Equations

$$\log\left[\frac{d_i}{b_i}\right] = A1 + B1 \log \alpha_i \quad (1)$$

where:

d_i = Moles of component i in the distillate
b_i = Moles of component i in the bottoms
α_i = Relative volatility of component i
A1,B1 = Correlation constants

$$f_i = d_i + b_i \quad (2)$$

$$\log\left[\frac{d_{HK}}{b_{HK}}\right] = A1 + B1 \log \alpha_{HK} \quad (3)$$

$$A1 = \log\left[\frac{d_{HK}}{b_{HK}}\right] \quad (4)$$

$$f_{HK} = d_{HK} + b_{HK} \quad (5)$$

$$f_{LK} = d_{LK} + b_{LK} \quad (6)$$

therefore:

$$A1 = \log\left[\frac{f_{HK} - b_{HK}}{b_{HK}}\right] \quad (7)$$

$$A1 = \log\left[\frac{1.0 - \frac{b_{HK}}{f_{HK}}}{\frac{b_{HK}}{f_{HK}}}\right] \quad (8)$$

$$\log\left[\frac{d_{LK}}{b_{LK}}\right] = \log\left[\frac{d_{HK}}{b_{HK}}\right] + B1 \log \alpha_{LK} \quad (9)$$

therefore:

$$B1 = \frac{\log\left[\left(\frac{d_{LK}}{b_{LK}}\right) / \left(\frac{d_{HK}}{b_{HK}}\right)\right]}{\log \alpha_{LK}} \quad (10)$$

$$B1 = \frac{\log\left[\left(\frac{\frac{d_{LK}}{f_{LK}}}{\frac{f_{LK} - d_{LK}}{f_{LK}}}\right)\left(\frac{\frac{b_{HK}}{f_{HK}}}{\frac{f_{HK} - b_{HK}}{f_{HK}}}\right)\right]}{\log \alpha_{LK}} \quad (11)$$

$$B1 = \frac{\log\left[\left(\frac{\frac{d_{LK}}{f_{LK}}}{1 - \frac{d_{LK}}{f_{LK}}}\right)\left(\frac{\frac{b_{HK}}{f_{HK}}}{1 - \frac{b_{HK}}{f_{HK}}}\right)\right]}{\log \alpha_{LK}} \quad (12)$$

$$\log\left[\frac{d_i/f_i}{1 - d_i/f_i}\right] = A1 + B1 \cdot \log \alpha_i \quad (13)$$

$$\frac{d_i/f_i}{1 - d_i/f_i} = 10^{A1} \cdot 10^{\log_{10}\alpha_i^{B1}} \quad (14)$$

$$= 10^{A1} \cdot \alpha_i^{B1}$$

$$d_i/f_i = 10^{A1} \cdot \alpha_i^{B1}\,(1 - d_i/f_i) \quad (15)$$

$$d_i/f_i = \frac{10^{A1} \cdot \alpha_i^{B1}}{1 + 10^{A1} \cdot \alpha_i^{B1}} \quad (16)$$

$$b_i/f_i = 1 - d_i/f_i \quad (17)$$

$$= 1 - \frac{10^{A1} \cdot \alpha_i^{B1}}{1 + 10^{A1} \cdot \alpha_i^{B1}} \quad (18)$$

$$b_i/f_i = \frac{1}{1 + 10^{A1} \cdot \alpha_i^{B1}} \quad (19)$$

$$N_{min.} = \frac{\log\left[\left(\frac{x_{LK}}{x_{HK}}\right)_D \cdot \left(\frac{x_{HK}}{x_{LK}}\right)_B\right]}{\log\left[\frac{\alpha_{LK}}{\alpha_{HK}}\right]} \quad (20)$$

Hence for component i, in the distillate

$$R_{min.} + 1 = \sum_{i=1}^{n} \frac{a_i \cdot x_{i,D}}{(\alpha_i - \theta)} \quad (21)$$

$$1 - q = \sum_{i=1}^{n} \frac{\alpha_i \cdot x_{i,F}}{(\alpha_i - \theta)} \quad (22)$$

PROPOSED EQUATIONS

Hengstebeck 1961

$$\log Y = A + B\log X + C\,(\log X)^2 + D\,(\log X)^3 + E\,(\log X)^4 \quad (23)$$

where:

A = −1.3640187
B = −3.0920489
C = −3.407344729
D = −1.74673876
E = −0.33268897

Liddle 1968

For $0.0 \leq X \leq 0.01$, $Y = 1.0 - 18.5715X$ (24)
For $0.01 < X < 0.90$ $Y = 0.545827 - 0.591422X + 0.002743/X$ (25)
For $0.90 \leq X \leq 1.0$ $Y = 0.16595 - 0.16595X$ (26)

Van-Winkle and Todd 1971

For $0.0078 < X < 0.125$, $Y = 0.5039 - 0.5968X - 0.0908 \log X$ (27)
For $0.125 < X$ to $X = 1.0$, $Y = 0.6257 - 0.9868X + 0.516X^2 - 0.1738X^3$ (28)

Molokavov, et al., 1972

$$0 \leq (X,Y) \leq 1.0$$

$$Y = 1 - \exp\left(\frac{1 + 54.4X}{11 + 117.2X} \cdot \frac{X - 1}{\sqrt{X}}\right) \quad (29)$$

Hohman and Lockhart 1972

$X = 0$, $Y = 0.65$
$X = 1.0$, $Y = 0.067$

$$Y = \frac{0.65 - 0.50X}{1.0 + 1.25X} \quad (30)$$

Eduljee 1975

$X = 0$, $Y = 1.0$
$X = 1.0$, $Y = 0$

$$Y = 0.75 - 0.75X^{0.5668} \quad (31)$$

Huan-Yang Chang 1981

For $X = 0$, $Y = 1$
$X = 1$, $Y = 0$

$$Y = 1 - \exp\left(1.49 + 0.315X - \frac{1.805}{X^{0.1}}\right) \quad (32)$$

Harg 1985

For $X = 0$, $Y = 1$
$X = 1.0$, $Y = 0$

$$Y = 1 - X^{1/3} \quad (33)$$

McCormick 1988

$X = 0$, $Y = 1$
$X = 1$, $Y = 0$
$Y = 1 - X^B$

$$B = 0.105 \log X + 0.44 \quad (34)$$

i.e., $R = \text{FACTOR} \cdot R_{min.}$ (35)

$$\log\frac{m}{p} = 0.206 \log\left[\frac{B}{D}\left(\frac{X_{HK}}{X_{LK}}\right)_F \cdot \left[\frac{(X_{LK})_B}{(X_{HK})_D}\right]^2\right] \quad (36)$$

where:

m = Number of theoretical stages above the feed plate
p = Number of theoretical stages below the feed plate