

# SPECIFICATION FOR CASTINGS, AUSTENITIC-FERRITIC (DUPLEX) STAINLESS STEEL, FOR PRESSURE-CONTAINING PARTS



SA-995/SA-995M



(23)

(Identical with ASTM Specification A995/A995M-20.)

# Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts

## 1. Scope

1.1 This specification covers austenitic-ferritic (duplex) stainless steel castings for valves, flanges, fittings, and other pressure-containing parts.

1.2 The duplex stainless steels offer a combination of enhanced mechanical properties and corrosion resistance when properly balanced in composition and properly heat treated. Ferrite levels are not specified, but these grades will develop a range of approximately 30 to 60 % ferrite with the balance austenite. It is the responsibility of the purchaser to determine which grade shall be furnished depending on design and service conditions, mechanical properties, and corrosion-resistant characteristics.

NOTE 1—Because of the possibility of precipitation of embrittling phases, the grades included in this specification are not recommended for service at temperatures above 600 °F [315 °C].

1.3 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.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel  
A703/A703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts  
E125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings  
E165/E165M Practice for Liquid Penetrant Testing for General Industry  
E562 Test Method for Determining Volume Fraction by Systematic Manual Point Count  
G48 Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *duplex stainless steel*—an iron-chromium-nickel-molybdenum alloy that, when properly heat treated, consists of approximately 30 to 60 % ferrite with the balance austenite.

## 4. General Conditions for Delivery

4.1 Material furnished to this specification shall conform to the applicable requirements of Specification A703/A703M, including the supplementary requirements that are indicated on the purchaser order. Failure to comply with the general requirements of Specification A703/A703M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A703/A703M, this specification shall prevail.

## 5. Ordering Information

5.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

5.1.1 A description of the casting by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

5.1.2 Quantity (weight and number of castings),

5.1.3 Specification designation and date of issue,

5.1.4 Grade of steel,

5.1.5 Supplementary requirements including acceptance criteria, and

**TABLE 1 Heat Treatment Requirements**

Grade	Heat Treatment
1B	Heat to 1900 °F [1040 °C] minimum, hold for sufficient time to heat casting uniformly to temperature, quench in water or rapid cool by other means.
2A	Heat to 2050 °F [1120 °C] minimum, hold for sufficient time to heat casting uniformly to temperature, quench in water or rapid cool by other means.
3A	Heat to 1950 °F [1070 °C] minimum, hold for sufficient time to heat casting uniformly to temperature, quench in water or rapid cool by other means.
4A	Heat to 2050 °F [1120 °C] minimum, hold for sufficient time to heat casting uniformly to temperature, and water quench; or the casting may be furnace cooled to a temperature no lower than 1850 °F [1010 °C], hold for 15 min minimum and then water quench. A rapid cool by other means may be employed in lieu of water quench.
5A	Heat to 2050 °F [1120 °C] minimum, hold for sufficient time to heat casting to temperature, furnace cool to a temperature no lower than 1910 °F [1045 °C], then quench in water or rapid cool by other means.
6A	Heat to 2010 °F [1100 °C] minimum, hold for sufficient time to heat casting uniformly to temperature, quench in water or rapid cool by other means, or the casting may be furnace cooled to a temperature no lower than 1925 °F [1050 °C], hold for 15 min minimum, and then quench in water or rapid cool by other means.
7A	Heat to 2065 °F [1130 °C] minimum, hold for sufficient time to heat casting to temperature, furnace cool to a temperature no lower than 1940 °F [1060 °C], then quench in water or rapid cool by other means.

5.1.6 Additional requirements.

## 6. Process

6.1 The steel shall be made by the electric furnace process with or without separate refining.

## 7. Heat Treatment

7.1 All castings shall be heat treated in accordance with Table 1.

## 8. Chemical Composition

8.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 2.

## 9. Tensile Properties

9.1 One tension test shall be made from each heat and shall conform to the requirements as to tensile properties prescribed in Table 3.

## 10. Quality

10.1 When additional inspection is desired, Supplementary Requirements S5, S6, and S10 may be ordered.

## 11. Repair by Welding

11.1 Repairs shall be made using procedures and welders qualified under Practice A488/A488M.

11.2 The composition of the deposited weld metal may be similar to that of the casting or may be suitably alloyed to achieve the desired corrosion resistance and mechanical properties.

11.3 Weld repairs shall be subject to the same quality standards as used to inspect the castings.

## 12. Post-Weld Heat Treatment After Major Weld Repair

12.1 Weld repairs shall be considered major in the case of a casting that has leaked on hydrostatic testing or when the depth of the cavity after preparation for repair exceeds 20 % of the actual wall thickness, or 1 in. [25 mm], whichever is smaller, or when the extent of the cavity exceeds approximately 10 in.<sup>2</sup> [65 cm<sup>2</sup>]. All other weld repairs shall be considered minor.

12.2 Castings shall be heat treated after major weld repairs. Heat treatment after minor weld repairs is not required unless Supplementary Requirement S11 is included in the purchase order.

12.3 Post-weld heat treatment shall be in accordance with Table 1.

## 13. Keywords

13.1 austenitic-ferritic; duplex stainless steel; pressure-containing; steel castings

TABLE 2 Chemical Requirements<sup>A,B</sup>

Material Grade Type UNS	Element, %											
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen	Copper	Tungsten	Other
CD4MCuN (1B) 25Cr-5Ni-Mo- Cu-N J93372	0.040	1.00	0.040	0.040	1.00	24.5–26.5	4.7–6.0	1.70–2.30	0.10–0.25	2.7–3.3	...	...
CE8MN (2A) 24Cr-10Ni-Mo-N J93345	0.080	1.00	0.040	0.040	1.50	22.5–25.5	8.0–11.0	3.0–4.5	0.10–0.30	...	...	...
CD6MN (3A) 25Cr-5Ni-Mo-N J93371	0.060	1.00	0.040	0.040	1.00	24.0–27.0	4.0–6.0	1.75–2.50	0.15–0.25	...	...	...
CD3MN (4A) 22Cr-5Ni-Mo-N J92205	0.030	1.50	0.040	0.040	1.00	21.0–23.5	4.5–6.5	2.5–3.5	0.10–0.30	1.00	...	...
CE3MN (5A) <sup>C</sup> 25Cr-7Ni-Mo-N J93404	0.030	1.50	0.040	0.040	1.00	24.0–26.0	6.0–8.0	4.0–5.0	0.10–0.30	...	...	...
CD3MWCuN (6A) <sup>D</sup> 25Cr-7Ni-Mo-N J93380	0.030	1.00	0.030	0.025	1.00	24.0–26.0	6.5–8.5	3.0–4.0	0.20–0.30	0.50–1.00	0.50–1.00	...
CD3MWN (7A) <sup>E</sup> 27Cr-7Ni-Mo- W-N J93379	0.030	1.00–3.00	0.030	0.020	1.00	26.0–28.0	6.0–8.0	2.0–3.5	0.30–0.40	1.00	3.0–4.0	B: 0.0010–0.0100 Ba: 0.0002–0.0100 Ce + La: 0.005–0.030

<sup>A</sup> All values are maximums, except where a range is provided.

<sup>B</sup> Where ellipses (...) appear in this table, there is no requirement, and the element need not be analyzed for or reported.

<sup>C</sup> % Cr + 3.3 % Mo + 16 % N  $\geq$  40.

<sup>D</sup> % Cr + 3.3 (% Mo + 0.5 % W) + 16 % N  $\geq$  40.

<sup>E</sup> % Cr + 3.3 (% Mo + 0.5 % W) + 16 % N  $\geq$  45.

TABLE 3 Tensile Requirements

Grade	1B	2A	3A	4A	5A	6A	7A
Type	25Cr-5Ni-Mo- Cu-N	24Cr-10Ni- Mo-N	25Cr-5Ni- Mo-N	22Cr-5Ni- Mo-N	25Cr-7Ni- Mo-N	25Cr-7Ni- Mo-N	27Cr-7Ni- Mo-W-N
Tensile strength, ksi [MPa], min	100 [690]	95 [655]	95 [655]	90 [620]	100 [690]	100 [690]	100 [690]
Yield strength (0.2 % offset), ksi [MPa], min	70 [485]	65 [450]	65 [450]	60 [415]	75 [515]	65 [450]	75 [515]
Elongation in 2 in. [50 mm], %, min <sup>A</sup>	16	25	25	25	18	25	20

<sup>A</sup> When ICI test bars are used in tensile testing as provided for in this specification, the gage length to reduced section diameter ratio shall be 4:1.

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not apply unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A703/A703M. Those which are ordinarily considered suitable for use with this specification are given below. Others enumerated in Specification A703/A703M may be used with this specification upon agreement between the manufacturer and purchaser.

### S1. Unspecified Elements

### S2. Destruction Tests

### S5. Radiographic Inspection

### S6. Liquid Penetrant Inspection

### S8. Charpy Impact Test

### S10. Examination of Weld Preparation

S10.1 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 liquid penetrant examination shall be in accordance with 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. Post-Weld Heat Treatment

S11.1 Castings shall be given a post-weld solution heat treatment in accordance with Table 1.

### S12. Prior Approval of Major Weld Repairs

Other supplementary requirements considered suitable for use with this specification are:

### S50. Estimating Ferrite Content

S50.1 Ferrite contents shall be determined by point count (Test Method E562), by other quantitative metallographic methods such as image analysis, by measurement of magnetic response, or by other methods upon agreement between the manufacturer and the purchaser. Frequency of testing and location of tests shall be by agreement between the manufacturer and the purchaser.

### S51. Prior Approval of Weld Material

S51.1 The purchaser must give approval of all weld filler materials to be used prior to any weld repairs.

### S52. Additional Requirements for Grade 6A

S52.1 *Casting Thickness, T*—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.

S52.2 *Charpy Impact Test*—Charpy impact test properties shall be determined by testing a set of three Charpy V-notch impact specimens made from each heat of material.

S52.2.1 The thickness of the test blocks used to create Charpy impact test specimens shall be equal to the casting thickness, *T*. Charpy impact test specimens shall be removed from a location at one-half the thickness of the test block.

S52.2.2 When the thickness of the test block is less than or equal to 4 in. [100 mm], Charpy impact testing shall be performed at one of the test temperatures listed in Table S52.1.

**TABLE S52.1 Charpy Impact Testing of Base Material**

NOTE 1—It is recommended that test temperature selection be determined based on the intended service temperature of the casting.

Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three speci- mens	Energy Value, ft-lbf [J], min for single specimen
-51 [-46]	103 [140]	77 [105]
-105 [-76]	66 [90]	48 [65]
-150 [-101]	44 [60]	33 [45]

The test temperature shall be provided by the purchaser. If the test temperature is not specified, the test temperature used shall be -51 °F [-46 °C]. The average value of the three specimens shall not be less than specified in Table S52.1, with no more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

S52.2.3 When the thickness of the test block is greater than 4 in. [100 mm], test temperature and absorbed energy values shall be agreed upon between the purchaser and the manufacturer.

S52.3 *Corrosion Testing*—A Test Methods G48 Method A ferric chloride pitting resistance test shall be performed for a duration of 24 h at 60 °C.

S52.3.1 The thickness of the test blocks used to create corrosion test specimens shall be equal to the casting thickness, *T*. Corrosion test specimens shall be removed from a location at one quarter the thickness of the test block.

S52.3.2 When the thickness of the test block is less than or equal to 4 in. [100 mm], test specimens shall show no evidence of pitting when examined optically at 20× magnification, and have a weight loss of <4g/m<sup>2</sup>.

S52.3.3 When the thickness of the test block is greater than 4 in. [100 mm], test block size and acceptance criteria shall be agreed upon between the purchaser and the manufacturer.

S52.4 *Weld Qualifications*—Repairs shall be made utilizing welding procedures qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, and repair welding shall be done by welders or welding operators meeting the qualification requirements of Section IX. In addition to the Section IX qualification limits, the weld test plate thickness shall be as agreed upon between the casting supplier and the purchaser, but no less than 1.5 times the maximum weld repair depth. The weld deposit thickness shall be at least 80 % of the maximum repair depth.

S52.4.1 When the thickness of the qualification coupon is less than or equal to 4 in. [100 mm], and the qualification coupon is subjected to a post-weld solution heat treatment in accordance with Table 1, Charpy impact testing shall be performed at one of the test temperatures listed in Table S52.2.

**TABLE S52.2 Weld Qualification Impact Testing for Post-Weld Solution-Treated Coupons**

NOTE 1—It is recommended that test temperature selection be determined based on the intended service temperature of the casting.

Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three specimens	Energy Value, ft-lbf [J], min for single specimen
−51 [−46]	74 [100]	55 [75]
−105 [−76]	44 [60]	33 [45]
−150 [−101]	33 [45]	26 [35]

The test temperature shall be provided by the purchaser. If the test temperature is not specified, the test temperature used shall be −51 °F [−46 °C]. Charpy impact test locations shall be at the weld cap and mid-thickness of the weld deposit. Three specimens shall be removed from each of these three locations: the fusion line, fusion line + 2 mm, and fusion line + 5 mm. The average value of the three specimens shall not be less than specified in Table Table S52.2, with no more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

**TABLE S52.3 Weld Qualification Impact Testing for As-Welded Coupons**

Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three specimens	Energy Value, ft-lbf [J], min for single specimen
−51 [−46]	89 [120]	66 [90]
−105 [−76]	44 [60]	33 [45]
−150 [−101]	33 [45]	26 [35]

S52.4.2 When the thickness of the qualification coupon is less than or equal to 4 in. [100 mm], and the qualification coupon is not subjected to a post-weld solution heat treatment, Charpy impact testing shall be performed at one of the test temperatures listed in Table S52.3. The test temperature shall be provided by the purchaser. If the test temperature is not specified, the test temperature used shall be −51 °F [−46 °C]. Charpy impact test locations shall be at the weld cap and mid-thickness of the weld deposit. Three specimens shall be removed from each of these three locations: the fusion line, fusion line + 2 mm, and fusion line + 5 mm. The average value of the three specimens shall not be less than specified in Table S52.3, with no more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

S52.4.3 When the thickness of the qualification coupon is greater than 4 in. [100 mm], test temperature, specimen location and quantity, and absorbed energy values shall be agreed upon between the purchaser and the manufacturer.

S52.4.4 A Test Methods G48 Method A test shall be performed on a sample removed from the weld qualification coupon; the sample shall include approximately 50 % weld material and 50 % base material. Weld test coupons subjected to a post-weld solution heat treatment shall be tested at 60 °C. Weld test coupons not being subjected to a post-weld solution heat treatment shall be tested at 50 °C. Regardless of heat treatment condition, the acceptance criteria and test time shall be the same as outlined in S52.3.