106. Thickness of Shell Angle Rings.—Where shell plates and end plate are connected by means of an external angle ring, the angle rings shall be no less in thickness than as follows:—

(1) For shell plates up to and including 5/8 inch in thickness.	10 per cent in excess of the thickness of the shell plate.
(2) For shell plate exceeding 5/8 inch in thickness and up to and including 1 inch in thickness.	90 per cent of the thickness but not less than 11/16 inch.
(3) For shell plates over 1 inch in thickness.	Made from angle bar having a section thickness of 1 inch.

107. Welded Shell Plates.—(*a*) Except as provided for in Chapter V and in regulation 107 (*d*) and 112, where longitudinal seams are welded, the weld shall be entirely covered by a butt strap or straps securely riveted to shell.

(*b*) For small steam domes not exceeding 15″ diameter when the welding is done by hammer and the plates do not exceed ½″ thickness, butt straps may be omitted.

(*c*) The strength of the weld covered by butt straps shall be assumed to be 50 per cent of that of the solid plate. The thickness of a single strap or combined thickness of double straps shall be not less than the thickness of the shell plate.

(*d*) As an alternative to riveting, shell boilers not exceeding 4′-6″ in diameter and the maximum working pressure of 120 lb. per sq. in. may be fabricated by fusion welding provided the longitudinal, circumferential and end seams comply with conditions laid down in Regulations 247 to 269.

The working pressure of such shells shall comply with Regulation 176 where J=100 and C=2·75.

108. Longitudinal Seams.—The longitudinal seams of shell belts shall be butt-jointed with double straps when the diameter or Working Pressure exceeds the limits stated below:—

Type of Boiler	When diameter exceeds	When Working Pressure exceeds
	Feet	Lbs./ Sq. in.
Loco Types	2½	200
Vertical Types	6	125
Other Types	6	80

109. Butt Straps.—Butt straps shall be cut from the shell plates, or, alternatively, all the butt straps of each required thickness shall be cut from one plate. The lengths of the straps wherever practicable shall be transverse to the direction of rolling of the plate. Straps shall be pressed or bent in rolls to the shell curvature.

110. Thinning of Butt Straps.—Thinning of the ends of butt straps which tuck under shell rings, shall be done cold by machine and not by heating or hammering. The shell plate shall be notched out to receive that thinned end of the butt strap, so that there shall be no undue thinning of the butt strap.

111. Alternative Construction.—As an alternative to the tucking of butt strap ends under the shell rings, the ends may be terminated at the edge of the shell rings or ends and electrically welded thereto.

112. Local Welding of Butt Seams.—(*a*) The ends of longitudinal butt seams of shell rings may be welded for a length not exceeding three times the overlap at the circumferential seam, provided the butt straps are run as closely as practicable to the circumferential seam.

(*b*) Only metal arc welding of the butt seams of shell rings shall be permitted.

(*c*) Where hemispherical shell crowns are pressed from plate they shall be pressed to form by machine in progressive stages without thinning and on completion shall be annealed.

END PLATES

113. Flat End Plates. (*a*) The end plates of boilers shall preferably be in one piece made from one rolled plate. Alternatively, the end plates may be built up from two pieces by riveting or by fusion butt-welding. In the latter case, the line of weld shall be parallel to the horizontal axis of the boiler and the entire plate after flanging shall be subjected to stress relieving and the weld shall be radiographed.

(*b*) The peripheral flanging of end plates shall be done by machine. Such flanging shall preferably be done in one operation, but where this is impracticable sectional or creep machine flanging may be permitted, provided that the plate is worked at a suitable temperature, and the plate is heated to an adequate distance beyond the portion under immediate treatment.

(*c*) Care must be taken to see that the flanges are circular and of good surface, free from local irregularities, and that they are parallel and square with the flat part of the plate. For the purpose of relieving internal stresses, all plates which have been flanged or locally heated shall afterwards be efficiently annealed unless during the last stage of manufacture they have been uniformly heated throughout.

(*d*) Flat portions of end plates, on completion of all flanging and machining operations, shall be flat and free from set or distortion.

114. Strengthening of Flat End Plate at Manhole.—(*a*) In the End Plates of Lancashire Boiler type the mudhole in the lower part of the front end plate shall be fitted with a flanged riveted strengthening ring, the thickness of the flat portion of which shall be not less than ($1 \cdot 5\ T + \frac{1}{8}$ in.) where T equals the thickness of the end plate in inches.

(*b*) In boilers 7 ft. 6 in. diameter and above, the mudhole frame shall be fitted with a peak to reinforce the portion of the end plate between and below the furnaces, and this peak shall be securely riveted thereto with rivets of similar pitch to the remainder of the frame.

(*c*) In all cases the front end plate gusset stays below the furnaces shall be placed as closely as possible to the mudhole frame.

(*d*) Where flat end plates are flanged for connection to the shell, the inside radius of flanging shall be not less than 1·75 times the plate thickness, with a minimum of $1\frac{1}{2}$ in.

115. End Plates in steam spaces.—When the end plates of boilers situated in the steam space are liable to contact with hot gases, the end plates shall be efficiently shielded from such contact.

116. Hemispherical Crowns.—(*a*) All segments shall be pressed in one heat to correct curvature. The adjacent plates shall bed closely at the seams and wherever possible at the junction of two seams the plates shall be machined down to provide a fair surface to the joint. If the thinning is done by heating and hammering the plate shall be subsequently annealed.

(*b*) The cylindrical portion of the crown shall be tangential to the hemispherical portion and fit truly to the shell.

117. Dished End and Crown Plates.—(*a*) The dished end plates of boilers shall preferably be in one piece made from one-rolled plate. If this is impracticable owing to the large diameter, the dished end plate may be made from two plates fusion butt welded together and in such cases the requirements of stress relieving and radiographic examination as provided for in Regulation 113 shall apply and the line of weld shall be parallel to the horizontal axis of the boiler.

The inside radius to which a plate is dished shall not be greater than the external diameter of the shell to which it is attached, except in the case of Lancashire and Cornish boilers when the radius shall not exceed $1\frac{1}{2}$ times the diameter of the shell.

(*b*) The inside radius of curvature of the flanges to the shell or firebox shall not be less than four times the thickness of the crown or end plate and in no case less than $2\frac{1}{2}$ inches.

(*c*) The inside radius of curvature to uptakes shall be not less than twice the thickness of the crown plate and in no case less than 1 inch.

(*d*) Bunged mouth-pieces may be welded on to end plates in place of the orthodox flanging for the attachment of furnace tubes. Such welding shall comply with provisions of Regulation 125.

(*e*) Manhole frames may be similarly welded on the front end plates, and will be subject to provisions of Regulation 125.

118. Tube Plates.—Smokebox tube plates shall be flanged for attachment to the barrel or shall be flat and connected thereto by an external riveted angle ring.

119. Parts of flat tube plates within the tube nests.—(*a*) Where the total area of all tube nests in directly fired multi-tubular boilers exceeds 7 sq. ft., stay tubes shall be fitted.

Where the total number of tubes in horizontal multitubular waste heat boilers and direct fired loco type boilers is arranged in one nest, the area of which exceed 21 sq. ft., stay tubes shall be fitted.

In all cases where the total number of tubes is arranged in more than one nest, stay tubes shall be fitted.

(*b*) The parts of tube plates which lie outside the nests of tubes shall be stayed or supported wherever the size of the area of pla e subject to steam

pressure necessitates staying or support, either by marginal stay tubes or other means.

120. Flanging of End Plates.—All flanges shall be a good fit to the shell and flues. Flogging and/or hammering in the fitting of these parts is prohibited. The caulking edges of all flanged plates shall be machined or machine gas cut.

FURNACES

121. Furnaces in general.—(*a*) No furnace or firebox top, whether plain or corrugated, shall exceed 7/8 inch in thickness, and all circular sectioned furnaces when new shall be as near the truly circular form as the type of joint will permit.

(*b*) The use of Z angle rings for furnace foundation seams shall be prohibited.

(*c*) As an alternative to riveting furnaces, furance crowns, uptakes and other plates not in tension may be jointed by fusion welding provided the conditions laid down in Regulations 122 to 129 are complied with. The end connections of such plates to the shell or shell crown shall also comply with such conditions. This construction shall not apply to furnaces of Lancashire and Cornish type boilers consisting wholly of plain sections.

122. Furnaces of Horizontal Boilers.—(*a*) The sections of the internal flues shall each be in one plate and shall be bent while cold to circular form and shall be welded longitudinally.

(*b*) The maximum permissible variation in diameter at any cross section shall not exceed the thickness of the plate.

(*c*) The weld shall be placed at the lower part of the flues, and shall break joint in successive sections by at least 12 inches.

(*d*) Each flange for the circular seams shall be formed at one heat by suitable machinery.

(*e*) The sections shall be allowed to cool gradually to avoid internal stresses.

(*f*) The caulking edges of all flue flanges shall be machined or machine gas cut.

(*g*) The circular seams shall be arranged so that they do not fall in line with those of the adjacent flue or with the circumferential seams of the shell and are at least 6 inches apart.

(*h*) When flues are flanged for attachment to both end plates the total length of each completed flue shall not exceed the length of the shell measured from the inner surface of the back end plate to the inner surface of the front end plate, both adjacent to the shell.

(*i*) Where the flues are flanged for attachment to the end plates, the end sections shall be 1/16 inch thicker than the remaining sections, except in cases where the calculated thickness is over 13/16 inch, when the end section shall be 7/8 inch in thickness.

(*j*) The flanged portion of furnace rings shall have radius of curvature of not less than 1 inch on water side.

(*k*) Sections of corrugated flues may be fusion butt welded circumferentially and afterwards stress relieved by heat treatment.

* (*i*) As an alternative to Adamson flanges, furnaces which are partly fitted with corrugated sections shall be strengthened by means of suitable stiffenine rings, adequately welded to the furnaces. In no case shall a flat stiffener be less than $2\frac{1}{2}" \times \frac{1}{2}"$.

123. Furnaces of Vertical Boilers.—(*a*) The furnaces of vertical boilers may be constructed in one or more lengthwise sections, each section being rolled from one plate to a full circle. In such cases, the component sections may be jointed circumferentially by electrically butt-welding or riveting. Where welded, they shall be stress relieved.

(*aa*) In the case of vertical boilers where tube plates form part of the firebox, the tube plate portion may be constructed in two vertical sections and the vertical seams when welded shall be stress relieved.

(*b*) Circular furnaces shall preferably be tappered, a tapper of $1\frac{1}{4}$ in in diameter per 1 foot of height being recommended. The minimum water space at the bottom between the furnaces and the shell shall not be less than 2 in. for boilers up to 2 ft. 6 in. in diameter and shall be not less than $2\frac{1}{2}$ in. for boilers over 2 ft. 6 in. in diameter.

(*c*) Where hemispherical furnace crowns are pressed from one plate they shall be pressed to form by machine in progressive stages without thinning and on completion shall be annealed.

(*d*) Ogee flanging where integral with the firebox or in a separate ring shall preferably be formed at one heat by suitable machinery and shall be allowed to cool gradually to avoid internal stresses.

(*e*) Furnaces of vertical type boilers may be attached to the shell at the firehole by a solid rectangular section steel ring riveted together or by a circular ring of substantial section fusion welded to shell and firebox. Where the latter construction is employed the opening in the shell for firehole shall be substantially compensated by a ring welded on the outside of the shell plate.

(*f*) At the firehole the firebox plate and the shell plate may be flanged and fusion welded together.

124. Longitudinal Seams.—The longitudinal seams of furnaces may be either:

(*a*) Forge Lap Welded.

(*b*) Fusion Butt Welded.

(*c*) Riveted.

Longitudinal seams of furnaces exceeding 3/8" thickness shall not be riveted.

125. Fusion Welded Longitudinal Seams.—Where the longitudinal seam is fusion welded the following precautions shall be observed:—

(*a*) Plates 5/8 inch and above in thickness shall be bevelled from both sides of each abutting edge but the bevel need not necessarily be the same on each side (*see* Figs. 1 and 2). Plates less than 5/8 inch in thickness may be bevelled from one side only of each abutting edge (*see* Figs. 3 and 4).

The included angle of the bevel shall be not less than 60° and the bevelling may be any one of the forms shown in Figs. 1—4.

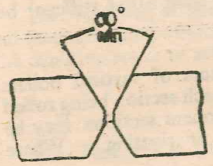


Fig. 1.

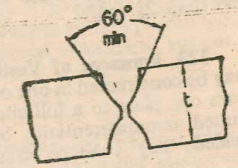


Fig. 2.

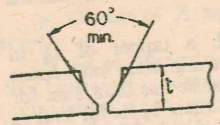


Fig. 3.

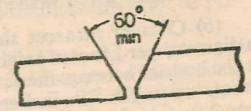


Fig. 4.

(*b*) In order to obtain full penetration of the weld metal a gap shall be maintained between the plates when they are being welded. Joints shall be welded from both sides, and the slag shall be removed after making each run. Before the second side of the joint is welded any slag or defect at the bottom of the first run shall be removed by grinding, chipping or machining. There shall be no appreciable undercutting of the plate.

(*c*) For the purposes of relieving internal stresses the plates adjacent to a fusion weld shall be efficiently annealed after welding, and when the firebox is forge-welded it should be allowed to cool gradually.

126. Furnace Crown.—(*a*) The furnace crown shall be made from one plate and the seam connecting it to the furnace shall not fall in line with any circumferential seam of the boiler shell.

(*b*) The furnace crown may be riveted to the vertical portion of the firebox, or alternatively, the joint may be fusion butt welded by the electric arc process, provided the conditions as to fusion welding in Regulation 125 are observed. Where the joint is to be welded the edges of the furnace crown and the firebox body shall be bevelled in accordance with Fig. 3 or Fig. 4. The depth of the flange of the furnace crown plate from the commencement of the curvature of the flanging radius shall be not less than four times the plate thickness with a minimum of 1½ inches. On completion of welding the firebox shall be effectively stress relieved by heat treatment (*see* also Reg. 128).

* **127. Cross Tubes.**—(*a*) Cross tubes shall be made from weldless steel tube or from plate or strip rolled and forge water gas welded. Where welded tubes are used the longitudinal welds shall be so situated that they are not exposed to the direct impact of the flame.

(*b*) Cross tubes shall not exceed 12 in. internal diameter. The minimum thickness shall be 5/16 in.

(*c*) Where cross tubes are flanged and riveted to the furnace the flanges shall be set to the curvature and taper of the furnace and shall be a good fit before riveting.

(*d*) Where welded construction is employed the tubes shall be of sufficient length to enter the furnace plate and the flush with the water side all round or project not more than 5/8 in. into the water space at any part of the circumference. Where the tubes are fusion welded in position the firebox plates shall be suitably chamfered and the joints shall be welded externally and internally (*see* Fig. 5).

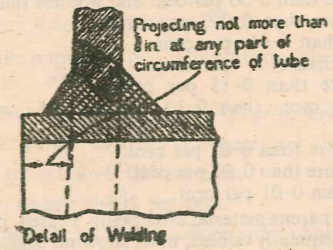


Fig. 5. Fusion welding of Cross Tubes of Vertical Cross Tube Boilers.

128. Uptakes.—(*a*) The uptakes shall be formed from weldless forge water gas welded or fusion butt welded steel tube and shall be securely riveted to the furnace crown plate and riveted to the shell crown plate.

(*b*) As an alternative to riveting the uptake may be fusion butt welded by the electric arc process to the upward flange of the opening in the firebox crown plate provided the conditions as to fusion welding in Regulation 125 are observed. The edges of the upward flange and the adjacent end of the uptake shall be bevelled in accordance with Fig. 3 or Fig. 4. The depth of the crown plate opening from the commencement of the curvature of the flanging radius shall be not less than twice the plate thickness with a minimum of 1 inch. On completion of welding the uptake and crown plate shall be effectively stress relieved by heat treatment.

Where the firebox crown plate is also fusion welded to the body of the firebox, the firebox complete with uptake shall be effectively stress relieved by heat treatment on completion of the welding.

(*c*) Welded uptakes shall be so arranged that the weld is directly facing the longitudinal centre line of the manhole.

129. Loco Type Fireboxes.—(*a*) The foundation seam shall be of riveted construction but all other seams may be welded subject to the depth of the flange being such that the welded seams fall between the 1st and 2nd rows of screwed stays or between the flange and the adjacent row screwed stays.

(*b*) The firehole mouthpiece may be similarly welded when the firebox and shell are flanged for the purpose.

(*c*) The welding shall comply with Regulation 125.

(*d*) The welding of copper fireboxes shall comply with the following regulation.

129-A. Welded Joints in Copper Fire Boxes.—(*i*) **Scope.**—All welding of Copper plates shall be carried out by the oxy-acetylene process. The Inspecting Authority may at his discretion also permit the use of propane, butane or other suitable fuel gases.

(*ii*) **Parent Metal.**—Phosphorus deoxidised arsenical copper in the fully annealed condition shall only be used for welded copper fire boxes.

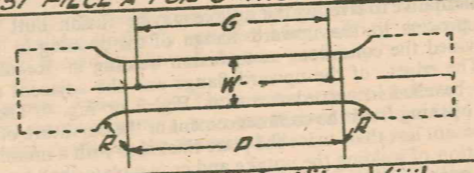
The composition of the copper shall be within the following limits:—

Phosphorus Deoxidised Arsenical Copper—
Copper (silver being counted as copper) not less than 99·20 per cent.
Antimony not more than 0·01 per cent.
Arsenic not more than 0·50 per cent and not less than 0·30 per cent.
Bismuth not more than 0·003 per cent.
Iron not more than 0·01 per cent.
Lead not more than 0·01 per cent.
Nickel not more than 0·15 per cent.
Phosphorus not more than 0·10 per cent and not less than 0·015 per cent.
Selenium not more than 0·02 per cent.
Tellurium not more than 0·02 per cent.
Tin not more than 0·01 per cent.

Pieces cut from the parent material after being heated in hydrogen for ½ hour at 800° C and subsequently cooled, must show no edge or surface cracking when subjected to a close bend test as described below.

The test piece AB is bent by steadily applied pressure or a succession of blows at right angles to the length AC and flattened close until A assumes the position indicated by D (*see* Figure 5A).

TEST PIECE A FOR OXYACETYLENE WELDING OF COPPER



NOMINAL THICKNESS OF TEST PIECE		(i)	(ii)	(iii)	(iv)
		UP TO-BUT NOT INCLUDING 3/16 IN.			3/16 IN AND THICKER
WIDTH	W	IN ½	IN 1	½ IN (MAX.)	IN ½ (MAX.)
GAUGE LENGTH	G	2	4	8	8
PARALLEL LENGTH (MIN)	P	2½	4½	9	9
RADIUS AT SHOULDER (MIN)	R	1	1	1	1
APPROX. TOTAL LENGTH.		8	12	18	18

WHEN THE WIDTH OF THE MATERIAL TO BE TESTED IS INSUFFICIENT TO PERMIT OF THE PREPARATION OF THE STANDARD TENSILE TEST PIECE, A PIECE OF THE FULL WIDTH OF THE MATERIAL MAY BE USED

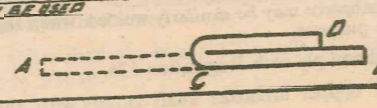


FIG. 5A.

(*iii*) **Filler Rod.**—The filler rod shall be phosphorus deoxidised non-arsenical copper and shall contain not more than 0·15 per cent and not less than 0·04 per cent phosphorus with the optional addition of silicon up to 0·15 per cent and with the optional addition of silver.

The basic copper used for the manufacture of the filler rods shall either be cathode copper or electrolytic tough pitch high conductivity copper conforming to the following chemical compositions respectively:

Chemical Composition of Cathode Copper—
Copper (silver being counted as copper) not less than 99·90 per cent.
Bismuth not more than 0·001 per cent.
Lead not more than 0·005 per cent.

Total of metallic impurities (excluding silicon, phosphorus and silver) not more than 0·03 per cent.

Chemical Composition of electrolytic tough pitch high conductivity Copper—
Copper (silver being counted as copper) not less than 99·90 per cent.
Bismuth not more than 0·001 per cent.
Lead not more than 0·005 per cent.

Total of all impurities (excluding silicon, phosphorus, oxygen and silver) not more than 0·03 per cent.

Where silicon has been added in the manufacture of the filler rods the amount present in the filler rod shall be stated by the supplier.

Test pieces cut from the filler rod after being heated in Hydrogen for ½ hour at 800° C and subsequently cooled must not show any surface cracking when subjected to a close bend test as described in clause (*ii*) above.

(*iv*) **Mechanical Test.**—The welding technique shall be tested as follows:—

Three test pieces shall be cut from the welded test specimen and shall be prepared to conform to the dimensions of test piece A. The weld shall be left in the unhammered state and shall be made transverse to the test Plate. The test piece shall be machined, filled or ground to remove excess weld metal and a maximum of 5 per cent of the thickness of the plate from each side.

Each of the three test pieces shall be tested and shall show a tensile strength not less than 9 tons per sq. inch for plates up to and including ½ inch in thickness and not less than 8 tons per sq. inch for plates over ½ inch up to and including 1 inch in thickness.

(*v*) **Number of Tests.**—One test plate not less than 6 in. long shall be welded by each operator (or pair of operators) employed on the work to represent each 15 ft. of welding or part thereof. The test plate shall be welded, using the same form of joint and welding technique as that employed on the work and wherever practicable shall be directly attached to the welded seam or other welded joint it represents.

STAYS

130. Bar Stays.—Bar stays shall not be welded at any part. They shall preferably have plus threads, the ends of the stays being upset or the middle portion being reduced for this purpose. Stay bars which have been worked in the fire shall be subsequently annealed.

131. Longitudinal Stays.—(*a*) Longitudinal and similar solid screwed stays shall be efficiently secured with nuts at each end and not merely riveted over. Where they are over 12 feet in length, they shall be supported at intervals of 6 ft. along its length.

(*b*) Where the stay is screwed through both plates, the stay and holes shall have a continuous thread and fitted with nuts and washers on the outside. Where the stay passes through clearing holes an internal nut and washer shall also be fitted. Where the stay is not normal to the surface of the plate the washer shall be shaped so as to form a true surface for the nuts or a knuckle joint may be fitted.

(*c*) In vertical boilers the stays shall either be screwed into both crown plates or screwed into the furnace crown plate and passed through clearing holes in the shell crown plate.

132. Nuts and Washers for Stays.—(*a*) The washers shall be at least $2\frac{1}{4}$ times the diameter of the threaded portion of the stay and not less than $\frac{1}{4}$ in. in thickness.

(*b*) The thickness of the external nuts shall be at least equal to the diameter of the threaded portion of the stay. Where bar stays pass through clearing holes in end plates, internal nuts of a thickness not less than two-thirds of the diameter of the threaded portion of the stay shall be fitted.

133. Jointed Stays.—Where jointed longitudinal stays are fitted, they shall, where practicable, be fitted with pins having an effective sectional area 25 per cent in excess of that of the stay. If the pins are slack in the holes, the total slackness shall not be more than 1/16 inch. The pins shall be as close as possible to the shoulder of the eye forging. The shoulder of the forging shall be at least $\frac{1}{2}$ inch wide all round, *i.e.*, the diameter at the shoulder shall be not less than the diameter of the hole plus 1 inch.

134. Diagonal Bar or Rod Stays.—The sectional area of diagonal rod or bar stay shall bear the same proportion to that of a direct stay as the length of the diagonal stay bears to the length of the perpendicular line from the end of the diagonal stay to the surface supported. The ends of diagonal stays, shall not be bent, but shall be attached to the plate with vevelled washers and nuts or with riveted tee, blocks or angles and shackle pins (*see* Regulation 133 for eyes and pins.)

SCREWED STAYS

135. Screwed Stays.—(*a*) Screwed stays and the holes for these shall be screwed with a continuous thread.

(*b*) The screwed threads of the stay shall be clean free from checks or imperfections, of full depth, correct Whitworth form and a good fit in the holes. The middle portion shall preferably be turned down to the bottom of the thread.

(*c*) The stays shall be screwed with fine threads of not less than 11 threads per inch.

(*d*) The diameter of the stay over the threads shall not be less than $\frac{3}{4}$ in. or twice the thickness of the firebox plate whichever is the greater.

(*e*) The pitch of the stays at the furnace of vertical boilers shall not exceed 14 times the thickness of the furnace plate.

(*f*) Where the stays are not fitted with nuts, the ends shall be riveted over to form substantial heads.

Alternatively stays may be screwed through the shell and firebox plates and the projecting ends shall be substantially fillet-welded in an approved manner. The projection of the end of the stay from the surface of the plate shall be not less than one quarter of the diameter of the stay but in no case less than $\frac{1}{4}$ in. The full end of the stay shall be visible on completion of the welding.

(*g*) Crown stays of Loco type boilers shall either be fitted with nuts or riveted over on the fire side.

136. Axial drilling.—All screwed stays less than 14 in. long should preferably be drilled with a tell-tale hole 3/16 in. diameter to a depth of $\frac{1}{2}$" beyond the inner face of the plate. Stays which are obscure on one side should preferably be made from hollow staybar.

137. Stay Nuts.—(*a*) Nuts to screw stays in combustion chambers and fireboxes shall not be less than $\frac{3}{4}$ inch thick for stays up to $1\frac{1}{8}$ inches diameter over threads, $\frac{7}{8}$ inch thick for $1\frac{3}{8}$ inches and $1\frac{3}{4}$ inches stays, 1 inch thick for $1\frac{7}{8}$ and 2 inches stays, and $1\frac{1}{8}$ inches thick for stays over 2 inches in diameter.

(*b*) The nuts shall be made of solid mild steel or of iron which shall be without weld if exposed to flame.

138. Spacing of End Stays—Allowance for curves, etc.—For the tops of fireboxes and combustion chambers the distance between the rows of stays nearest to the tube plate or firehole plate or back plate as the case may be, and the commencement of curvature of these plates at their flanges shall not be greater than the horizontal pitch of the stays.

GIRDER STAYS

139. Girder Stays for Firebox and Combustion Chamber Crowns.—(*a*) Each girder when of the normal type, fitted with stay bolts and nuts, shall be of the double plate interconnected type of sufficient strength to support its proportion of the load on the crown plate independently of the crown plate.

(*b*) The clear waterway between the crown plate and the underside of the girder bars shall be as large as practicable but in no case less than $1\frac{1}{2}$ inches as in Fig. 7.

(*c*) The ends of the girders shall not rest on the landing of the flat crown plate but shall be carefully fitted to bed directly on the bends of the corners of the vertical end or side plates.

(*d*) The toes of the girders shall be solid with the girder plates and not separate pieces attached thereto.

(*e*) Girders shall be properly attached to the crown plate by bolts or screws.

NOTE.—Alternative methods of staying may be used or unstayed firebox, crowns of special or patented design of equivalent strength may be fitted (*see* Regulations 230, 231 and 232).

(*f*) Where an all welded firebox is fitted, the girder stays may be welded to the firebox prior to stress relieving. The girder stays shall be recessed for waterways as in paragraph (*b*) (Figs. 6 and 7).

Such girders shall be securely welded by an approved method to the firebox crown. The method of welding and the proportions of attachment shall be to the satisfaction of the Inspecting Authority.

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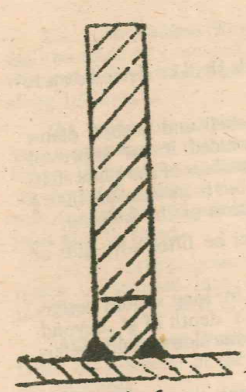


Fig. 6

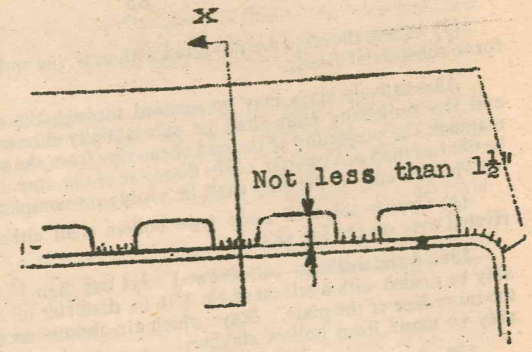


Fig. 7

GUSSET STAYS

140. Gusset Stays.—(*a*) Gusset plates shall be flat and perpendicular to the end plates. The gusset angles shall be fitted to bed closely to the shell end plate and gusset plates. Cranking or setting of the plates is prohibited.

(*b*) Gusset stays, where fitted, shall comprise flat plates secured by double angles to the shell and end plate respectively, and shall be designed in accordance with the following conditions:—

141. Breathing Space.—(*a*) Gusset stays shall be so arranged as to allow sufficient breathing space around furnace connections and tube nests.

(*b*) For Lancashire boilers the proportions shown in the table below are recommended for the portion of the end plates above the furnaces and flues:

Thickness of End Plates	L= (Fig. 8)	L= (Fig. 9)
in.	in.	in.
½	9	10
9/16	10	10
5/8	11	12
11/16 }	12	13
3/4 }		
13/16 }	12½	13½
Above 13/16 }		



Fig. 8



Fig. 9

(*c*) Fig. 8 shows the breathing space recommended for the following conditions: Flat end, furnace or flues flanged for attachment to end plate, furnaces and flues formed with Adamson flanged seams.

(*d*) Fig. 9 shows similar conditions to Fig. 8 except that the end plate is flanged outwards for the furnace or flue ring connection, the breathing spaces allowed being 1 in. more than those for the same thickness of plate in Fig. 8.

(*e*) Where a corrugated section not less than 6 feet long is included in each internal flue of a Lancashire boiler, the dimensions given in the table above may be reduced by approximately 1½ in. throughout.

(*f*) It is recommended that the breathing space below the furnaces and flues shall be approximately one half the dimensions given in the table above. Where it is desired to use any other arrangement which gives a greater or less degree of flexibility, the amount of breathing space shall be specially considered and modified as the necessity of the case requires.

(*g*) For gusset stays above tube nests, as fitted in waste heat boilers without internal furnaces, a breathing space of 8 inches from the centre line of the top tubes to the centre of the toe rivets of the gusset angles is recommended (*see* Fig. 9).

142. Gussets Angles.—The gusset angles connecting the stays to the shell and end plates shall be at least 7/8ths of the thickness of the shell plate, but shall be not less than ½ in. in thickness.

143. Load on Gusset Stay.—Each gusset stay supporting the end plate of a boiler shall be designed to carry the whole load due to pressure on the area supported by it.

144. Gusset Riveting.—(*a*) Rivets securing gusset stays shall not be less in diameter than the thickness of the cylindrical shell plate and the riveting shall be arranged so that the strength of the shell plate where drilled for the gusset rivets shall not be less than the strength of the longitudinal seams.

(*b*) Not less than three rivets shall be used to connect any gusset plate to any angle or any angle to the end plate or to the shell plate.

BOILER TUBES SUBJECT TO EXTERNAL PRESSURE

145. Steel and Wrought Iron Tubes.—Both plain and stay smoke tubes may be made either of wrought iron or steel and may be electric-resistance-welded lapwelded or weldless.

146. Fitting of Plain Tubes.—(*a*) Plain tubes shall be expanded at both ends. The expanding shall be parallel throughout the full thickness of the tube plate. Plain tubes may also be bell-mouthed, beaded, or welded at the gas inlet end.

(*b*) Where stay tubes are not fitted, the ends of the tubes shall be beaded over at the fire box end and beaded or bell-mouthed at the other end. If bell-mouthed the tubes shall protrude not less than ¼ inch beyond the tube plate.

STAY TUBES

147. Screw Threads of Stay Tubes.—(*a*) Stay tubes shall be screwed at both ends with continuous threads, and the holes in the tube plates shall be tapped with continuous threads. The pitch of the threads shall not be finer than 11

threads per inch. The stay tubes shall be expanded by roller expanders and not made tight by caulking only.

(*b*) Stay tubes may be attached by welding in which case they shall not be adjacent within the same tube nest except in local areas, where not more than two adjacent stay tubes may be attached by welding. The form of attachment shall be such that there is a mechanical hold in addition to the welding, as shown in Figure 9A. On completion of welding the stay tubes shall be lightly re-expanded.

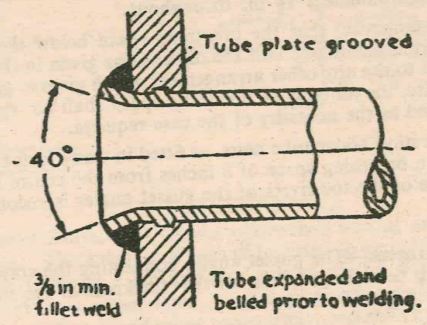


Fig 9A. Typical example of welded stay tube

148. Minimum thickness of Stay Tubes.—Minimum thickness of stay tubes shall be such that the stress on the not cross-sectional area either at the bottom of the threaded part or at the middle of the tube whichever is the lesser shall not exceed 527 kg./cm² (7500 lbs. per sq. in.). Thickness of stay tubes at any part shall not be less than 4·8 mm. (3/16 in.)

149. Thickened ends of Stay Tubes.—If stay tubes are required to have their thickness increased at the screwed ends so that the thickness at the bottom of the threads is approximately the same as in the body of the tube the thickening shall be attained by upsetting and not by welding process, and the tubes shall be annealed after the upsetting.

150. Load on Stay Tubes.—Stay tubes shall be designed to carry the whole load due to pressure on the area to be supported. In each case the area to be calculated is as follows:—

(*a*) For a stay tube within the tube nest the net area to be supported shall be the product of the horizontal and vertical pitches of the stay tube less the area of the tube holes embraced. Where the pitch of the stay tube is irregular the area shall be taken as the square of the mean pitch of the stay tubes (*i.e.*, one quarter the sum of four sides of any quadrilateral bounded by four adjacent stay tubes) less the area of the tube holes embraced.

(*b*) For a stay tube in the boundary row the net area to be supported shall be the area enclosed by lines passing midway between it and the adjacent points of support less the area of any tubes embraced. The adjacent points of support may be other stay tubes, or the commencement of curvature of flanging of centre line of the circle of rivets securing the end plate to the shell angle.

BOILER AND SUPERHEATER TUBES SUBJECT TO INTERNAL PRESSURE

151. Steel Tubes.—(*a*) All tubes which are subject to internal pressure of water or steam shall be cold drawn or hot finished seamless or electric-resistance welded in accordance with Regulations 36 to 63. Except as provided for in clause (*b*) below they shall be without joint.

(*b*) Tubes having an external diameter not exceeding 5 inches may be jointed and such joints may be flash welded, machine forge welded, arc or gas welded. Tubes above 5″ diameter may also be welded provided they are located outside the furnace. Such welds must conform to the requirements of Chapter VIII.

(*c*) Flash welding shall be undertaken on a welding machine of a type approved by the Inspecting Officer and the external fin caused by welding shall be completely removed. The internal fin caused by welding shall also be removed subject to a maximum height of 20 per cent of the wall thickness of the tube.

* (*d*) Arc welded butt joints shall be made by the metallic shielded arc process and stress relieved.

* (*e*) When gas welding is implied the technique followed shall be approved by an Inspecting Officer and all welds shall be suitably heat treated.

* (*f*) For design metal temperatures over 427° C (800° F) material to be used shall be in accordance with the Regulations 48, 53 and 56A.

(*g*) The technique employed in all field welding of tubes shall be subject to the approval of the Chief Inspector of Boilers.

* (*h*)

152. Attachment of Steel Tubes.—(*a*) Tubes shall be connected to the tube plates by one of the following methods:—

(1) Expanding.

(2) Strength welding.

(3) Mechanical bolted ball joint.

(*b*) Drift or roller expanded tubes shall project through the neck or bearing part in the holes by at least a quarter of an inch and shall be secured from drawing out by being bell mouthed to the extent of 1/32″ for each inch in diameter plus 2/32″.

(*c*) Tubes may be seal welded into fittings or headers for both boilers and superheaters after they have been expanded and flared provided the material in the fittings or headers does not contain carbon in excess of 0·35 per cent.

(*d*) In the case of drifted or roller expanded tubes, the tube holes in the tube plates of drums, pockets, or headers shall be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plate, there shall be a neck or belt of parallel seating of at least ½ in. depth measured in a plane normal to the axis of the tube at the holes.

* (*e*) Where the tubes are strength welded direct to the tube plates, the technique followed shall be approved by the Inspecting Authority and all welds shall be suitably heat treated.

(*f*) Tube spacers, supporting clips and lugs may be welded to the tubes. Flash welding of studs for supporting refractories, etc., is also permissible.

(*g*) The tubes shall be so arranged that they are accessible for cleaning internally and externally.

153. Copper Tubes.—Copper tubes up to one inch in external diameter may be used for small boilers; such tubes shall be not less than 12 s.w.g. thick.

HEADERS, MUD BOXES, ETC., OF WATER TUBE BOILERS

* **154.** (*a*) Headers, mud boxes, etc., of water tube boilers may be of solid drawn or welded steel, or of cast steel complying with the requirements of Regulations 73 to 80. Where welded, the welding shall be stress relieved and in all respects to the satisfaction of the Inspecting Authority.

(*b*) Each piece prior to being fitted in place shall be subjected to hydraulic tests to one-and-a-half times the maximum permissible working pressure of the boiler into which it is to be fitted.

(*c*) (*i*) The sighting hole doors and header caps shall be substantial and be capable of being removed or replaced from time to time without loss of efficiency or safety. They may be held in position either by means of bolts or by seal welding.

(*ii*) The bolts by which they are held in place shall be fitted to them in such alway as to satisfy the above conditions.

(*iii*) The doors shall be so designed that they will not blow out in the event of breakage of the bolt.

(*iv*) Circular holes also may be provided in addition to elliptical holes, if provision is made to prevent the door bolts from turning, while securing the joint.

(*d*) All flanges shall have a fillet with a radius of curvature at least equal to the thickness of the necks to which they are attached.

STAND PIPES, PADS, ETC.

155. Stand Pipes and Pads.—Stand pipes and seatings for carrying mountings shall be made of wrought, cast or fabricated steel. Where pipes are fabricated by welding they shall be stress relieved. These shall take the form of short stand pipes, pressed steel plate saddles, forged pads or pads cut from round rolled bar as may be most convenient and secured to the boiler by riveting or welding. Where short stand pipes are used they shall be of solid forged, fabricated or cas s eel. They shall be carefully bedded to the shell before attachment and where riveted the rivets shall be so pi ched as to ensure a tight joint. The jointing faces to which mountings are to be bolted shall be machined. Pads shall have sufficient thickness to allow the drilling of stud holes for mountings without the inner surface being pierced and the length of the screwed portion of the stud in the pad shall be not less than the diameter of the stud.

156.(*a*) **Design of Stand Pipes.**—Where short stand pipes are used, the bolting flanges shall be forged solid with the bodies or attached by combined screw

ing and welding or by welding alone. Solid forged stand pipes shall have a minimum thickness of flange and of body in accordance with the table below:—

	Maximum permissible working pressures lbs. per sq. in.							
	Upto 150		Above 150 and up to 250		Above 250 and up to 350		Above 350 and up to 600	
	Flange adjoining drum	Body	Flange adjoining drum	Body	Flange adjoining drum	Body	Flange adjoining drum	Body
Stand pipes in bore	in.	in.	in.	in.	in.	in.	in.	in.
3/4	—	—	—	—	—	—	3/4	3/8
	7/16	3/8	½	3/8	3/4	3/8	3/4	3/8
¼	7/16	3/8	½	3/8	3/4	3/8	3/4	3/8
1¼	7/16	3/8	½	7/16	3/4	½	3/4	½
2	7/16	3/8	9/16	7/16	3/4	½	7/8	½
2½	7/16	3/8	9/16	7/16	7/8	5/8	7/8	5/8
3	9/16	7/16	5/8	½	7/8	5/8	7/8	5/8
3½	9/16	7/16	5/8	½	7/8	5/8	7/8	5/8
4	9/16	7/16	5/8	½	7/8	5/8	7/8	5/8
4½	9/16	7/16	5/8	½	7/8	5/8	7/8	5/8
5	5/8	9/16	3/4	5/8	7/8	5/8	7/8	5/8
6	5/8	9/16	3/4	5/8	7/8	5/8	7/8	5/8
7	5/8	9/16	3/4	5/8	7/8	5/8	7/8	5/8
8	5/8	9/16	3/4	5/8	7/8	5/8	7/8	5/8
9	5/8	5/8	3/4	5/8	7/8	5/8	—	—
10	5/8	5/8	3/4	5/8	7/8	—	—	—
Pressed saddles	5/8	—	3/4	—	7/8	—	—	—

(*b*) The thickness of stand Pipes and Branches secured to drums and headers by expanding, screwing or welding shall be not less than that given in table below:—

Minimum Body Thicknesses of Stand Pipes and Branches secured by expanding, screwing or welding

Nominal bore of stand pipes and branches	Thickness of shell	Minimum body Thickness*
in.	in.	in.
Up to and including 1¼	¼ and over	¼
Over 1¼ up to and including 3½	5/8 and over	5/16
Over 2½ up to and including 4½	7/8 and over	7/16
Over 4½ up to and including 8	1 and over	½
Over 8 up to and including 10	1¼ and over	5/8

*For thinner shells than given above, minimum body thickness not less than one-half the hickness of the shell.

157. Pressed Plate Saddles.—Where pressed plate saddles are employed they shall be formed to bed closely to the boiler, and machined on the face jointing the mounting and on the edges. The studs for attachment of mountings if screwed through the saddle, shall each be fitted with a nut on the inside having a thickness equal to the diameter of the stud. Where the stud holes do not penetrate through the saddle, the length of the screwed portion of the stud in the plate shall not be less than the diameter of the stud.

158. Seatings for Mountings.—For pressures not exceeding 125 lbs. per sq. in. mountings with screwed ends not exceeding 1 in S.P.T. may be used: the screwed portion of any such mounting being an integral part thereof and the thickness at the bottom of the thread being not less than 3/16".

The mountings may be screwed:—

(*a*) Directly into the boiler shell plate, nuts being fitted on the waterside or

(*b*) Into steel distance pieces the length of thread engaged being in no case less than the bore of the mounting plus $\frac{1}{4}$ in.

159. Attachment of Mountings.—(*a*) Mountings may be attached directly to any shell or end plate where the plate is of sufficient thickness to allow a suitable surface to be obtained for the attachment of the boiler mountings.

(*b*) The minimum thickness at the hole in the shell or end plate shall be not less than the thickness required for the maximum permissible working pressure considering the plate as being unpierced.

(*c*) Where the boiler mountings are secured by studs, the studs shall have a full thread holding in the plate for at least one diameter. If the stud holes penetrate the whole thickness of the plate, the stud shall be screwed right through the plate and be fitted with a nut inside having a thickness equal to the diameter of the stud. Where bolts are used for securing mountings they shall be screwed right through the plate with their heads inside the shell or end plate.

160. Insufficient thickness of End Plates.—(*a*) In cases where the thickness of the end plate is insufficient for this purpose the mountings shall be joined to suitable steel seatings as provided in Regulation 155.

(*b*) The following constructions as to stand pipes attached to shells and end plates shall be permissible:—

(*i*) Where the internal diameter of the stand pipe does not exceed 1 inch, the stand pipe may be screwed into the plate and fitted with a nut on the waterside.

(*ii*) Where the internal diameter of the stand pipe exceeds 1 inch but does not exceed 2 inches, it may be screwed in and seal-welded.

(*iii*) Where the diameter of the stand pipe exceeds 2 inches, it may be welded to the end plate.

The foregoing provisions as to the stand pipe shall be regulated by the following conditions:—

(*i*) When stand pipes are screwed, the screwing shall be of Standard Pipe Thread.

(*ii*) Where stand pipes, saddles or other forms of seatings are fabricated by fusion welding they shall be stress relieved by heat treatment before attachment to the boiler.

(*iii*) Where the bore of the stand pipe or seating and the hole in the plate does not exceed 5 inches plus twice the thickness of the plate, the seating may be welded to the plate without subsequent heat treatment of the weld so made. Where the hole in the plate exceeds 5 inches plus twice the thickness of the plate, the plate to which the seating is attached shall be stress relieved by heat treatment.

161. Attachment of Water and Pressure Gauges.—Water gauge and pressure gauge syphons may be attached direct to the front end plates without the intervention of a pad or stand pipe, provided they are flanged and secured by studs. If the studs are screwed through the plate, nuts shall be fitted on the inside of the plate.

162. Mountings on Flat Plates.—Where the flanged mountings are attached direct to a flat plate, such mountings shall be provided with a substantial spigot, the full thickness of the boiler plate.

163. Bolts and Nuts.—Bolts and nuts shall be machined where they come in contact with the flanges, and all holes in saddles and pads shall be drilled.

NOTE—In all cases where boiler is lagged the joint of the mountings shall be clear of the lagging surface or the lagging kept clear of the flange so that the joint can be inspected and, when necessary, remade.

MANHOLES, MUDHOLES, ETC.

164. Access.—(*a*) Sufficient sight and cleaning holes shall be provided to permit of efficient inspecting and cleaning. Such holes shall normally be elliptical in form and not less than $3\frac{1}{2}$ in. $\times 2\frac{1}{2}$ in.*

(*b*) At least one manhole or sight hole shall be provided in the upper part of the cylindrical shell or in the shell crown, or end plate and this shall not be less than:—

	in.
Boilers not exceeding 2 ft. 6 in.	9×7
Boilers over 2 ft. 6 in. diameter and not exceeding 3 ft.	12×9
Boilers over 3 ft. diameter and not exceeding 3 ft. 6 in.	14×10
Boilers over 3 ft. 6 in. diameter and not exceeding 4 ft.	15×11
Boilers over 4 ft.	16×12

(*c*) Where the size or construction of the boiler does not permit of entry for cleaning and inspection sufficient cleaning holes shall be provided in the shell for these purposes.

(*d*) Where cross tubes are fitted in Vertical boilers one cleaning hole shall be provided opposite at least one end of each tube. At the bottom of the narrow water spaces at least three cleaning holes shall be provided. The cleaning holes shall be so arranged that the circumferential distance between

*NOTE.— Standard sizes of mudholes and sightholes are 7"×5", 5"×3½" and 3½"×2½".

them does not exceed 3 ft. unless the foundation ring is sufficiently accessible to permit of cleaning and inspection from the inside of the boiler.

NOTE.—Wherever praticable the frames should be secured to the inside of the shells so that the shorter axis is parallel to the longitudinal centre line of the boiler.

(*e*) Cleaning holes or mudholes in Loco Type boilers shall be provided at each bottom corner of the outer firebox casing, above the fire hole ring and on each side of saddle plate in line with bottom of barrel.

(*f*) In the case of small boilers or where the foregoing provisions are impracticable the cleaning holes or mudholes shall be as nearly as possible in the corner of the outer firebox casing and the holes as large as circumstances permit.

165. Compensating Rings and Frames for Openings in Shells.—(*a*) Compensating rings and frames for openings in shells shall be of wrought or cast steel. The compensation provided shall preferably be flanged frames, which shall be fitted in all cases where the shell plate exceeds 9/16 in. thick. Flanged frames shall be weldless and shall be flanged or pressed to provide a flat jointing surface for the cover.

(*b*) All compensating rings and frames shall be formed to bed closely to the surfaces to be connected. Where attached to cylindrical shells and are 12 in. × 9 in. or larger they shall be at least double riveted. All caulking edges shall be machined or machine gas cut.

(*c*) The flat jointing surfaces of all flanged or pressed frames and all doors or covers shall be machined.

166. Doors and Cross Bars.—(*a*) All internally fitted doors of manholes, mudholes and sightholes shall be of wrought steel built up or pressed to shape and annealed or made from one thickness of plate with a machined recess for the jointing material or may be a steel casting. Their spigot part or the recess shall not have a greater clearance than 1/16th inch all round, *i.e.* the axis shall not be less than 1/8th inch smaller than the holes in which they are fitted.

(*b*) The studs or bolts of large doors may be screwed through the plates and riveted over when the working pressure of the boilers does not exceed 200 lbs. per square inch. When such pressure exceeds 200 lbs. per square inch, the studs or bolts need not be screwed through the full thickness of the plate, provided that the depth of screwing is not less than the diameter of the stud and the stud is locked against turning by welding or other means approved by the Inspecting Authority. Lugs may be satisfactorily welded to manhole doors for the attachment of bolts. All welds shall be made to the satisfaction of the Inspecting Authority.

* (*c*) Internal doors for opening not larger than 9 in. × 7 in. size need only be fitted with one stud, which shall be provided with an integral colar and screwed through the plate with a nut on the inside of the door. Internal doors of opening not larger than 5 in. × 3½ in. may have the stud forged solid with the door or screwed, be efficiently riveted to the doors.

(*d*) The cross bars shall be of substantial proportions and of mild or wrought steel.

167. Raised Manhole Frames and Cover Plates.—(*a*) Raised circular manhole frames not exceeding 16 inches in diameter shall be at least ¾ inches thick in all parts. The circular cover plates and joint flanges for such frames shall be not less than:

1 inch thick for pressures not exceeding 120 lbs. sq. inch.

1⅛ inch thick for pressures over 120 lbs. but not exceeding 200 lbs. sq. inch.

1¼ inch thick for pressures over 200 lbs. but not exceeding 250 lbs. sq. inch.

For pressures 250 lbs. sq. inch and over raised circular manhole frames shall not be fitted.

The cover plates shall be secured by at least sixteen steel bolts not less than 1 inch diameter.

(*b*) Exteral raised circular mouthpieces shall be:

(1) formed in one piece without welds,

(2) formed from a suitable rolled section and forge welded, or

(3) fabricated by fusion welding provided they are stress relieved by heat treatment after welding and before attaching to the boiler.

Welds should be positioned so that they are located on the transverse centre line of the boiler. The jointing flanges of mouthpieces and covers shall be machined on the face and edge and on the bearing surface for the bolts.

Bolts and nuts shall be machined where in contact with the flanges and the joints should be formed inside and outside the bolts to preclude the possibility of flange distortion. Cover plates shall be dished outwards to a depth of approximately one-eighth of the internal diameter of the frame.

All frames and mouthpieces shall bed closely to the surfaces to which they are to be connected, and where riveted to cylindrical shells shall be at least double riveted. All caulking edges shall be machined or machine gas cut.

168. Position of Manhole in Shell.—Manholes in cylindrical shells shall be placed as far as possible from any riveted seams, preferably towards the back end of the boiler top.

169. Compensation Rings to Manholes.—(*a*) Compensation shall be provided in every case for the part cut out of a cylindrical shell for a manhole. The strength of the net section of compensating ring and also of the rivets securing them to the shell, compared with that part of the shell cut out, shall not be less than the efficiency of the longitudinal seam.

(*b*) The spacing of the rivets shall be such as not to reduce the strength of the shell plate below that of the longitudinal seams.

170. Compensation for cutting large holes in Shell Type Boilers.—(*a*) Where holes are cut in the cylindrical shell for the purpose of attaching a seating of frame or door, compensation shall be provided such that the added sectional area, including parts of the frame within 4 inches of the shell and excluding rivet holes, shall be not less than the sectional area of the plate removed which shall be the product of the diameter of the opening and the calculated thickness of the plate as found by Equation 1. Where holes are cut in the cylindrical shell for the purpose of fixing seating for mountings and the diameter of the holes is greater than 2½ times the thickness of the shell plate plus 2¾ inches, compensation shall be provided. Where a large opening is cut in a cylindrical shell to receive another part of the structure, the sides where

cut away shall be efficiently cross-stayed or strengthened in some other effective manner.

(*b*) **Riveted construction.**—Where frames, pads or branches are secured by riveting on shell for fixing of mountings or other pressure parts, the sectional area to be compensated shall be determined as follows:— (*See* Figure 25 A).

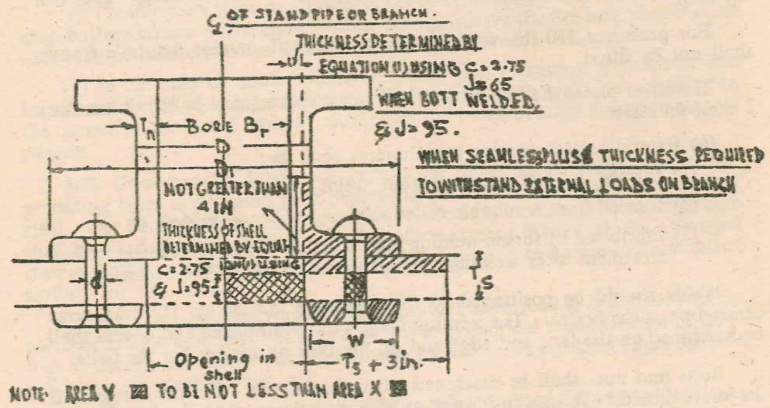


Fig. 25A Compensation for Riveted Stand Pipes Area to be compensated and Corresponding Area Allowance for Compensation.

(*i*) The cross-sectional area of the frame or pad excluding rivet holes, or in the case of a branch the cross-sectional area of the wall of the branch and flange, excluding rivet holes, minus the sectional area of a branch of the same bore having thickness calculated by equation 1 for the same design pressure, using C=2.75, J=65 when butt welded, and J=95 when seamless, plus the thickness required to withstand external loads. The area shall be measured within the limit specified in Figure 25-A.

Due allowance shall be made in case where the material used for the branch and/or compensating ring differs from that of the plate to which it is attached.

(*ii*) The area obtained by multiplying the difference between the actual shell thickness and the calculated thickness, by a length

$$2(3 \text{ in.} + T_s - d)$$

T_s=Thickness of shell plate in inches

d=diameter of rivet hole in inches.

In cases where the sum of (*i*) and (*ii*) is less than the sectional area to be compensated, a compensating plate shall be fitted having a total net cross-sectional area equal to the amount of the deficit.

171. Rivets securing compensating Rings and Stand Pipes.—(*a*) **For manholes or frames.**—The total effective shear strength of the rivets on each side of the longitudinal centre line shall be not less than the tensile strength of that portion of the shell plate, as found by Regulation 170, which is removed and

the rivets securing any compensating ring or frame shall be so arranged that the joint efficiency calculated on any line parallel to the axis of the boiler through any part of such ring or frame shall not be less than the efficiency of the longitudinal seam of the boiler.

(*b*) **For stand pipes.**—Where the hole in the shell to accommodate a standpipe does not exceed 8 inches diameter, the total effective shear strength of the rivets on each side of the longitudinal centre line shall not be less than 75 per cent. of the tensile strength of the portion of the plate, as found by Regulation 170, which has been removed.

The strength of rivets in double shear shall be taken as 1·875 times the strength of rivets in single shear.

RIVETING

172-A. Rivet Heads.—The rivet heads shall be of any one of the form [shown in sketch (1) Appenidx H-4] given below:

1. Snap head.
2. Ellipsoidal head.
3. Pan head.
4. Conical head.
5. Round countersunk head.
6. Pan head with tapered neck.
7. Steeple head.
8. Countersunk head.

The dimensions of these rivet heads shall conform to the proportions indicated in the sketch.

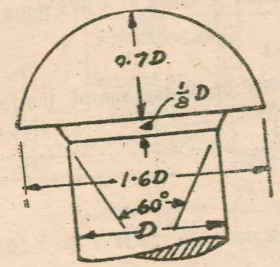
The Chief Inspector may, at his discretion, accept any slight variation in the proportion of these dimensions and forms.

172-B. Tolerances on shanks.—The tolerances on the diameters of the shanks measured at position XX, YY, ZZ shown in sketch 2, Appendix H-4 shall be within the limits given in table below:—

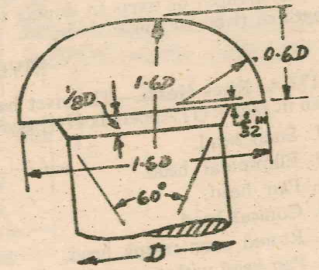
Diameter of Shanks

Reference position as shown in Sketch-2 Appendix H-4	Distance from rivet head or end	For rivets 5D and below in length		For rivets over 5D in length	
		Max.	Min.	Max.	Min.
XX	$\frac{D}{8}$ plus $\frac{1}{4}$ inch	D plus $\frac{1}{64}$ inch for D=1 inch and under	D	D plus $\frac{1}{64}$ inch fer D=1 inch and under	D
YY	$\frac{D}{2}$ from end	D	D—1/64 inch	D	D—1/64"
ZZ	$\frac{D}{2}$ from end	—	—	—	D—1/64"

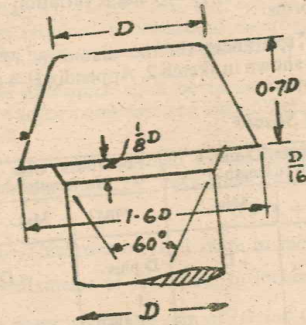
APPENDIX - H4. - SKETCH 1.
HEADS FOR BOILER RIVETS.



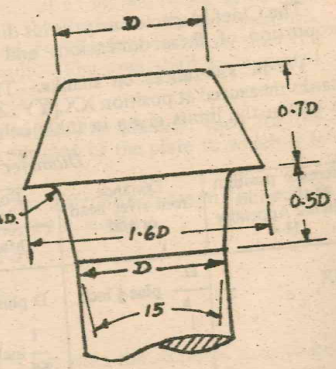
SNAP HEAD



ELLIPSOIDAL HEAD

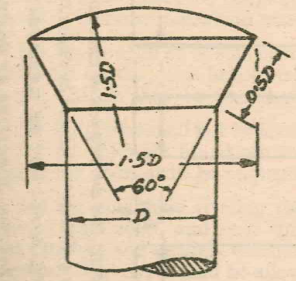


PAN HEAD.

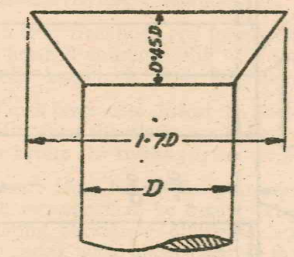


PAN HEAD WITH TAPERED NECK.

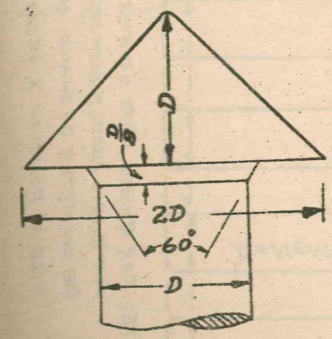
APPENDIX H4. SKETCH 1.
HEADS FOR BOILER RIVETS.



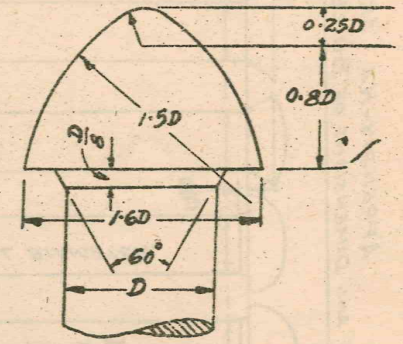
ROUND COUNTERSUNK HEAD.



COUNTERSUNK HEAD



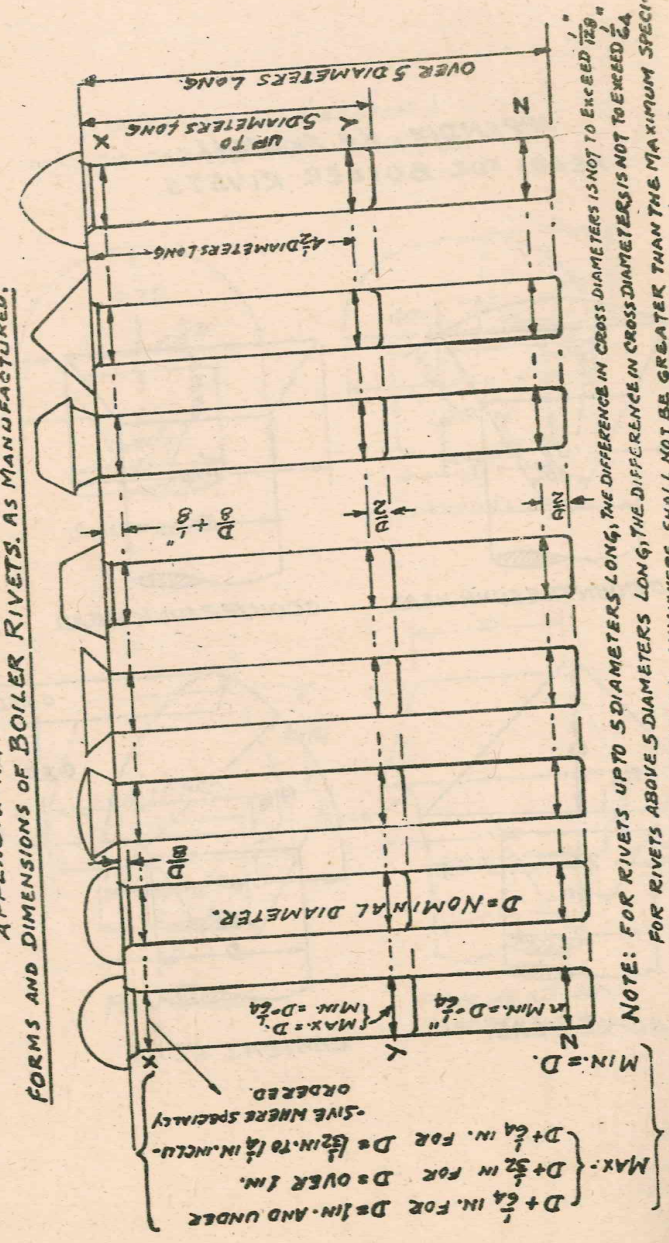
STEEPLE HEAD.



CONICAL HEAD

APPENDIX-H4 - SKETCH 2.

FORMS AND DIMENSIONS OF BOILER RIVETS. AS MANUFACTURED.



172-C. Rivet Holes.—(1) Rivet holes shall not be punched, but shall be drilled full size from the solid plate, and wherever possible rivet holes shall be drilled in place with plates, straps and ends bolted in position. After drilling the plates shall be separated, the burrs and the sharp edges of the holes shall be removed and the contact surfaces of the plates shall be cleaned. All tacking holes shall be drilled to a size which will allow the holes to be enlarged to the required rivet size by drilling or reamering. All rivet holes shall be slightly countersunk under each rivet head.

(2) The diameter of the rivet hole shall be not more than 1/16 in. larger than the standard diameter of the cold rivet as manufactured.

(3) Where sizes of rivets are mentioned the sizes refer to the diameters of the rivet holes not to the diameters of the rivets used before closing.

173. Riveting.—(*a*) Rivets shall be closed by hydraulic machinery wherever the design of the boiler permits; the rivets may be closed by hand or pneumatic hammer in position where hydraulic riveting is impracticable.

(*b*) Rivets shall be of sufficient length to fill rivet holes and form sound and substantial heads. The heads shall be finished concentrically with the rivet shanks. Rivets shall be heated uniformly throughout their full length.

(*c*) Drift pins shall not be used with such force as to distort the rivet holes. If the rivet holes are found not to be fair when the plates are bolted up for riveting the holes shall be reamered fair before the riveting is commenced.

(*d*) For hydraulic riveting the pressure shall be the least necessary to ensure a tight joint, and only sufficient pressure shall be used to close the rivets properly and securely without indenting, buckling or otherwise damaging the plate. The rivets shall be allowed to shrink while under pressure from the riveting machine.

174. Fullering and Caulking.—All seams shall be fullered or caulked inside and outside and this shall be done in such a manner that the plates are not sprung or damaged.

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