19.

(This number not assigned to a supplementary requirement.)

### S20. Weld Repair Charts

S20.1 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:

- (1) Exceeds approximately 10 in.<sup>2</sup> [65 cm<sup>2</sup>] for castings weighing up to 10 000 lb [4.5 tonnes];
- (2) Exceeds 20 in.<sup>2</sup> [130 cm<sup>2</sup>] for castings weighing from 10 000 lb to 30 000 lb [4.5 to 13.5 tonnes];
- (3) Exceeds approximately 30 in.<sup>2</sup> [200 cm<sup>2</sup>] for pieces weighing more than 30 000 lb [13.5 tonnes].

shall be documented.

S20.2 Weld repairs requiring documentation shall be documented on sketches or photographs, or both. The sketches or photographs shall show the location and major dimensions of cavities prepared for weld repair. The weld repair documentation shall be submitted to the purchaser at the completion of the order.

### S21. Heat Treatment Furnace Record

S21.1 A heat treatment chart showing time and temperature shall be prepared and be available for inspection by the purchaser.

### S22. Heat Treatment

S22.1 Test specimens shall be heat treated together with the castings they represent. Heat-treated specimens shall be tested and shall meet the tensile and impact properties specified.

S22.2 The remaining test specimens from Supplementary Requirement S22.1 representing the casting shall be treated thermally after the final (foundry) heat treatment to simulate heat treatments below the critical temperature that the casting may receive during fabrication, and then tested for mechanical properties. Time, temperature, and cooling rate shall be as stated in the order. In the case of post-weld heat treatment, the total time at temperature or temperatures for the test material shall be at least 80 % of the total time at temperature or temperatures during actual post-weld heat treatment of the fabrication of which the casting or castings are a part. The total time at temperature or temperatures for the test material may be performed in a single cycle. When this supplementary requirement is specified, the welding qualification test metal must be processed in the same manner.

### S23. Macroetch Test

S23.1 Apply Supplementary Requirement S1 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.

S23.2 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 (Note S23.1). 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.

NOTE S23.1—High-strength martensitic castings, in particular, may be damaged beyond use if the etch is applied directly to the casting.

S23.3 The preparation of the surface and the macroetching procedure with solution No. 1 (1:1 HCl) of Table 5 in Practice E340 shall be followed. The resulting etched surface shall be compared and rated with the reference photographs in Fig. S23.1 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. Table S23.1 relates the severity levels shown in these photographs with specific delineation widths and percent of boundary outlining in the etched structures.

S23.4 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 further evaluated by any of the following agreed-upon methods:

S23.4.1 Fracture testing to determine the amount of “rock candy” structure.

S23.4.2 Mechanical testing (bend, tensile, and so forth) to determine the ductility characteristics.

S23.4.3 Weld testing to determine crack susceptibility in the heat-affected zone of a circular groove welded with cellulose coated electrodes.

S23.5 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.

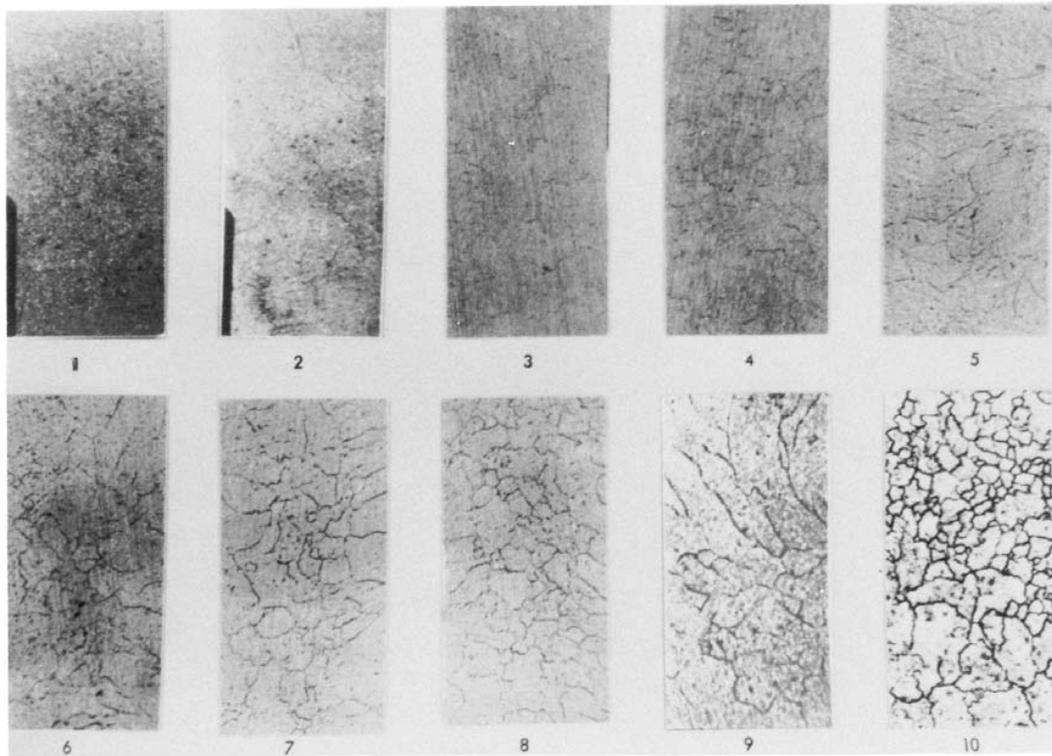
S23.6 Heavy section castings (3) whose configurations are amenable to the attachment of test coupons representative of the section thickness involved and from which standard 0.505-in. [12.827-mm] diameter tension specimens may be machined are exempt from this macroetch test if the results of the tension test on the coupon after heat treatment of the casting meet the minimum requirements specified for the grade of steel involved.

NOTE S23.2—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].

### S24. Specified Ferrite Content Range

S24.1 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 accordance with the specified ferrite content range.

S24.2 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.



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. S23.1 Reference Photographs of Macroetched Cast Steel

TABLE S23.1 Descriptive Data Applicable to Network Structures Shown in Fig. S23.1

NOTE 1—These ratings are based on the physical width and continuity of the precipitate pattern developed by the acid etchant on the primary austenitic grain boundaries of the cast steel. Supplementary testing is normally conducted to determine the final disposition of castings with ratings of 5 or greater.

Rating	Delineation Width, in.	Boundary Outline, %
1	Fine—0.001	20
2	Fine—0.001	40
3	Fine—0.001	60
4	Fine—0.002	80
5	Fine—0.002	100
6	Medium—0.005	100
7	Heavy—0.010	100
8	0.020	100
9	$\frac{1}{32}$	100
10	$\frac{1}{16}$	100

S24.3 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.

### S25. Heat Treatment Certification

S25.1 Heat treatment temperature and cycle times shall be shown on the certification report.

### S26. Alternate Tension Test Coupons and Specimen Locations for Castings

S26.1 Test coupons may be cast integrally with the castings or separately. Separately cast coupons shall be heat treated together with the castings they represent.

S26.2 The casting thickness,  $T$ , is the maximum thickness of the pressure-containing wall 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.

S26.3 One of the following shall apply:

S26.3.1 The longitudinal centerline of the test specimen shall be taken at least  $\frac{1}{4} T$  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  $\frac{1}{4} T$  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).)

S26.3.2 For ferritic and martensitic castings, partial severing of test coupons prior to final heat treatment is permitted.

S26.3.3 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 S26.3.1, 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.)

S26.3.4 When agreed upon between 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  $\frac{3}{4}$  in. [19 mm] to a heat-treated surface and  $1\frac{1}{2}$  in. [38 mm] from a second heat-treated surface. (See Specification A1067/A1067M, Fig. 7.)

S26.3.5 Where specimens are to be removed from the body of quenched and tempered castings, either the requirements of S26.3.1 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  $3T$  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  $\frac{1}{2}$  in. [13 mm] from the buffered surface and  $\frac{1}{4}T$  from other heat-treated surfaces (see Specification A1067/A1067M, Fig. 7). 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 S26.3.1

### S27. Hot Isostatic Pressing (HIPing)

S27.1 Castings shall be processed by hot isostatic pressing (HIPing) according to Practice A1080. 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.

### S28. Cleaning of Stainless Steels

S28.1 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 supplier. Acceptance testing shall be subject to agreement between the purchaser and supplier.

### S29.

(This number not assigned to a supplementary requirement.)

### S30.

(This number not assigned to a supplementary requirement.)

### S31.

(This number not assigned to a supplementary requirement.)

### S32.

(This number not assigned to a supplementary requirement.)

### S33. Stabilization Heat Treatment of CF8C

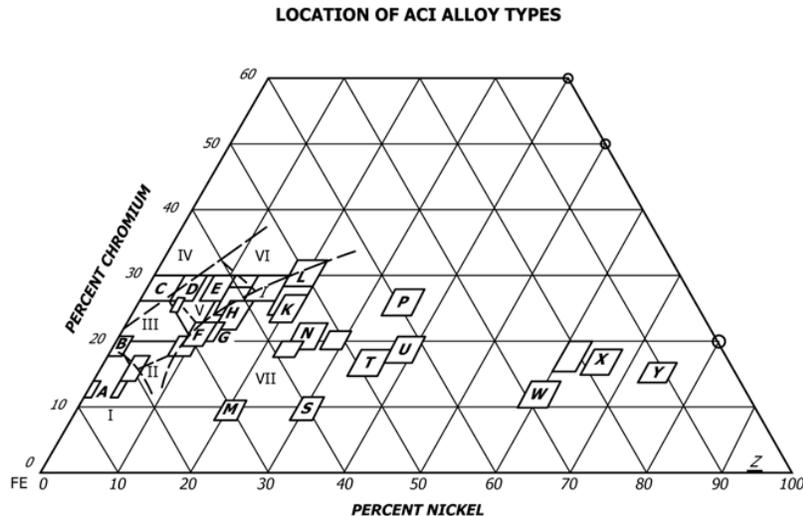
S33.1 CF8C shall be stabilized at 1600 to 1650 °F [870 to 900 °C] for a minimum time of 1 h/in. [25 mm] of thickness and water quenched or rapidly cooled by other means. The grade designation symbol shall be followed by the symbol "S33."

### S34. Stabilization Heat Treatment of CF10MC

S34.1 CF10MC shall be stabilized at 1600 to 1650 °F [870 to 900 °C] for a minimum time of 1 h/in. [25 mm] of thickness and water quenched or rapidly cooled by other means. The grade designation symbol shall be followed by the symbol "S34."

### S50–S69.

(These numbers reserved for assignment by individual product standards.)



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**

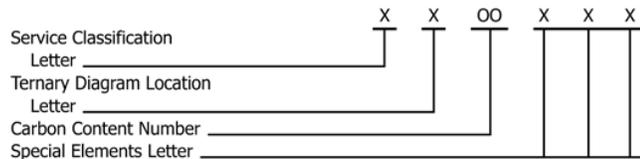
## APPENDIXES

### (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  $\pm 0.05$  % 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: the letter A indicates “Controlled Ferrite,” and the letter F indicates “Free Machining.”

X1.3 In Fig. X1.1, unlettered NiCr 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 grade CB-7Cu.

**X2. ADDITION OF NEW GRADES TO PRODUCT SPECIFICATIONS COVERED BY SPECIFICATION A703/A703M**

X2.1 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 X2.2 and X2.3 is not required.

X2.2 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:

X2.2.1 Chemical composition.

X2.2.2 Mechanical properties, as applicable to the product specification being cited. These may include, but are not limited, to the following:

X2.2.2.1 Ultimate tensile strength,

X2.2.2.2 Yield strength or yield point,

X2.2.2.3 Elongation,

X2.2.2.4 Reduction of area,

X2.2.2.5 Hardness, and

X2.2.2.6 Impact properties (Charpy V-notch).

X2.2.3 The test coupon size from which the test specimens were removed, stated for each test.

X2.2.4 Heat treatment requirements.

X2.2.5 Welding procedure. (Welding should be carried out using commercially available consumables.)

X2.2.6 Whether the material is covered by any patents.

X2.3 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.

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