Answer Key

Pressured Vessel and Wire Ropes

$\frac{D_i}{t} = \frac{15in}{3in} = 5 < 10$ ∴ Thick wall cylinders

$$S_{to} = \frac{2P_i r_i^2 - P_o(r_o^2 + r_i^2)}{r_o^2 - r_i^2}$$

$r_i = \frac{15in}{2} = 7.5\,in$

$r_o = \frac{15in}{2} + 3in = 10.5\,in$

$P_i = (70\,000\,kPa)\left(\frac{14.7\,psi}{101.325\,kPa}\right) = 10155.4404\,psi$

$P_o = (15\,000\,kPa)\left(\frac{14.7\,psi}{101.325\,kPa}\right) = 2176.1658\,psi$

subst:

$$= \frac{2\left(10155.4404\frac{lb}{in^2}\right)(7.5\,in)^2 - \left(2176.1658\frac{lb}{in^2}\right)(10.5^2 + 7.5^2)\,in^2}{(10.5^2 - 7.5^2)\,in^2}$$

$S_{to} = \left(14447.3229\frac{lb}{in^2}\right)\left(\frac{101.325\,kPa}{14.7\,psi}\right)\left(\frac{1\,mPa}{1000\,kPa}\right)$

$S_{to} = 99.5833\,mPa$

$$S_{to} = \frac{2 P_i r_i^2 - P_o (r_o^2 + r_i^2)}{r_o^2 - r_i^2}$$

$$14000 \frac{lb}{in^2} = \frac{2 \left(8500 \frac{lb}{in^2}\right)(10 in)^2 - P_o (14^2 + 10^2) in^2}{(14^2 - 10^2) in^2}$$

$$P_o = 1202.7027 \frac{lb}{in^2}$$

$$S_t = \frac{P D_i}{2t} \quad ; \quad P = \rho \left(\frac{g_o}{g_c}\right) h$$

$$= 740 \frac{kg}{m^3} \left(\frac{9.81 \, m/s^2}{1 \, \frac{kg-m}{N-s^2}} \right) (7 m)$$

$$P = 50815.8 \, Pa$$

$$P = 50815.8 \times 10^{-6} \, mPa$$

Subst;

$$20 \frac{N}{mm^2} = \frac{(50815.8 \times 10^{-6} N/mm^2)(3.5 \times 10^3 mm)}{2t}$$

$$t = 3.1759 \, mm$$

$$t = \frac{P_i}{2}\left[\sqrt{\frac{S_t + P_i}{S_t - P_i}} - 1\right]$$

$$55\text{mm} = \frac{320\text{mm}}{2}\left[\sqrt{\frac{S_t + 8.3\text{ MPa}}{S_t - 8.3\text{ MPa}}} - 1\right]$$

$$S_t = 28.9041\text{ MPa}$$

$$S_t = \frac{PD_i}{2t}$$

$$13000 \frac{lb}{in^2} = \frac{(600\ lb/in^2)(6\ in)}{2t}$$

$$t = 0.1385\ in$$

Spherical tank

$$S_t = S_L = \frac{P D_i}{4t}$$

$$18000\ kPa = \frac{P(12m)}{4(0.25m)}$$

$$P = 1500\ kPa$$

$$S_t = \frac{PD_i}{4te}$$

$$48\,MPa = \frac{8\,MPa\,D_i}{4(15\,mm)(0.90)}$$

$$D_i = 324\,mm$$

$$S_t = \frac{Pi}{2t} \quad ; \quad F.S. = \frac{S_u}{S_t}$$

$$\frac{S_u}{F.S.} = \frac{Pi}{2t} \quad ; \quad P = \frac{F}{\frac{\pi D_i^2}{4}}$$

$$2600\ kPa = \frac{2600\ kg\left(\frac{9.81\ m/s^2}{1000\ \frac{kg-m}{kN-s^2}}\right)}{\frac{\pi D_i^2}{4}}$$

$$D_i = 0.1118\ m$$

solve t;

$$\frac{55000\ kPa}{4.5} = \frac{2600\ kPa\ (0.1118\ m)}{2t}$$

$$t = 0.02377\ m$$

$$t = 23.77\ mm$$

and;

$$\frac{D_i}{t} \geq 10$$

$$\frac{0.1118\ m}{0.02377\ m} = 4.7034 \not\geq 10$$

Hence; thick walled pressure vessel

$$t = \frac{D_i}{2}\left[\sqrt{\frac{S_t + P_i}{S_t - P_i}} - 1\right]$$

$$= \frac{0.1118\ m}{2}\left[\sqrt{\frac{(55000\ kPa/4.5) + 2600\ kPa}{(55000\ kPa/4.5) - 2600\ kPa}} - 1\right]$$

$$t = 0.01348\ m$$

$$t = 13.48\ mm$$

check;

$$\frac{D_i}{t} < 10$$

$$\frac{0.1118\ m}{0.01348} = 8.2938 < 10$$

$$S_t = \frac{PD_i}{2te} = \frac{(12\,MPa)(380\,mm)}{2(28\,mm)(0.85)}$$

$$\boxed{S_t = 95.7983\ MPa}$$

$$\frac{S_y}{F.S.} = \frac{PD_i}{2t}$$

$$\frac{300\ mpa}{3} = \frac{10mpa\left(60\ in\right)\left(\frac{25.4\ mm}{1\ in}\right)}{2t}$$

$$\boxed{t = 76.2\ mm}$$

check;

$$\frac{D}{t} \geq 10$$

$$\frac{\left(60in\right)\left(\frac{25.4\ mm}{in}\right)}{76.2\ mm} = 20 \geq 10$$

$$S_t = \frac{PD_i}{2t} \quad ; \quad P = \gamma h = \left(9.81 \frac{kN}{m^3}\right)(15m) = 147.15\ kPa$$

$$60000\ kPa = \frac{(147.15\ kPa)(12m)}{2t}$$

$$t = 0.014715m$$

$$\boxed{t = 14.715mm}$$

Check:

$$\frac{D}{t} \geq 10$$

$$\frac{12m}{0.014715m} = 815.4944 \geq 10$$

$$\frac{D}{t} \geq 10$$

$$\frac{18\ in}{3/4\ in} = 24 \geq 10$$

Bursting steam pressure

$$S_L = \frac{PDi}{4te}$$

$$65000\ \frac{lb}{in^2} = \frac{P(18\ in)}{4(3/4\ in)(0.90)}$$

$$P = 9750\ psi$$

$$\frac{D}{t} \geq 10$$

$$\frac{600\ mm}{23\ mm} = 26.08 \geq 10$$

$$S_t = \frac{PD_i}{2t}$$

$$150\ MPa = \frac{P(600mm)}{2(23\ mm)}$$

$$\boxed{P = 11.5\ MPa}$$

$$F_b = \frac{0.38 d^2 E r d w}{D} = \frac{0.38 (2\,in)^2 \left(12 \times 10^6 \frac{lb}{in^2}\right)(0.090\,in)}{85\,in}$$

$$F_b = 19312.9412\ lbs$$

$$S_b = \frac{E r d_w}{D} = \frac{\left(12 \times 10^6 \frac{lb}{in^2}\right)(0.098 in)}{90 in}$$

$$S_b = 13066.6667 \frac{lb}{in^2}$$

$$\text{LOAD of Elevator} = (1800\ \text{kg})\left(\frac{2.2\ \text{lbs}}{1\ \text{kg}}\right) = 3960\ \text{lbs}$$

$$\#\ \text{of ropes} = \frac{3960\ \text{lbs}}{2150\ \text{lbs}} = 1.8419$$

$$\#\ \text{of ropes} = 2$$

$$FS = \frac{F_u - F_b}{F_t}$$

$$F_u = 76000\, d^2 = 72000\ (0.5in)^2 = 19000\ lbs$$

$$F_t = 8800\ lbs$$

$$F_b = \frac{0.38\, d^2 E_r\, dw}{D}$$

$$F_b = \frac{0.38\,(0.5in)^2 (12 \times 10^6\ psi)(0.063)(0.5in)}{25in}$$

$$F_b = 1436.4\ lbs$$

substy

$$FS = \frac{(19000 - 1436.4)\ lbs}{8800\ lbs}$$

$$FS = 1.9959$$

$$\boxed{FS = 2.0}$$

$$FS = \frac{F_u - F_o}{F_t} = \frac{(120\,000 - 55000)\,kg}{6500\,kg}$$

$$FS = 7.6471$$

$$F_b = \frac{AF_r d_w}{D} = \frac{0.38\, d^2 F_r (0.063) d}{D}$$

$$F_b = \frac{0.38\,(1.75\text{ in})^2 (30 \times 10^6 \text{ psi})(0.063)(1.75\text{ in})}{60\text{ in}}$$

$$F_b = 64151.7188 \text{ lbs}$$

$$S_b = \frac{Erdw}{D} = \frac{(30 \times 10^6 \text{ psi})(0.063)(2 \text{ in})}{50 \text{ in}}$$

$$S_b = 75600 \text{ psi}$$

Weight of the wire rope

$$W = 1.58 d^2 \; ; \; \frac{lb}{ft}$$

$$= 1.58 (2.5 in)^2$$

$$= \left(9.875 \frac{lb}{ft}\right)\left(110 m\right)\left(\frac{3.28 ft}{1 m}\right)$$

$$W = 3562.9 lbs$$