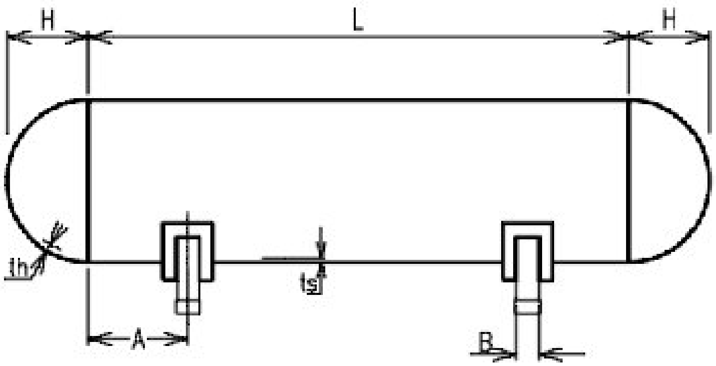
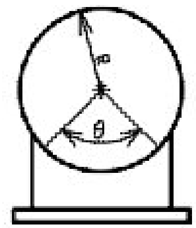
Holloway job # F____ *Date: x/x/xx*

Reference:C:\Users\dreeves\Documents\work\units.xmcd(R)





NOTATION:

All Dimensions in inches, unless noted

Q = Load on one saddle (lbs)
R = Radius of shell/head
S = Stress (lbs per square inch -psi)
t_s = wall thickness of shell
t_h = wall thickness of head
K = calculation constant
Θ = saddle contact angle (degrees)

Shell and Head material = SA ASTM 516-70 plate
Saddle Material = SA ASTM A-36 plate

Tangent to tangent of vessel--------Head tangent- $tan_{head} := 2 \cdot in$ $L := 30 \cdot ft + 2 \cdot tan_{head} = 364 \cdot in$

CL of saddle to tangent line-------- $A_{desired} := 62 \cdot in$ note ! $A_{max} := .2 \times L = 72.8 \cdot in$ $A := \min(A_{desired}, A_{max}) = 62 in$

Width of saddle--------------------- $B := 8 \cdot in$

Depth of head----------------------- $H := 30 \cdot in + tan_{head}$ 2:1 Elliptical $H = 32 \cdot in$

Design pressure - internal---------- $P := 600 \cdot psi$ Load on one saddle---------------- $Q := 48 \cdot kip$

Radius per vessel OD)------------ $R := 60 \cdot in$ Allowable stress-------------------- $S_{allow} := 17500 \cdot psi$

Shell thickness--------------------- $t_s := 1.25 \cdot in$ Yield point---------------------------- $Y_p := 38000 \cdot psi$

Head thickness--------------------- $t_h := 1.25 \cdot in$ Joint efficiency---------------------- $E := .85$

Wear Plate thickness--------------- $t_w := 0.5 \cdot in$ Contact Angle---------------------- $\theta := 120 \cdot deg$

$k_1 := .335$ since $A > \frac{R}{2}$

Longitudinal Bending Stress
S1----use larger of S_{1a} or S_{1b}

Stress at the saddles = S_{1a}

$$S_{1a} := \frac{Q \cdot A \cdot \left[1 - \left(\frac{1 - \frac{A}{L} + \frac{R^2 - H^2}{2 \cdot A \cdot L}}{1 + \frac{4 \cdot H}{3 \cdot L}}\right)\right]}{k_1 \cdot R^2 \cdot t_s} = 407.2 \cdot psi$$

Stress at midspan = S_{1b}

$$S_{1b} := \frac{\frac{Q \cdot L}{4} \cdot \left(\frac{1 + 2 \cdot \frac{R^2 - H^2}{L^2}}{1 + \frac{4 \cdot H}{3 \cdot L}} - \frac{4 \cdot A}{L}\right)}{\pi \cdot R^2 \cdot t_s} = 76.8 \cdot psi$$

$$S_1 := \max(S_{1a}, S_{1b}) = 407.2 \cdot psi$$

Stress due to internal pressure = $S_{int} := \frac{P \cdot R}{2 \cdot t_s} = 14400 \cdot psi$ $S_1 = 407.2 \cdot psi$ $S_1 + S_{int} = 14807 \cdot psi$

S1 is ok ...if (S1 + Sint) is less than (Sallow x E) $E = 85 \cdot \%$ $S_{allow} = 17500 \cdot psi$ $S_{allow} \times E = 14875 \cdot psi$

$$tension := \begin{cases} \text{"ok"} & \text{if } (S_{allow} \times E) \ge (S_1 + S_{int}) \\ \text{"need stiffener ring"} & \text{otherwise} \end{cases} = \text{"ok"}$$

$$compression := \begin{cases} \text{"compression is a non-factor"} & \text{if } \frac{t_s}{R} \ge 0.005 \\ \text{"compression is a factor"} & \text{otherwise} \end{cases} = \text{"compression is a non-factor"}$$

$$\frac{t_s}{R} = 0.021$$

Tangential Shear Stress ---- S2 governed by 3 conditions:
S2a (if A>R/2) , S2b shell or S2c head (if A<=R/2), -no stiffener rings.

Saddles away from Head = S2a

$K_2 := 1.171$ $\quad K_3 := 0.319$ $\quad A = 62\,in$ $\quad \frac{R}{2} = 30\,in$

$$S_{2a} := \frac{K_2 \cdot Q}{R \cdot t_s} \cdot \left(\frac{L - 2 \cdot A}{L + \frac{4}{3} \cdot H} \right) = 442.3 \cdot psi \qquad S_{2b} := \frac{K_3 \cdot Q}{R \cdot t_s} \cdot \left(\frac{L - 2 \cdot A}{L + \frac{4}{3} \cdot H} \right) = 120.5 \cdot psi$$

Saddles close to Head = S2c (shell)

$K_4 := 0.88$

$$S_{2c} := \frac{K_4 \cdot Q}{R \cdot t_s} = 563.2 \cdot psi$$

Saddles close to Head = S2d (head)

$$S_{2d} := \frac{K_4 \cdot Q}{R \cdot t_h} = 563.2 \cdot psi$$

Saddles close to Head = S2e (add'l stress in head)

$K_5 := 0.401$

$$S_{2e} := \frac{K_5 \cdot Q}{R \cdot t_h} = 256.64 \cdot psi \qquad S_2 := \max(S_{2a}, S_{2b}, S_{2c}, S_{2d}, S_{2e}) = 563.2 \cdot psi$$

When Saddles are close to Head, S3 = S2d + S2e

$$S_3 := S_{2d} + S_{2e} = 819.84 \cdot psi$$

S2 is okay if S2 is <= 0.8 x S_{allow} $\quad S_{allow} \times 0.8 = 14000 \cdot psi$

$$S_2 := \begin{cases} \text{"ok"} & \text{if } (S_{allow} \times 1.25) \ge S_2 \\ \text{"no good"} & \text{otherwise} \end{cases} = \text{"ok"}$$

S3 is okay if S3 + S_{int} is <= 1.25 x S_{allow} $\quad S_3 + S_{int} = 15220 \cdot psi$

$1.25 \cdot S_{allow} = 21875 \cdot psi$

$$S_3 := \begin{cases} \text{"ok"} & \text{if } (S_{allow} \times 1.25) \ge (S_3 + S_{int}) \\ \text{"no good"} & \text{otherwise} \end{cases} = \text{"ok"}$$

$\frac{A}{R} = 1.033$, therefore... $K_6 := 0.04$ $L = 364\,in$ $8 \cdot R = 480\,in$ $A = 62 \cdot in$ $\frac{R}{2} = 30 \cdot in$

$$S_{4a} := -1\left[\frac{Q}{4 \cdot \text{if}\left[A \le \frac{R}{2}, (t_s + t_w), t_s\right] \cdot \left(B + 1.56 \cdot \sqrt{R \cdot t_s}\right)} - \frac{3 \cdot K_6 \cdot Q}{2 \cdot \text{if}\left[A \le \frac{R}{2}, \left(t_s^2 + t_w^2\right), t_s^2\right]}\right] = 1396.9 \cdot psi$$

$$S_{4b} := -1 \cdot \left[\frac{Q}{4 \cdot \text{if}\left(A \le \frac{R}{2}, t_s + t_w, t_s\right) \cdot \left(B + 1.56 \cdot \sqrt{R \cdot t_s}\right)} - \frac{12 \cdot K_6 \cdot Q \cdot R}{L \cdot \text{if}\left[A \le \frac{R}{2}, \left(t_s^2 + t_w^2\right), t_s^2\right]}\right] = 1984.3 \cdot psi$$

$S_4 := \max\left(S_{4a}, S_{4b}\right) = 1984.3 \cdot psi$

$S_4 = 1984 \cdot psi$ $S_{allow} \times 1.5 = 26250 \cdot psi$

$$S_4 := \begin{cases} \text{"ok"} & \text{if } \left(S_{allow} \times 1.5\right) \ge S_4 \\ \text{"no good"} & \text{otherwise} \end{cases} = \text{"ok"}$$

$S_4 := \text{if}\left(L \ge 8 \cdot R, S_{4a}, S_{4b}\right) = 1984.3 \cdot psi$

S5 at bottom of shell

$K_7 := 0.76$

$$S_5 := \frac{K_7 \cdot Q}{\left(t_s + t_h\right) \cdot \left[B + 1.56 \cdot \sqrt{R \cdot \left(t_s + t_h\right)}\right]} = 538.3 \cdot psi$$

$\frac{Y_p}{2} = 19000 \cdot psi$

$$S_5 := \begin{cases} \text{"ok"} & \text{if } \left(\frac{Y_p}{2}\right) \ge S_5 \\ \text{"no good"} & \text{otherwise} \end{cases} = \text{"ok"}$$