



Designation: A 928/A 928M – 00

## Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal<sup>1</sup>

This standard is issued under the fixed designation A 928/A 928M; 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 nine 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 may 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 when desired.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the

two systems may result in nonconformance with the specification. The inch-pound units shall apply unless the M designation of the specification is specified in the order.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

A 240/A 240M Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels<sup>2</sup>

A 480/A 480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip<sup>2</sup>

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys<sup>3</sup>

A 999/A 999M Specification for General Requirements for Alloy and Stainless Steel Pipe<sup>3</sup>

E 426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys<sup>4</sup>

#### 2.2 ASME Boiler and Pressure Vessel Code:<sup>5</sup>

Section III, Nuclear Vessels

Section VIII, Unfired Pressure Vessels

Section IX, Welding Qualifications

#### 2.3 AWS Specifications:<sup>6</sup>

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

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

<sup>1</sup> 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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<sup>2</sup> Annual Book of ASTM Standards, Vol 01.03.

<sup>3</sup> Annual Book of ASTM Standards, Vol 01.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 03.03.

<sup>5</sup> Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

<sup>6</sup> Available from American Welding Society, 550 LeJeune Road, P.O. Box 351040, Miami, FL 33135.

**TABLE 1 Pipe and Filler Metal Specifications**

Grade	UNS Designation	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	A 240 S31200	...	...	...	...	...	...	...	...	...	...	...	...
...	S31260	A 240 S31260	...	...	...	...	...	...	...	...	...	...	...	...
...	S31500	A 240 S31500	...	...	...	...	...	...	...	...	...	...	...	...
...	S31803	A 240 S31803	...	...	...	...	...	...	...	...	...	...	...	...
...	S32205	A 240 S32205	...	...	...	...	...	...	...	...	...	...	...	...
...	S32304	A 240 S32304	...	...	...	...	...	...	...	...	...	...	...	...
...	S32550	A 240 S32550	...	...	...	...	...	...	...	...	...	...	...	...
...	S32750	A 240 S32750	...	...	...	...	...	...	...	...	...	...	...	...
329	S32900	A 240 type 329	...	...	...	...	...	...	...	...	...	...	...	...
...	S32950	A 240 S32950	...	...	...	...	...	...	...	...	...	...	...	...
...	S32760	A 240 S32760	...	...	...	...	...	...	...	...	...	...	...	...
...	S32520	A 240 S32520	...	...	...	...	...	...	...	...	...	...	...	...

A 5.30 Consumable Weld Inserts for Gas Tungsten Arc Welding

### 3. Terminology

#### 3.1 Definitions:

3.1.1 The definitions in Specification A 999/A 999M and Terminology A 941 are applicable to this specification.

### 4. Ordering Information

4.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:

- 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 A 999/A 999M),
- 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 A 999/A 999M).

### 5. General Requirements

5.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A 999/A 999M 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 A 240/A 240M, listed in Table 1.

#### 6.2 Welding:

6.2.1 The joints shall be full penetration double-welded or single-welded but 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, the root-pass may be made without the addition of filler metal.

6.2.2.2 For Class 4 pipe, the weld surface exposed inside the pipe may 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 1/8 in. [3 mm]. Any weld reinforcement may be removed at the manufacturer's option or by agreement between the manufacturer and the purchaser. The contour of the reinforcement should 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. The purchaser may choose a higher alloy filler metal when needed for corrosion resistance or other properties.

## 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 A 240/A 240M.

## 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 A 480/A 480M.

**TABLE 2 Heat Treatment**

UNS Designation	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
S32205	1870–2010 [1020–1100]	rapid cooling in air or water
S32304	1700–1920 [925–1050]	rapid cooling in air or water
S32550	1900 [1040], min	rapid cooling in air or water
S32750	1880–2060 [1025–1125]	rapid cooling in air or water
S32900	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

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, an analysis of the base metal and weld deposit of each pipe from the same heat or lot may be made, 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 A 999/A 999M, 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 (ovality) in any one section shall not exceed twice the permissible variations in outside diameter for the specified diameter as listed in Specification A 999/A 999M.

## 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 may request 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.

14.2 As an alternative to the requirements of 14.1, the test specimens may be taken 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) may 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) may be used for tension tests.

14.3.2.1 If turned specimens are used as given in 14.3.2.2 and 11.3.2.3, one complete set shall be made for each required tension test.

14.3.2.2 For thicknesses over  $\frac{1}{4}$  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  $\frac{5}{16}$  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 A 999/A 999M, 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 may 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 E 426.

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 may, at the option of the producer, 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 may 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 A 999/A 999M, 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).

**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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