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) Pipe

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 standard. The values given in parentheses are mathematical
conversions to SI units that are provided for information only
and are not considered standard.

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 (MSDS) 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
B168 Specification for Nickel-Chromium-Iron Alloys (UNS
N06600, N06601, N06603, N06690, N06693, N06025,
N06045, and N06696), Nickel-Chromium-Cobalt-
Molybdenum Alloy (UNS N06617), and Nickel-Iron-
Chromium-Tungsten Alloy (UNS N06674) Plate, Sheet,
and Strip
B536 Specification for Nickel-Iron-Chromium-Silicon Al-
loys (UNS N08330 and N08332) Plate, Sheet, and Strip
B775 Specification for General Requirements for Nickel and
Nickel Alloy Welded Pipe
B899 Terminology Relating to Non-ferrous Metals and Al-
loys
E10 Test Method for Brinell Hardness of Metallic Materials
E140 Hardness Conversion Tables for Metals Relationship
Among Brinell Hardness, Vickers Hardness, Rockwell
Hardness, Superficial Hardness, Knoop Hardness, and
Scleroscope Hardness
E1473 Test Methods for Chemical Analysis of Nickel,
Cobalt, and High-Temperature Alloys

2.2 ASME Standards:3
Boiler and Pressure Vessel Code, Section VIII Paragraph
UW-51
Boiler and Pressure Vessel Code, Section IX

3. Terminology

3.1 Definitions—Definitions for terms defined in Terminol-
ogy B899 shall apply unless otherwise defined by the require-
ments of this document.

4. General Requirement

4.1 Material furnished in accordance with this specification
shall conform to the applicable requirements of the current
dition of Specification B775 unless otherwise provided
herein.

5. Classification

5.1 Two classes of pipe are covered as follows:

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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.

approved in 1971. Last previous edition approved in 2004 as B546 – 04. DOI:
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3 Available from American Society of Mechanical Engineers (ASME), ASME
www.asme.org.

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Copyright by ASTM Int'l (all rights reserved);
5.1.1 Class 1—All welded joints to be 100 % inspected by radiography.
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 B536. The UNS N06617, UNS N06603, UNS N06025, and UNS N06045 alloy plate material shall conform to the requirements of Specification B168.
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 1/16 in. (1.6 mm) but not more than 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 B775.
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 B775.
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

<table>
<thead>
<tr>
<th>Element</th>
<th>N06617</th>
<th>N06603</th>
<th>N06025</th>
<th>N06045</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08 max</td>
<td>0.05–0.10</td>
<td>0.20–0.40</td>
<td>0.05–0.15</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.00 max</td>
<td>2.00 max</td>
<td>0.15 max</td>
<td>1.0 max</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.03 max</td>
<td>0.03 max</td>
<td>0.20 max</td>
<td>...</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.03 max</td>
<td>0.03 max</td>
<td>0.10 max</td>
<td>0.015 max</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.75 to 1.50</td>
<td>0.75 to 1.50</td>
<td>0.50 max</td>
<td>1.0 max</td>
</tr>
<tr>
<td>Chromium</td>
<td>17.0 to 20.0</td>
<td>17.0 to 20.0</td>
<td>24.0–26.0</td>
<td>20.0–24.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>34.0 to 37.0</td>
<td>34.0 to 37.0</td>
<td>Bal</td>
<td>remainder</td>
</tr>
<tr>
<td>Copper</td>
<td>1.00 max</td>
<td>1.00 max</td>
<td>0.50 max</td>
<td>0.5 max</td>
</tr>
<tr>
<td>Lead</td>
<td>0.005 max</td>
<td>0.005 max</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Tin</td>
<td>0.025 max</td>
<td>0.025 max</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Iron</td>
<td>remainder</td>
<td>remainder</td>
<td>8.0–11.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>...</td>
<td>...</td>
<td>2.4–3.0</td>
<td>0.8–1.5</td>
</tr>
<tr>
<td>Cobalt</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>10.0–15.0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>8.0–10.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>...</td>
<td>...</td>
<td>0.001–0.10</td>
<td>0.01–0.10</td>
</tr>
<tr>
<td>Yttrium</td>
<td>...</td>
<td>...</td>
<td>0.01–0.15</td>
<td>0.05–0.12</td>
</tr>
<tr>
<td>Cerium</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Titanium</td>
<td>...</td>
<td>...</td>
<td>0.010–0.025</td>
<td>...</td>
</tr>
</tbody>
</table>

A Element shall be determined arithmetically by difference.
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:
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 N0606603 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 B775.
13.4 The test specimens shall not be cut from the pipe or test plate until after final anneal.

### TABLE 2 Mechanical Properties

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Condition</th>
<th>Tensile Strength, min, psi (MPa)</th>
<th>Yield Strength, 0.2 %, offset, min, psi (MPa)</th>
<th>Elongation in 2 in. or 50 mm, or 4D, min, %</th>
<th>Hardness&lt;sup&gt;A&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNS N08330</td>
<td>Annealed</td>
<td>70 000 (483)</td>
<td>30 000 (207)</td>
<td>30</td>
<td>70 to 90 HRB</td>
</tr>
<tr>
<td>UNS N08332</td>
<td>Annealed</td>
<td>67 000 (462)</td>
<td>27 000 (186)</td>
<td>30</td>
<td>65 to 88 HRB</td>
</tr>
<tr>
<td>UNS N06603</td>
<td>Annealed</td>
<td>94 000 (650)</td>
<td>43 000 (300)</td>
<td>30</td>
<td>...</td>
</tr>
<tr>
<td>UNS N06617</td>
<td>Annealed</td>
<td>95 000 (655)</td>
<td>35 000 (240)</td>
<td>30</td>
<td>...</td>
</tr>
<tr>
<td>UNS N06025</td>
<td>Annealed</td>
<td>98 000 (680)</td>
<td>39 000 (270)</td>
<td>30</td>
<td>...</td>
</tr>
<tr>
<td>UNS N06045</td>
<td>Annealed</td>
<td>90 000 (620)</td>
<td>35 000 (240)</td>
<td>30</td>
<td>...</td>
</tr>
</tbody>
</table>

<sup>A</sup> Hardness values are informative only and not to be construed as the basis for acceptance.
14. Test Methods

14.1 Chemical Composition—In case of disagreement, the chemical composition shall be determined in accordance with Test Methods E1473.


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.

14.4 Hardness Conversion—Hardness Conversion Tables E140.

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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