Designation: B891 – 98 (Reapproved 2004)

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

This standard is issued under the fixed designation B891; 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] covers seamless and welded titanium and titanium 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 the standard. The values given in parentheses are for information only.

1.3 The following precautionary statement pertains to the test method portion only: Section 9 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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

B338 Specification for Seamless and Welded Titanium and Titanium Alloy Tubes for Condensers and Heat Exchangers

E426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

E1316 Terminology for Nondestructive Examinations

3. Ordering Information

3.1 Purchase orders for tubes described in this specification should include the following, to describe the tubes adequately.

3.1.1 ASTM designation and year of issue

3.1.2 Welded or Seamless

3.1.3 Grade number

3.1.4 Dimensions; diameter, 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, etc.) shall be as agreed upon between the manufacturer and purchaser. (Refer to Figs. 1 and 2)

3.1.5 Quantity

3.1.6 Packaging

3.1.7 Nondestructive tests

3.1.8 Mill test report

3.1.9 Certification

4. General Requirements

4.1 Tubes described by this specification shall be furnished with unenhanced ends.

4.2 Enhanced sections of the tube are normally supplied in the "as-finned" condition (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.

5. Materials and Manufacture

5.1 The integrally enhanced (*finned*) tubes shall be manufactured from seamless, welded, or welded/cold worked (WCW) plain tubes that conform to all requirements as specified in Specification B338.

5.2 Enhanced areas shall be produced by cold forming.

6. Condition

6.1 The tube after enhancing shall normally be supplied in the "as-finned" condition. When specified by the purchaser, for coiling or other fabricating operations, the tube may be annealed after enhancing.

[1] This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.01 on Titanium.

Current edition approved May 1, 2004. Published May 2004. Originally approved in 1998. Last previous edition approved in 1998 as B891 – 98ε1. DOI: 10.1520/B0891-98R04.

[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-_____ 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.

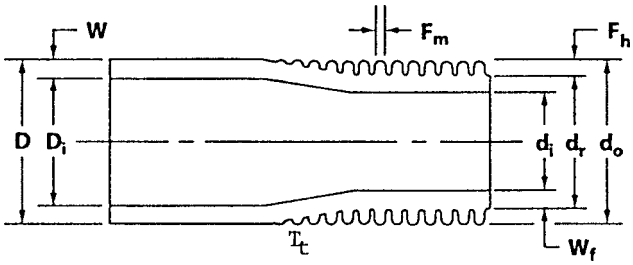

FIG. 1 Outside Enhancement Only

7. Chemical Composition

7.1 The grade titanium or titanium alloy specified shall conform to the chemical requirements prescribed in Specification B338.

8. Tensile Requirements

8.1 The tube prior to the finning operation, or unenhanced portions of the finned tube, shall conform to the grade requirements for tensile properties prescribed in Specification B338

9. Nondestructive Tests

9.1 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 annealed condition.

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

9.1.1.1 The reference standard used to adjust the sensitivity setting of the apparatus shall be sound and of the same nominal alloy, enhanced configuration, condition and nominal dimensions as the lot of tubes to be tested on a production basis. Drill four 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 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 the reference standard and replace when erroneous signals are produced from mechanical, metallurgical or other damage to the tube.

9.1.1.2 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.

9.1.1.3 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.

9.1.1.4 Tubes causing irrelevant signals because of moisture, 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 shall be considered to conform, provided the wall thickness in the enhanced and unenhanced areas is not less than the minimum specified.

9.1.1.5 Tubes causing relevant signals because of injurious 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.

9.1.2 *Pneumatic Test*—Each tube so tested 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 by placing the tube underwater or by using the pressure differential method. Any evidence of leakage shall be cause for rejection of that tube.

9.1.3 *Hydrostatic Test*—Each tube so tested shall withstand, without showing bulges, leaks or other defects, an internal hydrostatic pressure that will produce in the tube wall a stress of 50 % of the minimum specified yield strength at room temperature. This pressure shall be determined by the equation:

$$P = SEW_f/(d_r/2 - 0.4W_f) \quad (1)$$

where:

P = minimum hydrostatic test pressure, psi (or MPa),
S = one half the minimum yield strength, psi (or MPa),
W_f = wall under fin thickness, in. (or mm),
d_r = fin root diameter, in. (or mm),
E = 0.85 welded tube, and
E = 1.0 seamless and welded/cold worked tube.

9.1.3.1 The maximum hydrostatic test pressure shall not exceed 2500 psi (17.2 MPa) for sizes 1 in. (25.4 mm) and under. Hydrostatic pressure shall be maintained for not less than 5 s. When requested by the purchaser and so stated in the order, tubes shall be tested to one and one half times the specified working pressure, provided the fiber stress corresponding to those test pressures does not exceed one half the minimum specified yield strength of the material as determined by the equation given in 9.1.3. When one and one half times the working pressure exceeds 2500 psi (17.2 MPa), the hydrostatic test pressure shall be a matter of agreement between the manufacturer and purchaser.

10. Permissible Variations in Dimensions

10.1 *Diameter*—The outside diameter of the unenhanced sections shall not vary by more than the amount in Table 1, as measured 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 10.1.1 and 10.1.2.

10.1.1 The inside diameter dimension of the "go" ring gage shall be equal to the nominal tube diameter, plus the plus tolerance, plus 0.002 in (0.051 mm). The length of the "go" ring gage shall be 1 in. (25.4 mm) minimum.

10.1.2 The inside diameter dimension of the "no go" ring gage shall be equal to the nominal tube diameter minus the