Mass Flow Calculations Using Gas Dynamics Relations
Working Fluid: Air

Nomenclature
PL = pressure in low pressure vessel
Pe = exit pressure
Te = exit temperature
γ = Cp/Cv
M= mach number
V = Velocity
ρe = exit density
Ae = exit area of the nozzle
R = ideal gas constant of air
mdot = mass flow rat

Governing Equations:

$$P_L = P_e \cdot \left(1 + \frac{\gamma - 1}{2} \cdot M^2\right)^{\frac{\gamma}{\gamma - 1}}$$

$a = \sqrt{\gamma \cdot R \cdot T}$ $\quad V = M \cdot a \quad$ $\rho = \frac{P}{RT}$ $\quad A = \pi r^2 \quad$ $m_{dot} = \rho AV$

Variables

$\gamma := 1.4$ $\quad P_L := 104804Pa$ $\quad P_e := 101100Pa$ $\quad P_r := \frac{P_L}{P_e}$

$R_{air} := 287 \frac{J}{kg \cdot K}$ $\quad T_e := 297.15K$

$D_{nozzle} := .008m$ $\quad A_e := \pi \cdot \left(\frac{D_{nozzle}}{2}\right)^2$

Calculation of mass flow rate from the low pressure vessel to atmosphere:

$$M := \sqrt{\left(P_r^{\frac{\gamma-1}{\gamma}} - 1\right)\frac{2}{\gamma - 1}} \qquad M = 0.227$$

$$a := \sqrt{\gamma \cdot R_{air} \cdot T_e} \qquad a = 345.536\ \frac{m}{s}$$

$$V_e := M \cdot a \qquad V_e = 78.542\ \frac{m}{s}$$

$$\rho_e := \frac{P_e}{R_{air} \cdot T_e} \qquad \rho_e = 1.185\ \frac{kg}{m^3}$$

$$m_{dot} := \rho_e \cdot A_e \cdot V_e \qquad m_{dot} = 4.68 \times 10^{-3}\ \frac{kg}{s}$$