8–1 A spherical gas tank has an inner radius of $r = 1.5$ m. If it is subjected to an internal pressure of $p = 300$ kPa, determine its required thickness if the maximum normal stress is not to exceed 12 MPa.

$$\sigma_{allow} = \frac{p\,r}{2\,t}; \qquad 12(10^6) = \frac{300(10^3)(1.5)}{2\,t}$$

$$t = 0.0188 \text{ m} = 18.8 \text{ mm} \qquad \textbf{Ans}$$

8–2 A pressurized spherical tank is to be made of 0.5-in.-thick steel. If it is subjected to an internal pressure of p = 200 psi, determine its outer radius if the maximum normal stress is not to exceed 15 ksi.

$$\sigma_{allow} = \frac{p\,r}{2\,t}; \qquad 15(10^3) = \frac{200\,r_i}{2(0.5)}$$

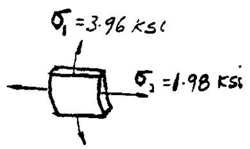
$$r_i = 75 \text{ in.}$$

$$r_o = 75 \text{ in.} + 0.5 \text{ in.} = 75.5 \text{ in.}$$ **Ans**

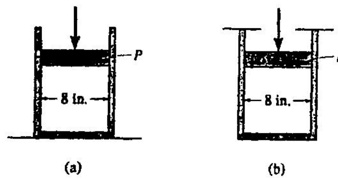
8-3. The tank of a cylindrical air compressor is subjected to an internal pressure of 90 psi. If the internal diameter of the tank is 22 in., and the wall thickness is 0.25 in., determine the stress components acting at a point. Draw a volume element of the material at this point, and show the results on the element.

$$\sigma_1 = \frac{p\,r}{t} = \frac{90\,(11)}{0.25} = 3960\text{ psi} = 3.96\text{ ksi} \qquad \textbf{Ans}$$

$$\sigma_2 = \frac{p\,r}{2\,t} = \frac{90(11)}{2(0.25)} = 1980\text{ psi} = 1.98\text{ ksi} \qquad \textbf{Ans}$$



•8–4 The thin-walled cylinder can be supported in one or two ways as shown. Determine the state of stress in the wall of the cylinder for both cases if the piston P causes the internal pressure to be 65 psi. The wall has a thickness of 0.25 in. and the inner diameter of the cylinder is 8 in.



Case (a) :

$$\sigma_1 = \frac{pr}{t}; \qquad \sigma_1 = \frac{65(4)}{0.25} = 1.04\text{ ksi} \qquad \textbf{Ans}$$

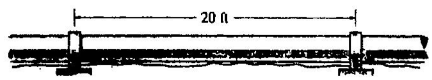
$$\sigma_2 = 0 \qquad \textbf{Ans}$$

Case (b) :

$$\sigma_1 = \frac{pr}{t}; \qquad \sigma_1 = \frac{65(4)}{0.25} = 1.04\text{ ksi} \qquad \textbf{Ans}$$

$$\sigma_2 = \frac{pr}{2t}; \qquad \sigma_2 = \frac{65(4)}{2(0.25)} = 520\text{ psi} \qquad \textbf{Ans}$$

8–5 The gas pipe line is supported every 20 ft by concrete piers and also lays on the ground. If there are rigid retainers at the piers that hold the pipe fixed, determine the longitudinal and hoop stress in the pipe if the temperature rises 60°F from the temperature at which it was installed. The gas within the pipe is at a pressure of 600 lb/in². The pipe has an inner diameter of 20 in. and thickness of 0.25 in. The material is A-36 steel.



Require,

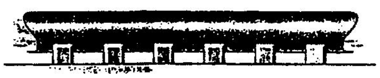
$$\delta_F = \delta_T; \qquad \delta_F = \frac{PL}{AE} = \frac{\sigma L}{E}, \qquad \delta_T = \alpha \Delta T L$$

$$\frac{\sigma_2(20)(12)}{29(10^6)} = (6.60)(10^{-6})(60)(20)(12)$$

$\sigma_2 = 11.5$ ksi **Ans**

$$\sigma_1 = \frac{pr}{t} = \frac{600(10)}{0.25} = 24 \text{ ksi}$$ **Ans**

8-6. The open-ended polyvinyl chloride pipe has an inner diameter of 4 in. and thickness of 0.2 in. If it carries flowing water at 60 psi pressure, determine the state of stress in the walls of the pipe.

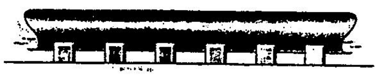


$$\sigma_1 = \frac{p\,r}{t} = \frac{60(2)}{0.2} = 600\text{ psi} \qquad \textbf{Ans}$$

$$\sigma_2 = 0 \qquad \textbf{Ans}$$

There is no stress component in the longitudinal direction since the pipe has open ends.

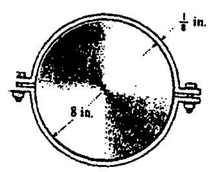
8-7. If the flow of water within the pipe in Prob. 8–6 is stopped due to the closing of a valve, determine the state of stress in the walls of the pipe. Neglect the weight of the water. Assume the supports only exert vertical forces on the pipe.



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

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

***8-8.** 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.



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

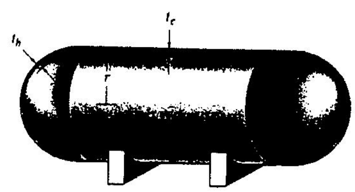
$$\sigma_1 = \frac{pr}{t}; \qquad 1600 = \frac{p(8)}{(1/8)}$$

$$p = 25 \text{ psi} \qquad \textbf{Ans}$$

$$\varepsilon_1 = \frac{\sigma_1}{E} = \frac{1600}{29(10^6)} = 55.1724(10^{-6})$$

$$\delta = \varepsilon_1 L = 55.1724(10^{-6})(\pi)(8 + \frac{1}{16}) = 0.00140 \text{ in.} \qquad \textbf{Ans}$$

10-55 The cylindrical pressure vessel is fabricated using hemispherical end caps in order to reduce the bending stress that would occur if flat ends were used. The bending stresses at the seam where the caps are attached can be eliminated by proper choice of the thickness t_h and t_c of the caps and cylinder, respectively. This requires the radial expansion to be the same for both the hemispheres and cylinder. Show that this ratio is $t_c/t_h = (2 - \nu)/(1 - \nu)$. Assume that the vessel is made of the same material and both the cylinder and hemispheres have the same inner radius. If the cylinder is to have a thickness of 0.5 in., what is the required thickness of the hemispheres? Take $\nu = 0.3$.



For cylindrical vessel :

$$\sigma_1 = \frac{p\,r}{t_c}; \qquad \sigma_2 = \frac{p\,r}{2\,t_c}$$

$$\varepsilon_1 = \frac{1}{E}[\sigma_1 - v(\sigma_2 + \sigma_3)] \qquad \sigma_3 = 0$$

$$= \frac{1}{E}\left(\frac{p\,r}{t_c} - \frac{v\,p\,r}{2\,t_c}\right) = \frac{p\,r}{E\,t_c}\left(1 - \frac{1}{2}v\right)$$

$$d\,r = \varepsilon_1\,r = \frac{p\,r^2}{E\,t_c}\left(1 - \frac{1}{2}v\right) \qquad (1)$$

For hemispherical end caps :

$$\sigma_1 = \sigma_2 = \frac{p\,r}{2\,t_h}$$

$$\varepsilon_1 = \frac{1}{E}[\sigma_1 - v(\sigma_2 + \sigma_3)]; \qquad \sigma_3 = 0$$

$$= \frac{1}{E}\left(\frac{p\,r}{2\,t_h} - \frac{v\,p\,r}{2\,t_h}\right) = \frac{p\,r}{2\,E\,t_h}(1 - v)$$

$$d\,r = \varepsilon_1\,r = \frac{p\,r^2}{2\,E\,t_h}(1 - v) \qquad (2)$$

Equate Eqs. (1) and (2) :

$$\frac{p\,r^2}{E\,t_c}\left(1 - \frac{1}{2}v\right) = \frac{p\,r^2}{2\,E\,t_h}(1 - v)$$

$$\frac{t_c}{t_h} = \frac{2\left(1 - \frac{1}{2}v\right)}{1 - v} = \frac{2 - v}{1 - v} \qquad \textbf{QED}$$

$$t_h = \frac{(1 - v)\,t_c}{2 - v} = \frac{(1 - 0.3)(0.5)}{2 - 0.3} = 0.206 \text{ in.} \qquad \textbf{Ans}$$

***10-56** A thin-walled spherical pressure vessel has an inner radius r, thickness t, and is subjected to an internal pressure p. If the material constants are E and ν, determine the strain in the circumferential direction in terms of the stated parameters.

Principal stresses :

$$\sigma_1 = \sigma_2 = \sigma = \frac{p\,r}{2\,t}; \qquad \sigma_3 = 0$$

Applying Hooke's law :

$$\varepsilon_1 = \varepsilon_2 = \varepsilon = \frac{1}{E}[\sigma_1 - \nu(\sigma_2 + \sigma_3)]$$

$$\varepsilon = \frac{1}{E}[\sigma - \nu\,\sigma] = \frac{1-\nu}{E}\sigma$$

$$= \frac{1-\nu}{E}(\frac{p\,r}{2\,t}) = \frac{p\,r}{2\,t\,E}(1-\nu) \qquad \textbf{Ans}$$