# MATERIAL BALANCE

**<u>Basis:</u>** 100 Kg moles of $C_2H_4O$

The conversion is taken as 95%

Of the 100 Kg moles of ethylene oxide sent, 95% is reacting.

The crude stream ‘a’ contain the products and 5 Kg moles of $C_2H_4O$

Neglecting the 5 Kg moles of $C_2H_4O$ i.e. assuming that all the 5 Kg moles of $C_2H_4O$ are going out with the top product of the tower.

On a ethylene oxide free basis.The weight fraction (%) of crude product Stream 'a' is:

85% - Monoglycol ether

10% - Diglycol ether

5% - Triglycol ether

The mole fraction of this stream 'a' on a ethylene oxide free basis is as:

89.885% - Monoglycol ether

7.101% - Diglycol ether

3.011% - Triglycol ether

For a crude product of 100 Kg moles ($C_2H_4O$-free),

89.885 Kg moles of monoglycol ether => 89.885 Kg moles of $C_2H_4O$

7.101 Kg moles of carbitol => 14.202 Kg moles of $C_2H_4O$

3.011 Kg moles of triglycol ether => 9.033 Kg moles of $C_2H_4O$

Therefore, Total ethylene oxide that has reacted for 100 Kg moles of ($C_2H_4O$-free) crude product =113.12 Kg moles of $C_2H_4O$.

For 100 Kg moles of $C_2H_4O$ sent only 95 Kg moles reacts.

Therefore,for 95 Kg moles of $C_2H_4O$ reacting,the total crude product ($C_2H_4O$-free) formed is

(95x 100)/113.12 = 83.981 Kg moles of crude product

The crude product is (83.981+5)Kg moles for 100 Kg moles of $C_2H_4O$ feed.

The total $C_2H_5OH$ reacting = [(83.981x89.885)/100 + (83.981x7.101)/100]

= 81.4504 Kg moles

The recycle must be such that the ratio is 1:6

Total recycle is: (6x100) – 81.450 = 518.5 Kg moles

The composition of the stream b is

518.55 Kg moles of $C_2H_4O$+(83.981+5)Kg moles of crude product

The composition of stream ‘a’ on a $C_2H_4O$ free basis is known.

**For tower (1):**

F = 83.981

F = D+W----------(1)

And $Fx_F = Dx_D + Wx_W$ ----------(2)

Now fixing $x_D$ as 0.99 and $x_W$ =0.05, $x_F$=0.89885

We have solving (1) and (2):

83.981x 0.89885= Dx0.99+(83.981-D)0.05

Solving for D we have

D = 75.837 Kg moles

And W = 8.143 Kg moles

Let us take the 0.01 mole fraction lost is distillate is all carbitol(it is lighter then triglycol ether)

Therefore carbitol lost above is 0.75837 Kg moles

Now W= 8.143 Kg moles and has (8.143x0.05)=0.40715 Kg moles of mono-glycol ether

The carbitol in crude stream ‘a’ on a $C_2H_4O$ free basis is

= (83.981x7.101)/100

= 5.963 Kg moles

Of this 5.963 Kg moles of carbitol, 0.75837 Kg moles of carbitol is lost in distillate.

Therefore carbitol present =5.963 – 0.75837

=5.205 Kg moles

The remaining in triglycol ether =8.143 – 5.205 – 0.40715

= 2.5307

**<u>For tower (2):</u>**

F =8.143 Kg moles

Fixing $x_D$ as 0.99 and this is the purity of the product and $x_W$ =0.05

We have F =D + W

$Fx_F = Dx_D + Wx_W$

And $x_F$ of carbitol =5.205/8.143 =0.639

8.143x0.6391 = Dx0.99 + (8.143-D)x0.05

Solving for D we get

D=5.1040 Kg moles

And W =3.038 Kg moles

For 100 Kg moles of feed we have

5.1040 Kg moles of carbitol of 0.99 purity

25 TPD = 186.567 Kg moles/day

The ethylene oxide feed is 3655.309 Kg mole/day

The $C_2H_5OH$ feed is (81.450x186.567)/5.1040

= 2977.249 Kg mole/day

Crude product($C_2H_4O$-free) is (83.981x3655.309)/100

=3069.765 Kg mole/day

Crude product with $C_2H_4O$ is (88.981x3655.309)/100

= 3252.530 Kg moles/day

The $C_2H_4O$ recycle is (518.55x3655.309)/100

= 18954.558 Kg mole/day

Mono glycol ether,distillate tower (1) =75.837x36.55309

=2772.069 kg moles/day

F of tower (2) is (8.143x3655.309)/100

= 297.6510 Kg moles/day

And D is (5.1040x3655.309)/100

= 186.566 Kg moles/day

And w is (3.038x3655.309)/100 = 111. 048 Kg moles/day