

**CYLINDRICAL MULTITUBULAR BOILERS,
MAIN, AUXILIARY, OR DONKEY.**Shipbuilders Burntisland S.B. Co'sYard No. 218Engineers Rankin & BlackmoreEngine No. 456

Boilermakers " "

Boiler No. _____

No. 2 S.E. or D.E. W.P. 200 lbs. T.P. lbs. Internal Dia. 11'-6" Length 11'-0"No. of Furnaces 2 H.S. each Br. 1200 sq. ft. G.S. sq. ft. Tensile Strength } Shell & Butt Straps 29/33Rivets not stated
assume 23 m shear

$$6.375 \text{ SHELL. (i.) \% Plate} = \frac{100(p-d)}{p} = \frac{100(7.4375 - 1.0625)}{7.4375} = 85.7$$

$$(ii.) \% \text{ Rivet} = \frac{100(S_2 \times a \times n \times C)}{S_1 \times p \times T} = \frac{100(23 \times .88664 \times 5 \times 1.875)}{29 \times 7.4375 \times 1.03125} = 86.0$$

$$5.3125 \text{ (iii.) \% Combined} = \frac{100(p-2d)}{p} + \frac{100(S_2 \times a \times C)}{S_1 \times p \times T} = \frac{100(7.4375 - 2.125)}{7.4375} + \frac{100(23 \times .88664 \times 1.875)}{29 \times 7.4375 \times 1.03125} = 88.6$$

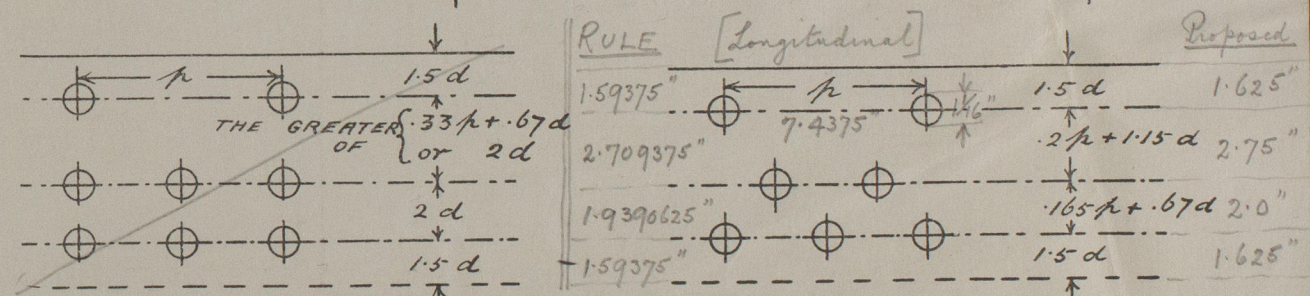
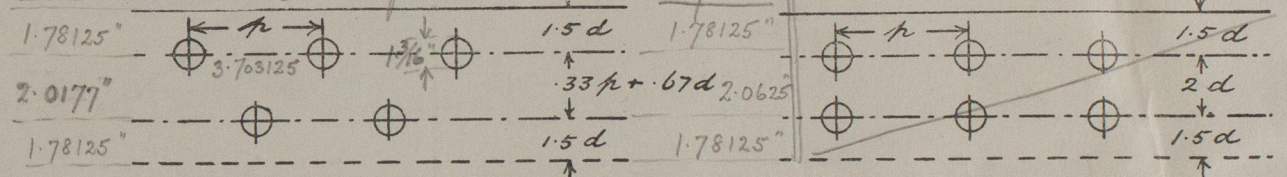
$$(iv.) \% \text{ More than 3 screw stays pierce shell} = \frac{100(p-d)}{p} = \checkmark$$

$$\text{Shell not exceeding } 1\frac{3}{4}" \text{ thick, W.P.} = \frac{(t-2) \times s \times J}{C \times D} = \frac{(33-2) \times 29 \times 85.7}{2.75 \times 138} = 203 \text{ lb./sq. in.}$$

$$\text{Shell exceeding } 1\frac{3}{4}" \text{ thick, with D.B. Straps, W.P.} = \frac{t \times S \times J}{2.85 \times D} = \checkmark$$

$$\text{Outer Butt Strap} = \frac{.625 \times (p-d)}{p-2d} \times T = \frac{.625(7.4375 - 1.0625)}{7.4375 - 2.125} \times 1.03125 = 0.774" \quad \text{Proposed } 0.8125"$$

$$\text{Inner Butt Strap} = .125 + \text{outer butt strap thickness} = .125 + .774 = 0.899" \quad \text{Proposed } 0.9375"$$

RULE RIVETING. [Circumferential] Proposed

$$\text{Maximum Pitch, inches} = (C \times T) + 1.625 = (6 \times 1.03125) + 1.625 = 7.8125" \quad \text{Proposed } 7.4375"$$

$$\text{Circ. End Seams (42 \%), Plate \%} = \frac{100(3.703125 - 1.1875)}{3.703125} = 67.9 \quad \text{Rivet \%} = \frac{100(23 \times 1.1075 \times 2 \times 1)}{29 \times 3.703125 \times 1.03125} = 46.0$$

Circ. End Seams of all Boilers (Shell exceeding $\frac{3}{8}"$), and Intermediate Seam of D.E. Boilers (Shell exceeding $\frac{1}{2}"$) to be double riveted.Circ. Intermediate Seams S.E. Brs. (60 %), Plate % = \checkmark Rivet % = \checkmark Circ. Intermediate Seams D.E. Brs. (62 %), Plate % = \checkmark Rivet % = \checkmark Circ. Intermediate Seams of S.E. Brs. Shell exceeding $1\frac{3}{8}"$ & D.E. Brs. Shell exceeding $1\frac{3}{8}"$ thick, to be treble riveted. \checkmark **FURNACES & C. C. BOTTOM PLATES.**Tensile Strength = 26/30

$$\text{Corrugated Furnaces, W.P.} = \frac{C(t-1)}{D} = \frac{4.80(18-1)}{40.125} = 203.3$$

Plain Furnaces and C.C. Bottom Plates (least pressure obtained by formulæ)

$$\text{W.P.} = \frac{(t-1)^2}{(L+24) \times D} \times \begin{cases} 1450 \text{ if welded or } \\ 1300 \text{ if riveted } \end{cases} = \frac{(26-1)^2 \times 1450}{(29.5+24) \times 44.625} = 379.8$$

$$\text{W.P.} = \frac{10(t-1)-L}{D} \times \begin{cases} 50 \text{ if welded or } \\ 45 \text{ if riveted } \end{cases} = \frac{10(26-1)-29.5}{44.625} \times 50 = 247$$

$$\text{C.C. Bottom Plate (plain furnaces)} \quad t = \frac{(L \times T) - (l \times t)}{B} = \checkmark$$

"Stand-out" of top end plates

$$x = \frac{1}{2} \sqrt{\frac{110(34-1)^2}{2 \times 200}} = 8.65"$$

Radius

Top end plates $r = 3\frac{1}{2} \times 1\frac{1}{6} = 3\frac{23}{32}$ or 3.71875 "

Bottom back end $r = 3\frac{1}{2} \times \frac{7}{8} = 3\frac{1}{6}$ or 3.0625 "

Bottom front end $r = 1\frac{7}{8} + 1 = 2\frac{7}{8}$ or 2.875 "

Furnaces $r = 2 + 1 = 3$ "

Back tube plate $r = \frac{25}{32} + \frac{7}{8} = 1\frac{21}{32}$ or 1.656 "

Compensation Plate for Manhole

Tensile strength of compensation plate = $29T/\square$ min

Strength of shell at XX = tensile strength of remaining shell plate (in red) + single shear of 14 - $1\frac{1}{6}$ " dia. rivets

$$i.e. = \{ [16.75 - (2 \times 1.0625)] \times 1.03125 \times 29 \} + (14 \times 88664 \times 23)$$

$$= 722.4 \text{ tons}$$

Strength of shell at butt-strip

$$= 28.75 \times 1.03125 \times 29 \times 845$$

$$= 726 \text{ tons}$$

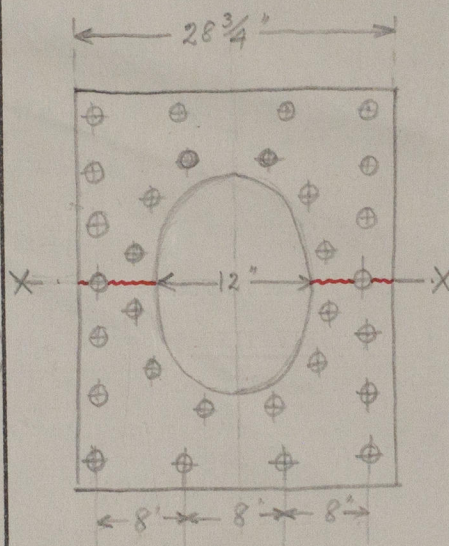
Hence, section at XX slightly weaker than longitudinal joint

AMENDMENTS.

Note: 2 stay tubes to be fitted with nuts

Transverse leg $\frac{336}{84} \times \frac{1089}{2 \times (15)^2} = 203$ (accept)

30 - $1\frac{1}{6}$ " dia. rivets
Plate $1\frac{1}{2}$ " thick



36 Rivets total in plate

17 Rivets to be fitted in each half

$$985 \times \frac{17}{14} = 12.00 \square$$

FLAT PLATES.

200 lb/sq"

Tensile Strength = $\frac{26}{30}$

4296

Top End Plates,

$$W.P. = \frac{C(t-1)^2}{a^2 + b^2} = \frac{96(34-1)^2}{(16.75)^2 + (15.25)^2} = 204$$

110,96,96

Loose Washers $\left\{ \begin{array}{l} 3.5D \times \frac{3}{8}t \\ 3p \times \frac{3}{8}t \end{array} \right\}$

$$W.P. = \frac{100}{a^2 + b^2} [(t-1)^2 + 15t_w^2] = \frac{100 \cdot 7(34-1)^2}{(19)^2} = 304$$

110,96,52

Riveted Washers $\left\{ \begin{array}{l} 3p \times \frac{3}{8}t \\ 3p \times \frac{3}{8}t \end{array} \right\}$

$$W.P. = \frac{100}{a^2 + b^2} [(t-1)^2 + 35t_w^2] = \frac{86 \times (34-1)^2}{(17.5)^2} = 306$$

96,96,72,52

Riveted Strips $\left\{ \begin{array}{l} 3p \times \frac{3}{8}t \\ 3p \times \frac{3}{8}t \end{array} \right\}$

$$W.P. = \frac{100}{a^2 + b^2} [(t-1)^2 + 55t_w^2] = \frac{79(34-1)^2}{2 \times (15.1)^2} = 188.8 \quad ? \quad (34-1)^2 = 195.5$$

72,72,52,52

Riveted Doublings $\left\{ \begin{array}{l} 3t \text{ to } 1t \end{array} \right\}$

$$W.P. = \frac{100}{a^2 + b^2} [(t-1)^2 + 85t_w^2] = \frac{62(32-1)^2}{2 \times (11.98)^2} = 208 \quad \checkmark \quad \frac{62(32-1)^2}{(4.125)^2 + (18.125)^2} = 172.5$$

96,96,72,72

Top End Plate, between tubes and stays, W.P. =

$$\frac{84(34-1)^2}{(15.375)^2 + (18.125)^2} = 162 \quad ? \quad + \frac{74(34-1)^2}{(19.5)^2 + (14)^2} = 139.8 \quad (see opposite)$$

63,63,72,72

Front Tube Plate w.w. space,

$$W.P. = \frac{C}{a^2 + b^2} [(t-1)^2 + 55t_w^2] = \frac{67.5(32-1)^2}{(8.25)^2 + (14)^2} = 245.7$$

38

Back Tube Plate in nests, W.P. =

$$\frac{C(t-1)^2}{p^2} = \frac{38(25-1)^2}{(9.524)^2} = 241.2$$

Back Tube Plate in compression, W.P. =

$$875 \times \frac{(D-d) \times t}{W \times D} = 875 \times \frac{(4.125 - 2.68) \times 25}{34.5625 \times 4.125} = 222$$

C.C. Girders; C for 1 stay = 247.5; for 2 or 3 = 371; for 4 or 5 = 412.5; for 6 = 433.

W.P. = $\frac{C \times d^2 \times t}{(L-P) \times D \times L} \times \frac{S}{28}$

$$= \frac{371 \times (9.25)^2 \times 48}{(34.5625 - 8.25) \times 8.5 \times 34.5625} \times \frac{29}{28} = 204.6$$

75

C.C. Back Plate, W.P. =

$$\frac{75 \times (21-1)^2}{(9.125)^2 + 8^2} = 203.6$$

75

C.C. Top Plate, W.P. =

$$\frac{75 \times (21-1)^2}{(8.25)^2 + (8.5)^2} = 213.7$$

75

C.C. Side Plate, W.P. =

$$\frac{75 \times (21-1)^2}{(9)^2 + (8.25)^2} = 201.2$$

96,84,52

Back Tube Plate at Wing space, W.P. =

$$\frac{77.3(25-1)^2}{(14.3)^2} = 218 \quad [96,52,52] \quad \frac{66.7(25-1)^2}{(12.5)^2} = 246$$

110,52,52

Front Tube Plate at Wing space, W.P. =

$$\frac{71.3(32-1)^2}{(14.75)^2} = 315$$

3296

Lower Front Plate at bottom, W.P. =

$$\frac{96(32-1)^2}{(18)^2} = 284.5$$

2286, 1296

Lower Back Plate at bottom, W.P. =

$$\frac{89.3(28-1)^2}{(16.5)^2} = 239 \quad [110,96,86,86] \quad \frac{94.5(28-1)^2}{(10.4)^2 + (12)^2} = 273.2$$

4286

Back End Plate at w.w. space, W.P. =

$$\frac{86(28-1)^2}{(8)^2 + (14.25)^2} = 235$$

MAIN STAYS.

Material Steel

Tensile Strength = $\frac{28}{32}$

$$W.P. = \frac{(34)^2 \times 9500}{28} \times \frac{28}{28} = \checkmark$$

$$\text{or } \frac{(2.5 - 1.25)^2 \times 9500}{16.75 \times 15.25} \times \frac{28}{28} = 210$$

SCREW STAYS.

Material Steel

No. of threads per inch 9

Tensile Strength = $\frac{26}{30}$

$$C.C. Stays, W.P. = \frac{(1.625 - 2.67)^2 \times 8250}{9 \times 8.25} = 205$$

$$W.W. Space Margin Stays, W.P. = \frac{(1.875 - 2.67)^2 \times 8250}{11.6875 \times 8} = 228$$

PLAIN TUBES.

Ext. Dia. = 3"

Thickness reqd. = 8

L.S.G., Thickness fitted = 8 L.S.G.

STAY TUBES.

Ext. Dia. = 3"

Thickness fitted = $\frac{5\frac{1}{2}}{14}$

No. of threads per inch = 9

$$\text{Do. } W.P. = \frac{7500 \times 1.50}{(10.3125 \times 8.25) - (5 \times 7.07)} = 226 + \frac{7500 \times 1.98}{(11.125 \times 8.25) - (3 \times 7.07)} = 210.4 \text{ (wide water)}$$

$$\text{MANHOLE COMPENSATION PLATE. Least percentage required} = \frac{85.7 \times \frac{200}{203}}{12.3 \square} = 84.5\%$$

$$\text{Section of Shell Plate cut out} = [12 + (2 \times 1.0625)] \times 1.03125 \times 845 \text{ Compensation fitted} = [16.75 - (2 \times 1.0625)] \times 1.03125 = 15.0625$$

$$\text{Riveting of Compensation Plate} = 14 \times 88664 \times \frac{23}{29} = 9.85 \square \text{ Plate \% at ends} = \frac{100(8 - 1.0625)}{8} = 86.72\%$$

$$\text{FLANGED MANHOLES, Depth of Flange} = \sqrt{t \times w} = \sqrt{875 \times 12} = 3.24" \text{ proposed } - 3.25"$$

STEAM DOME.

Plate \% = \checkmark

Rivet \% = \checkmark

$$\text{Shell, W.P.} = \frac{(t-2) \times S \times J}{C \times D} = \checkmark$$

$$\text{Crown, W.P.} = \frac{15 \times S \times (t-1)}{R} = \checkmark$$

SAFETY VALVES.

Area required = \checkmark

COPY OF APPROVED PLAN IS ~~NOT~~ RETAINED FOR REFERENCE.