**PFT-11.4.2** The welded joint may be made through the tubesheet or shell thickness. When the weld joint is made through the shell, a minimum of 80% of the pressure load shall be carried by the tubes, stays, or both.

**PFT-11.4.3** The weld is a full penetration weld equal at least to the full thickness of the base metal applied from either or both sides. When the full penetration weld is made through the shell, an external fillet weld with a minimum throat of \( \frac{1}{4} \) in. (6 mm) shall be provided, and no weld prep machining shall be performed on the flat tubesheet. The distance from the edge of the completed weld to the peripheral edge of the tubesheet shall not be less than the thickness of the tubesheet.

**PFT-11.4.4** The shell or wrapper sheet, where exposed to primary furnace gases and not water cooled, does not extend more than \( \frac{1}{8} \) in. (3 mm) beyond the outside face of the tubesheet.

**PFT-11.4.5** The weld attaching a furnace or a lower tubesheet of a vertical firetube boiler to the furnace sheet is wholly within the furnace sheet and is ground flush with the upper or water side of the tubesheet.

**PFT-11.4.6** The construction conforms in all other aspects to the requirements of this Section including welding, and postweld heat treatment, except that volumetric examination is not required.

**PFT-11.4.7** This construction shall not be used on the rear head of a horizontal-return tubular boiler.

**PFT-12 TUBES**

**PFT-12.1 Allowable Working Pressure.**

**PFT-12.1.1** The maximum allowable working pressure of tubes or flues of firetube boilers shall be as given in PG-28.1 and PG-28.3. The minimum thickness requirement of PG-9.3 does not apply to firetubes.

**PFT-12.1.2** The maximum allowable working pressure for copper tubes or nipples subjected to internal or external pressure shall not exceed 250 psi (1.7 MPa). The maximum temperature shall not exceed 406°F (208°C).

The maximum allowable working pressure for copper-clad tubes subjected to external pressure shall be determined by the formula in PG-28.3, in which \( t \) may be increased by one-half the thickness of the cladding.

**PFT-12.2 Attachment of Tubes.**

**PFT-12.2.1** Figure PFT-12.1 illustrates some of the acceptable types of tube attachments. Such connections shall be

(a) expanded and beaded as in illustrations (a), (b), and (d)
(b) expanded and beaded and seal welded as in illustration (c)
(c) expanded and seal welded as in illustration (e)
(d) welded, as in illustrations (f) and (g)

Note (1) Not less than \( t \) or \( \frac{1}{8} \) in. (3 mm), whichever is the greater, and not more than \( 2t \) or \( \frac{1}{4} \) in. (6 mm), whichever is the lesser.

Note (2) Not less than \( t \) or \( \frac{1}{8} \) in. (3 mm), whichever is the greater, and not more than \( \frac{T}{3} \) (see PFT-12.2.1.2).

Note (3) Not more than \( t \).

Note (4) Not less than \( t \) or \( \frac{1}{8} \) in. (3 mm), whichever is the greater, and not more than \( \frac{T}{3} \) (see PFT-12.2.1.2).
The tubesheet hole may be beveled or recessed. The depth of any bevel or recess shall not be less than the tube thickness or \( \frac{1}{8} \) in. (3 mm), whichever is greater, and not more than one-third of the tubesheet thickness, except that when tube thicknesses are equal to or greater than 0.150 in. (4 mm), the bevel or recess may exceed \( \frac{T}{3} \). Where the hole is beveled or recessed, the projection of the tube beyond the tubesheet shall not exceed a distance equal to the tube wall thickness [see Figure PFT-12.1, illustrations (f) and (g)].

PFT-12.2.1.3 On types of welded attachment shown in Figure PFT-12.1, illustrations (c) and (e), the tubes shall be expanded before and after welding. On types shown in illustrations (f) and (g), the tubes may be expanded.

PFT-12.2.2 Expanding of tubes by the Prosser method may be employed in combination with any beaded or seal welded attachment method [see Figure PFT-12.1, illustration (b)].

PFT-12.2.3 After seal welding as shown by Figure PFT-12.1, illustrations (c) and (e), a single hydrostatic test of the boiler shall suffice.

PFT-12.2.4 The inner surface of the tube hole in any form of attachment may be grooved or chamfered.

PFT-12.2.5 The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

PFT-12.2.6 Welded tube attachments as shown by Figure PFT-12.1, illustration (h), may be made with partial or no insertion of the tube into the flat tubesheet. The following requirements shall be met for these attachments:

(a) The tube and tubesheet materials shall be restricted to P-No. 1, P-No. 3, or P-No. 4 materials.

(b) The maximum design temperature at the weld joint shall not exceed 700°F (370°C).

(c) The weld shall be a full-penetration weld made from the I.D. of the tube. The throat of the weld shall be equal to or greater than the thickness of the tube. The root pass shall be made using the GTAW process.

(d) PWHT per PW-39 is mandatory. The exemptions to PWHT noted in Tables PW-39-1 through PW-39-14 shall not apply.

(e) In addition to meeting the performance qualification requirements of Section IX, before making a production weld each welder and welding operator shall demonstrate his or her ability to achieve complete weld penetration and minimum thickness by successfully welding six test pieces. The test pieces shall be welded in a mockup of the production weld. The mockup shall be of identical position, dimensions, and materials as that of the production weld. The test pieces shall be visually examined to verify complete penetration and sectioned to verify minimum weld thickness. The results shall be recorded and maintained with the performance qualification record.

(f) Each weld surface on the tube I.D. shall receive either a magnetic particle or liquid penetrant examination in accordance with A-260 or A-270 of Nonmandatory Appendix A, as applicable. In addition, a visual examination of the weld surface on the tube O.D. shall be performed. The maximum practicable number of these welds, but in no case fewer than 50%, shall be visually examined. Visual examination shall show complete penetration of the joint root and freedom from cracks.

COMBUSTION CHAMBERS

PFT-13 COMBUSTION CHAMBER TUBESHEET

PFT-13.1 The maximum allowable working pressure on a tubesheet of a combustion chamber, where the crown sheet is not suspended from the shell of the boiler, shall be determined by the following equation:

(U.S. Customary Units)

\[
P = 27,000 \frac{t(D - d)}{WD}
\]

(SI Units)

\[
P = 186 \frac{t(D - d)}{WD}
\]

where

\( D \) = least horizontal distance between tube centers on a horizontal row
\( d \) = inside diameter of tubes
\( P \) = maximum allowable working pressure
\( t \) = thickness of tubesheet
\( W \) = distance from the tubesheet to opposite combustion chamber sheet

Where tubes are staggered, the vertical distance between the center lines of tubes in adjacent rows must not be less than

\[
1/2 \sqrt{2dD + d^2}
\]

Example: Required the maximum allowable working pressure of a tubesheet supporting a crown sheet stayed by crown bars. Horizontal distance between centers, \( 4\frac{1}{8} \) in.; inside diameter of tubes, 2.782 in.; thickness of tubesheets \( 1\frac{1}{16} \) in.; distance from tubesheet to opposite combustion-chamber sheet, 34\( \frac{1}{8} \) in.; measured from outside of tubesheet to outside of back plate; material, steel. Substituting and solving the following equation:

\[
P = \frac{(4.125 - 2.782) \times 0.6875 \times 27,000}{34.25 \times 4.125} = 176 \text{ psi}
\]