ONTARIO POWER GENERATION

File Notes

Subject	Page 1 of 1
GAS FLOW THRU REGULATOR PER CGA E-4 - 2006	File no.
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$C_v = .2$

$P_H = 2000$ psig

$P_L = 100$ psig

$$\frac{P_L}{P_H} = \frac{100 + 14.7}{2000 + 14.7} = .0569$$

		GAS	
		ARGON A	METHANE CH_4
%		90	10
M	lbm/lbmol	39.9	16
R	ft-lbf/lbm°F	38.7	96.4
k		1.67	1.32
Cv		.074	.449
Cp		.124	.593

TOTAL MASS $m = m_1 + m_2 = 90 + 10 = 100$ lbm

$$R_m = \sum \frac{m_i R_i}{m} = \frac{m_1 R_1 + m_2 R_2}{m} = \frac{90 \times 38.7 + 10 \times 96.4}{100} = 44.47 \ \frac{\text{ft-lbf}}{\text{lbm°F}}$$

$$k_m = \frac{\sum m_i C_{pi}}{\sum m_i C_{vi}} = \frac{m_1 C_{p1} + m_2 C_{p2}}{m_1 C_{v1} + m_2 C_{v2}} = \frac{90 \times .124 + 10 \times .593}{90 \times .074 + 10 \times .449} = 1.533$$

$$M_m = \frac{\sum m_i}{\sum \frac{m_i}{M_i}} = \frac{m_1 + m_2}{\frac{m_1}{M_1} + \frac{m_2}{M_2}} = \frac{90 + 10}{\frac{90}{39.9} + \frac{10}{16}} = 34.715 \ \text{lbm/lbmol}$$

$$P_C/P_H = \left(\frac{2}{k_m+1}\right)^{\left(\frac{k_m}{k_m-1}\right)} = \left(\frac{2}{1.533+1}\right)^{\left(\frac{1.533}{1.533-1}\right)} = .51$$ (CRITICAL PRESSURE RATIO)

$\therefore \frac{P_L}{P_H} < \frac{P_C}{P_H}$ (SONIC FLOW)

USING
$$A = \frac{6413.248}{\sqrt{M_m}} \sqrt{k_m} \left(\frac{2}{k_m+1}\right)^{\left[\left(\frac{k_m}{k_m-1}\right)-.5\right]} = \frac{6413.248}{\sqrt{34.72}} \sqrt{1.533} \left(\frac{2}{1.533+1}\right)^{\left[\left(\frac{1.533}{1.533-1}\right)-.5\right]} = 768.7$$

AND
$$Q = \frac{A C_v P}{\sqrt{T}} = \frac{768.7 \times .2 \times 2014.7}{\sqrt{530}} = 13454 \ \text{SCFH}$$

$Q = 224$ SCFM

For C_v = 0.5, the flow is 0.5 x 7612 = 3806 scfh. Since it is a regulator, we use 0.8 x 3806 = 3045 scfh as the rated flow capacity of the second stage seat. The flow capacity of the regulator then is the smaller of the three calculated values, or 1786 scfh under those conditions.

A3 Isentropic flow through orifices—flow equations

NOTE—These equations assume ideal gases and constant specific heat ratios C_P / C_V.

C_v = flow coefficient

Q = flow in cfh @ 1 atm and 70 °F (scfh)

P_1 = inlet pressure (psia)

P_2 = outlet pressure (psia)

T_1 = inlet gas temperature in °R = °F + 460

M = Molecular weight of gas

K = Specific heat ratio of gas = C_p / C_v

P_c / P_1 = Critical pressure ratio of gas = $(2/(k+1))^{(k/(k-1))}$

A3.1 Sonic flow equations (apply if $P_2 / P_1 \leq P_c / P_1$)

For calculating C_v: $$C_V = \frac{Q\sqrt{T_1}}{AP_1}$$

For calculating flow: $$Q = \frac{A\,C_V\,P_1}{\sqrt{T_1}}$$

Constant A = $$\frac{6413.248}{\sqrt{M}}\sqrt{k}\left(\frac{2}{k+1}\right)^{\left(\left(\frac{k}{k-1}\right)-0.5\right)}$$

A3.2 Subsonic flow equations (apply if $P_2 / P_1 > P_c / P_1$)

For calculating C_v: $$C_V = \frac{Q\sqrt{T_1}}{B\sqrt{1-(P_2/P_1)^{\frac{(k-1)}{k}}}\left(P_1^{\frac{(k-1)}{k}}\right)\left(P_2^{\frac{1}{k}}\right)}$$

For calculating flow: $$Q = \frac{BC_v\sqrt{1-(P_2/P_1)^{\frac{(k-1)}{k}}}\left(P_1^{\frac{(k-1)}{k}}\right)\left(P_2^{\frac{1}{k}}\right)}{\sqrt{T_1}}$$

Constant B = $$\frac{9069.702}{\sqrt{M}}\sqrt{\frac{k}{k-1}}$$