Designation: B474 – 03(Reapproved 2009)

Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe[1]

This standard is issued under the fixed designation B474; 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 pipe suitable for high-temperature or corrosive service as listed in Table 1. (Although no restrictions are placed on the sizes of pipe that may be furnished under this specification, commercial practice is commonly limited to sizes not less than 8 in. (203 mm) nominal diameter.)

1.2 Five classes of pipe are covered as follows:

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

1.2.2 *Class 2*—Pipe shall be double welded by processes employing filler metal in all passes. No radiography is required.

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

1.2.4 *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.

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

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]

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

B127 Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip

B162 Specification for Nickel Plate, Sheet, and Strip

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

B333 Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip

B424 Specification for Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825, UNS N08221, and UNS N06845) Plate, Sheet, and Strip

B435 Specification for UNS N06002, UNS N06230, UNS N12160, and UNS R30556 Plate, Sheet, and Strip

B443 Specification for Nickel-Chromium-Molybdenum-Columbium Alloy(UNS N06625) and Nickel-Chromium-Molybdenum-SiliconAlloy (UNS N06219) Plate, Sheet, and Strip

B463 Specification for UNS N08020 Alloy Plate, Sheet, and Strip

B536 Specification for Nickel-Iron-Chromium-Silicon Alloys (UNS N08330 and N08332) Plate, Sheet, and Strip

B575 Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Tungsten, and Low-Carbon Nickel-Molybdenum-Chromium Alloy Plate, Sheet, and Strip

B582 Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip

B880 Specification for General Requirements for Chemical

[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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* New designation established in accordance with ASTM E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

[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.

TABLE 1 Recommended Heat Treatment

Alloy	UNS Designation	PWHT[A,B] Deg. F. (Deg. C)	Quench
200 (Ni)	N02200	1650-1700 (900 to 928)	Rapid Air/water
201 (Low C)	N02201	1650-1700 (900 to 928)	Rapid Air/water
400 (Ni-Cu)	N04400	1650-1700 (900 to 928)	Rapid Air/water
X (Ni-Cr-Mo-Fe)	N06002	2150 (1177)[C]	Rapid Air/water
C22[D] (Low C-Ni-Mo-Cr)	N06022	2050-(1120)[C]	Rapid Air/water
G30[D] (Ni-Cr-Fe-Mo-Cu)	N06030	2150 (1177)[C]	Rapid Air/water
C2000[D] (Ni-Cr-Mo-Cu)	N06200	2075-2125 (1135-1163)[B]	Rapid Air/water
230[D] (Ni-Cr-W-Mo)	N06230	2150-2250 (1177-1232)[B]	Rapid Air/water
600 (Ni-Cr-Fe)	N06600	1800-1850 (983 to 1010)	Rapid Air/water
601 (Ni-Cr-Fe-Al)	N06601	1600-1650 (874 to 900)[E]	Rapid Air/water
625 (Ni-Cr-Mo-Cb) Grade 1	N06625	1600 (871)[C]	Rapid Air/water
625 (Ni-Cr-Mo-Cb) Grade 2	N06625	2000 (1093)[C]	Rapid Air/water
G3[D] (Ni-Cr-Fe-Mo-Cu)	N06985	2100-2150 (1147 to 1177)[B]	Rapid Air/water
Alloy 20 (Cr-Ni-Fe-Mo-Cu-Cb)	N08020	1700-1850 (927 to 1010)	Rapid Air/water
...	N08024	1925-1975 (1052 to 1079)	Rapid Air/water
...	N08026	2050-2200 (1121 to 1204)	Rapid Air/water
825 (Ni-Fe-Cr-Mo-Cu)	N08825	1700-1800 (930 to 980)[E]	Rapid Air/water
C276 (Low C-Ni-Mo-Cr)	N10276	2050 (1121)[C]	Rapid Air/water
B2 (Ni-Mo)	N10665	1950 (1065)[C]	Rapid Air/water
B3[D] (Ni-Mo)	N10675	1950 (1065)[C]	Rapid Air/water

[A] Recommended temperatures—Different temperatures may be selected by either the purchaser or the manufacturer.
[B] Set temperatures, ±25°F (±14°C).
[C] Minimum set temperature.
[D] Registered Trademark of Haynes International.
[E] Heat treatment is highly dependent on intended service temperature — consult material manufacturer for specific heat treatments for end use temperature.

Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys
B899 Terminology Relating to Non-ferrous Metals and Alloys
E8 Test Methods for Tension Testing of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

2.2 *American Society of Mechanical Engineers Standard:*[3]
ASME Boiler and Pressure Vessel Code, Section IX and Section VIII, Div. 1

2.3 *American Welding Society Standards:*[4]
A5.4 Corrosion-Resisting Chromium and Chromium Nickel Steel Covered Welding Electrodes
A5.9 Corrosion-Resisting Chromium and Chromium Nickel Steel Welding Rods and Bare Electrodes
A5.11 Nickel and Nickel Alloy Covered Welded Electrodes
A5.14 Nickel and Nickel Alloy Bare Welding Rods and Electrodes

3. Terminology

3.1 Terms defined in Terminology B899 shall apply unless otherwise defined in this standard.

4. Ordering Information

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

4.1.1 Quantity (feet or number of lengths),
4.1.2 Name of material or UNS number (electric-fusion-welded pipe),
4.1.3 Alloy (Table 1),
4.1.4 Class (see 1.2),
4.1.5 Size (outside diameter and minimum wall thickness),
4.1.6 Length (specific or random),
4.1.7 ASTM designation and year of issue,
4.1.8 Authorization for repair of plate defects by welding without prior approval if such is intended (see 9.4),
4.1.9 Circumferential weld permissibility (see 8.3.2), and
4.1.10 Supplementary requirements.

5. Materials and Manufacture

5.1 *Materials*—The plate material shall conform to the requirements of the appropriate raw material specification listed in 2.1.

5.2 *Welding:*

5.2.1 The joints shall be full penetration double-welded or single-welded butt joints employing 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 employed (single or double) in making the weld. Where backing rings or strips are employed, 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 completely removed after welding, prior to any required radiography, and the exposed weld surface shall be examined visually for conformance to the requirements of 5.2.3. Welds made by procedures employing backing strips or rings which remain in place are prohibited. Welding procedures

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three 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.

and welding operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX.

5.2.2 Except as provided in 5.2.2.1 and 5.2.2.2, welds shall be made in their entirety by processes involving the deposition of filler metal.

5.2.2.1 For Class 4 pipe employing multiple passes, the root-pass may be completed without the addition of filler metal.

5.2.2.2 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.

5.2.2.3 All single-welded pipe shall be completely radiographed

5.2.3 The weld surface on either side of the weld shall be flush with the base plate or shall have a reasonably uniform crown, not to exceed ⅛ in. (3.2 mm). Any weld reinforcement may be removed at the manufacturer's option 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.

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

5.3 *Heat Treatment:*

5.3.1 The pipe furnished under this specification, shall be heat treated in accordance with Table 1. See Table 1 for recommended practice.

5.3.2 The purchase order shall specify one of the following conditions if the heat-treated condition specified by Table 1 is not desired by the purchaser.

5.3.2.1 *A final heat treatment other than that specified in* Table 1—Each pipe supplied under this requirement shall be stenciled with the final heat-treatment temperature in degrees Fahrenheit or degrees Celsius after the suffix "HT."

5.3.2.2 *No final heat-treatment of pipe fabricated of plate that has been heat treated at temperatures required by this specification*—Each pipe supplied under this requirement shall be stenciled with the suffix "HT-O."

5.3.2.3 *No final heat-treatment of pipe fabricated of plate that has not been heat treated at temperatures required by this specification*—Each pipe supplied under this requirement shall be stenciled with the suffix "HT-SO."

6. Chemical Composition

6.1 *Product Analysis of Plate*—The pipe manufacturer shall make an analysis of each mill heat of plate material. The product analysis so determined shall meet the requirements of the plate specification to which the material was ordered.

6.2 *Product Analysis of Weld*—The pipe manufacturer shall make an analysis of the finished deposited weld material from each lot of pipe. The chemical composition of the weld deposit shall fall within the chemical composition limits of the applicable AWS filler metal specification for the corresponding grade shown in Table 2 (or higher alloyed filler metal when approved by the purchaser) or shall conform to the chemical composition specified for the plate specification to which the material was ordered, or shall, subject to the 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 2 shall be reported and the filler metal identified on the pipe manufacturer's certificate of test. The composite analysis variations from Table 2 limits, that are caused by the dilution of the weld metal with the base metal, shall be agreed upon between purchaser and manufacturer.

6.3 A lot for product analysis shall consist of one heat.

7. Mechanical and Other Properties

7.1 *Mechanical Properties:*

7.1.1 The mechanical properties of the plate shall be in accordance with the plate specification to which it was ordered. Tension tests made by the plate manufacturer shall qualify the plate material.

7.1.2 Transverse tension tests taken across the welded joint shall have the same tensile property requirements as those specified for the plate.

7.1.3 A lot for mechanical testing shall consist of all material from the same heat (which may include more that one plate/slab/lot number), nominal size (excepting length) and heat treatment. When final heat treatment is in a batch-type furnace, a lot shall include only those pipes of the same size and the same heat (which may include more than one plate/slab/lot number) that are heat-treated in the same furnace charge. When heat treatment is in a continuous furnace, a lot shall include all pipe of the same size and heat (which may include more than one plate/slab/lot number), heat-treated in the same furnace at the same temperature, time at temperature, and furnace speed during one production run. At no time shall a lot consist of more than 20 000 lb (9070 kg).

7.1.4 Samples of the material to provide test specimens for mechanical and other properties shall be taken from such locations in each lot as to be representative of that lot. Test specimens shall be taken from material in the final condition. It is permissible for the test specimens to be taken from a test plate of the same material as the pipe, the test plate being attached to the end of the cylinder and welded as a prolongation of the pipe longitudinal weld seam, including any/all post weld heat treatments.

7.2 *Transverse Guided Weld Bend Test Requirements:*

7.2.1 Two bend test specimens shall be taken transversely from the weld area of the pipe or test plate. Except as provided in 7.2.2, 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.

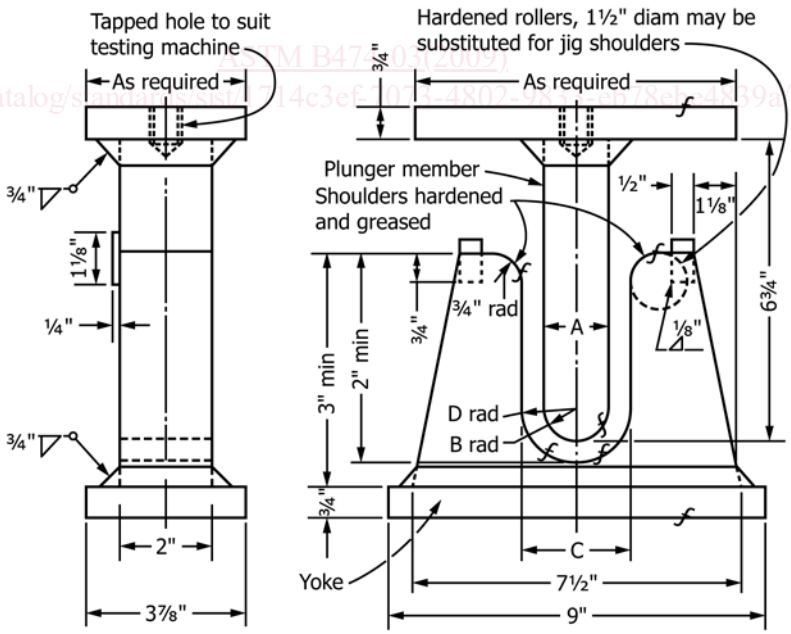
7.2.2 For wall thicknesses over ⅜ in. (9.5mm) but less than ¾ in. (19 mm) side-bend tests may be made instead of the face and root-bend tests. For specified wall thicknesses ¾ in. (19 mm) and over, both specimens shall be subjected to the side-bend test. Side-bend specimens shall be bent so that one of the side surfaces becomes the convex surface of the bend specimen.

TABLE 2 Pipe and Weld Filler Materials

Alloy	UNS Designation	ASTM Plate Specification	Filler Metal Clsssification and UNS Designation[A] for Applicable AWS Specification					
			A5.11		A5.9		A5.14	
			Class	UNS	Class	UNS	Class	UNS
200	N02200	B162	ENi-1	W82141	...	...	ERNi-1	N02061
201	N02201	B162	...	...	...	...	...	...
400	N04400	B127	ENiCu-7	W84190	...	...	ERNiCu-7	N04060
X	N06002	B435	ENiCrMo-2	W86002	...	...	ERNiCrMo-2	N06002
C22[B]	N06022	B575	ENiCrMo-10	W86022	...	...	ERNiCrMo-10	N06022
C2000[B]	N06200	B575	ENiCrMo-17[C]	W86200[C]	...	...	ERNiCrMo-17[C]	N06200[C]
C30[B]	N06030	B582	ENiCrMo-11	W86030	...	...	ERNiCrMo-11	N06030
230[B]	N06230	B435	ENiCrWMo-1[C]	W86231[C]	...	...	ERNiCrWMo-1	N06231
600	N06600	B168	N/A[D]	...	...	...	ERNiCr-3	N06082
601	N06601	B168	[E]	...	...	...	[E]	
625	N06625	B443	ENiCrMo-3	W86112	...	...	ERNiCrMo-3	N06625
G3	N06985	B582	ENiCrMo-9	W86985	...	...	ERNiCrMo-9	N06985
20CB	N08020	B463	...	...	ER320	N08021	...	...
...	...	...	...	...	ER320LR	N08022	...	...
Cr-Ni-Fe-Mo-Cu	N08024	B463	N/A[D]	...	...	...	...	...
20Mo6[F]	N08026	B463	ENiCrMo-3	W86112	...	...	ERNiCrMo-3	N06625
825	N08825	B424	ENiCrMo-3[G]	W86112	...	...	ERNiCrMo-3[G]	N06625
C276	N10276	B575	ENiCrMo-4	W80276	...	...	ERNiCrMo-4	N10276
B2	N10665	B333	ENiMo-7	W80665	...	...	ERNiMo-7	N10665
B3[B]	N10675	B333	ENiMo-10	W80875	...	...	ERNiMo-10	N10675

[A] New designation established in accordance with ASTM E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).
[B] Registered Trademark of Haynes International.
[C] Approved by AWS but not published.
[D] No AWS classification existed at the time of this writing—consult material manufacturer for recommended filler metal.
[E] Filler metal used is highly dependent on intended service temperature—consult material manufacturer for specific filler metal for end use temperature.
[F] Registered Trademark of Carpenter Steel.
[G] Recommended filler metal—this material is highly dependent on intended service temperature for best filler metal selection—consult material manufacturer for specific filler metal given the end use temperature.

7.2.3 Bends made in accordance with Fig. 1 shall be acceptable if no cracks or other imperfections exceeding ⅛ in.



NOTE 1—1 in. = 25.4 mm.

Test Specimen Thickness, in.	A	B	C	D
⅜	1½	¾	2⅜	1 3/16
t	4*t*	2*t*	6*t* + ⅛	3*t* + 1/16

FIG. 1 Guided-Bend Test Jig