\[ P = \text{maximum allowable working pressure, psi (MPa)} \]
\[ p = \text{maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal and} \]

**PG-46.3** When two plates are connected by stays and only one of these plates requires staying, the value of \( C \) shall be governed by the thickness of the plate requiring staying.

**PG-46.4** Acceptable proportions for the ends of through-stays with washers are indicated in Figure PG-46.2.

**PG-46.5** The maximum pitch shall be \( 8\frac{1}{2} \text{ in. (215 mm)} \) except that for welded-in staybolts the pitch may be greater provided it does not exceed 15 times the diameter of the staybolt.

For the application of PG-48 and PFT-26, see Figure A-8.

**PG-46.6** Where the staybolting of shells is unsymmetrical by reason of interference with butt straps or other construction, it is permissible to consider the load carried by each staybolt as the area calculated by taking the distance from the center of the spacing on one side of the bolt to the center of the spacing on the other side.

**PG-46.7** The ends of stays fitted with nuts shall not be exposed to the direct radiant heat of the fire.

**PG-46.8** Stays exceeding 120 diameters in length shall be supported at intervals not exceeding 120 diameters, or the cross-sectional area of the stay shall be increased by not less than 15% of its required area.

**PG-47 STAYBOLTS**

**PG-47.1** The ends of staybolts or stays screwed through the plate shall extend beyond the plate not fewer than two threads when installed, after which they shall be riveted over or upset by an equivalent process without excessive scoring of the plates; or they shall be fitted with threaded nuts through which the bolt or stay shall extend. The thread lead of both ends and both plates being stayed shall be synchronized to permit the bolt to be installed without stripping the threads. Both ends of solid staybolts 8 in. (200 mm) and less in length, if of uniform diameter throughout their length, shall be drilled with telltales holes at least \( \frac{1}{16} \text{ in. (5 mm)} \) in diameter to a depth extending at least \( \frac{3}{4} \text{ in. (13 mm)} \) beyond the inside of the plate. If such staybolts are reduced in section between their ends below their diameter at the root of the thread, the telltale holes shall extend at least \( \frac{3}{4} \text{ in. (13 mm)} \) beyond the point where the reduction in section commences. Hollow staybolts may be used in place of solid staybolts with drilled ends. Solid staybolts over 8 in. (200 mm) long and flexible staybolts of either the jointed or ball-and-socket type need not be drilled. Staybolts used in waterlegs of watertube and firetube boilers shall be hollow or drilled at both ends, in accordance with the requirements above stated, irrespective of their length. All threaded staybolts not normal to the stayed surface shall have not less than three engaging threads of which at least one shall be a full thread, but if the thickness of the material in the boiler is not sufficient to give one full engaging thread, the plate shall be sufficiently reinforced by a steel plate welded thereto. Except for locomotive boilers, telltale holes are not required in staybolts attached by welding.

**PG-47.2** The ends of steel stays upset for threading shall be fully annealed after upsetting.

**PG-47.3** Requirements for welded-in staybolts are given in PW-19.

**PG-48 LOCATION OF STAYBOLTS**

**PG-48.1** For staybolts adjacent to the riveted edges bounding a stayed surface, the value of \( p \) in PG-46 eqs. (1) and (2) may be taken as the distance from the edge of a staybolt hole to a straight line tangent to the edges of the rivet holes [see Figure A-8, illustrations (g-1) and (g-2)].

**PG-48.2** When the edge of a flat stayed plate is flanged, the distance from the center of the outermost stays to the inside of the supporting flange shall not be greater than the pitch of the stays plus the inside radius of the flange.
**PW-19.4** Diagonal stays shall be attached to the inner surface of the shell, but not the head, by fillet welds only, as described in PW-19.4.1 and PW-19.4.3. [See Figures PW-19.4(a) and PW-19.4(b).]

**PW-19.4.1** The fillet welds shall be not less than \( \frac{3}{8} \) in. (10 mm) size and shall continue the full length of each side of the portion of the stay in contact with the shell. The product of the aggregate length of these fillet welds times their throat shall be not less than 1.25 times the required cross-sectional area of the stay. A fillet weld across the end of the stay is optional but shall not be credited in calculating the required area of fillet welds.

**PW-19.4.3** The longitudinal center line of the stay, projected if necessary, shall intersect the inner surface of the plate to which the stay is attached within the outer boundaries of the attaching welds, also projected if necessary.

**PW-19.5** The pitch of stays attached by welding to flat surfaces shall comply with the requirements of PPT-27.

**PW-19.6** The welding shall be done in such a manner that excessive weld deposits do not project through the surface of the plate at the root of the weld.

**PW-19.7** The welding shall be postweld heat treated in accordance with PW-39.

**PW-19.8** Telltale holes are not required in staybolts attached by welding.

### FABRICATION

**PW-26 GENERAL**

The rules in the following paragraphs apply specifically to the fabrication of boilers and parts thereof that are fabricated by welding and shall be used in conjunction with the general requirements for fabrication in Part PG, as well as with the specific requirements for fabrication in the applicable Parts of this Section that pertain to the type of boiler under consideration.

**PW-27 WELDING PROCESSES**

The welding processes that may be used under this Part shall meet all the test requirements of Section IX and are restricted to PW-27.1 through PW-27.4.

**PW-27.1** The following welding processes may be used for any Section I construction: shielded metal arc, submerged arc, gas metal arc, hybrid plasma-gas metal arc, flux cored arc, gas tungsten arc, plasma arc, atomic hydrogen arc, oxyhydrogen, oxyacetylene, laser beam,
PG-28.3, the pressure $P_1$, determined from the following equation, which is a modification of the formula in PFT-23:

(U.S. Customary Units)

$$P_1 = 10,000,000 \frac{bd^3}{D_1 D^3}$$

(SI Units)

$$P_1 = 69 000 \frac{bd^3}{D_1 D^3}$$

where

$b$ = net width of crown bar
$D$ = two times the radius of the crown sheet
$D_1$ = longitudinal spacing of crown bar that shall not exceed twice the maximum allowable staybolt pitch
$d$ = depth of crown bar

provided that the maximum allowable working pressure must not exceed that determined by the equation for furnaces of the ring-reinforced type, in PG-28.3 when $L$ is made equal to $D_1$, and also provided that the diameter of the holes for the staybolts in the crown bars does not exceed $\frac{1}{4}d$, and the cross-sectional areas of the crown bars is not less than 4 in.$^2$ (2 580 mm$^2$). PG-46 governs the spacing of the staybolts or bolts attaching the sheet to the bars, and PFT-28, the size of the staybolts or bolts.

For constructions in which the crown sheet is not semicircular, or in which other features differ from those specified above, a test shall be made in accordance with PG-18 and the working pressure shall be based thereon.

PFT-30.3 Cast iron supporting lugs, legs, or ends shall not be used.

PFT-31 STAY TUBES

PFT-31.1 When tubes are used as stays in multitubular boilers to give support to the tubesheets, the required cross-sectional area of such tubes shall be determined in accordance with PG-49.

PFT-31.2 The required tubesheet thickness and maximum pitch of stay tubes shall be calculated using the following equations:

$$t = \sqrt{\frac{p}{C S}} \left( \frac{p^2}{4} - \frac{\pi d^2}{4} \right)$$

$$p = \sqrt{\frac{C S t^2}{p} + \frac{\pi d^2}{4}}$$

where

$C$ = 2.1 for tubesheets not over $\frac{7}{16}$ in. (11 mm) thick
$C$ = 2.2 for tubesheets over $\frac{7}{16}$ in. (11 mm) thick
$d$ = outside diameter of the tube
$P$ = design pressure

$p$ = maximum pitch measured between the centers of tubes in different rows, which may be horizontal, vertical, or inclined
$S$ = maximum allowable stress value for the tubesheet material given in Section II, Part D, Subpart 1, Table 1A
$t$ = required thickness of tubesheet

PFT-31.3 No calculation need be made to determine the availability of the required cross-sectional area or the maximum allowable pitch for tubes within or on the perimeter of a nest of tubes that are spaced at less than twice their average diameter.

PFT-31.4 Stay tubes may be attached by any of the acceptable means shown in Figure PFT-12.1.

PFT-32 STRESSES IN DIAGONAL STAYS

PFT-32.1 To determine the required area of a diagonal stay, multiply the area of a direct stay required to support the surface by the slant or diagonal length of the stay, and divide this product by the length of a line drawn at right angles to surface supported to center of palm of diagonal stay, as follows:

$$A = aL/l$$

where

$A$ = sectional area of diagonal stay
$a$ = sectional area of direct stay
$L$ = length of diagonal stay as indicated in Figure PFT-32
$l$ = length of line drawn at right angles to boiler head or surface supported to center of palm of diagonal stay, as indicated in Figure PFT-32, in. (mm)

Example: Given diameter of direct stay = 1 in., $a = 0.7854$ in.$^2$, $L = 60$ in., $l = 48$ in.; substituting and solving

$$A = (0.7854 \times 60)/48 = 0.98 \text{ sectional area, in.}^2$$

![Figure PFT-32](image-url)

Measurements for Determining Stresses in Diagonal Stays