Designation: B924 – 02 (Reapproved 2017)

Standard Specification for Seamless and Welded Nickel Alloy Condenser and Heat Exchanger Tubes With Integral Fins[1]

This standard is issued under the fixed designation B924; 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[2] describes seamless and welded nickel alloy tubing on which the external or internal surface, or both, has been modified by a cold forming process to produce an integral enhanced surface, for improved heat transfer. The tubes are used in surface condensers, evaporators, heat exchangers and similar heat transfer apparatus in unfinned end diameters up to and including 1 in. (25.4 mm).

1.2 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.

1.3 The following precautionary statement pertains to the test method portion only: Section 10 of this specification. *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 Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory requirements prior to use.*

1.4 *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:*[3]

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

B163 Specification for Seamless Nickel and Nickel Alloy Condenser and Heat-Exchanger Tubes

B167 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) Seamless Pipe and Tube

B407 Specification for Nickel-Iron-Chromium Alloy Seamless Pipe and Tube

B423 Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825, N08221, and N06845) Seamless Pipe and Tube

B444 Specification for Nickel-Chromium-Molybdenum-Columbium Alloys (UNS N06625 and UNS N06852) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Pipe and Tube

B468 Specification for Welded UNS N08020 Alloy Tubes

B515 Specification for Welded UNS N08120, UNS N08800, UNS N08810, and UNS N08811 Alloy Tubes

B516 Specification for Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06601, UNS N06603, UNS N06025, UNS N06045, UNS N06690, and UNS N06693) Tubes

B622 Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube

B626 Specification for Welded Nickel and Nickel-Cobalt Alloy Tube

B674 Specification for UNS N08925, UNS N08354, and UNS N08926 Welded Tube

B676 Specification for UNS N08367 Welded Tube

B677 Specification for UNS N08925, UNS N08354, and UNS N08926 Seamless Pipe and Tube

B690 Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Seamless Pipe and Tube

B704 Specification for Welded UNS N06625, UNS N06219 and UNS N08825 Alloy Tubes

B729 Specification for Seamless UNS N08020, UNS N08026, and UNS N08024 Nickel-Alloy Pipe and Tube

[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 ASME Boiler and Pressure Vessel Code applications, see related Specification SB-924 in Section II of that Code.

[3] 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.

B751 Specification for General Requirements for Nickel and Nickel Alloy Welded Tube
B829 Specification for General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube
B899 Terminology Relating to Non-ferrous Metals and Alloys
E426 Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys
E571 Practice for Electromagnetic (Eddy-Current) Examination of Nickel and Nickel Alloy Tubular Products

3. Terminology

3.1 For definition of general terms used in this specification, refer to Terminologies A941 and B899.

3.2 *Definitions of Terms Specific to this Document (Integral Fin Tube Nomenclature):*

D = outside diameter of unenhanced section
D_i = inside diameter of unenhanced section
d_r = root diameter of enhanced section outside of tube
d_o = outside diameter of enhanced section
d_i = inside diameter of enhanced section
W = wall thickness of unenhanced section
W_f = wall thickness of enhanced section
F_h = height of fin—enhanced section outside of tube
F_m = mean fin thickness—enhanced section outside of tube
P = mean rib pitch—enhanced section inside of tube
R_h = height of rib—enhanced section inside of tube
H_a = rib helix angle—enhanced section inside of tube
T_t = transition taper

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. Such requirements may include, but are not limited to, the following:

4.1.1 ASTM designation and year of issue (this specification),

4.1.2 ASTM designation and year of issue (plain tube specification),

4.1.3 Welded or seamless,

4.1.4 Alloy grade and UNS designation,

4.1.5 Dimensions; plain tube outside diameter, plain tube wall thickness (ave. or min. specified), length and location of unenhanced surfaces and the total tube length. Configuration of enhanced surfaces (fins per unit length, fin height, wall thickness under fin, rib pitch, rib height, etc.) shall be as agreed upon between the manufacturer and purchaser. (Refer to Figs. 1 and 2).

4.1.6 Temper (as-finned or stress relief annealed),

4.1.7 Quantity,

4.1.8 Packaging,

4.1.9 Nondestructive tests,

4.1.10 Customer inspection,

4.1.11 Mill test report, and

4.1.12 Certification.

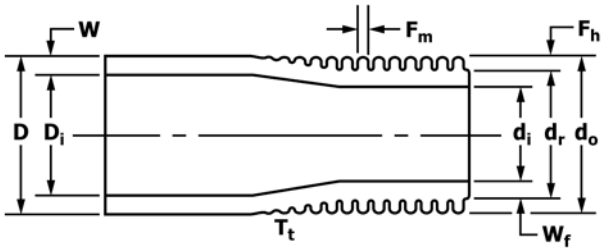

FIG. 1 Outside Enhancement Only

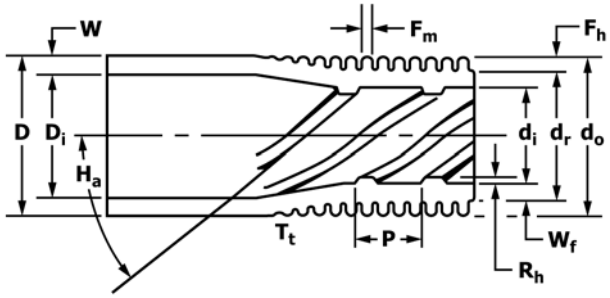

FIG. 2 Outside and Inside Enhancement

5. General Requirements

5.1 Seamless material furnished under this specification shall conform to the requirements of Specification B829, unless otherwise provided herein.

5.2 Welded material furnished under this specification shall conform to the applicable requirements of Specification B751, unless otherwise provided herein.

5.3 Enhanced (integrally finned) sections of the tube shall be produced by cold forming the tubing in such a manner that exterior fins, wall under the fin and inside ribs (when specified) are homogeneous.

5.4 Tubes described by this specification shall be furnished with unenhanced (plain) ends.

5.5 Enhanced sections of the tube are normally supplied in the "as finned" temper (cold worked condition produced by the enhancing operation). The unenhanced sections of the tube shall be in the annealed condition and shall be suitable for rolling-in operations.

6. Materials and Manufacture

6.1 The integrally enhanced (finned) tubes shall be manufactured from seamless, welded, or welded/cold worked plain tubes that conform to one of the following ASTM specifications: B163, B167, B407, B423, B444, B468, B515, B516, B622, B626, B674, B676, B677, B690, B704, and B729.

7. Temper

7.1 The tube after enhancing shall normally be supplied in the as-finned temper. When specified by the purchaser, for bending, coiling or other fabricating operations, enhanced portions of the tube may be stress relief annealed or solution annealed.

7.2 Heat treatment of enhanced sections and bend areas, or both, shall be in accordance with the governing plain tube specification.

8. Chemical Composition

8.1 The tubing specified shall conform to the chemical requirements prescribed in the governing plain tube specification.

9. Tensile Requirements

9.1 The tube prior to the finning operation, and unenhanced portions of the finned tube, shall conform to the requirements for tensile properties prescribed in the governing plain tube specification.

10. Test Requirements

10.1 After enhancing operations, subject each tube to a nondestructive electromagnetic test, and either a pneumatic or hydrostatic test as specified in the purchase order. Tubes shall normally be tested in the as-fabricated condition but, at the option of the manufacturer or purchaser, may be tested in the stress relief annealed condition.

10.1.1 *Eddy Current Test*—Eddy current inspect the tube in accordance with Practice E426 or E571, by passing it through an encircling coil designed to test the entire cross section of the tube.

10.1.1.1 The reference standard used to adjust the sensitivity setting of the apparatus shall be sound and of the same nominal alloy, enhanced configuration, condition (temper) and nominal dimensions as the lot of tubes to be tested on a production basis. Drill four (4) holes not larger than 0.031 in. (0.787 mm) in diameter radially through the enhanced wall in each of four successive planes at 0°, 90°, 180° and 270°. Use a suitable drill jig to guide the drill, taking care to avoid distortion of the adjacent fins. Locate one (1) hole in the weld for welded material. Space artificial discontinuities at least 16 in. (406 mm) apart to provide signal resolution adequate for interpretation. Discard and replace the reference standard when erroneous signals are produced from mechanical, metallurgical or other damage to the tube.

10.1.1.2 Adjust the eddy current test unit to obtain an optimum signal-to-noise ratio with the minimum sensitivity required to detect all four artificial defects in the reference standard on a repeatable basis. Equipment adjustments and tube speed maintained during calibration shall be the same for production tubes.

10.1.1.3 Set aside tubes showing an eddy current indication in excess of any signal obtained from artificial defects in the reference standard and subject them to retest or rejection.

10.1.1.4 Tubes causing irrelevant signals because of debris and like effects shall be considered to conform, should they not cause output signals beyond acceptable limits when retested. Tubes causing irrelevant signals because of visible and identifiable handling marks (rough fin tip, notches in the fin) shall be considered to conform, provided the wall thickness in the enhanced and unenhanced areas is not less than the minimum specified.

10.1.1.5 Tubes causing relevant signals because of injurious defects (incomplete welds, splits, embedded debris, broken tool impressions, ID defects) that reduce the wall thickness below the minimum specified shall be rejected. If, after retest and examination, no source for the reject signal can be discerned, the tube shall be rejected.

10.1.2 *Pneumatic Test*—When examined with this method, each tube shall withstand a minimum internal air pressure of 250 psi (1.72 MPa), for a minimum of 5 s, without showing evidence of leakage. The test method used shall permit easy detection of any leakage either by placing the tube under water or by using the pressure differential method as follows:

10.1.2.1 *Air Underwater Pressure Test*—Each tube shall be tested in accordance with Specification B751 except using test pressure specified in 10.1.2.

10.1.2.2 *Pressure Differential Test*—Procedure and acceptance criteria shall be agreed upon between the manufacturer and purchaser.

10.1.3 *Hydrostatic Test*—When examined with this method, each tube shall be tested to an internal hydrostatic test pressure of 1000 psi (6.9 MPa) provided that the fiber stress, calculated in accordance with the following equation, does not exceed the allowable fiber stress, S, indicated as follows:

$$P = 2S\,W_f/d_r \quad (1)$$

where:

P = hydrostatic test pressure, psi (MPa),
S = allowable fiber stress, for material in the condition (temper) furnished as specified in the product specification (S is calculated as the lower of ⅔ of the specified minimum 0.2 % offset yield strength or ¼ of the specified minimum ultimate strength for the material),
W_f = minimum wall thickness under fin permitted, in. (mm), including minus tolerance, if any, and
d_r = nominal fin root diameter of the tube, in. (mm).

10.1.3.1 Testing at a pressure greater than 1000 psi (6.9 MPa) can be done as agreed upon by the purchaser and manufacturer provided that the allowable fiber stress is not exceeded.

10.1.3.2 The test pressure must be held for a minimum of 5 s.

10.1.3.3 Any tube that leaks during hydrostatic testing shall be rejected.

10.1.3.4 The hydrostatic test may be performed before the tube is cut to final length, but must be performed after enhancing, bending, heat treatment or other forming operations.

11. Permissible Variations in Dimensions

11.1 *Diameter*—The outside diameter of the unenhanced sections shall not exceed the diameter tolerances shown in the governing plain tube specification as measured by micrometers and verified by “go” and “no go” ring gages. The diameter over the enhanced sections shall not exceed the diameter of the plain sections involved, as determined by a “go” ring gage unless otherwise specified. The dimensions of the ring gages shall be as described in 11.1.1 and 11.1.2.

11.1.1 The inside diameter dimension of the “go” ring gage shall be equal to the nominal tube diameter, plus the maximum

tolerance, plus 0.002 in. The length of the "go" ring gage shall be 1 in. (25.4 mm) minimum.

11.1.2 The inside diameter dimension of the "no go" ring gage shall be equal to the nominal tube diameter minus the maximum tolerance. The length of the "no go" ring gage shall be 1 in. (25.4 mm) minimum.

11.2 *Wall Thickness*—The wall thickness of enhanced and unenhanced sections shall not exceed the thickness tolerances shown in the governing plain tube specification unless otherwise agreed to between the manufacturer and purchaser. No tube at any point shall be less than the minimum thickness specified in the plain sections or in the enhanced sections.

11.3 *Length*—The length of the tubes shall not be less than that specified, but may exceed the specified value by the amounts given in Table 1.

11.3.1 The length of plain ends, as measured from the tube end to the first tool impression, shall not be less than that specified, but may exceed the specified value by ½ in. (12.7 mm).

11.3.2 The length of fin sections and lands (unenhanced portions) shall be as specified ±¼ in. (6.35 mm).

11.4 *Squareness of Cut*—The angle of cut of the end of any tube may depart from square by not more than 0.016 in.

11.5 *Straightness*—The tube shall be reasonably straight and free of bends or kinks.

12. Workmanship, Finish, and Appearance

12.1 Finished tubes shall be clean and free of foreign material, shall have smooth ends free of burrs, and shall be free of injurious external and internal imperfections. Minor defects may be removed, provided the dimensional tolerances of Section 11 are not exceeded.

12.2 A slight amount of oxidation on the surface resulting from heat treatment after enhancing or bending is acceptable. When the plain tube specification allows for a slight amount of oxidation on the surface resulting from heat treatment, this is also acceptable.

13. Inspection

13.1 The manufacturer shall inspect and make the necessary tests to verify that the enhanced tubes furnished conform to the requirements of the customer purchase order and to the requirements of this specification.

13.2 Witnessing of testing or inspection by the purchaser's representative shall be agreed upon by the purchaser and the manufacturer as part of the purchase contract.

14. Certified Test Report

14.1 The manufacturer shall furnish to the purchaser a Certified Test Report in accordance with requirements in Specification B829 for seamless material, or Specification B751 for welded material.

TABLE 1 Length Tolerances

Specified Length, ft (m)	Tolerance, in (mm)
Up to 24 (7.3), incl	±⅛ (3.2)
Over 24 to 34 (7.3 to 10.4), incl	±¼ (6.4)
Over 34 to 44 (10.4 to 13.4) incl	±⅜ (9.5)
Over 44 (13.4)	±½ (12.7) max.

14.2 In addition, the Certified Test Report shall include the following information and test results, as modified, when applicable:

14.2.1 *Plain Tube:*

14.2.1.1 ASTM material designation,

14.2.1.2 Welded or seamless,

14.2.1.3 Alloy grade and UNS designation,

14.2.1.4 Tube dimensions (outside diameter and wall thickness),

14.2.1.5 Heat number,

14.2.1.6 Heat analysis,

14.2.1.7 Product analysis, when specified,

14.2.1.8 Tensile properties,

14.2.1.9 Flattening test acceptable,

14.2.1.10 Reverse flattening test acceptable,

14.2.1.11 Flaring test acceptable,

14.2.1.12 Flange test acceptable,

14.2.1.13 Hardness test values,

14.2.1.14 Hydrostatic or pneumatic test, test pressure and test results,

14.2.1.15 Non-destructive electric test method and test results,

14.2.1.16 Impact test results,

14.2.1.17 Other test results or information required to be reported by the governing bare tube specification, and

14.2.1.18 Test results or information required to be reported by supplementary requirements, or other requirements designated in the purchase order shall be reported, but may be reported in a separate document.

14.2.2 *Enhanced Tube:*

14.2.2.1 ASTM material designation,

14.2.2.2 Manufacturer name and order number,

14.2.2.3 Customer name and purchase order number,

14.2.2.4 Product description or part number,

14.2.2.5 Quantity,

14.2.2.6 Eddy current test results,

14.2.2.7 Pneumatic test, test pressure and test results, when specified,

14.2.2.8 Hydrostatic test, test pressure and test results, when specified,

14.2.2.9 Stress relief annealed, when specified, and

14.2.2.10 Results of any other checks or testing required by the customer purchase order.

15. Rejection

15.1 Provisions for rejection shall be in accordance with requirements in Specification B829 for seamless material, or Specification B751 for welded material.

16. Packaging and Package Marking

16.1 The tube shall be packaged in accordance with the manufacturer's standard practice, unless otherwise agreed upon between the manufacturer and the purchaser and so stated in the purchase order.

16.2 Each shipping unit shall be legibly marked with the name of the supplier, name of the customer, ship to address,

purchase order number, alloy designation, size or part number, tube length and number of pieces.

17. Keywords

17.1 condenser tube; enhanced tube; heat exchanger tube; integral fin tube; nickel alloys; seamless tube; welded tube