REFINERY LIGHT ENDS SEPARATION

BACKGROUND:

The large amount of carbon dioxide in the natural gas from the well dictates the use of an extractive distillation system to separate the ethane from the carbon dioxide because of an azeotrope. The bottoms from the ethane recovery column is called natural gas liquid (NGL) and is fed to three distillation columns operating in series. The feed is a mixture of Ethane(C2) , Propane (C3), Iso-butane (iC4), n-butane (nC4), iso-pentane (iC5), and n-pentane (nC5). Propane, Butane, Iso-butane are removed successively in a high pressure 3 stage distillation columns.

PROCESS DESCRIPTION :

The first column is a De-Propanizer. The separation of Propane from the butane isomer mixture is a bit difficult. The column has 50 stages with Condenser Pressure at 17 atm. The top and bottom pressure is 17.1 and 17.5 atm respectively. High pressure in the condenser allows usage of cooling water for temperature reduction. Feed enters at 17.4 atm to the 18th Stage.
Design specifications for this column are 0.01% Iso butane ,all ethane in distillate ; 0.1mol% propane in bottoms.

The second column is a De-Butanizer. Its function is to take the iC4 and nC4 components overhead for subsequent separation in the downstream column. The separation in the debutanizer is between the nC4 and the iC5, which is fairly easy with a relative volatility of 2.2 at 322 K. A column with 31 stages is used, operating at 7.1 atm with feed reduced to a pressure of 7.3 atm to stage 16.
The design specifications are 0.2 mol % iC5 in the distillate and 0.2 mol % nC4 in the bottoms.

The third column is a De-IsoButanizer. Separation between iC4 and nC4 is relatively difficult, so a 80 stage column is used. It operates at 6.6 atm with feed admitted to stage 39.
he design specifications are 2 mol % nC4 in the distillate and 2 mol % iC4 in the bottoms.

RESULTS:

	PROPANE	ISOBUTANE-RICH	BUTANE-RICH
Molar Flow	3993.55	4370.2	1814.91kmol/h
Liquid Phase (Mixture) Molar Fraction	1	0.999997	0.999964
Molar Fraction (Mixture) / Ethane	0.00150664	1.65355E-13	1.95299E-17
Molar Fraction (Mixture) / Propane	0.998393	0.0018396	1.38107E-17
Molar Fraction (Mixture) / Isobutane	0.0001	0.97816	0.02
Molar Fraction (Mixture) / N-butane	3.44469E-07	0.02	0.972875

CONCLUSIONS AND RECOMMENDATIONS:

1. Because the iC4/nC4 separation is quite difficult (1.3 relative volatility at 322 K), this separation is to be performed when the mixture is essentially binary so as to minimize energy requirements. So, the De-Butanizer is followed by De-IsoButanizer.
2. The feed stage and the corresponding Reboiler Duty can be played around to achieve the minimum heat load which reduces operating costs.
3. The process is sensitive to thermodynamic parameters defined. A very small fraction of vapours do appear that are specific to the models defined.

4. The bottom product from De-Propanizer is sent to through a pressure varying value to the inlet of De-Butanizer. The out -let pressure of the valve at over-head of column 2 is modified, to bring the entire stream to liquid phase. Stream Results after and before passing through a valve is shown below:

	MSTR-010	MSTR-006	
Temperature	328.831	328.829	K
Pressure	7.1003	7.1	atm
Vapor Phase Molar Fraction	0	1.60113E-05	
Liquid Phase (Mixture) Molar Fraction	1	0.999984	
Phases	Liquid Only	Mixed	

5. The thermodynamic parameters defined in a custom Chem-Sep model is as follows.

K Value	Prausnitz
EOS	Peng-Robinson 76
Solution	Regular
Enthalpy	Excess,Modified Antoine Parameters loaded.

6. For Dynamic Simulation, Single-end control structures are widely used in industry with one control degree of freedom used to control a temperature or a composition. Setting the other control degree of freedom requires selecting between a reflux ratio structure and a refluxto-feed structure. In addition, the issue of whether to use molar ratios or mass reflux-to-feed ratios should be considered. Luyben discusses control of the columns in detail.

REFERENCES:

1. Use of Mass or Molar Reflux-to-Feed Ratios In Distillation Single-End Control Structures. William L.Luyben.
2. Flowsheeting Reference: http://www.chemsep.com/downloads/index.html