pressurized instead of being open to the atmosphere, the pressure head would replace h_{atm} in Eq. 18.30 but would be implicit in $h_{p(s)}$ in Eq. 18.31.

$$\text{NPSHA} = h_{\text{atm}} + h_{z(s)} - h_{f(s)} - h_{\text{vp}} \qquad 18.30$$

$$\text{NPSHA} = h_{p(s)} + h_{\text{v}(s)} - h_{\text{vp}} \qquad 18.31$$

The net positive suction head available (NPSHA) for most positive displacement pumps includes a term for acceleration head.[19]

$$\text{NPSHA} = h_{\text{atm}} + h_{z(s)} - h_{f(s)} - h_{\text{vp}} - h_{\text{ac}} \qquad 18.32$$

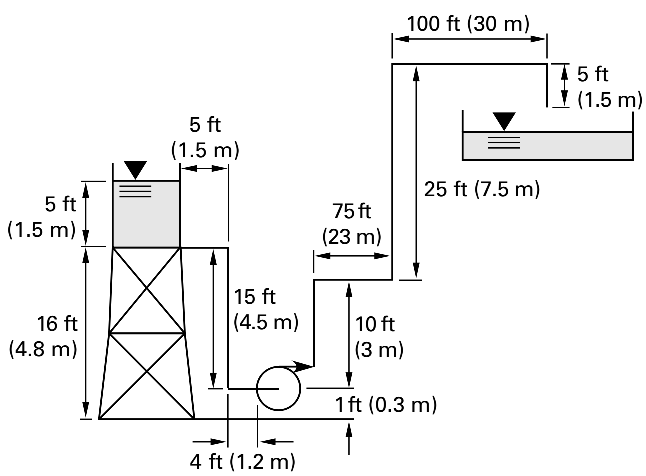
$$\text{NPSHA} = h_{p(s)} + h_{\text{v}(s)} - h_{\text{vp}} - h_{\text{ac}} \qquad 18.33$$

If NPSHA is less than NPSHR, the fluid will cavitate. The criterion for cavitation is given by Eq. 18.34. (In practice, it is desirable to have a safety margin.)

$$\text{NPSHA} < \text{NPSHR} \quad \left[\begin{array}{c}\text{criterion for}\\ \text{cavitation}\end{array}\right] \qquad 18.34$$

Example 18.8

2.0 ft^3/sec (56 L/s) of 60°F (16°C) water are pumped from an elevated feed tank to an open reservoir through 6 in (15.2 cm), schedule-40 steel pipe, as shown. The friction loss for the piping and fittings in the suction line is 2.6 ft (0.9 m). The friction loss for the piping and fittings in the discharge line is 13 ft (4.3 m). The atmospheric pressure is 14.7 psia (101 kPa). What is the NPSHA?



(not to scale)

SI Solution

The density of water is approximately 1000 kg/m^3. The atmospheric head is

$$h_{\text{atm}} = \frac{p}{\rho g} = \frac{(101\ \text{kPa})\left(1000\ \frac{\text{Pa}}{\text{kPa}}\right)}{\left(1000\ \frac{\text{kg}}{\text{m}^3}\right)\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)}$$
$$= 10.3\ \text{m}$$

For 16°C water, the vapor pressure is approximately 0.01818 bars. The vapor pressure head is

$$h_{\text{vp}} = \frac{p}{\rho g} = \frac{(0.01818\ \text{bar})\left(1 \times 10^5\ \frac{\text{Pa}}{\text{bar}}\right)}{\left(1000\ \frac{\text{kg}}{\text{m}^3}\right)\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)}$$
$$= 0.2\ \text{m}$$

From Eq. 18.30, the NPSHA is

$$\begin{aligned}\text{NPSHA} &= h_{\text{atm}} + h_{z(s)} - h_{f(s)} - h_{\text{vp}}\\ &= 10.3\ \text{m} + 6\ \text{m} + \cancel{4.8}\ \text{m} - 0.3\ \text{m}\\ &\quad -0.9\ \text{m} - 0.2\ \text{m}\\ &= 19.7\ \text{m}\end{aligned}$$

Customary U.S. Solution

The specific weight of water is approximately 62.4 lbf/ft^3. The atmospheric head is

$$h_{\text{atm}} = \frac{p}{\gamma} = \frac{\left(14.7\ \frac{\text{lbf}}{\text{in}^2}\right)\left(12\ \frac{\text{in}}{\text{ft}}\right)^2}{62.4\ \frac{\text{lbf}}{\text{ft}^3}}$$
$$= 33.9\ \text{ft}$$

For 60°F water, the vapor pressure head is 0.59 ft. Use 0.6 ft.

From Eq. 18.30, the NPSHA is

$$\begin{aligned}\text{NPSHA} &= h_{\text{atm}} + h_{z(s)} - h_{f(s)} - h_{\text{vp}}\\ &= 33.9\ \text{ft} + 20\ \text{ft} + \cancel{16}\ \text{ft} - 1\ \text{ft} - 2.6\ \text{ft} - 0.6\ \text{ft}\\ &= 65.7\ \text{ft}\end{aligned}$$

[19]The friction loss and the acceleration terms are both maximum values, but they do not occur in phase. Combining them is conservative.