Calculations for the bolted helium vessel

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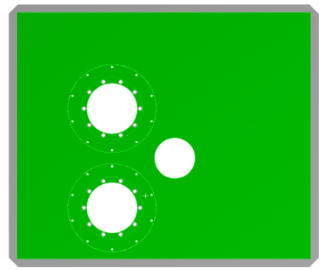
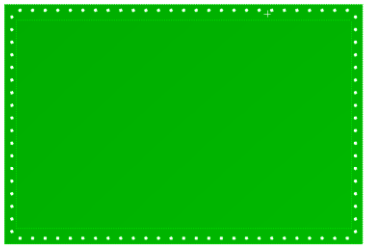
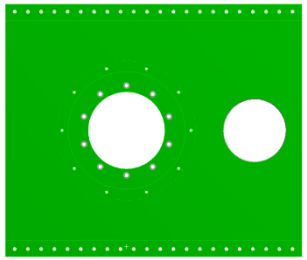
Input

Pitch p [mm]
0.8
Bolt diameter d [mm]
5
Tensile stress area At [mm2]
14.18
Corresponding bolt diameter in ANSYS d1 [mm]
4.05
Pretension constant K
0.8
Titanium proof stress Sp [MPa]
225
Preload F [N]
2552.86
Wrenching torque T [Nm]
2.55

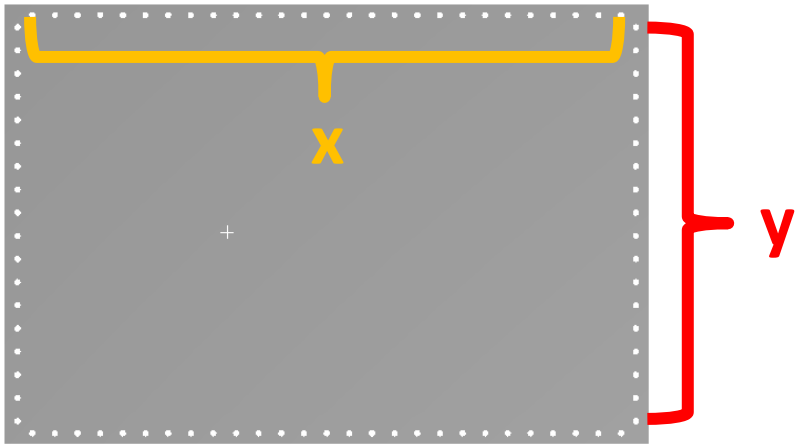
Top/bottom wall area A1 [mm2]
220000
Weight of the top/bottom wall Q1 [N]
294.3
Larger side wall area A2 [mm2]
215000
Weight of the larger wall Q2 [N]
196.2
Smaller side wall area A3 [mm2]
161000
Weight of the smaller side wall Q3 [N]
117.72
Total weight (vessel + cavity) Q [N]
1765.8
Pressure Pr [MPa]
0.18
Force from pressure F1 [N]
39600
Force from pressure F2 [N]
38700
Force from pressure F3 [N]
28980
Coefficient of static friction μ
0.3

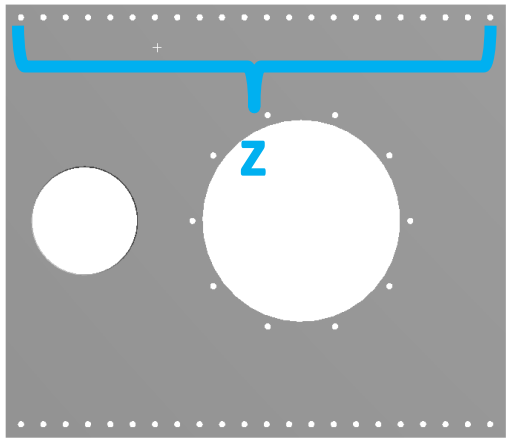






Number of bolts

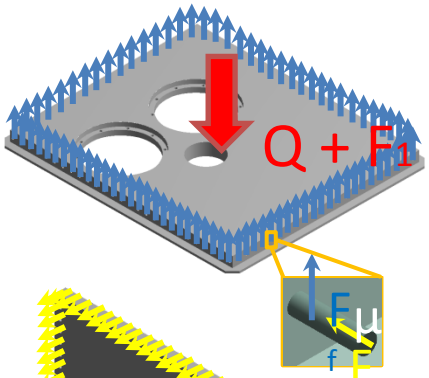




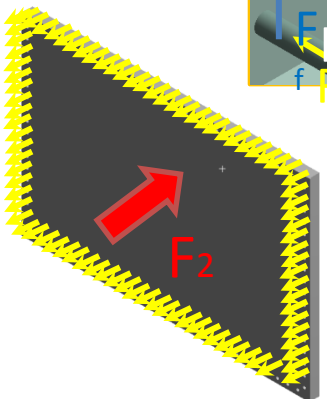
Number of bolts in a row x
27
Number of bolts in a row y
18
Number of bolts in a row z
22

Calculations

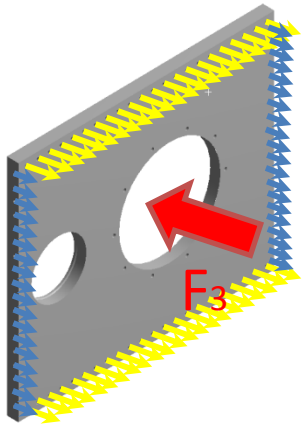
Shear Carried by Friction



$$x + z = \frac{F_1 + Q}{2\mu F}$$



$$x + y = \frac{F_2}{2F}$$



$$\mu y + z = \frac{F_3}{2F}$$

$$x > \frac{Q + F_1 + \mu^2 F_2 - \mu F_3}{2F\mu(\mu + 1)}$$

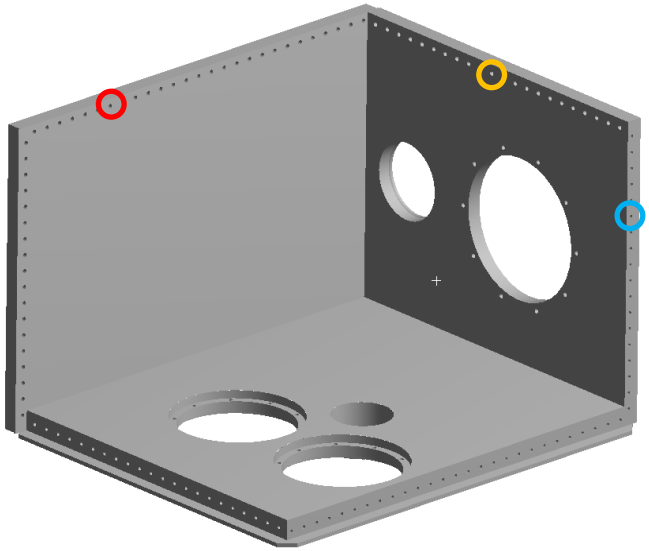
$$y > \frac{-Q - F_1 + \mu F_2 + \mu F_3}{2F\mu(\mu + 1)}$$

$$z > \frac{Q + F_1 - \mu F_2 + F_3}{2F(\mu + 1)}$$

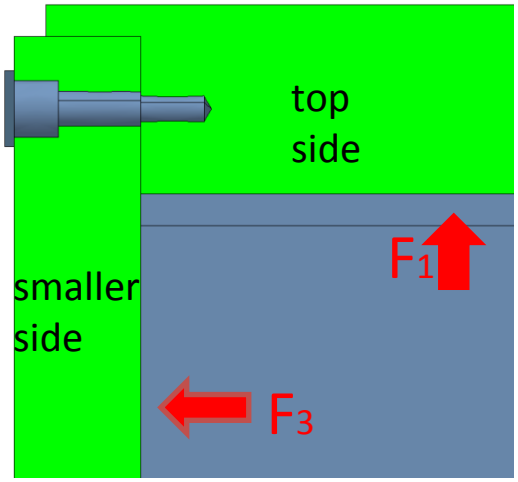
Min number of bolts in a row x
18
Min number of bolts in a row y
0
Min number of bolts in a row z
9

Calculations

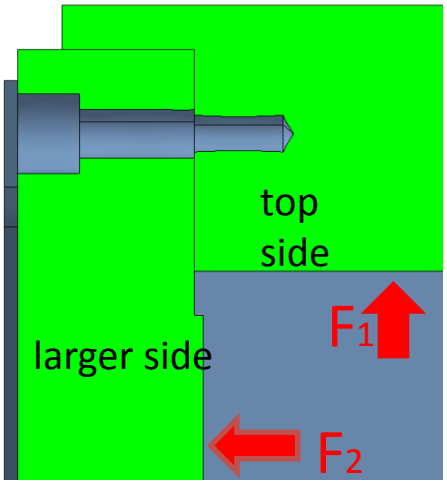
Shear Carried by Bolts



2



1



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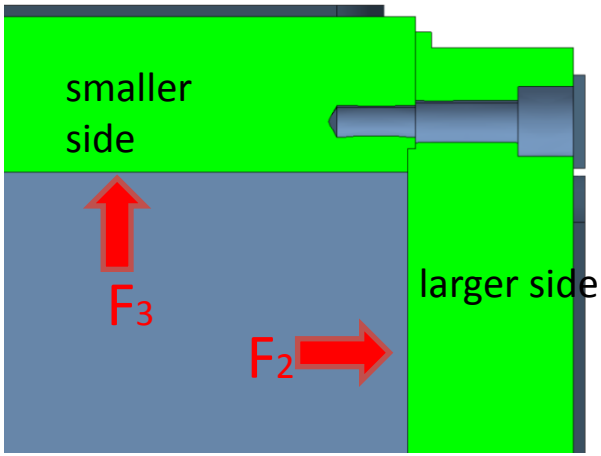


Calculations

$$\tau_{1,2} = \frac{F_1 + Q}{2A_t(x+z)}$$

$$\tau_3 = \frac{F_3}{2A_t(y+z)}$$

$$\sigma_{1,3} = \frac{F_2}{2A_t(x+y)}$$

$$\sigma_2 = \frac{F_3}{2A_t(y+z)}$$

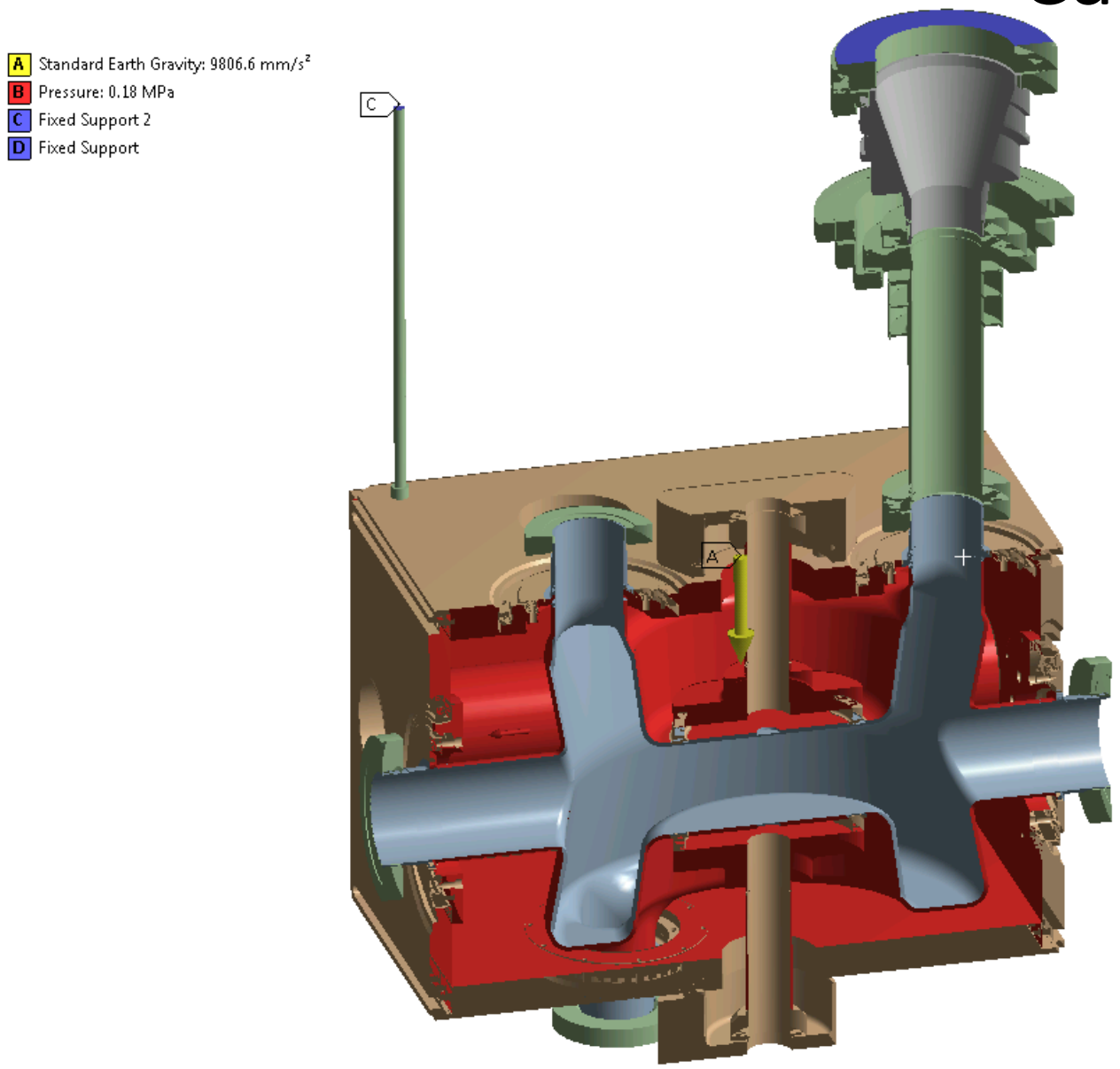
$$\sigma_{ri} = \sqrt{(\sigma_0 + \sigma_i)^2 + 4(\tau_i)^2}$$

Shear Carried by Bolts

Shear stress for the bolts 1 τ1 [MPa]
29.76
Shear stress for the bolts 2 τ2 [MPa]
29.76
Shear stress for the bolts 3 τ3 [MPa]
25.54
Normal stress for the bolts 1 σ1 [MPa]
30.32
Normal stress for the bolts 2 σ2 [MPa]
25.54
Normal stress for the bolts 3 σ3 [MPa]
30.32
Prestress σ0 [MPa]
180
Combined stress σr1 [MPa]
218.58
Combined stress σr2 [MPa]
213.99
Combined stress σr3 [MPa]
216.43
Safety factor η1
1.03
Safety factor η2
1.05
Safety factor η3
1.04

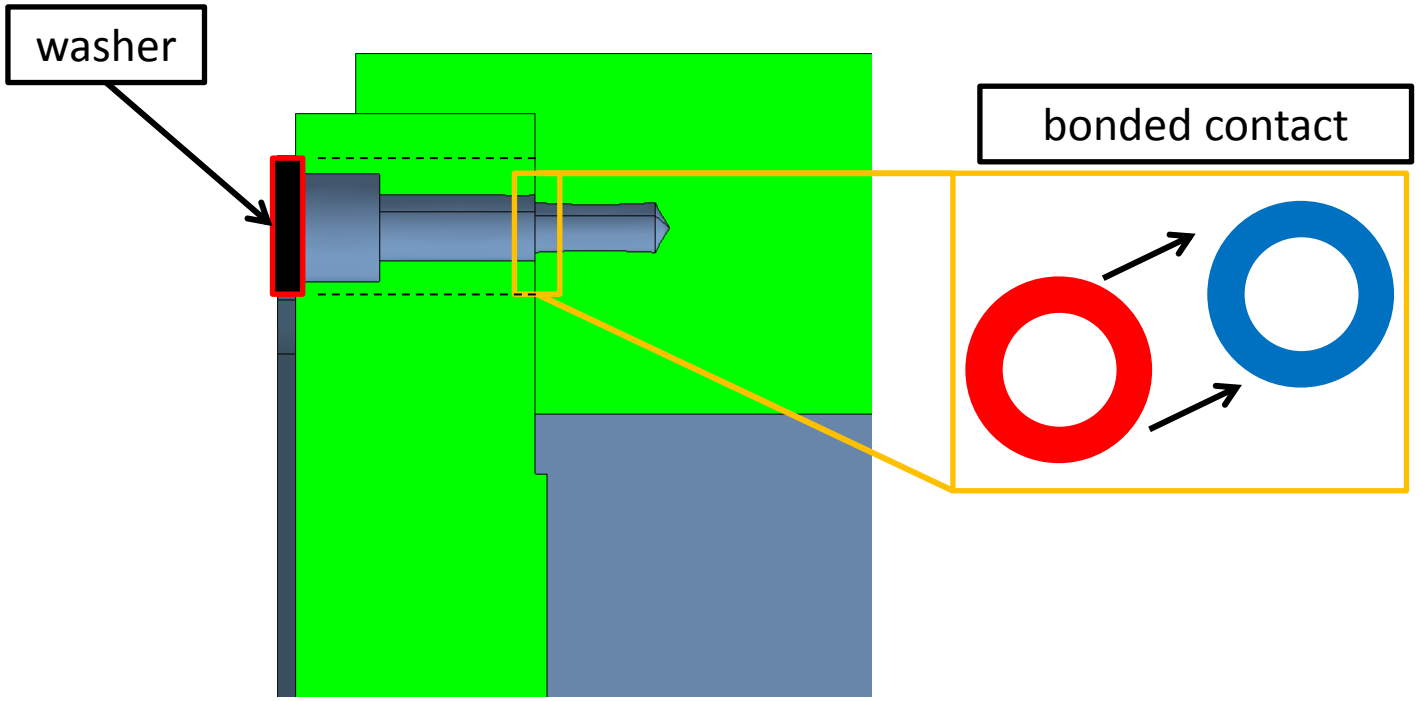
Calculations

FEA



Contact

For each bolt the washer face was projected onto the adjacent faces of the walls and after that the faces were sticked.



Stress on cavity (TBC)