MATERIAL BALANCE

Plant is to be designed to produce 150-tons/day/ day of Monoethanolamine.
Reactants used:

- Ammonia and
- Ethylene oxide

Ammonia entering mixes with recycled ammonia and enters as a 30% solution of ammonia. Both ammonia and ethylene oxide are mixed and fed to the reactor. Reactor is maintained at temperature of 150^{o}C and pressure 160 bar. Reaction occurs in the liquid phase.

Ammonia utilization is 100% and Ethylene oxide is 95% and 5% is lost during the operation. Ammonia to Ethylene oxide ratio is taken as 0.5. Excess ammonia is passed to get the desired concentration of MEA, i.e. the product coming out of the reactor consist of 70% of MEA, 20% of DEA and 5% of TEA. Water entering with the ammonia acts as inert material.

REACTOR

Basis:

100 tons/day per day of ethanolamine mixture coming out of the reactor, consist 70% MEA, 20% DEA and 5% of TEA. Hence MEA present for the 100 tons/day of ethanolamine mixture is 70 tons/day per day.
Reactions occurring in the reactor are as follows:

$$NH_3 + C_2H_4O \longrightarrow NH_2\text{-}CH_2\text{-}CH_2\text{-}OH$$

$$NH_2\text{-}CH_2\text{-}CH_2\text{-}OH + C_2H_4O \longrightarrow NH(CH_2CH_2OH)_2$$

$$NH(CH_2CH_2OH)_2 + C_2H_4O \longrightarrow N(CH_2CH_2OH)_3$$

From above three equations it is observed that one mole of ammonia gives one mole of MEA. Hence ammonia required to for 70 tons/day of MEA is

$$17\times 70/61.08 = 19.48 \text{ tons/day/ day}$$

Similarly one mole of ammonia is required to produce one mole of DEA and TEA. Hence ammonia required for production of 25 tons/day of DEA and %tons/day of TEA is:

$$17\times25 / 105.2 + 17\times 5 / 149.2 = 4.039 + 0.569 = 4.608 \text{ tons/day}$$

Therefore total quantity of ammonia required for 100 tons/day of ethanolamine mixture is given by:

$$19.48 + 4.608 = 24.09 \text{ tons/day.}$$

Similarly ethylene oxide required is;

$44 \times 70 / 61.08 + 44 \times 25 / 105.2 + 44 \times 5 / 149.2 = 75.81$ tons/day.

But ethylene oxide utilization is 95 % hence actual amount required is

$$75.81/ 0.95 = 79.8 \text{ tons/day/day}$$

For 150 tons/day of MEA in the ethanolamine mixture, amount ammonia and ethylene oxide required are:

Ammonia required $= 24.09 \times 150 / 70$

$= 51.62$ tons/day

Ethylene oxide required $= 79.8 \times 150 /70$

$= 171$ tons/day

In order to get the desired conversion ammonia must be passed in excess. Ammonia to Ethylene oxide ratio is taken as 0.5

Hence the amount of ammonia must be entered into the reactor is given by

$$0.5\times 171 = 85.5 \text{ tons/day}$$

Hence the excess ammonia entering is $= 85.5 - 51.62$

$= 33.88$ tons/day it is recycled.

Water has to be supplied = ammonia supplied $\times 70 / 30$

$= 85.5 \times 70/ 30$

$= 199.5$ tons/day

Input to the reactor:

Ammonia	85.5 tons/day
Ethylene oxide	171.0 tons/day
Water	199.5 tons/day
Output from the reactor:	
Ammonia	33.88 tons/day
MEA	150.0 tons/day
DEA	53.54 tons/day
TEA	10.71 tons/day

AMMONIA FLASH

Here in these equipments the ammonia, which is excess in quantity is completely removed and is taken that there is no removal of water occurs in this equipment. Therefore the ammonia entering is 33.88 tons/day, is completely removed. Recycle stream consist only ammonia. Hence

$$\text{Recycle ratio} = 33.88 / (199.5 + 33.88 + 150 + 53.57 + 10.71)$$

$$R = 0.0746$$

DEHYDRATION TOWER

Feed entering consist amines mixture along with water. Water has to be removed in this column. 98% of the water entering the column is removed as 99% distillate with 1% MEA. Hence amount of distillate is

$$199.5 \times 0.98 / 0.99$$

$$D = 197.48 \text{ tons/day}$$

Overall mass balance

$$F = D + W$$

Feed (F) = 413.78 tons/day

Therefore $W = 216.3$ tons/day

Component balance

$$F \times x_f = D \times x_d + W \times x_w$$

Therefore

$$x_w = 0.0182$$

Amount of MEA lost in the distillate is = 1.97 tons/day

MEA TOWER

The amount of water entering the tower is very small hence it is neglected for the further calculation in the MEA tower.

Amount MEA in the feed = 150 – 1.97

= 148.03 tons/day

DEA entering = 53.57 tons/day

TEA entering = 10.71 tons/day

Therefore x_f = 0.697 Kg of MEA per Kg of feed

The purity of the MEA to be produced is 99 %. Hence x_d = 0.99

It is assumed that the 99% of Monoethanolamine entering is recovered, hence the amount of the distillate is:

$$D = 148.03 \times 0.99 / 0.99$$

$$= 148.03 \text{ tons/day}$$

Amount of MEA going into the residue is = 0.01 × 148.03

= 1.4803 tons/day

Overall material balance $F = D + W$

$W = 64.28$ tons/day

Therefore x_w = 0.023 Kg of MEA/ Kg residue