

일반적인 증류탑에서의 에너지 절감(1): NMP+Water System

2017년 11월 3일(금)

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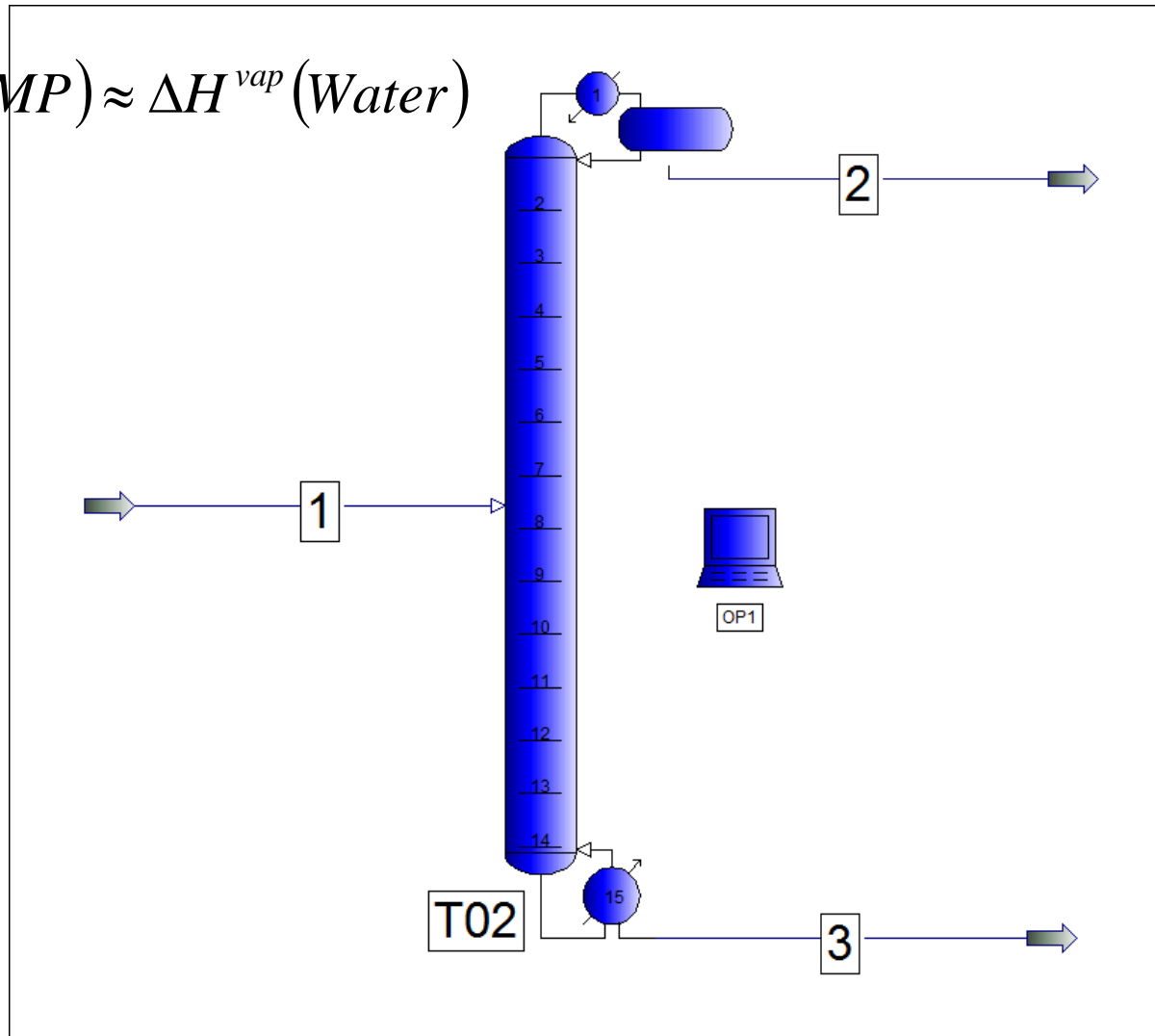
조 정 호

Feedstock Information:

- NMP Concentration Case Feedstock
 - Water content: 80wt%
 - Feedstock flow rate: 500 Ton/month (694 Kg/hr)
 - NBP(NMP): 204.27°C
 - NBP(H₂O): 100.00°C

NMP Concentration Column: Single Column

$$5 \times \Delta H^{vap}(\text{NMP}) \approx \Delta H^{vap}(\text{Water})$$



Column Summary:

COLUMN SUMMARY

TRAY	TEMP DEG C	PRESSURE BAR	NET FLOW RATES			HEATER DUTIES M*KCAL/HR
			LIQUID	VAPOR	FEED	
			KG/HR			
1C	45.0	1.05	279.3			558.6L -0.5009
2	104.8	1.20	310.2	837.9		
3	105.2	1.22	310.2	868.8		
4	105.6	1.23	310.2	868.8		
5	105.9	1.25	310.2	868.8		
6	106.3	1.26	310.6	868.8		
7	106.7	1.28	313.2	869.1		
8	107.5	1.29	600.9	871.8	259.0L	
9	108.1	1.31	1088.6	900.4	441.0L	
10	108.5	1.32	1089.0	947.2		
11	108.8	1.34	1089.7	947.6		
12	109.2	1.35	1095.6	948.3		
13	110.4	1.37	1205.0	954.2		
14	124.6	1.38	2438.8	1063.6		
15R	185.4	1.40		2297.4		141.4L <u>0.5104</u>

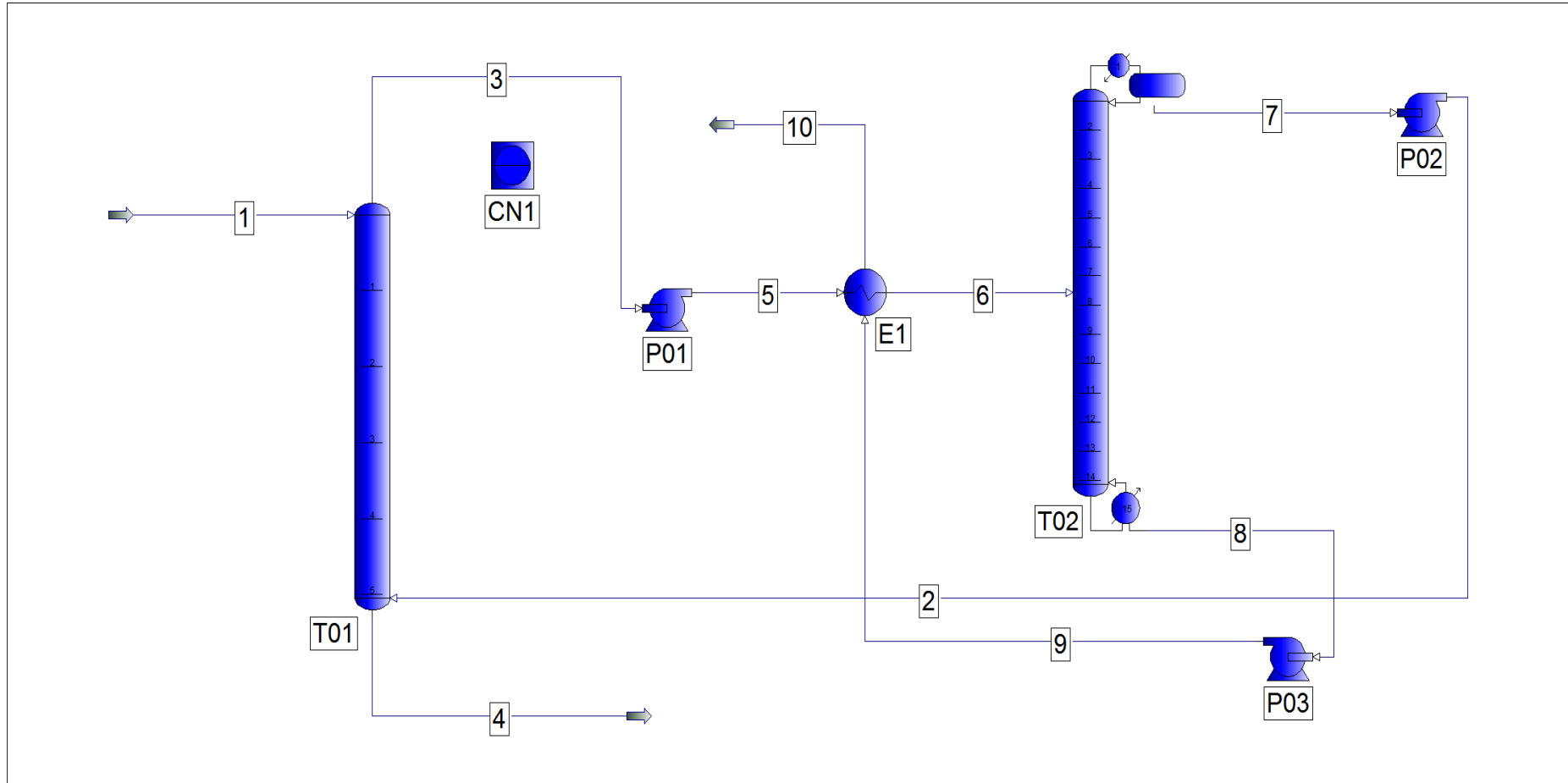
Stream Summary:

STREAM ID	1	2	3
NAME			
PHASE	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL02	NRTL02	NRTL02
FLUID RATES, KG/HR			
1 NMP	140.0000	1.1276E-05	<u>140.0000</u>
2 WATER	560.0000	558.5859	1.4141
3 C6H5CL	0.0000	0.0000	0.0000
TOTAL RATE, KG/HR	700.0000	558.5859	141.4141
TEMPERATURE, C	45.0000	45.0000	185.3886
PRESSURE, BAR	3.5000	1.0500	1.4000
ENTHALPY, M*KCAL/HR	0.0276	0.0252	0.0119
MOLECULAR WEIGHT	21.5405	18.0153	94.8613
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000	1.0000

Stream Summary:

STREAM ID	1	2	3
NAME			
PHASE	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL02	NRTL02	NRTL02
FLUID WEIGHT PERCENTS			
1 NMP	20.0000	2.0187E-06	<u>99.0000</u>
2 WATER	80.0000	100.0000	1.0000
3 C6H5CL	0.0000	0.0000	0.0000
TOTAL RATE, KG/HR	700.0000	558.5859	141.4141
TEMPERATURE, C	45.0000	45.0000	185.3886
PRESSURE, BAR	3.5000	1.0500	1.4000
ENTHALPY, M*KCAL/HR	0.0276	0.0252	0.0119
MOLECULAR WEIGHT	21.5405	18.0153	94.8613
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000	1.0000

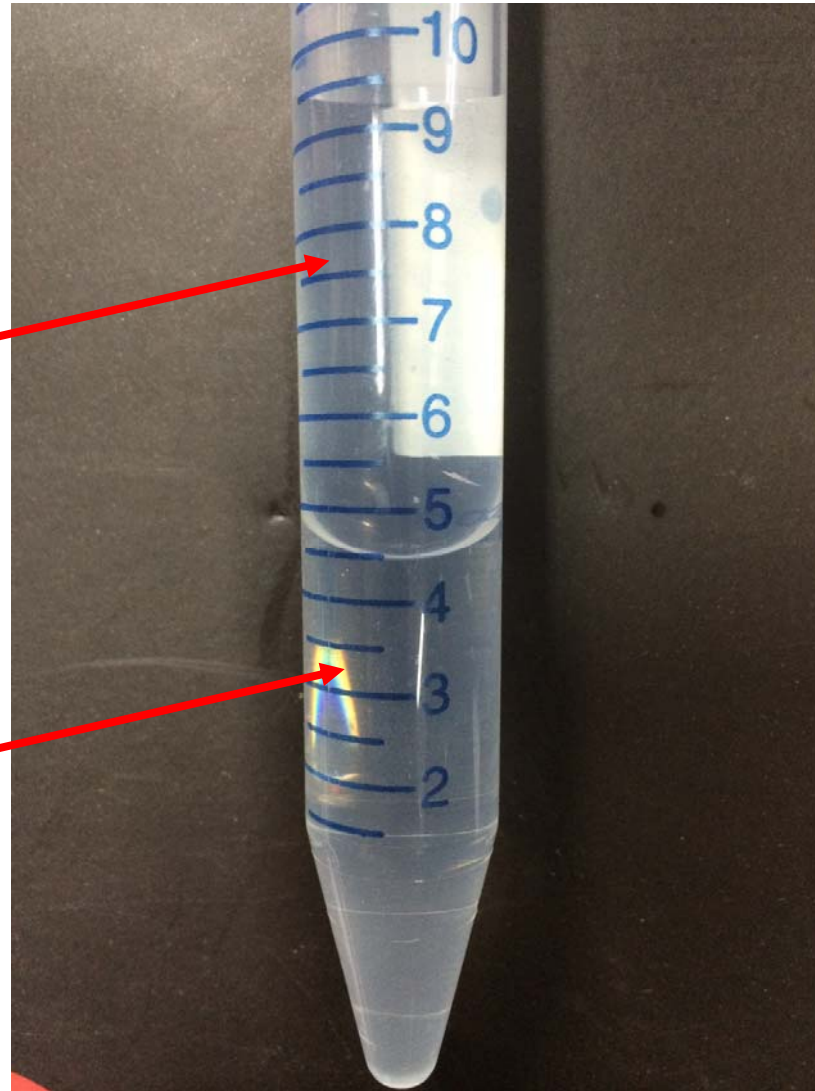
NMP Recovery Unit: Extractor + Recovery Column



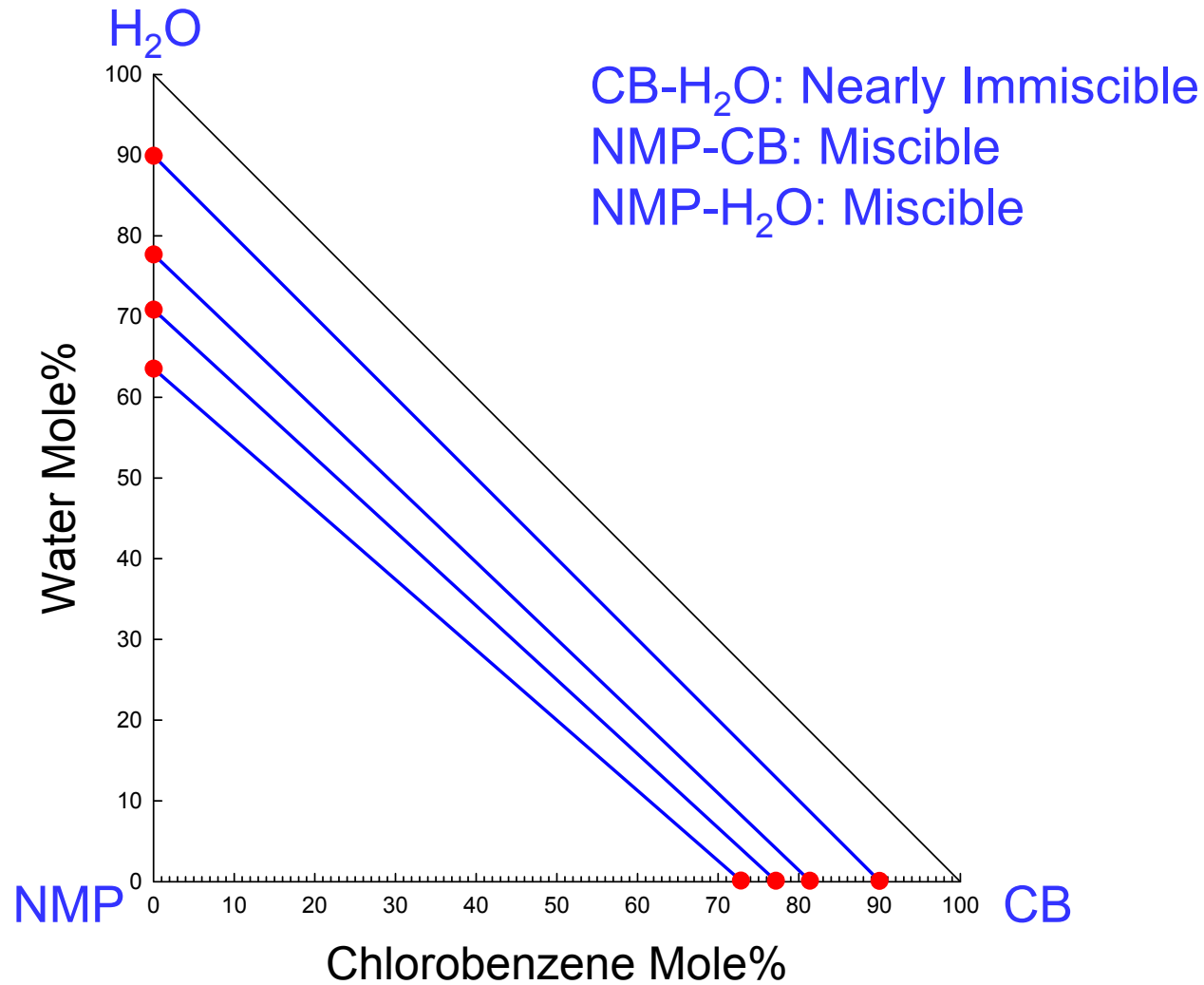
NMP Recovery Unit: Extractor + Recovery Column

Upper Phase:
Water-rich Phase

Lower Phase:
Chlorobenzene-rich Phase



Estimated Ternary Diagram: CB+H₂O+NMP at 25°C



Extraction Column Summary:

COLUMN SUMMARY

TRAY	TEMP DEG C	PRESSURE BAR	NET FLOW RATES				HEATER DUTIES M*KCAL/HR
			L2	L1	FEED	PRODUCT	
1	45.0	3.50	626.4		700.0L	1652.8L	
2	45.0	3.62	588.1	1579.2			
3	45.1	3.75	570.9	1540.9			
4	45.1	3.88	563.9	1523.7			
5	45.2	4.00		1516.7	1514.1L	561.5H	

Distillation Column Summary:

COLUMN SUMMARY

TRAY	TEMP DEG C	PRESSURE BAR	NET FLOW RATES			HEATER DUTIES M*KCAL/HR	
			LIQUID	VAPOR	FEED		PRODUCT
			KG/HR				
1C	45.0	1.05	454.2			1514.1L	-0.2149
2	138.0	1.20	662.5	1968.3			
3	138.6	1.22	660.7	2176.6			
4	139.1	1.23	658.2	2174.8			
5	139.6	1.25	654.6	2172.3			
6	140.3	1.26	647.7	2168.7			
7	141.2	1.28	632.3	2161.9			
8	143.1	1.29	2976.6	2146.4	1654.4L		
9	144.0	1.31	2961.7	2836.3			
10	146.1	1.32	2840.9	2821.4			
11	156.1	1.34	2511.4	2700.6			
12	180.6	1.35	2227.8	2371.1			
13	202.8	1.37	2162.3	2087.5			
14	213.0	1.38	2167.2	2022.0			
15R	216.5	1.40		2026.9		140.3L	<u>0.2161</u>

Stream Summary:

STREAM ID	1	<u>2</u>	3	4
NAME				
PHASE	LIQUID	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01	NRTL01	NRTL01
FLUID RATES, KG/HR				
1 NMP	140.0000	6.0090E-03	138.8983	1.1070
2 WATER	560.0000	1.8321	1.8307	560.0016
3 C6H5CL	0.0000	1512.2723	1512.0700	0.4413
TOTAL RATE, KG/HR	700.0000	1514.1104	1652.7990	561.5499
TEMPERATURE, C	45.0000	45.1999	45.0224	45.1547
PRESSURE, BAR	3.5000	4.0000	3.5000	4.0000
ENTHALPY, M*KCAL/HR	0.0276	0.0219	0.0241	0.0253
MOLECULAR WEIGHT	21.5405	111.8481	110.6558	18.0563
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000	0.0000
WEIGHT FRAC TOTAL LIQUID	1.0000	1.0000	1.0000	1.0000

Stream Summary:

STREAM ID	5	6	7	<u>8</u>
NAME				
PHASE	LIQUID	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01	NRTL02	NRTL02
FLUID RATES, KG/HR				
1 NMP	138.8983	138.8983	6.0090E-03	<u>138.8953</u>
2 WATER	1.8307	1.8307	1.8321	1.1386E-12
3 C6H5CL	1512.0700	1512.0700	1512.2723	1.4030
TOTAL RATE, KG/HR	1652.7990	1652.7990	1514.1104	140.2983
TEMPERATURE, C	45.0224	63.8089	45.0000	216.5282
PRESSURE, BAR	3.5000	3.5000	1.0500	1.4000
ENTHALPY, M*KCAL/HR	0.0241	0.0347	0.0218	0.0141
MOLECULAR WEIGHT	110.6558	110.6558	111.8481	99.2510
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000	1.0000	1.0000

Stream Summary:

STREAM ID	9	10
NAME		
PHASE	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01
FLUID RATES, KG/HR		
1 NMP	138.8953	138.8953
2 WATER	1.1386E-12	1.1386E-12
3 C6H5CL	1.4030	1.4030
TOTAL RATE, KG/HR	140.2983	140.2983
TEMPERATURE, C	216.5282	64.8089
PRESSURE, BAR	1.4000	1.4000
ENTHALPY, M*KCAL/HR	0.0141	3.4997E-03
MOLECULAR WEIGHT	99.2510	99.2510
WEIGHT FRAC VAPOR	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000

Stream Summary:

STREAM ID	1	2	3	4
NAME				
PHASE	LIQUID	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01	NRTL01	NRTL01
FLUID WEIGHT PERCENTS				
1 NMP	20.0000	3.9687E-04	8.4038	0.1971
2 WATER	80.0000	0.1210	0.1108	99.7243
3 C6H5CL	0.0000	99.8786	91.4854	0.0786
TOTAL RATE, KG/HR	700.0000	1514.1104	1652.7990	561.5499
TEMPERATURE, C	45.0000	45.1999	45.0224	45.1547
PRESSURE, BAR	3.5000	4.0000	3.5000	4.0000
ENTHALPY, M*KCAL/HR	0.0276	0.0219	0.0241	0.0253
MOLECULAR WEIGHT	21.5405	111.8481	110.6558	18.0563
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000	0.0000
WEIGHT FRAC TOTAL LIQUID	1.0000	1.0000	1.0000	1.0000

Stream Summary:

STREAM ID	5	6	7	<u>8</u>
NAME				
PHASE	LIQUID	LIQUID	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01	NRTL02	NRTL02
FLUID WEIGHT PERCENTS				
1 NMP	8.4038	8.4038	3.9687E-04	<u>99.0000</u>
2 WATER	0.1108	0.1108	0.1210	8.1153E-13
3 C6H5CL	91.4854	91.4854	99.8786	1.0000
TOTAL RATE, KG/HR	1652.7990	1652.7990	1514.1104	140.2983
TEMPERATURE, C	45.0224	63.8089	45.0000	216.5282
PRESSURE, BAR	3.5000	3.5000	1.0500	1.4000
ENTHALPY, M*KCAL/HR	0.0241	0.0347	0.0218	0.0141
MOLECULAR WEIGHT	110.6558	110.6558	111.8481	99.2510
WEIGHT FRAC VAPOR	0.0000	0.0000	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000	1.0000	1.0000

Stream Summary:

STREAM ID	9	10
NAME		
PHASE	LIQUID	LIQUID
THERMO ID	NRTL01	NRTL01
FLUID WEIGHT PERCENTS		
1 NMP	99.0000	99.0000
2 WATER	8.1153E-13	8.1153E-13
3 C6H5CL	1.0000	1.0000
TOTAL RATE, KG/HR	140.2983	140.2983
TEMPERATURE, C	216.5282	64.8089
PRESSURE, BAR	1.4000	1.4000
ENTHALPY, M*KCAL/HR	0.0141	3.4997E-03
MOLECULAR WEIGHT	99.2510	99.2510
WEIGHT FRAC VAPOR	0.0000	0.0000
WEIGHT FRAC LIQUID	1.0000	1.0000

Review Results Summary:

- Single Column을 사용할 경우
 - Reboiler heat duty: 0.5104×10^6 Kcal/hr
 - NMP Purity: 99.0wt%
 - 증류탑 하부 온도: 185.4°C
 - Heating medium으로 HP Steam 사용
- Extractor + Recovery Column을 사용할 경우
 - Reboiler heat duty: 0.2161×10^6 Kcal/hr
 - NMP Purity: 99.0wt%
 - 재생탑 하부 온도: 216.5°C
 - Heating medium으로 Hot oil을 사용해야 함



THANK YOU

