

FINTUBE, LLC

Standard Specification for High Frequency Electric Resistance Welded Finned Tubes (Effective May 2002)

1. Scope

1.1 This Specification covers the external attachment of fins to tubes or pipes, for extended heat transfer surface, using the high frequency electric resistance welding process, for use in boilers, economizers, fired heaters and other heat transfer equipment.

1.2 Tube and fin materials may be carbon, ferritic alloy or austenitic alloy steel and need not be matching materials.

1.3 This specification covers dimensions, tolerances and tests of high frequency electric resistance welded finned tubes.

1.4 This specification and the applicable material specifications are expressed in both inch-pound and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished in inch-pound units.

1.5 The values stated in inch-pound units or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other.

2. Referenced Documents

2.1 ASTM Standards:

- A 109/A 109M Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold Rolled
- A 240 Specification for Heat-resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip, for Pressure Vessels
- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A 622/A 622M Standard Specification for Drawing Steel (DS), Sheet and Strip, Carbon, Hot-Rolled
- A 1008/A 1008M Specification for steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability (Replacing A 366)
- A 1011/A 1011M Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High Strength Low-Alloy with Improved Formability (Replacing A 569)
- ASME Boiler & Pressure Vessel Code, Section VIII, Division I
- ASME Boiler & Pressure Vessel Code, Section I, Power Boilers

3. Terminology

3.1 For definitions of terms, refer to ASTM A 941, Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys.

3.2 Where the term "tube" is used, material normally designated as "pipe" is also included.

3.3 Fins are a steel attachment, with a large height to thickness ratio, welded to the tube for extended heat transfer surface. Fins are called cross, spiral, and helical, referring to their orientation with the tube.

3.4 A fin wrap is one 360-degree spiral of fin material.

4. Ordering Information

4.1 The purchaser is responsible for specifying all information necessary for ordering the required materials. Information for ordering tube and fin material shall include:

4.2 Tube Information List:

- 4.2.1 Quantity
- 4.2.2 Tube specification, grade or type
- 4.2.3 OD and wall thickness
- 4.2.4 Length after finning
- 4.2.5 End finish
- 4.2.6 Other special requirements for tubes
- 4.2.7 Supplementary Requirements

4.3 Fin Information List:

- 4.3.1 Fin type (solid or serrated)
- 4.3.2 Segment width (for serrated)
- 4.3.3 Fin height
- 4.3.4 Fin thickness
- 4.3.5 Fin pitch (number of fins per foot, or per inch)
- 4.3.6 Length and location of finned sections.
- 4.3.7 Fin material type (or chemical composition)
- 4.3.8 Other special requirements for fin material
- 4.3.9 Supplementary Requirements.

5. Manufacture

5.1 The attachment of the fin to the tube shall be by the high frequency electric resistance welding process (250 kHz minimum).

5.2 The fin is considered to be a nonpressure-bearing attachment with essentially no load-carrying function, joined to a pressure part by an automatic, machine welding process with no addition of filler metal.

5.3 The high frequency electric resistance fin welding process does not change the tube wall or OD beyond the tube specification acceptable limits, and

adds only the weight of the fin material to the finned tube.

6. Chemical Composition

6.1 The chemical composition of the tube material, as shown on the mill test report, shall conform to the requirements for the grade or type specified.

6.2 The chemical composition of fin material shall conform to the following requirements:

6.2.1 Carbon steel fins: ASTM A 1008 / A 1008M, or A 366/A 366M

6.2.2 Ferritic alloy steel fins: ASTM A 240

6.2.3 Austenitic alloy steel fins: ASTM A 240

7. Dimensions, Tolerances and Requirements, Bare Tubes

7.1 Tube Outside Surface:

7.1.1 Must have an average surface roughness not exceeding 500 μ in. (12.5 μ m).

7.1.2 Protective coating, if used, must not exceed 0.008 in. (0.20mm).

7.1.3 Scale or rust must not infringe into specified minimum tube wall.

7.1.4 To be suitable for finning, the tube surface must be free from pits, dents, laminations, gouges or other surface defects exceeding 0.01 in. (0.3 mm) in depth which limit the contact of the fin edge with the tube.

7.2 Tube Dimensions, Tolerances

7.2.1 Wall Thickness: The measured tube wall thickness shall be more than 3% of the outside tube diameter.

7.2.2 Outside Diameter: The maximum and minimum diameters at any cross section shall not deviate from the nominal diameter by more than ± 0.020 in. ($\pm .5$ mm) or the applicable tube specification tolerance, whichever is less.

7.2.3 Straightness: Tubes shall be straight with a maximum deviation of 0.1 in. (2.5mm) in any 10 ft. (3m) section.

8. Dimensions, Tolerances and Requirements, Fins

8.1 Fin Tolerances:

8.1.1 Thickness: Fin thickness after being welded to the tube shall be as specified within the tolerance shown in Table 1. Solid fin thickness shall be measured at a point 0.6 of the specified fin height from the outer edge of the fin. Serrated fin thickness shall be measured halfway between the base of the fin and the lowest point of the serration.

TABLE 1 Fin Thickness Tolerance, in. (mm)

Specified Thickness	Tolerance (+ or -)
0.024-0.031 (0.61-0.81)	0.003 (0.07)
0.032-0.039 (0.81-1.00)	0.004 (0.10)
0.040-0.063 (1.01-1.60)	0.005 (0.13)

0.064-0.079 (0.61-2.00)	0.006 (0.15)
0.080-0.098 (2.01-2.50)	0.007 (0.17)
0.099-0.138 (2.51-3.50)	0.008 (0.20)

8.1.2 Fin Height: Fin Height after welding, measured perpendicular to the tube surface, shall be as specified ± 0.03 in. (0.8 mm) for fin heights 0.79 in. (20 mm) and under and ± 0.04 in. (1.0 mm) for fin heights over 0.79 in. (20 mm). (Ref. Fig. 1)

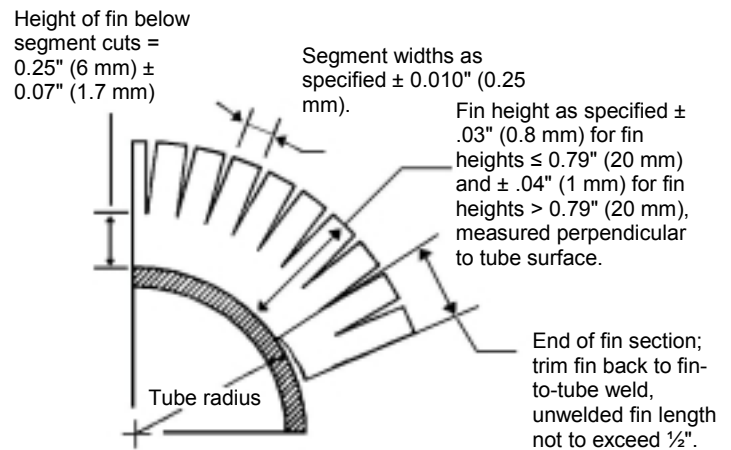


Figure 1 FIN DETAIL

8.1.3 Fin Spacing: The number of fins per unit length of tube shall be as specified, ± 2 percent, measured over at least 12 inches of welded fins. (Ref. Fig. 2)

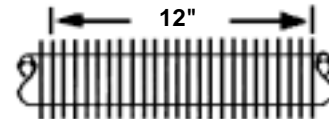


Figure 2 SPACING FIN PITCH

8.1.4 Inclination: The fin shall be welded 90 degrees to the tube surface. Inclination of the fin shall not exceed 5 degrees from the vertical for fin heights 0.79 in (20 mm) and under and 10 degrees from the vertical for fin heights over 0.79 in. (20 mm). (Ref. Fig. 3)

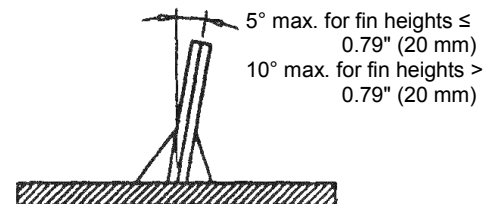


Figure 3 FIN INCLINATION

8.1.5 Corrugation: The total width of corrugation at the fin base, excluding any weld expulsion, shall

not exceed three times the specified fin thickness (see Fig. 4) measured at a point 0.06" above the tube surface.

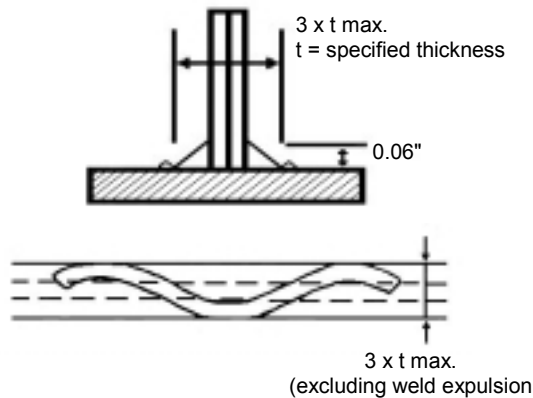


Figure 4 FIN CORRUGATION

8.1.6 Tears: Occasional tears in the outer edge of solid fins may occur during wrapping but shall not require repair as long as the number of wraps showing tears is less than 10 percent of the total wraps on any one tube.

8.1.7 Standard segment geometry: (For serrated fins)

Standard segment widths are 0.156 in. (4.0 mm), 0.172 in. (4.5 mm), and 0.313 in. (8.0 mm). The segment width shall be as specified, ± 0.010 in. (0.25 mm), excluding any burrs. (Ref. Fig. 1)

The cuts shall extend to a point 0.25 in. (6 mm) \pm 0.07 in. (1.7mm), above the tube surface, or as otherwise agreed upon.

Degree of twist of individual segments shall be limited so that the apparent thickness of the fin strip is no greater than 1.75 times the specified thickness (Fig. 5).

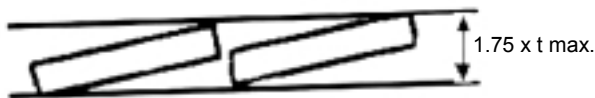


Figure 5 SERRATED FIN APPARENT THICKNESS

8.2 Finned Tube Tolerances:

8.2.1 Straightness: Finished finned tubes shall be straight with a maximum deviation of 0.2 in. (5 mm) in any 10 ft. (3.0 m) section of tube as shown in Figure 6 (Straightness). For tubes shorter than 10 ft. (3.0 m), the tolerance shall be reduced proportionate to the length.

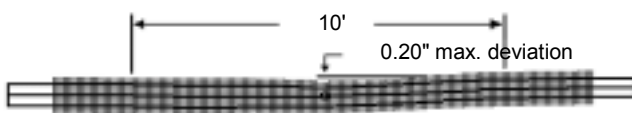


Figure 6 FINTUBE STRAIGHTNESS

8.2.2 Bare Sections: The location of each end of each finned section on a tube as measured from the starting end of the tube shall be as specified, ± 0.25 in. (6 mm) or one fin spacing whichever is greater.

8.2.3 Length: Finished finned tubes shall have a length tolerance as specified in the applicable bare tube specification.

8.2.4 Tube Ends: After finning, tube end dimensions (including ovality) shall be in accordance with the base tube specification.

9. Fin-to-Tube Weld Requirements:

9.1 Weld Width: The average width of the weld bond between the fin and the tube shall be a minimum of 90 percent.

9.2 Interruptions in welding are permissible provided they do not exceed 2.5 percent of the finned length on any one tube, and provided they do not exceed five consecutive fin wraps and do not occur within 6 in. (150 mm) of another interruption or the end of a finned section.

9.3 Unwelded lengths at the end of fin sections shall be trimmed back to the fin-to-tube weld. Unwelded fin length not to exceed 1/2". (Ref. Fig. 1)

9.4 The Heat Affected Zone in the tube wall and fin adjacent to the fin-to-tube weld is of very low penetration and results in only superficial changes in the tube and fin material properties. Tubes will be supplied in the as-welded condition.

10. Inspection and Tests:

10.1 Weld Bond: During production, the weld bond on every fifth tube will be tested by removing one wrap of fin from the trailing end of the tube. The fractured surface of the fin-to-tube weld shall be visually inspected, and the arithmetic average width of the weld bond as evidenced by the white metal exposed shall be no less than 90 percent of the measured fin thickness. If the arithmetic average width of weld bond is less than 90 percent, the weld bond of the previously finned tube will be checked, (back to the previously inspected 5th tube, if necessary), until weld bond that averages 90 percent is found. In the event of disagreement on the visual inspection, a tensile test of the fin-to-tube weld on a representative sample yielding the minimum average values (shown in Supplementary Requirements), based on the measured fin thickness, shall be considered evidence of an acceptable weld.

10.2 Inspections of tube and fin dimensions shall be performed on the first piece and at the following intervals:

Overall Tube Length	every 2 nd hour
Fin Thickness	2 nd hour then every 4 th hour
Fin Height	every 2 nd hour
Fin Pitch	every 2 nd hour

Bare "A" End	every 2 nd hour
Bare "C" End	every 2 nd hour
Fin Length	every 2 nd hour
Fin Inclination	2 nd hour then every 4 th hour
Weld Bond	every 5 th tube
Degree of Twist first piece only	
Fin Corrugation	every 2 nd hour (solid fin only)
Serr/Uncut Base	after serrated cutter change
Serr/Width	after serrated cutter change

10.3 Fin and tube materials will usually show some discoloration due to oxidation or bluing near the weld and occasionally over the whole surface. Finned tubes may also develop light surface rust before receipt by the purchaser. Neither of these conditions is considered cause for rejection.

10.4 Inspection for fin damage after finning:

Fin damage due to material handling shall not exceed 2% of total peripheral area. Individual fin damage areas shall not exceed 6 in.² (0.03 m²). Fin damage is defined as fins bent or crushed to the extent they are in contact with adjacent fins. Peripheral Area (in.²)= Fin OD (in.) x Finned Length (ft) x 3.14 x 12 (in./ft).

11. Product Marking:

11.1 Weather resistant labels shall be applied to each finned tube, and will contain the following information:

Job Number, Customer Name, Customer Purchase Order Number, Finning Division Item Number, Customer Mark Number, Finning Division

Name, and Heat Code (for traceability to heat number).

11.2 Labels may also include other special information as requested by customer.

12 Product Packaging:

12.1 Standard manufacturer's bundling shall be provided unless specified otherwise by customer. Standard bundling includes wooden saddle supports secured by steel banding, spaced at no more than 10-foot length intervals. Completed bundles will weigh a maximum of 12,000 pounds. The completed tube bundles will have no fin to fin engagement. Individual tube ends shall be capped, unless otherwise agreed upon.

13. Certificate of Compliance and Test Reporting:

13.1 When specified in the purchase order, a manufacturer's certificate shall be furnished to the purchaser stating that the material was manufactured, sampled and tested in accordance with this specification and meets all requirements.

13.2 For fin material other than carbon steel, the manufacturer shall supply certification that the chemical composition conforms to the requirements for the grade or type specified.

13.3 Material Test Reports for the base tubing shall be supplied to the purchaser.

13.4 When specified in the purchase order, the results of all tests performed under this specification shall be supplied to the purchaser.

SUPPLEMENTARY REQUIREMENTS

S1. TENSILE TEST

S1.1 Customer may specify in the purchase order the intervals at which tensile tests shall be performed on finned samples. A section of one wrap of fin with a maximum width of 50% of bare tube diameter shall be placed in a tensile testing machine with suitable grips in accordance with A370. The fin shall be pulled radially from the tube and the maximum force, F, recorded. The tensile strength of the weld, S, is calculated as follows:

$$S = F / (T \times W)$$

Where:

S is the tensile strength, ksi (MPa)

F is the maximum tensile force, lbs. (N)

T is the measured fin thickness, inches (mm)

W is the width of the fin section inches (mm)

The tensile strength calculated shall be no less than:

Carbon steel fin material: 40 ksi (275 MPa)

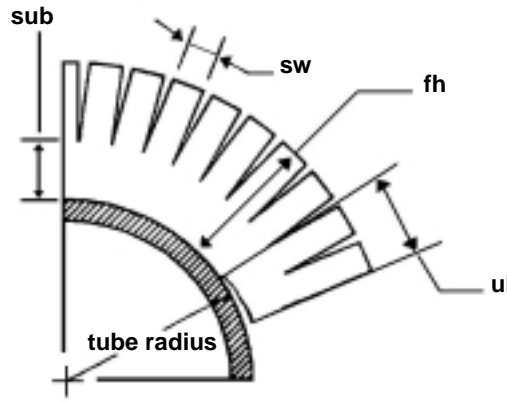
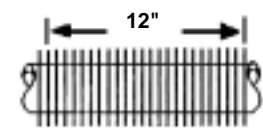
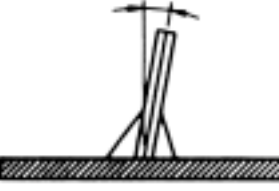
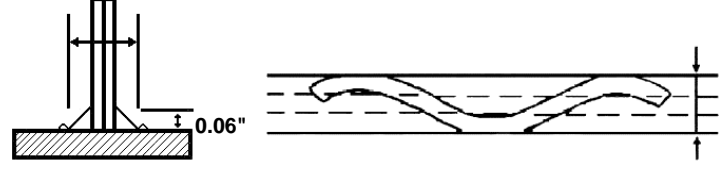

409 stainless fin material: 45 ksi (310 MPa)

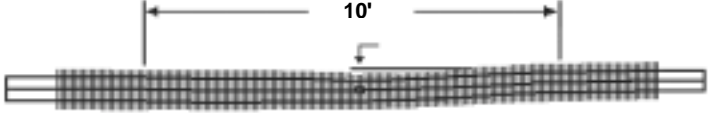
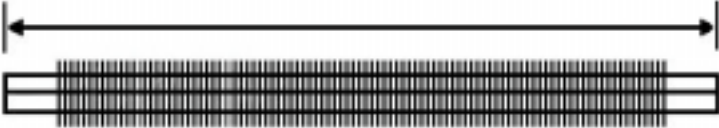
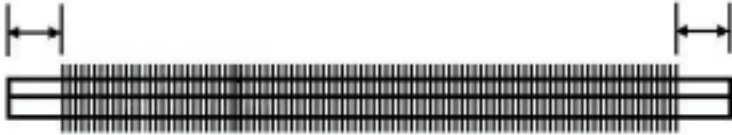
304 stainless fin material: 50 ksi (344 MPa)

NOTE: ksi x 6.895 = MPa



Fintube Technologies, Inc.

Criteria		Fintube Technologies, Inc. Standard	International Standard
FIN DETAIL 	sub= Serr/uncut base	= 0.25" (6mm) ± 0.07" (1.7mm)	= 0.27" (7 mm) ± 0.12" (3 mm)
	sw= segment width	± .010" (0.025 mm)	± 0.03" (0.8 mm)
	fh= fin height tolerance	± 0.03" (0.8 mm) for fin heights ≤ 0.79" ± 0.04" (1.0 mm) for fin heights > 0.79"	± 0.04" (1.0 mm)
	ul= unwelded length at the ends of finned sections	not to exceed ½"	
SPACING FIN PITCH 		± 2% measured over at least 12" (300 mm) of welded fins	- 2% + 5% measured over at least 12" (300 mm) of welded fins
FIN INCLINATION 	fin heights ≤ 0.79" (20mm)	5° maximum	maximum 10°
	fin heights > 0.79" (20mm)	10° maximum	
FIN CORRUGATION 		maximum 3 x t excluding weld expulsion (t = nominal thickness)	maximum 3 x t (t = nominal thickness)
SERRATED FIN APPARENT THICKNESS (DEGREE OF TWIST) 		1.75 x t maximum (t = nominal thickness)	2 x t maximum (t = nominal thickness)

Criteria		Fintube Technologies, Inc. Standard	International Standard
FINTUBE STRAIGHTNESS 		maximum deviation 0.2" (5 mm) per 10' (3 m)	maximum deviation 0.2" (5 mm) in any 10' (3 m) section
LENGTH TOLERANCE 		as specified in applicable bare tube specification	as specified in applicable bare tube specification
BARES TOLERANCE 		± .25" (6 mm) or 1 fin spacing whichever is greater	± .25" (6 mm) or 1 fin spacing whichever is greater
UNWELDED WRAPS	per tube	maximum 2.5%	maximum 2.5%
	Distance between 2 sets of unwelded wraps or end of tube	6" minimum (150 mm)	6" minimum (150 mm)
	number of consecutive unwelded wraps	maximum 5	maximum 5
SPECIFIED FIN THICKNESS	0.024" – 0.031" (t < 0.81 mm) 0.032" – 0.039" (t ≥ 0.81 < 1.00 mm) 0.040" – 0.063" (t ≥ 1.00 < 1.60 mm) 0.064" – 0.079" (t ≥ 1.60 < 2.00 mm) 0.080" – 0.098" (t ≥ 2.00 < 2.50 mm) 0.099" – 0.138" (t ≥ 2.50 mm)	0.003" (± 0.07 mm) 0.004" (± 0.10 mm) 0.005" (± 0.13 mm) 0.006" (± 0.15 mm) 0.007" (± 0.17 mm) 0.008" (± 0.20 mm)	0.004" (± 0.10 mm) 0.005" (± 0.13 mm) 0.006" (± 0.15 mm) 0.007" (± 0.17 mm) 0.008" (± 0.20 mm)
WELD ATTACHMENT WIDTH (= white metal exposed on the fractured surface of removed fin)		90% of the measured fin thickness or tensile test of: 40 ksi(275 MPa):CS 45 ksi(310 MPa):409SS 50 ksi(344 MPa):304SS	90% of the nominal fin thickness or tensile test yielding a minimum value of 25 ksi (170 MPa)
TEARING OF FIN		<10% maximum per tube	<10% maximum per tube