Calculation of Minimum Liquid Flow Rate:

The minimum liquid (solvent) flow rate is calculated when the exit solvent concentration from the absorber (**X_1**) is ***in equilibrium*** with the entering gas concentration to the absorber (**Y_1**). However, this calculations based on the equilibrium relationship natural:

A. If the equilibrium relationship is linear $(\mathbf{Y^* = m\,X})$:

The exit solvent concentration from the absorber (**X_1**) is calculated from the equilibrium relationship as below:

$$\mathbf{Y_1 = m\,X_1}$$

$$\rightarrow \boxed{\mathbf{X_1 = \frac{Y_1}{m}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ (\mathbf{1})$$

Overall solute material balance on the absorber column:

$$\mathbf{G_s\,(Y_1 - Y_2) = L_s\,(X_1 - X_2)}$$

$$\mathbf{\frac{L_s}{G_s} = \frac{Y_1 - Y_2}{X_1 - X_2}}$$

For pure solvent ($\mathbf{X_2 = 0}$**):**

$$\boxed{\mathbf{\frac{L_s}{G_s} = \frac{Y_1 - Y_2}{X_1}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (\mathbf{2})$$

To calculate minimum liquid flow rate $\left[\left(\frac{L_s}{G_s}\right)_{min}\right]$ we subsititute Eq. (1) into Eq. (2)

$$\mathbf{\left(\frac{L_s}{G_s}\right)_{min} = \frac{Y_1 - Y_2}{\frac{Y_1}{m}} = m\,\frac{Y_1 - Y_2}{Y_1} = m\left(1 - \frac{Y_2}{Y_1}\right)}$$

:

$$\left(\frac{L_s}{G_s}\right)_{min} = m\left(1 - \frac{Y_2}{Y_1}\right)$$

B. If the non- equilibrium relationship is linear:

Where: $\left(\frac{L_s}{G_s}\right)_{actual} = (1.1 - 1.5)\left(\frac{L_s}{G_s}\right)_{min}$

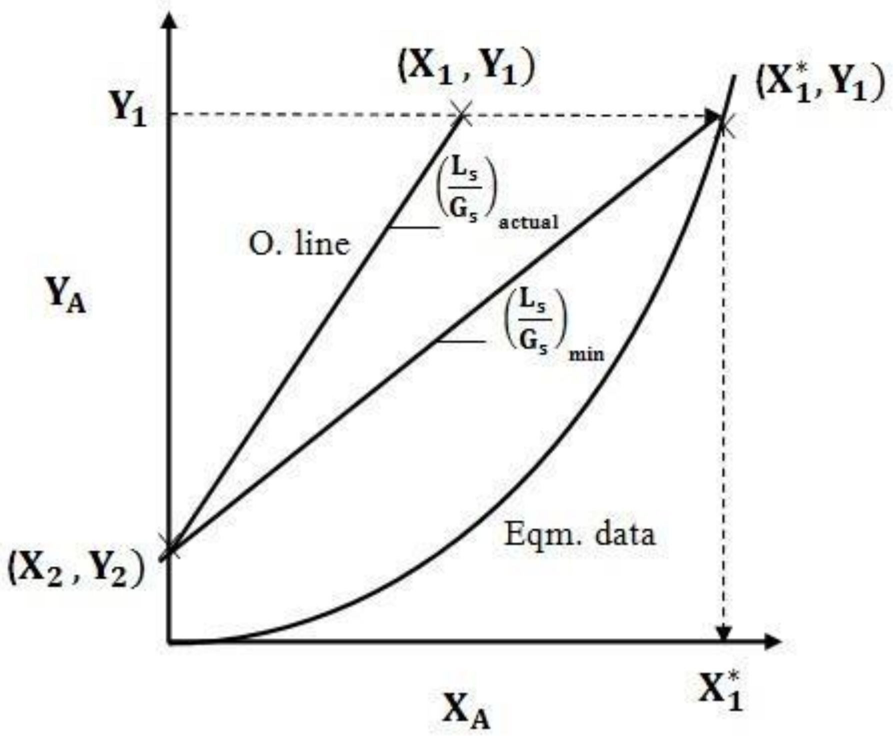
The exit solvent concentration from the absorber (X_1) is calculated from the equilibrium relationship as below:

$$\left(\frac{L_s}{G_s}\right)_{min} = \frac{Y_1 - Y_2}{X_1^* - X_2}$$

For pure solvent ($X_2 = 0$):

$$\left(\frac{L_s}{G_s}\right)_{min} = \frac{Y_1 - Y_2}{X_1^*}$$

Where: X_1^* the exit liquid concentration which is in equilibrium with (Y_1) is calculated from the plot as show bellow:



Example (3):

A solute gas is absorbed from a dilute gas-air mixture by counter current scrubbing with a solvent in a packed tower. The equilibrium relation is **Y = m X**. Show that the number of transfer units (**NOG**) required is given by the following equation:

If (99%) of the solute is to be recovered using a liquid rate of 1.75 times the minimum and the height of transfer unit is (1 m). What the height of packing will be required.

Solution:

Z = HOG * NOG

For linear equilibrium relationship:

$$\left(\frac{L_s}{G_s}\right)_{min} = m\left(1 - \frac{Y_2}{Y_1}\right)$$

$$\mathbf{Y_2} = (\mathbf{1} - \mathbf{Recovery})\ \mathbf{Y_1} = (1 - 0.99)\ Y_1 = 0.01\ Y_1$$

$$Y_2 = 0.01\ Y_1$$

$$\left(\frac{L_s}{G_s}\right)_{min} = m\left(1 - \frac{0.01\ Y_1}{Y_1}\right) = 0.99\ m$$

$$\left(\frac{L_s}{G_s}\right)_{actual} = 1.75\ \left(\frac{L_s}{G_s}\right)_{min} = (1.75)\ (0.99\ m) = 1.7325\ m$$

$$\phi = \frac{m\ G_s}{L_s} = \frac{m}{1.7325\ m} = 0.577$$

NOG = 8.88 Z = HOG * NOG = (1) (8.8) = 8.8 m