Design Study of a Port for use in a Manned Submersible

https://www.engineersedge.com/material_science/circular_plate_uniform_load_13638.htm
https://www.engineersedge.com/material_science/circular_plate_uniform_load_13639.htm
https://structville.com/2020/11/elastic-analysis-of-circular-plates.html
SSRG International Journal of Civil Engineering (SSRG-IJCE) Volume 2 Issue 5 May 2015

SafetyFactor := 5.0 Safety Factor per PVHO

DesignGoal := 1320·ft·SafetyFactor DesignGoal = 6600 ft

Material Properties:

Plexiglas Grade G

Tensile Strength, maximun = 10,500 psi

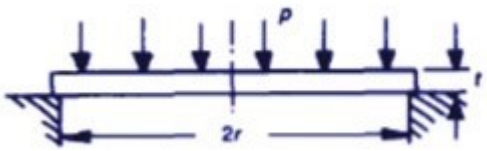
Poissons Ratio $\mu := .35$

Youngs Modulus $E := 450 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Flexural Modulus of Elasticity

Flexural Strength, maximun $\sigma := 16000 \cdot \frac{lbf}{in^2}$

Circular Plate Uniform Load Edges Simply Supported

https://www.engineersedge.com/material_science/circular_plate_uniform_load_13638.htm



Design Variables:

Radius $r := 3.5 \cdot in$

Plate Thickness $t := 1.0 \cdot in, 1.125 \cdot in .. 2.0 \cdot in$

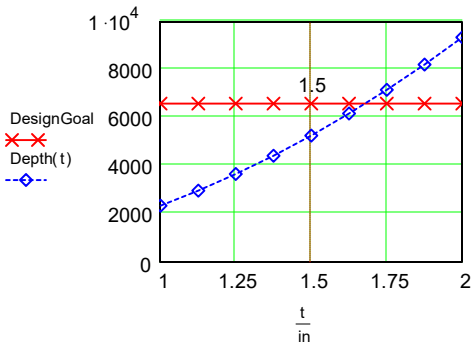
Constants:

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

Equations:

$$Depth(t) := \frac{\sigma \cdot 8 \cdot t^2}{3(3 + \mu) \cdot r^2 \cdot SeaWaterDensity}$$

Stress at Center = Flexural Strength

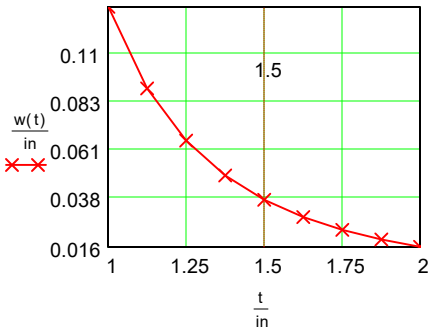


t/in =	Depth(t)/ft =
1	2339
1.125	2961
1.25	3655
1.375	4423
1.5	5263
1.625	6177
1.75	7164
1.875	8224
2	9357

$q := 586.666 \frac{lbf}{in^2}$ Uniform Load = 1320 ft. SeaWater

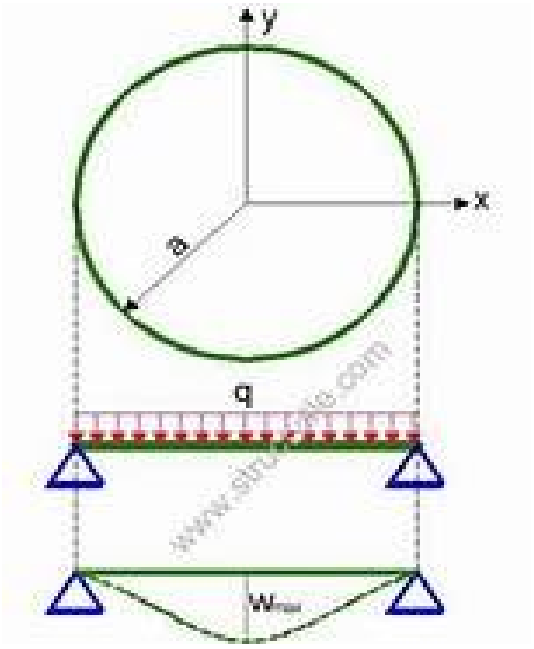
$D(t) := \frac{E t^3}{12\left(1 - \mu^2\right)}$ Flexural Rigidity

$w(t) := \frac{(5 + \mu) \cdot q \cdot r^4}{64(1 + \mu) D(t)}$ Deflection at Center



$\frac{t}{in}$ =	$\frac{w(t)}{in}$ =
1	0.128
1.125	0.09
1.25	0.065
1.375	0.049
1.5	0.038
1.625	0.03
1.75	0.024
1.875	0.019
2	0.016

https://structville.com/2020/11/elastic-analysis-of-circular-plates.html



Design Variables:

R(a)dius of Plate $a := 3.5 \cdot in$

(h)eight of Plate $h := 1.0 \cdot in, 1.125 \cdot in .. 2.0 \cdot in$

Constants:

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

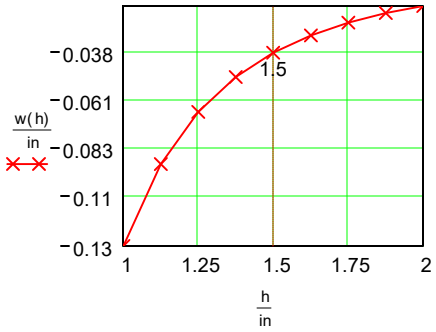
Equations:

$q := 586.666 \cdot \frac{lbf}{in^2}$ Uniform Load = 1320 ft. SeaWater

$r := 0 \cdot in$ Center of the Plate

$D(h) := \frac{E \cdot h^3}{12 \cdot (1 - \mu^2)}$ Flexural Rigidity

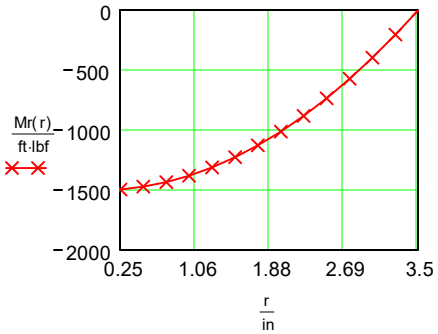
$w(h) := \frac{-q \cdot (a^2 - r^2)}{64 \cdot D(h)} \times \frac{(5 + \mu)}{(1 + \mu)} \times (a^2 - r^2)$ Deflection at Center at a depth of 1320 ft.



h/in =	w(h)/in =
1	-0.128
1.125	-0.09
1.25	-0.065
1.375	-0.049
1.5	-0.038
1.625	-0.03
1.75	-0.024
1.875	-0.019
2	-0.016

$r := 0 \cdot in, .25 \cdot in .. 3.5 \cdot in$ (r)adius

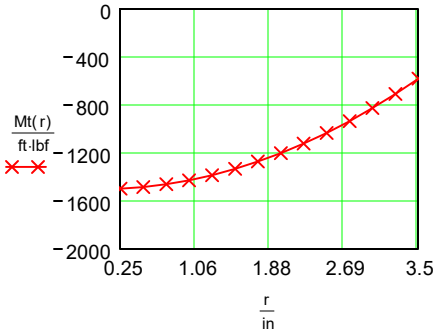
$Mr(r) := \frac{-q \cdot (a^2 - r^2) \cdot (3 + \mu)}{16}$ Radial Moment



r/in =	Mr(r)/(ft·lbf/ft) =
0	-1505
0.25	-1497
0.5	-1474
0.75	-1436
1	-1382
1.25	-1313
1.5	-1228
1.75	-1129
2	-1013
2.25	-883
2.5	-737
2.75	-576
3	-399
3.25	-207
3.5	-0

$$Mt(r) := \frac{-q\cdot\left[(3+\mu)\cdot a^2 - (1+3\cdot\mu)\cdot r^2\right]}{16}$$

Tangential Moment



$\frac{r}{in}$ =	$\frac{Mt(r)}{\frac{ft\cdot lbf}{ft}}$ =
0	-1505
0.25	-1500
0.5	-1486
0.75	-1462
1	-1430
1.25	-1387
1.5	-1336
1.75	-1275
2	-1204
2.25	-1124
2.5	-1035
2.75	-936
3	-828
3.25	-711
3.5	-584

Design Variables:

R(a)dius of Plate $a := 3.5\cdot in$

(h)eight of Plate $h := 1.5\cdot in$

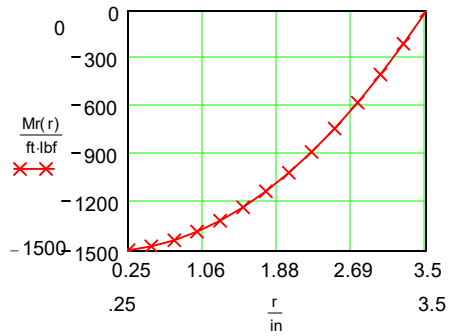
Constants:

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

$$D := \frac{E\cdot h^3}{12\cdot\left(1-\mu^2\right)}$$

$$C3 := -q\cdot a^2\frac{(3+\mu)}{32\cdot D\cdot(1+\mu)}$$

$$Mr(r) := D\cdot\left[2\cdot C3\cdot(1+\mu) + q\cdot\frac{r^2}{16\cdot D}\cdot(3+\mu)\right]$$



$\frac{r}{in}$ =	$\frac{Mr(r)}{\frac{ft\cdot lbf}{ft}}$ =
0	-1505
0.25	-1497
0.5	-1474
0.75	-1436
1	-1382
1.25	-1313
1.5	-1228
1.75	-1129
2	-1013
2.25	-883
2.5	-737
2.75	-576
3	-399
3.25	-207
3.5	-0

Maximum Moment occurs at the Center of the Plate (r=0)

$$Mmax := \frac{-q \cdot a^2 \cdot (3 + \mu)}{16} \qquad \frac{Mmax}{\frac{ft \cdot lbf}{ft}} = -1505$$

Circular Plate Edges Clamped, Uniform Load

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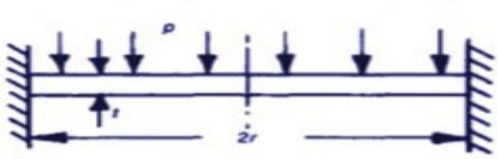


Design Variables:

Constants:

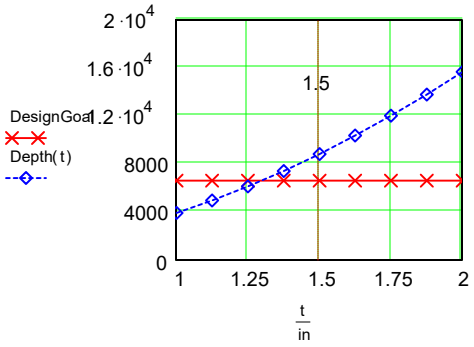
Radius $r := 3.5 \cdot in$

Plate Thickness $t := 1.0 \cdot in, 1.125 \cdot in .. 2.0 \cdot in$

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

Equations:

$$Depth(t) := \frac{\sigma \cdot 4 \cdot t^2}{3 \cdot r^2 \cdot SeaWaterDensity}$$ Stress at Edge

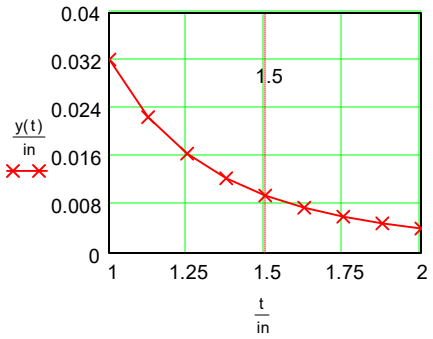


$\frac{t}{in}$ =	$\frac{Depth(t)}{ft}$ =
1	3918
1.125	4959
1.25	6122
1.375	7408
1.5	8816
1.625	10347
1.75	12000
1.875	13776
2	15673

$p := 586.666 \frac{lbf}{in^2}$ Uniform Load = 1320 ft. SeaWater

$D(t) := \frac{E t^3}{12(1 - \mu^2)}$ Flexural Rigidity

$y(t) := \frac{p \cdot r^4}{64 D(t)}$ Deflection at Center



$\frac{t}{in}$ =	$\frac{y(t)}{in}$ =
1	0.032
1.125	0.023
1.25	0.016
1.375	0.012
1.5	0.01
1.625	0.008
1.75	0.006
1.875	0.005
2	0.004