

ASTM - A556/A556M

SPECIFICATION FOR SEAMLESS COLD-DRAWN CARBON STEEL FEEDWATER HEATER TUBES

This specification covers minimum-wall-thickness, seamless cold-drawn carbon steel tubes including bending into the form of U-tubes, if specified, for use in tubular feedwater heaters.

The tubing sizes covered shall be 5/8 to 1 1/4 in. [15.9 to 31.8 mm] outside diameter, inclusive, with minimum wall thicknesses equal to or greater than 0.045 in. [1.1 mm].

❖ **Heat Treatment :-**

1. Cold-drawn tubes shall be heat treated after the final cold-draw pass at a temperature of 1200°F [640°C] or higher to ensure ductility satisfactory for rolling into tube sheets and to meet mechanical properties as specified.
2. If stress-relief anneal of the U-bends is specified, the anneal shall consist of heating the bent portion within a range of 1100 to 1200°F [585 to 640°C].

❖ **Chemical Composition :-**

The steel shall conform to one of the requirements as to chemical composition as prescribed in Table 1.

Table 1

Element	Grade A2	Grade B2	Grade C2
Carbon, max	0.18	0.27	0.3
Manganese	0.27–0.63	0.29–0.93	0.29–1.06
Phosphorus, max	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035
Silicon, max	...	0.1	0.1

❖ **Permissible Variations in Dimensions (Fig. 1) :-**

1. Permissible variations from the specified outside diameter shall not exceed ± 0.004 in. [0.10 mm] for tubing under 1.0 in. [25.4 mm] outside diameter nor ± 0.006 in. [0.15 mm] for tubing 1.0 in. [25.4 mm] to 1.25 in. [31.7 mm] inclusive. These tolerances do not apply to the bent portion of the U-tubes.
2. At the bent portion of a U-tube, for $R = 2 \times D$, neither the major nor minor diameter of the tube shall deviate from nominal by more than 10%. If $1(1/2) D$ is specified, tolerances could be greater.
3. Permissible variations from the specified minimum wall thickness shall not exceed + 20% or – 0 for the straight tubing. The wall thickness of the U-tube in the bent section shall be not less than the value determined by: $t_f = T(2R)/(2R+D)$
 where: t_f = wall thickness after bending, in. [mm],
 T = specified minimum tube wall thickness, in. [mm],
 R = center line bend radius, in. [mm], and D = nominal outside tube diameter, in. [mm].
4. In the case of U-tubes, the length of the tube legs, as measured from the point of tangency of the bend and the tube leg to the end of the tube leg, shall not be less than specified, but may exceed the specified values by the amount given in Table 2. The difference in lengths of the tube legs shall not be greater than 1/8 in. [3 mm] unless otherwise specified.
5. The end of any tube may depart from the square by not more than the amount given in Table 3.
6. The bent portion of the U-tube shall be substantially uniform in curvature and not exceed $\pm 1/16$ in. [± 1.5 mm] of the normal center line radius.

Table 2

Leg Length, ft [m]	Plus Tolerance, in. Leg Length, ft [m] [mm]
Up to 20 [6], incl	1/8 [3.2]
Over 20 to 30 [6 to 9], incl	5/32 [4.0]
Over 30 to 40 [9 to 12.2], incl	3/16 [4.8]

Table 3

Tube OD, in. [mm]	Tolerance in. [mm]
5/8 [15.9]	0.010 [0.25]
Over 5/8 to 1 1/4 [15.9 to 31.7], incl	0.016 [0.4]

❖ **Mechanical Properties :-**

1. Tensile Properties — The material shall conform to the requirements as to tensile properties prescribed in Table 4.
2. Hardness Requirements — The tubes shall not exceed the Rockwell Hardness shown in Table 5.

Table 4

	Grade A2	Grade B2	Grade C2
Tensile strength, min, ksi [MPa]	47[320]	60[410]	70[480]
Yield strength, min, ksi [MPa]	26[180]	37[260]	40[280]
Elongation in 2 in. or 50 mm, min, % (longitudinal)	35	30	30

Table 5

Grade A2	HR B72
Grade B2	HR B79
Grade C2	HR B89

❖ **Mechanical Tests Required :-** 1. Tension Test.

2. Flattening Test.
3. Flaring Test.
4. Hardness Test — Brinell or Rockwell hardness tests shall be made on specimens from two tubes from each lot.
5. Hydrostatic Test—Each U-tube shall be subjected to a hydrostatic test, using a noncorrosive fluid, or when agreed upon between the purchaser and manufacturer, they may be tested at 1(1/2) times the specified design working pressure.

❖ **Non-destructive Test (Electric Test) :-**

Each tube shall be tested after the finish heat treatment following the final cold-drawn pass by passing through a non-destructive tester capable of detecting defects on the entire cross section of the tube.

1. Ultrasonic examination :-
The ultrasonic examination referred to in this specification is intended to detect longitudinal discontinuities having a reflective area similar to or larger than the calibration reference notches. For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.0 MHz, and the maximum transducer size shall be 1.5 in. (38 mm).
2. Eddy current examination :-

The eddy current examination referenced in this specification has the capability of detecting significant discontinuities, especially of the short abrupt type.

For eddy current testing, the excitation coil frequency shall be chosen to ensure adequate penetration, yet provide good signal-to-noise ratio. The maximum coil frequency shall be:

Specified Wall Thickness	Maximum Frequency
<0.050 in.	100 KHz
0.050 to 0.150	50 KHz
>0.150	10 KHz

3. Flux leakage examination :-

The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented discontinuities.

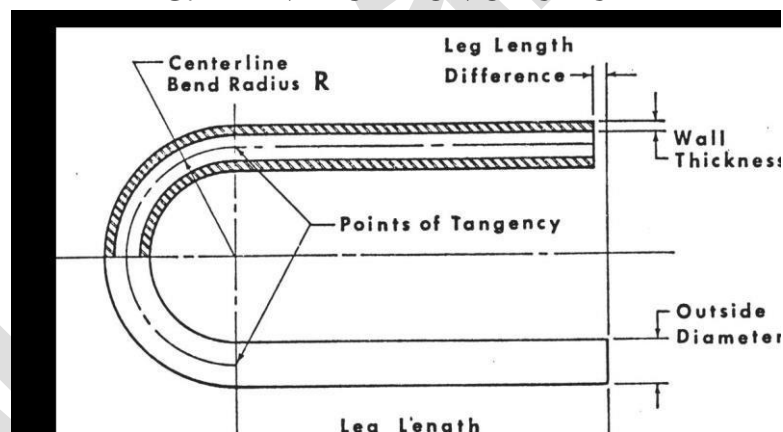
For eddy current testing, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

- i. Drilled Hole
- ii. Transverse Tangential Notch
- iii. Longitudinal Notch

4. Hydrostatic test :-

This test has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure.

FIG. 1 BENT PORTION OF U-TUBE



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