3.70

3.70 Air at standard conditions flows through the cylindrical drying stack shown in Fig. P3.70. If viscous effects are negligible and the inclined water-filled manometer reading is 20 mm as indicated, determine the flowrate.

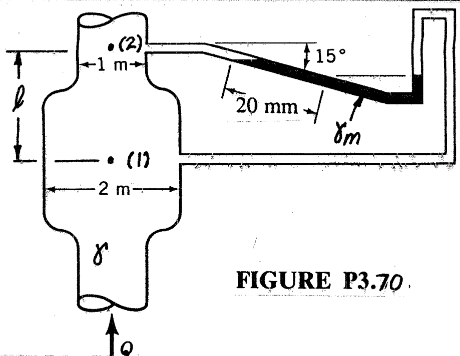

FIGURE P3.70

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2$$ where $z_1=0$, $z_2=\ell$ and

$$V_2=\frac{A_1}{A_2}V_1=\left(\frac{D_1}{D_2}\right)^2V_1=\left(\frac{2\,m}{1\,m}\right)^2V_1=4V_1$$

Thus,

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}=\frac{p_2}{\gamma}+\frac{(4V_1)^2}{2g}+\ell$$

or

$$\frac{15V_1^2}{2g}=\frac{p_1-p_2}{\gamma}-\ell \qquad (1)$$

However, $p_2+\gamma\ell_2+\gamma_m h=p_1-\gamma(\ell-h-\ell_2)$ where $h=(20\,mm)\sin 15$

or

$$\frac{p_1-p_2}{\gamma}=\left(\frac{\gamma_m}{\gamma}-1\right)h+\ell \qquad (2)$$

By combining Eqs. (1) and (2)

$$\frac{15V_1^2}{2g}=\left(\frac{\gamma_m}{\gamma}-1\right)h$$

or

$$V_1=\sqrt{\frac{2g\left(\frac{\gamma_m}{\gamma}-1\right)h}{15}}=\sqrt{\frac{2\left(9.81\,\frac{m}{s^2}\right)\left(\frac{9.80\times10^3\,\frac{N}{m^3}}{12.0\,\frac{N}{m^3}}-1\right)(0.02\sin 15)}{15}}$$

$$=2.35\,\frac{m}{s}$$

Thus,

$$Q=A_1V_1=\frac{\pi}{4}D_1^2V_1=\frac{\pi}{4}(2m)^2\left(2.35\,\frac{m}{s}\right)=\underline{\underline{7.38\,\frac{m^3}{s}}}$$