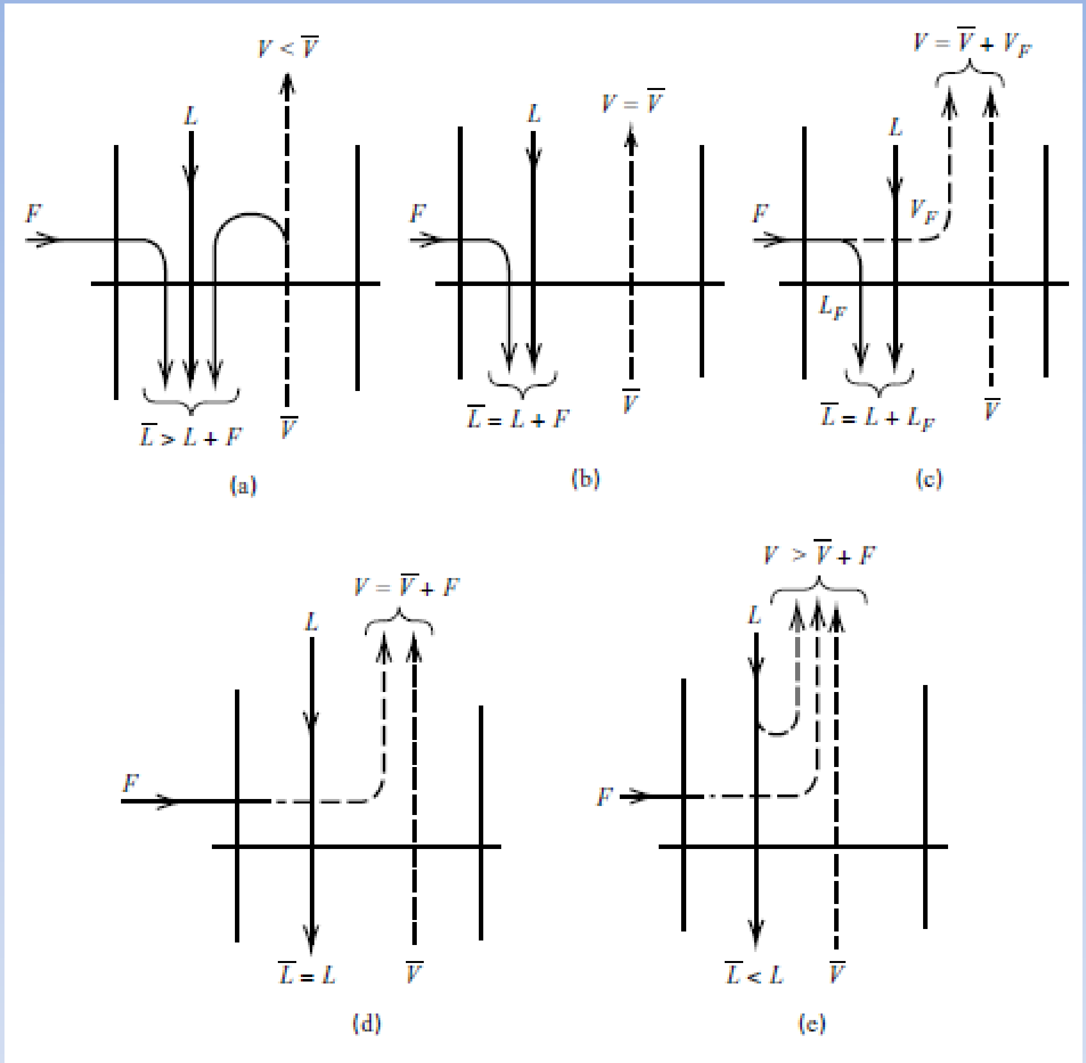
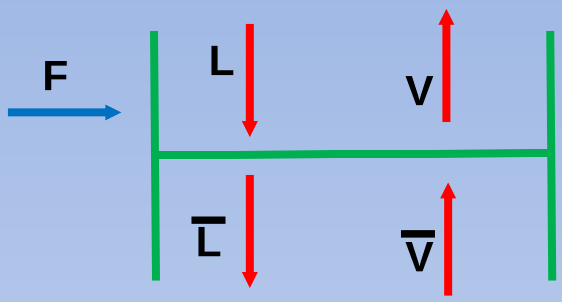
Fondamenti delle operazioni unitarie dell'industria chimica

Distillazione - parte seconda



(a) Liquido sottoraffreddato;
(b) Liquido saturo;
(c) Misto liquido e vapore;
(d) Vapore saturo;
(e) Vapore surriscaldato.



$$F + L + \bar{V} = \bar{L} + V$$

$$FH_F + LH_L + \bar{V}H_V = \bar{L}H_L + VH_V$$

$$\left(\bar{L} - L\right)H_L = \left(\bar{V} - V\right)H_V + FH_F$$

$$\frac{\left(\bar{L} - L\right)H_L}{F} = \frac{\left(\bar{V} - V\right)H_V}{F} + H_F$$

$$\frac{\left(\bar{L} - L\right)H_L}{F} = \frac{\left(\bar{L} - L\right)H_V}{F} + H_F - H_V$$

$$\frac{\left(\bar{L} - L\right)}{F} = \frac{H_V - H_F}{H_V - H_L}$$

$$q = \frac{\left(\bar{L} - L\right)}{F} = \frac{H_V - H_F}{H_V - H_L}$$

$$q = \frac{\left(\bar{L} - L\right)}{F} = \frac{H_V - H_F}{H_V - H_L}$$

$$\frac{\text{Calore necessario a portare 1 mole di feed a vapore saturo}}{\text{Calore latente molare di vaporizzazione}}$$

$$q = \frac{\left(\bar{L} - L\right)}{F} = \frac{H_V - H_F}{H_V - H_L}$$

Liquido sottoraffreddato	$q > 1$
Liquido saturo	$q = 1$
Liquido + vapore	$1 > q > 0$
Vapore saturo	$q = 0$
Vapore surriscaldato	$q < 0$

↓ T_F, H_F

$$q = \frac{(\bar{L} - L)}{F} = \frac{H_V - H_F}{H_V - H_L}$$

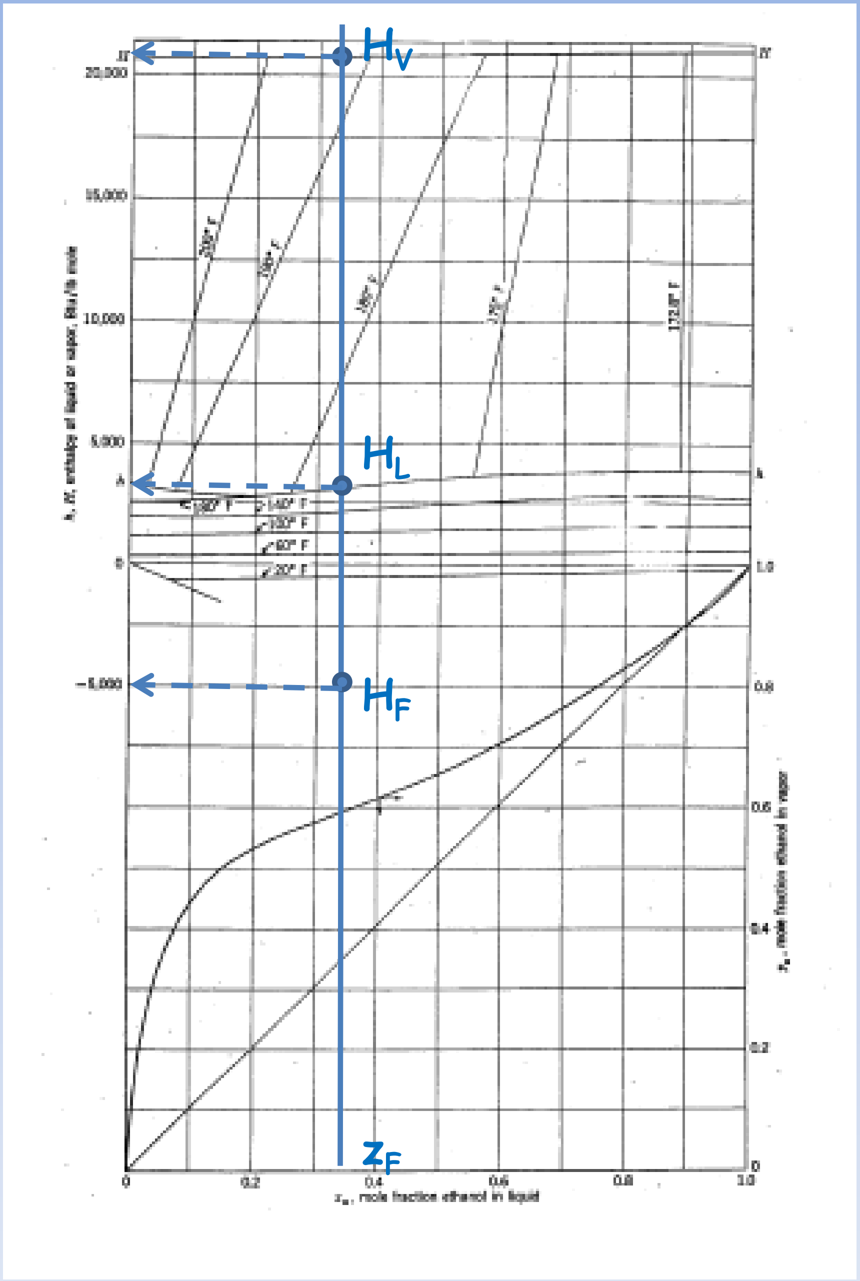
Liquido sottoraffreddato	$q > 1$
Liquido saturo	$q = 1$
Liquido + vapore	$1 > q > 0$
Vapore saturo	$q = 0$
Vapore surriscaldato	$q < 0$

H_F = -5000

H_L = 3120

H_V = 20700 *(BTU/lbmol)*

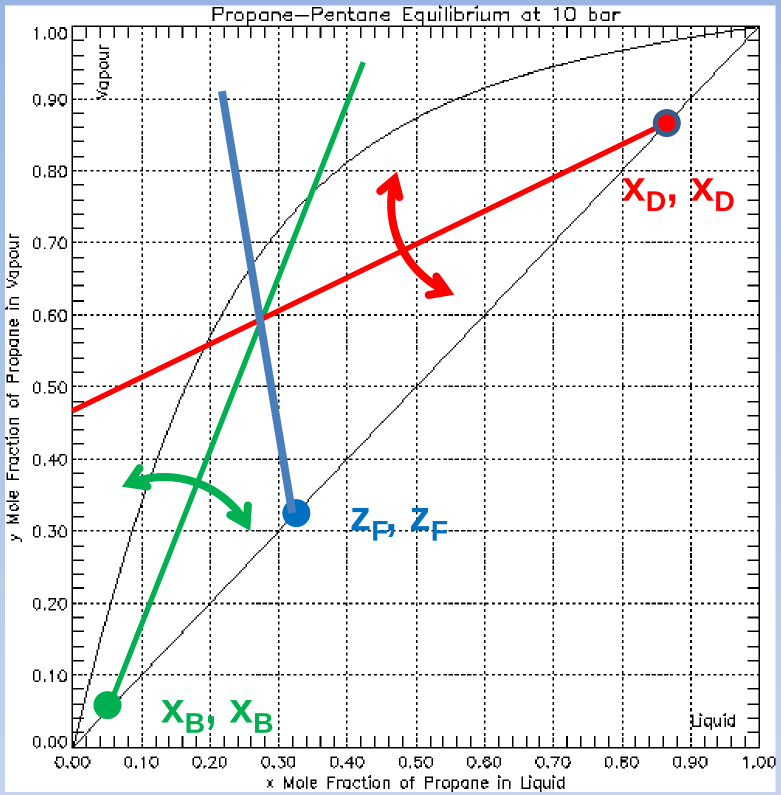
$$q = \frac{20700 - (-5000)}{20700 - 3120} = \frac{25700}{17580} = 1.461$$



$$yV = Lx + Dx_D$$

$$y\bar{V} = \bar{L}x - Bx_B$$

$$(\bar{V} - V)y = (\bar{L} - L)x - (Bx_B + Dx_D)$$

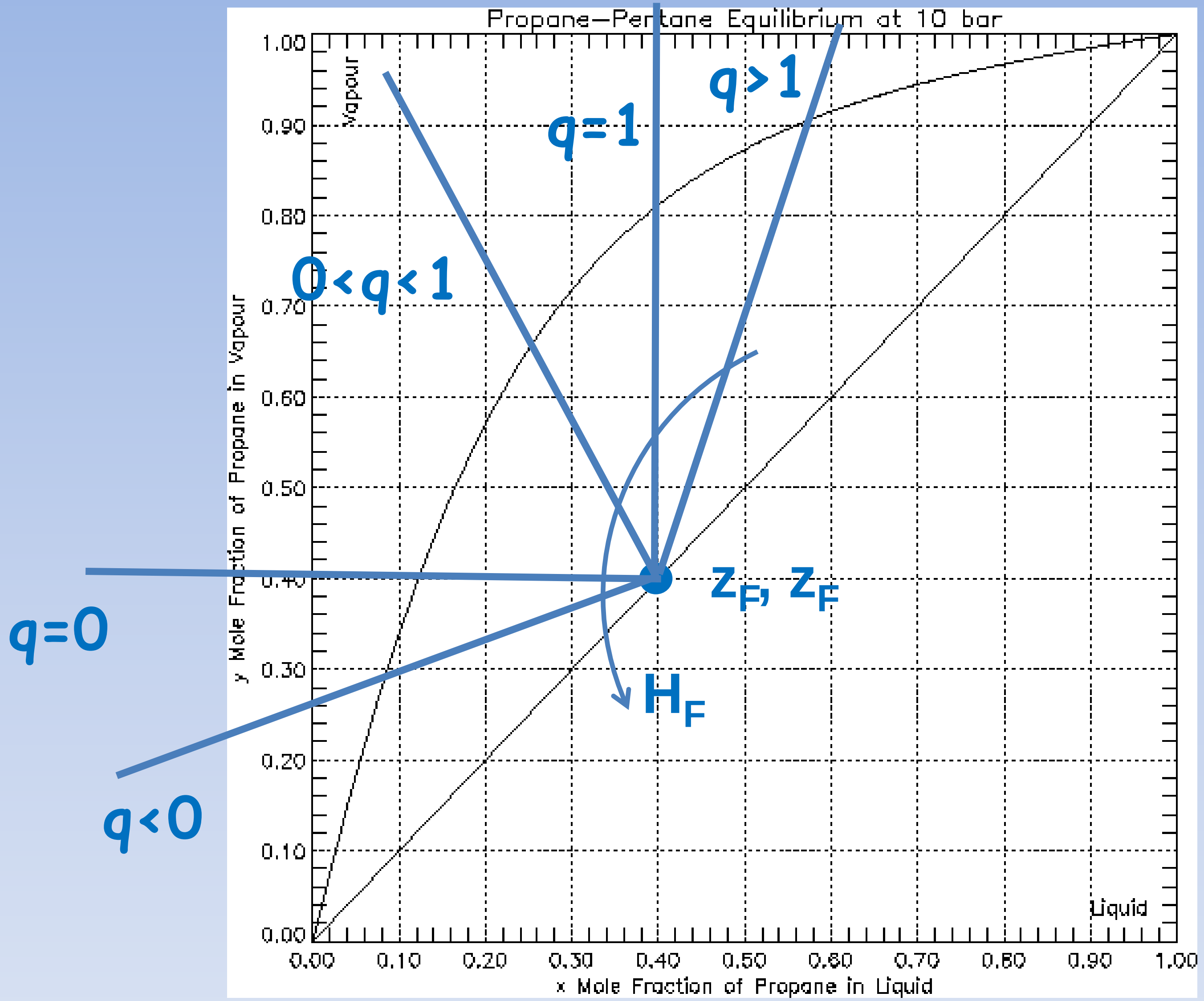


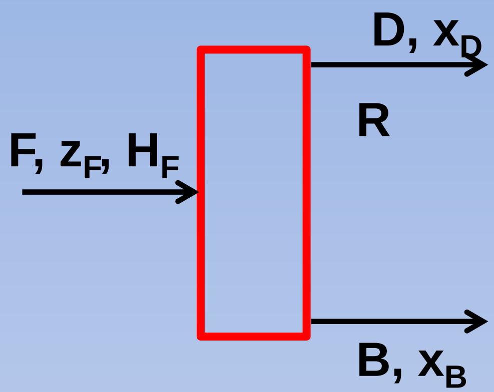
$$y = \frac{q}{q-1}x - \frac{z_F}{q-1}$$

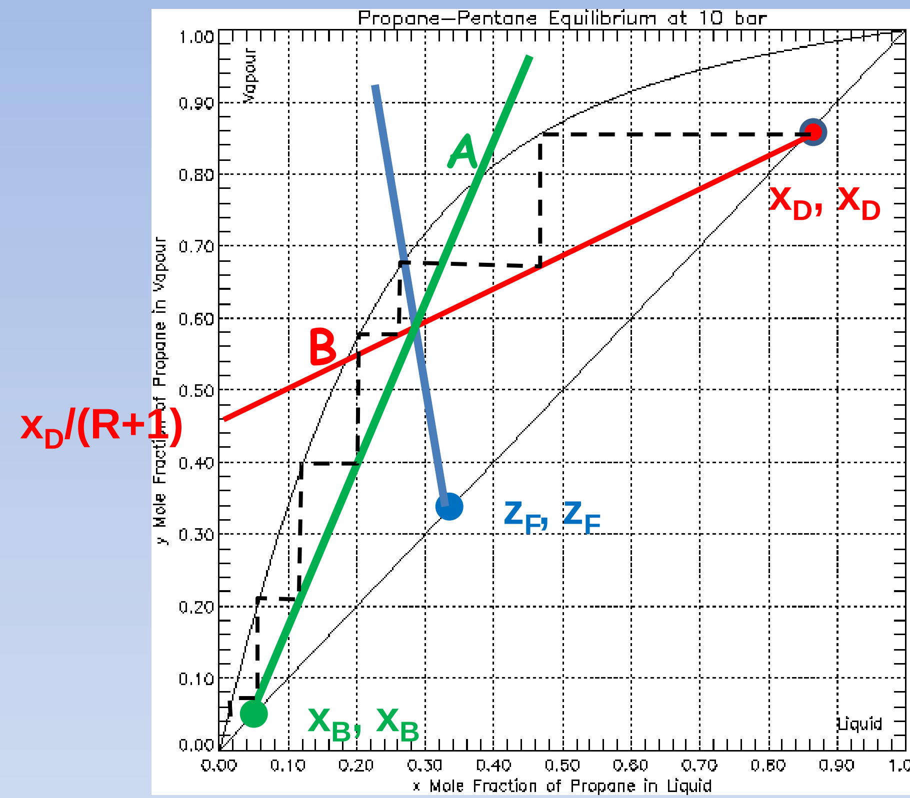
$$(\bar{L} - L) = Fq$$

$$(\bar{V} - V) = F(q-1)$$

$$(Bx_B + Dx_D) = Fz_F$$

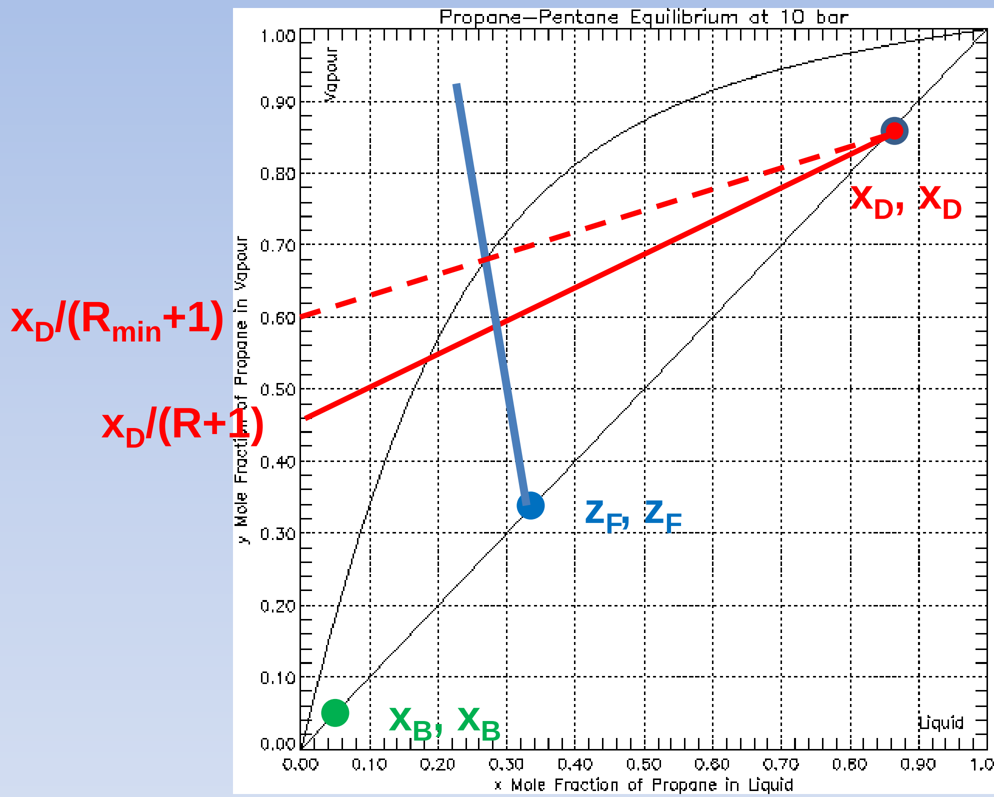

Propane–Pentane Equilibrium at 10 bar
y Mole Fraction of Propane in Vapour
x Mole Fraction of Propane in Liquid
Vapour
Liquid
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
q>1
q=1
0<q<1
q=0
q<0
z_F, z_F
H_F





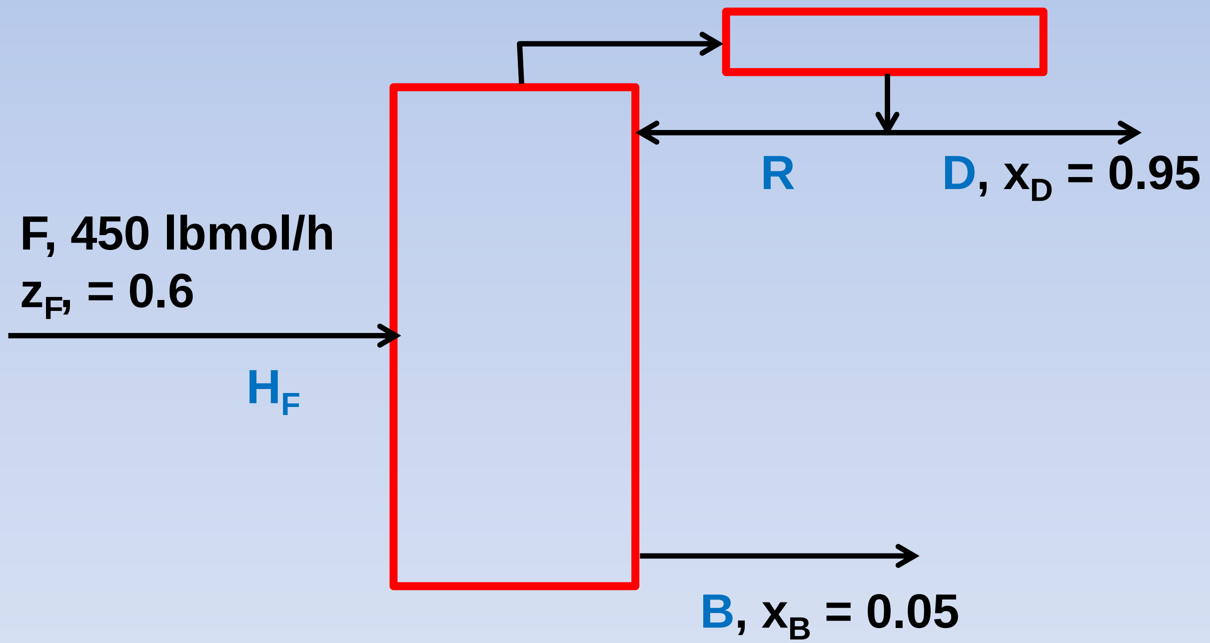
$N_P = 6$

Feed al terzo piatto


Propane–Pentane Equilibrium at 10 bar
y Mole Fraction of Propane in Vapour
x Mole Fraction of Propane in Liquid
Vapour
Liquid
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
xD/(Rmin+1)
xD/(R+1)
xD, xD
zF, zF
xB, xB

Esercitazione numerica n. 3 – Distillazione

2) Four hundred and fifty lbmol/h of a mixture of 60 mol% benzene and 40 mol% toluene is to be separated into a liquid distillate and a liquid bottoms product of 95 mol% and 5 mol% benzene, respectively. The feed enters the column with a molar per-cent vaporization equal to the distillate-to-feed ratio. Use the McCabe–Thiele method to compute, at 1 atm: N_{min}, R_{min}, and N for R/Rmin = 1.3, and the optimal feed-stage location.



1) $F = D + B$

2) $Fz_F = Dx_D + Bx_B$

1) $450 = D + B$

2) $270 = 0.95D + 0.05B$

$22.5 = 0.05D + 0.05B$

$270 = 0.95D + 0.05B$

$247.5 = 0.9D$

D = 275 lbmol/h; B = 175 lbmol/h

D/F = 0.611 = vaporizzato/feed

$$H_F = H_L + 0.611(H_v - H_L)$$

$$H_v - H_F = H_v - H_L - 0.611(H_v - H_L)$$

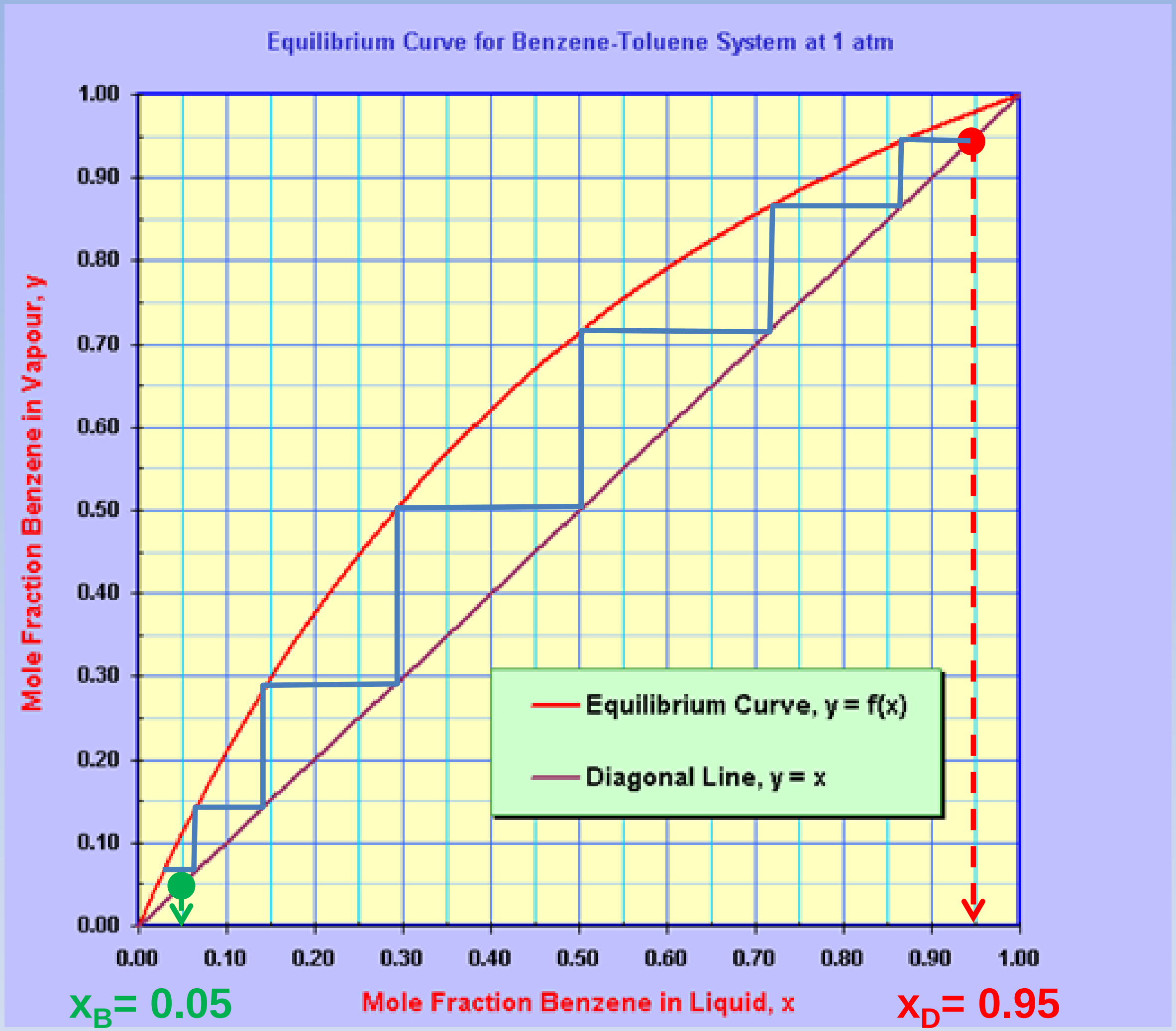
$$H_v - H_F = 0.389(H_v - H_L)$$

$$q = 0.389$$

$$q/(q-1) = -0.637$$

$$Y = -0.637x + 0.981$$

$N_{min} = 7$


Equilibrium Curve for Benzene-Toluene System at 1 atm
Mole Fraction Benzene in Vapour, y
Mole Fraction Benzene in Liquid, x
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Equilibrium Curve, y = f(x)
Diagonal Line, y = x
x_B = 0.05
x_D = 0.95

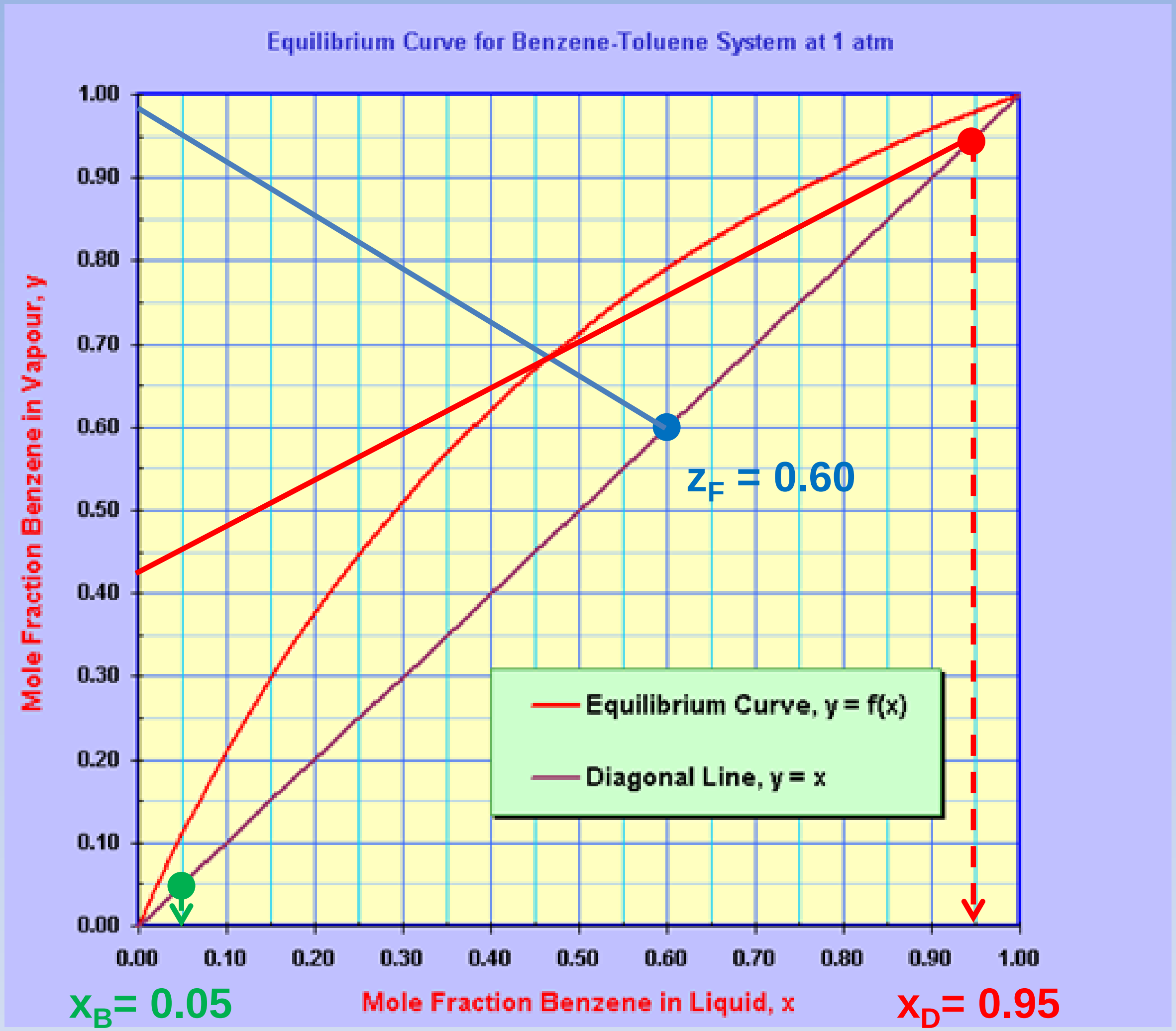
$N_{min} = 7$

$Y = -0.637x + 0.981$

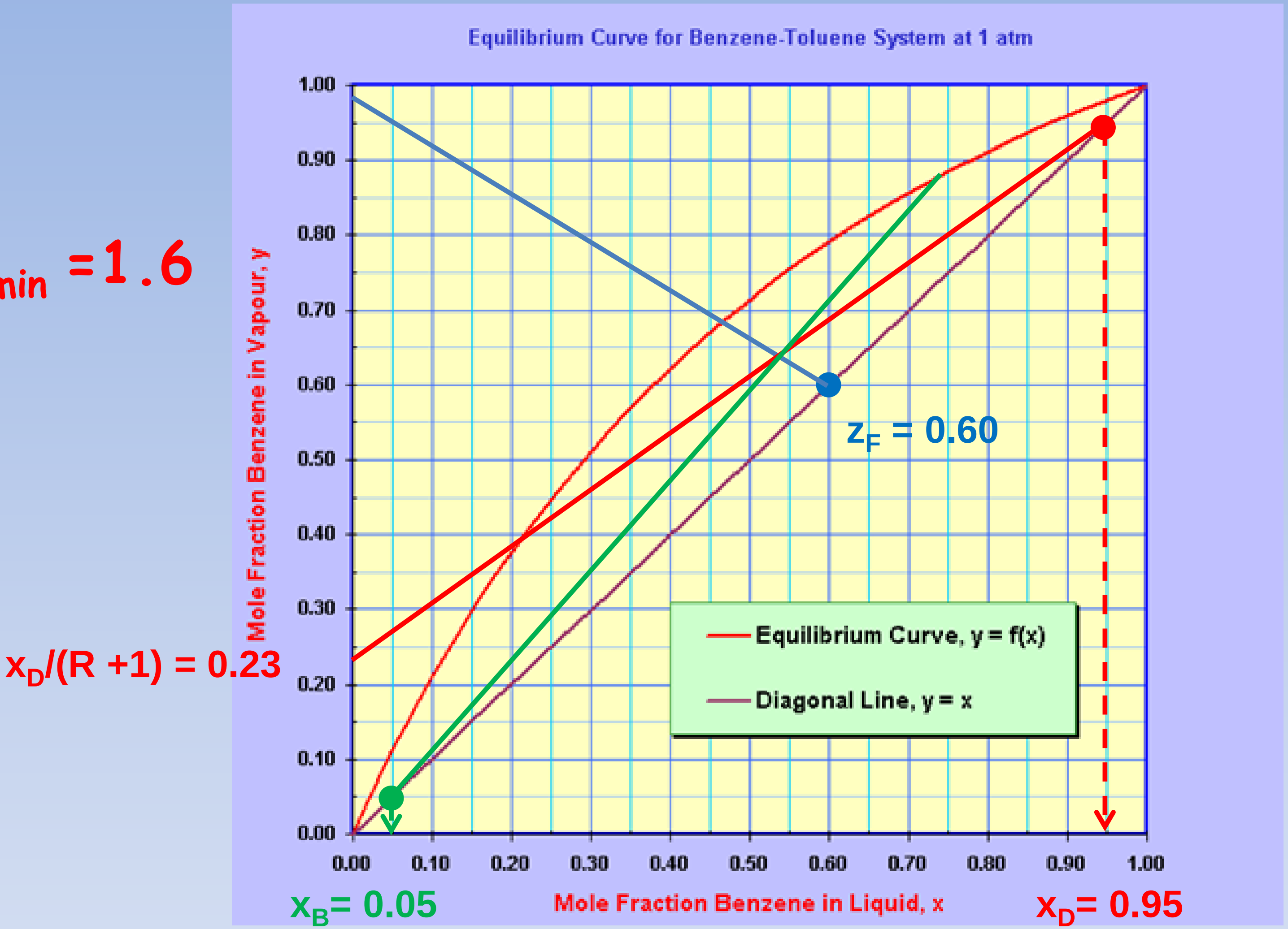
$x_D/(R_{min} + 1) = 0.425$

$R_{min} = 1.23$

$R = 1.3R_{min} = 1.6$

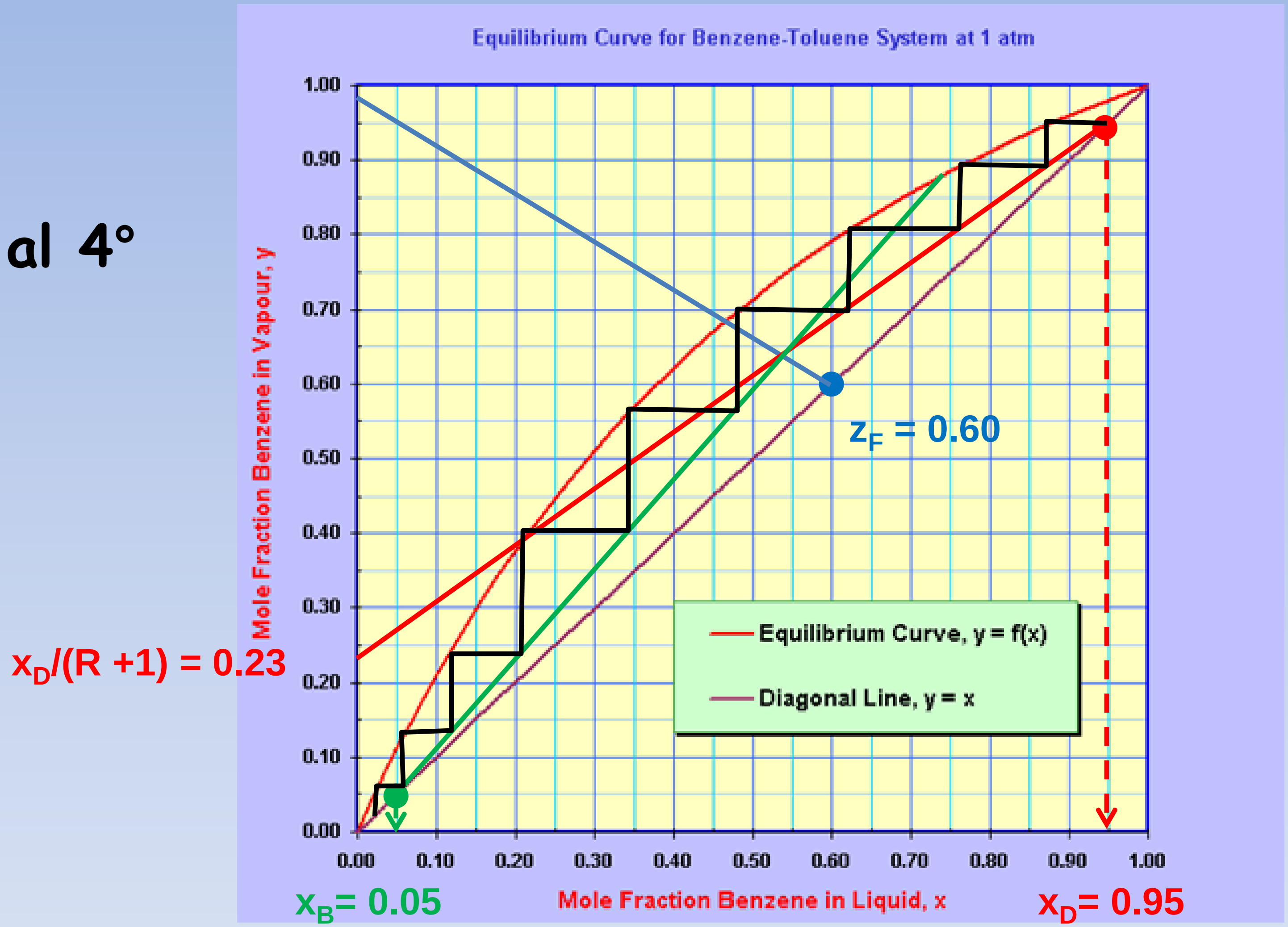


$R = 1.3R_{min} = 1.6$



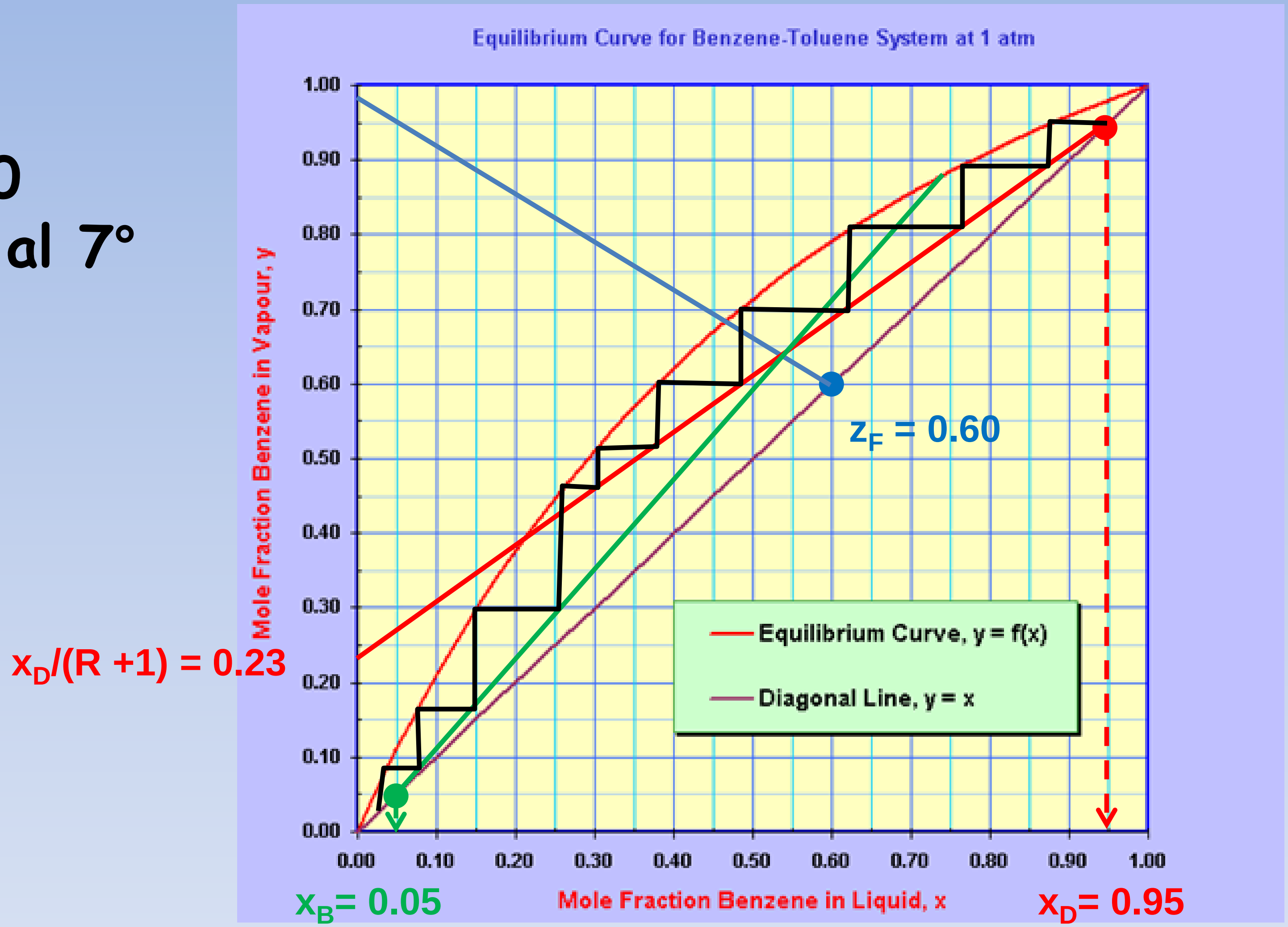
Equilibrium Curve for Benzene-Toluene System at 1 atm
Mole Fraction Benzene in Vapour, y
Mole Fraction Benzene in Liquid, x
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Equilibrium Curve, y = f(x)
Diagonal Line, y = x
z_F = 0.60
x_D/(R +1) = 0.23
x_B= 0.05
x_D= 0.95

N$_P$=9
Feed al 4°

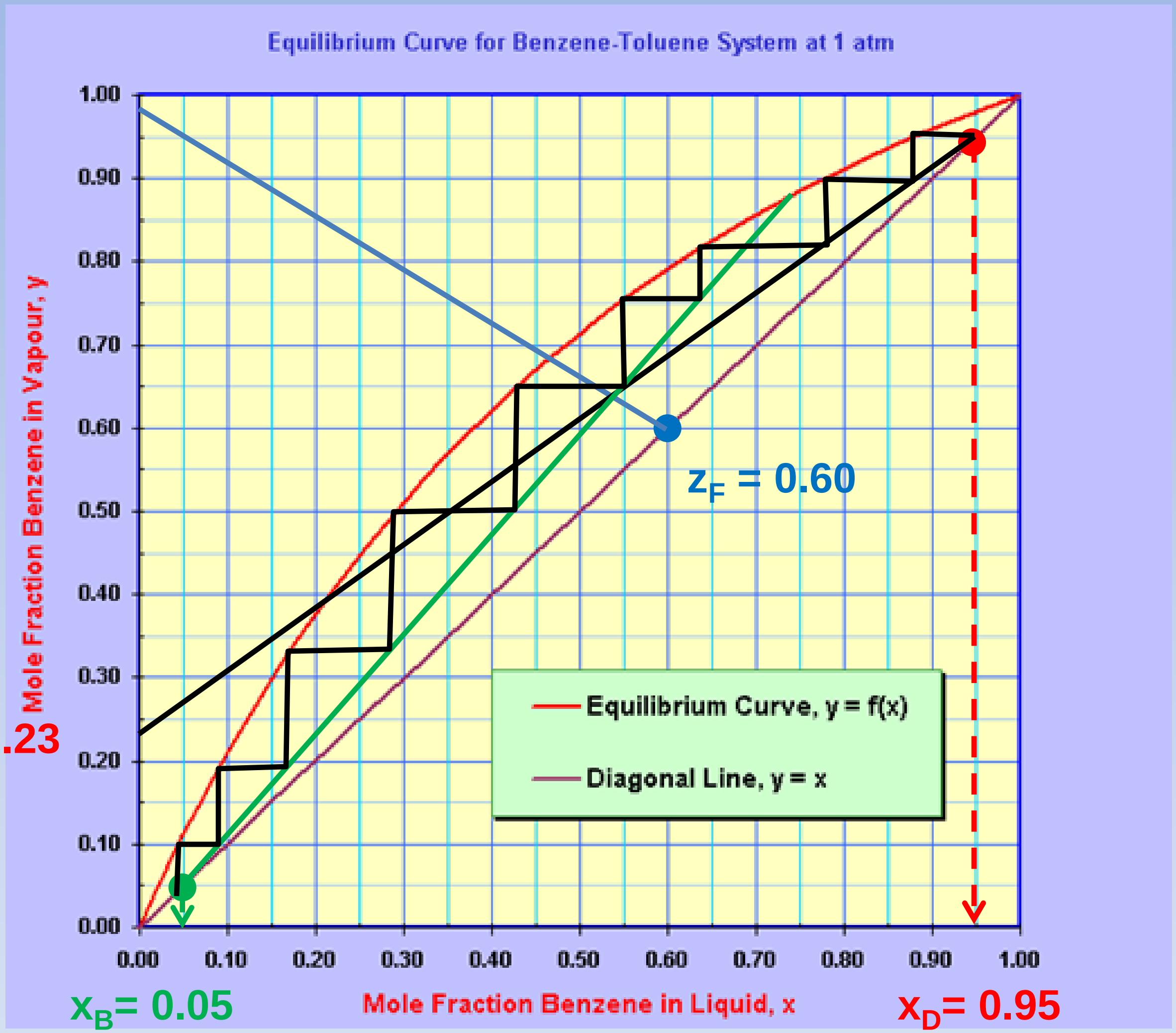


Equilibrium Curve for Benzene-Toluene System at 1 atm
Mole Fraction Benzene in Vapour, y
Mole Fraction Benzene in Liquid, x
Equilibrium Curve, y = f(x)
Diagonal Line, y = x
z_F = 0.60
$x_D/(R+1)$ = 0.23
x_B= 0.05
x_D= 0.95

N_P=10
Feed al 7°



N_P=9
Feed al 3°



$x_D/(R+1) = 0.23$

$x_B = 0.05$

$x_D = 0.95$