6.7 Flow Orifice Sizing

- Assume flange-to-flange maximum pressure drop ($h_{w\,max}$, Miller p.9-21).

Typical installation	=	2,500 mmH_2O [100 inH_2O]
Bubble point liq and venturi's	=	1,250 mmH_2O [50 inH_2O]
Gases	$\leq$	1.0 inH_2O × Operating pres (psia)

- Calculate required maximum flow (meter max) at standard conditions:

$$Q_{meter\,max} \simeq \frac{Q_{rated}}{0.8}$$

- Round meter max to even 5-10 m^3/h (at standard or normal conditions). Check that all cases are 30-90% of meter max (3:1 flow ratio, Miller p.9-106).
- Calculate β and orifice bore at meter max flow and dP.

6.8 Beta Ratio Limits

- Beta ratio $\beta = \frac{d}{D} = \frac{Bore}{Pipe\,ID}$
- Change pipe size or pressure drop to stay within beta ratio range for flow meters.
- Do not change pipe more than one standard pipe size.
- Beta ratio limits for flow meters are (Miller Table 9.54):

Flow meter	β Range
Square edge orifice	0.2-0.75 (design 0.7 max)
Quadrant edge orifice	0.24-0.6
Venturi	0.4-0.7

- Restriction orifices can have smaller/larger beta ratios.
- Small restriction orifices normally have a standard drill size hole.

6.17 Two-Phase Expansion Factor - Close-up Taps

- The two-phase expansion factor is based on the Omega equation of state proposed by Epstein et al (1983) and refined by Leung (1992).

$$\frac{\rho_{ref}}{\rho} = \omega\left[\frac{P_{ref}}{P} - 1\right] + 1$$

  Any two-phase point (including bubble point liquid) can be used as reference.

- The equations below are modifications of Leung's equations to express it in terms of the upstream pressure (P_1) instead of stagnation pressure (P_0).

$$Y_{\omega 1} = \sqrt{\frac{(1-\beta^4)\left[(1-r_s) + \omega r_s \ln\left(\frac{r_s}{r}\right) + (1-\omega)(r_s - r)\right]}{(1-r)\left[\left[\omega(\frac{r_s}{r} - 1) + 1\right]^2 - \beta^4\right]}}$$

ω = Compressibility parameter
r = Larger of $\frac{P_2}{P_1}$ or r_c
r_s = Larger of $\frac{P_{1s}}{P_1}$ or $\frac{P_2}{P_1}$
r_c = Smaller of $\frac{P_c}{P_1}$ or $\frac{P_s}{P_1}$
P_1 = Upstream pressure (kPa abs)[psia]
P_2 = Downstream pressure (kPa abs)[psia], at close-up taps
P_s = Bubble point pressure at T_1 (kPa abs)[psia]

- Several equations have been proposed for ω causing a fair bit of confusion. It is the most accurate and easiest to calculate ω directly from its definition (ISO 4126).

$$\rho_i = \left[\frac{x_1}{\rho_{iG}} + \frac{(1-x_1)}{\rho_L} + N(x_i - x_1)\left(\frac{1}{\rho_{iG}} - \frac{1}{\rho_L}\right)\right]^{-1}$$

$$\omega = \frac{\left(\frac{\rho_{1s}}{\rho_i} - 1\right)}{\left(\frac{P_{1s}}{P_i} - 1\right)} \quad \text{with } \omega \geq 0$$

$$\epsilon = \frac{(x_i - x_{1s})}{\left(1 - \frac{P_i}{P_{1s}}\right)}$$

P_{1s}, ρ_{1s}, x_{1s} = Pressure, density and vapour mass fraction based on the smaller of P_1 or P_s
P_i, ρ_i, x_i = Pressure, densities and vap mass frac at intermediate point. Based on isentropic flash from P_1 to P, but isenthalpic flash is acceptable. API 520 uses $P = 0.9P_1$, Diers uses $P = 0.7P_1$.
N = Boiling delay factor, 1=HEM, 0=Frozen model