



Standard Specification for Electric Fusion-Welded Ni-Cr-Co-Mo Alloy (UNS N06617), Ni-Fe-Cr-Si Alloys (UNS N08330 and UNS N08332), Ni-Cr- Fe-Al Alloy (UNS N06603), Ni-Cr-Fe Alloy (UNS N06025), and Ni-Cr-Fe-Si Alloy (UNS N06045) Pipe¹

This standard is issued under the fixed designation B 546; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers electric fusion-welded nickel-chromium-cobalt-molybdenum alloy UNS N06617, nickel-iron-chromium-silicon alloys UNS N08330 and UNS N08332, Ni-Cr-Fe-Al Alloy (UNS N06603), Ni-Cr-Fe Alloy UNS N06025, and Ni-Cr-Fe-Si Alloy UNS N06045 pipe intended for heat resisting applications and general corrosive service.

1.2 This specification covers pipe in sizes 3 in. (76.2 mm) nominal diameter and larger and possessing a minimum wall thickness of 0.083 in. (2.11 mm).

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

B 168 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip
B 536 Specification for Nickel-Iron-Chromium-Silicon Al-

loys (UNS N08330 and N08332) Plate, Sheet, and Strip
B 775 Specification for General Requirements for Nickel and Nickel Alloy Welded Pipe

B 899 Terminology Relating to Non-ferrous Metals and Alloys

E 10 Test Method for Brinell Hardness of Metallic Materials

E 140 Hardness Conversion Tables for Metals (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, and Knoop Hardness)

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

2.2 ASME Standards:

Boiler and Pressure Vessel Code, Section VIII, Paragraph UW-51³

Boiler and Pressure Vessel Code, Section IX³

3. Terminology

3.1 Definitions:

3.1.1 Definitions for terms defined in Terminology B 899 shall apply unless otherwise defined by the requirements of this document.

4. General Requirement

4.1 Material furnished in accordance with this specification shall conform to the applicable requirements of the current edition of Specification B 775 unless otherwise provided herein.

5. Classification

5.1 Two classes of pipe are covered as follows:

5.1.1 *Class 1*—All welded joints to be 100 % inspected by radiography.

¹ This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

5.1.2 *Class 2*—No radiographic examination is required.

6. Ordering Information

6.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

- 6.1.1 Alloy (Table 1),
- 6.1.2 ASTM designation and year of issue,
- 6.1.3 Class (See 5.1),
- 6.1.4 Dimensions (standard pipe size and schedule),
- 6.1.5 Length (specific or random),
- 6.1.6 Quantity (feet or number of pieces),
- 6.1.7 Certification—State if certification is required,
- 6.1.8 Whether type of filler metal and deposited composition is required (see 8.3),
- 6.1.9 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished, and
- 6.1.10 *Purchaser Inspection*—If purchaser wishes to witness tests or inspection of material at place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed.

7. Materials and Manufacture

7.1 *Materials*—The UNS N08330 and UNS N08332 alloy plate material shall conform to the requirements of Specification B 536. The UNS N06617, UNS N06603, UNS N06025, and UNS N06045 alloy plate material shall conform to the requirements of Specification B 168.

7.2 *Welding:*

7.2.1 The joints shall be double-welded, full-penetration welds made by qualified operators in accordance with procedures in the ASME Boiler and Pressure Vessel Code, Section IX.

7.2.2 The weld shall be made either manually or automatically by an electric process involving the deposition of filler metal.

7.2.3 The joint shall be reinforced at the center of the weld on each side of the formed plate by a weld bead at least $\frac{1}{16}$ in. (1.6 mm) but not more than $\frac{1}{8}$ in. (3.2 mm). This reinforcement (weld bead) may be removed at the manufacturer's option or by agreement between the manufacturer and the purchaser. The contour of the reinforcement (weld bead) shall be smooth, with no valley or groove along the edge or in the center of the weld, and the deposited metal shall be fused smoothly and uniformly into the formed-plate surface. The finish of the welded joint shall be reasonably smooth and free of irregularities, grooves, or depressions.

7.2.4 Weld defects shall be repaired by removal to sound metal and rewelding. Subsequent heat treatment and inspection shall be as required on the original welds.

7.3 *Heat Treatment*—All pipe shall be furnished in the annealed condition.

7.4 *Surface Finish*—The pipe shall be free from scale. When bright annealing is used, descaling is not necessary.

8. Chemical Composition

8.1 The material shall conform to the composition limits specified in Table 1. One test is required for each lot as defined in Specification B 775.

8.2 If a product analysis is performed, it shall meet the chemistry limits prescribed in Table 1, subject to the analysis tolerances specified in Table 1 of Specification B 775.

8.3 The chromium and nickel content of the deposited weld metal shall conform to the minimum chromium and nickel contents required for the base metal. Note that the composition of the deposited weld metal may not be the same as the base metal. The user should establish suitability for his particular application. When specified in the purchase order (see section 6.1.8), the manufacturer shall report the type of filler metal used along with a chemical analysis of the deposited weld metal.

9. Mechanical and Other Requirements

9.1 *Tensile Properties:*

TABLE 1 Chemical Requirements

Element	Composition Limits, %					
	N08330	N08332	N06603	N06617	N06025	N06045
Carbon	0.08 max	0.05–0.10	0.20–0.40	0.05–0.15	0.15–0.25	0.05–0.12
Manganese	2.00 max	2.00 max	0.15 max	1.0 max	0.15 max	1.0 max
Phosphorus	0.03 max	0.03 max	0.20 max	...	0.02 max	0.02 max
Sulfur	0.03 max	0.03 max	0.10 max	0.015 max	0.010 max	0.010 max
Silicon	0.75 to 1.50	0.75 to 1.50	0.50 max	1.0 max	0.5 max	2.5–3.0
Chromium	17.0 to 20.0	17.0 to 20.0	0.24–0.26	20.0–24.0	24.0–26.0	26.0–29.0
Nickel	34.0 to 37.0	34.0 to 37.0	Bal	remainder	Bal	45.0 min
Copper	1.00 max	1.00 max	0.50 max	0.5 max	0.1 max	0.3 max
Lead	0.005 max	0.005 max	...	...	...	...
Tin	0.025 max	0.025 max	...	...	...	...
Iron	remainder ^A	remainder	8.0–11.0	3.0 max	8.0–11.0	21.0–25.0
Aluminum	...	...	2.4–3.0	0.8–1.5	1.8–2.4	...
Cobalt	...	...	...	10.0–15.0	...	...
Molybdenum	...	...	...	8.0–10.0	...	...
Zirconium	...	...	0.01–0.10	...	0.01–0.10	...
Yttrium	...	...	0.01–0.15	...	0.05–0.12	...
Cerium	...	...	...	...	...	0.3–0.09
Titanium	...	...	0.010–0.025	...	...	...

^A Element shall be determined arithmetically by difference.

9.1.1 Transverse tension tests taken across the weld joints shall meet the requirements shown in Table 2.

9.2 Transverse Guided-Bend Weld Tests:

9.2.1 Two bend test specimens shall be taken transversely from the pipe. One shall be subject to a face guided-bend test and the second to a root guided-bend test.

9.2.2 The bend test shall be acceptable if no cracks or other defects exceeding 1/8 in. (3.2 mm) in any direction be present in the weld metal or between the weld and the pipe metal after bending. Cracks which originate along the edges of the specimen during testing and that are less than 1/4 in. (6.4 mm) measured in any direction, shall not be considered.

9.3 *Pressure (Leak) Test*—Any pipe that shows leaks during hydrostatic testing shall be rejected.

9.4 *Grain Size*—Annealed alloy UNS N08332 shall conform to an average grain size of ASTM No. 5 or coarser.

9.5 *Annealing Temperature*—Alloy UNS N08330 shall be annealed at 1900°F (1040°C) minimum. Alloy UNS N08332 shall be annealed at 2100°F (1150°C) minimum. Alloy UNS N06617 shall be annealed at 2050°F (1121°C) minimum. Alloy UNS N06025 shall be annealed at 2100°F (1150°C) minimum. Alloy UNS N06603 and UNS N06045 shall be annealed at 2120°F (1160°C) minimum.

10. Permissible Variations in Dimensions

10.1 *Permissible Variations*—The dimensions at any point in a length of pipe shall not exceed the following:

10.1.1 *Straightness*, Using a 10-ft. (3.05-m) straightedge placed so that both ends are in contact with the pipe; 1/8 in. (3.2 mm).

10.1.2 *Thickness*—The minimum wall thickness at any point in the pipe shall not be more than 0.01 in. (0.25 mm) under the nominal thickness.

10.2 Lengths:

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

11. Workmanship, Finish, and Appearance

11.1 *Finish*—Pipe shall be furnished with oxide removed. When final test treatment is performed in a protective atmosphere, descaling is not necessary.

11.2 *Weld Repair of Plate Defects Occurring During Pipe Fabrication*—Repair of injurious defects, which occur during the fabrication of the pipe from plate, shall be permitted only subject to the approval of the purchaser. Defects shall be thoroughly checked out before welding. Inspection of weld defects shall be by radiographic or liquid-penetrant technique,

at the option of the producer. If the pipe has already been annealed, it shall be annealed again except in the case of small voids, that in the estimation of the purchaser’s inspector, do not require reannealing. Each length of repaired pipe shall be subjected to the hydrostatic test.

12. Number of Tests Required

12.1 *Transverse Tension Test*—One test shall be made to represent each lot of finished pipe.

12.2 *Transverse Guided-Bend Weld Test*—Two tests shall be made to represent each lot of finished pipe.

12.3 *Grain Size, Hardness*—One test per lot.

12.4 *Pressure (Leak) Test*—Each length of pipe shall be subjected to the hydrostatic test.

12.5 *Chemical Analysis*—One test per lot.

13. Specimen Preparation

13.1 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.

13.2 As an alternative to the requirements of 13.1, 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.

13.3 Tension specimens shall be the full thickness of the material and shall be machined to the form and dimensions shown for large diameter products in Specification B 775.

13.4 The test specimens shall not be cut from the pipe or test plate until after final anneal.

14. Test Methods

14.1 *Chemical Composition*—In case of disagreement, the chemical composition shall be determined in accordance with Test Methods E 1473.

14.2 *Brinell Hardness*—Test Method E 10.

14.3 *Pressure (Leak) Test*—Each length of pipe shall be tested based on allowable fiber stress, for material as follows:

- UNS N06617—23 300 psi (or 161 MPa)
- UNS N08330—17 500 psi (or 121 MPa)
- UNS N08332—16 600 psi (or 114 MPa)
- UNS N06025—24 500 psi (or 169 MPa)
- UNS N06045—22 500 psi (or 155 MPa)
- UNS N06603—24 000 psi (or 165 MPa)

14.3.1 Visual examination is to be made when the material is under pressure for hydrostatic testing. The full length of material must be examined for leaks.

TABLE 2 Mechanical Properties

Alloy	Condition	Tensile Strength, min, psi (MPa)	Yield Strength, 0.2 %, offset, min, psi (MPa)	Elongation in 2 in. or 50 mm, or 4D, min, %	Hardness ^A
UNS N08330	Annealed	70 000 (483)	30 000 (207)	30	70 to 90 HRB
UNS N08332	Annealed	67 000 (462)	27 000 (186)	30	65 to 88 HRB
UNS N06603	Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06617	Annealed	95 000 (655)	35 000 (240)	30	...
UNS N06025	Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045	Annealed	90 000 (620)	35 000 (240)	30	...

^A Hardness values are informative only and not to be construed as the basis for acceptance.

14.4 *Hardness Conversion*—Hardness Conversion Tables E 140.

14.5 *Radiographic Examination*:

14.5.1 For Class 1 welded-joint quality, all welded joints shall be 100 % inspected by radiography.

14.5.2 Radiographic examination shall be in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, latest edition, Paragraph UW-51.

15. Packaging and Package Marking

15.1 Pipes which have been weld repaired in accordance with 7.2.4 shall be marked WR.

16. Keywords

16.1 fusion-welded pipe; N08330; N08332; N06603; N06617; N06025; N06045

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