Hydrodynamics Modeling of Distillation Tray of MLNG Depropanizer Column

by

Fong Yee Chuin

Dissertation submitted in partial fulfillment of

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(Chemical Engineering)

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Universiti Teknologi PETRONAS,

Bandar Seri Iskandar,

31750, Tronoh,

Perak Darul Ridzuan.

CERTIFICATION OF APPROVAL

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Approved by,

____
(Mr. Nooryusmiza Yusoff)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

November 2003

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

FONG YEE CHUIN

ABSTRACT

Hydrodynamics modelling in a distillation column covers three important aspects; namely operating region, pressure drop across plate and plate efficiencies. All these three are inter-related. Operating region provide the limit for the vapour and liquid flow allowable for the column operation. Meanwhile, pressure drop across plate allows for determination of plate pressure drop which affects the overall pressure drop for the column. Lastly, plate efficiencies allows for prediction of separation efficiencies which affects the overall separation performance. It also reflects the ability of the contactors to perform the required separation. Distillation is a process of physically separating a mixture into two or more products that have different boiling points, by preferentially boiling the more volatile components out of the mixture

As for this project, the main focus is in producing the feasible operating region for depropanizer column (C-1503) of MLNG plant. The quantified region can also be used to identify the type of physical constraint that upsetting the column operation. In MLNG plant, Bintulu, hydrodynamics detail research especially the downcomer section, Shell Calming Section tray is enquired to ensure a smooth operation throughout without disconcerting the column performance. Besides that, a consistent demand of pure propane from customer added the need to meet the product specification through an optimum working region.

Hydrodynamics studies consists of calculating the maximum and minimum operating region for tray column by considering four significant upset contributions phenomena, i.e., entrainment flooding, downcomer backup, weeping and sealing. The ultimate research is to produce a visual presentation of the operating regime with respect to liquid and vapor loads. The project started off with a good literature understanding of the hydraulic behaviour of distillation column. Then, it proceeded with identification of correlation step, where justification and assumptions were made before any further engineering calculation. Software aid-tool such as HYSYS, MATLAB and Microsoft Excel were used to assist in getting primary raw input data and also to solve numbers of equations. The result of the simulation and calculation for depropanizer steady state shows that the developed model can be concluded as realistic and can represent accurately a feasible yet an optimum region of the column.

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TABLE OF CONTENTS

NOMENCLATURE

A_{DC} =Downcomer area (m^2)

A_c =Active area or also known as bubble area (m^2)

A_S =Slot area (m^2)

A_h =Hole area (m^2)

BU =Donwcomer backup (mm tray liquid)

CSH =Calming Section Height (mm)

F =Foam factor

g =Gravitational constant (m/s^2)

GPM =Liquid flow rate (gpm)

H_l =Clear liquid height on tray (mm tray liquid)

H_{ow} =Liquid crest over calming section weir (mm tray liquid)

H_{sub} =Liquid back-up in the downcomer due to submergence (mm tray liquid)

H_w =Outlet weir height of tray (mm)

L_w =Total weir length on the tray (m)

P_{fl} =Percentage of entrainment flooding (%)

Q_v =Volumetric flow rate of vapour to the tray (m^3/s)

Q_l =Volumetric flow of liquid from the tray (m^3/s)

TS =Tray spacing (mm)

V =Vapor mass flow rate (kg/s)

α =Tray spacing correction factor

β =Entrainment correction factor

ΔP_{dry} =Dry tray pressure drop (mPa)

ΔP_{ud} =Pressure drop under downcomer (mPa)

$\Delta \rho$ =Density difference of liquid and vapour phase (kg/m^3)

ε_l =Liquid fraction in dispersion on tray

λ_c =Load factor based on column area (m/s)

λ_H =Hole load factor (m/s)

λ_{HS} =Hole load factor at seal point (m/s)

λ_{HW} =Hole load factor at weep point (m/s)

$\lambda_{\max}$ =Maximum load factor of tray (m/s)

ρ_l =Vapor density (kg/m^3)

ρ_v =Liquid density (kg/m^3)

φ =Flow parameter

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

The introduction chapter comprises of background study, problem statement, objective and scope of study of the research project. Each sub topic is being discussed in chronological order.

1. 1 Background Study

Malaysia Liquefied Natural Gas (MLNG) in Bintulu, Sarawak is the largest single location natural gas processing complex in the world where it contributes approximately 5% to the Gross Domestic Product (GDP) of Malaysia. Natural gas can be processed and categorized into Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG) and Natural Gas Liquid (NGL). LNG comprises methane, ethane and a small volume percent of propane. On the other hand, LPG is made up of propane and butane. Besides that, NGL consists of LPG, pentane, heavier components like natural gasoline and condensate. Non hydrocarbon (N_2, CO_2, H_2S, Hg and etc) in natural gas are first to be separated before any liquefaction and fractionation processes. The summary of the natural gas component cut is illustrated in Figure 1.1.

Besides supplying LPG and LNG, the plant also exports pure propane to Japan as part of the company income. Hence, a continuous and smooth run of depropanizer column is paramount important to provide a consistent supply to the increasing market demand. The successful operation of the plant depends on the operability of its separation columns. The range of operation of the installed trays governs the maximum and minimum gas and liquid loads the column can handle and consequently the capacity and turndown capability of a plant. For both the vapor and the liquid flow rate, lower and upper limits exist. The operating point of a column should be chosen carefully by considering different hydraulic mechanisms constraints.

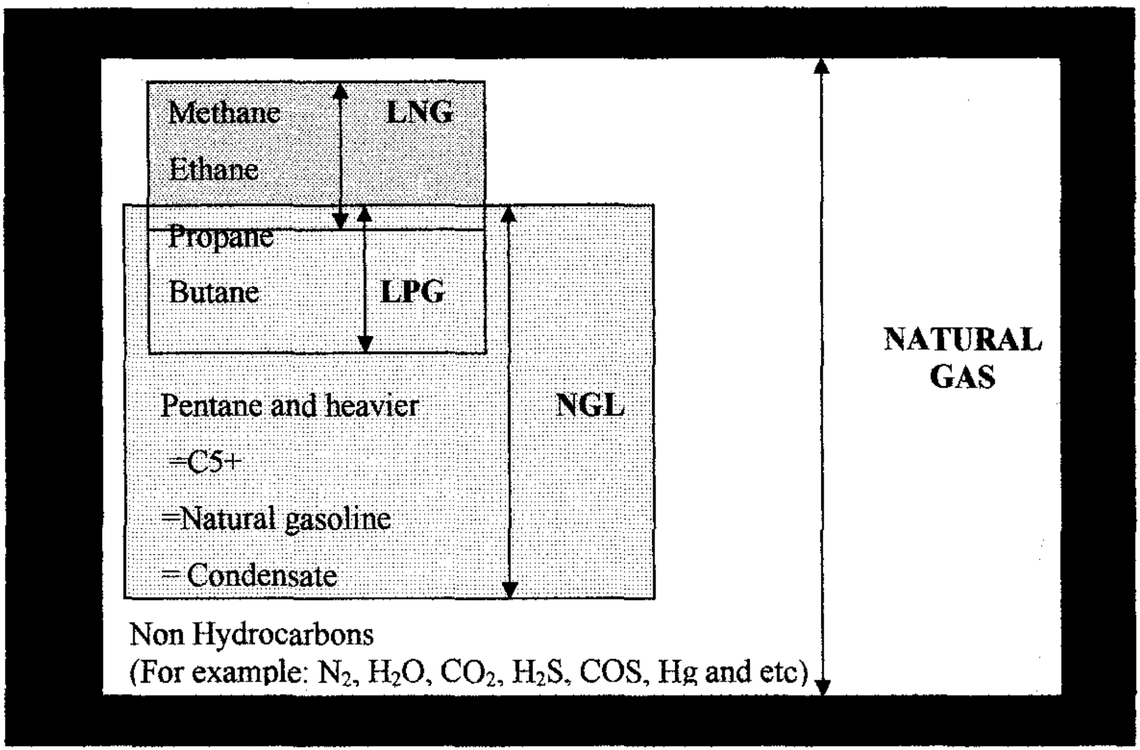

Figure 1.1: Terminology and constituents of natural gas in MLNG plant

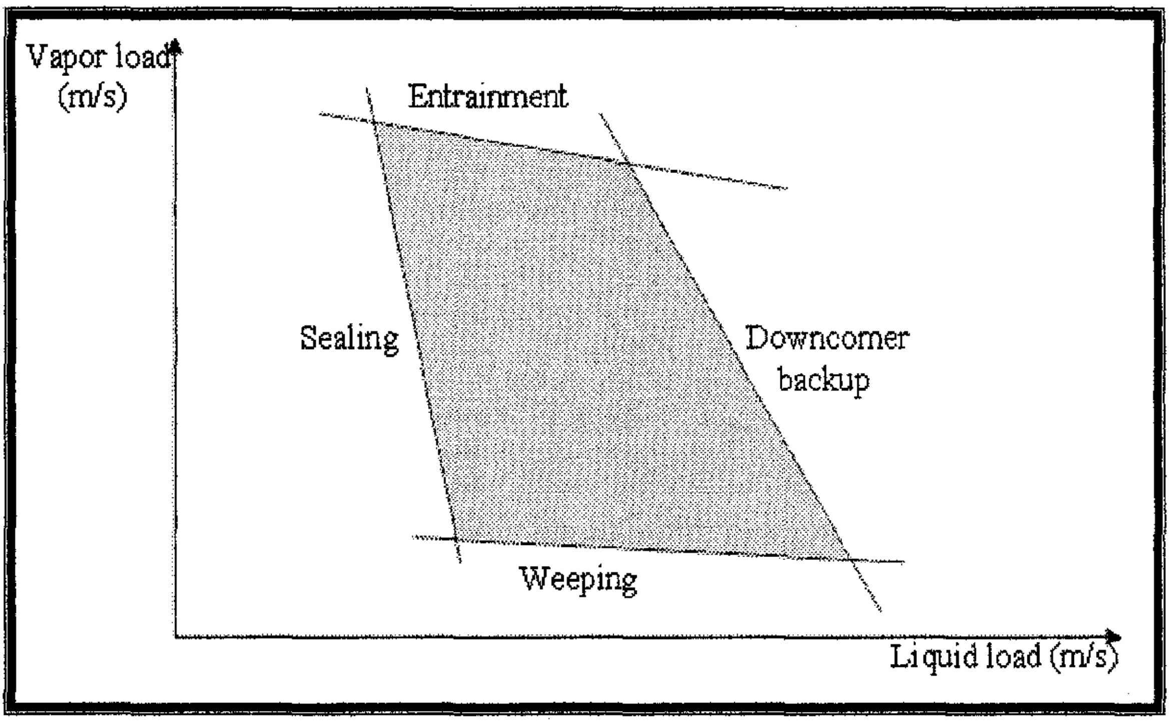

Figure1.2: Typical operating limits of a distillation tray

The hydraulic mechanisms include downcomer flooding, entrainment, weeping, pressure drop across tray, clear liquid height and flow regimes. The maximum and minimum liquid and vapour loads of these constraints (Figure 1.2) are then used as a benchmark at the later stage to improve the tower operating. The area of satisfactory operation (shaded) is bounded by the tray stability limits or constraints. Based on Figure 1.2, the vapor and liquid load are in term of m/s where it is obtained from (Q/A_{ac}). Given that A_{ac} is a constant value of bubble (active) area of a column and Q is the volumetric flow rate.

1.2 Problem Statement

The existing distillation tower often does not operate at its optimum level of separation process. Apparently, from the economic point of view, inefficient separation causes losses to the plant operation. The losses are excess energy consumption and sudden column operation shutdown due to the occurrence of physical constraint such as entrainment flooding. Moreover, operator and engineers find it hard to actually justify the type of tray capacity limits when upset takes place in the depropanizer column. Hence, the maximum and minimum limits of liquid and vapour flow of the column become handy to solve uncertainty justification as well as to keep the column within the satisfactory operation. The technical and economical feasible operating region of the distillation process depends mainly on the design of the internal contactors and of course depends on the control skills of the operators.

1.3 Objective and Scope of Study

The main objective of this study is to determine the best operating conditions in terms of volumetric flow rate in maximizing the propane yield from a depropanizer column with a Shell Calming section tray technology, with the aid of HYSYS and MATLAB software tools. The HYSYS simulation is used to obtain the existing operation condition of the depropanizer column in MLNG by using limited inputs data of the feed stream. Meanwhile, the purpose of MATLAB tool is necessary to solve the physical constraints equations. The initial operating region is then shrunk to construct the most satisfactory operating region by setting the propane purity as 99%. Nevertheless, HYSYS simulation is used again for the last stage to confirm the result of the plotted optimum region with plant daily operation output. It is often easier to display operating region in term of vapor and liquid volumetric flow rate for the convenient and better approach needed by the plant operators and engineers to do any further research or adjustment. Besides that, the typical operating region pattern will not be affected as the vapor and liquid load is obtained by dividing volumetric flow rate with a constant value of column active area.

In the second part of the study, the process variables are identified, for example the density range of liquid and vapour phase and the maximum tray loading of the column. Furthermore, assumptions and justifications were made to simplify the mathematical models in the MATLAB programming.

CHAPTER 2

LITERATURE REVIEW AND THEORY

Literature review was carried out to understand the project work scope .Besides that, the purpose is also to equip the student with essential and advanced knowledge in order to start and complete the research work successfully.

Distillation tray is essentially a device to contact the vapor/ liquid thus allowing heat and mass transfer to occur as illustrated in Figure 2.1. Many types of distillation trays are available in the industry.

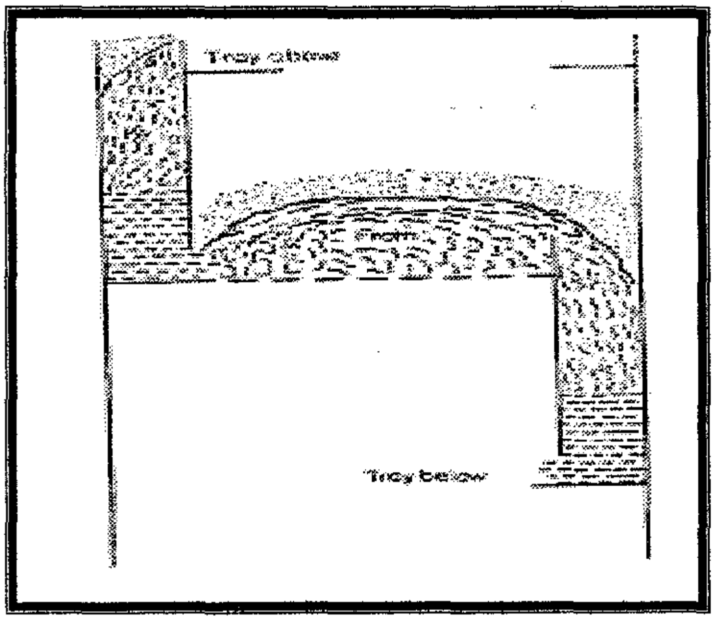

Figure 2.1: The classical tray hydraulic model

The conventional type of tray used in industry is shown in Figure 2.2. However there is an available high capacity internal tray, named Shell calming tray. The tray picture is demonstrated in Figure 2.3. The development of calming section tray completed in the end of 60's and first introduced in year 1962. According to Dr. Frits J. Zuiderweg (1954), calming section is the first device that could increase the capacity of large diameter dual flow trays. The rectangular shaped calming sections are relatively narrow and short, because of this they can be distributed more easily across the tray area.

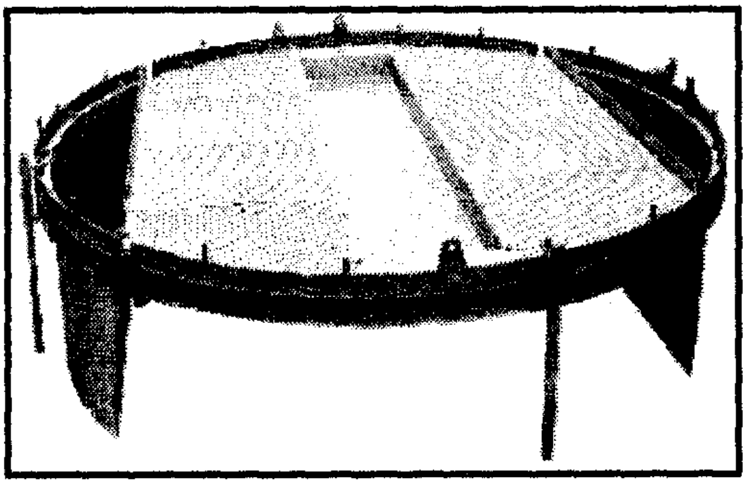

Figure 2.2: Conventional downcomer tray for two passes liquid flow

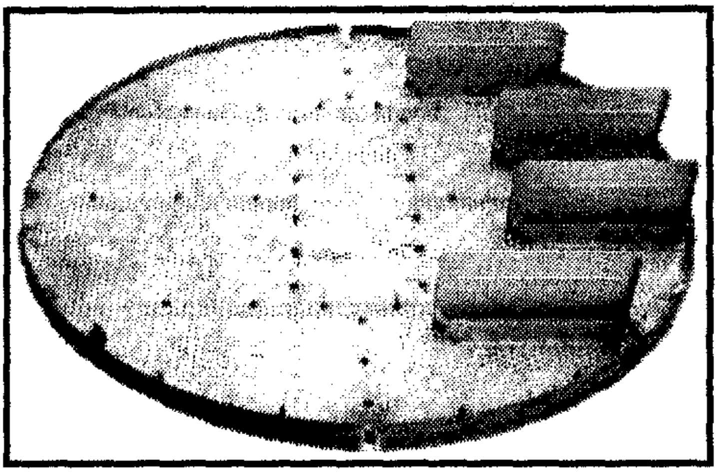

Figure 2.3: Shell calming section tray

The tray is a vapor-liquid contacting device with liquid downcomers of a special box-like construction known as 'Calming Sections'. A number of these calming sections can be used on one tray instead of one or two downcomer which is typical for a conventional tray design. The calming sections are evenly distributed over the tray in prescribed manner, trays with higher liquid loads being designed with more calming sections. High capacity tray is designed to save CAPEX in debottlenecking of the existing plants. Compensation of lower tray efficiency by increasing traffic (reboiler or reflux ratio) in a column reduces the capacity gain. Calming section trays have been successfully applied in a wide range of services including distillation, absorption and stripping.

The advantages of using Shell calming trays are it has a relatively lower cost and it is easy to scale up to a larger diameter. Severe problems such as back mixing and operational instability due to excessive weir loading can be solved by using the Shell calming trays. In addition, there are certain advantages in the simple mechanical construction of calming section trays. The tray is supported on a continuous ring welded to the column wall. Hence, installation time is lesser compared to the conventional type. The construction is less rigid and easier to accommodate out- of roundness of the column than conventional downcomer trays.

The perforation type used on the Calming Section tray is valve bubbler. Valve perforation can be round or rectangular, with or without a caging structure. The valve disks rise as vapor rate is increased; as vapor rate falls, the disk openings are reduced. This stops the liquid from weeping and gives the valve its main advantage-good operation at low flow rates and therefore a high turndown. Valve perforation has a high capacity with moderate entrainment and pressure drop. It shares the market demand of 70% relatively to sieve tray which is only approximately 25% (Kister and Haas, 1992).

A tray performs well if there is an intimate contacting between the vapor and liquid followed by good separation of the two phases. To establish this, vapor and liquid streams have to be maintained within certain limits. The flooding and downcomer backup capacity are the maximum operating limit when the tray has lost its function. Meanwhile, the minimum operating limits of a tray are determined by weeping and insufficient downcomer sealing. Flooding is an excessive accumulation of liquid inside the column. This accumulation is generally caused by spray entrainment flooding. At low liquid flow rates, trays operate in the spray regime, where most of the liquid in the tray is in the form of liquid drops. As vapor velocity is raised, a condition is reached whereby the bulk of these drops are entrained into the tray above. Froth entrainment flooding mechanism is not considered as part of the operating limit as the studied column tray spacing is larger than 18 inch. The froth envelope seldom approaches the tray above. Besides that, as the vapor velocity is raised, a condition is reached when some of the froth inverts into spray which has been taken into account in spray entrainment mechanism. Hence, the maximum vapor limit is governed by only spray entrainment flooding for the depropanizer column. On the other hand, the maximum liquid limit is determined by the downcomer backup. It occurs when the backup of aerated liquid in the downcomer exceeds the tray spacing. The factors that resist liquid flow from the downcomer onto the tray below are the froth height on the tray, the pressure drop on the tray and the friction loss under the downcomer apron. These factors cause liquid to back up in the downcomer.

The minimum vapor operating limits of the depropanizer column are governed by weeping where the liquid descends through tray perforations and part of the liquid flows over the downcomers. The liquid descending through the perforations short-circuits the primary contacting zone, causing reduction in tray efficiency. According to Lockett and Banik (1986), weeping mechanism varies with hole diameter and weep rate. The last studied hydraulic mechanism is sealing. It is used to identify the minimum liquid operating limit. The seal point is when the dispersion height in the tray equals to the weir height and the weeping rate approaches 100%.

In modeling depropanizer unit of using HYSYS simulator, HYSYS requires an accurate model in order to start the simulation sequences. Since there is still some insufficient data at this moment, the success of the result output is based mainly on the assumptions made by the student in modeling the distillation column in the base design. Further research and modification are made to match the column feed, product yield (distillate) and bottom product with the HYSYS result. The property package (Prop Pkg) page is the first page of the Fluid Package property view. For oil, gas and petrochemical application, Peng Robinson (PR) is generally the recommended property package.

CHAPTER 3

METHODLOGY/ PROJECT WORK

A project strategy as illustrated in Figure 3.1 is used as a guide to facilitate the work planning. The project flow starts off with problem recognition and identification. When the problem associated with the project had been defined clearly, methods are devised to tackle the project. This initial thinking and planning process offered manageable goals to target and a direction to progress. This is explained in **CHAPTER 1**.

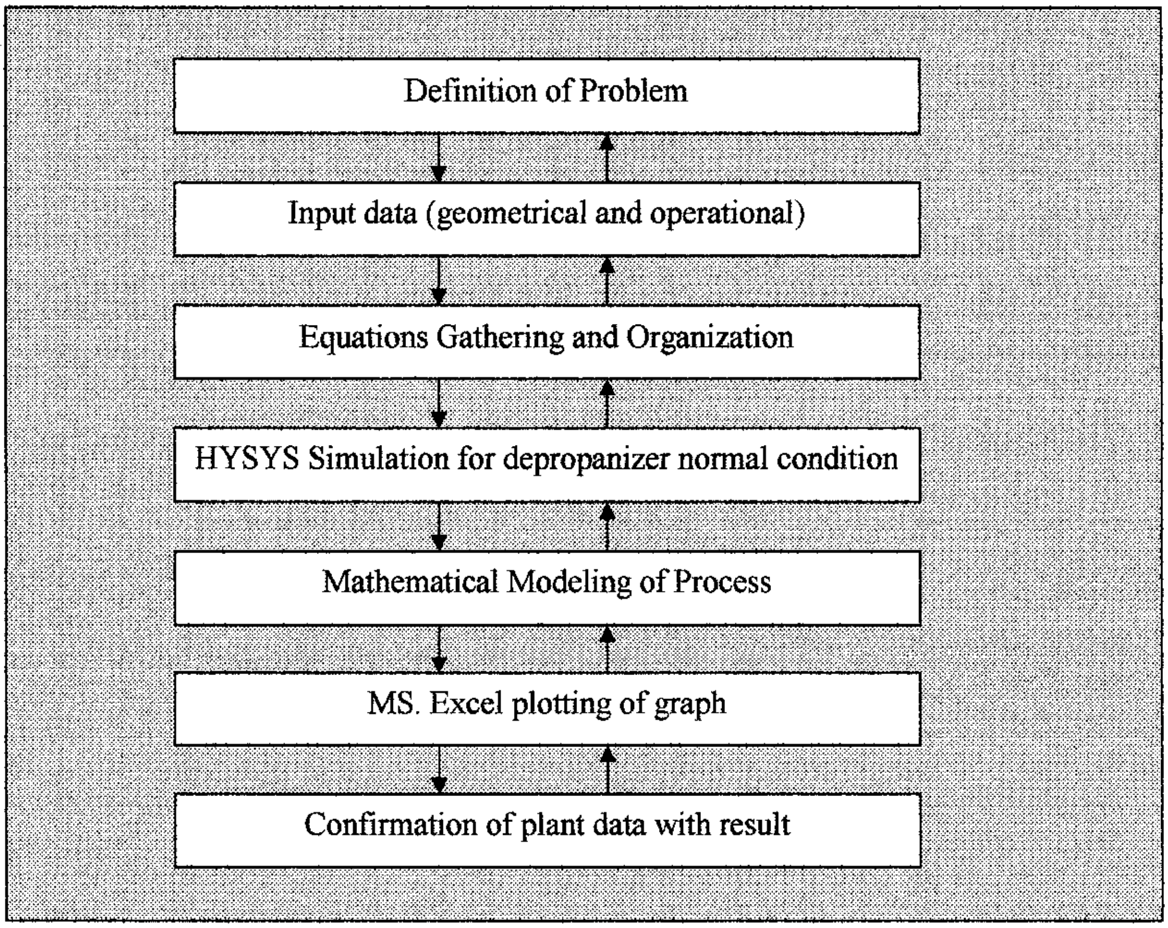

Figure 3.1: Project management process flow

3.1 Procedure Identification

3.1.1 Input data

Based on the project process flow, once the problem statements had been identified, the projects is proceeding to another level that is input data gathering. The input information consists of PID drawings, plant daily operational output sheet of depropanizer column on August 2003. The data is sorted into geometrical and operational type as tabulated in Table 3.1 and Table 3.2.

Table 3.1: Geometrical data of depropanizer column (C-1503)

No	Parameters	Dimension
1	A_c	1.469 m^2
2	A_{DC}	2.4122 m^2
3	A_s	0.0241 m^2
4	A_h	1.254 m^2
5	H_W	65 mm
6	L_w	580 mm
7	Downcomer height	416 mm
8	CSH	415 mm
9	TS	600 mm
10	Number of valve per tray	160
11	Number of tray	46

Table 3.2: Operational plant data of depropanizer column (C-1503)

No	Parameter	
1	Top vapor temperature	44.70 ° C
2	Propane export (distillate)	107.91 ton/day
3	Bottom product to C-1504	82.3 ton/day
4	Column top pressure	14.30 bar gauge = 1531kPa
5	Number of stages	46
6	Reboiler pressure drop	0 kPa
7	Condenser pressure drop	0 kPa
8	Reboiler pressure	1532 kPa
9	Inlet stage	17
10	Condenser	Total

3.1.2 Equations gathering and organization

In the application of correlations and equations for the hydraulic mechanisms behaviors, considerable assumptions are required to eliminate insignificant parameters. Therefore, it is critical that rational judgment and consideration is given before excluding some of these negligible factors to prevent oversimplification but simultaneously avoid inclusion of extensive factors that complicate the hydrodynamic model.

3.1.2.1 Hydraulic mechanism equation

Each physical constraint mechanisms have their own assumptions based on the type of correlations chosen from. For **entrainment flooding**, it is formulated in terms of

$$P_{fl} = \frac{\lambda_c}{\lambda_{\max}} \cdot \frac{1}{F} \cdot 100\% \tag{3.1}$$

The column load factor is defined as:

$$\lambda_c = \frac{V}{\rho_v A_x} \sqrt{\frac{\rho_v}{\rho_l - \rho_v}} (m/s) \tag{3.2}$$

The limiting capacity or better known as maximum load factor of tray $\lambda_{\max}$ is calculated by correlation below:

$$\lambda_{\max} = \frac{0.122 E_1 F \alpha \beta}{1 + 1.286\varphi} \tag{3.3}$$

The flow parameter is denoted as:

$$\varphi = \frac{M_l}{M_v} \sqrt{\frac{\rho_l}{\rho_v}} = \frac{Q_l}{Q_v} \sqrt{\frac{\rho_l}{\rho_v}} \tag{3.4}$$

Entrainment flooding is also being defined as column loading as percentage flooding. The flooding limit (constraint) is < 85%. Foaming factor, F of 1 is applied in depropanizer system according to Shell Global Solutions Inc. B.V. The reason is by assuming no free water present in the column. Besides that, the tray spacing correction factor, $\alpha = 1$ for tray spacing more than or equal to 600mm. The entrainment correction factor, $\beta = 1$ as well because the calculated φ is always larger than 0.03. Furthermore, the vapor capacity enhancement, $E_1 = 1$ as no sieve tray is used inside the column.

The **downcomer backup flooding** check is carried out for the maximum (flooding) flow rates to ensure there is no premature downcomer limitation. The equation is:

$$BU = \frac{\Delta P_{dry}}{g(\rho_l - \rho_v)} + H_l + \frac{\Delta P_{ud}}{g(\rho_l - \rho_v)} + H_{sub} \text{ in mm} \tag{3.5}$$

The backup pressure in terms of tray liquid is expressed as the sum of tray pressure drop, pressure drop under downcomer and downcomer submergence.

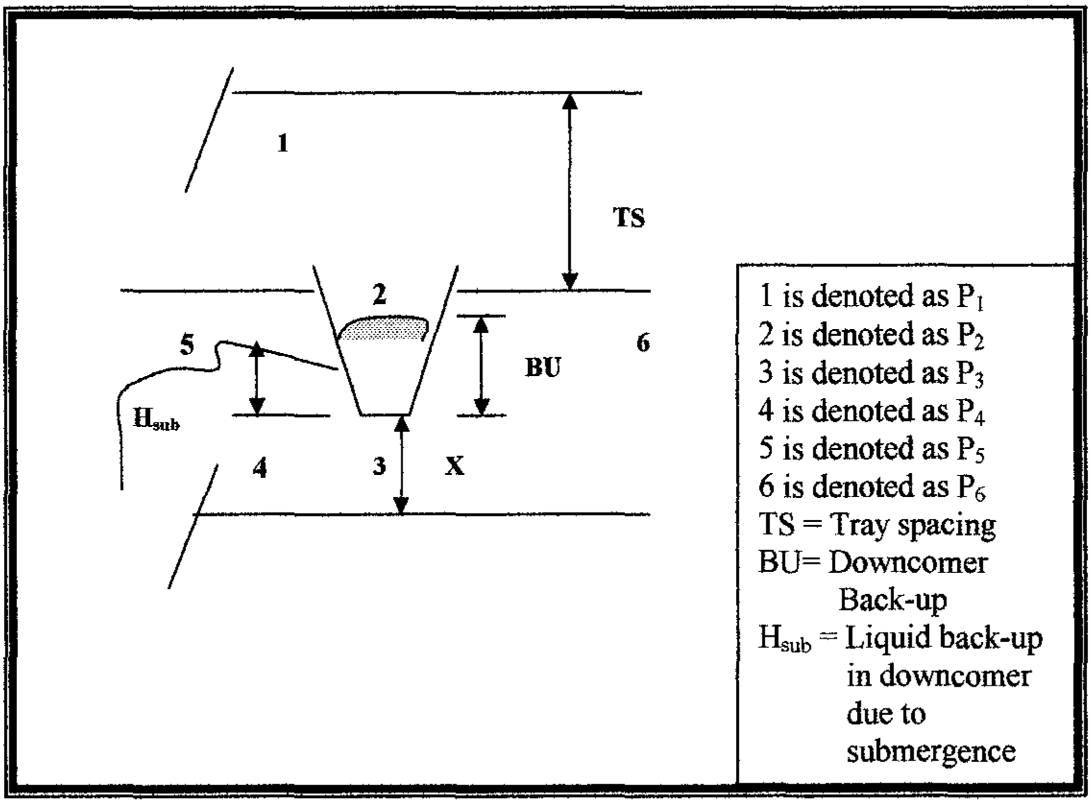

Figure 3.2: Pressure balance around a Shell calming section tray and downcomer outlet pressure drop

$$\begin{aligned}
&P2 - P1 = (TS - BU - X + TS)g\rho_v \\
&P3 - P2 = BUg\rho_l \\
&\underline{P4 - P3 = -\Delta P_{UD}} \\
&P4 - P1 = -\Delta P_{UD} + BUg(\rho_l - \rho_v) + 2TSg\rho_v - Xg\rho_v
\end{aligned}$$

$$\begin{aligned}
&P4 - P5 = H_{sub}g\rho_l \\
&P5 - P6 = (TS - H_{sub} - X)g\rho_v \\
&\underline{P6 - P1 = \Delta P_{tray} = \Delta P_{dry} + H_l g(\rho_l - \rho_v) + TSg\rho_v}
\end{aligned}$$

$$\begin{aligned}
&P4 - P1 = H_{sub}g(\rho_l - \rho_v) + 2TSg\rho_v + H_l g(\rho_l - \rho_v) + \Delta Pdry - Xg\rho_v \\
&BUg(\rho_l - \rho_v) = \Delta P_{dry} + H_l g(\rho_l - \rho_v) + \Delta P_{ud} + H_{sub}
\end{aligned}$$

The dry pressure drop is calculated based on the below equation:

$$\Delta P_{dry} = 27\frac{1000}{(\rho_l - \rho_v)} \text{ in mm} \tag{3.6}$$

The liquid head on the tray, H_l is denoted as:

$$H_l = \varepsilon_1 H_w + H_{ow} \text{ in mm} \tag{3.7}$$

Given that the crest over the weir H_{ow} is:

$$H_{ow} = 830\left(\frac{Q_{l\max}}{L_w}\right)^{2/3}\left(\frac{\rho_l}{\rho_l - \rho_v}\right)^{1/3} \text{ in mm} \tag{3.8}$$

$Q_{L\max}$ is obtained from

$$Q_{L\max} = Q_l\frac{100}{P_{FL}} \text{ in m}^3\text{/s} \tag{3.9}$$

Where P_{FL} is taken as the fix value of 52% (safe flooding) from the plant normal operating condition and it is not based on the maximum limit of entrainment which gives 85% allowance of flooding.

Pressure drop under downcomer is defined as:

$$\Delta P_{ud} = 0.03\left(\frac{GPM}{100A_{DC}}\right)^2 \text{ in mm} \tag{3.10}$$

A conservative estimate of the back-up due to the submergence of the calming sections in the froth bed at maximum loading is:

$$H_{sub} = (CSH - H_w)\frac{H_l}{TS} \text{ in mm} \tag{3.11}$$

Downcomer backup occurs when BU > 0.9 x downcomer height. For the specific depropanizer column, the downcomer height is 416 mm. Hence, the maximum BU limits is 375mm tray liquid (0.9x 416mm =374.4mm ≈ 375mm).

Weeping constraint is determined from:

$$\lambda_{HW} = 0.056\left(\frac{H_W}{50}\right)^{1/2}\varphi^{-0.3} \tag{3.12}$$

It occurred when the below inequality is met.

$$\lambda_{HW} \geq \lambda_{\max} \tag{3.13}$$

Where $\lambda_{\max}$ is calculated based on equation (3.3).

Sealing hydraulic mechanism is determined from:

$$\lambda_{HS} = \frac{0.17}{(1+4.2\varphi)}\left(\frac{H_w}{50}\right)^{1/2}\left(1+\frac{3A_s}{A_H}\right) \tag{3.14}$$

Sealing or being known as dumping mechanism occurs when

$$\lambda_{HS} \geq \lambda_{\max} \tag{3.15}$$

Where $\lambda_{\max}$ is calculated based on equation (3.3).

3.2 Tool Required

3.2.1 HYSYS Simulation Tool

In modeling a unit operation using HYSYS simulator, several known parameters are essential and specified as the input. The importance of the HYSYS modeling is to obtain the depropanizer column normal vapor and liquid volumetric flowrate and also for the later stage of achieving an improved operating region. The feed stream of the column was initially simulated from HYSYS. The feed output result (Table 3.3) was then used as feed parameter for the depropanizer modeling.

Table 3.3: Feed stream of depropanizer column (C-1503)

No	Parameter	
1	Liquid phase fraction	0.0709
2	Temperature	113.3 ° C
3	Pressure	1856 kPa
4	Inlet flow rate	636.97 ton/day
5	Ethane in feed	0.0021
6	Propane in feed	0.2073
7	i-Butane in feed	0.1559
8	n-Butane in feed	0.2327
9	i-Pentane in feed	0.1362
10	n-Pentane in feed	0.0881
11	Hexane in feed	0.1777

A schematic diagram of the distillation column used for the separation process is illustrated in Figure 3.3. Operational data in Table 3.2 is also used as the input values of

HYSYS simulation. It is given (from MLNG plant) that each tray pressure drop is approximately 22Pa (plant source). Hence, the pressure drop across the column is calculated as 1kPa (22Pa x 45 trays= 990Pa≈1000 Pa) with top pressure of 1531kPa and bottom pressure of 1532kPa.

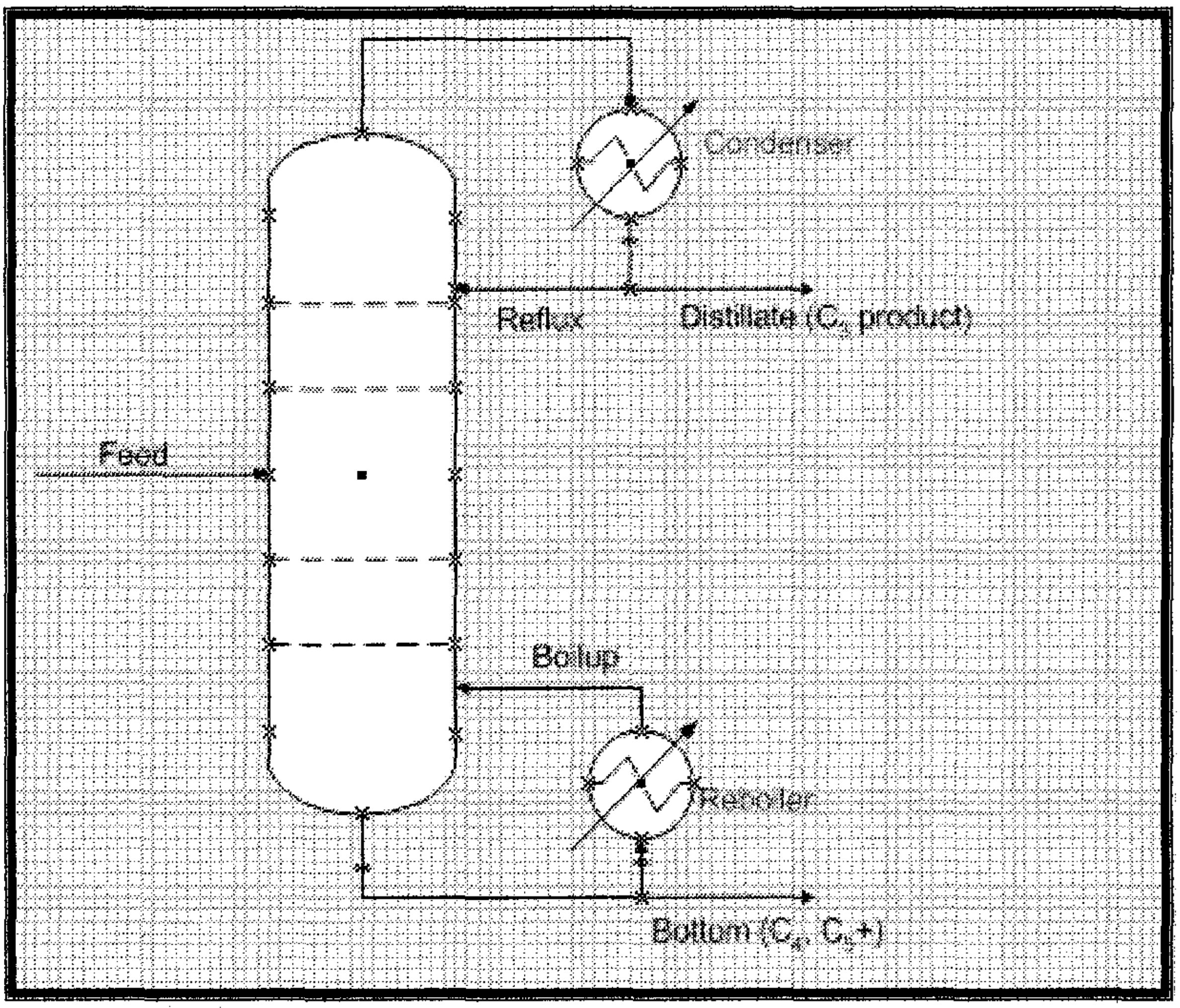

Figure 3.3: Process flow diagram of depropanizer column

The simulation step is as follows:

1. Select the properties package and definition of the basis (PR package)
2. Enter specifications for the feed stream (Table 3.3)
3. Enter specification for the distillation column (Table 3.2)
4. Run the model until convergence is obtained.
5. Analyze the simulation result and compare with the plant required specifications.
6. Manipulate the other specification parameters if the desired output not met.

The output of the vapor/ liquid volumetric flow rate (load) will then be used as a benchmark to calculate the four hydraulic mechanisms (entrainment, downcomer backup, weeping, sealing).

3.2.2 MATLAB Mathematical Equation Solving

Once the most accurate HYSYS output is achieved, the mathematical equations of the four constraints are programmed into MATLAB. The one operating point of (liquid and vapor volumetric flowrate) was then varied according to individual mechanism requirement. Normal MATLAB programming language is used for calculating and finding all the mechanism limits by meeting the constraints of each equation as discussed above before. Generally, a consistent increment or decrement of vapor and liquid density is assumed to be consistent. A step-by-step technique was self- developed to calculate each limit. Further explanation will be discussed in **CHAPTER 4**.

3.2.3 Plotting Operating Region

Once all four hydraulic mechanisms are obtained, the output from MATLAB is plotted on liquid volume flowrate, m^3/hr (-x axis) vs. vapor volume flowrate, m^3/hr (y-axis) graph by using Microsoft Excel .The initial graph has a wide and loose operating region. Further restriction and optimization is done by specified the top product (propane) purity of minimum 99%together with either C_4/C_3 top mole fraction or C_3/C_4 bottom mole fraction. It is expected to have a tighter and smaller region compared to the initial graph. The first graph is then shifted accordingly based on HYSYS result.

3.2.4 Confirmation of Result

The corrected graph which is the optimum operating region is then confirmed with the plant data by putting in all the data points. Good plant data points are expected to be fall inside the feasible operating region and vice versa. The process flow is repeated if the random data points do not reflect a satisfactory region for controlling purpose.

CHAPTER 4

RESULTS AND DISCUSSIONS

Generally, this chapter discussed the results obtained from each methodology part of **CHAPTER 3**. The results and discussions include determination of the first operating point, MATLAB output for each maximum and minimum point, shifting step from the initial operating region and plant data validation.

4.1. Determination of First Operating Point

The simulation results are accessed from the Column Property View, which gives the pressure, temperature, liquid and vapor flow rates of feed stream and product streams. As stated earlier, the simulation result was at first utilized to find the normal operating point of liquid and vapor volume flowrates. The result of the modeling obtained from HYSYS is attached in Appendix B. The result provides the starting point for the MATLAB calculation. Table 4.1 shows a brief summary on the result.

Table 4.1: Summary result of HYSYS simulation

No	Parameter	
1	Liquid flow rate	54 m^3/hr
2	Vapor flow rate	60 m^3/hr
3	Propane distillate fraction(liquid)	0.99
4	Reflux ratio	7.5
5	Bottom product rate	22430 kg/hr
6	Reflux rate	27100 kg/hr
7	Distillate product rate	3620 kg/hr
8	Component ratio (C_3/C_4) at the bottom	2.45 mol%
9	Component ratio (C_4/C_3) at the top	0.05 mol%

Two specifications namely reflux ratio and bottom product rate (butane, C_5 and heavier components) are chosen to monitor the finding due to the fact that these two specifications have a great effect on tower performance and their effect on product composition. Both parameters give a good and reliable vapor and liquid flow rates. Based on Table 4.1, it is confirmed that the result can be used as the starting point by judging at the component ratio on top and bottom and also the distillate purity.

4.2 MATLAB Calculation Output

The MATLAB programming result is attached in Appendix C. The method used to find the individual limit points follows a proper sequence. In order to meet the deadline of the project as well as the objectives of the project, the student wrote simple mathematical language to find each maximum and minimum point due to the late usage of HYSYS facility. Besides that, it reduced any complexity and of course it is much more convenient. Not much worry of the user-friendliness of simple MATLAB programming as most of the inputs are geometrical input together with few variable parameters. Apparently, the mathematical calculation result had already included the maximum column loading, which means that if the column feed capacity is to be changed in future, the volumetric flow rates should fall within the optimum operating region, please refer Figure 4.7. Instead, the adjustment should be made from Figure 4.7.

4.2.1 Entrainment Point

The starting point obtained from the HYSYS is denoted as OP in Figure 4.1. The first point of entrainment is denoted as (1), where the liquid load is held constant and varies the vapor load. The density of liquid remains constant but density of vapor is increased 0.05 for interval vapor load of 10 m^3/hr. In order to determine the second point (2) of the entrainment limit, point A has to be calculated to get a higher point than (1). Point (B) is a random point which is preferable to exit the sealing limit, point (A). This is to ensure an accurate estimation of the slope line by connecting point (2) and point (1). The highest limits of entrainment for both points should be less than 90% of flooding percentage. Therefore, the value of LA =22m^3/hr, L1= 21m^3/hr, V1= 106 m^3/hr and V2 =116 m^3/hr.

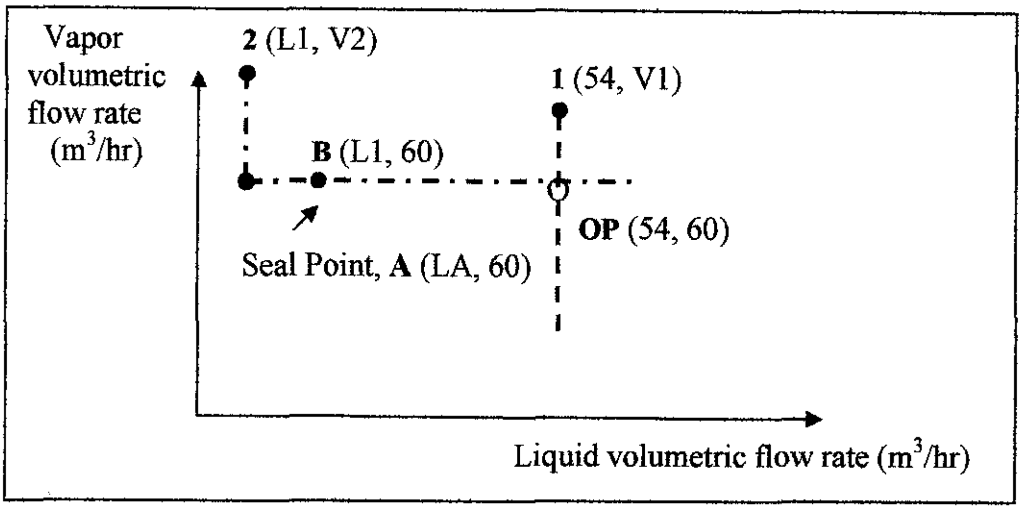

Figure 4.1: Step to calculate entrainment points from MATLAB

4.2.2. Sealing Point

Same application is used to calculate the sealing points from point (OP). In the previous step of calculating entrainment point, one seal point has already been identified as point (A) in the earlier session; hence only one point is needed to join the constraint line. The second seal point is denoted as (3). Point (A) and (3) are two potential sealing points. Random point of (B) is used to obtain point (3) as long as point B vapor flow rate is lower than point OP.Again, point (3) is obtained by using constant vapor load and vapor density while varies liquid density and liquid flow rate. L2 is the maximum value of liquid in which $\lambda_{max} > \lambda_{HS}$. Figure 4.2 shows the sketch location of point (3), point (A) and point (B). The calculated L2 = 23.5 m^3/hr and V3=50 m^3/hr.

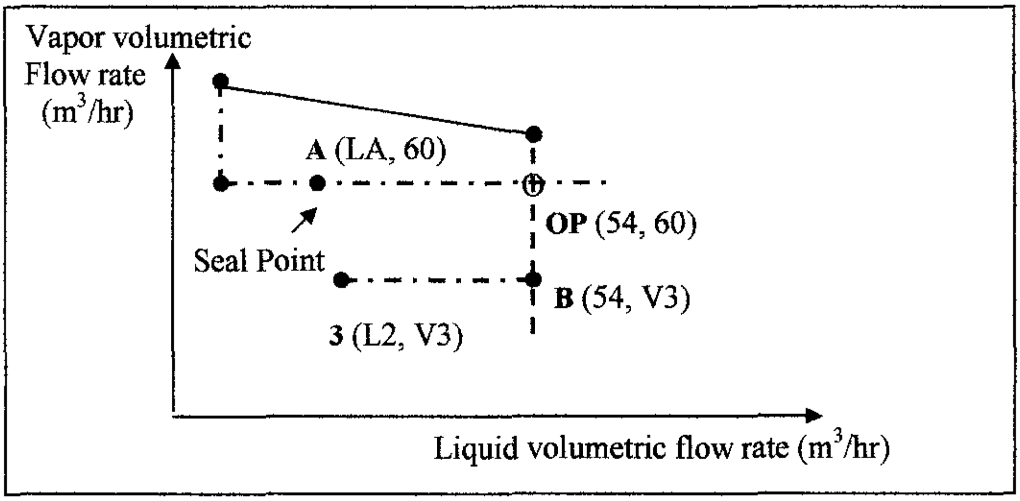

Figure 4.2: Step to calculate sealing points from MATLAB

4.2.3 Weeping Point

As for weeping, same logic was introduced. Potential point (4) is justified by using weeping equation from the base point (A). Liquid flow rate and liquid density are held while vapor density and flow rate are varied accordingly. The second weep point (5) was determined by using constant liquid flow rate and constant liquid density. The weeping line is constructed by connected point (4) and point (5). The maximum limit of both points is the last points where $\lambda_{max} > \lambda_{HW}$. The sketch of point (4) and point (5) are illustrated in Figure 4.3. V4= 12 m^3/hr and V5= 21 m^3/hr.

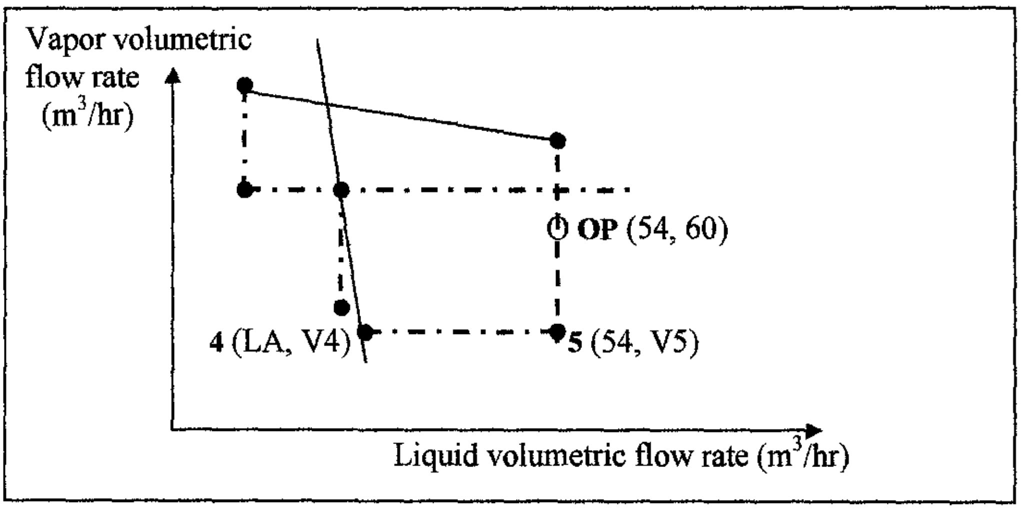

Figure 4.3: Step to calculate weeping points from MATLAB

4.2.4 Downcomer Backup Point

Point (OP) and point (B) are used as the base points in calculating potential point (6) and point (7) respectively. Please refer Figure 4.4 to have a clearer view of the estimated location of the points. Both downcomer points, (6) and (7) are calculated by setting constant vapor density and vapor flow rate but with a proportional increment of liquid flow rate and liquid density from their respective reference points. L3 and L4 are the maximum liquid points where they should meet the constraint of <375mm liquid. Hence, L3= 144 m^3/hr and L4 = 149 m^3/hr from MATLAB result.

The original (initial) set of the feasible operating region as in Figure 4.6 display clearly each constraints boundary limits. The upper capacity limit is the onset of entrainment flooding. At moderate and high liquid flow rates, the entrainment flooding limit is normally reached when vapor flow is raised, while the downcomer flooding limits is normally reached when liquid flow is raised. All these can be observed and interpreted easily from the figure. Moreover, the vapor flow rate of the tray is within a relatively narrow range while the liquid flow rate can be varied over a wider range. The lower boundary which is the weeping constraint may be exceeded to a certain extent without encountering any flow problems. However, the mass transfer efficiency may gradually decreases. Generally, the operating conditions should be selected such that sufficient safety margin to the border lines exists.

Besides that, plant engineer and operator can actually predict the type of physical constraints inside the column if any upset occurs by referring the respective liquid and vapor volumetric flow rates to the operating region. This will definitely save unnecessary maintenance cost of using gamma technique for detecting the column behavior.

Further step was carried out, that is to have a tighter operating region. This also means that to provide a more focus control region to the operators. HYSYS simulator and Microsoft Excel software tools are used for this purpose as well. First part of the step is to reduce weeping and sealing boundaries. Two specifications are then specified in HYSYS. Apparently three specifications have been justified as required from plant, there are;

1. C_3 product purity =99%
2. C_4/C_3 top vapor mole fraction =0.0005
3. C_3/C_4 bottom liquid mole fraction =0.022

Hence, trial and error method was used to choose the best and reasonable vapor and liquid flow rates. Based on the HYSYS output as attached in Appendix D, set (c) is chosen. This is because it gives a high C_3 purity product of 0.995 simultaneously. As for set (a), although both specifications of top purity and C_4/C_3 mole fraction are met, the

C_3/C_4 bottom mole fraction is 0.395 which is 16.94% so much higher than the required specification. Besides that, set (b) gives a low result of C_4/C_3 top mole fraction, approximately 0.003 compared to the required specification of 0.0005. Based on the relative comparison, it is concluded that the minimum vapor flow rate is set at $50m^3/hr$ and the minimum liquid flow rate is at $40m^3/hr$. The initial lines were then shifted inward to the region by using Microsoft Excel. The summary of the sets are tabulated in Table 4.4.

Table 4.4: HYSYS output result for each different specifications sets of sealing and weeping

Set	Specifications Monitoring	Top C_3 product purity	C_4/C_3 top mole fraction	C_3/C_4 bottom mole fraction
a	• C_4/C_3 top mole fraction • Top C_3 purity	match	match	0.395
b	• Top C_3 purity • C_3 /C_4 bottom mole fraction	match	0.003	match
c	• C_3 /C_4 bottom mole fraction • C_4/C_3 top mole fraction	0.995	match	match

The second part of the step is to reduce downcomer backup boundary. As for downcomer flooding, same approach was used as before but with totally two different specifications. From the initial operation region, the maximum limit of the vapor flow rate is approximately $100m^3/hr$. Hence it is predetermined that the liquid flow rate should not be so much higher than $100m^3/hr$ as a benchmark. Hence, one of the specifications is liquid flow rate and the other specification is C_3/C_4 bottom mole fraction. Three different sets of HYSYS simulation were obtained. Please refer Appendix E. Set (a) and set (b) results are merely the same although there is a change in liquid flow rate of $50m^3/hr$. Further trial and error was carried out. Eventually, it was encountered that when liquid flow rate is at $90m^3/hr$, the distillate rate changes from 4170 kg/hr to 4160 kg/hr. It is illustrated in set (c). Hence, it is being justified that the liquid flow rate of $90m^3/hr$ will bring an impact to the distillate rate where the product selling price is lower and higher liquid rate more than $100m^3/hr$ does not show a significant change in distillate rate at all. In addition, it is always important that not to

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The improved and optimum hydrodynamic model in terms of liquid and vapor flow rates of depropanizer column was developed based on HYSYS simulation and engineering equation solved by using MATLAB tool. The model was based on altogether four mechanism constraints, namely entrainment flooding, downcomer backup, weeping and sealing. Constant decrement and increment of liquid and vapor density is one of the main assumptions made in the MATLAB mathematical calculation.

As a conclusion, the optimum operating region, Figure 4.7 of depropanizer column provides an acceptable region of operation where high distillate rate, high purity of 99%, minimum C_4/C_3 top vapor mole fraction of 0.0005 and minimum C_3/C_4 bottom liquid mole fraction of 0.022 were met with the plant requirement. The model is indeed useful for preliminary prediction of the daily column dynamic behavior due to its simplicity. For example, plant engineers can predict the temperature profile of the column from each tray flow rate. Besides that, the specific type of hydraulic constraint can be identified by using Figure 4.7 if any upset occurs inside depropanizer column. However, this model has not been justified experimentally of its validity and therefore it is suggested to correlate with the overall column distillation behavior by using tray efficiency method in another advance stage of research.

5.2 Recommendation for Future Work

As whole the project had been completed though it may not be the most successful one due to HYSYS limitation and unforeseen circumstances. There are few areas in which the process of working on the research project can be improved better to a position which make the result more quality.

i. It is recommended to do an overall column efficiency test based on the chosen operating region. It helps to clear doubts of engineers on the column efficiency. Further modeling on column efficiency based on the hydrodynamic result from this project will give a valuable insight of the column economy operational management.

ii. It is important to be familiar with the software used. Although students have the basic knowledge to operate HYSYS but the familiarization and learning step took some time before any good output can be used. The student started using HYSYS facility only during week 8 (more than half of the project time frame) where the duration of the project is 13 weeks. This is due to the technical and management problem faced in the university where the previous simulation labs have been changed to different new location labs. Thus, this impeded student's work progress. Hence, less time is allocated to student to further improve the simulation result. It is strongly suggested that student that is doing simulation project to have the privilege to use HYSYS simulator in selected PETRONAS research institute such as Petronas Research and Scientific Services (PRSS).

iii. Simple and less sophisticated MATLAB language is used in the project. As discussed earlier, delay of HYSYS facility inhibits the student to progress any further as the properties of one good (normal) plant operation data point (as a starting point) is needed in MATLAB to calculate the mechanism constraints limits. Therefore, the student did not have much time left to explore the sophisticated programming language instead simple MATLAB language is used which also gives same result. The student limitation of presenting good and quality MATLAB programming can be sharpen up if only there is no delay of HYSYS software in the beginning of the project.

iv. Limitation of available literature review of the special Shell Calming section. No official website to be visited as it is a special downcomer section developed by Shell global research department. Besides that, limited knowledge on the section caused some delayed in understanding the hydraulic movement behaviors. It will be great if plant engineer gives more co-operations in sharing relevant and useful information, to enhance student understanding on the special tray features compared with the conventional tray. Definitely, it will fasten the project work space and gives faster result to plant as the project objectives are one of the plant existing problem. In addition, student is able to produce a more quality work piece for the benefit of the plant and university reputation.

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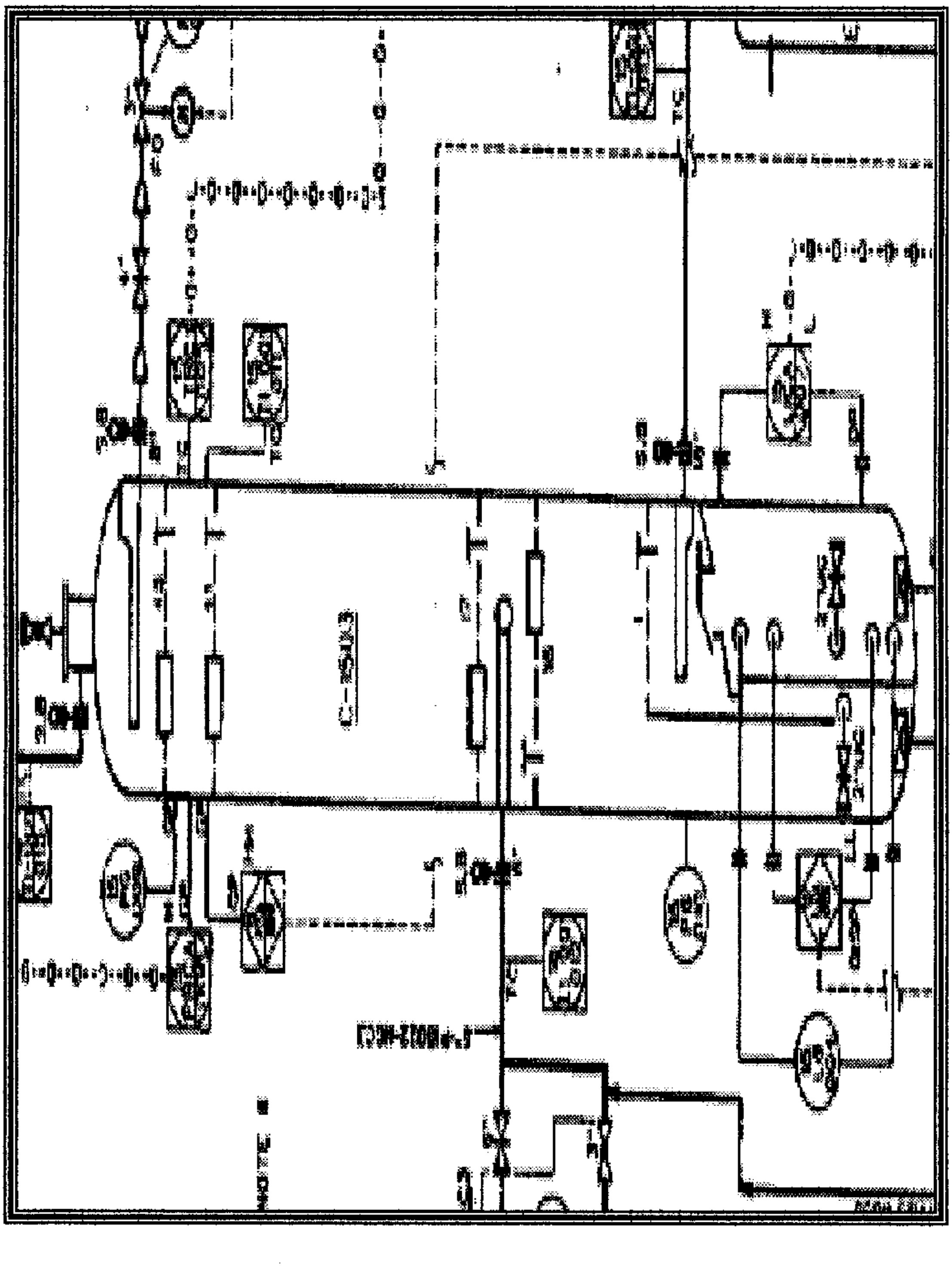
APPENDICES

APPENDIX A: PID Drawing of Depropanizer Column (C-1503)



APPENDIX B: HYSYS Result at Normal Operating Condition

Workbook: T-100 (COL1)

Material Streams

	Reflux	To Condenser	Boilup	To Reboiler	2
ur Fraction	0.0000	1.0000	1.0000	0.0000	0.0000
erature (C)	43.75	44.36	120.6	111.5	43.75
sure (kPa)	1531	1531	1532	1532	1531
Flow (kgmole/h)	617.6	700.0	474.7	804.0	82.35
Flow (kg/h)	2.715e+004	3.077e+004	3.000e+004	5.244e+004	3619
Volume Flow (m3/h)	53.74	60.90	50.53	87.21	7.165
Flow (kJ/h)	-7.246e+007	-7.290e+007	-6.090e+007	-1.192e+008	-9.661e+006

	3	1			
ur Fraction	0.0000	0.0709			
erature (C)	120.6	113.3			
sure (kPa)	1532	1909			
Flow (kgmole/h)	329.3	411.7			
Flow (kg/h)	2.244e+004	2.606e+004			
Volume Flow (m3/h)	36.68	43.85			
Flow (kJ/h)	-4.972e+007	-5.869e+007			

Compositions

e	Reflux	To Condenser	Boilup	To Reboiler	2
Mole Frac (Ethane)	0.0105	0.0105	0.0000	0.0000	0.0105
Mole Frac (Propane)	0.9894	0.9894	0.0284	0.0216	0.9894
Mole Frac (i-Butane)	0.0001	0.0001	0.2944	0.2536	0.0001
Mole Frac (n-Butane)	0.0000	0.0000	0.3747	0.3403	0.0000
Mole Frac (i-Pentane)	0.0000	0.0000	0.1358	0.1499	0.0000
Mole Frac (n-Pentane)	0.0000	0.0000	0.0782	0.0913	0.0000
Mole Frac (n-Hexane)	0.0000	0.0000	0.0885	0.1432	0.0000

e	3	1			
Mole Frac (Ethane)	0.0000	0.0021			
Mole Frac (Propane)	0.0117	0.2073			
Mole Frac (i-Butane)	0.1949	0.1559			
Mole Frac (n-Butane)	0.2909	0.2327			
Mole Frac (i-Pentane)	0.1703	0.1362			
Mole Frac (n-Pentane)	0.1101	0.0881			
Mole Frac (n-Hexane)	0.2221	0.1777			

Energy Streams

e	Q-100	Q-101			
Flow (kJ/h)	9.221e+006	8.536e+006			

Unit Ops

Operation Name	Operation Type	Feeds	Products	Ignored	Calc. Level
iler	Reboiler	To Reboiler Q-101	3 Boilup	No	500.0 *
TS	Tray Section	Reflux Boilup 1	To Reboiler To Condenser	No	500.0 *
denser	Total Condenser	To Condenser Q-100	2 Reflux Q-100	No	500.0 *

* Specified by user.

Tray Section: Main TS

Vapour Draws Summary

	Name:	Name:	Name:
lumber			
erature (C)			
ure (kPa)			
Flow (kg/h)			
Flow (kgmole/h)			
Volume Flow (m3/h)			
Enthalpy (kJ/kgmole)			
Enthalpy (kJ/kg)			
low (kJ/h)			
ular Weight			
Entropy (kJ/kgmole-C)			
Entropy (kJ/kg-C)			
Density (kgmole/m3)			
Density (kg/m3)			
iq Mass Den (kg/m3)			
Heat Cap (kJ/kgmole-C)			
Heat Cap (kJ/kg-C)			
nal Cond (W/m-K)			
sity (cP)			
ce Tension (dyne/cm)	---	---	---
tor			

Liquid Draws Summary

	Name:	Name:	Name:
Number			
erature (C)			
sure (kPa)			
Flow (kg/h)			
r Flow (kgmole/h)			
d Volume Flow (m3/h)			
r Enthalpy (kJ/kgmole)			
Enthalpy (kJ/kg)			
Flow (kJ/h)			
cular Weight			
r Entropy (kJ/kgmole-C)			
s Entropy (kJ/kg-C)			
r Density (kgmole/m3)			
s Density (kg/m3)			
iq Mass Den (kg/m3)			
r Heat Cap (kJ/kgmole-C)			
s Heat Cap (kJ/kg-C)			
mal Cond (W/m-K)			
osity (cP)			
ace Tension (dyne/cm)			
ctor			

Water Draws Summary

	Name:	Name:	Name:
Number			
perature (C)			
ssure (kPa)			
s Flow (kg/h)			
ar Flow (kgmole/h)			

Tray Section: Main TS (continued)

Water Draws Summary

		Name:	Name:	Name:
r Volume Flow	(m3/h)			
r Enthalpy	(kJ/kgmole)			
s Enthalpy	(kJ/kg)			
Flow	(kJ/h)			
cular Weight				
r Entropy	(kJ/kgmole-C)			
s Entropy	(kJ/kg-C)			
r Density	(kgmole/m3)			
s Density	(kg/m3)			
iq Mass Den	(kg/m3)			
r Heat Cap	(kJ/kgmole-C)			
s Heat Cap	(kJ/kg-C)			
mal Cond	(W/m-K)			
osity	(cP)			
ace Tension	(dyne/cm)			
ctor				

User Variables

_Main TS Tray :

		Liquid	Vapour	Feed : Reflux	Feed :
perature	(C)	44.36	44.36	43.75	
sure	(kPa)	1531	1531	1531	
s Flow	(kg/h)	2.727e+004	3.077e+004	2.715e+004	
r Flow	(kgmole/h)	619.1	700.0	617.6	
id Volume Flow	(m3/h)	53.88	60.90	53.74	
ar Enthalpy	(kJ/kgmole)	-1.174e+005	-1.041e+005	-1.173e+005	
s Enthalpy	(kJ/kg)	-2665	-2369	-2669	
t Flow	(kJ/h)	-7.268e+007	-7.290e+007	-7.246e+007	
ecular Weight		44.04	43.95	43.95	
ar Entropy	(kJ/kgmole-C)	99.01	140.8	99.27	
s Entropy	(kJ/kg-C)	2.248	3.203	2.259	
ar Density	(kgmole/m3)	10.43	0.7766	10.46	
s Density	(kg/m3)	459.3	34.13	459.7	
Liq Mass Den	(kg/m3)	507.3	506.7	506.7	
ar Heat Cap	(kJ/kgmole-C)	142.3	94.32	141.7	
s Heat Cap	(kJ/kg-C)	3.230	2.146	3.223	
rmal Cond	(W/m-K)	8.347e-002	2.180e-002	8.367e-002	
osity	(cP)	8.240e-002	9.617e-003	8.253e-002	
ace Tension	(dyne/cm)	4.680	---	4.716	
actor		5.561e-002	0.7468	5.555e-002	

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	44.58	44.58		
ssure	(kPa)	1531	1531		
s Flow	(kg/h)	2.731e+004	3.088e+004		
ar Flow	(kgmole/h)	619.6	701.4		
id Volume Flow	(m3/h)	53.92	61.04		
ar Enthalpy	(kJ/kgmole)	-1.174e+005	-1.042e+005		
s Enthalpy	(kJ/kg)	-2664	-2367		
t Flow	(kJ/h)	-7.275e+007	-7.311e+007		
ecular Weight		44.07	44.03		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
r Entropy	(kJ/kgmole-C)	98.92	140.4		
; Entropy	(kJ/kg-C)	2.244	3.190		
r Density	(kgmole/m3)	10.42	0.7766		
; Density	(kg/m3)	459.2	34.19		
.iq Mass Den	(kg/m3)	507.5	507.3		
r Heat Cap	(kJ/kgmole-C)	142.5	94.55		
; Heat Cap	(kJ/kg-C)	3.233	2.147		
nal Cond	(W/m-K)	8.340e-002	2.180e-002		
ɔsity	(cP)	8.236e-002	9.618e-003		
ıce Tension	(dyne/cm)	4.667	---		
:tor		5.563e-002	0.7463		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
ɔerature	(C)	44.66	44.66		
sure	(kPa)	1531	1531		
; Flow	(kg/h)	2.732e+004	3.093e+004		
r Flow	(kgmole/h)	619.7	701.9		
d Volume Flow	(m3/h)	53.94	61.09		
r Enthalpy	(kJ/kgmole)	-1.174e+005	-1.043e+005		
; Enthalpy	(kJ/kg)	-2664	-2367		
Flow	(kJ/h)	-7.278e+007	-7.319e+007		
cular Weight		44.09	44.06		
r Entropy	(kJ/kgmole-C)	98.89	140.3		
; Entropy	(kJ/kg-C)	2.243	3.185		
r Density	(kgmole/m3)	10.41	0.7765		
; Density	(kg/m3)	459.1	34.21		
.iq Mass Den	(kg/m3)	507.6	507.4		
.r Heat Cap	(kJ/kgmole-C)	142.6	94.64		
s Heat Cap	(kJ/kg-C)	3.234	2.148		
mal Cond	(W/m-K)	8.336e-002	2.180e-002		
ɔsity	(cP)	8.235e-002	9.618e-003		
ɜce Tension	(dyne/cm)	4.662	---		
ctor		5.564e-002	0.7461		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	44.70	44.70		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	2.733e+004	3.094e+004		
ır Flow	(kgmole/h)	619.7	702.1		
id Volume Flow	(m3/h)	53.94	61.11		
ır Enthalpy	(kJ/kgmole)	-1.175e+005	-1.043e+005		
s Enthalpy	(kJ/kg)	-2663	-2366		
l Flow	(kJ/h)	-7.279e+007	-7.322e+007		
ecular Weight		44.10	44.07		
ır Entropy	(kJ/kgmole-C)	98.91	140.3		
s Entropy	(kJ/kg-C)	2.243	3.183		
ır Density	(kgmole/m3)	10.41	0.7765		
s Density	(kg/m3)	459.1	34.22		
.iq Mass Den	(kg/m3)	507.7	507.5		
ır Heat Cap	(kJ/kgmole-C)	142.6	94.67		
s Heat Cap	(kJ/kg-C)	3.234	2.148		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
mal Cond	(W/m-K)	8.335e-002	2.181e-002		
osity	(cP)	8.235e-002	9.618e-003		
ace Tension	(dyne/cm)	4.660	---		
ctor		5.565e-002	0.7461		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	44.74	44.74		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	2.733e+004	3.095e+004		
ır Flow	(kgmole/h)	619.6	702.1		
id Volume Flow	(m3/h)	53.94	61.11		
ır Enthalpy	(kJ/kgmole)	-1.175e+005	-1.043e+005		
s Enthalpy	(kJ/kg)	-2663	-2366		
t Flow	(kJ/h)	-7.278e+007	-7.323e+007		
ecular Weight		44.11	44.08		
ır Entropy	(kJ/kgmole-C)	98.95	140.3		
s Entropy	(kJ/kg-C)	2.243	3.182		
ır Density	(kgmole/m3)	10.41	0.7765		
s Density	(kg/m3)	459.1	34.23		
Liq Mass Den	(kg/m3)	507.7	507.6		
ır Heat Cap	(kJ/kgmole-C)	142.6	94.70		
s Heat Cap	(kJ/kg-C)	3.234	2.148		
rmal Cond	(W/m-K)	8.332e-002	2.181e-002		
osity	(cP)	8.237e-002	9.619e-003		
ace Tension	(dyne/cm)	4.659	---		
ctor		5.565e-002	0.7461		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
ıperature	(C)	44.79	44.79		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	2.733e+004	3.095e+004		
ar Flow	(kgmole/h)	619.3	701.9		
iid Volume Flow	(m3/h)	53.93	61.10		
ar Enthalpy	(kJ/kgmole)	-1.175e+005	-1.043e+005		
ss Enthalpy	(kJ/kg)	-2663	-2366		
t Flow	(kJ/h)	-7.278e+007	-7.322e+007		
ecular Weight		44.13	44.09		
ar Entropy	(kJ/kgmole-C)	99.03	140.3		
ss Entropy	(kJ/kg-C)	2.244	3.183		
ar Density	(kgmole/m3)	10.41	0.7763		
ss Density	(kg/m3)	459.2	34.23		
Liq Mass Den	(kg/m3)	507.9	507.6		
ar Heat Cap	(kJ/kgmole-C)	142.7	94.72		
ss Heat Cap	(kJ/kg-C)	3.233	2.148		
rmal Cond	(W/m-K)	8.329e-002	2.181e-002		
cosity	(cP)	8.241e-002	9.620e-003		
face Tension	(dyne/cm)	4.659	---		
actor		5.567e-002	0.7461		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	44.86	44.86		
sure	(kPa)	1531	1531		
Flow	(kg/h)	2.733e+004	3.095e+004		
r Flow	(kgmole/h)	618.8	701.6		
d Volume Flow	(m3/h)	53.91	61.09		
r Enthalpy	(kJ/kgmole)	-1.176e+005	-1.044e+005		
Enthalpy	(kJ/kg)	-2662	-2366		
Flow	(kJ/h)	-7.276e+007	-7.322e+007		
cular Weight		44.16	44.11		
r Entropy	(kJ/kgmole-C)	99.15	140.4		
Entropy	(kJ/kg-C)	2.245	3.183		
r Density	(kgmole/m3)	10.40	0.7761		
Density	(kg/m3)	459.3	34.23		
iq Mass Den	(kg/m3)	508.0	507.7		
r Heat Cap	(kJ/kgmole-C)	142.7	94.77		
Heat Cap	(kJ/kg-C)	3.232	2.148		
mal Cond	(W/m-K)	8.324e-002	2.182e-002		
sity	(cP)	8.248e-002	9.621e-003		
ace Tension	(dyne/cm)	4.658	---		
ctor		5.569e-002	0.7461		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	45.00	45.00		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	2.732e+004	3.095e+004		
r Flow	(kgmole/h)	617.8	701.1		
id Volume Flow	(m3/h)	53.86	61.07		
r Enthalpy	(kJ/kgmole)	-1.177e+005	-1.044e+005		
s Enthalpy	(kJ/kg)	-2662	-2365		
t Flow	(kJ/h)	-7.272e+007	-7.320e+007		
cular Weight		44.22	44.14		
r Entropy	(kJ/kgmole-C)	99.34	140.5		
s Entropy	(kJ/kg-C)	2.246	3.184		
r Density	(kgmole/m3)	10.39	0.7758		
s Density	(kg/m3)	459.4	34.24		
iq Mass Den	(kg/m3)	508.4	507.9		
r Heat Cap	(kJ/kgmole-C)	142.9	94.84		
s Heat Cap	(kJ/kg-C)	3.231	2.149		
mal Cond	(W/m-K)	8.314e-002	2.182e-002		
osity	(cP)	8.259e-002	9.624e-003		
ace Tension	(dyne/cm)	4.658	---		
ctor		5.572e-002	0.7462		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	45.24	45.24		
ssure	(kPa)	1531	1531		
s Flow	(kg/h)	2.731e+004	3.094e+004		
r Flow	(kgmole/h)	616.1	700.2		
id Volume Flow	(m3/h)	53.79	61.03		
r Enthalpy	(kJ/kgmole)	-1.179e+005	-1.045e+005		
s Enthalpy	(kJ/kg)	-2660	-2365		

Tray Section: Main TS (continued)

_Main TS

Tray :

		Liquid	Vapour	Feed :	Feed :
Flow	(kJ/h)	-7.265e+007	-7.316e+007		
cular Weight		44.33	44.19		
r Entropy	(kJ/kgmole-C)	99.65	140.7		
s Entropy	(kJ/kg-C)	2.248	3.185		
r Density	(kgmole/m3)	10.37	0.7751		
s Density	(kg/m3)	459.7	34.25		
iq Mass Den	(kg/m3)	508.9	508.2		
r Heat Cap	(kJ/kgmole-C)	143.1	94.97		
s Heat Cap	(kJ/kg-C)	3.228	2.149		
mal Cond	(W/m-K)	8.298e-002	2.184e-002		
osity	(cP)	8.279e-002	9.629e-003		
ace Tension	(dyne/cm)	4.658	---		
ctor		5.578e-002	0.7463		

__Main TS

Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	45.68	45.68		
ssure	(kPa)	1531	1531		
s Flow	(kg/h)	2.729e+004	3.093e+004		
ar Flow	(kgmole/h)	613.1	698.5		
id Volume Flow	(m3/h)	53.65	60.95		
ar Enthalpy	(kJ/kgmole)	-1.183e+005	-1.046e+005		
s Enthalpy	(kJ/kg)	-2657	-2363		
t Flow	(kJ/h)	-7.252e+007	-7.309e+007		
ecular Weight		44.51	44.28		
ar Entropy	(kJ/kgmole-C)	100.1	141.1		
s Entropy	(kJ/kg-C)	2.249	3.186		
ar Density	(kgmole/m3)	10.34	0.7738		
ss Density	(kg/m3)	460.1	34.27		
Liq Mass Den	(kg/m3)	510.0	508.7		
ar Heat Cap	(kJ/kgmole-C)	143.4	95.20		
ss Heat Cap	(kJ/kg-C)	3.223	2.150		
rmal Cond	(W/m-K)	8.270e-002	2.186e-002		
cosity	(cP)	8.314e-002	9.637e-003		
face Tension	(dyne/cm)	4.658	---		
actor		5.588e-002	0.7465		

1__Main TS

Tray :

		Liquid	Vapour	Feed :	Feed :
nperature	(C)	46.44	46.44		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	2.725e+004	3.091e+004		
lar Flow	(kgmole/h)	607.8	695.4		
uid Volume Flow	(m3/h)	53.39	60.81		
lar Enthalpy	(kJ/kgmole)	-1.189e+005	-1.049e+005		
ss Enthalpy	(kJ/kg)	-2653	-2360		
at Flow	(kJ/h)	-7.227e+007	-7.296e+007		
lecular Weight		44.83	44.44		
lar Entropy	(kJ/kgmole-C)	100.8	141.6		
ss Entropy	(kJ/kg-C)	2.248	3.186		
lar Density	(kgmole/m3)	10.28	0.7716		
ss Density	(kg/m3)	460.9	34.29		
l Liq Mass Den	(kg/m3)	511.8	509.6		

* Specified by user.

Tray Section: Main TS (continued)

__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
r Heat Cap (kJ/kgmole-C)	144.1	95.60		
; Heat Cap (kJ/kg-C)	3.214	2.151		
mal Cond (W/m-K)	8.221e-002	2.191e-002		
osity (cP)	8.373e-002	9.651e-003		
ace Tension (dyne/cm)	4.659	---		
ctor	5.605e-002	0.7469		

:__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
perature (C)	47.79	47.79		
sure (kPa)	1531	1531		
s Flow (kg/h)	2.717e+004	3.086e+004		
ır Flow (kgmole/h)	598.8	690.1		
id Volume Flow (m3/h)	52.95	60.56		
ır Enthalpy (kJ/kgmole)	-1.200e+005	-1.054e+005		
s Enthalpy (kJ/kg)	-2644	-2356		
t Flow (kJ/h)	-7.183e+007	-7.271e+007		
ecular Weight	45.37	44.72		
ır Entropy (kJ/kgmole-C)	101.7	142.4		
s Entropy (kJ/kg-C)	2.241	3.185		
ır Density (kgmole/m3)	10.19	0.7677		
s Density (kg/m3)	462.2	34.33		
Liq Mass Den (kg/m3)	514.8	511.2		
ır Heat Cap (kJ/kgmole-C)	145.2	96.30		
s Heat Cap (kJ/kg-C)	3.200	2.153		
rmal Cond (W/m-K)	8.139e-002	2.199e-002		
osity (cP)	8.468e-002	9.676e-003		
ace Tension (dyne/cm)	4.663	---		
ıctor	5.633e-002	0.7475		

}__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
ıperature (C)	50.09	50.09		
ssure (kPa)	1531	1531		
ss Flow (kg/h)	2.705e+004	3.079e+004		
ar Flow (kgmole/h)	584.6	681.1		
iid Volume Flow (m3/h)	52.25	60.12		
ar Enthalpy (kJ/kgmole)	-1.217e+005	-1.061e+005		
ss Enthalpy (kJ/kg)	-2629	-2347		
t Flow (kJ/h)	-7.112e+007	-7.227e+007		
ecular Weight	46.28	45.20		
ar Entropy (kJ/kgmole-C)	102.8	143.6		
ss Entropy (kJ/kg-C)	2.222	3.177		
ar Density (kgmole/m3)	10.03	0.7612		
ss Density (kg/m3)	464.3	34.41		
Liq Mass Den (kg/m3)	519.9	513.9		
ar Heat Cap (kJ/kgmole-C)	147.1	97.52		
ss Heat Cap (kJ/kg-C)	3.179	2.157		
rmal Cond (W/m-K)	8.011e-002	2.214e-002		
cosity (cP)	8.614e-002	9.718e-003		
face Tension (dyne/cm)	4.669	---		
actor	5.679e-002	0.7485		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	53.85	53.85		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	2.686e+004	3.067e+004		
r Flow	(kgmole/h)	563.3	666.9		
d Volume Flow	(m3/h)	51.18	59.42		
r Enthalpy	(kJ/kgmole)	-1.242e+005	-1.073e+005		
s Enthalpy	(kJ/kg)	-2605	-2333		
Flow	(kJ/h)	-6.997e+007	-7.155e+007		
cular Weight		47.69	45.99		
r Entropy	(kJ/kgmole-C)	104.1	145.2		
s Entropy	(kJ/kg-C)	2.183	3.158		
r Density	(kgmole/m3)	9.801	0.7509		
s Density	(kg/m3)	467.4	34.53		
Liq Mass Den	(kg/m3)	527.8	518.4		
r Heat Cap	(kJ/kgmole-C)	150.2	99.57		
s Heat Cap	(kJ/kg-C)	3.151	2.165		
mal Cond	(W/m-K)	7.823e-002	2.237e-002		
osity	(cP)	8.813e-002	9.785e-003		
ace Tension	(dyne/cm)	4.679	---		
ctor		5.746e-002	0.7500		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	59.71	59.71		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	2.649e+004	3.048e+004		
r Flow	(kgmole/h)	531.8	645.7		
id Volume Flow	(m3/h)	49.46	58.34		
r Enthalpy	(kJ/kgmole)	-1.278e+005	-1.090e+005		
s Enthalpy	(kJ/kg)	-2566	-2310		
t Flow	(kJ/h)	-6.798e+007	-7.040e+007		
cular Weight		49.82	47.21		
r Entropy	(kJ/kgmole-C)	105.5	147.2		
s Entropy	(kJ/kg-C)	2.117	3.119		
r Density	(kgmole/m3)	9.470	0.7357		
s Density	(kg/m3)	471.8	34.73		
Liq Mass Den	(kg/m3)	539.3	525.3		
r Heat Cap	(kJ/kgmole-C)	155.2	102.8		
s Heat Cap	(kJ/kg-C)	3.116	2.178		
mal Cond	(W/m-K)	7.581e-002	2.274e-002		
osity	(cP)	9.058e-002	9.885e-003		
ace Tension	(dyne/cm)	4.699	---		
ctor		5.843e-002	0.7521		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	68.76	68.76		
ssure	(kPa)	1531	1531		
s Flow	(kg/h)	2.558e+004	3.011e+004		
r Flow	(kgmole/h)	481.4	614.1		
id Volume Flow	(m3/h)	46.37	56.62		
r Enthalpy	(kJ/kgmole)	-1.330e+005	-1.114e+005		
s Enthalpy	(kJ/kg)	-2503	-2272		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
t Flow	(kJ/h)	-6.405e+007	-6.841e+007		
ecular Weight		53.15	49.03		
ır Entropy	(kJ/kgmole-C)	107.6	149.9		
s Entropy	(kJ/kg-C)	2.025	3.058		
ır Density	(kgmole/m3)	9.008	0.7128		
s Density	(kg/m3)	478.7	34.95		
Liq Mass Den	(kg/m3)	556.5	535.4		
ır Heat Cap	(kJ/kgmole-C)	163.1	107.9		
s Heat Cap	(kJ/kg-C)	3.069	2.200		
rmal Cond	(W/m-K)	7.311e-002	2.334e-002		
osity	(cP)	9.361e-002	1.004e-002		
ace Tension	(dyne/cm)	4.755	---		
actor		5.980e-002	0.7557		

__Main TS Tray :

		Liquid	Vapour	Feed : 1	Feed :
perature	(C)	83.57	83.57	113.3	
ssure	(kPa)	1531	1531	1909	
s Flow	(kg/h)	4.562e+004	2.920e+004	2.606e+004	
ar Flow	(kgmole/h)	776.8	563.7	411.7	
iid Volume Flow	(m3/h)	79.18	53.54	43.85	
ar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.144e+005	-1.426e+005	
s Enthalpy	(kJ/kg)	-2399	-2208	-2253	
t Flow	(kJ/h)	-1.094e+008	-6.448e+007	-5.869e+007	
ecular Weight		58.74	51.80	63.29	
ar Entropy	(kJ/kgmole-C)	113.0	154.6	128.6	
s Entropy	(kJ/kg-C)	1.924	2.984	2.031	
ar Density	(kgmole/m3)	8.336	0.6767	4.719	
s Density	(kg/m3)	489.7	35.06	298.6	
Liq Mass Den	(kg/m3)	582.6	550.3	600.8	
ar Heat Cap	(kJ/kgmole-C)	177.0	115.9	203.0	
s Heat Cap	(kJ/kg-C)	3.013	2.237	3.207	
rmal Cond	(W/m-K)	7.043e-002	2.439e-002	---	
osity	(cP)	9.734e-002	1.028e-002	---	
face Tension	(dyne/cm)	4.896	---	---	
actor		6.194e-002	0.7630	---	

3__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
nperature	(C)	83.63	83.63		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	4.564e+004	2.319e+004		
lar Flow	(kgmole/h)	777.0	447.4		
uid Volume Flow	(m3/h)	79.21	42.50		
lar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.144e+005		
ss Enthalpy	(kJ/kg)	-2399	-2208		
at Flow	(kJ/h)	-1.095e+008	-5.119e+007		
lecular Weight		58.74	51.83		
lar Entropy	(kJ/kgmole-C)	113.0	154.5		
ss Entropy	(kJ/kg-C)	1.924	2.981		
lar Density	(kgmole/m3)	8.335	0.6768		
ss Density	(kg/m3)	489.6	35.07		
Liq Mass Den	(kg/m3)	582.6	550.4		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
r Heat Cap	(kJ/kgmole-C)	177.1	116.0		
s Heat Cap	(kJ/kg-C)	3.014	2.237		
mal Cond	(W/m-K)	7.040e-002	2.439e-002		
osity	(cP)	9.730e-002	1.028e-002		
ace Tension	(dyne/cm)	4.891	---		
ctor		6.194e-002	0.7628		

|__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	83.66	83.66		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	4.566e+004	2.321e+004		
ar Flow	(kgmole/h)	777.1	447.7		
id Volume Flow	(m3/h)	79.22	42.52		
ar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.144e+005		
s Enthalpy	(kJ/kg)	-2399	-2207		
t Flow	(kJ/h)	-1.095e+008	-5.123e+007		
ecular Weight		58.75	51.84		
ar Entropy	(kJ/kgmole-C)	113.0	154.5		
s Entropy	(kJ/kg-C)	1.924	2.980		
ar Density	(kgmole/m3)	8.333	0.6768		
s Density	(kg/m3)	489.6	35.08		
Liq Mass Den	(kg/m3)	582.6	550.4		
ar Heat Cap	(kJ/kgmole-C)	177.1	116.0		
s Heat Cap	(kJ/kg-C)	3.014	2.237		
rmal Cond	(W/m-K)	7.039e-002	2.439e-002		
osity	(cP)	9.728e-002	1.028e-002		
ace Tension	(dyne/cm)	4.889	---		
actor		6.194e-002	0.7628		

)__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	83.69	83.69		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	4.566e+004	2.322e+004		
ar Flow	(kgmole/h)	777.2	447.8		
uid Volume Flow	(m3/h)	79.23	42.54		
ar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.144e+005		
ss Enthalpy	(kJ/kg)	-2398	-2207		
at Flow	(kJ/h)	-1.095e+008	-5.125e+007		
ecular Weight		58.75	51.85		
ar Entropy	(kJ/kgmole-C)	113.0	154.5		
ss Entropy	(kJ/kg-C)	1.924	2.979		
ar Density	(kgmole/m3)	8.332	0.6768		
ss Density	(kg/m3)	489.5	35.09		
Liq Mass Den	(kg/m3)	582.7	550.5		
ar Heat Cap	(kJ/kgmole-C)	177.1	116.0		
ss Heat Cap	(kJ/kg-C)	3.015	2.238		
rmal Cond	(W/m-K)	7.038e-002	2.439e-002		
cosity	(cP)	9.727e-002	1.028e-002		
face Tension	(dyne/cm)	4.888	---		
actor		6.195e-002	0.7627		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	83.72	83.72		
sure	(kPa)	1531	1531		
s Flow	(kg/h)	4.567e+004	2.323e+004		
ar Flow	(kgmole/h)	777.3	447.9		
id Volume Flow	(m3/h)	79.24	42.55		
ar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.145e+005		
s Enthalpy	(kJ/kg)	-2398	-2207		
t Flow	(kJ/h)	-1.095e+008	-5.126e+007		
ecular Weight		58.76	51.86		
ar Entropy	(kJ/kgmole-C)	113.0	154.5		
s Entropy	(kJ/kg-C)	1.923	2.978		
ar Density	(kgmole/m3)	8.331	0.6768		
s Density	(kg/m3)	489.5	35.10		
Liq Mass Den	(kg/m3)	582.7	550.5		
ar Heat Cap	(kJ/kgmole-C)	177.2	116.1		
s Heat Cap	(kJ/kg-C)	3.015	2.238		
rmal Cond	(W/m-K)	7.037e-002	2.439e-002		
cosity	(cP)	9.726e-002	1.028e-002		
ace Tension	(dyne/cm)	4.887	---		
actor		6.195e-002	0.7627		

2__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
nperature	(C)	83.75	83.75		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	4.568e+004	2.323e+004		
ar Flow	(kgmole/h)	777.3	447.9		
uid Volume Flow	(m3/h)	79.26	42.56		
ar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.145e+005		
ss Enthalpy	(kJ/kg)	-2398	-2207		
at Flow	(kJ/h)	-1.095e+008	-5.128e+007		
ecular Weight		58.77	51.87		
ar Entropy	(kJ/kgmole-C)	113.0	154.5		
ss Entropy	(kJ/kg-C)	1.923	2.978		
ar Density	(kgmole/m3)	8.330	0.6767		
ss Density	(kg/m3)	489.5	35.10		
Liq Mass Den	(kg/m3)	582.7	550.6		
ar Heat Cap	(kJ/kgmole-C)	177.2	116.1		
ss Heat Cap	(kJ/kg-C)	3.015	2.238		
rmal Cond	(W/m-K)	7.035e-002	2.440e-002		
cosity	(cP)	9.725e-002	1.028e-002		
face Tension	(dyne/cm)	4.885	---		
actor		6.196e-002	0.7626		

3__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
nperature	(C)	83.79	83.79		
ssure	(kPa)	1531	1531		
ss Flow	(kg/h)	4.569e+004	2.324e+004		
lar Flow	(kgmole/h)	777.4	448.0		
uid Volume Flow	(m3/h)	79.27	42.57		
lar Enthalpy	(kJ/kgmole)	-1.409e+005	-1.145e+005		
ss Enthalpy	(kJ/kg)	-2398	-2207		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
: Flow	(kJ/h)	-1.096e+008	-5.129e+007		
cular Weight		58.78	51.89		
r Entropy	(kJ/kgmole-C)	113.0	154.5		
s Entropy	(kJ/kg-C)	1.923	2.977		
r Density	(kgmole/m3)	8.328	0.6767		
s Density	(kg/m3)	489.5	35.11		
Liq Mass Den	(kg/m3)	582.7	550.6		
r Heat Cap	(kJ/kgmole-C)	177.2	116.1		
s Heat Cap	(kJ/kg-C)	3.015	2.238		
mal Cond	(W/m-K)	7.034e-002	2.440e-002		
osity	(cP)	9.725e-002	1.028e-002		
ace Tension	(dyne/cm)	4.884	---		
ctor		6.196e-002	0.7626		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	83.85	83.85		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.571e+004	2.326e+004		
r Flow	(kgmole/h)	777.5	448.1		
id Volume Flow	(m3/h)	79.29	42.59		
r Enthalpy	(kJ/kgmole)	-1.410e+005	-1.145e+005		
s Enthalpy	(kJ/kg)	-2398	-2206		
t Flow	(kJ/h)	-1.096e+008	-5.132e+007		
cular Weight		58.79	51.90		
r Entropy	(kJ/kgmole-C)	113.1	154.5		
s Entropy	(kJ/kg-C)	1.923	2.976		
r Density	(kgmole/m3)	8.326	0.6766		
s Density	(kg/m3)	489.5	35.12		
Liq Mass Den	(kg/m3)	582.8	550.7		
r Heat Cap	(kJ/kgmole-C)	177.3	116.2		
s Heat Cap	(kJ/kg-C)	3.016	2.238		
rmal Cond	(W/m-K)	7.032e-002	2.440e-002		
osity	(cP)	9.723e-002	1.028e-002		
ace Tension	(dyne/cm)	4.882	---		
ctor		6.197e-002	0.7625		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	83.93	83.93		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.573e+004	2.327e+004		
r Flow	(kgmole/h)	777.7	448.2		
id Volume Flow	(m3/h)	79.32	42.61		
r Enthalpy	(kJ/kgmole)	-1.410e+005	-1.146e+005		
s Enthalpy	(kJ/kg)	-2397	-2206		
t Flow	(kJ/h)	-1.096e+008	-5.135e+007		
ecular Weight		58.81	51.93		
r Entropy	(kJ/kgmole-C)	113.1	154.5		
s Entropy	(kJ/kg-C)	1.923	2.975		
r Density	(kgmole/m3)	8.323	0.6766		
s Density	(kg/m3)	489.4	35.13		
Liq Mass Den	(kg/m3)	582.8	550.8		

Tray Section: Main TS (continued)

__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
ar Heat Cap (kJ/kgmole-C)	177.4	116.3		
s Heat Cap (kJ/kg-C)	3.016	2.239		
rmal Cond (W/m-K)	7.029e-002	2.440e-002		
osity (cP)	9.722e-002	1.028e-002		
ace Tension (dyne/cm)	4.880	---		
ictor	6.198e-002	0.7625		

__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
perature (C)	84.04	84.04		
ssure (kPa)	1532	1532		
s Flow (kg/h)	4.576e+004	2.330e+004		
ar Flow (kgmole/h)	777.9	448.3		
id Volume Flow (m3/h)	79.36	42.64		
ar Enthalpy (kJ/kgmole)	-1.410e+005	-1.146e+005		
s Enthalpy (kJ/kg)	-2397	-2206		
t Flow (kJ/h)	-1.097e+008	-5.138e+007		
ecular Weight	58.83	51.96		
ar Entropy (kJ/kgmole-C)	113.1	154.5		
s Entropy (kJ/kg-C)	1.923	2.974		
ar Density (kgmole/m3)	8.318	0.6765		
s Density (kg/m3)	489.4	35.15		
Liq Mass Den (kg/m3)	582.9	551.0		
ar Heat Cap (kJ/kgmole-C)	177.5	116.4		
s Heat Cap (kJ/kg-C)	3.017	2.239		
rmal Cond (W/m-K)	7.025e-002	2.441e-002		
cosity (cP)	9.720e-002	1.028e-002		
face Tension (dyne/cm)	4.877	---		
actor	6.200e-002	0.7624		

7__Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
nperature (C)	84.18	84.18		
ssure (kPa)	1532	1532		
ss Flow (kg/h)	4.580e+004	2.333e+004		
lar Flow (kgmole/h)	778.1	448.5		
uid Volume Flow (m3/h)	79.42	42.68		
lar Enthalpy (kJ/kgmole)	-1.411e+005	-1.147e+005		
ss Enthalpy (kJ/kg)	-2396	-2205		
at Flow (kJ/h)	-1.098e+008	-5.144e+007		
lecular Weight	58.87	52.01		
lar Entropy (kJ/kgmole-C)	113.2	154.6		
ss Entropy (kJ/kg-C)	1.922	2.972		
lar Density (kgmole/m3)	8.312	0.6763		
ss Density (kg/m3)	489.3	35.17		
l Liq Mass Den (kg/m3)	583.0	551.2		
lar Heat Cap (kJ/kgmole-C)	177.6	116.5		
ss Heat Cap (kJ/kg-C)	3.018	2.240		
ermal Cond (W/m-K)	7.020e-002	2.442e-002		
cosity (cP)	9.717e-002	1.029e-002		
rface Tension (dyne/cm)	4.873	---		
actor	6.202e-002	0.7623		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	84.37	84.37		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.586e+004	2.337e+004		
ar Flow	(kgmole/h)	778.4	448.8		
id Volume Flow	(m3/h)	79.49	42.73		
ar Enthalpy	(kJ/kgmole)	-1.411e+005	-1.148e+005		
s Enthalpy	(kJ/kg)	-2396	-2204		
t Flow	(kJ/h)	-1.099e+008	-5.151e+007		
ecular Weight		58.91	52.07		
ar Entropy	(kJ/kgmole-C)	113.2	154.6		
s Entropy	(kJ/kg-C)	1.922	2.970		
ar Density	(kgmole/m3)	8.304	0.6761		
s Density	(kg/m3)	489.2	35.21		
Liq Mass Den	(kg/m3)	583.2	551.5		
ar Heat Cap	(kJ/kgmole-C)	177.8	116.7		
s Heat Cap	(kJ/kg-C)	3.019	2.241		
rmal Cond	(W/m-K)	7.013e-002	2.443e-002		
osity	(cP)	9.713e-002	1.029e-002		
ace Tension	(dyne/cm)	4.867	---		
actor		6.204e-002	0.7621		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	84.63	84.63		
ssure	(kPa)	1532	1532		
s Flow	(kg/h)	4.593e+004	2.342e+004		
ar Flow	(kgmole/h)	778.9	449.1		
id Volume Flow	(m3/h)	79.58	42.81		
ar Enthalpy	(kJ/kgmole)	-1.412e+005	-1.149e+005		
s Enthalpy	(kJ/kg)	-2395	-2203		
t Flow	(kJ/h)	-1.100e+008	-5.160e+007		
ecular Weight		58.97	52.16		
ar Entropy	(kJ/kgmole-C)	113.3	154.7		
s Entropy	(kJ/kg-C)	1.921	2.966		
ar Density	(kgmole/m3)	8.294	0.6758		
s Density	(kg/m3)	489.1	35.25		
Liq Mass Den	(kg/m3)	583.4	551.9		
ar Heat Cap	(kJ/kgmole-C)	178.1	116.9		
s Heat Cap	(kJ/kg-C)	3.020	2.242		
rmal Cond	(W/m-K)	7.004e-002	2.444e-002		
osity	(cP)	9.708e-002	1.029e-002		
face Tension	(dyne/cm)	4.860	---		
actor		6.208e-002	0.7619		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
nperature	(C)	84.97	84.97		
ssure	(kPa)	1532	1532		
ss Flow	(kg/h)	4.603e+004	2.349e+004		
ar Flow	(kgmole/h)	779.4	449.5		
uid Volume Flow	(m3/h)	79.70	42.90		
ar Enthalpy	(kJ/kgmole)	-1.413e+005	-1.151e+005		
ss Enthalpy	(kJ/kg)	-2393	-2202		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
Flow	(kJ/h)	-1.102e+008	-5.173e+007		
cular Weight		59.05	52.27		
r Entropy	(kJ/kgmole-C)	113.4	154.8		
; Entropy	(kJ/kg-C)	1.920	2.962		
r Density	(kgmole/m3)	8.280	0.6754		
; Density	(kg/m3)	489.0	35.30		
.iq Mass Den	(kg/m3)	583.7	552.4		
r Heat Cap	(kJ/kgmole-C)	178.5	117.3		
; Heat Cap	(kJ/kg-C)	3.022	2.244		
mal Cond	(W/m-K)	6.991e-002	2.446e-002		
ɔsity	(cP)	9.701e-002	1.027e-002		
ace Tension	(dyne/cm)	4.850	---		
ctor		6.213e-002	0.7616		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	85.42	85.42		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.615e+004	2.359e+004		
ır Flow	(kgmole/h)	780.2	450.1		
id Volume Flow	(m3/h)	79.87	43.02		
ır Enthalpy	(kJ/kgmole)	-1.415e+005	-1.153e+005		
s Enthalpy	(kJ/kg)	-2391	-2200		
: Flow	(kJ/h)	-1.104e+008	-5.189e+007		
ɛcular Weight		59.16	52.41		
ır Entropy	(kJ/kgmole-C)	113.5	154.9		
s Entropy	(kJ/kg-C)	1.919	2.956		
ır Density	(kgmole/m3)	8.262	0.6750		
s Density	(kg/m3)	488.7	35.38		
Liq Mass Den	(kg/m3)	584.0	553.0		
ır Heat Cap	(kJ/kgmole-C)	179.0	117.7		
s Heat Cap	(kJ/kg-C)	3.025	2.246		
rmal Cond	(W/m-K)	6.975e-002	2.448e-002		
osity	(cP)	9.692e-002	1.028e-002		
ace Tension	(dyne/cm)	4.837	---		
ıctor		6.219e-002	0.7612		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
ıperature	(C)	86.00	86.00		
ssure	(kPa)	1532	1532		
s Flow	(kg/h)	4.632e+004	2.372e+004		
ar Flow	(kgmole/h)	781.2	450.9		
iid Volume Flow	(m3/h)	80.08	43.19		
ar Enthalpy	(kJ/kgmole)	-1.417e+005	-1.156e+005		
ss Enthalpy	(kJ/kg)	-2389	-2197		
t Flow	(kJ/h)	-1.107e+008	-5.211e+007		
ecular Weight		59.29	52.61		
ar Entropy	(kJ/kgmole-C)	113.7	155.1		
ss Entropy	(kJ/kg-C)	1.917	2.948		
ar Density	(kgmole/m3)	8.238	0.6744		
ss Density	(kg/m3)	488.5	35.48		
Liq Mass Den	(kg/m3)	584.5	553.9		

Tray Section: Main TS (continued)

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
r Heat Cap	(kJ/kgmole-C)	179.6	118.3		
s Heat Cap	(kJ/kg-C)	3.029	2.249		
mal Cond	(W/m-K)	6.954e-002	2.451e-002		
osity	(cP)	9.680e-002	1.028e-002		
ace Tension	(dyne/cm)	4.820	---		
ctor		6.226e-002	0.7606		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	86.74	86.74		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.654e+004	2.388e+004		
r Flow	(kgmole/h)	782.6	451.9		
d Volume Flow	(m3/h)	80.36	43.40		
r Enthalpy	(kJ/kgmole)	-1.419e+005	-1.160e+005		
s Enthalpy	(kJ/kg)	-2386	-2194		
t Flow	(kJ/h)	-1.110e+008	-5.240e+007		
cular Weight		59.46	52.86		
r Entropy	(kJ/kgmole-C)	113.9	155.3		
s Entropy	(kJ/kg-C)	1.915	2.937		
r Density	(kgmole/m3)	8.208	0.6736		
s Density	(kg/m3)	488.1	35.60		
Liq Mass Den	(kg/m3)	585.0	554.9		
r Heat Cap	(kJ/kgmole-C)	180.4	119.1		
s Heat Cap	(kJ/kg-C)	3.033	2.252		
rmal Cond	(W/m-K)	6.928e-002	2.454e-002		
osity	(cP)	9.664e-002	1.029e-002		
ace Tension	(dyne/cm)	4.798	---		
ctor		6.236e-002	0.7599		

__Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
perature	(C)	87.68	87.68		
sure	(kPa)	1532	1532		
s Flow	(kg/h)	4.681e+004	2.410e+004		
ar Flow	(kgmole/h)	784.4	453.2		
id Volume Flow	(m3/h)	80.72	43.68		
ar Enthalpy	(kJ/kgmole)	-1.422e+005	-1.164e+005		
s Enthalpy	(kJ/kg)	-2382	-2190		
t Flow	(kJ/h)	-1.115e+008	-5.277e+007		
ecular Weight		59.68	53.17		
ar Entropy	(kJ/kgmole-C)	114.1	155.5		
s Entropy	(kJ/kg-C)	1.912	2.924		
ar Density	(kgmole/m3)	8.171	0.6727		
s Density	(kg/m3)	487.6	35.77		
Liq Mass Den	(kg/m3)	585.8	556.3		
ar Heat Cap	(kJ/kgmole-C)	181.4	120.0		
s Heat Cap	(kJ/kg-C)	3.039	2.257		
rmal Cond	(W/m-K)	6.894e-002	2.459e-002		
osity	(cP)	9.643e-002	1.030e-002		
face Tension	(dyne/cm)	4.769	---		
actor		6.249e-002	0.7590		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
rature	(C)	88.82	88.82		
re	(kPa)	1532	1532		
low	(kg/h)	4.715e+004	2.437e+004		
low	(kgmole/h)	786.7	455.0		
Volume Flow	(m3/h)	81.18	44.04		
nthalpy	(kJ/kgmole)	-1.425e+005	-1.170e+005		
nthalpy	(kJ/kg)	-2378	-2185		
low	(kJ/h)	-1.121e+008	-5.325e+007		
lar Weight		59.94	53.56		
ntropy	(kJ/kgmole-C)	114.4	155.7		
ntropy	(kJ/kg-C)	1.909	2.907		
ensity	(kgmole/m3)	8.126	0.6716		
ensity	(kg/m3)	487.0	35.97		
Mass Den	(kg/m3)	586.6	558.0		
Heat Cap	(kJ/kgmole-C)	182.6	121.2		
eat Cap	(kJ/kg-C)	3.047	2.263		
al Cond	(W/m-K)	6.853e-002	2.464e-002		
ity	(cP)	9.616e-002	1.031e-002		
e Tension	(dyne/cm)	4.734	---		
or		6.264e-002	0.7578		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	90.17	90.17		
ure	(kPa)	1532	1532		
Flow	(kg/h)	4.757e+004	2.471e+004		
Flow	(kgmole/h)	789.7	457.3		
Volume Flow	(m3/h)	81.73	44.50		
Enthalpy	(kJ/kgmole)	-1.429e+005	-1.177e+005		
Enthalpy	(kJ/kg)	-2373	-2179		
low	(kJ/h)	-1.129e+008	-5.385e+007		
ular Weight		60.24	54.04		
Entropy	(kJ/kgmole-C)	114.8	156.0		
Entropy	(kJ/kg-C)	1.905	2.887		
Density	(kgmole/m3)	8.073	0.6704		
Density	(kg/m3)	486.3	36.23		
q Mass Den	(kg/m3)	587.6	560.0		
Heat Cap	(kJ/kgmole-C)	184.1	122.7		
Heat Cap	(kJ/kg-C)	3.056	2.270		
ial Cond	(W/m-K)	6.804e-002	2.470e-002		
sity	(cP)	9.581e-002	1.032e-002		
ce Tension	(dyne/cm)	4.692	---		
tor		6.281e-002	0.7563		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	91.72	91.72		
ure	(kPa)	1532	1532		
Flow	(kg/h)	4.806e+004	2.513e+004		
Flow	(kgmole/h)	793.3	460.3		
Volume Flow	(m3/h)	82.40	45.05		
Enthalpy	(kJ/kgmole)	-1.434e+005	-1.186e+005		
Enthalpy	(kJ/kg)	-2366	-2172		

Tray Section: Main TS (continued)

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
low (kJ/h)	-1.137e+008	-5.458e+007		
ılar Weight	60.58	54.59		
Entropy (kJ/kgmole-C)	115.1	156.3		
Entropy (kJ/kg-C)	1.900	2.863		
Density (kgmole/m3)	8.013	0.6692		
Density (kg/m3)	485.4	36.53		
Mass Den (kg/m3)	588.7	562.3		
Heat Cap (kJ/kgmole-C)	185.8	124.4		
Heat Cap (kJ/kg-C)	3.068	2.278		
al Cond (W/m-K)	6.748e-002	2.477e-002		
ity (cP)	9.539e-002	1.034e-002		
e Tension (dyne/cm)	4.642	---		
or	6.301e-002	0.7545		

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
rature (C)	93.44	93.44		
ıre (kPa)	1532	1532		
Flow (kg/h)	4.862e+004	2.562e+004		
Flow (kgmole/h)	797.7	464.0		
Volume Flow (m3/h)	83.16	45.72		
Enthalpy (kJ/kgmole)	-1.438e+005	-1.195e+005		
Enthalpy (kJ/kg)	-2360	-2164		
low (kJ/h)	-1.147e+008	-5.546e+007		
ılar Weight	60.94	55.22		
Entropy (kJ/kgmole-C)	115.5	156.5		
Entropy (kJ/kg-C)	1.895	2.835		
Density (kgmole/m3)	7.948	0.6680		
Density (kg/m3)	484.4	36.88		
Mass Den (kg/m3)	589.8	564.8		
Heat Cap (kJ/kgmole-C)	187.7	126.3		
Heat Cap (kJ/kg-C)	3.080	2.288		
ıal Cond (W/m-K)	6.686e-002	2.485e-002		
sity (cP)	9.488e-002	1.035e-002		
e Tension (dyne/cm)	4.586	---		
or	6.323e-002	0.7524		

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
erature (C)	95.27	95.27		
ıre (kPa)	1532	1532		
Flow (kg/h)	4.923e+004	2.618e+004		
Flow (kgmole/h)	802.7	468.4		
Volume Flow (m3/h)	84.00	46.48		
Enthalpy (kJ/kgmole)	-1.443e+005	-1.205e+005		
Enthalpy (kJ/kg)	-2353	-2156		
Flow (kJ/h)	-1.158e+008	-5.645e+007		
ular Weight	61.33	55.90		
Entropy (kJ/kgmole-C)	115.9	156.7		
Entropy (kJ/kg-C)	1.889	2.804		
Density (kgmole/m3)	7.880	0.6668		
Density (kg/m3)	483.3	37.27		
q Mass Den (kg/m3)	591.0	567.5		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
Heat Cap	(kJ/kgmole-C)	189.8	128.5		
Heat Cap	(kJ/kg-C)	3.095	2.298		
al Cond	(W/m-K)	6.620e-002	2.493e-002		
ity	(cP)	9.424e-002	1.036e-002		
e Tension	(dyne/cm)	4.525	---		
or		6.347e-002	0.7500		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	97.14	97.14		
ure	(kPa)	1532	1532		
Flow	(kg/h)	4.988e+004	2.680e+004		
Flow	(kgmole/h)	808.2	473.4		
Volume Flow	(m3/h)	84.89	47.32		
Enthalpy	(kJ/kgmole)	-1.447e+005	-1.216e+005		
Enthalpy	(kJ/kg)	-2345	-2148		
Flow	(kJ/h)	-1.170e+008	-5.755e+007		
ular Weight		61.71	56.60		
Entropy	(kJ/kgmole-C)	116.2	156.8		
Entropy	(kJ/kg-C)	1.883	2.771		
Density	(kgmole/m3)	7.811	0.6657		
Density	(kg/m3)	482.1	37.68		
q Mass Den	(kg/m3)	592.3	570.3		
Heat Cap	(kJ/kgmole-C)	191.9	130.7		
Heat Cap	(kJ/kg-C)	3.110	2.309		
al Cond	(W/m-K)	6.556e-002	2.501e-002		
sity	(cP)	9.321e-002	1.037e-002		
e Tension	(dyne/cm)	4.465	---		
or		6.370e-002	0.7474		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	98.99	98.99		
ure	(kPa)	1532	1532		
Flow	(kg/h)	5.052e+004	2.744e+004		
Flow	(kgmole/h)	813.7	478.8		
Volume Flow	(m3/h)	85.78	48.21		
Enthalpy	(kJ/kgmole)	-1.452e+005	-1.226e+005		
Enthalpy	(kJ/kg)	-2338	-2139		
Flow	(kJ/h)	-1.181e+008	-5.870e+007		
ular Weight		62.09	57.31		
Entropy	(kJ/kgmole-C)	116.5	156.8		
Entropy	(kJ/kg-C)	1.876	2.737		
Density	(kgmole/m3)	7.745	0.6648		
Density	(kg/m3)	480.9	38.10		
q Mass Den	(kg/m3)	593.5	573.0		
Heat Cap	(kJ/kgmole-C)	194.0	132.9		
Heat Cap	(kJ/kg-C)	3.125	2.320		
al Cond	(W/m-K)	6.502e-002	2.509e-002		
sity	(cP)	9.303e-002	1.039e-002		
ce Tension	(dyne/cm)	4.408	---		
tor		6.392e-002	0.7448		

Tray Section: Main TS (continued)

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
rature (C)	100.8	100.8		
re (kPa)	1532	1532		
low (kg/h)	5.114e+004	2.808e+004		
Flow (kgmole/h)	818.8	484.3		
Volume Flow (m3/h)	86.62	49.10		
Enthalpy (kJ/kgmole)	-1.455e+005	-1.236e+005		
nthalpy (kJ/kg)	-2330	-2131		
low (kJ/h)	-1.192e+008	-5.984e+007		
lar Weight	62.45	57.99		
Entropy (kJ/kgmole-C)	116.6	156.7		
ntropy (kJ/kg-C)	1.868	2.702		
Density (kgmole/m3)	7.682	0.6639		
Density (kg/m3)	479.8	38.50		
Mass Den (kg/m3)	594.7	575.6		
Heat Cap (kJ/kgmole-C)	196.1	135.2		
Heat Cap (kJ/kg-C)	3.140	2.331		
al Cond (W/m-K)	6.447e-002	2.517e-002		
ity (cP)	9.282e-002	1.040e-002		
e Tension (dyne/cm)	4.349	---		
or	6.414e-002	0.7422		

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
erature (C)	102.6	102.6		
re (kPa)	1532	1532		
Flow (kg/h)	5.170e+004	2.870e+004		
Flow (kgmole/h)	822.9	489.4		
Volume Flow (m3/h)	87.35	49.94		
Enthalpy (kJ/kgmole)	-1.459e+005	-1.244e+005		
Enthalpy (kJ/kg)	-2322	-2122		
low (kJ/h)	-1.201e+008	-6.090e+007		
ular Weight	62.82	58.64		
Entropy (kJ/kgmole-C)	116.8	156.5		
Entropy (kJ/kg-C)	1.859	2.669		
Density (kgmole/m3)	7.622	0.6629		
Density (kg/m3)	478.9	38.87		
q Mass Den (kg/m3)	596.0	578.1		
Heat Cap (kJ/kgmole-C)	198.2	137.3		
Heat Cap (kJ/kg-C)	3.154	2.341		
al Cond (W/m-K)	6.392e-002	2.525e-002		
ity (cP)	9.258e-002	1.041e-002		
e Tension (dyne/cm)	4.291	---		
tor	6.433e-002	0.7398		

_Main TS Tray :

	Liquid	Vapour	Feed :	Feed :
erature (C)	104.5	104.5		
ure (kPa)	1532	1532		
Flow (kg/h)	5.216e+004	2.926e+004		
Flow (kgmole/h)	824.5	493.5		
Volume Flow (m3/h)	87.87	50.67		
Enthalpy (kJ/kgmole)	-1.463e+005	-1.252e+005		
Enthalpy (kJ/kg)	-2313	-2112		

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
low	(kJ/h)	-1.206e+008	-6.179e+007		
ular Weight		63.26	59.29		
Entropy	(kJ/kgmole-C)	117.0	156.3		
Entropy	(kJ/kg-C)	1.849	2.636		
Density	(kgmole/m3)	7.559	0.6613		
Density	(kg/m3)	478.2	39.21		
q Mass Den	(kg/m3)	597.6	580.7		
Heat Cap	(kJ/kgmole-C)	200.3	139.4		
Heat Cap	(kJ/kg-C)	3.167	2.352		
ıal Cond	(W/m-K)	6.339e-002	2.535e-002		
sity	(cP)	9.231e-002	1.042e-002		
ce Tension	(dyne/cm)	4.238	---		
tor		6.454e-002	0.7377		

_Main TS Tray :

		Liquid	Vapour	Feed :	Feed :
erature	(C)	107.1	107.1		
ure	(kPa)	1532	1532		
Flow	(kg/h)	5.245e+004	2.972e+004		
Flow	(kgmole/h)	820.6	495.2		
Volume Flow	(m3/h)	87.97	51.19		
Enthalpy	(kJ/kgmole)	-1.469e+005	-1.260e+005		
Enthalpy	(kJ/kg)	-2299	-2099		
Flow	(kJ/h)	-1.206e+008	-6.238e+007		
ular Weight		63.92	60.02		
Entropy	(kJ/kgmole-C)	117.5	156.4		
Entropy	(kJ/kg-C)	1.839	2.605		
Density	(kgmole/m3)	7.477	0.6582		
Density	(kg/m3)	477.9	39.51		
iq Mass Den	(kg/m3)	600.2	583.8		
Heat Cap	(kJ/kgmole-C)	203.1	141.9		
Heat Cap	(kJ/kg-C)	3.177	2.364		
nal Cond	(W/m-K)	6.285e-002	2.551e-002		
sity	(cP)	9.204e-002	1.044e-002		
ce Tension	(dyne/cm)	4.191	---		
tor		6.480e-002	0.7362		

_Main TS Tray :

		Liquid	Vapour	Feed : Boilup	Feed :
erature	(C)	111.5	111.5	120.6	
ure	(kPa)	1532	1532	1532	
Flow	(kg/h)	5.244e+004	3.002e+004	3.000e+004	
Flow	(kgmole/h)	804.0	491.3	474.7	
Volume Flow	(m3/h)	87.21	51.28	50.53	
Enthalpy	(kJ/kgmole)	-1.482e+005	-1.268e+005	-1.283e+005	
Enthalpy	(kJ/kg)	-2272	-2076	-2030	
Flow	(kJ/h)	-1.192e+008	-6.232e+007	-6.090e+007	
cular Weight		65.22	61.10	63.21	
Entropy	(kJ/kgmole-C)	119.5	157.5	161.7	
Entropy	(kJ/kg-C)	1.832	2.577	2.558	
Density	(kgmole/m3)	7.338	0.6513	0.6359	
Density	(kg/m3)	478.6	39.79	40.19	
iq Mass Den	(kg/m3)	605.4	588.5	597.4	

* Specified by user.

Tray Section: Main TS (continued)

_Main TS Tray :

		Liquid	Vapour	Feed : Boilup	Feed :
Heat Cap	(kJ/kgmole-C)	207.7	145.4	152.3	
Heat Cap	(kJ/kg-C)	3.184	2.380	2.410	
ıal Cond	(W/m-K)	6.216e-002	2.579e-002	2.641e-002	
;ity	(cP)	9.183e-002	1.049e-002	1.060e-002	
:e Tension	(dyne/cm)	4.155	---	---	
tor		6.529e-002	0.7356	0.7359	

Vapour Mole Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0105	0.9894	0.0001	0.0000	0.0000
2__Main TS	0.0049	0.9949	0.0002	0.0000	0.0000
3__Main TS	0.0030	0.9967	0.0003	0.0000	0.0000
4__Main TS	0.0023	0.9972	0.0005	0.0000	0.0000
5__Main TS	0.0020	0.9971	0.0009	0.0001	0.0000
6__Main TS	0.0019	0.9965	0.0015	0.0001	0.0000
7__Main TS	0.0019	0.9953	0.0026	0.0002	0.0000
8__Main TS	0.0019	0.9932	0.0044	0.0005	0.0000
9__Main TS	0.0019	0.9895	0.0074	0.0012	0.0000
10__Main TS	0.0019	0.9830	0.0126	0.0025	0.0000
11__Main TS	0.0019	0.9715	0.0212	0.0054	0.0000
12__Main TS	0.0019	0.9516	0.0351	0.0113	0.0001
13__Main TS	0.0019	0.9179	0.0566	0.0230	0.0004
14__Main TS	0.0019	0.8636	0.0875	0.0448	0.0017
15__Main TS	0.0019	0.7827	0.1260	0.0812	0.0057
16__Main TS	0.0020	0.6755	0.1631	0.1312	0.0172
17__Main TS	0.0021	0.5525	0.1801	0.1793	0.0432
18__Main TS	0.0010	0.5531	0.1804	0.1795	0.0433
19__Main TS	0.0004	0.5532	0.1806	0.1797	0.0433
20__Main TS	0.0002	0.5530	0.1808	0.1798	0.0433
21__Main TS	0.0001	0.5526	0.1810	0.1800	0.0433
22__Main TS	0.0000	0.5520	0.1814	0.1802	0.0434
23__Main TS	0.0000	0.5512	0.1818	0.1805	0.0434
24__Main TS	0.0000	0.5500	0.1824	0.1809	0.0435
25__Main TS	0.0000	0.5485	0.1832	0.1815	0.0436
26__Main TS	0.0000	0.5464	0.1844	0.1822	0.0437
27__Main TS	0.0000	0.5435	0.1859	0.1833	0.0439
28__Main TS	0.0000	0.5396	0.1879	0.1847	0.0441
29__Main TS	0.0000	0.5344	0.1907	0.1865	0.0444
30__Main TS	0.0000	0.5274	0.1944	0.1890	0.0448
31__Main TS	0.0000	0.5182	0.1992	0.1923	0.0453
32__Main TS	0.0000	0.5061	0.2056	0.1967	0.0460
33__Main TS	0.0000	0.4906	0.2138	0.2023	0.0469
34__Main TS	0.0000	0.4708	0.2242	0.2094	0.0481
35__Main TS	0.0000	0.4462	0.2371	0.2183	0.0494
36__Main TS	0.0000	0.4165	0.2526	0.2292	0.0511
37__Main TS	0.0000	0.3818	0.2706	0.2421	0.0531
38__Main TS	0.0000	0.3426	0.2905	0.2569	0.0553
39__Main TS	0.0000	0.3001	0.3116	0.2735	0.0578
40__Main TS	0.0000	0.2562	0.3324	0.2915	0.0604
41__Main TS	0.0000	0.2126	0.3515	0.3105	0.0632
42__Main TS	0.0000	0.1712	0.3672	0.3303	0.0664
43__Main TS	0.0000	0.1335	0.3774	0.3504	0.0704
44__Main TS	0.0000	0.1003	0.3800	0.3699	0.0765

Tray Section: Main TS (continued)

Vapour Mole Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
45__Main TS	0.0000	0.0720	0.3716	0.3865	0.0870
46__Main TS	0.0000	0.0482	0.3467	0.3938	0.1056

Tray Number	n-Pentane	n-Hexane
1__Main TS	0.0000	0.0000
2__Main TS	0.0000	0.0000
3__Main TS	0.0000	0.0000
4__Main TS	0.0000	0.0000
5__Main TS	0.0000	0.0000
6__Main TS	0.0000	0.0000
7__Main TS	0.0000	0.0000
8__Main TS	0.0000	0.0000
9__Main TS	0.0000	0.0000
10__Main TS	0.0000	0.0000
11__Main TS	0.0000	0.0000
12__Main TS	0.0000	0.0000
13__Main TS	0.0001	0.0000
14__Main TS	0.0005	0.0000
15__Main TS	0.0021	0.0004
16__Main TS	0.0077	0.0032
17__Main TS	0.0229	0.0199
18__Main TS	0.0229	0.0200
19__Main TS	0.0229	0.0200
20__Main TS	0.0229	0.0200
21__Main TS	0.0229	0.0200
22__Main TS	0.0230	0.0200
23__Main TS	0.0230	0.0201
24__Main TS	0.0230	0.0201
25__Main TS	0.0231	0.0201
26__Main TS	0.0231	0.0202
27__Main TS	0.0232	0.0203
28__Main TS	0.0233	0.0204
29__Main TS	0.0235	0.0205
30__Main TS	0.0237	0.0207
31__Main TS	0.0240	0.0209
32__Main TS	0.0243	0.0212
33__Main TS	0.0248	0.0216
34__Main TS	0.0254	0.0221
35__Main TS	0.0261	0.0228
36__Main TS	0.0270	0.0235
37__Main TS	0.0280	0.0244
38__Main TS	0.0292	0.0255
39__Main TS	0.0305	0.0266
40__Main TS	0.0318	0.0277
41__Main TS	0.0333	0.0289
42__Main TS	0.0349	0.0301
43__Main TS	0.0369	0.0315
44__Main TS	0.0399	0.0334
45__Main TS	0.0456	0.0373
46__Main TS	0.0568	0.0489

Liquid Mole Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0042	0.9956	0.0002	0.0000	0.0000

Tray Section: Main TS (continued)

Liquid Mole Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
2__Main TS	0.0020	0.9977	0.0003	0.0000	0.0000
3__Main TS	0.0012	0.9982	0.0006	0.0000	0.0000
4__Main TS	0.0009	0.9981	0.0010	0.0001	0.0000
5__Main TS	0.0008	0.9974	0.0017	0.0001	0.0000
6__Main TS	0.0008	0.9961	0.0029	0.0003	0.0000
7__Main TS	0.0008	0.9937	0.0049	0.0006	0.0000
8__Main TS	0.0008	0.9895	0.0084	0.0013	0.0000
9__Main TS	0.0008	0.9821	0.0143	0.0029	0.0000
10__Main TS	0.0007	0.9691	0.0240	0.0061	0.0000
11__Main TS	0.0007	0.9465	0.0398	0.0128	0.0001
12__Main TS	0.0007	0.9081	0.0644	0.0262	0.0005
13__Main TS	0.0007	0.8458	0.0998	0.0512	0.0019
14__Main TS	0.0007	0.7525	0.1444	0.0930	0.0065
15__Main TS	0.0007	0.6269	0.1884	0.1516	0.0199
16__Main TS	0.0006	0.4778	0.2109	0.2099	0.0506
17__Main TS	0.0006	0.3235	0.1865	0.2267	0.0971
18__Main TS	0.0003	0.3237	0.1866	0.2268	0.0971
19__Main TS	0.0001	0.3236	0.1867	0.2269	0.0971
20__Main TS	0.0001	0.3234	0.1869	0.2270	0.0971
21__Main TS	0.0000	0.3231	0.1871	0.2271	0.0971
22__Main TS	0.0000	0.3226	0.1873	0.2273	0.0972
23__Main TS	0.0000	0.3220	0.1877	0.2275	0.0972
24__Main TS	0.0000	0.3211	0.1882	0.2278	0.0972
25__Main TS	0.0000	0.3199	0.1888	0.2283	0.0973
26__Main TS	0.0000	0.3183	0.1897	0.2288	0.0974
27__Main TS	0.0000	0.3162	0.1909	0.2296	0.0975
28__Main TS	0.0000	0.3133	0.1925	0.2307	0.0977
29__Main TS	0.0000	0.3094	0.1946	0.2321	0.0979
30__Main TS	0.0000	0.3042	0.1974	0.2340	0.0981
31__Main TS	0.0000	0.2974	0.2011	0.2364	0.0985
32__Main TS	0.0000	0.2887	0.2058	0.2396	0.0989
33__Main TS	0.0000	0.2776	0.2119	0.2437	0.0995
34__Main TS	0.0000	0.2638	0.2194	0.2488	0.1002
35__Main TS	0.0000	0.2471	0.2284	0.2550	0.1010
36__Main TS	0.0000	0.2274	0.2390	0.2624	0.1020
37__Main TS	0.0000	0.2052	0.2508	0.2710	0.1030
38__Main TS	0.0000	0.1811	0.2634	0.2807	0.1042
39__Main TS	0.0000	0.1559	0.2760	0.2912	0.1055
40__Main TS	0.0000	0.1307	0.2877	0.3025	0.1068
41__Main TS	0.0000	0.1067	0.2974	0.3143	0.1084
42__Main TS	0.0000	0.0845	0.3040	0.3264	0.1106
43__Main TS	0.0000	0.0649	0.3059	0.3383	0.1140
44__Main TS	0.0000	0.0479	0.3010	0.3483	0.1202
45__Main TS	0.0000	0.0336	0.2858	0.3525	0.1315
46__Main TS	0.0000	0.0216	0.2536	0.3403	0.1499

Tray Number	n-Pentane	n-Hexane
1__Main TS	0.0000	0.0000
2__Main TS	0.0000	0.0000
3__Main TS	0.0000	0.0000
4__Main TS	0.0000	0.0000
5__Main TS	0.0000	0.0000
6__Main TS	0.0000	0.0000
7__Main TS	0.0000	0.0000

Tray Section: Main TS (continued)

Liquid Mole Fractions

Tray Number	n-Pentane	n-Hexane			
8__Main TS	0.0000	0.0000			
9__Main TS	0.0000	0.0000			
10__Main TS	0.0000	0.0000			
11__Main TS	0.0000	0.0000			
12__Main TS	0.0001	0.0000			
13__Main TS	0.0006	0.0001			
14__Main TS	0.0025	0.0005			
15__Main TS	0.0089	0.0037			
16__Main TS	0.0268	0.0234			
17__Main TS	0.0599	0.1057			
18__Main TS	0.0599	0.1057			
19__Main TS	0.0599	0.1057			
20__Main TS	0.0599	0.1057			
21__Main TS	0.0599	0.1057			
22__Main TS	0.0599	0.1057			
23__Main TS	0.0599	0.1057			
24__Main TS	0.0599	0.1057			
25__Main TS	0.0600	0.1057			
26__Main TS	0.0600	0.1057			
27__Main TS	0.0601	0.1058			
28__Main TS	0.0601	0.1058			
29__Main TS	0.0602	0.1059			
30__Main TS	0.0604	0.1059			
31__Main TS	0.0606	0.1060			
32__Main TS	0.0608	0.1062			
33__Main TS	0.0611	0.1063			
34__Main TS	0.0614	0.1065			
35__Main TS	0.0618	0.1067			
36__Main TS	0.0623	0.1069			
37__Main TS	0.0628	0.1071			
38__Main TS	0.0634	0.1073			
39__Main TS	0.0640	0.1075			
40__Main TS	0.0646	0.1076			
41__Main TS	0.0653	0.1078			
42__Main TS	0.0663	0.1082			
43__Main TS	0.0680	0.1089			
44__Main TS	0.0714	0.1112			
45__Main TS	0.0782	0.1184			
46__Main TS	0.0913	0.1432			

Vapour Mass Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0072	0.9927	0.0001	0.0000	0.0000
2__Main TS	0.0034	0.9964	0.0002	0.0000	0.0000
3__Main TS	0.0020	0.9976	0.0004	0.0000	0.0000
4__Main TS	0.0016	0.9978	0.0007	0.0000	0.0000
5__Main TS	0.0014	0.9974	0.0011	0.0001	0.0000
6__Main TS	0.0013	0.9966	0.0020	0.0002	0.0000
7__Main TS	0.0013	0.9950	0.0034	0.0003	0.0000
8__Main TS	0.0013	0.9922	0.0057	0.0007	0.0000
9__Main TS	0.0013	0.9874	0.0098	0.0015	0.0000
10__Main TS	0.0013	0.9788	0.0165	0.0033	0.0000
11__Main TS	0.0013	0.9639	0.0277	0.0070	0.0000

Tray Section: Main TS (continued)

Vapour Mass Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
12__Main TS	0.0013	0.9383	0.0456	0.0146	0.0002
13__Main TS	0.0013	0.8955	0.0728	0.0296	0.0007
14__Main TS	0.0013	0.8280	0.1105	0.0567	0.0026
15__Main TS	0.0012	0.7310	0.1551	0.0999	0.0087
16__Main TS	0.0012	0.6075	0.1934	0.1556	0.0254
17__Main TS	0.0012	0.4704	0.2021	0.2012	0.0602
18__Main TS	0.0006	0.4706	0.2023	0.2013	0.0602
19__Main TS	0.0003	0.4705	0.2024	0.2014	0.0602
20__Main TS	0.0001	0.4703	0.2026	0.2016	0.0603
21__Main TS	0.0001	0.4699	0.2029	0.2017	0.0603
22__Main TS	0.0000	0.4693	0.2032	0.2019	0.0603
23__Main TS	0.0000	0.4684	0.2037	0.2022	0.0604
24__Main TS	0.0000	0.4673	0.2043	0.2026	0.0605
25__Main TS	0.0000	0.4658	0.2051	0.2031	0.0606
26__Main TS	0.0000	0.4637	0.2062	0.2038	0.0607
27__Main TS	0.0000	0.4608	0.2077	0.2048	0.0609
28__Main TS	0.0000	0.4570	0.2098	0.2061	0.0611
29__Main TS	0.0000	0.4518	0.2125	0.2079	0.0614
30__Main TS	0.0000	0.4450	0.2162	0.2102	0.0619
31__Main TS	0.0000	0.4360	0.2210	0.2133	0.0624
32__Main TS	0.0000	0.4243	0.2272	0.2173	0.0631
33__Main TS	0.0000	0.4093	0.2351	0.2224	0.0641
34__Main TS	0.0000	0.3904	0.2451	0.2289	0.0652
35__Main TS	0.0000	0.3673	0.2573	0.2369	0.0666
36__Main TS	0.0000	0.3399	0.2717	0.2465	0.0683
37__Main TS	0.0000	0.3084	0.2881	0.2577	0.0702
38__Main TS	0.0000	0.2736	0.3058	0.2704	0.0723
39__Main TS	0.0000	0.2368	0.3240	0.2844	0.0746
40__Main TS	0.0000	0.1996	0.3414	0.2993	0.0770
41__Main TS	0.0000	0.1636	0.3566	0.3150	0.0795
42__Main TS	0.0000	0.1302	0.3680	0.3311	0.0826
43__Main TS	0.0000	0.1004	0.3741	0.3473	0.0866
44__Main TS	0.0000	0.0746	0.3725	0.3626	0.0931
45__Main TS	0.0000	0.0529	0.3599	0.3743	0.1045
46__Main TS	0.0000	0.0348	0.3299	0.3746	0.1247

Tray Number	n-Pentane	n-Hexane
1__Main TS	0.0000	0.0000
2__Main TS	0.0000	0.0000
3__Main TS	0.0000	0.0000
4__Main TS	0.0000	0.0000
5__Main TS	0.0000	0.0000
6__Main TS	0.0000	0.0000
7__Main TS	0.0000	0.0000
8__Main TS	0.0000	0.0000
9__Main TS	0.0000	0.0000
10__Main TS	0.0000	0.0000
11__Main TS	0.0000	0.0000
12__Main TS	0.0000	0.0000
13__Main TS	0.0002	0.0000
14__Main TS	0.0008	0.0001
15__Main TS	0.0033	0.0007
16__Main TS	0.0114	0.0056
17__Main TS	0.0318	0.0332

Tray Section: Main TS (continued)

Vapour Mass Fractions

Tray Number	n-Pentane	n-Hexane			
18__Main TS	0.0319	0.0332			
19__Main TS	0.0319	0.0332			
20__Main TS	0.0319	0.0332			
21__Main TS	0.0319	0.0333			
22__Main TS	0.0319	0.0333			
23__Main TS	0.0320	0.0333			
24__Main TS	0.0320	0.0333			
25__Main TS	0.0320	0.0334			
26__Main TS	0.0321	0.0335			
27__Main TS	0.0322	0.0336			
28__Main TS	0.0323	0.0337			
29__Main TS	0.0325	0.0339			
30__Main TS	0.0327	0.0341			
31__Main TS	0.0330	0.0344			
32__Main TS	0.0334	0.0348			
33__Main TS	0.0339	0.0353			
34__Main TS	0.0345	0.0359			
35__Main TS	0.0352	0.0366			
36__Main TS	0.0361	0.0375			
37__Main TS	0.0371	0.0386			
38__Main TS	0.0382	0.0397			
39__Main TS	0.0393	0.0409			
40__Main TS	0.0406	0.0422			
41__Main TS	0.0419	0.0434			
42__Main TS	0.0434	0.0448			
43__Main TS	0.0453	0.0463			
44__Main TS	0.0486	0.0485			
45__Main TS	0.0548	0.0536			
46__Main TS	0.0671	0.0689			

Liquid Mass Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0029	0.9969	0.0002	0.0000	0.0000
2__Main TS	0.0013	0.9982	0.0004	0.0000	0.0000
3__Main TS	0.0008	0.9984	0.0007	0.0000	0.0000
4__Main TS	0.0006	0.9980	0.0013	0.0001	0.0000
5__Main TS	0.0006	0.9971	0.0022	0.0002	0.0000
6__Main TS	0.0005	0.9953	0.0038	0.0004	0.0000
7__Main TS	0.0005	0.9922	0.0065	0.0008	0.0000
8__Main TS	0.0005	0.9867	0.0111	0.0017	0.0000
9__Main TS	0.0005	0.9770	0.0187	0.0037	0.0000
10__Main TS	0.0005	0.9601	0.0314	0.0079	0.0001
11__Main TS	0.0005	0.9310	0.0516	0.0166	0.0002
12__Main TS	0.0005	0.8825	0.0825	0.0335	0.0008
13__Main TS	0.0005	0.8060	0.1253	0.0643	0.0029
14__Main TS	0.0004	0.6958	0.1760	0.1134	0.0099
15__Main TS	0.0004	0.5548	0.2198	0.1768	0.0288
16__Main TS	0.0003	0.3965	0.2307	0.2296	0.0687
17__Main TS	0.0003	0.2429	0.1846	0.2244	0.1193
18__Main TS	0.0001	0.2430	0.1847	0.2244	0.1193
19__Main TS	0.0001	0.2429	0.1848	0.2245	0.1193
20__Main TS	0.0000	0.2427	0.1849	0.2245	0.1193
21__Main TS	0.0000	0.2425	0.1851	0.2247	0.1193

Tray Section: Main TS (continued)

Liquid Mass Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
22__Main TS	0.0000	0.2421	0.1853	0.2248	0.1193
23__Main TS	0.0000	0.2416	0.1856	0.2250	0.1193
24__Main TS	0.0000	0.2409	0.1860	0.2252	0.1193
25__Main TS	0.0000	0.2399	0.1866	0.2256	0.1194
26__Main TS	0.0000	0.2386	0.1874	0.2261	0.1194
27__Main TS	0.0000	0.2368	0.1885	0.2267	0.1195
28__Main TS	0.0000	0.2345	0.1899	0.2276	0.1196
29__Main TS	0.0000	0.2313	0.1918	0.2288	0.1197
30__Main TS	0.0000	0.2272	0.1943	0.2303	0.1199
31__Main TS	0.0000	0.2217	0.1976	0.2323	0.1201
32__Main TS	0.0000	0.2147	0.2018	0.2349	0.1204
33__Main TS	0.0000	0.2058	0.2071	0.2382	0.1207
34__Main TS	0.0000	0.1949	0.2137	0.2423	0.1211
35__Main TS	0.0000	0.1818	0.2215	0.2473	0.1216
36__Main TS	0.0000	0.1665	0.2306	0.2532	0.1221
37__Main TS	0.0000	0.1494	0.2407	0.2600	0.1227
38__Main TS	0.0000	0.1310	0.2512	0.2677	0.1234
39__Main TS	0.0000	0.1121	0.2616	0.2760	0.1241
40__Main TS	0.0000	0.0934	0.2709	0.2849	0.1249
41__Main TS	0.0000	0.0758	0.2784	0.2943	0.1260
42__Main TS	0.0000	0.0597	0.2829	0.3038	0.1277
43__Main TS	0.0000	0.0455	0.2830	0.3130	0.1310
44__Main TS	0.0000	0.0334	0.2766	0.3201	0.1371
45__Main TS	0.0000	0.0232	0.2599	0.3206	0.1485
46__Main TS	0.0000	0.0146	0.2260	0.3033	0.1658

Tray Number	n-Pentane	n-Hexane			
1__Main TS	0.0000	0.0000			
2__Main TS	0.0000	0.0000			
3__Main TS	0.0000	0.0000			
4__Main TS	0.0000	0.0000			
5__Main TS	0.0000	0.0000			
6__Main TS	0.0000	0.0000			
7__Main TS	0.0000	0.0000			
8__Main TS	0.0000	0.0000			
9__Main TS	0.0000	0.0000			
10__Main TS	0.0000	0.0000			
11__Main TS	0.0000	0.0000			
12__Main TS	0.0002	0.0000			
13__Main TS	0.0009	0.0001			
14__Main TS	0.0037	0.0008			
15__Main TS	0.0129	0.0064			
16__Main TS	0.0363	0.0379			
17__Main TS	0.0736	0.1551			
18__Main TS	0.0735	0.1550			
19__Main TS	0.0735	0.1550			
20__Main TS	0.0735	0.1550			
21__Main TS	0.0735	0.1550			
22__Main TS	0.0735	0.1550			
23__Main TS	0.0736	0.1550			
24__Main TS	0.0736	0.1549			
25__Main TS	0.0736	0.1549			
26__Main TS	0.0736	0.1549			
27__Main TS	0.0736	0.1548			

Tray Section: Main TS (continued)

Liquid Mass Fractions

Tray Number	n-Pentane	n-Hexane			
28__Main TS	0.0737	0.1548			
29__Main TS	0.0737	0.1547			
30__Main TS	0.0738	0.1546			
31__Main TS	0.0739	0.1545			
32__Main TS	0.0740	0.1543			
33__Main TS	0.0741	0.1541			
34__Main TS	0.0742	0.1538			
35__Main TS	0.0744	0.1534			
36__Main TS	0.0746	0.1529			
37__Main TS	0.0748	0.1524			
38__Main TS	0.0750	0.1517			
39__Main TS	0.0752	0.1510			
40__Main TS	0.0755	0.1503			
41__Main TS	0.0759	0.1497			
42__Main TS	0.0766	0.1493			
43__Main TS	0.0781	0.1494			
44__Main TS	0.0814	0.1514			
45__Main TS	0.0883	0.1596			
46__Main TS	0.1010	0.1893			

Vapour LiqVolume Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0102	0.9897	0.0001	0.0000	0.0000
2__Main TS	0.0048	0.9950	0.0002	0.0000	0.0000
3__Main TS	0.0029	0.9968	0.0003	0.0000	0.0000
4__Main TS	0.0022	0.9972	0.0006	0.0000	0.0000
5__Main TS	0.0020	0.9969	0.0010	0.0001	0.0000
6__Main TS	0.0019	0.9962	0.0018	0.0001	0.0000
7__Main TS	0.0019	0.9948	0.0030	0.0003	0.0000
8__Main TS	0.0018	0.9924	0.0052	0.0006	0.0000
9__Main TS	0.0018	0.9880	0.0088	0.0013	0.0000
10__Main TS	0.0018	0.9803	0.0149	0.0029	0.0000
11__Main TS	0.0018	0.9669	0.0251	0.0061	0.0000
12__Main TS	0.0018	0.9438	0.0414	0.0128	0.0001
13__Main TS	0.0018	0.9051	0.0664	0.0260	0.0006
14__Main TS	0.0018	0.8436	0.1015	0.0502	0.0022
15__Main TS	0.0018	0.7539	0.1442	0.0895	0.0073
16__Main TS	0.0018	0.6376	0.1830	0.1418	0.0216
17__Main TS	0.0018	0.5064	0.1961	0.1881	0.0527
18__Main TS	0.0009	0.5068	0.1964	0.1883	0.0527
19__Main TS	0.0004	0.5068	0.1966	0.1885	0.0527
20__Main TS	0.0002	0.5066	0.1968	0.1886	0.0528
21__Main TS	0.0001	0.5062	0.1971	0.1888	0.0528
22__Main TS	0.0000	0.5056	0.1974	0.1890	0.0528
23__Main TS	0.0000	0.5048	0.1979	0.1893	0.0529
24__Main TS	0.0000	0.5036	0.1985	0.1897	0.0530
25__Main TS	0.0000	0.5021	0.1993	0.1902	0.0531
26__Main TS	0.0000	0.4999	0.2005	0.1909	0.0532
27__Main TS	0.0000	0.4970	0.2020	0.1919	0.0534
28__Main TS	0.0000	0.4932	0.2041	0.1933	0.0536
29__Main TS	0.0000	0.4879	0.2069	0.1950	0.0539
30__Main TS	0.0000	0.4810	0.2107	0.1974	0.0543
31__Main TS	0.0000	0.4718	0.2156	0.2005	0.0549

Tray Section: Main TS (continued)

Vapour LiqVolume Fractions

ray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
32__Main TS	0.0000	0.4599	0.2220	0.2046	0.0556
33__Main TS	0.0000	0.4445	0.2303	0.2099	0.0565
34__Main TS	0.0000	0.4251	0.2406	0.2165	0.0577
35__Main TS	0.0000	0.4012	0.2534	0.2248	0.0591
36__Main TS	0.0000	0.3726	0.2686	0.2347	0.0608
37__Main TS	0.0000	0.3395	0.2859	0.2465	0.0628
38__Main TS	0.0000	0.3026	0.3050	0.2599	0.0650
39__Main TS	0.0000	0.2632	0.3247	0.2747	0.0674
40__Main TS	0.0000	0.2230	0.3439	0.2906	0.0699
41__Main TS	0.0000	0.1837	0.3611	0.3074	0.0726
42__Main TS	0.0000	0.1470	0.3746	0.3247	0.0757
43__Main TS	0.0000	0.1139	0.3825	0.3422	0.0799
44__Main TS	0.0000	0.0851	0.3828	0.3591	0.0862
45__Main TS	0.0000	0.0606	0.3718	0.3727	0.0974
46__Main TS	0.0000	0.0402	0.3436	0.3760	0.1170

Tray Number	n-Pentane	n-Hexane
1__Main TS	0.0000	0.0000
2__Main TS	0.0000	0.0000
3__Main TS	0.0000	0.0000
4__Main TS	0.0000	0.0000
5__Main TS	0.0000	0.0000
6__Main TS	0.0000	0.0000
7__Main TS	0.0000	0.0000
8__Main TS	0.0000	0.0000
9__Main TS	0.0000	0.0000
10__Main TS	0.0000	0.0000
11__Main TS	0.0000	0.0000
12__Main TS	0.0000	0.0000
13__Main TS	0.0001	0.0000
14__Main TS	0.0007	0.0001
15__Main TS	0.0027	0.0006
16__Main TS	0.0096	0.0045
17__Main TS	0.0276	0.0273
18__Main TS	0.0276	0.0273
19__Main TS	0.0276	0.0274
20__Main TS	0.0276	0.0274
21__Main TS	0.0277	0.0274
22__Main TS	0.0277	0.0274
23__Main TS	0.0277	0.0274
24__Main TS	0.0277	0.0275
25__Main TS	0.0278	0.0275
26__Main TS	0.0279	0.0276
27__Main TS	0.0279	0.0277
28__Main TS	0.0281	0.0278
29__Main TS	0.0282	0.0280
30__Main TS	0.0285	0.0282
31__Main TS	0.0287	0.0285
32__Main TS	0.0291	0.0288
33__Main TS	0.0296	0.0293
34__Main TS	0.0302	0.0299
35__Main TS	0.0309	0.0306
36__Main TS	0.0318	0.0315
37__Main TS	0.0328	0.0325

* Specified by user.

Tray Section: Main TS (continued)

Vapour LiqVolume Fractions

Tray Number	n-Pentane	n-Hexane			
38__Main TS	0.0340	0.0336			
39__Main TS	0.0352	0.0348			
40__Main TS	0.0365	0.0360			
41__Main TS	0.0379	0.0373			
42__Main TS	0.0394	0.0386			
43__Main TS	0.0414	0.0401			
44__Main TS	0.0446	0.0423			
45__Main TS	0.0505	0.0470			
46__Main TS	0.0624	0.0609			

Liquid LiqVolume Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
1__Main TS	0.0041	0.9957	0.0002	0.0000	0.0000
2__Main TS	0.0019	0.9977	0.0004	0.0000	0.0000
3__Main TS	0.0011	0.9982	0.0007	0.0000	0.0000
4__Main TS	0.0009	0.9979	0.0011	0.0001	0.0000
5__Main TS	0.0008	0.9971	0.0020	0.0001	0.0000
6__Main TS	0.0008	0.9955	0.0034	0.0003	0.0000
7__Main TS	0.0007	0.9927	0.0059	0.0007	0.0000
8__Main TS	0.0007	0.9878	0.0100	0.0015	0.0000
9__Main TS	0.0007	0.9791	0.0169	0.0033	0.0000
10__Main TS	0.0007	0.9639	0.0284	0.0069	0.0000
11__Main TS	0.0007	0.9377	0.0469	0.0145	0.0002
12__Main TS	0.0007	0.8937	0.0753	0.0295	0.0007
13__Main TS	0.0007	0.8236	0.1155	0.0570	0.0024
14__Main TS	0.0006	0.7208	0.1644	0.1020	0.0083
15__Main TS	0.0006	0.5866	0.2095	0.1624	0.0248
16__Main TS	0.0005	0.4317	0.2264	0.2172	0.0608
17__Main TS	0.0005	0.2762	0.1892	0.2217	0.1102
18__Main TS	0.0002	0.2763	0.1894	0.2217	0.1102
19__Main TS	0.0001	0.2763	0.1895	0.2218	0.1103
20__Main TS	0.0000	0.2761	0.1896	0.2219	0.1103
21__Main TS	0.0000	0.2758	0.1898	0.2220	0.1103
22__Main TS	0.0000	0.2754	0.1900	0.2222	0.1103
23__Main TS	0.0000	0.2748	0.1904	0.2224	0.1103
24__Main TS	0.0000	0.2741	0.1908	0.2226	0.1104
25__Main TS	0.0000	0.2730	0.1915	0.2230	0.1104
26__Main TS	0.0000	0.2716	0.1923	0.2235	0.1105
27__Main TS	0.0000	0.2696	0.1934	0.2242	0.1106
28__Main TS	0.0000	0.2670	0.1949	0.2251	0.1107
29__Main TS	0.0000	0.2635	0.1970	0.2264	0.1108
30__Main TS	0.0000	0.2589	0.1997	0.2280	0.1110
31__Main TS	0.0000	0.2529	0.2032	0.2302	0.1113
32__Main TS	0.0000	0.2451	0.2077	0.2330	0.1117
33__Main TS	0.0000	0.2353	0.2134	0.2365	0.1121
34__Main TS	0.0000	0.2231	0.2205	0.2409	0.1126
35__Main TS	0.0000	0.2084	0.2290	0.2463	0.1133
36__Main TS	0.0000	0.1912	0.2388	0.2527	0.1140
37__Main TS	0.0000	0.1720	0.2498	0.2601	0.1148
38__Main TS	0.0000	0.1512	0.2613	0.2683	0.1157
39__Main TS	0.0000	0.1296	0.2728	0.2774	0.1166
40__Main TS	0.0000	0.1083	0.2833	0.2870	0.1177
41__Main TS	0.0000	0.0881	0.2918	0.2971	0.1190

Tray Section: Main TS (continued)

Liquid LiqVolume Fractions

Tray Number	Ethane	Propane	i-Butane	n-Butane	i-Pentane
42__Main TS	0.0000	0.0695	0.2972	0.3075	0.1210
43__Main TS	0.0000	0.0532	0.2980	0.3176	0.1243
44__Main TS	0.0000	0.0391	0.2922	0.3258	0.1306
45__Main TS	0.0000	0.0273	0.2758	0.3277	0.1420
46__Main TS	0.0000	0.0173	0.2419	0.3127	0.1600

Tray Number	n-Pentane	n-Hexane
1__Main TS	0.0000	0.0000
2__Main TS	0.0000	0.0000
3__Main TS	0.0000	0.0000
4__Main TS	0.0000	0.0000
5__Main TS	0.0000	0.0000
6__Main TS	0.0000	0.0000
7__Main TS	0.0000	0.0000
8__Main TS	0.0000	0.0000
9__Main TS	0.0000	0.0000
10__Main TS	0.0000	0.0000
11__Main TS	0.0000	0.0000
12__Main TS	0.0002	0.0000
13__Main TS	0.0008	0.0001
14__Main TS	0.0031	0.0007
15__Main TS	0.0110	0.0052
16__Main TS	0.0318	0.0315
17__Main TS	0.0673	0.1348
18__Main TS	0.0673	0.1348
19__Main TS	0.0673	0.1348
20__Main TS	0.0673	0.1348
21__Main TS	0.0673	0.1348
22__Main TS	0.0673	0.1348
23__Main TS	0.0673	0.1348
24__Main TS	0.0673	0.1348
25__Main TS	0.0674	0.1348
26__Main TS	0.0674	0.1348
27__Main TS	0.0674	0.1348
28__Main TS	0.0675	0.1348
29__Main TS	0.0676	0.1347
30__Main TS	0.0677	0.1347
31__Main TS	0.0678	0.1347
32__Main TS	0.0679	0.1347
33__Main TS	0.0681	0.1346
34__Main TS	0.0684	0.1346
35__Main TS	0.0686	0.1345
36__Main TS	0.0689	0.1343
37__Main TS	0.0693	0.1341
38__Main TS	0.0696	0.1339
39__Main TS	0.0700	0.1336
40__Main TS	0.0705	0.1333
41__Main TS	0.0710	0.1330
42__Main TS	0.0718	0.1330
43__Main TS	0.0734	0.1335
44__Main TS	0.0767	0.1357
45__Main TS	0.0836	0.1437
46__Main TS	0.0964	0.1717

* Specified by user.

Tray Section: Main TS (continued)

DYNAMICS

Nozzle Pressure Flow K Factors

Holdup	VToAbove (kg/s/sqrt(kPa-kg/m3))	Holdup	VToAbove (kg/s/sqrt(kPa-kg/m3))
1__Main TS	---	24__Main TS	---
2__Main TS	---	25__Main TS	---
3__Main TS	---	26__Main TS	---
4__Main TS	---	27__Main TS	---
5__Main TS	---	28__Main TS	---
6__Main TS	---	29__Main TS	---
7__Main TS	---	30__Main TS	---
8__Main TS	---	31__Main TS	---
9__Main TS	---	32__Main TS	---
10__Main TS	---	33__Main TS	---
11__Main TS	---	34__Main TS	---
12__Main TS	---	35__Main TS	---
13__Main TS	---	36__Main TS	---
14__Main TS	---	37__Main TS	---
15__Main TS	---	38__Main TS	---
16__Main TS	---	39__Main TS	---
17__Main TS	---	40__Main TS	---
18__Main TS	---	41__Main TS	---
19__Main TS	---	42__Main TS	---
20__Main TS	---	43__Main TS	---
21__Main TS	---	44__Main TS	---
22__Main TS	---	45__Main TS	---
23__Main TS	---	46__Main TS	---

K Values Adjusted for Steady State

Initialization Options

form Dry Start Up:	Not Active	Initialize From User:	Not Active	Fixed Pressure	Not Active

Holdup

Holdup	Pressure (kPa)	Volume (m3)	Bulk Liquid Volume (m3)
1__Main TS	0.0000	0.0000 *	---
2__Main TS	0.0000	0.0000 *	---
3__Main TS	0.0000	0.0000 *	---
4__Main TS	0.0000	0.0000 *	---
5__Main TS	0.0000	0.0000 *	---
6__Main TS	0.0000	0.0000 *	---
7__Main TS	0.0000	0.0000 *	---
8__Main TS	0.0000	0.0000 *	---
9__Main TS	0.0000	0.0000 *	---
10__Main TS	0.0000	0.0000 *	---
11__Main TS	0.0000	0.0000 *	---
12__Main TS	0.0000	0.0000 *	---
13__Main TS	0.0000	0.0000 *	---
14__Main TS	0.0000	0.0000 *	---
15__Main TS	0.0000	0.0000 *	---
16__Main TS	0.0000	0.0000 *	---
17__Main TS	0.0000	0.0000 *	---
18__Main TS	0.0000	0.0000 *	---
19__Main TS	0.0000	0.0000 *	---

Tray Section: Main TS (continued)

Holdup	Pressure (kPa)	Volume (m3)		Bulk Liquid Volume (m3)
20__Main TS	0.0000	0.0000	*	---
21__Main TS	0.0000	0.0000	*	---
22__Main TS	0.0000	0.0000	*	---
23__Main TS	0.0000	0.0000	*	---
24__Main TS	0.0000	0.0000	*	---
25__Main TS	0.0000	0.0000	*	---
26__Main TS	0.0000	0.0000	*	---
27__Main TS	0.0000	0.0000	*	---
28__Main TS	0.0000	0.0000	*	---
29__Main TS	0.0000	0.0000	*	---
30__Main TS	0.0000	0.0000	*	---
31__Main TS	0.0000	0.0000	*	---
32__Main TS	0.0000	0.0000	*	---
33__Main TS	0.0000	0.0000	*	---
34__Main TS	0.0000	0.0000	*	---
35__Main TS	0.0000	0.0000	*	---
36__Main TS	0.0000	0.0000	*	---
37__Main TS	0.0000	0.0000	*	---
38__Main TS	0.0000	0.0000	*	---
39__Main TS	0.0000	0.0000	*	---
40__Main TS	0.0000	0.0000	*	---
41__Main TS	0.0000	0.0000	*	---
42__Main TS	0.0000	0.0000	*	---
43__Main TS	0.0000	0.0000	*	---
44__Main TS	0.0000	0.0000	*	---
45__Main TS	0.0000	0.0000	*	---
46__Main TS	0.0000	0.0000	*	---

* Specified by user.

APPENDIX C: MATLAB RESULT

FIRST POINT OF ENTRAINMENT

ssumptions:

1. Constant liquid density
2. Constant liquid volumetric flow rate
3. Consistent decrement of vapor density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of vapor(m3/hr)
Ql = liquid volumetric flow rate (m3/hr) is a constant value of 54 (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
Ac = active area of the column (m2) is given as 1.469 (m2)
b = flow parameter
L = load factor on column area (m/hr)
Lc = load factor on column area (m/s)
Lmax = maximum load factor of tray (m/s)
Pfl = Entrainment flooding percentage (%)
0.122 and 1.286 are constants value of maximum load equation,
(please refer CHAPTER 3)

```
=[61:5:61+a*5];
459.1;
=[34.22:-0.1:34.22+a*-0.1];
(Qv.*pl)./(pv.*1.469).*sqrt(pv./(pl-pv));
=L./3600;
54./Qv.*sqrt(pv./pl);
ax=0.122./(1+ b.*1.286);
=(Lc./Lmax)*100;
le(:,1)=Qv.';
le(:,2)=Lc.';
le(:,3)=Lmax.';
le(:,4)=Pfl.';
p(table);
1.0000    0.0439    0.0931    47.1866
6.0000    0.0476    0.0948    50.1884
1.0000    0.0513    0.0963    53.1984
6.0000    0.0549    0.0977    56.2167
1.0000    0.0586    0.0990    59.2432
6.0000    0.0623    0.1001    62.2782
1.0000    0.0661    0.1011    65.3216
6.0000    0.0698    0.1021    68.3734
)1.0000    0.0735    0.1029    71.4339
)6.0000    0.0773    0.1037    74.5029
11.0000    0.0810    0.1044    77.5806
16.0000    0.0848    0.1051    80.6671
21.0000    0.0886    0.1057    83.7623
26.0000    0.0923    0.1063    86.8664
31.0000    0.0961    0.1069    89.9794
36.0000    0.1000    0.1074    93.1014
```

SECOND POINT OF ENTRAINMENT

ssumptions:
1.Constant liquid density
2.Constant liquid volumetric flow rate
3.Consistent decrement of vapor density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of vapor(m3/hr)
Ql = liquid volumetric flow rate (m3/hr) is a constant value of 21 (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
Ac = active area of the column (m2) is given as 1.469 (m2)
b = flow parameter
L = load factor on column area (m/hr)
Lc = load factor on column area (m/s)
Lmax = maximum load factor of tray (m/s)
Pfl = Entrainment flooding percentage (%)
0.122 and 1.286 are constants value of maximum load equation, please refer CHAPTER 3

```
=[61:5:61+a*5];
469.6;
[34.22:-0.1:34.22+a*-0.1];
Qv.*pl)./(pv.*1.469).*sqrt(pv./(pl-pv));
L./3600;
.1./Qv.*sqrt(pv./pl);
ax=0.122./(1+ b.*1.286);
=(Lc./Lmax)*100;
e(:,1)=Qv.';
e(:,2)=Lc.';
e(:,3)=Lmax.';
e(:,4)=Pfl.';
)(table);
.0000    0.0444    0.1090   40.7219
5.0000    0.0481    0.1099   43.7560
1.0000    0.0518    0.1107   46.7985
5.0000    0.0555    0.1114   49.8493
1.0000    0.0592    0.1120   52.9085
5.0000    0.0630    0.1125   55.9762
1.0000    0.0667    0.1130   59.0525
6.0000    0.0705    0.1135   62.1373
)1.0000    0.0743    0.1139   65.2308
)6.0000    0.0781    0.1142   68.3331
.1.0000    0.0819    0.1146   71.4441
.6.0000    0.0857    0.1149   74.5639
21.0000    0.0895    0.1152   77.6927
26.0000    0.0933    0.1154   80.8304
31.0000    0.0972    0.1157   83.9771
36.0000    0.1010    0.1159   87.1330
```

FIRST POINT OF SEALING CONSTRAINT

ssumptions:
1.Constant vapor density
2.Constant vapor volumetric flow rate
3.Consistent decrement of liquid density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of liquid volumetric flow rate(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)is given as 60 m3/hr
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
As = slot area (m2)
Af = fractional hole area
Ah = bubbling area (m2)is given as 1.254 (m2)
b = converting vapor volumetric flow rate(m3/hr) unit into (m3/s) unit
c = flow parameter
Lh = hole load factor (m/s)
Lhs = load factor at seal point (m/s)

```
=90;
[459.1:2:459.1+a*2];
34.23;
pi*0.016*0.003*160;
0/3600;
b./As.*sqrt(pv./(pl-pv));
As/1.254;
[55:-0.5:55+a*-0.5];
l./60.*sqrt(pv./pl);
=0.17./(1+c.*4.2).*sqrt(65/50)*(1+3*Af);
e(:,1)=Lh.';
e(:,2)=Ql.';
e(:,3)=Lhs.';
(table);
.1961   55.0000   0.0999
.1956   54.5000   0.1005
.1952   54.0000   0.1011
.1947   53.5000   0.1017
.1943   53.0000   0.1023
.1938   52.5000   0.1029
.1934   52.0000   0.1035
.1929   51.5000   0.1041
.1925   51.0000   0.1047
.1920   50.5000   0.1053
.1916   50.0000   0.1059
.1912   49.5000   0.1065
.1908   49.0000   0.1072
.1903   48.5000   0.1078
.1899   48.0000   0.1084
.1895   47.5000   0.1091
```

.1891	47.0000	0.1097
.1887	46.5000	0.1104
.1883	46.0000	0.1110
.1879	45.5000	0.1117
.1874	45.0000	0.1123
.1870	44.5000	0.1130
.1866	44.0000	0.1137
.1862	43.5000	0.1144
.1859	43.0000	0.1150
.1855	42.5000	0.1157
.1851	42.0000	0.1164
.1847	41.5000	0.1171
.1843	41.0000	0.1178
.1839	40.5000	0.1185
.1835	40.0000	0.1193
.1832	39.5000	0.1200
.1828	39.0000	0.1207
.1824	38.5000	0.1215
.1820	38.0000	0.1222
.1817	37.5000	0.1229
.1813	37.0000	0.1237
.1809	36.5000	0.1244
.1806	36.0000	0.1252
.1802	35.5000	0.1260
.1799	35.0000	0.1268
.1795	34.5000	0.1275
.1792	34.0000	0.1283
.1788	33.5000	0.1291
.1785	33.0000	0.1299
.1781	32.5000	0.1308
.1778	32.0000	0.1316
.1774	31.5000	0.1324
.1771	31.0000	0.1332
.1767	30.5000	0.1341
.1764	30.0000	0.1349
.1761	29.5000	0.1358
.1757	29.0000	0.1366
.1754	28.5000	0.1375
.1751	28.0000	0.1384
.1747	27.5000	0.1393
.1744	27.0000	0.1402
.1741	26.5000	0.1411
.1738	26.0000	0.1420
.1735	25.5000	0.1429
.1731	25.0000	0.1438
.1728	24.5000	0.1448
.1725	24.0000	0.1457
.1722	23.5000	0.1467
.1719	23.0000	0.1476
.1716	22.5000	0.1486
.1713	22.0000	0.1496
.1710	21.5000	0.1506
.1707	21.0000	0.1516

0.1703	20.5000	0.1526
0.1700	20.0000	0.1536
0.1697	19.5000	0.1546
0.1694	19.0000	0.1557
0.1692	18.5000	0.1567
0.1689	18.0000	0.1578
0.1686	17.5000	0.1589
0.1683	17.0000	0.1600
0.1680	16.5000	0.1611
0.1677	16.0000	0.1622
0.1674	15.5000	0.1633
0.1671	15.0000	0.1644
0.1668	14.5000	0.1656
0.1665	14.0000	0.1667
0.1663	13.5000	0.1679
0.1660	13.0000	0.1691
0.1657	12.5000	0.1703
0.1654	12.0000	0.1715
0.1651	11.5000	0.1727
0.1649	11.0000	0.1739
0.1646	10.5000	0.1752
0.1643	10.0000	0.1764

SECOND POINT OF SEALING CONSTRAINT

Assumptions:
1.Constant vapor density
2.Constant vapor volumetric flow rate
3.Consistent decrement of liquid density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of liquid volumetric flow rate(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)is given as 40 m3/hr
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
As = slot area (m2)
Af = fractional hole area
Ah = bubbling area (m2)is given as 1.254 (m2)
b = converting vapor volumetric flow rate(m3/hr) unit into (m3/s) unit
c = flow parameter
Lh = hole load factor (m/s)
Lhs = load factor at seal point (m/s)

```
90;
=[459.1:1:459.1+a*1];
=35.43;
=pi*0.016*0.003*160;
40/3600;
=b./As.*sqrt(pv./(pl-pv));
=As/1.254;
=[54:-0.5:54+a*-0.5];
Ql/40.*sqrt(pv./pl);
s=0.17./(1+c.*4.2).*sqrt(65/50)*(1+3*Af);
le(:,1)=Lh.';
le(:,2)=Ql.';
le(:,3)=Lhs.';
p(table);
).1332   54.0000   0.0796
).1330   53.5000   0.0801
).1329   53.0000   0.0806
).1327   52.5000   0.0812
).1325   52.0000   0.0817
).1324   51.5000   0.0822
).1322   51.0000   0.0827
).1321   50.5000   0.0833
).1319   50.0000   0.0838
).1318   49.5000   0.0844
).1316   49.0000   0.0849
).1315   48.5000   0.0855
).1313   48.0000   0.0861
).1312   47.5000   0.0866
).1310   47.0000   0.0872
).1309   46.5000   0.0878
).1307   46.0000   0.0884
```

.1306	45.5000	0.0890
.1304	45.0000	0.0896
.1303	44.5000	0.0902
.1301	44.0000	0.0909
.1300	43.5000	0.0915
.1298	43.0000	0.0921
.1297	42.5000	0.0928
.1296	42.0000	0.0934
.1294	41.5000	0.0941
.1293	41.0000	0.0948
.1291	40.5000	0.0954
.1290	40.0000	0.0961
.1288	39.5000	0.0968
.1287	39.0000	0.0975
.1286	38.5000	0.0982
.1284	38.0000	0.0990
.1283	37.5000	0.0997
.1281	37.0000	0.1004
.1280	36.5000	0.1012
.1279	36.0000	0.1019
.1277	35.5000	0.1027
.1276	35.0000	0.1035
.1274	34.5000	0.1043
.1273	34.0000	0.1051
.1272	33.5000	0.1059
.1270	33.0000	0.1067
.1269	32.5000	0.1075
.1268	32.0000	0.1084
.1266	31.5000	0.1092
.1265	31.0000	0.1101
.1263	30.5000	0.1110
.1262	30.0000	0.1119
.1261	29.5000	0.1128
.1259	29.0000	0.1137
.1258	28.5000	0.1146
.1257	28.0000	0.1156
.1256	27.5000	0.1165
.1254	27.0000	0.1175
.1253	26.5000	0.1185
.1252	26.0000	0.1195
.1250	25.5000	0.1205
.1249	25.0000	0.1215
.1248	24.5000	0.1226
.1246	24.0000	0.1236
.1245	23.5000	0.1247
.1244	23.0000	0.1258
.1243	22.5000	0.1269
.1241	22.0000	0.1280
.1240	21.5000	0.1292
.1239	21.0000	0.1304
.1237	20.5000	0.1315
.1236	20.0000	0.1327
.1235	19.5000	0.1340

1234	19.0000	0.1352
1232	18.5000	0.1365
1231	18.0000	0.1378
1230	17.5000	0.1391
1229	17.0000	0.1404
1228	16.5000	0.1418
1226	16.0000	0.1431
1225	15.5000	0.1445
1224	15.0000	0.1460
1223	14.5000	0.1474
1221	14.0000	0.1489
1220	13.5000	0.1504
1219	13.0000	0.1519
1218	12.5000	0.1535
1217	12.0000	0.1551
1215	11.5000	0.1567
1214	11.0000	0.1584
1213	10.5000	0.1601
1212	10.0000	0.1618
1211	9.5000	0.1635
1209	9.0000	0.1653

FIRST POINT OF WEEPING CONSTRAINT

Assumptions:
1.Constant liquid density
2.Constant liquid volumetric flow rate
3.Consistent increment of vapor density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of vapor(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)
Qv_1 = vapor volumetric flow rate (m3/s)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3) is given as 459.0
As = slot area (m2)
b = flow parameter
Lh = hole load factor on tray (m/s)
Lhw = hole load factor at weep point (m/s)

```
10;
=[34.22:0.1:34.22+a*0.1];
=pi*0.016*0.003*160;
=[61:-5:61+a*-5];
_1=Qv./3600;
=Qv_1./As.*sqrt(pv./(459-pv));
=54;
Ql./Qv.*sqrt(pv./459);
w=0.056*((65/50)^0.5).*(b.^-0.3);
le(:,1)=Qv.';
le(:,2)=Lh.';
le(:,3)=Lhw.';
p(table);
1.0000   0.1993   0.0978
6.0000   0.1833   0.0952
1.0000   0.1672   0.0926
6.0000   0.1510   0.0897
1.0000   0.1348   0.0866
6.0000   0.1186   0.0833
1.0000   0.1023   0.0796
6.0000   0.0859   0.0755
1.0000   0.0695   0.0708
5.0000   0.0530   0.0652
1.0000   0.0365   0.0582
```

SECOND POINT OF WEEPING CONSTRAINT

Assumptions:

1.Constant liquid density
2.Constant liquid volumetric flow rate
3.Consistent increment of vapor density

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of vapor(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qv = vapor volumetric flow rate (m3/hr)
Qv_1 = vapor volumetric flow rate (m3/s)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3) is given as 470.5
As = slot area (m2)
b = flow parameter
Lh = hole load factor on tray (m/s)
Lhw = hole load factor at weep point (m/s)

```
6;
=[36.94:0.5:36.94+a*0.5];
=pi*0.016*0.003*160;
=[21:-3:21+a*-3];
_1=Qv./3600;
=Qv_1./As.*sqrt(pv./(470.5-pv));
=149;
Ql./Qv.*sqrt(pv./470.5);
w=0.056*((65/50)^0.5).*(b.^-0.3);
le(:,1)=Qv.';
le(:,2)=Lh.';
le(:,3)=Lhw.';
p(table);
 1.0000    0.0706    0.0520
 8.0000    0.0609    0.0495
 5.0000    0.0511    0.0468
 2.0000    0.0412    0.0437
 9.0000    0.0311    0.0400
 6.0000    0.0209    0.0353
 3.0000    0.0105    0.0286
```

FIRST POINT OF DOWNCOMER BACKUP

Assumptions:

1. Constant vapor density
2. Constant vapor volumetric flow rate
3. Consistent decrement of liquid density of 0.2
4. Liquid fraction in dispersion is 0.2

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

a = range of liquid volumetric flow rate(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qlmax = maximum liquid volumetric flow rate at 52% (normal plant) flooding percentage
Qv = vapor volumetric flow rate (m3/hr)constant value of 61 (m3/hr)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
delta_p = density difference (kg/m3)
How = liquid crest over calming section weir
Hw = weir height is given as 65mm
Hl = Clear liquid height on tray
Lw = weir length is given as 0.58m
c = converting volumetric flow rate of m3/hr unit into gpm unit
Ac = active area of the column (m2) is given as 1.469 (m2)
Adc = downcomer area (m2) is given as 2.4122 (m2)
Pud = pressure drop under downcomer
Pdry = dry tray pressure drop
Hsub = liquid back-up in downcomer due to submergence

```
2;
=[54:5:54+a*5];
ıax=Ql./3600*100/52;
[470.5:-0.2:470.5+a*-0.2];
=34.22;
a_p=pl-pv;
v=830*((Qlmax./0.58).^(2/3)).*((pl./delta_p).^(1/3));
0.2*65+How;
M=Ql./0.227125;
=0.03*((GPM./100/2.4122).^2);
y=27000./delta_p;
b=350*(Hl./600);
=(Pdry./delta_p./9.812)+Hl+(Pud./delta_p./9.812)+Hsub;
e(:,1)=Ql.';
e(:,2)=BU.';
(table);
)000  202.8566
.0000  213.9425
.0000  224.7194
.0000  235.2193
.0000  245.4687
.0000  255.4899
.0000  265.3020
.0000  274.9214
```

4.0000	284.3626
9.0000	293.6380
04.0000	302.7588
09.0000	311.7347
14.0000	320.5746
19.0000	329.2865
24.0000	337.8773
29.0000	346.3537
34.0000	354.7215
39.0000	362.9861
4.0000	371.1523
9.0000	379.2248
4.0000	387.2077
9.0000	395.1049
4.0000	402.9200

SECOND POINT OF DOWNCOMER BACKUP

ssumptions:
1. Constant vapor density
2. Constant vapor volumetric flow rate
3. Consistent decrement of liquid density of 0.2
4. Liquid fraction in dispersion is 0.2

INITIALIZING CONSTANT PARAMETERS AND EQUILIBRIUM DATA

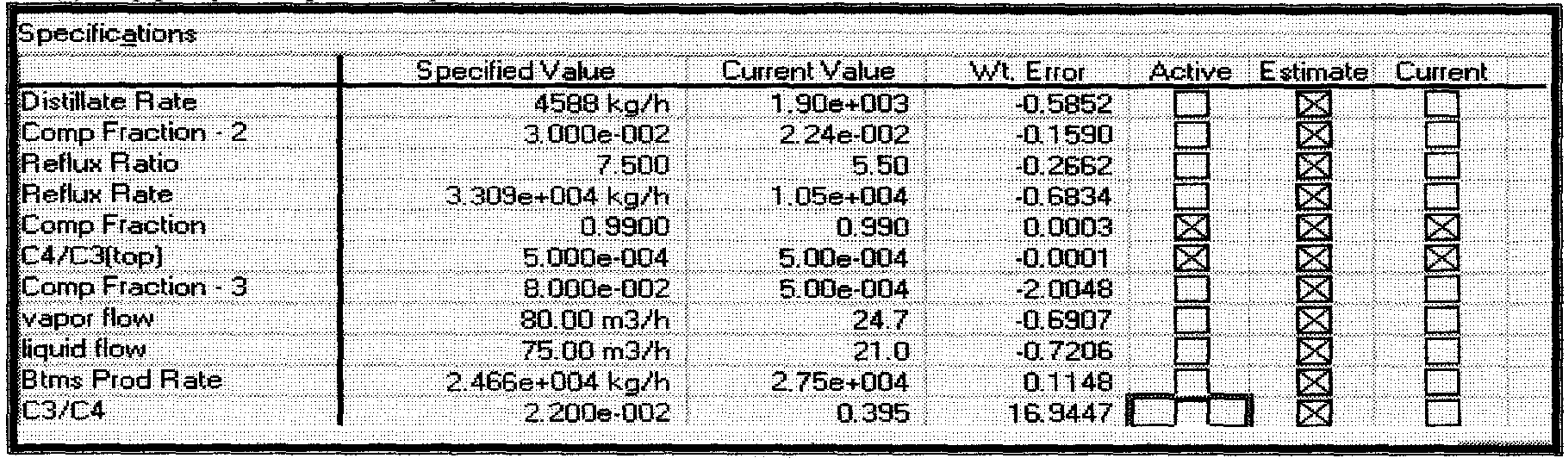
a = range of liquid volumetric flow rate(m3/hr)
Ql = liquid volumetric flow rate (m3/hr)
Qlmax = maximum liquid volumetric flow rate at 52% (normal plant) flooding percentage
Qv = vapor volumetric flow rate (m3/hr) at constant value of 21 (m3/hr)
pl = liquid density (kg/m3)
pv = vapor density (kg/m3)
delta_p = density difference (kg/m3)
How = liquid crest over calming section weir
Hw = weir height is given as 65mm
Hl = Clear liquid height on tray
Lw = weir length is given as 0.58m
c = converting volumetric flow rate of m3/hr unit into gpm unit
Ac = active area of the column (m2) is given as 1.469 (m2)
Adc = downcomer area (m2) is given as 2.4122 (m2)
Pud = pressure drop under downcomer
Pdry = dry tray pressure drop
Hsub = liquid back-up in downcomer due to submergence

```
2;
=[54:5:54+a*5];
nax=Ql./3600*100/52;
[470.5:-0.2:470.5+a*-0.2];
=36.94;
ta_p=pl-pv;
w=830*((Qlmax./0.58).^(2/3)).*((pl./delta_p).^(1/3));
=0.2*65+How;
M=Ql./0.227125;
d=0.03*((GPM./100/2.4122).^2);
ry=27000./delta_p;
ub=350*(Hl./600);
=(Pdry./delta_p./9.812)+Hl+(Pud./delta_p./9.812)+Hsub;
le(:,1)=Ql.';
le(:,2)=BU.';
p(table);
4.0000  203.2371
9.0000  214.3463
4.0000  225.1460
9.0000  235.6680
4.0000  245.9390
9.0000  255.9814
4.0000  265.8142
```

.0000	275.4541
.0000	284.9153
.0000	294.2104
4.0000	303.3505
9.0000	312.3455
4.0000	321.2043
9.0000	329.9347
4.0000	338.5439
9.0000	347.0384
4.0000	355.4241
9.0000	363.7064
4.0000	371.8902
9.0000	374.9800
4.0000	387.9801
9.0000	395.8943
4.0000	403.7262

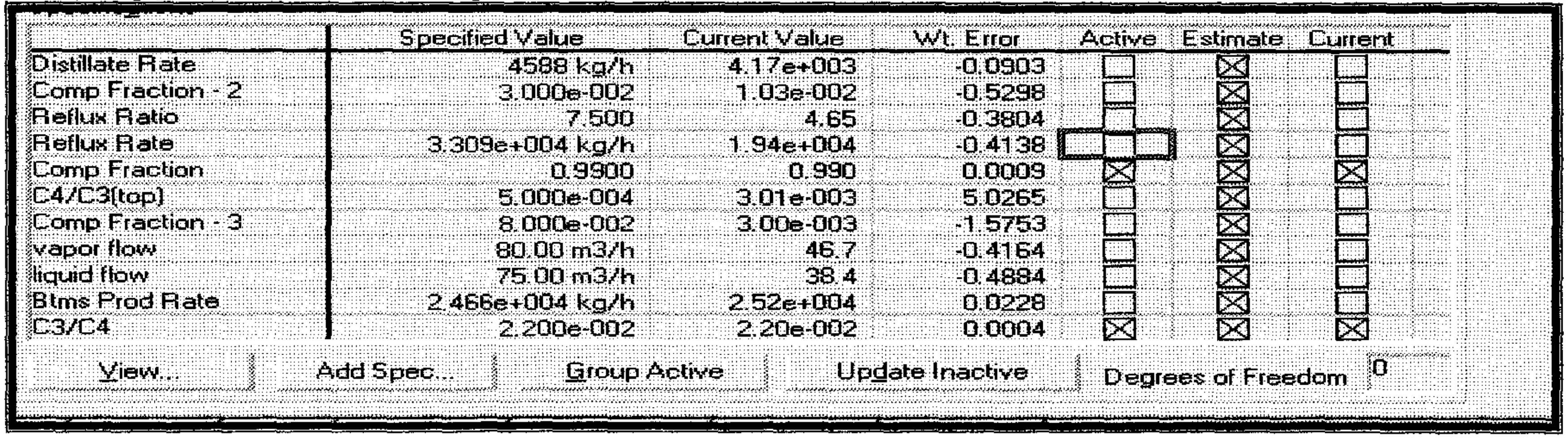
APPENDIX D: HYSYS Result of Optimum Region of Sealing and Weeping

Set (a): Top purity and top C_4/C_3 vapor mole fraction



	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Distillate Rate	4588 kg/h	1.90e+003	-0.5852	☐	☒	☐
Comp Fraction - 2	3.000e-002	2.24e-002	-0.1590	☐	☒	☐
Reflux Ratio	7.500	5.50	-0.2662	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	1.05e+004	-0.6834	☐	☒	☐
Comp Fraction	0.9900	0.990	0.0003	☒	☒	☒
C4/C3(top)	5.000e-004	5.00e-004	-0.0001	☒	☒	☒
Comp Fraction - 3	8.000e-002	5.00e-004	-2.0048	☐	☒	☐
vapor flow	80.00 m3/h	24.7	-0.6907	☐	☒	☐
liquid flow	75.00 m3/h	21.0	-0.7206	☐	☒	☐
Btms Prod Rate	2.466e+004 kg/h	2.75e+004	0.1148	☐	☒	☐
C3/C4	2.200e-002	0.395	16.9447	☐	☒	☐

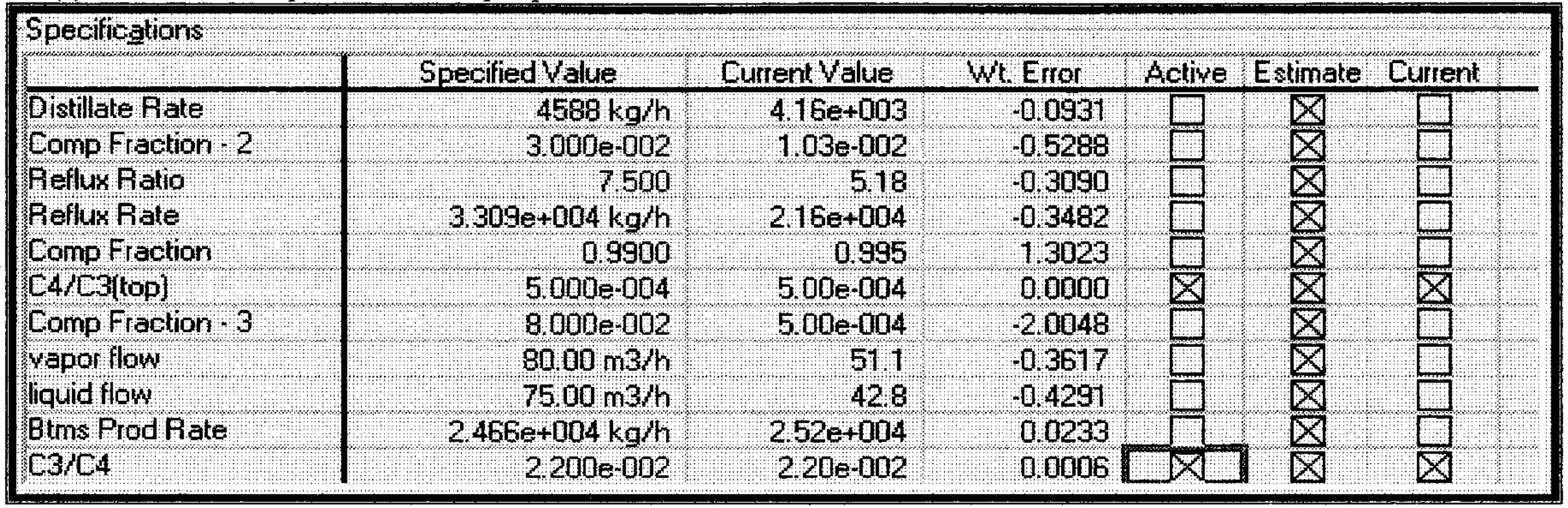
Set (b): Top purity and bottom C_3/C_4 liquid mole fraction



	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Distillate Rate	4588 kg/h	4.17e+003	-0.0903	☐	☒	☐
Comp Fraction - 2	3.000e-002	1.03e-002	-0.5298	☐	☒	☐
Reflux Ratio	7.500	4.65	-0.3804	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	1.94e+004	-0.4138	☐	☒	☐
Comp Fraction	0.9900	0.990	0.0009	☒	☒	☒
C4/C3(top)	5.000e-004	3.01e-003	5.0265	☐	☒	☐
Comp Fraction - 3	8.000e-002	3.00e-003	-1.5753	☐	☒	☐
vapor flow	80.00 m3/h	46.7	-0.4164	☐	☒	☐
liquid flow	75.00 m3/h	38.4	-0.4884	☐	☒	☐
Btms Prod Rate	2.466e+004 kg/h	2.52e+004	0.0228	☐	☒	☐
C3/C4	2.200e-002	2.20e-002	0.0004	☒	☒	☒

Degrees of Freedom 0

Set (c): C_3/C_4 bottom liquid and C_4/C_3 top vapor mole fraction

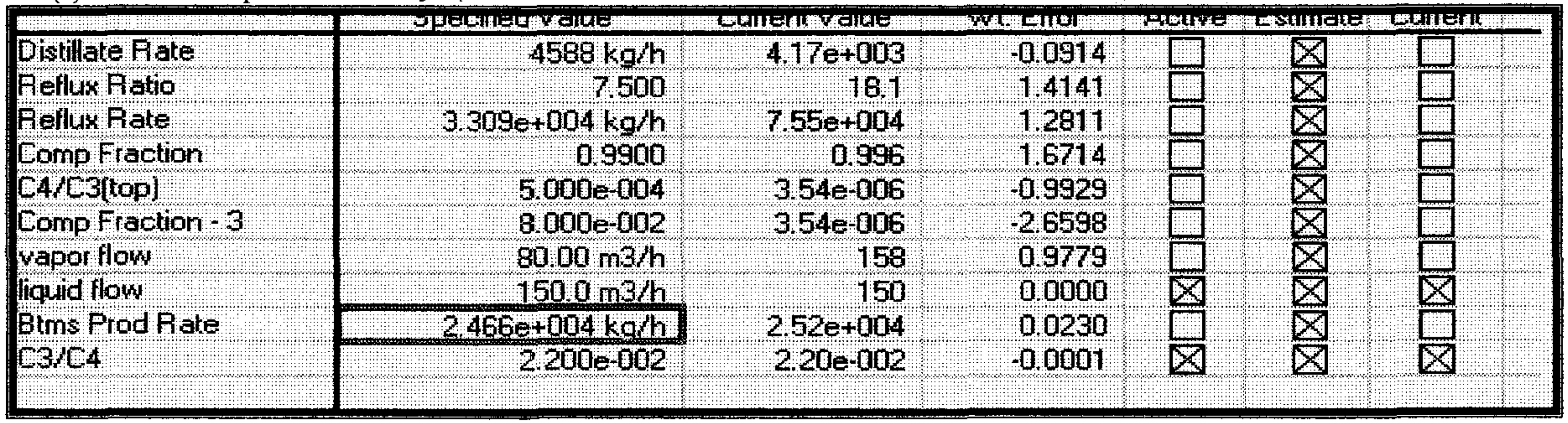


Specifications

	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Distillate Rate	4588 kg/h	4.16e+003	-0.0931	☐	☒	☐
Comp Fraction - 2	3.000e-002	1.03e-002	-0.5288	☐	☒	☐
Reflux Ratio	7.500	5.18	-0.3090	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	2.16e+004	-0.3482	☐	☒	☐
Comp Fraction	0.9900	0.995	1.3023	☐	☒	☐
C4/C3(top)	5.000e-004	5.00e-004	0.0000	☒	☒	☒
Comp Fraction - 3	8.000e-002	5.00e-004	-2.0048	☐	☒	☐
vapor flow	80.00 m3/h	51.1	-0.3617	☐	☒	☐
liquid flow	75.00 m3/h	42.8	-0.4291	☐	☒	☐
Btms Prod Rate	2.466e+004 kg/h	2.52e+004	0.0233	☐	☒	☐
C3/C4	2.200e-002	2.20e-002	0.0006	☐☒☐	☒	☒

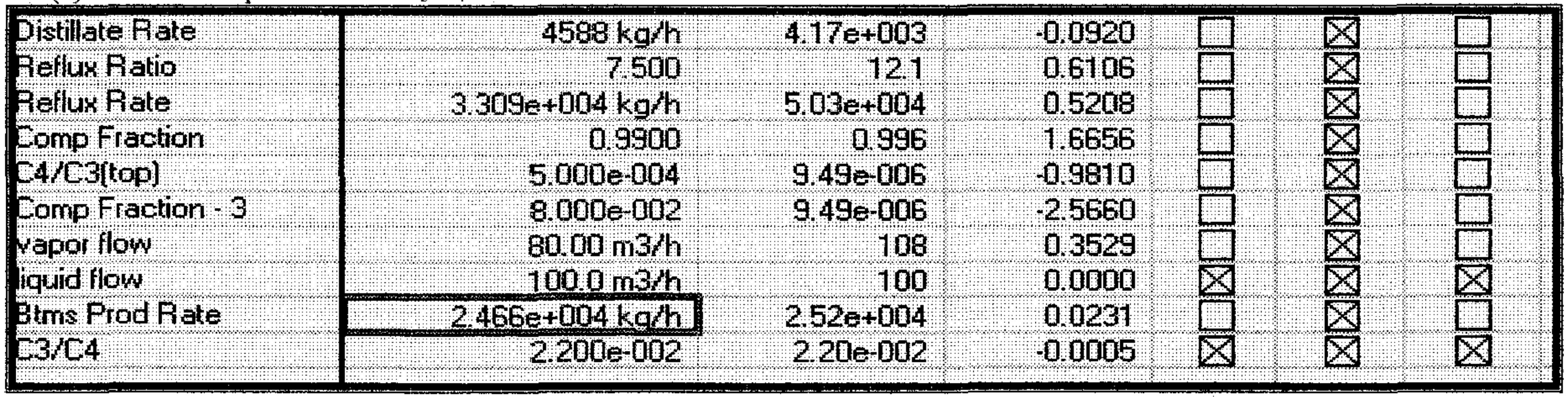
APPENDIX E: HYSYS Result of Optimum Region of Downcomer Backup

Set (a): 150 m^3/hr liquid flow and C_3/C_4 bottom mole fraction



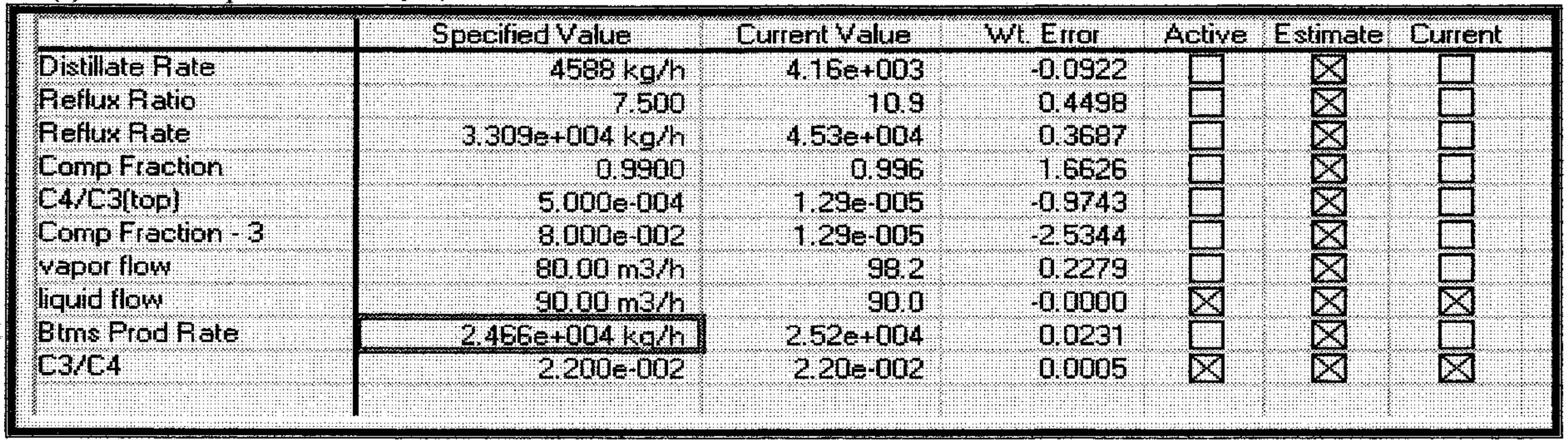
	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Distillate Rate	4588 kg/h	4.17e+003	-0.0914	☐	☒	☐
Reflux Ratio	7.500	18.1	1.4141	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	7.55e+004	1.2811	☐	☒	☐
Comp Fraction	0.9900	0.996	1.6714	☐	☒	☐
C4/C3(top)	5.000e-004	3.54e-006	-0.9929	☐	☒	☐
Comp Fraction - 3	8.000e-002	3.54e-006	-2.6598	☐	☒	☐
vapor flow	80.00 m3/h	158	0.9779	☐	☒	☐
liquid flow	150.0 m3/h	150	0.0000	☒	☒	☒
Btms Prod Rate	2.466e+004 kg/h	2.52e+004	0.0230	☐	☒	☐
C3/C4	2.200e-002	2.20e-002	-0.0001	☒	☒	☒

Set (b): 100 m^3/hr liquid flow and C_3/C_4 bottom mole fraction



Distillate Rate	4588 kg/h	4.17e+003	-0.0920	☐	☒	☐
Reflux Ratio	7.500	12.1	0.6106	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	5.03e+004	0.5208	☐	☒	☐
Comp Fraction	0.9900	0.996	1.6656	☐	☒	☐
C4/C3(top)	5.000e-004	9.49e-006	-0.9810	☐	☒	☐
Comp Fraction - 3	8.000e-002	9.49e-006	-2.5660	☐	☒	☐
vapor flow	80.00 m3/h	108	0.3529	☐	☒	☐
liquid flow	100.0 m3/h	100	0.0000	☒	☒	☒
Btms Prod Rate	2.466e+004 kg/h	2.52e+004	0.0231	☐	☒	☐
C3/C4	2.200e-002	2.20e-002	-0.0005	☒	☒	☒

Set (c): 90 m^3/hr liquid flow and C_3/C_4 bottom mole fraction



	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Distillate Rate	4588 kg/h	4.16e+003	-0.0922	☐	☒	☐
Reflux Ratio	7.500	10.9	0.4498	☐	☒	☐
Reflux Rate	3.309e+004 kg/h	4.53e+004	0.3687	☐	☒	☐
Comp Fraction	0.9900	0.996	1.6626	☐	☒	☐
C4/C3(top)	5.000e-004	1.29e-005	-0.9743	☐	☒	☐
Comp Fraction - 3	8.000e-002	1.29e-005	-2.5344	☐	☒	☐
vapor flow	80.00 m3/h	98.2	0.2279	☐	☒	☐
liquid flow	90.00 m3/h	90.0	-0.0000	☒	☒	☒
Btms Prod Rate	2.466e+004 kg/h	2.52e+004	0.0231	☐	☒	☐
C3/C4	2.200e-002	2.20e-002	0.0005	☒	☒	☒