$ORIGIN := 1$

$T := 373.15 \qquad P := 30$

Methane

$T_c := 190.6 \qquad P_c := 46.1 \qquad \omega := 0.011$

$T_r := \frac{T}{T_c} = 1.958 \qquad P_r := \frac{P}{P_c} = 0.651$

$\alpha := \left[1 + \left(0.37464 + 1.54226 \cdot \omega - 0.26992 \cdot \omega^2\right) \cdot \left(1 - \sqrt{T_r}\right)\right]^2 = 0.712$

$A := 0.45724 \cdot \frac{P_r}{T_r^2} \cdot \alpha = 0.055 \qquad B := 0.0778 \cdot \frac{P_r}{T_r} = 0.026$

$p := -1 + B \qquad q := A - 2B - 3 \cdot B^2 \qquad r := -A \cdot B + B^2 + B^3$

$N := X^3 + p \cdot X^2 + q \cdot X + r \;\Big|\; \begin{matrix} \text{solve , X} \\ \text{assume , X = real} \end{matrix} \rightarrow 0.97335026651954664607$

$Z := \max(N) = 0.973$

$\phi := \exp\left[Z - 1 - \ln(Z - B) - \frac{A}{B \cdot \sqrt{8}} \cdot \ln\left[\frac{Z + \left(1 + \sqrt{2}\right) \cdot B}{Z + \left(1 - \sqrt{2}\right) \cdot B}\right]\right] = 0.972$

Ethane

$T_{cv} := 305.3 \qquad P_{cv} := 49 \qquad \omega := 0.099$

$T_{rv} := \frac{T}{T_c} = 1.222 \qquad P_{rv} := \frac{P}{P_c} = 0.612$

$$\alpha := \left[1 + \left(0.37464 + 1.54226\cdot\omega - 0.26992\cdot\omega^2\right)\cdot\left(1 - \sqrt{T_r}\right)\right]^2 = 0.892$$

$$A := 0.45724\cdot\frac{P_r}{T_r^{\,2}}\cdot\alpha = 0.167 \qquad B := 0.0778\cdot\frac{P_r}{T_r} = 0.039$$

$$p := -1 + B \qquad q := A - 2B - 3\cdot B^2 \qquad r := -A\cdot B + B^2 + B^3$$

$$N := X^3 + p\cdot X^2 + q\cdot X + r \;\Big|\; \begin{matrix}\text{solve}\\ \text{assume , } X = \text{real}\end{matrix} \rightarrow 0.87020053012053604464$$

$$Z := \max(N) = 0.87$$

$$\phi := \exp\left[Z - 1 - \ln(Z - B) - \frac{A}{B\cdot\sqrt{8}}\cdot\ln\left[\frac{Z + \left(1 + \sqrt{2}\right)\cdot B}{Z + \left(1 - \sqrt{2}\right)\cdot B}\right]\right] = 0.879$$

Alternative Solution

$$root(p, q, r) := \left|\begin{array}{l} v \leftarrow \begin{pmatrix} r \\ q \\ p \\ 1 \end{pmatrix} \\ x \leftarrow \text{polyroots}(v) \\ \text{for } \; i \in 1 \,..\, 3 \\ \quad x_i \leftarrow 0 \quad \text{if} \quad \text{Im}(x_i) \neq 0 \\ x1 \leftarrow \max(x) \\ y \leftarrow \min(x) \\ x2 \leftarrow \left|\begin{array}{ll} \max(x) & \text{if} \quad y = 0 \\ y & \text{otherwise} \end{array}\right. \\ \begin{pmatrix} x1 \\ x2 \end{pmatrix} \end{array}\right.$$

$$T_c := \begin{pmatrix} 190.6 \\ 305.3 \end{pmatrix} \qquad P_c := \begin{pmatrix} 46.1 \\ 49.0 \end{pmatrix} \qquad \omega := \begin{pmatrix} 0.011 \\ 0.099 \end{pmatrix}$$

$$\phi(T, P) := \left| \begin{array}{l} \text{for} \quad i \in 1 .. 2 \\ \quad T.r_i \leftarrow \dfrac{T}{T.c_i} \\ \quad P.r_i \leftarrow \dfrac{P}{P.c_i} \\ \quad \alpha_i \leftarrow \left[1 + \left[0.37464 + 1.54226\,\omega_i - 0.26992\left(\omega_i\right)^2\right] \cdot \left(1 - \sqrt{T.r_i}\right)\right]^2 \\ \quad A_i \leftarrow 0.45724 \cdot \dfrac{P.r_i \cdot \alpha_i}{\left(T.r_i\right)^2} \\ \quad B_i \leftarrow 0.07780 \cdot \dfrac{P.r_i}{T.r_i} \\ \quad p_i \leftarrow -1 + B_i \\ \quad q_i \leftarrow A_i - 2\,B_i - 3\left(B_i\right)^2 \\ \quad r_i \leftarrow \left(-A\right)_i \cdot B_i + \left(B_i\right)^2 + \left(B_i\right)^3 \\ \quad Z_i \leftarrow \text{root}\left(p_i, q_i, r_i\right)_1 \\ \quad \Theta_i \leftarrow \dfrac{A_i}{\sqrt{8} \cdot B_i} \cdot \ln\left[\dfrac{Z_i + \left(1 + \sqrt{2}\right) \cdot B_i}{Z_i + \left(1 - \sqrt{2}\right) \cdot B_i}\right] \\ \quad \phi_i \leftarrow \exp\left(Z_i - 1 - \ln\left(Z_i - B_i\right) - \Theta_i\right) \\ \phi \end{array} \right.$$

$$\phi(T, P) = \begin{pmatrix} 0.972 \\ 0.879 \end{pmatrix}$$