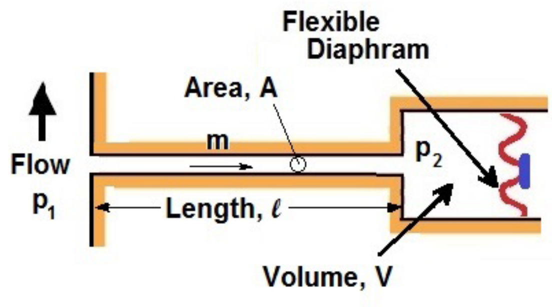
Solution to Problem 520A:

The frequency response of an individual remote transducer is limited by the dynamic response of the connection tube whose length and area we denote by ℓ and A: The pressures, p_1 and p_2, at the two ends of



the connection tube are related through the unsteady Bernoulli equation to the rate of change with time of the mass flow rate, m, in that tube:

$$p_1 - p_2 = \frac{\ell}{A}\left\{\frac{dm}{dt}\right\} \tag{1}$$

But dm/dt must be equal to $\rho(dV/dt)$ where ρ is the fluid density and V is the internal volume of the transducer which will change with the internal pressure, p_2, and be dependent on the flexibility of the transducer diaphragm. Representing that relation by $dV/dt = \kappa\; dp_2/dt$ it follows that the response of the combination of the connection tube and the transducer to the measured pressure, p_1, is

$$p_1 - p_2 = \frac{\ell}{A}\left\{\kappa\rho\frac{dp_2}{dt}\right\} \tag{2}$$

It follows that the radian resonance frequency, ω, of the combination when p_1 is constant is given by

$$\omega = \sqrt{\frac{A}{\kappa\rho\ell}} \tag{3}$$

or

$$f = \frac{1}{2\pi}\sqrt{\frac{A}{\kappa\rho\ell}} = 13.4\ Hz \tag{4}$$

Note that as the connection tube gets longer (or as its cross-sectional area gets smaller, the limiting frequency gets lower and lower. Hence the measurement of high frequencies often requires flush-mounted transducers with $\ell \rightarrow 0$.