



Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal¹

This standard is issued under the fixed designation A928/A928M; 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 electric-fusion-welded steel pipe suitable for corrosive service.

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this specification for traditional terms such as nominal diameter, size, and nominal size.

1.2 This specification covers grades of ferritic/austenitic steel as indicated in Table 1. The selection of the proper alloy and requirements for heat treatment shall be at the discretion of the purchaser, dependent on the service conditions to be encountered.

1.3 Five classes of pipe are covered as follows:

1.3.1 *Class 1*—Pipe shall be double welded by processes using filler metal in all passes and shall be radiographed completely.

1.3.2 *Class 2*—Pipe shall be double welded by processes using filler metal in all passes. No radiograph is required.

1.3.3 *Class 3*—Pipe shall be single welded by processes using filler metal in all passes and shall be radiographed completely.

1.3.4 *Class 4*—Same as Class 3, except that the weld pass exposed to the inside pipe surface is permitted to be made without the addition of filler metal (see 6.2.2.1 and 6.2.2.2).

1.3.5 *Class 5*—Pipe shall be double welded by processes using filler metal in all passes and shall be spot radiographed.

1.4 Supplementary requirements covering provisions ranging from additional testing to formalized procedures for manufacturing practice are provided. Supplementary Requirements S1 through S4 are included as options to be specified in the purchase order when desired.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. 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 non-conformance with the standard. The inch-pound units shall apply unless the M designation of the specification is specified in the order.

1.6 *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

A240/A240M Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

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

A999/A999M Specification for General Requirements for Alloy and Stainless Steel Pipe

E426 Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys

2.2 ASME Boiler and Pressure Vessel Code:³

Section III

Section VIII

Section IX

2.3 AWS Specifications:⁴

A 5.4 Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes

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 A01.10 on Stainless and Alloy Steel Tubular Products.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁴ Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

- A 5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes**
- A 5.11 Nickel and Nickel-Alloy Covered Welding Electrodes**
- A 5.14 Nickel and Nickel-Alloy Bare Welding Rods and Electrodes**
- A 5.22 Flux Cored Corrosion-Resisting Chromium and Chromium-Nickel Steel Electrodes**
- A 5.30 Consumable Weld Inserts for Gas Tungsten Arc Welding**

3. Terminology

3.1 Definitions:

3.1.1 The definitions in Specification **A999/A999M** and Terminology **A941** are applicable to this specification.

4. Ordering Information

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

- 4.1.1 Quantity (feet, metres, or number of lengths),
- 4.1.2 Name of material (electric-fusion-welded pipe),
- 4.1.3 Grade (see **Table 1**),
- 4.1.4 Class (see **1.3**),
- 4.1.5 Size (outside diameter and nominal wall thickness),
- 4.1.6 Length (specific or random),
- 4.1.7 End finish (section on ends of Specification **A999/A999M**),
- 4.1.8 Authorization for repair of plate defects by welding and subsequent heat treatment without prior approval, if such is intended (see **13.3**),
- 4.1.9 Specification designation,
- 4.1.10 Special requirements,
- 4.1.11 Statement invoking requirements of **13.4**, if such is intended,
- 4.1.12 Circumferential weld permissibility (see Section **17**),
- 4.1.13 Supplementary Requirements (S1 through S4),
- 4.1.14 Applicable ASME Code, if known,
- 4.1.15 For ASME Code Section III applications, the service classification intended, and
- 4.1.16 Certification requirements (see section on certification of Specification **A999/A999M**).

5. General Requirements

5.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification **A999/A999M** unless otherwise provided herein.

6. Materials and Manufacture

6.1 *Materials*—The steel plate material shall conform to the requirements of one of the grades of Specification **A240/A240M**, listed in **Table 1**.

6.2 Welding:

6.2.1 The joints shall be full penetration double-welded or single-welded butt joints using fusion welding processes as defined under Definitions, ASME Boiler and Pressure Vessel Code, Section IX. This specification makes no provision for

any difference in weld quality requirements, regardless of the weld joint type used (single or double) in making the weld. Where backing rings or strips are used, the ring or strip material shall be of the same P-Number (Table QW-422 of Section IX) as the plate being joined. Backing rings or strips shall be removed completely after welding, prior to any required radiography, and the exposed weld surface shall be examined visually for conformance to the requirements of **6.2.3**. Welds made by procedures using backing strips or rings that remain in place are prohibited. Welding procedures and welding operators shall be qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX.

6.2.2 Except as provided in **6.2.2.1** and **6.2.2.2**, welds shall be made in their entirety by processes involving the deposition of filler metal.

6.2.2.1 For Class 4 pipe using multiple passes, it is permitted to make the root-pass without the addition of filler metal.

6.2.2.2 For Class 4 pipe, it is permitted that the weld surface exposed inside the pipe be the result from a single pass made from the inside of the pipe without the addition of filler metal.

6.2.2.3 All single-welded pipe shall be radiographed completely.

6.2.3 The weld surface on either side of the weld may be flush with the base plate or may have a reasonably uniform crown, not to exceed $\frac{1}{8}$ in. [3 mm]. It is permitted to remove any weld reinforcement, at the option of the manufacturer or by agreement between the manufacturer and purchaser. The contour of the reinforcement shall be reasonably smooth and free of irregularities. The deposited metal shall be fused uniformly into the plate surface. No concavity of contour is permitted unless the resulting thickness of weld metal is equal to or greater than the minimum thickness of the adjacent base metal.

6.2.4 Weld defects shall be repaired by removal to sound metal and rewelding. Subsequent heat treatment and examination (that is, visual, radiographic, and dye penetrant) shall be as required on the original welds.

6.3 Heat Treatment:

6.3.1 Unless otherwise stated in the order, heat treatment shall be performed after welding and in accordance with the requirements of **Table 2**.

6.3.2 If the purchaser desires pipe without heat treatment subsequent to welding, the purchase order shall specify the following condition:

6.3.2.1 *No final heat treatment of pipe fabricated of plate that has been heat treated as required by **Table 2** for the particular grade.* Each pipe supplied under this requirement shall be stenciled with the suffix “HT-O.”

7. Chemical Composition

7.1 The chemical composition of the plate shall conform to the requirements of the applicable specification and grade listed in **Table 1**.

7.2 Unless otherwise specified in the purchase order, the chemical composition of the welding material shall conform to the requirements of the applicable AWS specification for the corresponding grade given in **Table 1** or shall conform to the chemical composition specified for the plate, or shall, subject to purchaser approval, be a filler metal more highly alloyed

than the base metal when needed for corrosion resistance or other properties. Use of a filler metal other than that listed in **Table 1** or conforming to the chemical composition specified for the plate shall be reported and the filler metal identified on the certificate of tests. When nitrogen is a specified element for the ordered grade, the method of analysis shall be a matter of agreement between the purchaser and the manufacturer.

8. Heat Analysis

8.1 The chemical analysis of the steel shall be determined by the plate manufacturer and shall conform to the requirements for the particular grade as prescribed in Specification **A240/A240M**.

9. Product Analysis

9.1 At the request of the purchaser's inspector, an analysis of one length of flat-rolled stock from each heat, or from base metal and weld deposit from two pipes from each lot, shall be made by the manufacturer. A lot of pipe shall consist of the following number of lengths of the same size and wall thickness from any one heat of steel:

NPS Designator	Lengths of Pipe in Lot
Under 2	400 or fraction thereof
2 to 5, incl	200 or fraction thereof
6 and over	100 or fraction thereof

9.2 The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section 7, subject to the product analysis tolerances of Table 1 in Specification **A480/A480M**.

9.3 If the analysis of one of the tests specified in 8.1 or 9.1 does not conform to the requirements specified in Section 7, it is permitted to obtain an analysis of the base metal and weld deposit of each pipe from the same heat or lot, and all pipe conforming to the requirements shall be accepted.

10. Tensile Requirements

10.1 The plate used in making the pipe shall conform to the requirements as to tensile properties of the applicable specifications listed in **Table 1**. Tension tests made by the plate manufacturer shall qualify the plate material.

10.2 The transverse tension test taken across the welded joint specimen shall have a tensile strength not less than the specified minimum tensile strength of the plate.

11. Permissible Variations of Dimensions for Thin-Wall Pipe

11.1 For thin-wall pipe, defined as pipe having a wall thickness of 3 % or less of the specified outside diameter, the diameter tolerance, as listed in Specification **A999/A999M**, shall apply only to the mean of the extreme (maximum and minimum) outside diameter readings in any one cross section.

11.2 For thin-wall pipe, the difference in extreme outside readings (called the ovality) in any one section shall not exceed twice the permissible variations in outside diameter for the specified diameter as listed in Specification **A999/A999M**.

12. Transverse Guided-Bend Weld Tests

12.1 Two bend test specimens shall be taken transversely from the pipe. Except as provided in 12.2, one shall be subject to a face guided-bend test and the second to a root guided-bend test. One specimen shall be bent with the inside surface of the pipe against the plunger, and the other with the outside surface against the plunger.

12.2 For specified wall thicknesses over $\frac{3}{8}$ in. [9.5 mm] but less than $\frac{3}{4}$ in. [19 mm], side-bend tests may be made instead of the face and root-bend tests. For specified wall thicknesses $\frac{3}{4}$ in. [19 mm] and over, both specimens shall be subjected to the side-bend tests. Side-bend specimens shall be bent so that one of the side surfaces becomes the convex surface of the bend specimen.

12.3 The bend test shall be acceptable if no cracks or other defects exceeding $\frac{1}{8}$ in. [3 mm] in any direction are present in the weld metal or between the weld and the pipe metal after bending. Cracks that originate along edges of the specimen during testing, and that are less than $\frac{1}{4}$ in. [6.5 mm] measured in any direction, shall not be considered.

13. Workmanship, Finish, and Appearance

13.1 The finished pipe shall have a workmanlike finish.

13.2 *Repair of Plate Defects by Machining or Grinding*—Pipe showing slivers may be machined or ground inside or outside to a depth that shall ensure the removal of all included scale and slivers, providing the wall thickness is not reduced below the specified minimum wall thickness. Machining or grinding shall follow inspection of the pipe as rolled, and it shall be followed by supplementary visual inspection.

13.3 *Repair of Plate Defects by Welding*—Defects that violate minimum wall thickness may be repaired by welding, but only with the approval of the purchaser. Areas shall be prepared suitably for welding with tightly closed defects removed by grinding. Open, clean defects, such as pits or impressions, may require no preparation. All welders, welding operators, and weld procedures shall be qualified to the ASME Boiler and Pressure Vessel Code, Section IX. Unless the purchaser specifies otherwise, pipe required to be heat treated under the provisions of 6.3 shall be heat treated or reheat treated following repair welding. Repaired lengths, where repair depth is greater than $\frac{1}{4}$ of the thickness, shall be pressure tested or repressure tested after repair and heat treatment (if any). Repair welds shall also be examined by suitable nondestructive examination techniques, including any techniques required specifically of the primary weld.

13.4 The pipe shall be free of scale and contaminating iron particles. Pickling, blasting, or surface finishing is not mandatory when pipe is bright annealed. The purchaser is permitted to require in the purchase order that a passivating treatment be applied.

14. Test Specimens and Methods of Testing

14.1 Transverse tension and bend test specimens shall be taken from the end of the finished pipe; the transverse tension and bend test specimens shall be flattened cold before final machining to size.



TABLE 1 Pipe and Filler Metal Specifications

UNS Designation	Grade ^A	ASTM Plate Specification No. and Grade	A5.4		A5.9		A5.11		A5.14		A5.22		A5.30	
			Class	UNS	Class	UNS	Class	UNS	Class	UNS	Class	UNS	Class	UNS
S31200	...	A240 S31200	B	B	B	B	B	B	B	B	B	B	B	B
S31260	...	A240 S31260	B	B	B	B	B	B	B	B	B	B	B	B
S31500	...	A240 S31500	B	B	B	B	B	B	B	B	B	B	B	B
S31803	...	A240 S31803	E2209...	W39209...	ER2209...	S39209...	B	B	B	E2209TOX...	W39239...	B	B	B
S32003	...	A240 S32003	B	B	B	B	B	B	B	B	B	B	B	B
S32101	...	A240 S32101	E2307-XX	S82371	ER2307	S82371	B	B	B	E2307TX-X	B	B	B	B
S32202	...	A240 S32202	B	B	B	B	B	B	B	B	B	B	B	B
S32205	2205	A240 S32205	E2209...	W39209...	ER2209...	S39209...	B	B	B	E2209TOX...	W39239...	B	B	B
S32304	2304	A240 S32304	B	B	B	B	B	B	B	B	B	B	B	B
S32506	...	A240 S32506	B	B	B	B	B	B	B	B	B	B	B	B
S32550	255	A240 S32550	E2553...	W39553...	ER2553...	S39553...	B	B	B	E2553TOX...	W39533...	B	B	B
S32750	2507	A240 S32750	E2594...	W39594...	ER2594...	S32750...	B	B	B	B	B	B	B	B
S32900	329 ^C	A240 type 329	B	B	B	B	B	B	B	B	B	B	B	B
S32950	...	A240 S32950	B	B	B	B	B	B	B	B	B	B	B	B
S32760	...	A240 S32760	B	B	B	B	B	B	B	B	B	B	B	B
S32520	...	A240 S32520	B	B	B	B	B	B	B	B	B	B	B	B
S81921	...	A240 S81921	E2209...	W39209...	ER2209...	S39209...	B	B	B	E2209TOX...	W39239...	B	B	B
S82121	...	A240 S82121	E2209...	W39209...	ER2209...	S39209...	B	B	B	E2209TOX...	W39239...	B	B	B
S82441	...	A240 S82441	B	B	B	B	B	B	B	B	B	B	B	B

^A Except as indicated, common name, not a trademark, widely used, not associated with any one producer.^B An AWS standard filler metal is not yet available for inclusion in this table.^C A grade designation originally assigned by the American Iron and Steel Institute (AISI).



TABLE 2 Heat Treatment

UNS Designation	Grade ^A	Temperature, °F [°C]	Quench
S31200	...	1920–2010 [1050–1100]	rapid cooling in water
S31260	...	1870–2010 [1020–1100]	rapid cooling in water
S31500	...	1800–1900 [980–1040]	rapid cooling in air or water
S31803	...	1870–2010 [1020–1100]	rapid cooling in air or water
S32003	...	1850–2010 [1010–1100]	rapid cooling in air or water
S32101	...	1870 [1020] min	rapid cooling in air or water
S32202	...	1870–1975 [1020–1080]	rapid cooling in air or water
S32205	2205	1870–2010 [1020–1100]	rapid cooling in air or water
S32304	2304	1700–1920 [925–1050]	rapid cooling in air or water
S32506	...	1870–2050 [1020–1120]	rapid cooling in air or water
S32550	255	1900 [1040], min	rapid cooling in air or water
S32750	2507	1880–2060 [1025–1125]	rapid cooling in air or water
S32900	329 ^B	1700–1750 [925–955]	rapid cooling in air or water
S32950	...	1820–1880 [990–1025]	rapid cooling in air or water
S32760	...	2010–2085 [1100–1140]	rapid cooling in air or water
S32520	...	1975–2050 [1080–1120]	rapid cooling in air or water
S81921	...	1760–2010 [960–1100]	rapid cooling in air or water
S82121	...	1830–2010 [1000–1100]	rapid cooling in air or water
S82441	...	1870 [1020] min	rapid cooling in air or water

^A Except as indicated, common name, not a trademark, widely used, not associated with any one producer.

^B A grade designation originally assigned by the American Iron and Steel Institute (AISI).

14.2 As an alternative to the requirements of 14.1, the manufacturer is permitted to take the test specimens from a test plate of the same material as the pipe, which is attached to the end of the cylinder and welded as a prolongation of the pipe longitudinal seam.

14.3 Tension test specimens shall be made in accordance with Section IX, Part QW-150 of the ASME Boiler and Pressure Vessel Code and shall be one of the types shown in QW-462.1 of that code.

14.3.1 Reduced-section specimens conforming to the requirements given in QW-462.1(b) are permitted to be used for tension tests on all thicknesses of pipe having outside diameters greater than 3 in. [76 mm].

14.3.2 Turned specimens conforming to the requirements of QW-462.1(d) are permitted to be used for tension tests.

14.3.2.1 If turned specimens are used as given in 14.3.2.2 and 14.4, one complete set shall be made for each required tension test.

14.3.2.2 For thicknesses over 1¼ in. [32 mm], multiple specimens shall be cut through the full thickness of the weld with their centers parallel to the material surface and not over 1 in. [25 mm] apart. The centers of the specimens adjacent to material surfaces shall not exceed ⅝ in. [16 mm] from the surface.

14.4 The test specimens shall not be cut from the pipe or test plate until after final heat treatment.

15. Mechanical Tests Required

15.1 *Transverse Tension Test*—One test shall be made to represent each lot (see Note 2) of finished pipe.

NOTE 2—The term lot is defined in 9.1.

15.2 *Transverse Guided-Bend Test*—One test (two specimens) shall be made to represent each lot (see Note 2) of finished pipe.

15.3 *Nondestructive Test*—Each length of pipe shall be subjected to a hydrostatic test as defined in 15.3.1 or, with the

approval of the purchaser, each length of pipe having a wall thickness up through 0.165 in. (4.2 mm) shall be subjected to a nondestructive electric test as defined in 15.3.2.

15.3.1 *Hydrostatic Test*—Each length of pipe shall be subjected to a hydrostatic test in accordance with Specification A999/A999M, unless specifically exempted under the provision of 15.3.1.1. Pressure shall be held for a sufficient time to permit the inspector to examine the entire length of the welded seam.

15.3.1.1 With the agreement of the manufacturer, the purchaser is permitted to complete the hydrostatic test requirement with the system pressure test, which may be lower or higher than the specification test pressure, but in no case shall the test pressure be lower than the system design pressure. Each length of pipe furnished without the completed manufacturer's hydrostatic test shall include with the mandatory marking the letters NH.

15.3.2 *Nondestructive Electric Test*—Each length of pipe shall be subjected to a nondestructive electric test in accordance with Practice E426.

15.3.2.1 For pipe up through NPS 4, the eddy-current test shall be applied to the total pipe area. For pipe larger than NPS 4, the eddy-current test is permitted, at the option of the producer, to be applied to the weld area only rather than the total pipe area.

16. Radiographic Examination

16.1 For Classes 1, 3, and 4 pipe, all welded joints shall be examined completely by radiography.

16.2 For Class 5 pipe, the welded joints shall be spot radiographed to the extent of not less than 12 in. [300 mm] of radiograph per 50 ft [15 m] of weld.

16.3 For Classes 1, 3, and 4 pipe, radiographic examination shall be in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, latest edition, Paragraph UW-51.

16.4 For Class 5 pipe, radiographic examination shall be in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest edition, Paragraph UW-52.

16.5 Radiographic examination is permitted to be performed prior to heat treatment.

17. Lengths

17.1 Circumferentially welded joints of the same quality as the longitudinal joints shall be permitted by agreement between the manufacturer and the purchaser.

18. Product Marking

18.1 In addition to the marking prescribed in Specification **A999/A999M**, the markings of each length of pipe shall include the plate material designations as shown in **Table 1**, the marking requirements of **6.3** and **15.3**, and Class 1, 2, 3, or 4, as appropriate (see **1.3**).

19. Keywords

19.1 arc welded steel pipe; corrosive service; duplex (austenitic-ferritic) stainless steel; fusion welded steel pipe; steel pipe; welded steel pipe

SUPPLEMENTARY REQUIREMENTS

FOR PIPE REQUIRING SPECIAL CONSIDERATION

One or more of the following supplementary requirements shall apply when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and the manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

S1.1 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical requirements shall be rejected.

S2. Tension and Bend Tests

S2.1 Tension tests (see Section **10**) and bend tests (see Section **12**) shall be made on specimens to represent each length of pipe. Failure of any test specimen to meet the requirements shall be cause for the rejection of the pipe length represented.

S3. Penetration Oil and Powder Examination

S3.1 All welded joints shall be subjected to examination by a penetrant oil and powder method. The details of the method and the disposition of flaws detected shall be a matter for agreement between the purchaser and the manufacturer.

S4. Ferrite Control in Weld Deposits

S4.1 The ferrite content of the deposited weld metal in any length of pipe may be determined. The procedural details pertaining to this subject (that is, welding, plate and weld deposit chemistry, testing equipment and method, number and location of test sites, and ferrite control limits) shall be a matter for agreement between the purchaser and the manufacturer.

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