Practice Problem 1

- Cylindrical boiler has an outside diameter of 2.75 m, a wall thickness of 32 mm, and a yield strength of 340 MPa. Calculate the following:
  a) If internal pressure is 2.3 MPa, find maximum normal stress
  b) If internal pressure is 2.3 MPa, find maximum shear stress
  c) If a factor of safety of 2.5 with respect to yielding must be maintained, find the maximum allowable pressure inside the tank

a) $\sigma_{max} = \sigma_{hoop} = \frac{pd}{2t}$

$d = (2.75\,m) - 2(0.032\,m) = 2.686\,m$

$\sigma_{hoop} = \frac{(2.3\,MPa)(2.686\,m)}{2(0.032\,m)}$

$\sigma_{hoop} = 96.5\,MPa$

b) $\tau_{abs\,max} = \frac{pd}{4t} + \frac{p}{2} = \frac{(2.3\,MPa)(2.686\,m)}{4(0.032\,m)} + \frac{2.3\,MPa}{2}$

$\tau_{abs\,max} = 49.4\,MPa$

c) $\sigma_{allow} = \frac{340\,MPa}{2.5} = 136\,MPa = \frac{pd}{2t}$

$p_{max} = \frac{2(136\,MPa)(0.032\,m)}{(2.686\,m)}$

$p_{max} = 3.24\,MPa$

$p_{max} \sim 470\,psia$

Practice Problem 2

In thermodynamics class we have boilers with internal pressure of 1600 psia (and temperature of 1100 °F). Those boilers have an outside diameter of 12 ft, a yield strength (at high temperature) of 35 ksi, and require a factor of safety with respect to yielding of 2.5. Calculate the minimum wall thickness.

$$\sigma_{allow} = \frac{35\ ksi}{2.5} = 14\ ksi$$

$$\sigma_{hoop} = \frac{pd}{2t} \qquad d = OD - 2t$$

$$(14\ ksi) = \frac{(1.6\ ksi)(144\ in - 2t)}{2t}$$

$$2t = \left(\frac{1.6\ ksi}{14\ ksi}\right)(144\ in - 2t)$$

$$2t = (0.1143)(144\ in - 2t) = 16.457\ in - 0.2286t$$

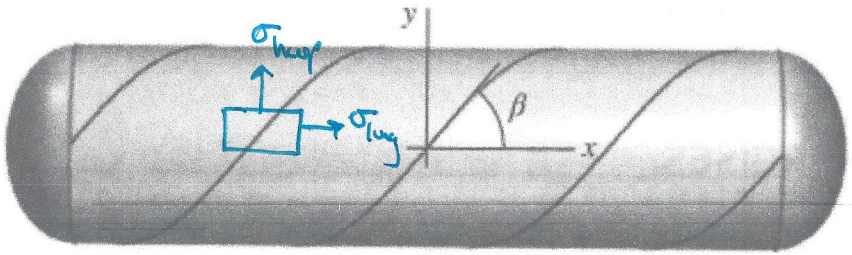
$$2.2286t = 16.457\ in$$

$$t = 7.38\ in$$

approximation

$$14\ ksi = \frac{(1.6\ ksi)(144\ in)}{2t} \qquad t \sim 8.22\ in$$

Practice Problem 3



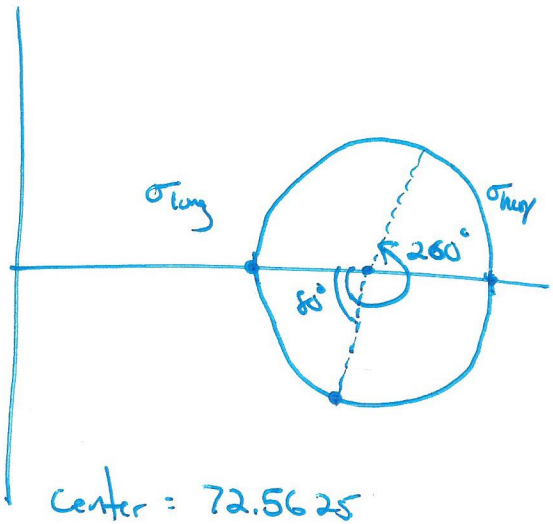
Pressure tank shown above is fabricated from spirally wrapped metal plates with an orientation of $\beta = 40°$. The ID of the tank is 720 mm, and wall thickness is 8 mm. If the gage pressure inside the tank is 2.15 MPa, calculate:

a) Normal stress perpendicular to the weld
b) Shear stress parallel to the weld

} in-plane

$$\sigma_{hoop} = \frac{pd}{2t} = \frac{(2.15\ MPa)(720\ mm)}{2(8\ mm)} = 96.75\ MPa$$

$$\sigma_{long} = \frac{\sigma_{hoop}}{2} = 48.375\ MPa$$



center = 72.5625

radius = 24.1875

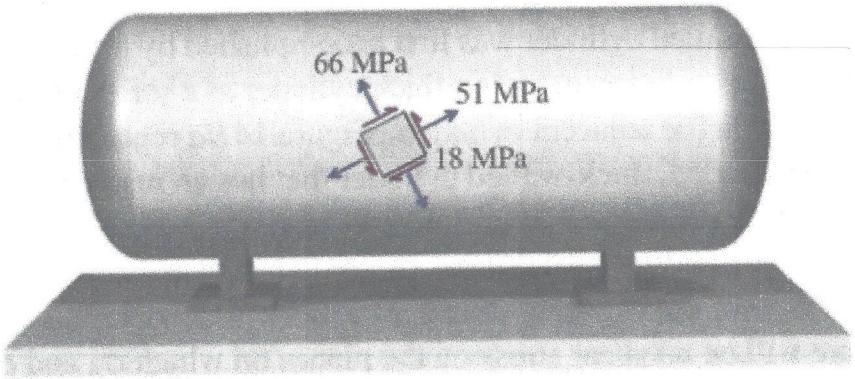
$$\sigma_{40} = (72.5625) - (24.1875)\cos(260)$$

$$\sigma_{40} = 76.76\ MPa$$

$$\tau_{40} = -\sin(80)(24.1875)$$

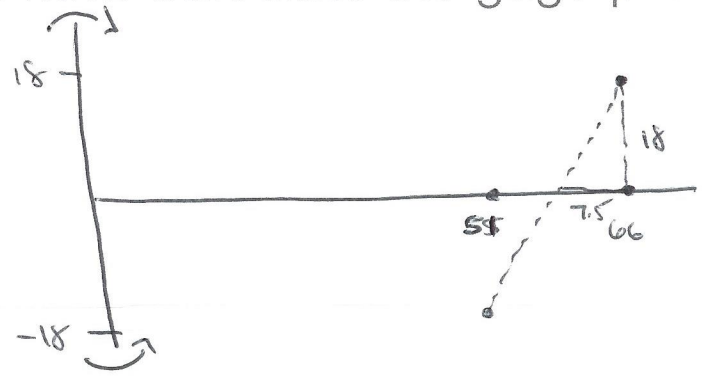
$$\tau_{40} = -23.82\ MPa$$

Practice Problem 4



Pressure tank shown above is has stress state as shown. The ID of the tank is 830 mm, and wall thickness is 10 mm. Calculate the gage pressure inside the tank.

Mohrs circle



center = 58.5

radius = 19.5

$\sigma_{p1} = 78$ MPa

$\sigma_{p2} = 39$ MPa

$\sigma_{hoop} = 78\text{ MPa} = \frac{pd}{2t}$

$p = (78\text{ MPa})\frac{(2(10\text{mm}))}{830\text{mm}}$

$p = 1.88$ MPa