Pump Up Time For Air Tanks

W.D. Filler

This is an equation that I have seen in various places in industry but I have not found a derivation so I decided to come up with one myself. If air is added to a receiver with initial pressure and mass of P_1 , m_1 and final pressure and mass of P_2 , m_2 and the mass of the air added to the tank is m_i then one can state that $m_1 + m_i = m_2$ or $m_i = m_2 - m_1$

From the ideal gas law $PV = mRT$ or $m = \frac{PV}{RT}$ and combining this equation with the mass balance equation we get

$$\frac{P_i V_i}{RT_i} = \frac{P_2 V_2}{RT_2} - \frac{P_1 V_1}{RT_1} \tag{1}$$

Since the volume of the tank does not change $V_2 = V_1 = V$ and for the purpose of this calculation it is assumed the the temperatures are equal although this will never be true in practice.

For constant flow rate of air into the tank V_i becomes Q * t where Q is the volume flow rate in CFM and t is the total time.

$$P_i \cdot Q \cdot t = V(P_2 - P_1) \tag{2}$$

Since the volume flow rate of air compressors is reported at standard conditions P_i is just P_{atm}. Air receivers are normally sized in gallons and the conversion factor is approximately 7.48 gallons per cubic foot. If the time is given in seconds we finally have

$$t = \frac{60 \cdot V(P_2 - P_1)}{7.48 \cdot P_{atm} \cdot Q} \tag{3}$$