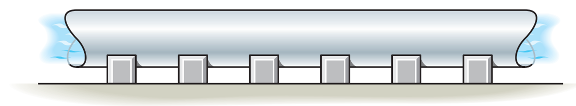
8–6. If the flow of water within the pipe in Prob. 8–5 is stopped due to the closing of a valve, determine the state of stress in the walls of the pipe. Neglect the weight of the water. Assume the supports only exert vertical forces on the pipe.

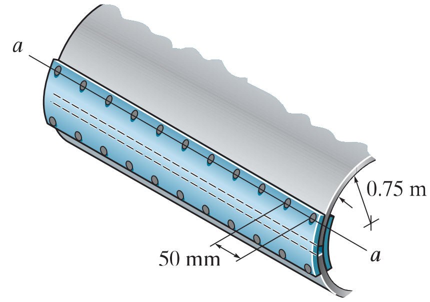


$$\sigma_1 = \frac{p\,r}{t} = \frac{60(2)}{0.2} = 600 \text{ psi}$$ **Ans.**

$$\sigma_2 = \frac{p\,r}{2\,t} = \frac{60(2)}{2(0.2)} = 300 \text{ psi}$$ **Ans.**

Ans:
$\sigma_1 = 600$ psi, $\sigma_2 = 300$ psi

8–7. A boiler is constructed of 8-mm thick steel plates that are fastened together at their ends using a butt joint consisting of two 8-mm cover plates and rivets having a diameter of 10 mm and spaced 50 mm apart as shown. If the steam pressure in the boiler is 1.35 MPa, determine (a) the circumferential stress in the boiler's plate apart from the seam, (b) the circumferential stress in the outer cover plate along the rivet line *a–a*, and (c) the shear stress in the rivets.



a) $\sigma_1 = \dfrac{pr}{t} = \dfrac{1.35(10^6)(0.75)}{0.008} = 126.56(10^6) = 127\text{ MPa}$ **Ans.**

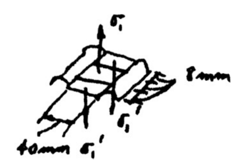
b) $126.56\,(10^6)(0.05)(0.008) = \sigma_1{}'(2)(0.04)(0.008)$

$\sigma_1{}' = 79.1\text{ MPa}$ **Ans.**

c) From FBD(a)

$+\uparrow \Sigma F_y = 0; \qquad F_b - 79.1(10^6)[(0.008)(0.04)] = 0$

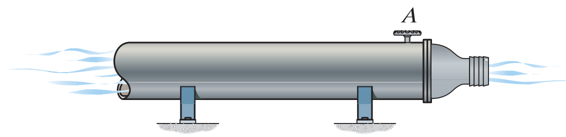
$F_b = 25.3\text{ kN}$



$(\tau_{avg})_b = \dfrac{F_b}{A} - \dfrac{25312.5}{\frac{\pi}{4}(0.01)^2} = 322\text{ MPa}$ **Ans.**

Ans:
(a) $\sigma_1 = 127\text{ MPa}$,
(b) $\sigma_1{}' = 79.1\text{ MPa}$, $(\tau_{avg})_b = 322\text{ MPa}$

***8–8.** The steel water pipe has an inner diameter of 12 in. and wall thickness 0.25 in. If the valve A is opened and the flowing water is under a gauge pressure of 250 psi, determine the longitudinal and hoop stress developed in the wall of the pipe.



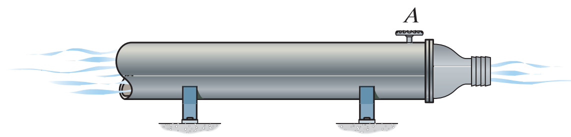
Normal Stress: Since the pipe has two open ends,

$$\sigma_{\text{long}} = \sigma_2 = 0 \qquad \textbf{Ans.}$$

Since $\dfrac{r}{t} = \dfrac{6}{0.25} = 24 > 10$, thin-wall analysis can be used.

$$\sigma_h = \sigma_1 = \frac{pr}{t} = \frac{250(6)}{0.25} = 6000 \text{ psi} = 6 \text{ ksi} \qquad \textbf{Ans.}$$

8–9. The steel water pipe has an inner diameter of 12 in. and wall thickness 0.25 in. If the valve A is closed and the water pressure is 300 psi, determine the longitudinal and hoop stress developed in the wall of the pipe. Draw the state of stress on a volume element located on the wall.

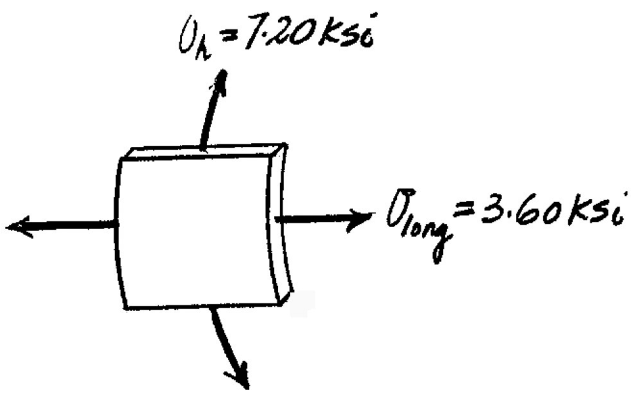


Normal Stress: Since $\frac{r}{t} = \frac{6}{0.25} = 24 > 10$, thin-wall analysis can be used.

$$\sigma_{\text{hoop}} = \sigma_1 = \frac{pr}{t} = \frac{300(6)}{0.25} = 7200 \text{ psi} = 7.20 \text{ ksi} \qquad \textbf{Ans.}$$

$$\sigma_{\text{loop}} = \sigma_2 = \frac{pr}{2t} = \frac{300(6)}{2(0.25)} = 3600 \text{ psi} = 3.60 \text{ ksi} \qquad \textbf{Ans.}$$

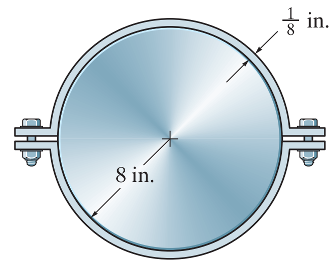
The state of stress on an element in the pipe wall is shown in Fig. *a*.



(a)

Ans:
$\sigma_{\text{hoop}} = 7.20$ ksi, $\sigma_{\text{long}} = 3.60$ ksi

8–10. The A-36-steel band is 2 in. wide and is secured around the smooth rigid cylinder. If the bolts are tightened so that the tension in them is 400 lb, determine the normal stress in the band, the pressure exerted on the cylinder, and the distance half the band stretches.



$$\sigma_1 = \frac{400}{2(1/8)(1)} = 1600 \text{ psi}$$ **Ans.**

$$\sigma_1 = \frac{pr}{t}; \quad 1600 = \frac{p(8)}{(1/8)}$$

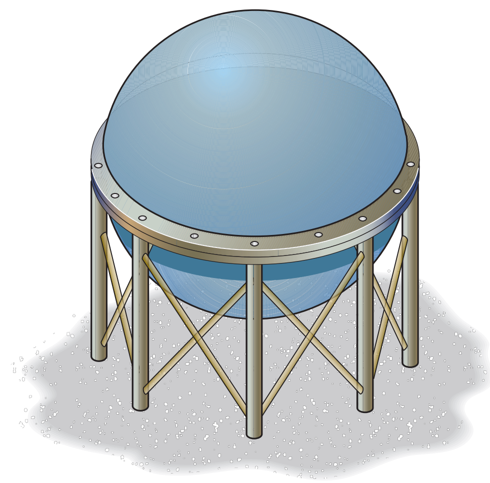
$$p = 25 \text{ psi}$$ **Ans.**

$$\epsilon_1 = \frac{\sigma_1}{E} = \frac{1600}{29(10^6)} = 55.1724(10^{-6})$$

$$\delta = \epsilon_1 L = 55.1724(10^{-6})(\pi)\left(8 + \frac{1}{16}\right) = 0.00140 \text{ in.}$$ **Ans.**

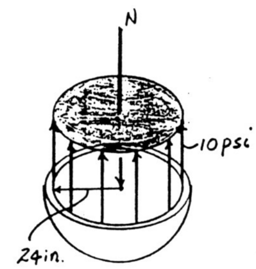
Ans:
$\sigma_1 = 1.60$ ksi, $p = 25$ psi, $\delta = 0.00140$ in.

8–11. Two hemispheres having an inner radius of 2 ft and wall thickness of 0.25 in. are fitted together, and the inside gauge pressure is reduced to -10 psi. If the coefficient of static friction is $\mu_s = 0.5$ between the hemispheres, determine (a) the torque T needed to initiate the rotation of the top hemisphere relative to the bottom one, (b) the vertical force needed to pull the top hemisphere off the bottom one, and (c) the horizontal force needed to slide the top hemisphere off the bottom one.



Normal Pressure: Vertical force equilibrium for FBD(a).

$$+\uparrow \Sigma F_y = 0; \qquad 10\left[\pi(24^2)\right] - N = 0 \qquad N = 5760\pi \text{ lb}$$



The Friction Force: Applying friction formula

$$F_f = \mu_s N = 0.5(5760\pi) = 2880\pi \text{ lb}$$

a) **The Required Torque:** In order to initiate rotation of the two hemispheres relative to each other, the torque must overcome the moment produced by the friction force about the center of the sphere.

$$T = F_f r = 2880\pi(2 + 0.125/12) = 18190 \text{ lb} \cdot \text{ft} = 18.2 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

b) **The Required Vertical Force:** In order to just pull the two hemispheres apart, the vertical force P must overcome the normal force.

$$P = N = 5760\pi = 18096 \text{ lb} = 18.1 \text{ kip} \qquad \textbf{Ans.}$$

c) **The Required Horizontal Force:** In order to just cause the two hemispheres to slide relative to each other, the horizontal force F must overcome the friction force.

$$F = F_f = 2880\pi = 9048 \text{ lb} = 9.05 \text{ kip} \qquad \textbf{Ans.}$$

Ans:
(a) $T = 18.2$ kip · ft,
(b) $P = 18.1$ kip,
(c) $F = 9.05$ kip