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
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SafetyFactor := 5.0 Safety Factor per PVHO

DesignGoal := 300·ft·SafetyFactor DesignGoal = 1500 ft

Material Properties:

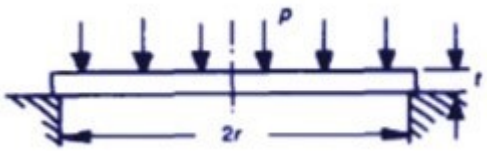
Plexiglas Grade G

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 $r := 3 \cdot in$

Plate Thickness $t := .5 \cdot in, .625 \cdot in .. 1.5 \cdot in$

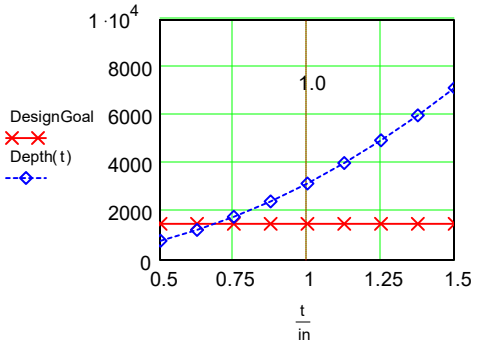
Constants:

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

Equations:

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

Stress at Center = Flexural Strength

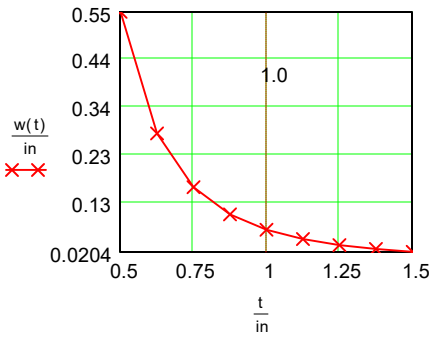


t/in =	Depth(t)/ft =
0.5	796
0.625	1244
0.75	1791
0.875	2438
1	3184
1.125	4030
1.25	4975
1.375	6020
1.5	7164

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

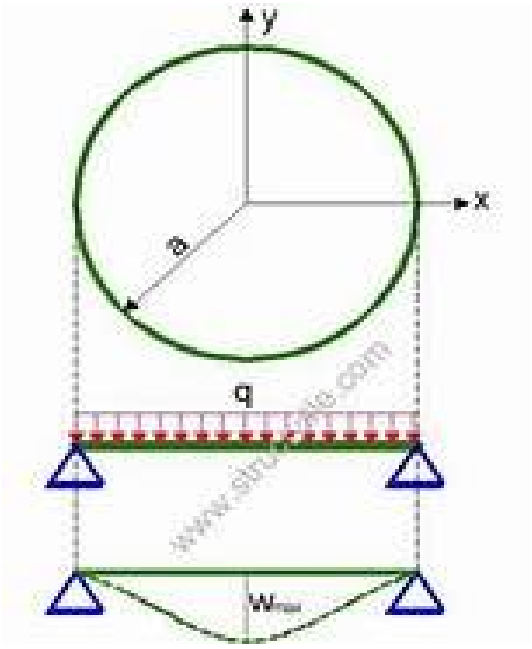
$D(t) := \frac{E t^3}{12\left(1 - \mu^2\right)}$ Flexural Rigidity

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



t/in =	w(t)/in =
0.5	0.551
0.625	0.282
0.75	0.163
0.875	0.103
1	0.069
1.125	0.048
1.25	0.035
1.375	0.026
1.5	0.02

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



Design Variables:

R(a)dius of Plate $a := 3 \cdot in$

(h)eight of Plate $h := .5 \cdot in, .625 \cdot in .. 1.5 \cdot in$

Constants:

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

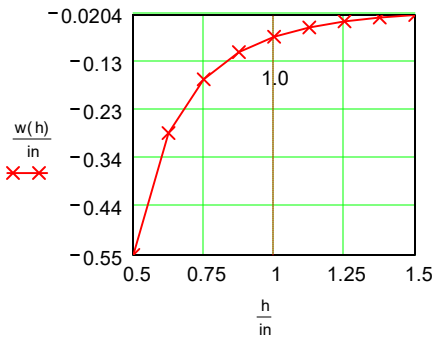
Equations:

$q := 586.666 \cdot \frac{lbf}{in^2}$ 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

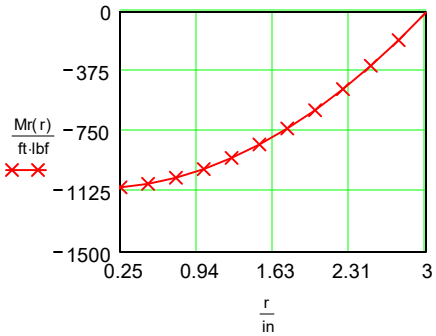
$w(h) := \frac{-q \cdot (a^2 - r^2)}{64 \cdot D(h)} \times \frac{(5 + \mu)}{(1 + \mu)} \times (a^2 - r^2)$ Deflection at Center at a depth of 1320 ft.



h/in =	w(h)/in =
0.5	-0.551
0.625	-0.282
0.75	-0.163
0.875	-0.103
1	-0.069
1.125	-0.048
1.25	-0.035
1.375	-0.026
1.5	-0.02

$r := 0 \cdot in, .25 \cdot in .. 3 \cdot in$ (r)adius

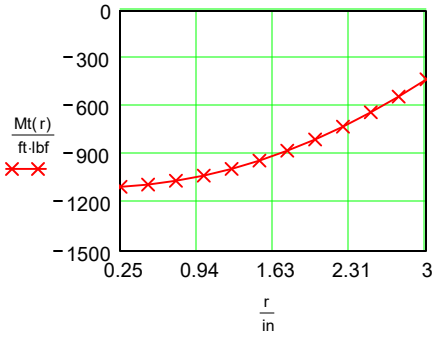
$Mr(r) := \frac{-q \cdot (a^2 - r^2) \cdot (3 + \mu)}{16}$ Radial Moment



r/in =	Mr(r)/(ft·lbf/ft) =
0	-1105
0.25	-1098
0.5	-1075
0.75	-1036
1	-983
1.25	-914
1.5	-829
1.75	-729
2	-614
2.25	-484
2.5	-338
2.75	-177
3	-0

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

Tangential Moment



r / in	Mt(r) / (ft·lbf/ft)
0	-1105
0.25	-1101
0.5	-1087
0.75	-1063
1	-1030
1.25	-988
1.5	-936
1.75	-875
2	-805
2.25	-725
2.5	-636
2.75	-537
3	-429

Design Variables:

R(a)dius of Plate $a := 3\cdot in$

(h)eight of Plate $h := 1\cdot in$

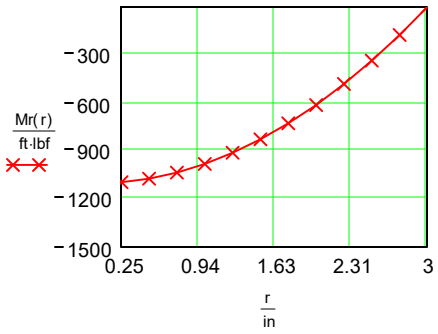
Constants:

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

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

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

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



r / in	Mr(r) / (ft·lbf/ft)
0	-1105
0.25	-1098
0.5	-1075
0.75	-1036
1	-983
1.25	-914
1.5	-829
1.75	-729
2	-614
2.25	-484
2.5	-338
2.75	-177
3	-0

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

$$Mmax := \frac{-q \cdot a^2 \cdot (3 + \mu)}{16} \qquad \frac{Mmax}{\frac{ft \cdot lbf}{ft}} = -1105$$

Circular Plate Edges Clamped, Uniform Load

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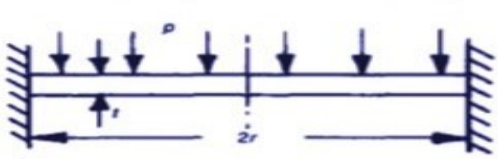


Design Variables:

Constants:

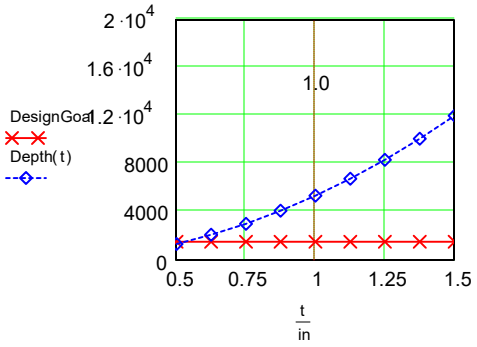
Radius $r := 3 \cdot in$

Plate Thickness $t := .5 \cdot in, .625 \cdot in .. 1.5 \cdot in$

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

Equations:

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

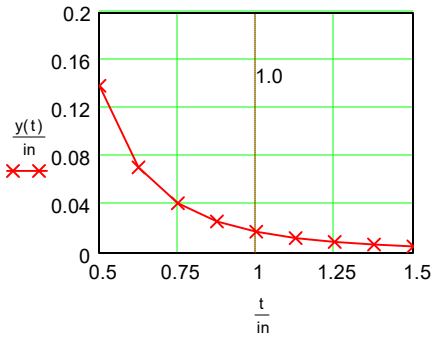


t/in =	Depth(t)/ft =
0.5	1333
0.625	2083
0.75	3000
0.875	4083
1	5333
1.125	6750
1.25	8333
1.375	10083
1.5	12000

$p := 586.666 \frac{lbf}{in^2}$ 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



$\frac{t}{in}$ =	$\frac{y(t)}{in}$ =
0.5	0.139
0.625	0.071
0.75	0.041
0.875	0.026
1	0.017
1.125	0.012
1.25	0.009
1.375	0.007
1.5	0.005