Design Study of a Ring Stiffened Cylinder for use as a Manned Submersible

Ring Collapse using Formula (88) - Trilling, Charles

"The Influense of Stiffening Rings on the Strength of Thin Cylindrical Shells Under External Pressure", U.S. Experimantal Model Basin Report No. 396 February 1935, p. 6, Equation [8]

$\text{SafetyFactor} := 2.0$

$\text{DesignGoal} := 1320 \cdot \text{ft} \cdot \text{SafetyFactor}$ $\qquad$ $\text{DesignGoal} = 2640\,\text{ft}$

Design Variables:

Outside Diameter	$OD := 42.0 \cdot \text{in}$
Shell Thickness	$t := .5 \cdot \text{in}$
Shell Length	$\text{Len} := 104.25 \cdot \text{in}$
Number of Rings	$\text{num} := 2$
Ring Depth	$RD := 2.5 \cdot \text{in}$
Ring Width	$RW := 2 \cdot \text{in}$
Ring Web Thickness	$b := .375 \cdot \text{in}, .4375 \cdot \text{in} .. .625 \cdot \text{in}$
Ring Flange Thickness	$RFT(b) := b$

Constants:

$\text{SeaWaterDensity} := 64 \cdot \frac{\text{lbf}}{\text{ft}^3}$

Len = Shell length, Semi-Eliptiical Straight Flange and Effective length of the Semi-Eliptical Head
Len = 96" + 2 * 1.5" + 2 * 42"/4 * .25 = 104.25"

Material Properties:

Poissons Ratio	$\mu := .3$
Youngs Modulus	$E := 30 \cdot 10^6 \cdot \frac{\text{lbf}}{\text{in}^2}$

Equations:

$$L := \frac{\frac{1}{3} \cdot \frac{OD}{2} + \text{Len} + \frac{1}{3} \cdot \frac{OD}{2}}{\text{num} + 1}$$

Mean Diameter $\quad D := OD - t$

Mean Radius $\quad R := \frac{D}{2}$

$$\theta := L \cdot \left[\frac{3 \cdot \left(1 - \mu^2\right)}{R^2 \cdot t^2}\right]^{\frac{1}{4}} \qquad N := \frac{\cosh(\theta) - \cos(\theta)}{\sinh(\theta) - \sin(\theta)}$$

$$A(b) := RFT(b) \cdot RW + (RD - RFT(b)) \cdot b$$

$$B(b) := \frac{b \cdot t}{A(b) + b \cdot t}$$

$$\beta(b) := \frac{2 \cdot N}{A(b) + b \cdot t} \cdot \left[\frac{1}{3 \cdot \left(1 - \mu^2\right)}\right]^{\frac{1}{4}} \cdot \left(R \cdot t^3\right)^{\frac{1}{2}}$$

$$A1(b) := RW \cdot RFT(b) \qquad I1(b) := \frac{RFT(b)^3 \cdot RW}{12}$$

$$A2(b) := (RD - RFT(b)) \cdot b \qquad I2(b) := \frac{(RD - RFT(b))^3 \cdot b}{12}$$

$$A3(b) := t \cdot b \qquad I3(b) := \frac{t^3 \cdot b}{12}$$

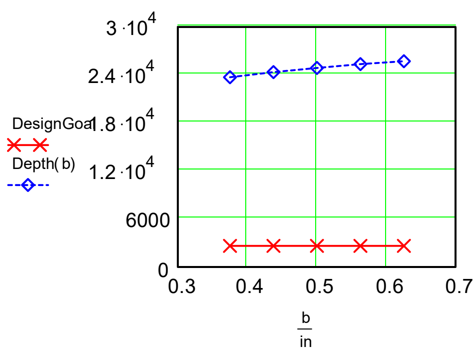
$$y(b) := \frac{\left(\frac{RFT(b)}{2}\right) \cdot A1(b) + \left(\frac{RD - RFT(b)}{2} + RFT(b)\right) \cdot A2(b) + \left(RD + \frac{t}{2}\right) \cdot A3(b)}{A1(b) + A2(b) + A3(b)}$$

$$Itemp(b) := I1(b) + I2(b) + I3(b) + \left(y(b) - \frac{RFT(b)}{2}\right)^2 \cdot A1(b) + \left[y(b) - \frac{(RD - RFT(b))}{2} - RFT(b)\right]^2 \cdot A2(b)$$

$$I(b) := Itemp(b) + \left(RD + \frac{t}{2} - y(b)\right)^2 \cdot A3(b)$$

$$F(b) := \frac{1}{(1 + \beta(b))} \cdot \left[\left(1 - \frac{1}{2} \cdot \mu\right) \cdot \beta(b) \cdot \left(\frac{A(b)}{t} + b\right) + b\right] \qquad Df(b) := OD - 2 \cdot (RD + t - y(b))$$

$$Depth(b) := \frac{24 \cdot E \cdot I(b)}{Df(b)^3 \cdot F(b) \cdot SeaWaterDensity}$$



$\frac{b}{in} =$

0.375
0.438
0.5
0.563
0.625

$$\frac{Depth(b)}{ft} = \begin{pmatrix} 23709 \\ 24332 \\ 24867 \\ 25327 \\ 25718 \end{pmatrix}$$