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A student training manual for running the HYSIM computer simulation program

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ABSTRACT

A STUDENT TRAINING MANUAL FOR RUNNING THE HYSIM COMPUTER SIMULATION PROGRAM

by
Roberta Rosty

Hyprotech's HYSIM computer simulation program is used in the chemical processing industry (CPI) to simulate unit operations, which aid in the design of various different kinds of processing plants. It is important then that chemical engineering students should gain early exposure to a simulation program such as HYSIM, in order to facilitate their comprehension of process engineering design work using this type of program, and to bridge the gap between the textbook knowledge they gain of unit operations in the classroom with some of the actual process engineering work-a-day methods available for solving problems.

The objective of this work was to provide detailed examples of HYSIM computer runs for various unit operations, plus other areas covered by HYSIM, such as pressure drop calculations and pipe sizing. Each example contains a description of the process, a process flow diagram and the steps needed to be taken by the HYSIM user to run that particular example. The results obtained from the run are shown at the end of each example.

These examples are being supplied as a guide or training method so that the user can gain the proficiency in running the HYSIM program, that will then translate to the solving of other similar problems, given either in the classroom or in the field.

A STUDENT TRAINING MANUAL FOR RUNNING THE HYSIM COMPUTER SIMULATION PROGRAM

by
Roberta Rosty

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This professional project is dedicated to my family and

in the memory of

Dr. H. T. Chen and Dr. J. E. McCormick.

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CHAPTER 1

INTRODUCTION

This Student Training Manual for the HYSIM process simulation program contains examples of the various unit operations offered in the HYSIM program with extensive commentary. Other areas are covered as well, such as fittings, piping, and pressure drop calculations. The last section covers an example of how to connect various unit operations into one process.

The reference for the HYSIM information in this training manual and for some of the technical examples is the HYSIM User's Guide (Ref. 1) and the HYSIM Special Features, References and Applications Guide (Ref. 2). The HYSIM (Hyprotech Simulation Program) used was version 2.53, released on September 14, 1994. The address of Hyprotech is as follows:

Hyprotech
300 Hyprotech Centre
1110 Centre Street North
Calgary, Alberta, Canada T2E 2R2
(403) 520-6000

Hyprotech
11490 Westheimer, Suite 750
Houston, TX 77077-6841
(713) 870-1900
(713) 870-1039 (FAX)
(800) 475-0011

The introduction of each section will contain the reference for all or a portion of the particular technical example used. If no reference is stated, then the technical example was made-up by the author.

Some examples in this manual contain metric units and some are done in field or English units. Examples for both systems were used to illustrate the method for accessing different units in HYSIM (metric is the default system of units), and to show that the system of units in which the data for a problem is obtained doesn't need to be converted to use HYSIM. Other units, besides metric or Field, may also be used as defined by the HYSIM user.

CHAPTER 2

HYSIM FEATURES

2.1 Starting, Leaving and Saving HYSIM

2.1.1 Starting HYSIM

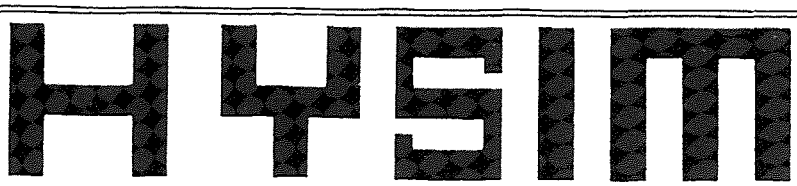
Instructions: The HYSIM computer simulation program can be started by following the actions below. These instructions are for the use of a version of HYSIM that exists on the users' personal computer (PC). Network versions will require a command to load from the network storage device.

The words to be highlighted or typed are indicated in **bold** typeface in the Action section below. The function keys to be used are indicated inside the bracket < > symbols (e.g. the <**Enter**> key). Comments are indicated in *italicized* print.

Step	Action
1	Is the computer and terminal turned on at your workstation? • If Yes, proceed with Step 2. • If No, turn on the computer and terminal now.
2	Are you in the DOS operating system (i.e. at a C:\> prompt)? • If Yes, proceed with Step 3. • If No, exit your existing software package, until you are in the DOS operating system, and then proceed with Step 3.
	Changing directories to the HYSIM subdirectory.
3	At the C:\> prompt, type **CD\HYSIM** and press the <**Enter**> key.
	Getting the HYSIM program from the HYSIM subdirectory in DOS.
4	Type **HYSIM** at the C:\HYSIM> prompt and press the <**Enter**> key.
	The HYSIM banner with a start-up menu will then come up on the screen and will appear as follows.

HYSIM Banner with the Start-up Menu

```
Yes                 No                  Project          Configuration
Do                  Learn
Yes continue with a stored case
Do you wish to continue with a previous case?Use the F1 key for help)
>
```




```
The Truly Interactive Process Simulator from HYPROTECH Ltd.
        Version     C2.53       Released 09/14/94
          Licensed to N.J.I.T. - Engineering
```

2.1.2 Leaving and Saving HYSIM

Step	Action
1	Are you at the HYSIM main menu, as shown below? • If Yes, proceed with Step 2. • If No, push the <Esc> key enough times, until you get back to the main menu.

HYSIM Main Menu

```
Work_Sheet          Specify             Operation           Print
PFD                 Remove              Store               New
Ignore              Restore             Hold                Go
Utility             Size                Report              Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

Step	Action
2	Highlight **Exit** on the main menu and then push the <**Enter**> key. *(You may also exit HYSIM by typing "Exit" at the prompt.)*
3	Do you want to save the case? • If Yes, type the name of the case after the prompt (>) and then press the <**Enter**> key; • If No, type **quit** and then press the <**Enter**> key.
	The DOS prompt (C:\HYSIM>) will then appear on the screen.
4	Do you want to use another software package, besides HYSIM? • If Yes, enter that package now. • If No, turn-off the terminal and computer at your workstation.

2.1.3 Termination of HYSIM Computations

A convenient method of terminating HYSIM computations is to use the <Ctrl><Break> key sequence.

The following sections provide information on the uses of the form and special function keys in HYSIM. This information was taken from the Reference 1, pages 3-38 and 3-39.

Function	Key*
A) To move the cursor:	**Use the following key(s):**
1) One character to the right or left on the same entry blank**	<→> or <←>
2) To the next blank	<Tab> or <Enter> or <↓>
3) To the previous blank	<↑> or <Shift><Tab>
4) To past the last character in the blank the cursor is presently in.	<End>
5) To the first character in the blank the cursor is presently in.	<Home>
B) To delete:	
1) The character to the left of the cursor.	<Backspace>
2) The character at the cursor position	<Delete>
3) The character at the cursor position and all the characters to the right of it.	<Ctrl><End>
4) All the characters in all of the blanks.	<Ctrl><Home>
C) To use the values currently in the blanks to answer the appropriate questions.	<Insert>
D) To exit the form and abort the activity currently in (if the cursor is at the beginning of a blank). **To return the blank to its original value** and move the cursor to the beginning of the blank (if the cursor is not at the beginning of the blank). The <Esc> key quits or gets you out of the current activity.	<Esc>
E) To terminate print operation and flowsheet calculation sequence, and some HYSIM Utility calculations and several of the lengthy stream specification outputs.	<Ctrl><Break>

*The name on a key is indicated in the < > type of brackets. The key name in the brackets is the same name which can be found on a key located on a standard 101-keyboard. If two or more keys are required to be pressed in sequence, each key to be pressed will be indicated inside the < > type of brackets.

**Blanks are each entry block on a HYSIM form, which requires one specific data or name entry per block.

F) Blank Spaces

Blank spaces are not allowed in user supplied names (e.g. the name of an operation). They are interpreted as the end of the entire name or command. When asked to "enter the operation name," either type the name you wish (without blanks) or enter a dash (-), and HYSIM will assign the next available unit operation number.

G) Help with HYSIM

If you require help at any point, the <**F1**> key or the question mark key <**?**> can be pressed.

H) Special Function Keys

The following information describes the *usage of the F1 through F10 keys*, when using HYSIM:

<**F1**> This is the *help key*, which will give details on the current activity.
<**F2**> This key *will bring up a menu of choices*, for certain applications such as when <**F2**> is pressed in a blank space needed to be filled in on a form.
<**F3**> This key is an *editing function key*.
<**F6**> This key allows you to *reorder selected components*.
<**F7**> This key *invokes the HYSIM calculator*.
<**F8**> This key *uses the value on the bottom of the calculator stack as the answer* to the current question.
<**F9**> This key *automatically runs the Calculator Routine* that has been specified for the Macro.
<**F10**> This key *temporarily removes the current window from the screen*, and by pressing it again, allows you to get the screen back again.

The following screen will appear for the selection of a property package for the particular application which you are working on:

```
Peng_Robinson       Soave_Redlich_Kwon Chao_Seader       Grayson_Streed
Activity_Models     Vapour_Pressure    Amines            PR_Options
SRK_Options         Steam              Tabular           User_Defined
Peng_Robinson a Hyprotech enhanced PR - recommended for most HC cases
 Which property package do you require
>
```

Listed below is a brief description of each property package listed. For more information consult Reference 1, pages 4-1 to 4-69.

1) **Peng-Robinson Equation of State (PR)** - Recommended for most oil, gas and petrochemical applications. The Peng-Robinson Equation of State will solve single, two-phase or three-phase systems and is applicable at temperatures greater than -456°F (-271°C), and for pressures less than 15,000 psia (100,000 kPa). The PR equation of state performs rigorous three-phase flash calculations for systems containing water, methanol or glycol. It will also do these calculations for systems containing other hydrocarbons than methanol or glycol, or components that are not hydrocarbons in the second liquid phase. The type of systems recommended for this method are: TEG Dehydration, Sour Water, Cryogenic Gas Processing, Air Separation, Atmospheric Crude Towers, Vacuum Towers, High Hydrogen Systems, Reservoir Systems, and Hydrate Inhibition.

2) **Soave-Redlich-Kwong Equation (SRK)** - The SRK equation is applicable for hydrocarbon mixtures with temperatures greater than -225°F (-143°C) and for pressures less than 5,000 psia (35,000 kPa). This method should not be used for non-ideal systems or if methanol or glycol is a component in the problem. The SRK equation is applicable for rigorous three-phase flash calculations for systems containing water.

3) **Chao-Seader (CS)** - The CS package can be used for light hydrocarbon mixtures or for three phase flashes resulting from immiscibility, with pure water as the second liquid phase. It is recommended for problems containing mostly water (or steam). It can also be used for three-phase flashes, with water as the second liquid phase. The Chao-Seader methods' useful range is: 0 to 500 °F (-18 to 260 °C) and below 1500 psia (10,000kPa).

4) **Grayson-Streed Package (GS)** - The GS package is a semi-empirical model that can be used for three phase flashes with pure water as the second liquid phase. The Grayson-Streed Model is an extension of the Chao-Seader Method, with special attention paid to hydrogen as a component. It is recommended for problems containing mostly water (or steam) or for systems having a high concentration of hydrogen, such as hydrotreating units. This correlation is also good for crude vacuum towers (at less than 10 mm Hg), atmospheric crude towers, topping units and heavy ends vacuum applications. It can also be used for three-phase flashes, with water as the second liquid phase. The Grayson-Stread Method is useful over a temperature range of 0 to 800 °F (-18 to 425 °C) and below 3000 psia (20,000kPa).

5) **Activity Coefficient Models** - Activity Coefficient Models are recommended for chemical systems because of liquid phase non-idealities The following models are available: Margules, vanLaar, Wilson, Non-Random-Two-Liquid (NRTL), Universal Quasi Chemical (UNIQUAC), and Chein-Null.

6) **Vapor Pressure Models** - Vapor Pressure Models are the modified Antoine model, the Braun (BK10) model, and the Esso-Tabular model. They are designed to handle heavier hydrocarbon systems at lower pressures. (They cannot be used for Vapor-Liquid Equilibrium (VLE) predictions at high pressures or when light hydrocarbons are present in significant quantities). This method is recommended for vacuum towers.

The modified Antoine Pressure Model can be used for ideal low pressure systems. The Braun K10 Model and Esso-Tabular Model are both for use with low pressure hydrocarbon systems, and are not good for applications where there is a large quantity of acid gases or light hydrocarbons.

7) **Amines** - The Amines Property Package contains the thermodynamic models developed for AMSIM, which is a proprietary amine plant simulator. The Amines property package is an optional property package with the HYSIM program. It can be obtained from Hyprotech, if it is not already a part of your current package.

8) **Peng- Robinson Options (PR-Options)** - The variations of the Peng-Robinson (PR-Options) menu selection includes: the sour water model using the Peng-Robinson Equation of State (Sour-PR), Peng-Robinson with Lee-Kesler Enthalpies (PR-LK-Enth), Peng-Robinson-Stryjek-Vera (PRSV), Peng-Robinson-Stryjek-Vera with Lee-Kesler Enthalpies (PRSV-LK-Enth) and Peng-Robinson without automatic calculation of Hydrocarbon-Hydrocarbon K_{ij}'s (PR-No-HC- K_{ij}) packages. The PRSV equation of state is more suitable than the Peng-Robinson (PR) for handling non-ideal systems. The PRSV equation of state performs rigorous three phase flash calculations for systems containing water, methanol or glycol, as well as systems containing hydrocarbons besides methanol or glycols or non-hydrocarbons in the second liquid phase. The values for both binary interaction coefficients are assumed to be equal in the PRSV option.

This PR-Options option is recommended for Atmospheric Crude Towers, Vacuum Towers and Reservoir Systems.

9) **Soave-Redlich-Kwong Equation Options (SRK Options)** - The property packages available under the SRK Options, variations of the SRK Equation of State, are the: Sour water model using the Soave-Redlich-Kwong Equation of State (Sour-SRK), the Soave-Redlich-Kwong with Lee-Kesler Enthalpies (SRK-LK-Enth), the Soave-Redlich-Kwong without automatic calculation of the Hydrocarbon-Hydrocarbon K_{ij} constant calculations (SRK-No-HC-K_{ij}), Kabadi-Danner and the Zudkevitch-Joffe modification of the Redlich-Kwong equation of state (Zudkevitch-Joffe-RK) equations.

The Sour-SRK uses the SRK equation of state with the Wilson model. The SRK-LK-Enth uses Lee-Kesler enthalpies which may have more accuracy for heavy hydrocarbon systems. The SRK-No-HC- K_{ij} Option uses the SRK model with no automatic calculation of any unknown interaction coefficients (K_{ij}) between hydrocarbons. The Kabadi-Danner model is an enhancement

9) Soave-Redlich-Kwong Equation Options (SRK-Options) (continued) -
of the SRK equation of state to improve the vapor-liquid-liquid equilibrium results for water-hydrocarbon systems. The Zudkevitch-Joffe model is an enhancement of the Redlich-Kwong equation of state, for better prediction of vapor-liquid equilibria for hydrocarbon systems.

10) Steam - Under the Steam Package, you can select either the American Society of Mechanical Engineers (ASME) Steam or the National Bureau of Standards (NBS) Steam. ASME Steam uses the ASME 1967 steam tables, and NBS Steam uses the NBS 1984 steam tables, which supposedly have better data in the region of the Critical Point.

11) Tabular- Tabular Package calculations are based on polynomial expressions that are a function of temperature, but the Tabular Package must be used with one of the other HYSIM property packages. (An example would be the calculation of the viscosities of chemicals using the Tabular Package, while the Activity Models package calculated the rest of the properties).

12) User Defined- User proprietary packages, coded in C and compiled with Metaware 2.3 - High 386, may be linked with HYSIM. (An interface routine is available with the linkable version of HYSIM and contains documentation of the parameters and the functionality of the routine).

2.4.1 The Component Selection Menu

All of the components to be used in a particular application must be specified to HYSIM at the beginning of the initial case run. (Case retrieval is explained under Section 2.5 - The Start-Up Menu.) The following screen will initially appear when you are to make your component selection:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

2.4.2 Description of the Component Selection Screen

2.4.2.1 Middle Column

The chemical list in the middle of the screen contains three columns. The first column lists a specific chemical using its synonym; the second column lists the same chemical using its chemical name, and the third column lists the same chemical again using its chemical formula (containing the actual number of atoms of each element in the molecule or formula). The chemical list itself is very long and you can search for a component by any of the three methods listed above. A typed list of all of the chemical components available in HYSIM are listed in Appendix A of Reference 2.

2.4.2 Description of the Component Selection Screen (continued)
2.4.2.1 Middle Column (continued)

The first two component names listed in the second column are: OIL and HYPOTHETICAL. These two general names can be selected and tabulated forms will then appear, so that the user can fill in physical property data to specify a user-defined component. (If it is known that the hypothetical component is an oil, use the oil form; otherwise use the hypothetical form). These forms are available to define components which are not apart of the "Component Selection" List.

2.4.2.2 Criteria Column (Rightmost Column)

The chemical group names in the "Criteria" column can be selected if you know the group of chemicals the particular chemical you wish to specify is in. (Selected means using the arrow keys to place a cursor over the chemical name and then pressing the <Enter> key).

If you select the group of chemicals first, the list of chemicals in the middle of the screen will change, listing only the group of chemicals you have specified. You can now select your chemical from the shortened list. If the next chemical you wish to select is in another chemical group, you can select that chemical group and the list in the middle of the screen will change again.

2.4.2.3 Selected Column (Leftmost Column)

The leftmost column is empty initially because no components have been selected initially by the user. As the HYSIM user selects components, they are listed in the "Selected" column.

2.4.3 Directly Typing the Name of a Component

If the HYSIM name for a component is known it can be typed directly into the "Selected" column. If the component name is not known exactly, one can start to enter the name in the "Selected" column and the middle column will adjust to list the components that match what has been typed so far.

2.4.4 The Component Selection Menu Function Keys

Use the following function keys to perform the following functions while in the Component Selection Menu:

<F1>- Help key.
<F3>- Use this key to access the Secondary Component Selection Menu. (No on-line search feature).
<F4>- Use this key to switch between searching by synonym or searching by formula.
<F5>-Use this key to either examine the makeup of an oil or hypothetical or to display all synonyms for a particular component.
<F6>- Use this key to move the position of items in the selected column.
<F8>- Use this key to replace a selected component with a new one.

The start-up menu in HYSIM is the first menu which will be encountered by the user, and appears as follows:

The Start-Up Menu

```
Yes                 No                  Project          Configuration
Do                  Learn
Yes continue with a stored case
Do you wish to continue with a previous case?(Use the F1 key for help)
>
```

The start-up menu has the following selections available to the HYSIM user to answer the following question:

*Do you wish to continue with a previous case?**

A new case is one in which you are starting from scratch, and a previous case is a case which was started at an earlier time and has been stored.

1) *Yes* - Continue with a stored case.
2) *No* - Ask the questions necessary to define the components.
3) *Project* - Select a project to work under.
4) *Configuration* - Set various program parameters.
5) *Do* - Read commands from a script files.
6) *Learn* - Record input in file as it is entered.

*The above descriptive text reflects what appears on the screen as each of the above answers is highlighted.

The following screens will appear after each of the above is selected: (Selection of a menu item in HYSIM denotes using the arrow keys (←, ↑, →, or ↓) located on the keyboard to place the cursor over the menu choice you have selected, which causes the selected item to change color, and then pressing the <Enter> key).

1) Yes

When you select *Yes* the following menu, listing the stored cases, such as the following screen will appear:

```
CASESTDY.SIM        TUTORIAL.SIM        Parent_dir\          ?
CASESTDY.SIM
 What is the name of the case you wish to continue with?
>
```

The following file extensions are used in HYSIM:

.sim	- Simulation case files.	.exe	- Executable files.
.prn	- Printed files.	.oil	- Stored oil assays.
.cmd	- Command files.	.rpt	- Report templates.
.dat	- Data files.	.prj	- Project subdirectories.

2) No

When you select *No* the following menu will appear:

```
Peng_Robinson       Soave_Redlich_Kwon Chao_Seader       Grayson_Streed
Activity_Models     Vapour_Pressure    Amines            PR_Options
SRK_Options         Steam              Tabular           User_Defined
Peng_Robinson a Hyprotech enhanced PR - recommended for most HC cases
>Which property package do you require
```

The different property package choices are described briefly on the screen when they are highlighted (the cursor is placed over them using the arrow keys). The brief description that appears on the screen is indicated below. If more information is needed on the different property packages and what package is most pertinent for the particular application at hand, refer to pages 4-1 to 4-69 of Reference 1.

The details on the Equations of State listed below can be found on pages 7 to 9.

a) *Peng-Robinson* - a Hyprotech enhanced PR (Peng-Robinson) - recommended for most HC (Hydrocarbon) Cases.

b) *Soave-Redlich-Kwon* - a standard SRK (Soave-Redlich-Kwong).

c) *Chao-Seader*

d) *Grayson-Streed* - an improved Chao-Seader correlation.

e) *Activity-Models* - dual model packages for chemical problems.

f) *Vapour-Pressure* - vapour pressure models, BK10 (Braun K10 Model), Esso-Tab (Esso Tabular Model), Modified Antoine.

g) *Amines* - D.B. Robinson's property package for gas sweetening (optional).

h) *PR_Options* - dual model/expanded PR (Peng-Robinson) - sour water, LK (Lee-Kesler) enthalpies, PRSV (Peng-Robinson-Stryjek-Vera) equation of state, etc. The options are: Sour-PR (Wilson's API-Sour Model and the Peng-Robinson equation of state), PR-LK-Enth (Peng-Robinson equation of state with Lee-Kesler enthalpies), PRSV (Peng-Robinson-Stryjek-Vera equation of state), PRSV-LK-Enth (Peng-Robinson-Stryjek-Vera equation of state with Lee-Kesler enthalpies), and PR-No-HC-K_{ij} (Peng-Robinson equation of state,with the zero K_{ij} option, where unknown hydrocarbon interaction coefficents are not calculated).

i) *SRK_Options* - dual model SRK (Soave-Redlich-Kwong) - sour water, LK (Lee-Kesler) enthalpies, etc. The options are: Sour-SRK (Soave-Redlich-Kwong equation of state with the Wilson API-Sour Model), SRK-LK-Enth (Soave-Redlich-Kwong equation of state using Lee-Kesler enthalpies), SRK-No-HC- K_{ij} (Soave-Redlich-Kwong equation of state, with the zero K_{ij} option, where unknown hydrocarbon interaction coefficients are not calculated) , Kabadi-Danner model and Zudkevitch-Joffe-RK (Zudkevitch-Joffe model of the Redlich-Kwong equation of state).

j) *Steam* - ASME (The American Society of Mechanical Engineers) - 1967 or NBS (National Bureau of Standards) 84 steam tables.

k) *Tabular* - use tabular K's (K-factors), Enthalpies, or Physical Props (Properties) for comps (components).

l) *User_Defined* - No comment appears when this selection is highlighted.

3) Project -When a project has been created and named in HYSIM, a new sub-directory is created, using the project name and the directory extension .prj. (For example, a project named Fred will be Fred.prj.)

The following screen will appear when *project* is selected.

```
Select              Create
Select choose an existing project
Do you wish to select an existing project?
>
```

The following selections are available to the HYSIM user to answer the question:
Do you wish to select an existing project?

a) *Select* - Chose an existing project.
b) *Create* - Start a new project.

4) Configuration

The following screen will appear after *configuration* has been selected.

```
Screen  Graphics_printer   Graphics_dimension Text_printer
Units   Miscellaneous      Print              Save
Screen configure the appearance of HYSIM
What do you want to configure
>
```

The following selections are available under "Configuration":

a) *Screen* - Configure the appearance of Hysim.
b) *Graphics-Printer* - Set the configuration for the PFD (Process Flow Diagram) and plots.
c) *Graphics-Dimension* - Set plot dimensions for the PFD and plots.
d) *Text-Printer* - Information about text printers.
e) *Units* - Set the default unit system, add or modify units.
f) *Miscellaneous* - Configure other sundry items. These sundry items include:
    Accounting - Save usage charges in an accounting file.
    Beep-Delay - Time calculation will run before beep.
    Backup-frequency - Time between timed automatic backups.
    Overwrite-backup - Backup cases as filename.BAK whenever one is saved.
    Macro - Specify the name of the calculator program to be executed with 'F9'.
g) *Print* - Display the current configurations.
h) *Save* - Store the current configuration for future runs.

5) Do

The *Do* command is used to read commands from script files. The Command File read by HYSIM is in the ASCII format, and is useful when using the If, Else and Endif commands, to automate HYSIM runs. The End Command returns control back to the keyboard.

The following screen will appear after selecting *Do*:

```
Parent_dir\          ?
?
Select command file>
```

6) Learn

The *Learn* command is used to record input in a file as it is entered into HYSIM, and will be used in an ASCII file. (The End command returns control back to the keyboard).

The following screen will appear after selecting *Learn*:

```
Parent_dir\          ?
Parent_dir\
 Enter command file name
>
```

The following screen is called the Main Menu. This menu is reached after the HYSIM user has specified the property package to be used and the components that are in the current case, or has retrieved an old case. From this point on, it does not matter in which order the HYSIM user enters information. When HYSIM has enough information, it will complete the Worksheet.

The Main Menu

```
Work_Sheet          Specify          Operation          Print
PFD                 Remove           Store              New
Ignore              Restore          Hold               Go
Utility             Size             Report             Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

Text in parenthesis is viewed on the screen when each one of the following commands is highlighted:

1) **Worksheet** - Streams in a spreadsheet format.
2) **Specify** - Input information about process streams.
3) **Operation** - Add or change a process unit operation.
4) **Print** - Display data and results.
5) **PFD** - Display the flowsheet process flow diagram.
6) **Remove** - Used to delete streams, unit operations, or cases.
7) **Store** - Save the current case as a disk file.
8) **New** - A new case or new set of components is desired.
9) **Ignore** - Temporarily remove a unit operation from the flowsheet.
10) **Restore** - Restores an operation which has been ignored.
11) **Hold** - Turn off the automatic recalculation of changed flowsheets.
12) **Go** - Turn on the recalculation and update flowsheet.
13) **Utility** - Gives access to miscellaneous utility features.
14) **Size** - Physical sizing of unit operations.
15) **Report** - Print detailed input and output reports - using a standard format.
16) **Toggle** - Switch to another case keeping the current case loaded.
17) **Exit** - End the current session and return to DOS.

After you have selected one of the commands 1 through 16, you will always eventually return to this Main Menu, by hitting the **<Esc>** key. In some cases, pressing the **<Insert>** or the **<Enter>** key will also get you back to the Main Menu.

In addition to selecting a menu item with the mouse, one can type the menu item or even the first few letters and then press the **<Enter>** key. This is a convenient method of accomplishing menu selection.

1) **Work_Sheet** - When the *Work_Sheet* command is highlighted and the <Enter> key is then pressed, the following type of Worksheet will appear on the screen.

Streams

	New Value =			
Stream	---	---	---	---
Vapour_Frac	---	---	---	---
Temperature	---	---	---	---
Pressure	---	---	---	---
Flow	---	---	---	---
Mass_Flow	---	---	---	---
LiqVol_Flow	---	---	---	---
Energy_Flow	---	---	---	---
Stream	---	---	---	---
Vapour_Frac	---	---	---	---
Temperature	---	---	---	---
Pressure	---	---	---	---
Flow	---	---	---	---
Mass_Flow	---	---	---	---
LiqVol_Flow	---	---	---	---
Energy_Flow	---	---	---	---

The worksheet shown above is how the worksheet will appear before any process stream names and conditions have been specified. As this information is specified, the above worksheet will fill. An example of a completed worksheet is shown below:

The stars or asterisks (*) are shown next to the user-supplied data. The rest of the data which appears in the worksheet without an star or asterisk (*) has been calculated by the HYSIM computer simulation program. Some versions of HYSIM use a color change in text to differentiate between user-supplied data and that data calculated by HYSIM.

Data can be entered either by typing in the stream name in the blank labeled Stream and then typing in the data directly into the Worksheet, or through usage of the Specify command. In the example shown below, the following stream names have been entered: Feed, Vapor, Liquid, and Solids.

Streams

	New Value =		kgmole/h	
Stream	Feed	Vapor	Liquid	Solids
Vapour_Frac	0.0000	0.0000	0.0000	0.0000
Temperature	25.0000*	25.0000	25.0000	25.0000
Pressure	101.0000*	91.0000	91.0000	91.0000
Flow	100.0000*	0.0000	75.0000*	25.0000
Mass_Flow	1651.4026	0.0000	1351.1326	300.2700
LiqVol_Flow	1.5367	0.0000	1.3539	0.1829
Energy_Flow	-2.56188E+06	0.0000	-2.58812E+06	26225.2350
Stream	---	---	---	---
Vapour_Frac	---	---	---	---
Temperature	---	---	---	---
Pressure	---	---	---	---
Flow	---	---	---	---
Mass_Flow	---	---	---	---
LiqVol_Flow	---	---	---	---
Energy_Flow	---	---	---	---
Attached to	Solids			

2) **Specify** - When the Specify main menu command has been highlighted and then the <**Enter**> key has been pressed, the following menu will then appear on the screen:

```
Temperature          Pressure       Flow                 Composition
Vapour_fraction      Name           T-P                  Conditions
Stream               Energy_Flow    Individual_comp      Mass_flow
LiqVolume_flow       Number         Note                 ?Stream_name
Temperature
 What would you like to specify?
>
```

By highlighting and pressing the <Enter> key for one of the following variables, you can specify or input known information about different streams to the computer program. The default units used in the HYSIM program are SI or metric units: °C, kilograms (kg), kilopascals (kPa), meters (m), etc. To change to any other set of units, see the "Changing Units" Section 2.8 in this manual.

The units classified as Field units include: °F, pounds mass (lb), pounds force per square inch (psia), feet (ft), etc. Field units are also commonly known as British or English units. The standard conversion between the metric and the Field units are as follows:

1 atm = 14.696 psia = 101 kPa 1 ft = 0.3048 m

°F = 1.8(°C) + 32 1 lb(mass) = 0.4536 kg

a) **Temperature** - Specify the Temperature (°C) of any stream in the case.

b) **Pressure** - Specify the absolute Pressure (kiloPascals, kPa) of any stream in the case.

c) **Flow** - Specify the molar flow (kg-mols/hr) of any stream.

d) **Composition** - Specify the Composition of any stream in mole, liquid volume or mass flow rates or in mole, liquid volume or mass fractions of the total stream flow rate.

e) **Vapour (Vapor) Fraction** - Specify the fraction (0.0000-1.0000) of vapor in any stream in the case.

f) **Name**- Specify any Stream Name (12 characters maximum).

g) **T-P** - Specify both the Temperature (°C) and Pressure (kPa) conditions of any stream in the case.

h) **Conditions** - Specify the Temperature (°C), Pressure (kPa), and Molar Flow (kg-mols/hr) conditions of any stream in the case.

i) **Stream** - Specify the Conditions and Composition (as described above) of any stream in the case.

j) **Energy-Flow** - Specify the Energy Flow (kiloJoules/hr, kJ/hr) of a pure Energy stream, such as the energy being supplied to a single-sided heater case.

k) **Individual-comp** - Specify the composition (as described above) of individual components within a stream.

l) **Mass-flow** - Specify the mass flowrate (kg/hr) of any stream in the case.

m) **LiqVolume-flow** - Specify the *ideal liquid* volumetric rate (cubic meters/hr, m^3/hr) of a stream. An ideal system is considered to be one where the components are of the same "family" of hydrocarbons or chemicals, and which have close boiling points. (Ref. 3, Vol. 2, pp. 1 and 2)

n) **Number** - Specify the number associated with a stream.

o) **Note** - Specify a short note that will accompany each stream and operation.

p) **?Stream-name** - Specify the conditions and composition (as described above) of a New Stream

3) **Operation** - When the Operation Main Menu Command is highlighted and then the <Enter> key is pressed the following screen, asking for you to give the operation a name (e.g. V-100, Column, etc.), will appear:

```
?New
?New enter a new name to install a new operation
Enter the operation name
>
```

A name (we used Robin) for the operation (flow sheet reference symbol or process unit reference name) should be typed in after the prompt (>) as shown below:

```
?New

Enter the operation name
>Robin
```

After pressing the <Enter> key, the following screen will then appear, naming the different operations that are available in HYSIM:

```
Heat_Exchanger      Column           Comp/Expander Set
Cooler/Heater       Fractionate      Pump          Adjust
LNG                 Separator        Balance       Recycle
Mixer               Separator_3      Mole_Balance  Command_File
Tee                 Solid_Separator  Mass_Balance  Calculator
Valve               Reactor          Gbalance      Pipe_Segment
Link_Case           Data_Recorder
Heat_Exchanger Two sided heat exchanger
 What type of unit do you want to install
>
```

4) **Print** - This command is used to print various inputted and HYSIM generated information to the screen. Refer to Section 2.7 entitled "Printing" of this manual for a full explanation of how to use the Print command.

5) **PFD** - By highlighting the PFD (Process Flow Diagram) command on the Main Menu and then pressing the <Enter> key, you can see a diagram of the unit operation(s) that is in the case in which you are working. By using the key <F2>, you can access a menu of operations that can be performed on the PFD, such as printing it to the printer. Press the <Esc> key to get back to the Main Menu.

6) **Remove** - The Remove command is used to Delete streams, operations or cases.
The following screen will appear when the Remove command is highlighted and the <Enter> key is pressed:

```
Streams            Operations          Cases
Streams all the specifications for the named stream will be removed
 Do you want to remove streams operations or cases
>
```

To remove either a stream, operation, or case, highlight the pertinent word, press the <Enter> key, and then highlight the name of the stream, operation or case which you wish removed and then press the <Enter> key again.

7) **Store** - By highlighting the word Store and pressing the <Enter> key the present case can be stored in a disk file.
A screen listing all of the current files stored will then appear similar to the one shown below, at which time you can store the case into an old file or into a new one. If you are storing the case in a new file, you must name it first by typing that name after the prompt and then hitting the <Enter> key. If you are storing the case in an old file, highlight the name of the old file listed on the menu, and then press the <Enter> key. If you do not wish to store the case into any file, then type the word "Quit" after the prompt and then press the <Enter> key.

```
CASESTDY.SIM       QIOT.SIM           ROSTY.SIM      TUTORIAL.SIM
Parent_dir\        LLE.PRJ\           VLE.PRJ\       ?
CASESTDY.SIM
 Enter the name of the case to save the result in or Quit
>
```

8) **New** - When the word New is highlighted and the <Enter> key is pressed, the following screen will appear, in which you can specify to HYSIM whether you wish to specify a new case, basis (new components), oil, Property_Package or Project.

```
Case               Basis              Oil     Property_Package
Project
Case start a completely new case
 What do you wish to change?
>
```

9) **Ignore** - When you highlight the word Ignore and press the <Enter> key, a screen similar to the following one, will appear in which you can either select or enter the names of the operations you wish ignored (temporarily removed from the flow sheet).

```
V-100              V-101              -
V-100
Enter the names of the operations you wish ignored
>
```

10) **Restore** - When you highlight the word Restore and press the <Enter> key, a screen similar to the following one, will appear in which you can either select or enter the names of the operations you wish restored (bring back an operation that was Ignored or temporarily removed from the flow sheet).

```
V-100                V-101                -
V-100
 Which operations do you wish restored
>
```

11) **Hold** - When you highlight the word Hold and then press the <Enter> key, HYSIM will not automatically recalculate worksheets as you make changes to them, as it normally does. (Sometimes HYSIM will impose a Hold on its calculations without the Hold being specified, due to that fact that there is an error or other problems.) To restore the HYSIM program to normal automatic calculations, highlight the word Go on the main menu and then press the <Enter> key.

12) **Go** - By highlighting the word Go and then pressing the <Enter> key, the HYSIM program will be restored to normal automatic calculations from the Hold mode. The Hold and Go commands can alternatively be typed from the keyboard. This is normally faster then selecting the command.

13) **Utility** - The Utility command gives the HYSIM user tools in which to specify or present additional information. When the word Utility is highlighted and the <Enter> key is pressed, the following menu will appear on the screen:

```
Configuration      Solids          Heat_Curves         Make
Move_Before        Critical        Pinch               End
Rename_Operation   Envelope        Get_Dist_Results    ExitDo
Oper_Description   Property_Table  Short_Cut_Dist      If
Case_Description   STX_ACX         Depressure          Else
Do_Command         HTFS            DOS                 Endif
List               Tray_Calc       DelPFD              User_prop
Configuration set screen colours, conversion units etc.
 Which utility do you want?
>
```

The following text in parenthesis is viewed on the screen when each one of the following commands is highlighted:

a) **Configuration** - Set screen colours, conversion units, etc.
b) **Solids** - Check for the freezing of solids in streams.
c) **Heat-Curves** - Heat exchanger profiles.
d) **Make** - Create a file of commands.

e) **Move-Before** - Rearranges stream and operation menus and output.
f) **Critical** - Stream critical properties.
g) **Pinch** - Perform multiple heat exchanger analysis.
h) **End** - Must be last command in a file of commands.
i) **Rename-Operation** - Renames an operation already installed in the flowsheet.
j) **Envelope** - Temperature vs pressure phase diagram for any stream.
k) **Get-Dist-Results** - Specify a stream with results from a column run.
l) **ExitDo** - Terminate a do command before count is done.
m) **Oper-Description** - Supply a 60 character description of operations.
n) **Property-Table** - Create a table of dependent and independent variables.
o) **Short-Cut-Dist** - Fenske Underwood distillation calculation.
p) **If** - Controls conditional execution of HYSIM commands.
q) **Case-Description** - Enter up to 20 lines of text description for the case.
r) **STX-ACX** - Run the heat exchanger programs from HTC. STX and ACX are third party optional programs provided by Heat Transfer Consultants.
s) **Depressure** - Pressure vs time Depressuring Unit.
t) **Else** - To be used in conjunction with the IF command.
u) **Do-Command** - Perform a set of commands read from a file.
v) **HTFS** - Create transfer file for M. TASC heat exchanger program from HTFS. A data file will run the M-Tasc heat exchanger programs, which are third party optional programs.
w) **DOS** - Perform a operating system (DOS) command.
x) **Endif** - To end an IF command.
y) **List** - List the contents of a file. Do not use on stored cases.
z) **Tray-Calc** - Utility to transfer column data to Tray-Calc program.
aa) **DelPFD** - Delete PFD.
bb) **User-prop** - Add user properties to the current case.

14) **Size** - When the word Size is highlighted on the Main Menu and the <Enter> key is then pressed, the following screen will appear. The size command allows you to size pipes, pipe segments, columns, towers, separators, solid separators, heat exchangers and LNG heat exchangers.

```
Pipe_Segment        Column      Separator          Heat_Exchanger
Pipe_Size           Tower_Size  Solid_Separator    LNG
Pipe_Segment detailed information for an installed pipe_segment
 What do you wish to size?
>
```

15) **Report** - Highlighting the word Report on the Main Menu and then pressing the <Enter> key will result in the following menu on the screen which allows the user to run a report and to either edit, create or delete the format of the report.

```
Run                 Edit_Format   Create_Format      Delete_Format
Run a report
What would you like to do?
>
```

16) **Toggle** - Highlighting the word Toggle and then pressing the <Enter> key allows you to switch to another case while keeping the current case loaded. The following screen will appear asking you to either create or load a new case into memory, or to toggle to another case which has already been stored.

```
NewCase
NewCase Create or load a new case
Select case
>
```

17) **Exit** - Highlighting the word Exit on the Main Menu and then pressing the <Enter> key will result in the following type of screen, which lists all of the files that have been stored in HYSIM. If you wish to save the case in an old file, highlight that name and then press the <Enter> key. If you wish to save the case in a new file, type the name of the new file, and then press the <Enter> key. If you don't wish to save the file then just type the word "Quit" and then press the <Enter> key.

```
CASESTDY.SIM        PFR.SIM          QIOT.SIM    QIUIT.SIM
QUIY.SIM            ROSTY.SIM        SAMPLE.SIM  TUTORIAL.SIM
Parent_dir\         LLE.PRJ\         VLE.PRJ\    ?
CASESTDY.SIM
 Enter the name of the case to save the result in or Quit
>
```

Instructions: The "print" command in HYSIM is used to print results of calculations by HYSIM to the screen, such as stream summaries and equipment specifications.

In order to print results to the printer, one must specify that they want to use the printer in HYSIM by using the following sequence of commands: first highlighting the word "**print**", (highlighting means using the arrow keys to move the cursor over the particular word which is needed, such as print, and then the block with the word changes color so that the word is then highlighted). The <Enter> key is then pressed. The word "**printer**" is highlighted next, and then the <Enter> key is pressed again.

The "Prt On" will appear on the screen when the above sequence of commands is used. It alerts the HYSIM user to the fact that the printer is now ready to print any results when the Print command is used again. To toggle the printer off, press the ***Print*** *<Enter>* ***Printer*** *<Enter> command sequence again. The "Prt On" label will then disappear.)* The actions to be used to print HYSIM calculation results are shown below: (Note: the print options available while specifying a column operation or sizing a column are different from the options shown below, and are listed in this manual on pages 42, and page 46-47, respectively.)

Step	Action
1	Are you at the HYSIM main menu? • If Yes, go to Step 2. • If No, press the **<Esc>** key enough times until you get to the main menu.
	Printing calculation results to the screen.
2	Highlight the word **Print** and then press the **<Enter>** key;
	The following screen will appear:

```
Streams              Operations          Spec_Sheets    Hypotheticals
Format               Cost                File           Printer
Cases                Description         Oil_Input      ?
Streams flowsheet stream information can be printed
What would you like to print?
>
```

Step	Action
3	Do you wish to send printed results to the printer? • If No, go to step 4. • If Yes, highlight the word **Printer** and then press the **<Enter>** key; *The screen will now appear as shown below.* Then press the word **Print** again and then press the **<Enter>** key. *(to get back to the Print menu shown above).*

```
Work_Sheet           Specify             Operation          Print
PFD                  Remove              Store              New
Ignore               Restore             Hold               Go
Utility              Size                Report             Toggle
Exit                 ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units - Prt On   9879552
>
```

Step	Action
4	Do you wish to print the flowsheet stream information? • If No, go to step 7. • If Yes, highlight the word **Streams** and then press the <**Enter**> key; *The following screen will appear:*

```
Vapour_fraction     Temperature          Pressure          Flow
Enthalpy/Energy     Conditions           Properties        Composition
Note                All                  Phase             Summary
Boiling_Point_Curv  Cold_Properties      Attachments
Vapour_fraction mole fraction vapour in the stream
 Which stream variable do you want to print
>
```

5	Highlight the specification selection which you wish to print from the menu (such as: Pressure) and then press the <**Enter**> key.
	The following screen will then appear:

```
A                    B                    C                    -
A
 Enter the stream(s) to be printed
>
```

6	Highlight the stream name that you want printed, (or if you want all the streams printed highlight the dash (-)), and then press the <**Enter**> key;
7	Do you wish to print the list of unit operations in the flowsheet? • If No, go to step 9. • If Yes, highlight the word **Operations** and then press the <**Enter**> key;
	The following screen will then appear:

```
No1                  No2                  -
No1
 Which operations do you wish printed
>
```

8	Highlight the unit operation name that you want printed, (or if you want all the unit operations printed highlight the dash (-)) and then press the <**Enter**> key;
9	Do you wish to print the Stream, Unit Operation, Flowsheet or Hypothetical specification sheets? (Stream specification sheets will include the physical conditions and properties of a stream. Unit operation specification sheets will formally print out specifications for a unit operation in the flowsheet. Flowsheet specifications details all specifications which were supplied to the flowsheet. Hypothetical specification sheets detail the physical properties of a user-defined hypothetical component in the case.) • If No, go to step 16. • If Yes, highlight the word **Spec_Sheets** and then press the <**Enter**> key;
	The screen will appear as shown on the top of the next page.

```
Streams          Operations          Flowsheet     Hypotheticals
Streams print detailed specification sheets for streams
 What do you wish specifications for ?
>
```

Step	Action
10	Do you want specifications for Streams? • If No, go to Step 12 . • If Yes, highlight **Streams** and then press the <**Enter**> key; *The screen will appear as follows:*

```
A                    B                    C                    E
Energy               F                    -
A
Enter the stream(s) to be printed
>
```

11	Type the name of the stream you wish a Specification sheet for, or if you want them for all the streams, highlight the dash (-) , and then press the <**Enter**> key;
12	Do you want specifications for operations? • If No, go to step 14. • If Yes, highlight the word **Operations** and then press the <**Enter**> key; (*The screen will then appear as follows:*)

```
No1                  No2                  -
No1
 Select the operations to be printed
>
```

13	Type the operation you want printed after the prompt (>) or if you want all the streams printed highlight the dash (-) and then press the <**Enter**> key;
14	Do you want to print specification sheets for a flowsheet? • If No, go to Step 15 . • If Yes, highlight **Flowsheet** and then press the <**Enter**> key;
15	Do you want to print specification sheets for Hypothetical Components? • If No, go to Step 16 . • If Yes, highlight **Hypotheticals** and then press the <**Enter**> key;
16	Do you wish to print a figure or graph which is currently on the screen? • If No, go to Step 20. • If Yes, go to Step 17.
17	Press the <**F2**> key;
18	Highlight the word **Print** and then press the <**Enter**> key;

Step	Action
19	Press the <Insert> key.
20	Do you wish to change the format of the printed results? • If No, press the <Esc> key until you are back at the Main Menu. • If Yes, highlight the word **Format** and then press the <Enter> key and follow the instructions below.

Formatting Instructions: The Format Menu appears below; to make changes to the format of your printout, highlight the appropriate selection on the Format Menu and then press the <Enter> key. The descriptions for each menu selection is given below.

FORMAT MENU

```
Comp_Fractions      Title           Stars          SI
Comp_Flows          Form_Feed       No_Stars       Field
Mole                Width           No_Names       User
Mass                Page            Spread_sheet   Density
LiqVolume           Header          Decimals       Mole_Density
Comp_Fractions print compositions using fractions
 Enter the format control command
>
```

Choose one or more of the following options which refer to different characteristics of the printout.

1) **Comp-Fractions** - The printout of stream compositions will be on a component fraction basis (e.g. mole fraction), which is the default setting.

2) **Title** - A title of your choosing will be printed on all printouts. HYSIM will ask you to input the title that you wish.

3) **Stars** - Stars (asterisks) will be printed beside stream variables which have been specified. All streams calculated by HYSIM will have no stars next to them. This is the default setting.

4) **SI** - The results will be printed in SI (metric) units which are the default units.

5) **Comp-Flows** - The composition of the streams will be reported as component flow rates (e.g. molar flow rate, mass flow rate). The default is Comp-Fractions.

6) **Form_Feed** - Each set of stream information will be printed on a separate sheet.

7) **No-Stars** - Stars (asterisks) will not be printed beside stream variables which have personally been specified by the user. Stars is the default setting.

8) **Field** - The printout will be in Field units (i.e. lbs, lb-mols, °F, psia, etc.) The default is SI or metric units.

9) **Mole** - The composition of the streams will be printed on a molar basis. Comp-Fractions is the default setting.

10) **Width** - Use this command to change the number of streams printed across the page. The maximum number of streams that can be specified across a page is 16. The default value is four streams.

11) **No-Names** - The stream names given by the user to each of the streams used will not be printed. The default is to have the stream names printed.

12) **User** - The printout will be in the units selected by the user. SI or metric units are the default setting.

13) **Mass** - The composition of the streams will be printed on a mass basis. Comp-fractions are the default setting.
14) **Page** - The printer will advance to the top of a new page, when activated with the Print Printer command, and then the screen will be cleared.
15) **Spread sheet** - The output will be printed in a tabular speadsheet form, with all of the text output containing quotation marks around them, making them suitable for import to a spreadsheet program such as Lotus 1-2-3.
16) **Density** - The density and specific heat data will be printed on a mass basis.
17) **Liq-Volume** - The composition information will be reported on a standard ideal liquid volume basis.
18) **Header** - The printer advances to a new page and the case name banner or header will be printed at the top of the page.
19) **Decimals** - The number of decimal places for the stream component compositions can be specified. The default is four decimal places.
20) **Mole-Density** - The density of a stream can be printed out as a mole density.

Step	Action
21	Press the <Esc> key enough times to get back to the Main Menu.

Instructions: The default system of units used by HYSIM is the International System of Units (SI) or what is commonly known as the metric system, e.g. kilograms (kg),°C or K, kilopascals (kPa), etc. If you would like to use field units (e.g. lbs, °F, psia, etc.) you must instruct HYSIM that you wish to use these units. Then the blanks which appear on the various screens that pop-up will be in field units instead of metric units. The following example is for changing the default metric unit system to field units in HYSIM. If you would rather use different units than either of these, specify user defined units.

The following table will step out the procedure to change units in HYSIM. Each step outlines the actions which you must take. Words or items that a HYSIM user must highlight or keys that the user must press are indicated in **bold** typeface. All keys to be pressed are indicated by placing the letters or symbols on the key inside < > brackets. Highlighting means that the HYSIM user should use the arrow keys (<←>,<↑>,<→>, or <↓>) to place the cursor over the word or item indicated so that it is highlighted (changes color). The comments are in *italicized* print.

Step	Action
1	Are you at the Start-up Menu? • If Yes, proceed with Step 2. • If No, proceed to Step 6.
2	Highlight the word **Configuration** and then press the <**Enter**> key;
3	Highlight the word **Units** and then press the <**Enter**> key;
4	Highlight the word **Field** and then press the <**Enter**> key;
5	Press the <**Esc**> key and go to Step 12;
6	Are you at the Main Menu? • If Yes, proceed with Step 7. • If No, press the <Esc> key until you are back to the Main Menu.
7	Highlight the word **Utility** and then press the <**Enter**> key;
8	Highlight the word **Configuration** and then press the <**Enter**> key;
9	Highlight the word **Units** and then press the <**Enter**> key;
10	Highlight the word **Field** and then press the <**Enter**> key;
11	Press the <**Esc**> key;
12	Return to the next step in your case.

CHAPTER 3

UNIT OPERATION EXAMPLES

Chapter 3 contains examples of the following six different types of columns in Section 3.1, plus sections on: Section 3.2 - *Compressors/Expanders*, Section 3.3 - *Heat Exchangers* (Shell and Tube, Single Sided and LNG/ Multi-Pass), Section 3.4 - *Mixers*, Section 3.5 - *Pumps*, Section 3.6 - *Reactors* (Stoichiometric, Equilibrium, Gibbs, Continuously Stirred Tank (CSTR), and Plug Flow), and Section 3.7 - *Separators* (Two-Phase, Three-Phase, and Solids).

3.1.1 Absorber Column

Objective - This exercise is an example of an absorber column calculation. The purpose of the absorber column is to selectively recover a component or components in the gas stream using a liquid medium and a specified number of contact stages, with one or more components being absorbed from the gaseous stream into the liquid medium. The absorber unit operation could also be used for stripping or desorption, where the component or components in the liquid stream would be transferred into the gaseous medium. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, an absorber column has two feed streams. One liquid feed stream, *TEGin*, is triethylene glycol (abbreviated as TEGlycol in HYSIM) and the other feed stream, *Gasin*, is a methane rich gas stream (plus some water and no triethylene glycol). Both feed streams enter the column at 100°F and essentially 1100 psia. The objective is to remove the water from the gas stream, by absorption into the liquid triethylene glycol stream. The bottom stream emitted from the Absorber, named *TEGOut*, contains almost all of the triethylene glycol and water in the system, showing that the water was absorbed by the triethylene glycol rich feed stream. Almost all of the methane was emitted in the *GasOut* stream from the Absorber column.

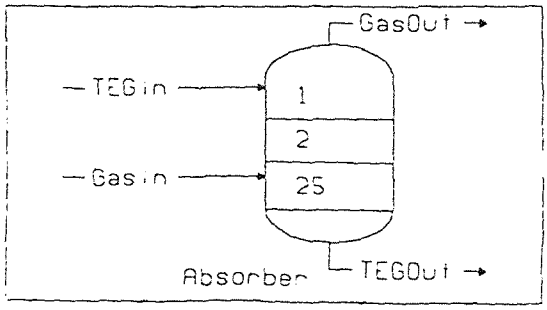
Technical Example Reference: Reference 4 - The paper entitled, "Energy and Emission Optimization of the Glycol Dehydrator Process", by D. G. Colley, W.Y. Svrcek, and Hamish Adam, July 1992, which was presented at the 1992 Gas Research Institute Glycol Dehydrator Air Emission Conference, New Orleans, Louisiana, on July 20-22, 1992.

Other References: Refs. 1 and 2.

Directions - Pages 32 through 49 outline the execution of an absorber column example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

A flow diagram of this unit operation, called *Absorber*, is shown below:



3.1.1 Absorber Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

3.1.1 Absorber Column (continued)

Step	Action
	Selecting the components in the feed streams.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following 19 components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **Benzene** and then press the **<Enter>** key; Highlight the word **Toluene** and then press the **<Enter>** key; Highlight the word **o-Xylene** and then press the **<Enter>** key; Highlight the word **E-Benzene** and then press the **<Enter>** key; Highlight the word **Hydrogen** and then press the **<Enter>** key; Highlight the formula **H2O** and then press the **<Enter>** key; Highlight the word **Helium** and then press the **<Enter>** key; Highlight the word **Nitrogen** and then press the **<Enter>** key; Highlight the formula **CO2** and then press the **<Enter>** key; Highlight the formula **H2S** and then press the **<Enter>** key; Highlight the word **TEGlycol.**
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
n-Butane	CarbondiSulphide	CS2	CS2	ALL
i-Pentane	di-M-Sulphide	diM-Sulphide	C2H6S	HC
n-Pentane	di-M-Sulfoxide	diMSulfoxide	C2H6OS	SOLID
n-Hexane	di-M-diSulphide	diMdiSulphid	C2H6S2	MISC
Benzene	M-E-Sulfide	M-E-Sulfide	C3H8S	AMINE
Toluene	di-E-Sulphide	diE-Sulphide	C4H10S	ALCOHOL
o-Xylene	di-E-diSulphide	diE-diSulphd	C4H10S2	KETONE
E-Benzene	i-P-Sulphide	iP-Sulphide	C6H14S	ALDEHYDE
Hydrogen	HCN	HCN	HCN	ESTER
H2O	NaOH	NaOH	NaOH	CARBACID
Helium	Cyanogen	Cyanogen	C2N2	HALOGEN
Nitrogen	D-M-Formamide	DMF	C3H7NO	NITRILE
CO2	Methanol	Methanol	CH4O	PHENOL
H2S	EG	EGlycol	C2H6O2	ETHER
TEGlycol	Furfural	Furfural	C5H4O2	USER
	R-11	Refrig-11	CCl3F	

Search by SYNONYM

F1 - Help, F4 - Flip Srch, F5 - Exam, F6 - Move,
F3 - Menu, PRESS INSERT TO SUBMIT F8 - Change

3.1.1 Absorber Column (continued)

Step	Action
5	Press the <**Insert**> key;
	The following screen will then appear:

```
Work_Sheet          Specify             Operation       Print
PFD                 Remove              Store           New
Ignore              Restore             Hold            Go
Utility             Size                Report          Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units which appear on the HYSIM forms which pop-up, changed from the default metric system (e.g. °C, kg, kPa, m, etc.) to field units (e.g. °F, lb, psia, ft, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the feed stream, Gasin.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Gasin** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature in °F of the Gasin stream.
14	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Gasin stream in psia.
15	Type the number **1104** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Gasin stream in lb-mols/hr.
16	Type the number **2632** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Gasin stream.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown on the following page.

3.1.1 Absorber Column (continued)

Stream Mole Fractions

Methane		Ethane	
Propane		i-Butane	
n-Butane		i-Pentane	
n-Pentane		n-Hexane	
Benzene		Toluene	
o-Xylene		E-Benzene	
Hydrogen		H2O	
Helium		Nitrogen	
CO2		H2S	
TEGlycol			

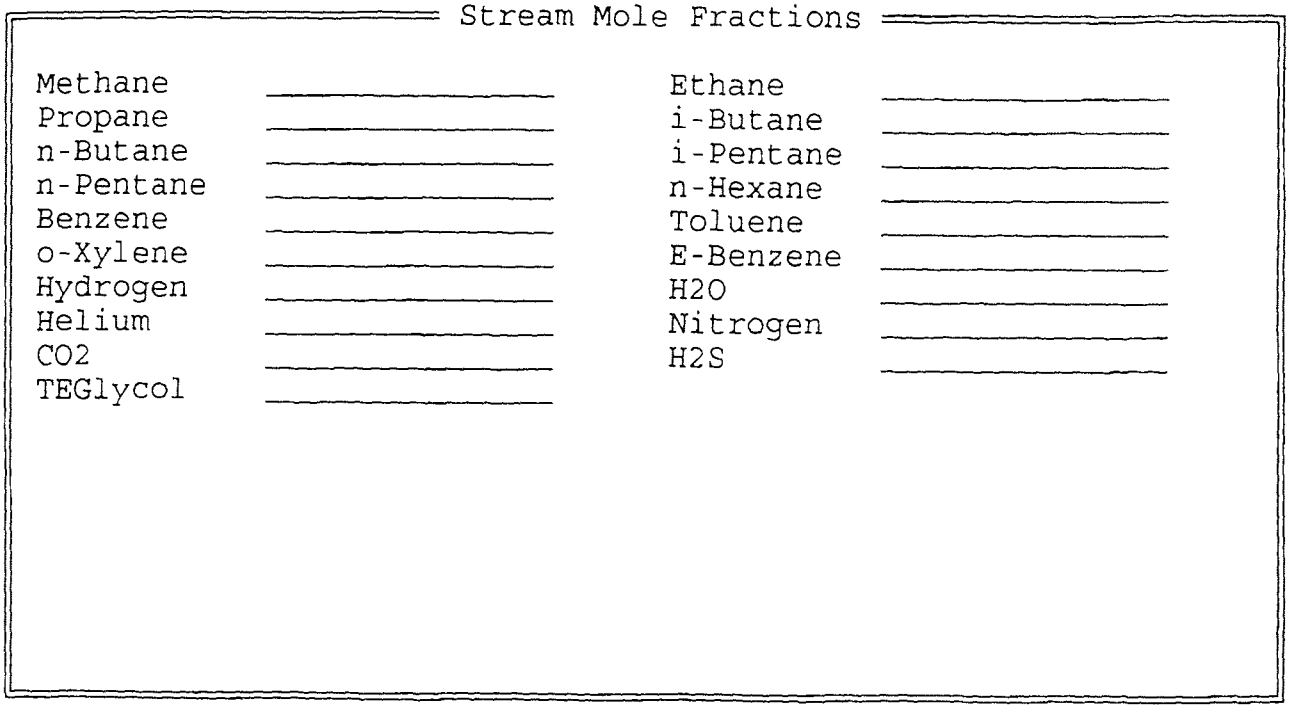
Step	Action
	Selecting the components in the Gasin stream.
18	*Enter the following mole fractions beside each component in the Gasin stream:* After the word, Methane, type the number **0.82774** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.07559** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.02053** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0033** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.00431** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0012** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0009** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0008** in the blank and then press the <**Enter**> key; After the word, Benzene, type the number **0.0004** in the blank and then press the <**Enter**> key; After the word, Toluene, type the number **0.0002** in the blank and then press the <**Enter**> key; After the word, o-Xylene, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, E-Benzene, type the number **0.00005** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0.0001** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.0012** in the blank and then press the <**Enter**> key; After the word, Helium, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **0.00361** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.04075** in the blank and then press the <**Enter**> key; After the formula, H2S, type the number **0.01912** in the blank and then press the <**Enter**> key; After the word, TEGlycol, type the number **0** in the blank;
	The screen will now appear as shown below:

Stream Mole Fractions

Methane	0.82774	Ethane	0.07559
Propane	0.02053	i-Butane	0.0033
n-Butane	0.00431	i-Pentane	0.0012
n-Pentane	0.0009	n-Hexane	0.0008
Benzene	0.0004	Toluene	0.0002
o-Xylene	0.0001	E-Benzene	0.00005
Hydrogen	0.0001	H2O	0.0012
Helium	0.0001	Nitrogen	0.00361
CO2	0.04075	H2S	0.01912
TEGlycol	0		

3.1.1 Absorber Column (continued)

Step	Action
	Specifying the conditions of the TEGin stream.
19	Press the <**Insert**> key;
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Type the word **TEGin** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the TEGin stream in °F.
23	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the TEGin stream in psia.
24	Type the number **1100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the TEGin stream in lb-mols/hr as unknown by typing an "x".
25	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the TEGin stream.
26	Highlight the word **Mole_Fractions** after the prompt and then press the <**Enter**> key;
	The screen will appear as shown below:



3.1.1 Absorber Column (continued)

Step	Action
	Selecting the components in the TEGin stream.
27	*Enter the following mole fractions beside each component in the TEGin stream:* After the word, Methane, type the number **0** in the blank and then press the **<Enter>** key; After the word, Ethane, type the number **0** in the blank and then press the **<Enter>** key; After the word, Propane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Pentane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Pentane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Hexane, type the number **0** in the blank and then press the **<Enter>** key; After the word, Benzene, type the number **0** in the blank and then press the **<Enter>** key; After the word, Toluene, type the number **0** in the blank and then press the **<Enter>** key; After the word, o-Xylene, type the number **0** in the blank and then press the **<Enter>** key; After the word, E-Benzene, type the number **0** in the blank and then press the **<Enter>** key; After the word, Hydrogen, type the number **0** in the blank and then press the **<Enter>** key; After the formula, H2O, type the number **0** in the blank and then press the **<Enter>** key; After the word, Helium, type the number **0** in the blank and then press the **<Enter>** key; After the word, Nitrogen, type the number **0** in the blank and then press the **<Enter>** key; After the formula, CO2, type the number **0** in the blank and then press the **<Enter>** key; After the formula, H2S, type the number **0** in the blank and then press the **<Enter>** key; After the word, TEGlycol, type the number **1** in the blank;
	The screen will now appear as shown below:

Stream Mole Fractions

Methane	0	Ethane	0
Propane	0	i-Butane	0
n-Butane	0	i-Pentane	0
n-Pentane	0	n-Hexane	0
Benzene	0	Toluene	0
o-Xylene	0	E-Benzene	0
Hydrogen	0	H2O	0
Helium	0	Nitrogen	0
CO2	0	H2S	0
TEGlycol	1		

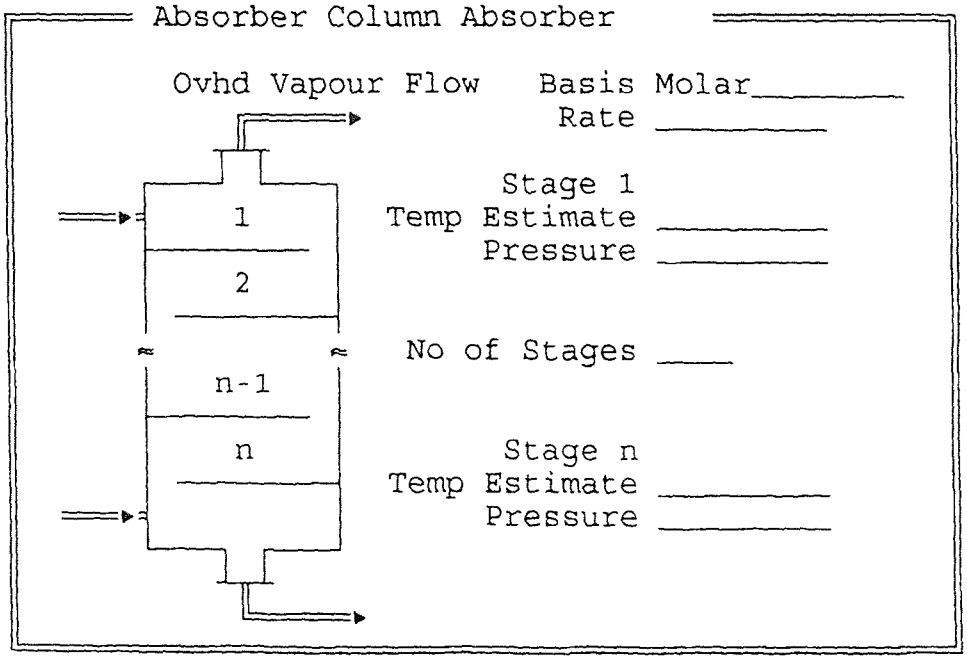
3.1.1 Absorber Column (continued)

Step	Action
28	Press the <**Insert**> key;
29	Highlight the word **Worksheet** and then press the <**Enter**> key;
	Specifying the flow rate of stream TEGin in barrels/day.
30	*Move the cursor using the arrow keys until the cursor is over the LiqVol_Flow row and the TEGin column, then:* Type the number **22.9** and then press the <**Enter**> key.
	The following screen will then appear:

Streams

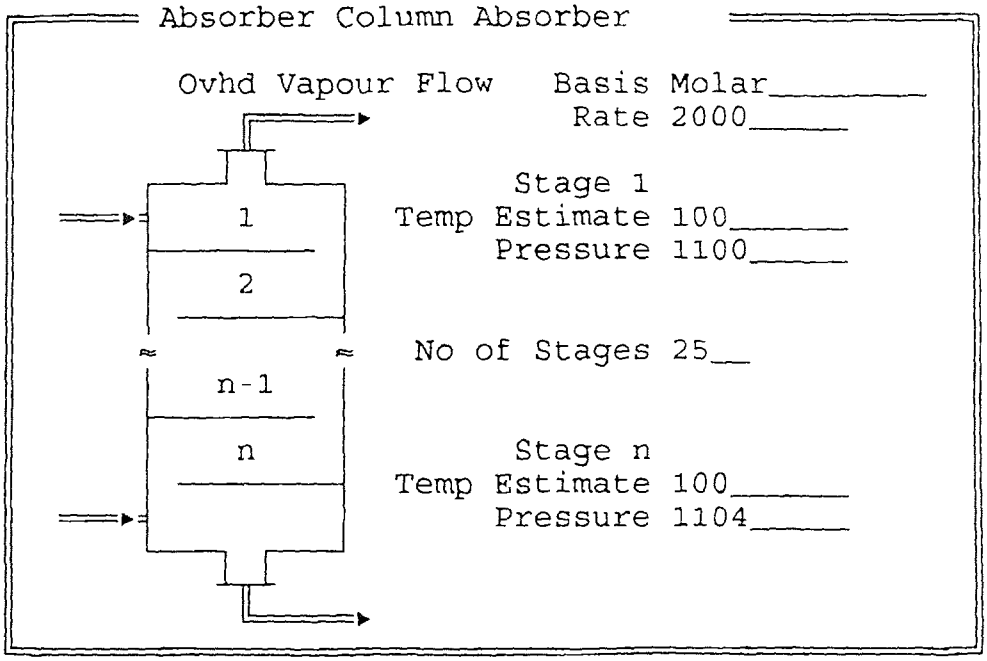
	New Value =		barrel/day	
Stream	Gasin	TEGin	---	---
Vapour_Frac	1.0000	0.0000	---	---
Temperature	100.0000*	100.0000*	---	---
Pressure	1104.0000*	1100.0000*	---	---
Flow	2631.9999*	2.5132	---	---
Mass_Flow	51993.3165	377.3979	---	---
LiqVol_Flow	10250.1186	22.9000*	---	---
Energy_Flow	1.03624E+07	-38549.2240	---	---

Step	Action
	Specifying the type of operation we want to perform on the Gasin and TEGin streams.
31	Press the <**Insert**> key;
32	Type the word **Absorber** and then press the <**Enter**> key;
33	Highlight the word **Column** and then press the <**Enter**> key;
34	Highlight the word **Absorber** and then press the <**Enter**> key;
	The screen will then appear as shown below:



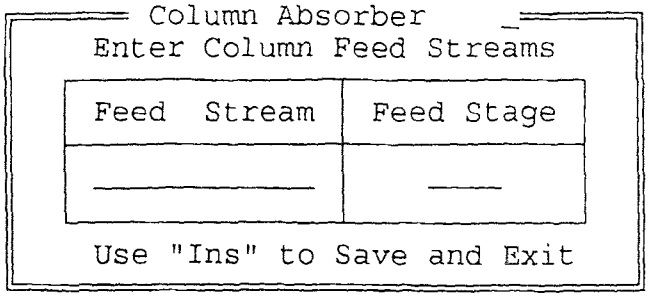
3.1.1 Absorber Column (continued)

Step	Action
	Specifying the known data for the Absorber Column.
35	Press the <**Enter**> key.
	Specifying the Vapor Overhead Rate in lb-mols/hr.
36	Type the number **2000** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 1 in °F.
37	Type the number **100** and then press the <**Enter**> key;
	Specifying the Pressure of Stage 1 in psia.
38	Type the number **1100** and then press the <**Enter**> key;
	Specifying the Number of Stages in the Absorber Column.
39	Type the number **25** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 25 in °F.
40	Type the number **100** and then press the <**Enter**> key;
	Specifying the Pressure of Stage 25 in psia.
41	Type the number **1104**;
	The screen will then appear as shown below:

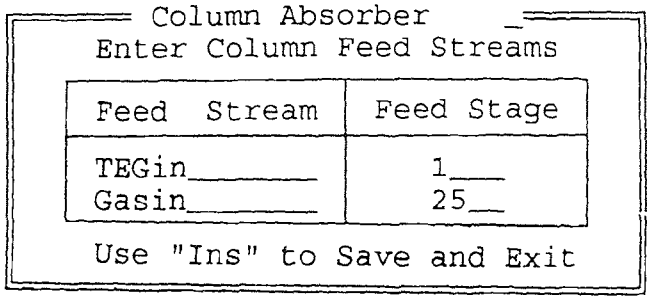


Step	Action
42	Press the <**Insert**> key.
	The screen on the following page for specifying the name of the feed streams and the stage at which they enter the Absorber column will then appear. *("Ins" refers to the <Insert> key)*

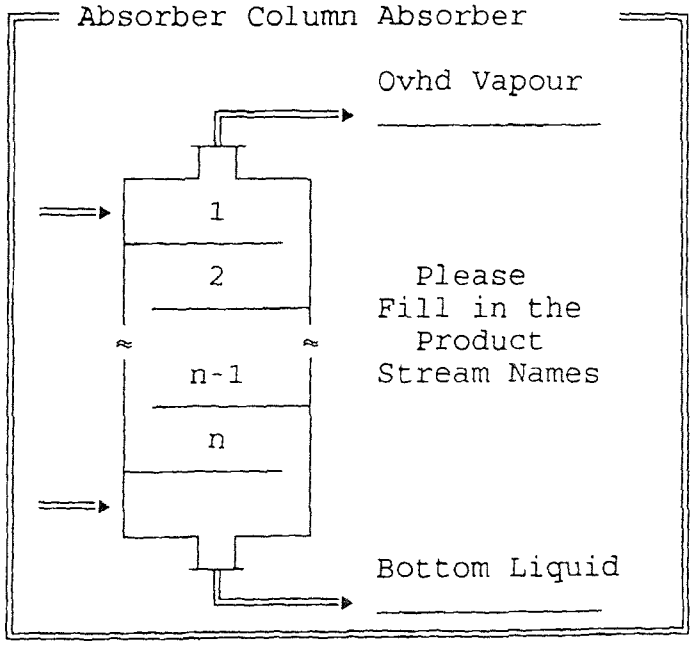
3.1.1 Absorber Column (continued)



Step	Action
	Specifying at what stage the feed stream enters the Absorber Column.
43	Type the word **TEGin** and then press the <**Enter**> key.
44	Type the number **1** and then press the <**Enter**> key.
45	Type the word **Gasin** and then press the <**Enter**> key.
46	Type the number **25**.
	The following screen will then appear:

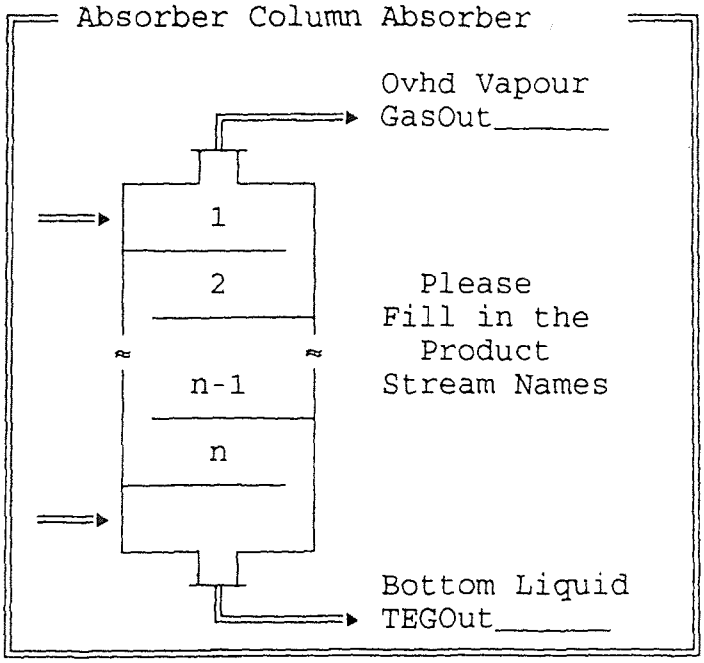


Step	Action
47	Press the <**Insert**> key;
	The following screen will then appear:



3.1.1 Absorber Column (continued)

Step	Action
	Specifying the names of the streams going out of the Absorber Column.
48	Type the word **GasOut** and then press the <**Enter**> key.
49	Type the word **TEGOut**.
	The screen should then appear as shown below.



Step	Action
50	Press the <**Insert**> key.
	The following column menu will then appear:

```
Print                Change               Run                  Restart
Size                 Hold                 Configuration
Print permits printing of both input and output
COLUMN - Prop Pkg PR - Field Units   9879552
>
```

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in nonconvergence of a column calculation which leads to frustration with an input data error.

3.1.1 Absorber Column (continued)

Step	Action
	Running the Absorber Column program.
51	Highlight the word **Run** and then press the <**Enter**> key.
52	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:
The various options available for the column, after you have finished step 52 are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option)
a) *Input* - Input data is printed.
b) *Feeds* - Feed composition and conditions are printed.
c) *Stages* - The temperature, pressure, liquid and vapor flow rates, any feed or drawoffs of each stage are reported, along with the duty of the first and last stage.
d) *Products* - The temperature, pressure, composition, and total flow rate of the overhead and bottom product streams are printed.
e) *Physical_Props* - The molecular weight, flow rate, density, reduced temperature and pressure are reported for each stage.
f) *Transport_Props* - The vapor and liquid dynamic viscosity and thermal conductivity are printed, along with the liquid surface tension.
g) *Exchanger_Profiles* - The condenser and reboiler heating curve data is printed.
h) *Composition* - The composition profile of selected components in the liquid and vapor phase are printed.
i) *Efficiencies* - The efficiency of each stage is printed.
j) *Pumparound_info* - If a pumparound is used, the information can be printed.
k) *All* - All of the information from a to j above will be printed.
l) *Graph* - Temperatures, flowrates, mole fractions or key ratios can be printed in graphical form.
m) *SI* - The current output will be printed in metric units.
n) *Field* - The current output will be printed in Field (or English units).
o) *User* - The current output will be printed in user-defined units.
p) *Comp_Fractions* - The output will be printed on a mole, mass, or volume fractional basis.
q) *Comp_Flows* - The output will be printed as mole, mass or volume flows.
r) *Printer* - The printer will be toggled on. Selecting "Printer" once more will toggle the printer off.
s) *File* - The printout will be saved in a file.
t) *Mole* - The output will be printed on a mole basis.
u) *Mass* - The output will be printed on a mass basis.
v) *LiqVolume* - The output will be printed on a standard ideal liquid volume basis.
w) *Title* - Input a title which will be on all printouts.
x) *Boiling_Pt_Curves* - The True Boiling Point (TBP), D86, or Specific Gravity boiling point curves will be printed out.
y) *Cold_Properties* - The Research Octane Number (RON), Pour Point, and Flash Point will be printed.
z) *User_Props* - If properties have been supplied by the user, these values will be printed out.

3.1.1 Absorber Column (continued)

Step	Action
53	Highlight the word **Feeds** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
54	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

**** Column Feeds ****

Feed Stream Name Enters on stage	TEGin 1	Gasin 25
Vapour Fraction	0.0000	1.0000
Temperature - F	100.00	100.00
Pressure - psia	1100.00	1104.00
Flowrate - lbmole/hr	2.51	2632.00
Enthalpy - Btu/hr	-38549.2	10362446.4
Methane - Mole Frac	0.0000	0.8277
Ethane - Mole Frac	0.0000	0.0756
Propane - Mole Frac	0.0000	0.0205
i-Butane - Mole Frac	0.0000	0.0033
n-Butane - Mole Frac	0.0000	0.0043
i-Pentane - Mole Frac	0.0000	0.0012
n-Pentane - Mole Frac	0.0000	0.0009
n-Hexane - Mole Frac	0.0000	0.0008
Benzene - Mole Frac	0.0000	0.0004
Toluene - Mole Frac	0.0000	0.0002
o-Xylene - Mole Frac	0.0000	9.999E-05
E-Benzene - Mole Frac	0.0000	4.999E-05
Hydrogen - Mole Frac	0.0000	9.999E-05
H2O - Mole Frac	0.0000	0.0012
Helium - Mole Frac	0.0000	9.999E-05
Nitrogen - Mole Frac	0.0000	0.0036
CO2 - Mole Frac	0.0000	0.0408
H2S - Mole Frac	0.0000	0.0191
TEGlycol - Mole Frac	1.0000	0.0000

Step	Action
55	Press the <**F10**> key;
56	Highlight the word **Print** and then press the <**Enter**> key.

The various print options available are shown on page 42.

3.1.1 Absorber Column (continued)

Step	Action
57	Highlight the word **Products** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
58	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

**** Products ****

Leaving from stage Product Phase Assigned to Stream Name	1 Vapour GasOut	25 Liquid TEGOut
Temperature - F	101.61	100.71
Pressure - psia	1100.00	1104.00
Methane - Mole Frac	0.828787	0.011065
Ethane - Mole Frac	0.075683	0.002029
Propane - Mole Frac	0.020555	0.000656
i-Butane - Mole Frac	0.003304	0.000037
n-Butane - Mole Frac	0.004315	0.000055
i-Pentane - Mole Frac	0.001202	8.77E-06
n-Pentane - Mole Frac	0.000901	0.000026
n-Hexane - Mole Frac	0.000801	3.66E-06
Benzene - Mole Frac	0.000398	0.001135
Toluene - Mole Frac	0.000199	0.000548
o-Xylene - Mole Frac	0.000099	0.000370
E-Benzene - Mole Frac	0.000050	0.000125
Hydrogen - Mole Frac	0.000100	5.31E-06
H2O - Mole Frac	6.22E-06	0.531092
Helium - Mole Frac	0.000100	4.45E-06
Nitrogen - Mole Frac	0.003614	0.000353
CO2 - Mole Frac	0.040780	0.009954
H2S - Mole Frac	0.019104	0.017953
TEGlycol - Mole Frac	4.81E-07	0.424581
Total Flow - lbmole/hr	2628.60	5.92

Step	Action
59	Press the <**F10**> key;
60	Highlight the word **Size** and then press the <**Enter**> key
61	Highlight the word **Auto_Section** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page. *(NFP is an abbreviation for Number of Flow Paths).*

3.1.1 Absorber Column (continued)

Auto-Section Information

Tower Internals: valve_tray	
Area Tolerance 0.60	When the ratio between the current calc'd area and either of min/max previous areas for the section exceeds this tol, a new DIAM section is started. Higher, more sections; Lower, fewer sections.
NFP Diam Factor 0.15	When a new number of flow paths will result in a diameter difference >= Diam Factor * old diameter, a new NFP Section is started. Not required for packed columns. Lower, more sections; Higher, fewer sections.

Step	Action
62	Press the <**Insert**> key;
	The screen will then appear as follows:

Valve Tray Input
Section: 1

System Factor: 1.00

Number of Flow Paths: __ (leave blank for maximum)

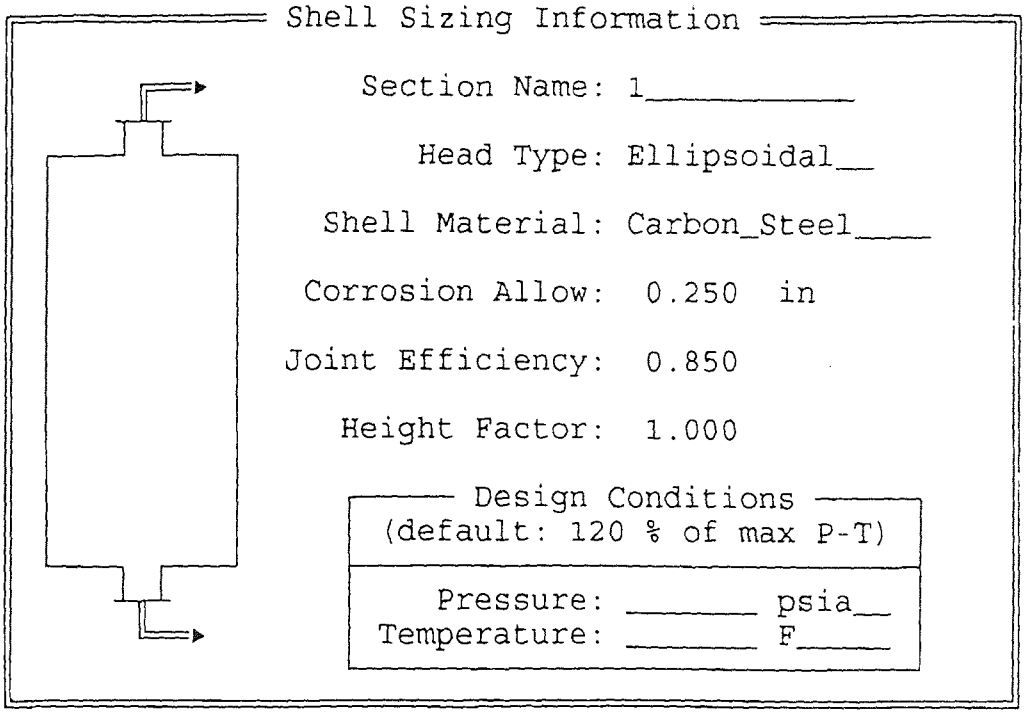
Orifice: Flat___ Tray Spacing: 24.000 in
Manual: Glitsch Max DC Backup: 50.000 %
Max Flooding: 82.000 %
DC Clear: 1.500 in Max Δp/Tray: 4.000 in liq

Weir Ht: 2.000 in Weir: Straight
Loading: 95.999 USGPM/ft DC Type: Vertical
Vlv Dens: 513.158 lb/ft3 Hole Area: 15.300 % of AA
Vlv Thck: 0.060 in Tray Thick: 0.134 in

Material: Carbon_Steel____ Tray Diam: _____ ft
(specify only if rating)

Step	Action
63	Press the <**Insert**> key;
	The screen will then appear as shown on the following page.

3.1.1 Absorber Column (continued)



Step	Action
64	Press the **<Insert>** key;
	The Sizing calculation will begin. At the calculation step for stage 15, the <Enter> key must be pressed to continue calculations for the next section. When calculations have stopped, press the <Enter> key.
65	Press the **<Enter>** key;
	The Sizing calculation will begin again for the next section. At the calculation step for stage 25, the <Enter> key must be pressed to continue calculations for the last stage. When calculations have stopped, press the <Enter> key.
66	Press the **<Enter>** key;
67	Press the **<Esc>** key;
68	Highlight the word **Size** and then press the **<Enter>** key.
69	Highlight the word **Print** and then press the **<Enter>** key.

Print Options:

The print options available for the Sizing calculations are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Summary* - A summary of the calculations will be printed out.
b) *Detailed* - a table of detailed information, including Section performance, dimensions, orifice information, downcomer dimensions, downcomer and weir information, shell information and uninstalled cost estimates will be printed out.
c) *One_Tray* - Detailed information for one tray will be printed out.

3.1.1 Absorber Column (continued)

Print Options (continued):

There are also options available to :
1) have the output printed in metric (*SI*), *Field* or *User*-defined units.
2) have the material printed to the screen also printed to the *printer*.
3) have the printout saved by selecting *File*.

Step	Action
70	Highlight the word **Summary** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
71	Press the <**F10**> key;
	The screen will then appear as seen on the following page. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down. (DC is the abbreviation for downcomer).
	The table shown below will then appear:

COLUMN SIZING SECTION SUMMARY Page - 1

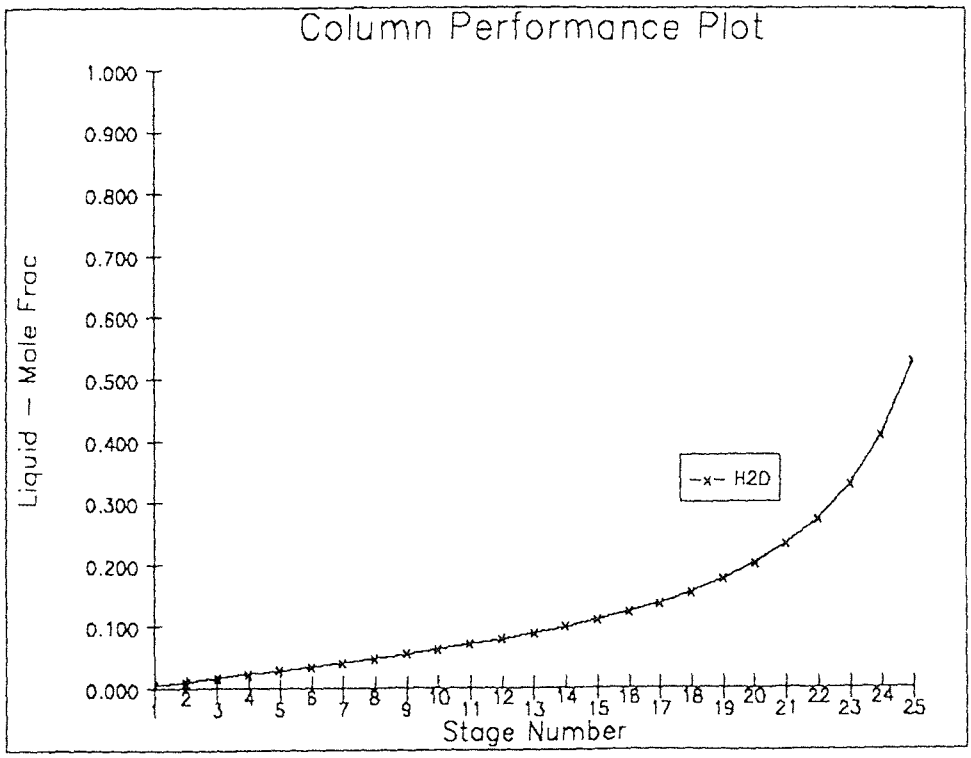
SECTION NAME	Section_1	Section_2	
Stages	1 - 14	16 - 24	
Internals	Valve Tray	Valve Tray	
Diameter	2.000 ft	2.000 ft	
X-sect. Area	3.142 ft2	3.142 ft2	
Section Height	28.000 ft	18.000 ft	
Section DeltaP	2.047 psi	1.314 psi	
Max Flooding	75.136 %	74.872 %	
Max DC Backup	24.043 %	23.964 %	
Max Weir Load	0.689 USGPM/ft	0.732 USGPM/ft	
Max DP/Tray	0.147 psi	0.147 psi	
Active Area	2.936 ft2	2.936 ft2	
DC Area	0.103 ft2	0.103 ft2	
Side DC Width	1.750 in	1.750 in	
Area	0.103 ft2	0.103 ft2	
Cntr DC Width	0.000 in	0.000 in	
Area	0.000 ft2	0.000 ft2	
O.C. DC Width	0.000 in	0.000 in	
Area	0.000 ft2	0.000 ft2	
O.S. DC Width	0.000 in	0.000 in	
Area	0.000 ft2	0.000 ft2	

3.1.1 Absorber Column (continued)

Step	Action
72	Press the <**F10**> key;
73	Press the <**Esc**> key two times;
74	Highlight the word **Print** and then press the <**Enter**> key.

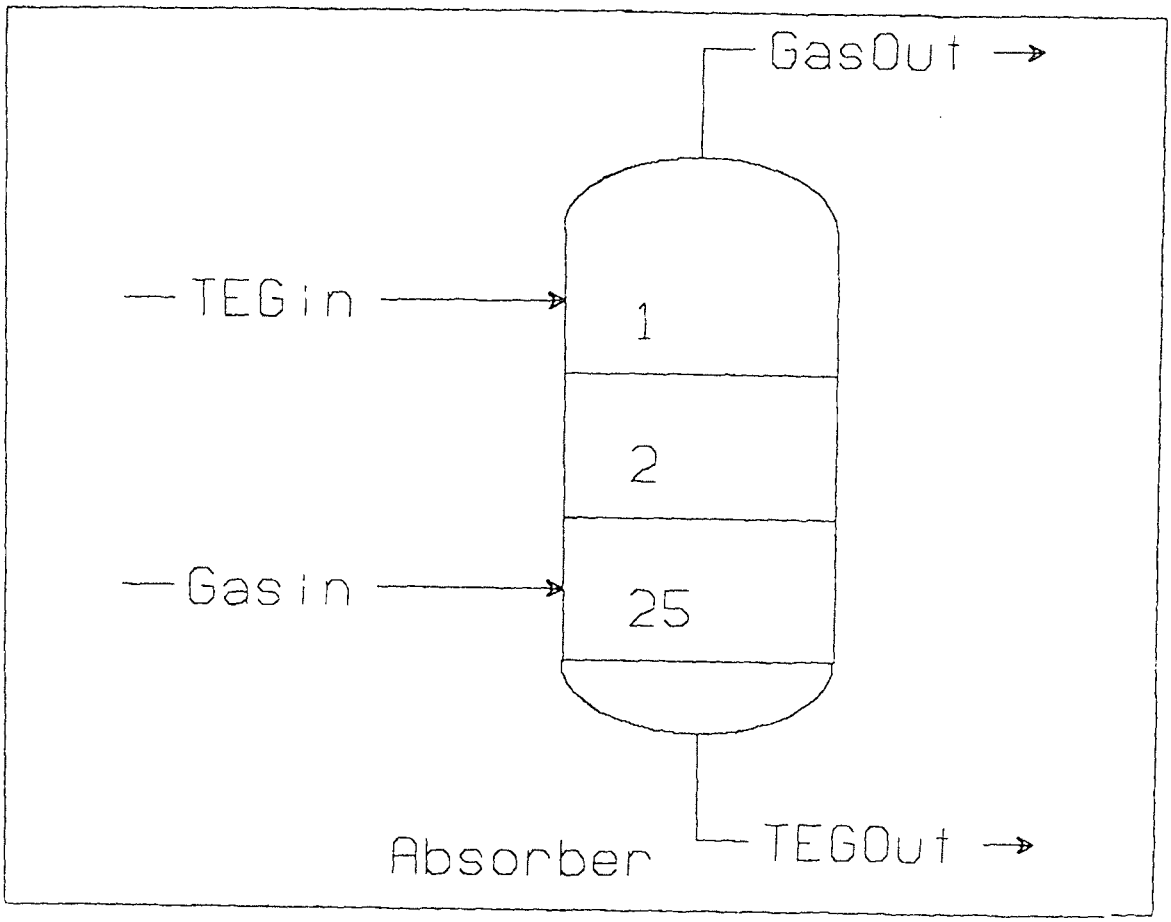
The varous print options available are shown on page 42.

Step	Action
75	Highlight the word **Graph** and then press the <**Enter**> key.
76	Highlight the word **Component** and then press the <**Enter**> key.
77	Highlight the word **Liquid** and then press the <**Enter**> key.
78	Highlight the formula **H2O** and then press the <**Enter**> key.
	The graph shown below will then appear.



3.1.1 Absorber Column (continued)

Step	Action
79	Press the <**Esc**> key four times until you are back at the Main Menu.
80	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



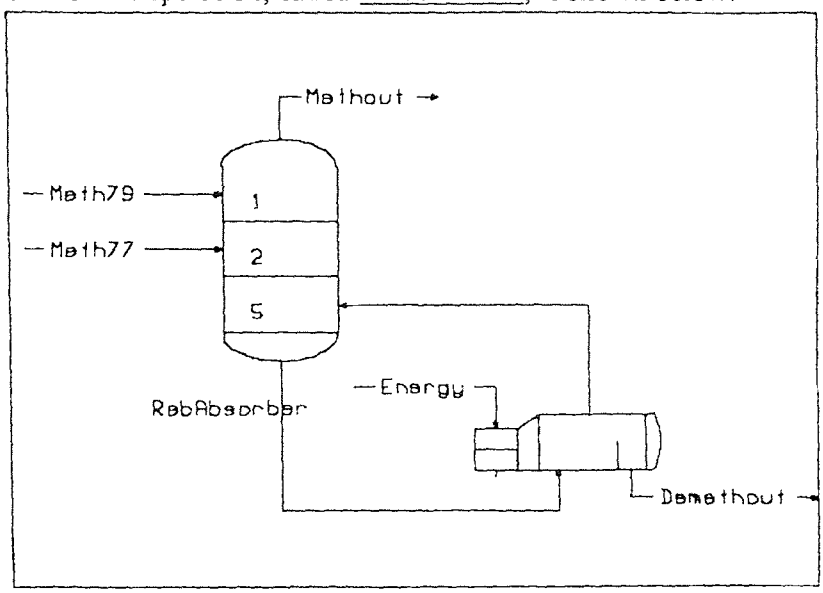
Step	Action
	Getting back to the Main Menu.
81	Press the <**Esc**> key until you reach the Main Menu.
82	Do you want to continue adding other unit operations to this absorber column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.1.2 Reboiled Absorber Column

Objective - This exercise is an example of a reboiled absorber column. The purpose of the absorber column is to separate different components from feed streams using a specified number of contact stages, with one or more components being absorbed from one stream into another. The reboiled absorber unit operation could also be used for reboiled stripping or desorption. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
The reboiled absorber in this exercise is a demethanizer. Two feed streams, *Meth79* and *Meth77*, enter the reboiled absorber column with approximately the same molar fractional composition of methane (0.79 and 0.77, respectively). The two streams leaving the reboiled absorber contain vastly different amounts of methane, however. The overhead product stream, *Methout*, has a mole fraction of methane of 0.959, whereas the bottoms product stream, *Demethout*, contains a mole fraction of methane of only 0.005.
Technical Example Reference: Reference 2 - HYSIM Special Features and Applications Guide, Version C2.50, March 1994, pages GP-1 to GP-6.
Other References: Refs. 1 & 2.

Directions - Pages 51 through 62 outline the execution of a reboiled absorber column example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.
Follow the Action Step instructions below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

A flow diagram of this unit operation, called *RebAbsorber*, is shown below:



3.1.2 Reboiled Absorber Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

3.1.2 Reboiled Absorber Column (continued)

Step	Action
	Selecting the components in the feed streams.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **Nitrogen** and then press the **<Enter>** key; Highlight the formula **CO2** and then press the **<Enter>** key;
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	SO3	SO3	SO3	ALL
Ethane	CO	CO	CO	HC
Propane	Sulphur_Rhombic	S_Rhombic	S	SOLID
i-Butane	Sulphur_Monoclinic	S_Monoclinic	S	MISC
n-Butane	Sulphur_Amorphous	S_Amorphous	S	AMINE
i-Pentane	Sulphur_Liq_150	S_Liq_150	S	ALCOHOL
n-Pentane	Sulphur_Liq_190	S_Liq_190	S	KETONE
n-Hexane	Sulphur_Liq_280	S_Liq_280	S	ALDEHYDE
Nitrogen	Sulphur_Vapour	S_Vapour	S	ESTER
CO2	Carbon	Carbon	C	CARBACID
	H2S	H2S	H2S	HALOGEN
	CarbonOxiSulphide	COS	COS	NITRILE
	CarbondiSulphide	CS2	CS2	PHENOL
	di-M-Sulphide	diM-Sulphide	C2H6S	ETHER
	di-M-Sulfoxide	diMSulfoxide	C2H6OS	USER
	di-M-diSulphide	diMdiSulphid	C2H6S2	

Search by SYNONYM

F1 - Help,F3 - Menu,F4 - Flip Srch, F5 - Exam,F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

3.1.2 Reboiled Absorber Column (continued)

Step	Action
5	Press the <**Insert**> key;
	The following screen will then appear:

```
Work_Sheet          Specify          Operation        Print
PFD                 Remove           Store            New
Ignore              Restore          Hold             Go
Utility             Size             Report           Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the Meth79 stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the name **Meth79** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Meth79 stream in °F.
14	Type the symbol and number **-142** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Meth79 stream in psia.
15	Type the number **330** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Meth79 stream in lb-mols/hr.
16	Type the number **6.1343** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Meth79 stream will be given in mole fractions.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
                    Stream Mole Fractions

Methane     _____________      Ethane      _____________
Propane     _____________      i-Butane    _____________
n-Butane    _____________      i-Pentane   _____________
n-Pentane   _____________      n-Hexane    _____________
Nitrogen    _____________      CO2         _____________
```

3.1.2 Reboiled Absorber Column (continued)

Step	Action
	Selecting the components in the Meth79 stream.
18	*Enter the following mole fractions beside each component in the Meth79 stream:* After the word, Methane, type the number **0.7885** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1678** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0310** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0025** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0013** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0003** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **0.0034** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0051** in the blank;
	The screen will now appear as shown below:

```
                    Stream Mole Fractions

Methane     0.7885_____          Ethane      0.1678_____
Propane     0.0310_____          i-Butane    0.0025_____
n-Butane    0.0013_____          i-Pentane   0.0003_____
n-Pentane   0.0001_____          n-Hexane    0_____
Nitrogen    0.0034_____          CO2         0.0051_____
```

Step	Action
	Specifying the conditions of the Meth77 stream.
19	Press the <**Insert**> key;
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Type the name **Meth77** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Meth77 stream in °F.
23	Type the symbol and number **-136** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Meth77 in psia.
24	Type the number **330** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Meth77 stream in lb-mols/hr.
25	Type the number **21.2984** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Meth77 stream will be given in mole fractions.
26	Highlight the word **Mole_Fractions** after the prompt (>) and then press the <**Enter**> key;
	The screen will appear as shown below:

```
                    Stream Mole Fractions

Methane     _____________        Ethane      _____________
Propane     _____________        i-Butane    _____________
n-Butane    _____________        i-Pentane   _____________
n-Pentane   _____________        n-Hexane    _____________
Nitrogen    _____________        CO2         _____________
```

3.1.2 Reboiled Absorber Column (continued)

Step	Action
	Selecting the components in the Meth77 stream.
27	*Enter the following mole fractions beside each component in the Meth77 stream:* After the word, Methane, type the number **0.7650** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1379** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0594** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0115** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0090** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0046** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0028** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0014** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **0.0047** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0037** in the blank;
	The screen will now appear as shown below:

Stream Mole Fractions

Methane	0.7650	Ethane	0.1379
Propane	0.0594	i-Butane	0.0115
n-Butane	0.0090	i-Pentane	0.0046
n-Pentane	0.0028	n-Hexane	0.0014
Nitrogen	0.0047	CO2	0.0037

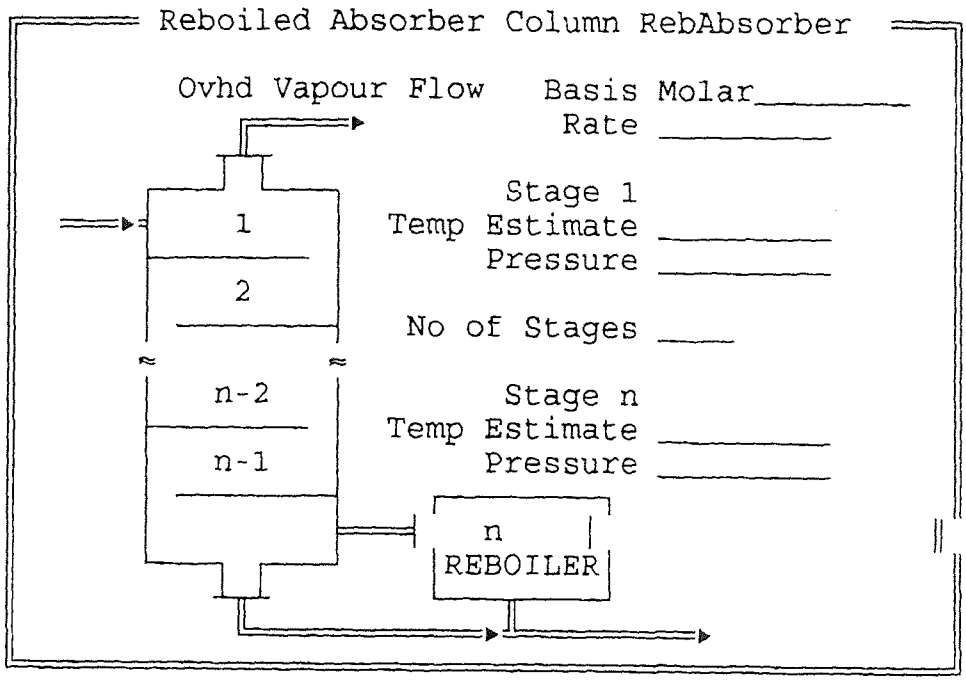
Step	Action
28	Press the <**Insert**> key;
29	Highlight the word **Worksheet** and then press the <**Enter**> key;
	The following screen will then appear:

Streams

	New Value =			
Stream	Meth79	Meth77	---	---
Vapour_Frac	0.0154	0.2577	---	---
Temperature	-142.0000*	-136.0000*	---	---
Pressure	330.0000*	330.0000*	---	---
Flow	6.1343*	21.2984*	---	---
Mass_Flow	120.4285	451.0878	---	---
LiqVol_Flow	25.1851	89.4009	---	---
Energy_Flow	-6150.4075	-12826.1786	---	---

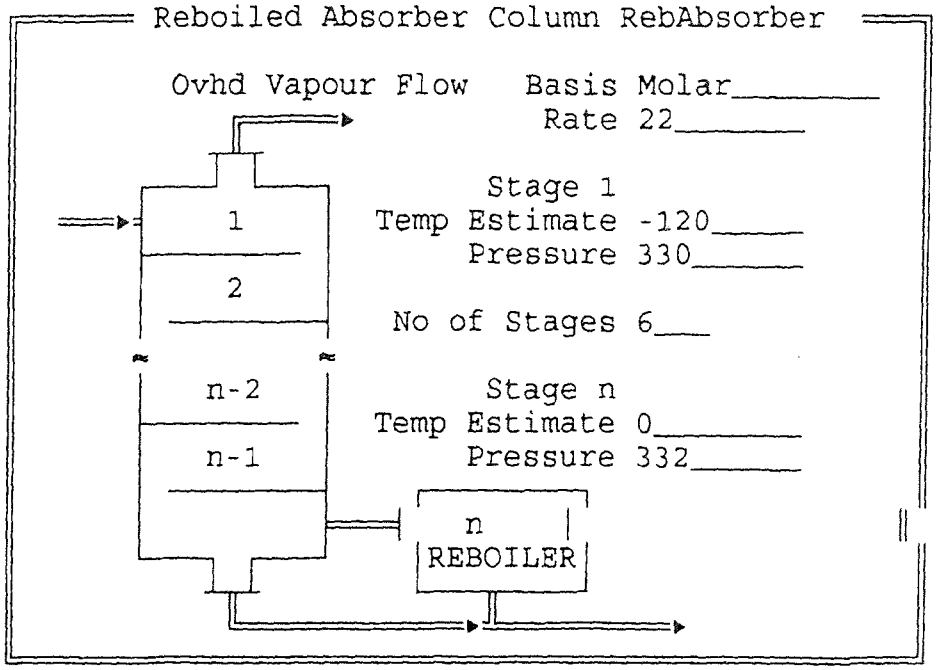
Step	Action
	Specifying the type of operation we want to perform on the Meth77 and Meth79 streams.
30	Press the <**Insert**> key;
31	Type the word **RebAbsorber** and then press the <**Enter**> key;
32	Highlight the word **Column** and then press the <**Enter**> key;
33	Highlight the word **Reboiled_absorber** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.1.2 Reboiled Absorber Column (continued)

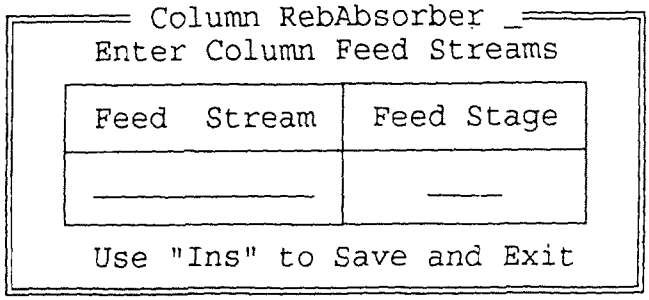


Step	Action
	Specifying the known data for the reboiled absorber column.
34	Press the **<Enter>** key.
	Specifying the Vapor Overhead Rate in lb-mols/hr.
35	Type the number **22** and then press the **<Enter>** key;
	Specifying the Temperature Estimate of Stage 1 in °F.
36	Type the number **-120** and then press the **<Enter>** key;
	Specifying the Pressure of Stage 1 in psia.
37	Type the number **330** and then press the **<Enter>** key;
	Specifying the Number of Stages in the Absorber Column.
38	Type the number **6** and then press the **<Enter>** key;
	Specifying the Temperature Estimate of Stage 6 in °F.
39	Type the number **0** and then press the **<Enter>** key;
	Specifying the Pressure of Stage 6 in psia.
40	Type the number **332**;
	The screen will then appear as on the following page.

3.1.2 Reboiled Absorber Column (continued)

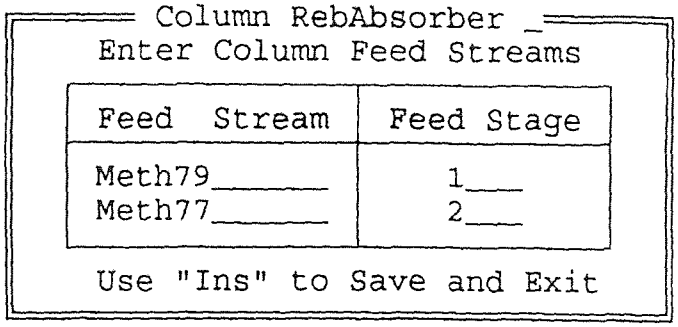


Step	Action
41	Press the <**Insert**> key.
	The following screen for specifying the name of the feed streams and the stage at which they enter the Reboiled Absorber column will then appear:

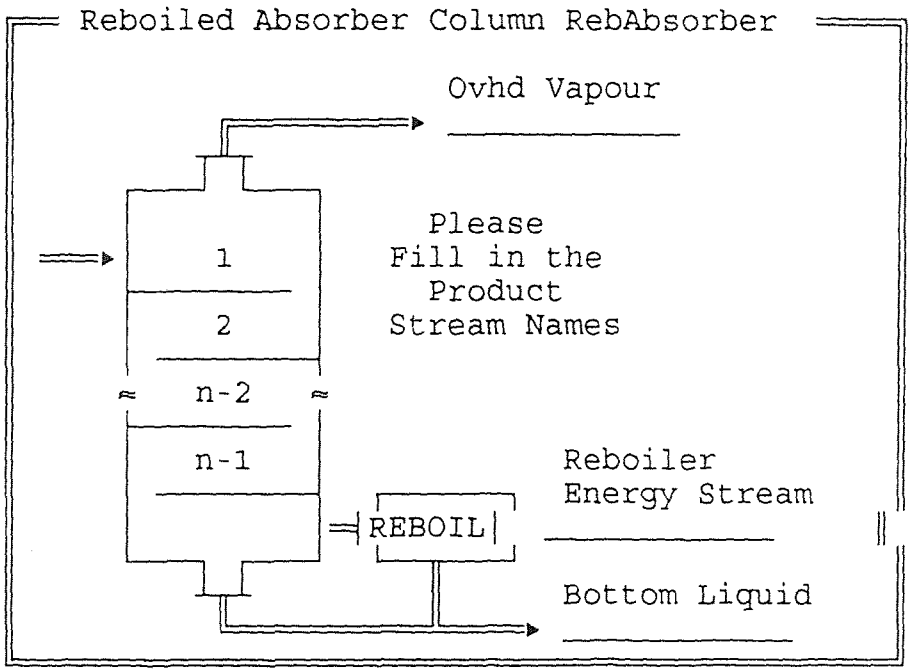


Step	Action
	Specifying at what stage the feed streams enter the Absorber Column.
42	Type the word **Meth79** and then press the <**Enter**> key.
43	Type the number **1** and then press the <**Enter**> key.
44	Type the word **Meth77** and then press the <**Enter**> key.
45	Type the number **2**.
	The screen shown on the following page will then appear.

3.1.2 Reboiled Absorber Column (continued)

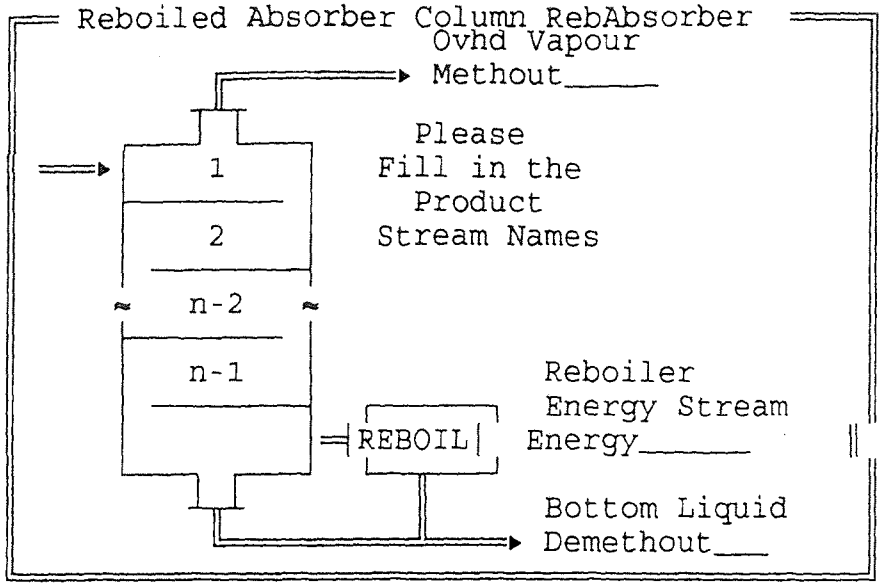


Step	Action
46	Press the <**Insert**> key;
	The following screen will then appear: (Two feed streams should show).



Step	Action
	Specifying the names of the streams coming out of the reboiled absorber column.
47	Type the word **Methout** and then press the <**Enter**> key.
48	Type the word **Energy** and then press the <**Enter**> key.
49	Type the word **Demethout**.
	The screen should then appear as shown on the following page.(Two feed streams should show).

3.1.2 Reboiled Absorber Column (continued)



Step	Action
50	Press the <**Insert**> key.

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in non-convergence of a column calculation which leads to frustration with an input data error.

Step	Action
	Running the Reboiled Absorber Column program.
51	Highlight the word **Run** and then press the <**Enter**> key.
52	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:

The various options available for the column, after you have finished step 52 are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Input* - Input data is printed.

b) *Feeds* - Feed composition and conditions are printed.

c) *Stages* - The temperature, pressure, liquid and vapor flow rates, any feed or drawoffs of each stage are reported, along with the duty of the first and last stage.

d) *Products* - The temperature, pressure, composition, and total flow rate of the overhead and bottom product streams are printed.

e) *Physical_Props* - The molecular weight, flow rate, density, reduced temperature and pressure are reported for each stage.

f) *Transport_Props* - The vapor and liquid dynamic viscosity and thermal conductivity are printed, along with the liquid surface tension.

g) *Exchanger_Profiles* - The condenser and reboiler heating curve data is printed.

h) *Composition* - The composition profile of selected components in the liquid and vapor phase are printed.

i) *Efficiencies* - The efficiency of each stage is printed.

3.1.2 Reboiled Absorber Column (continued)

Print Options (continued):

j) *Pumparound_info* - If a pumparound is used, the information can be printed.
k) *All* - All of the information from a to j above will be printed.
l) *Graph* - Temperatures, flowrates, mole fractions or key ratios can be printed in graphical form.
m) *SI* - The current output will be printed in metric units.
n) *Field* - The current output will be printed in Field (or English units).
o) *User* - The current output will be printed in user-defined units.
p) *Comp_Fractions* - The output will be printed on a mole, mass, or volume fractional basis.
q) *Comp_Flows* - The output will be printed as mole, mass or volume flows.
r) *Printer* - The printer will be toggled on. Selecting "Printer" once more will toggle the printer off.
s) *File* - The printout will be saved in a file.
t) *Mole* - The output will be printed on a mole basis.
u) *Mass* - The output will be printed on a mass basis.
v) *LiqVolume* - The output will be printed on a standard ideal liquid volume basis.
w) *Title* - Input a title which will be on all printouts.
x) *Boiling_Pt_Curves* - The True Boiling Point (TBP), D86, or Specific Gravity boiling point curves will be printed out.
y) *Cold_Properties* - The Research Octane Number (RON), Pour Point, and Flash Point will be printed.
z) *User_Props* - If properties have been supplied by the user, these values will be printed out.

Step	Action
53	Highlight the word **Feeds** and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
54	Press the **<F10>** key;
	The screen will then appear as shown below: Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

**** Column Feeds ****

Feed Stream Name Enters on stage		Meth79 1	Meth77 2
Vapour Fraction		0.0154	0.2577
Temperature	- F	-142.00	-136.00
Pressure	- psia	330.00	330.00
Flowrate	- lbmole/hr	6.13	21.30
Enthalpy	- Btu/hr	-6150.4	-12826.2
Methane	- Mole Frac	0.7885	0.7650
Ethane	- Mole Frac	0.1678	0.1379
Propane	- Mole Frac	0.0310	0.0594
i-Butane	- Mole Frac	0.0025	0.0115
n-Butane	- Mole Frac	0.0013	0.0090
i-Pentane	- Mole Frac	0.0003	0.0046
n-Pentane	- Mole Frac	9.999E-05	0.0028
n-Hexane	- Mole Frac	0.0000	0.0014
Nitrogen	- Mole Frac	0.0034	0.0047
CO2	- Mole Frac	0.0051	0.0037

3.1.2 Reboiled Absorber Column (continued)

Step	Action
55	Press the <**F10**> key;
56	Highlight the word **Print** and then press the <**Enter**> key.

The various print options are shown on pages 59-60.

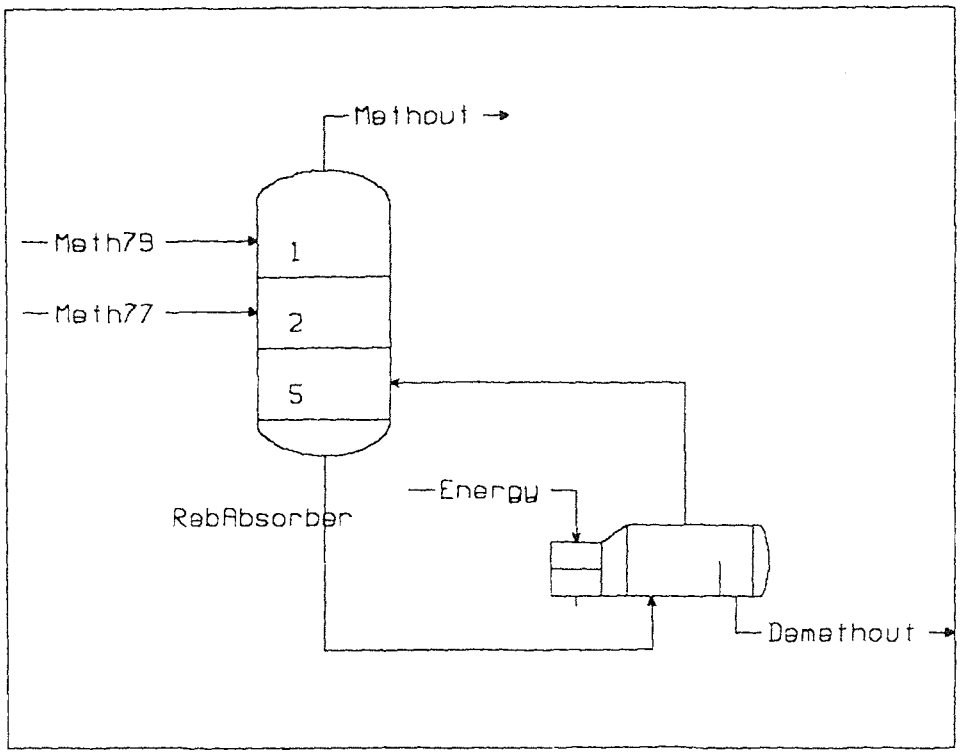
Step	Action
57	Highlight the word **Products** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
58	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

**** Products ****

Leaving from stage Product Phase Assigned to Stream Name	1 Vapour Methout	6 Liquid Demethout
Temperature - F	-128.05	64.00
Pressure - psia	330.00	332.00
Methane - Mole Frac	0.959229	0.005022
Ethane - Mole Frac	0.030364	0.607117
Propane - Mole Frac	0.000637	0.265288
i-Butane - Mole Frac	0.000012	0.047856
n-Butane - Mole Frac	3.65E-06	0.036736
i-Pentane - Mole Frac	2.10E-07	0.018371
n-Pentane - Mole Frac	4.18E-08	0.011090
n-Hexane - Mole Frac	0.000000	0.005488
Nitrogen - Mole Frac	0.005498	9.37E-08
CO2 - Mole Frac	0.004255	0.003032
Total Flow - lbmole/hr	22.00	5.43

3.1.2 Reboiled Absorber Column (continued)

Step	Action
59	Press the <**F10**> key;
60	Press the <**Esc**> key until you are back at the Main Menu.
61	Highlight the letters **PFD** and then press the <**Enter**> key.
	The screen similar to the following one will then appear:

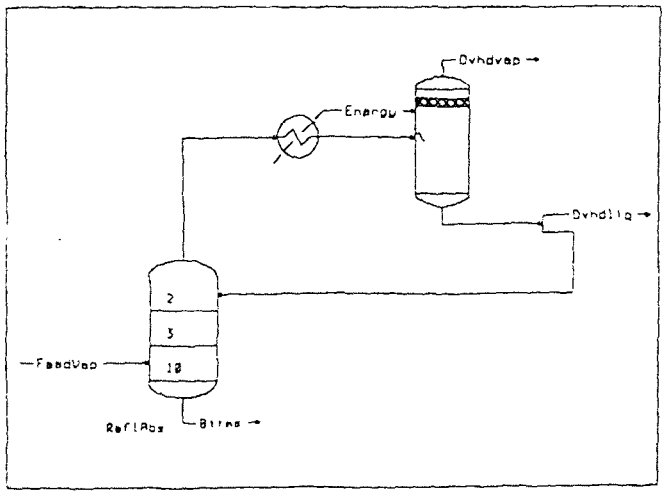


Step	Action
	Getting back to the Main Menu.
62	Press the <**Esc**> key until you reach the Main Menu.
63	Do you want to continue adding other unit operations to this reboiled absorber column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.1.3 Refluxed Absorber Column

Objective - This exercise is an example of an absorber column with a pump back reflux stream. The purpose of the absorber column is to separate different components from feed streams using a specified number of contact stages with one or more components being absorbed from one stream into another. The refluxed absorber unit operation could also be used for refluxed stripping or desorption. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
This exercise for a refluxed absorber has a vapor oil feed stream at 740°F and 0.39 psia. The True Boiling Point (TBP) data for this oil assay is inputted into the HYSIM program. HYSIM then cuts and blends the oil. Each cut is then given a different component name by HYSIM. The refluxed absorber is used to separate the higher boiling point components which are emitted in the bottoms (*Btms*) stream, from the components with a middle or lower boiling point range. The middle range boiling point components come off mainly in the distillate (*Ovhdliq*) stream. The lower boiling point components are emitted in the overhead (*Ovhdvap*) stream.
Technical Example Reference: Reference 2 - HYSIM Special Features and Applications Guide, Version C2.50, dated March 1994, pages R-8 to R-14.
Other References: Refs. 1 & 2.

Directions - Pages 64 through 77 outline the execution of a refluxed absorber column example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.
Follow the Action Step instructions below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.
A process flow diagram of this refluxed absorber operation, called *ReflAbs*, is shown below:



3.1.3 Refluxed Absorber Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

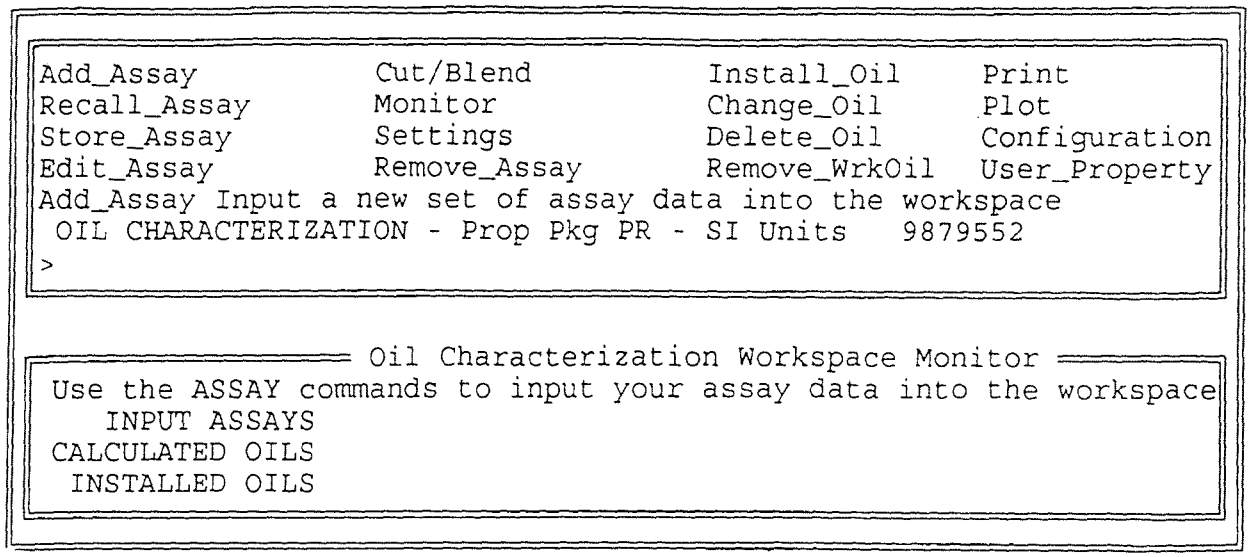
Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

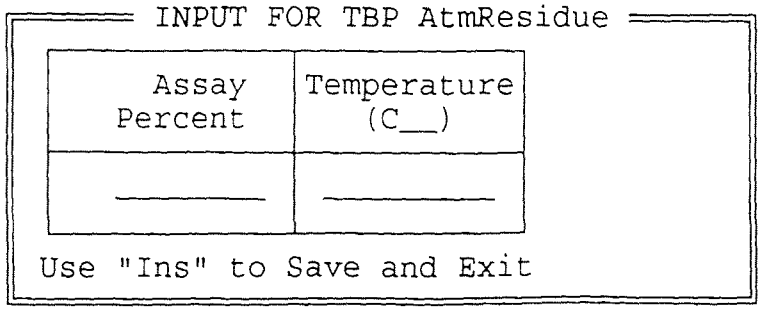
F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream. Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column.
4	Highlight the word **Oil** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.1.3 Refluxed Absorber Column (continued)



Step	Action
	Inputting a new set of oil assay data.
5	Highlight the word **Add_Assay** and then press the <**Enter**> key;
	Naming the new oil.
6	Type the word **AtmResidue** and then press the <**Enter**> key;
	Specifying that the type of data which will be put into the program for the oil is TBP (True Boiling Point) data.
7	Highlight the letters **TBP** and then press the <**Enter**> key;
	Specifying that no data options are required and that input is on a liquid volume basis.
8	Highlight the word **None** and then press the <**Enter**> key;
	The following screen will then appear:



3.1.3 Refluxed Absorber Column (continued)

Step	Action
	Specifying that the TBP data is in °F and not °C.
9	Type the letter **F** and then press the **<Enter>** key;
	Inputting the TBP assay for the AtmResidue oil.
10	Type the number **0** and then press the **<Enter>** key;
11	Type the number **436.0** and then press the **<Enter>** key;
12	Type the number **5** and then press the **<Enter>** key;
13	Type the number **646.4** and then press the **<Enter>** key;
14	Type the number **10** and then press the **<Enter>** key;
15	Type the number **724.7** and then press the **<Enter>** key;
16	Type the number **20** and then press the **<Enter>** key;
17	Type the number **818.7** and then press the **<Enter>** key;
18	Type the number **30** and then press the **<Enter>** key;
19	Type the number **885.6** and then press the **<Enter>** key;
20	Type the number **40** and then press the **<Enter>** key;
21	Type the number **947.0** and then press the **<Enter>** key;
22	Type the number **50** and then press the **<Enter>** key;
23	Type the number **998.0** and then press the **<Enter>** key;
24	Type the number **60** and then press the **<Enter>** key;
25	Type the number **1035.6** and then press the **<Enter>** key;
26	Type the number **70** and then press the **<Enter>** key;
27	Type the number **1067.4** and then press the **<Enter>** key;
28	Type the number **80** and then press the **<Enter>** key;
29	Type the number **1096.4** and then press the **<Enter>** key;
30	Type the number **90** and then press the **<Enter>** key;
31	Type the number **1124.5** and then press the **<Enter>** key;
32	Type the number **100** and then press the **<Enter>** key;
33	Type the number **1154.2**;
	The following screen will then appear:

INPUT FOR TBP AtmResidue

Assay Percent	Temperature (F__)
0	436.0
5	646.4
10	724.7
20	818.7
30	885.6
40	947.0
50	998.0
60	1035.6
70	1067.4
80	1096.4
90	1124.5
100	1154.2

Use "Ins" to Save and Exit

3.1.3 Refluxed Absorber Column (continued)

Step	Action
34	Press the <**Insert**> key;
	The following screen will then appear:

```
                    Bulk Oil Properties

    Molecular Weight : _____________
Mass Density [ kg/m3]: _____________
         Watson UOPK : _____________
Viscosity  1 [    cP]: _____________   Viscosity Temp. 1:    37.78___
Viscosity  2 [    cP]: _____________   Viscosity Temp. 2:    98.89___


** Note ** Bulk properties are required only if a distillation
           curve is not available, if the first three bulk properties
           are supplied MW and density will take precedence
```

Step	Action
	Specifying that no bulk properties of the oil will be provided.
35	Press the <**Insert**> key;
	Specifying that you want HYSIM to cut and blend the oil.
36	Highlight the words **Cut/Blend** and then press the <**Enter**> key;
	Specifying that the cut should be done automatically based on recommended cut ranges.
37	Highlight the word **Auto_Cut** and then press the <**Enter**> key;
	Specifying that the oil AtmResidue should be installed into the current HYSIM case.
38	Highlight the word **Install_Oil** and then press the <**Enter**> key;
	Naming the stream which represents the AtmResidue oil in the flowsheet as Feed.
39	Type the word **FeedVap** and then press the <**Enter**> key;
	The following screen will then appear:

```
Add_Assay          Cut/Blend          Install_Oil        Print
Recall_Assay       Monitor            Change_Oil         Plot
Store_Assay        Settings           Delete_Oil         Configuration
Edit_Assay         Remove_Assay       Remove_WrkOil      User_Property
Add_Assay Input a new set of assay data into the workspace
 OIL CHARACTERIZATION - Prop Pkg PR - SI Units   9879552
>

                Oil Characterization Workspace Monitor
 All of your oils are installed so it looks like you are done! ESC to quit
    INPUT ASSAYS AtmResidue
 CALCULATED OILS AtmResidue
  INSTALLED OILS [1]_AtmResidue
```

3.1.3 Refluxed Absorber Column (continued)

Step	Action
	Getting back to the Main Menu.
40	Press the <**Esc**> key;
	The following screen will then appear:

```
Work_Sheet          Specify          Operation          Print
PFD                 Remove           Store              New
Ignore              Restore          Hold               Go
Utility             Size             Report             Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>

 Your selected components are
NBP[1]_232     NBP[1]_246     NBP[1]_261  NBP[1]_275  NBP[1]_290
NBP[1]_304     NBP[1]_318     NBP[1]_334  NBP[1]_347  NBP[1]_362
NBP[1]_377     NBP[1]_391     NBP[1]_406  NBP[1]_420  NBP[1]_441
NBP[1]_469     NBP[1]_498     NBP[1]_526  NBP[1]_554  NBP[1]_582
NBP[1]_609
```

Step	Action
	Specifying that you want the units changed from the default metric system units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
41	Highlight the word **Utility** and then press the <**Enter**> key;
42	Highlight the word **Configuration** and then press the <**Enter**> key;
43	Highlight the word **Units** and then press the <**Enter**> key;
44	Highlight the word **Field** and then press the <**Enter**> key;
	Returning to the Main Menu.
45	Press the <**Esc**> key.
	Specifying the conditions of the FeedVap stream.
46	Highlight the word **Specify** and then press the <**Enter**> key;
47	Highlight the word **Stream** and then press the <**Enter**> key;
48	Highlight the word **FeedVap** and then press the <**Enter**> key;
	Specifying the temperature of the FeedVap stream in °F.
49	Type the number **1500** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the FeedVap stream in psia.
50	Type the number **2** after the prompt (>) and then press the <**Enter**> key;

3.1.3 Refluxed Absorber Column (continued)

Step	Action
	Specifying the flow of the FeedVap stream in lb-mols/hr.
51	Type the number **1391.9788** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the compositions of each component in the FeedVap stream will be given in mole fractions.
52	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

Stream Mole Fractions

NBP[1]_232	0.0099	NBP[1]_246	0.0104
NBP[1]_261	0.0108	NBP[1]_275	0.0111
NBP[1]_290	0.0116	NBP[1]_304	0.0123
NBP[1]_318	0.0127	NBP[1]_334	0.0170
NBP[1]_347	0.0196	NBP[1]_362	0.0179
NBP[1]_377	0.0325	NBP[1]_391	0.0327
NBP[1]_406	0.0324	NBP[1]_420	0.0393
NBP[1]_441	0.0840	NBP[1]_469	0.0883
NBP[1]_498	0.0854	NBP[1]_526	0.0941
NBP[1]_554	0.1203	NBP[1]_582	0.1337
NBP[1]_609	0.1240		

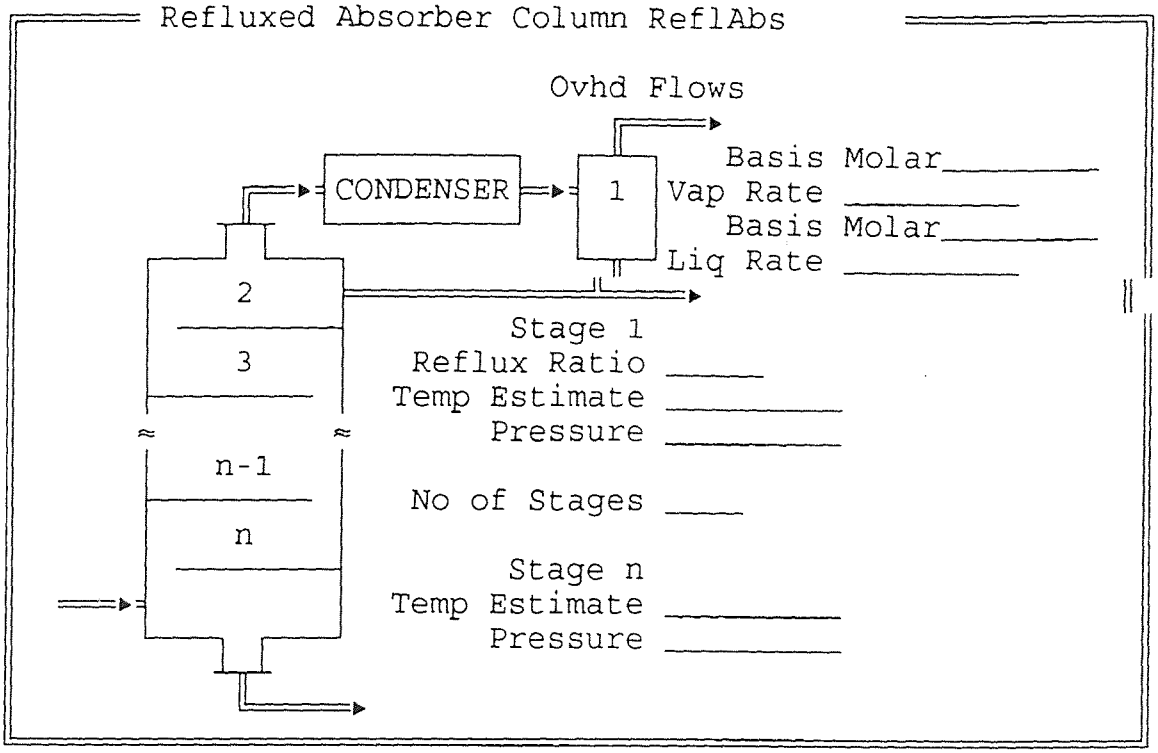
Step	Action
53	Press the <**Insert**> key;
54	Highlight the word **Worksheet** and then press the <**Enter**> key;
	The following screen will then appear:

Streams

	New Value =			
Stream	FeedVap	---	---	---
Vapour_Frac	1.0000	---	---	---
Temperature	1500.0000*	---	---	---
Pressure	2.0000*	---	---	---
Flow	1391.9788*	---	---	---
Mass_Flow	605428.2854	---	---	---
LiqVol_Flow	44807.7029	---	---	---
Energy_Flow	6.57489E+08	---	---	---

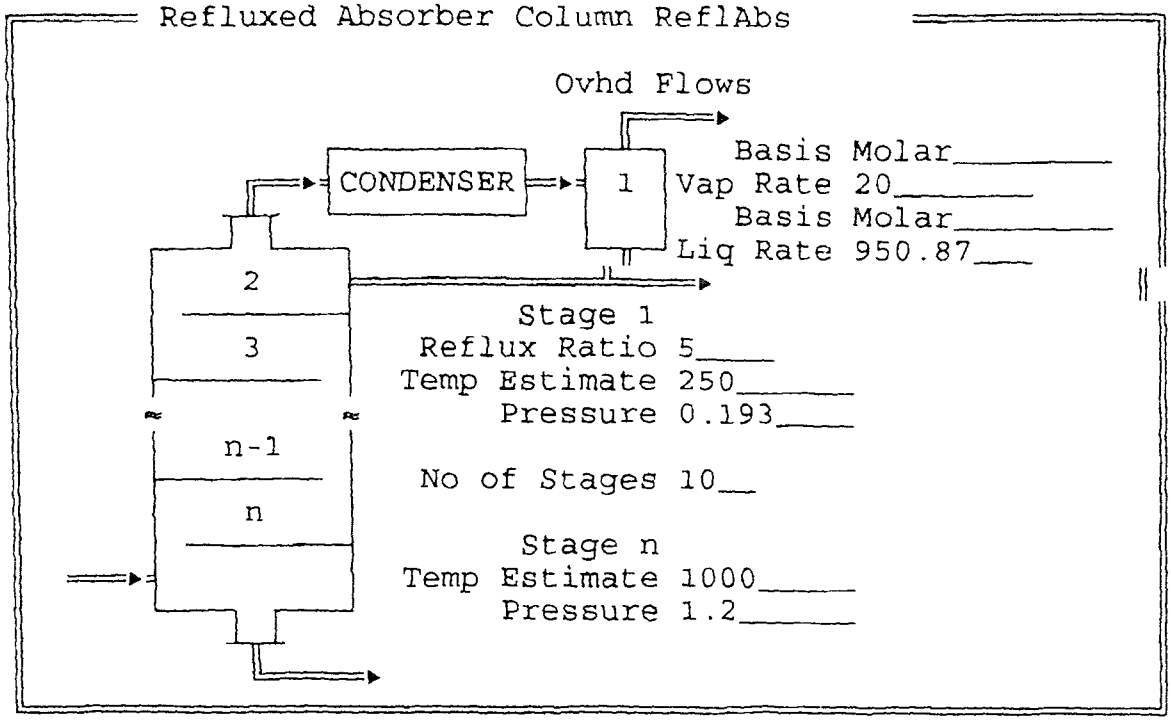
Step	Action
	Specifying the type of operation you want to perform on the Feed stream.
55	Press the <**Insert**> key;
56	Type the words **ReflAbs** and then press the <**Enter**> key;
57	Highlight the word **Column** and then press the <**Enter**> key;
58	Highlight the word **Refluxed_absorber** and then press the <**Enter**> key;
	The screen will then appear as shown on the next page.

3.1.3 Refluxed Absorber Column (continued)

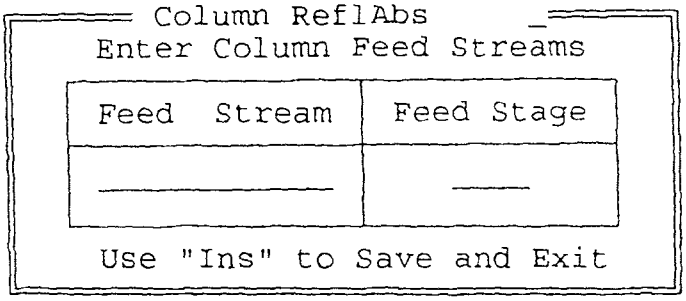


Step	Action
	Specifying the known data for the refluxed absorber column.
59	Press the <**Enter**> key.
	Specifying the Vapor Overhead Rate in lb-mols/hr.
60	Type the number **20** and then press the <**Enter**> key two times;
	Specifying the Liquid Overhead Rate in lb-mols/hr.
61	Type the number **950.87** and then press the <**Enter**> key;
	Specifying the Reflux Ratio in Stage 1.
62	Type the number **5** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 1 in °F.
63	Type the number **250** and then press the <**Enter**> key;
	Specifying the Pressure of Stage 1 in psia.
64	Type the number **0.193** and then press the <**Enter**> key;
	Specifying the Number of Stages in the Absorber Column.
65	Type the number **10** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 10 in °F.
66	Type the number **1000** and then press the <**Enter**> key;
	Specifying the Pressure of Stage10 in psia.
67	Type the number **1.2**;
	The screen will then appear as shown on the next page.

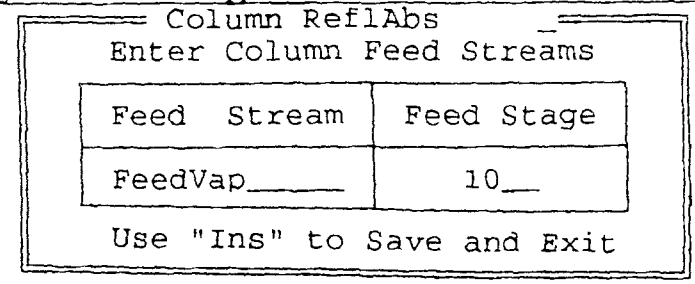
3.1.3 Refluxed Absorber Column (continued)



Step	Action
68	Press the <**Insert**> key.
	The following screen for specifying the name of the Feed stream and the stage at which it enters the Refluxed Absorber column will then appear:

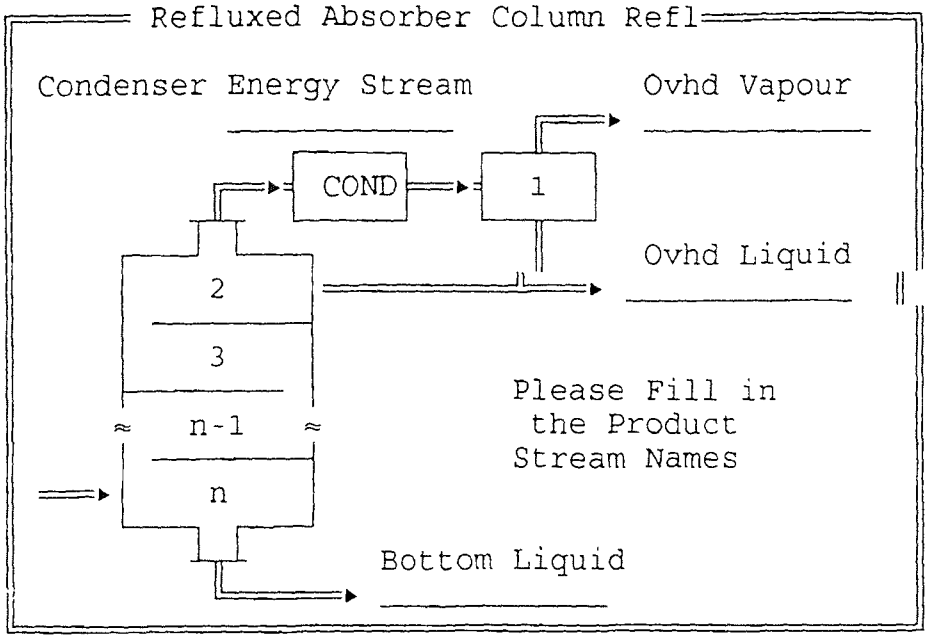


Step	Action
	Specifying at what stage the FeedVap stream enters the Absorber Column.
69	Type the word **FeedVap** and then press the <**Enter**> key.
70	Type the number **10**.
	The following screen will then appear:

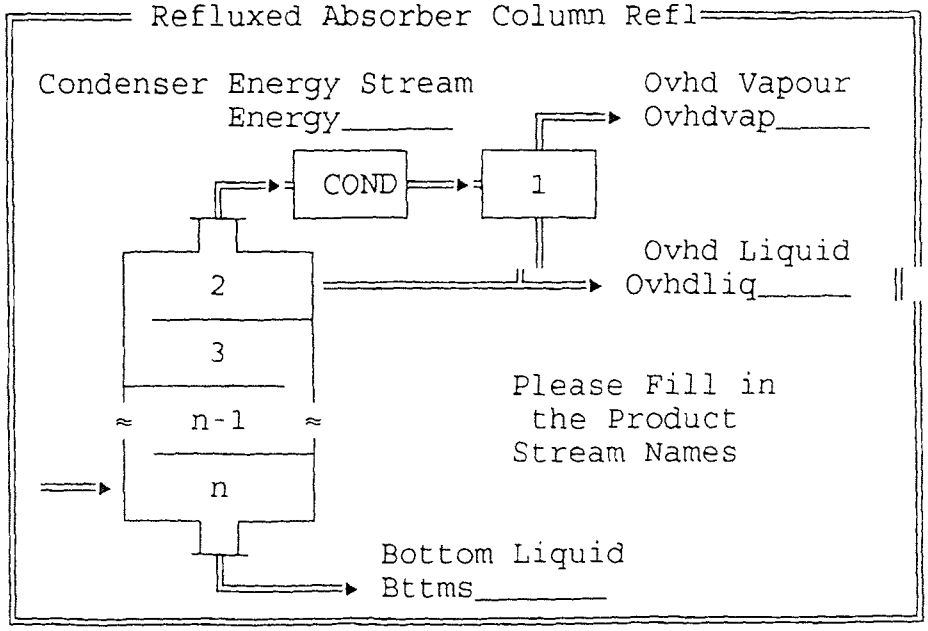


3.1.3 Refluxed Absorber Column (continued)

Step	Action
71	Press the <**Insert**> key.
	The following screen will then appear:



Step	Action
	Specifying the names of the streams going out of the refluxed absorber column.
72	Type the word **Energy** and then press the <**Enter**> key.
73	Type the word **Ovhdvap** and then press the <**Enter**> key.
74	Type the word **Ovhdliq** and then press the <**Enter**> key.
75	Type the word **Bttms**.
	The screen should then appear as shown below:



3.1.3 Refluxed Absorber Column (continued)

Step	Action
76	Press the <**Insert**> key.

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in nonconvergence of a column calculation which leads to frustration with an input data error.

Step	Action
	Running the Refluxed Absorber Column program.
77	Highlight the word **Run** and then press the <**Enter**> key.
78	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:

The various options available for the column, after you have finished step 78 are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Input* - Input data is printed.
b) *Feeds* - Feed composition and conditions are printed.
c) *Stages* - The temperature, pressure, liquid and vapor flow rates, any feed or drawoffs of each stage are reported, along with the duty of the first and last stage.
d) *Products* - The temperature, pressure, composition, and total flow rate of the overhead and bottom product streams are printed.
e) *Physical_Props* - The molecular weight, flow rate, density, reduced temperature and pressure are reported for each stage.
f) *Transport_Props* - The vapor and liquid dynamic viscosity and thermal conductivity are printed, along with the liquid surface tension.
g) *Exchanger_Profiles* - The condenser and reboiler heating curve data is printed.
h) *Composition* - The composition profile of selected components in the liquid and vapor phase are printed.
i) *Efficiencies* - The efficiency of each stage is printed.
j) *Pumparound_info* - If a pumparound is used, the information can be printed.
k) *All* - All of the information from a to j above will be printed.
l) *Graph* - Temperature, flowrates, mole fractions or key ratios can be printed in graphical form.
m) *SI* - The current output will be printed in metric units.
n) *Field* - The current output will be printed in Field (or English units).
o) *User* - The current output will be printed in user-defined units.
p) *Comp_Fractions* - The output will be printed on a mole, mass, or volume fractional basis.
q) *Comp_Flows* - The output will be printed as mole, mass or volume flows.
r) *Printer* - The printer will be toggled on. Selecting "Printer" once more will toggle the printer off.
s) *File* - The printout will be saved in a file.
t) *Mole* - The output will be printed on a mole basis.
u) *Mass* - The output will be printed on a mass basis.
v) *LiqVolume* - The output will be printed on a standard ideal liquid volume basis.
w) *Title* - Input a title which will be on all printouts.

3.1.3 Refluxed Absorber Column (continued)

Print Options (continued):

x) *Boiling_Pt_Curves* - The True Boiling Point (TBP), D86, or Specific Gravity boiling point curves will be printed out.

y) *Cold_Properties* - The Research Octane Number (RON), Pour Point, and Flash Point will be printed.

z) *User_Props* - If properties have been supplied by the user, these values will be printed out.

Step	Action
79	Highlight the word **Feeds** and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
80	Press the **<F10>** key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

**** Column Feeds ****

Feed Stream Name Enters on stage	FeedVap 10
Vapour Fraction	1.0000
Temperature - F	1500.00
Pressure - psia	2.00
Flowrate - lbmole/hr	1391.98
Enthalpy - Btu/hr	657489338.0
NBP[1]_232 - Mole Frac	0.0099
NBP[1]_246 - Mole Frac	0.0104
NBP[1]_261 - Mole Frac	0.0108
NBP[1]_275 - Mole Frac	0.0111
NBP[1]_290 - Mole Frac	0.0116
NBP[1]_304 - Mole Frac	0.0123
NBP[1]_318 - Mole Frac	0.0127
NBP[1]_334 - Mole Frac	0.0170
NBP[1]_347 - Mole Frac	0.0196
NBP[1]_362 - Mole Frac	0.0179
NBP[1]_377 - Mole Frac	0.0325
NBP[1]_391 - Mole Frac	0.0327
NBP[1]_406 - Mole Frac	0.0324
NBP[1]_420 - Mole Frac	0.0393
NBP[1]_441 - Mole Frac	0.0840
NBP[1]_469 - Mole Frac	0.0883
NBP[1]_498 - Mole Frac	0.0854
NBP[1]_526 - Mole Frac	0.0941
NBP[1]_554 - Mole Frac	0.1203
NBP[1]_582 - Mole Frac	0.1337
NBP[1]_609 - Mole Frac	0.1240

3.1.3 Refluxed Absorber Column (continued)

Step	Action
81	Press the <**F10**> key.
	Printing the Product conditions and compositions.
82	Highlight the word **Print** and then press the <**Enter**> key.

The various print options are shown on pages 73 - 74.

Step	Action
83	Highlight the word **Products** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
84	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

Leaving from stage Product Phase Assigned to Stream Name	1 Vapour Ovhdvap	1 Liquid Ovhdliq	10 Liquid Bttms
Temperature - F	374.77	374.77	845.27
Pressure - psia	0.19	0.19	1.20
NBP[1]_232 - Mole Frac	0.262888	0.008926	8.61E-06
NBP[1]_246 - Mole Frac	0.209840	0.010769	0.000010
NBP[1]_261 - Mole Frac	0.158318	0.012420	0.000013
NBP[1]_275 - Mole Frac	0.113912	0.013848	0.000015
NBP[1]_290 - Mole Frac	0.079964	0.015318	0.000019
NBP[1]_304 - Mole Frac	0.054869	0.016873	0.000024
NBP[1]_318 - Mole Frac	0.035690	0.017781	0.000029
NBP[1]_334 - Mole Frac	0.028241	0.024273	0.000047
NBP[1]_347 - Mole Frac	0.020236	0.028280	0.000065
NBP[1]_362 - Mole Frac	0.010667	0.026005	0.000073
NBP[1]_377 - Mole Frac	0.010722	0.047254	0.000164
NBP[1]_391 - Mole Frac	0.006351	0.047658	0.000201
NBP[1]_406 - Mole Frac	0.003382	0.047276	0.000253
NBP[1]_420 - Mole Frac	0.002236	0.057308	0.000388
NBP[1]_441 - Mole Frac	0.001911	0.122463	0.001198
NBP[1]_469 - Mole Frac	0.000576	0.128283	0.002123
NBP[1]_498 - Mole Frac	0.000147	0.123409	0.003774
NBP[1]_526 - Mole Frac	0.000041	0.133672	0.009143
NBP[1]_554 - Mole Frac	9.01E-06	0.117079	0.133152
NBP[1]_582 - Mole Frac	2.14E-08	0.001101	0.439468
NBP[1]_609 - Mole Frac	0.000000	2.01E-06	0.409833
Total Flow - lbmole/hr	19.99	950.88	421.11

3.1.3 Refluxed Absorber Column (continued)

Step	Action
85	Press the <**F10**> key.
	Printing the Physical Properties of the Liquid and Vapor leaving each stage.
86	Highlight the word **Print** and then press the <**Enter**> key.

The various print options are shown on pages 73 - 74.

Step	Action
87	Highlight the word **Physical_Props** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it
88	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

Vapour Leaving From Each Stage

**** Physical Properties ****

Stage No	Mole Wt	Flow Rates lb/hr	Flow Rates ACFM	Density lb/ft3	Reduced Temp	Reduced Press
1	191.67	3831.77	15440.411	4.1E-03	0.648	0.001
2	370.60	1.752E+06	3.055E+06	9.5E-03	0.706	0.002
3	467.08	2.968E+06	3.182E+06	0.016	0.702	0.003
4	490.75	3.676E+06	3.021E+06	0.020	0.709	0.005
5	500.18	3.899E+06	2.630E+06	0.025	0.716	0.006
6	506.53	3.972E+06	2.278E+06	0.029	0.724	0.007
7	513.25	3.978E+06	1.983E+06	0.033	0.731	0.008
8	521.97	3.953E+06	1.737E+06	0.038	0.738	0.009
9	533.27	3.931E+06	1.537E+06	0.043	0.745	0.010
10	546.49	3.944E+06	1.382E+06	0.048	0.752	0.012

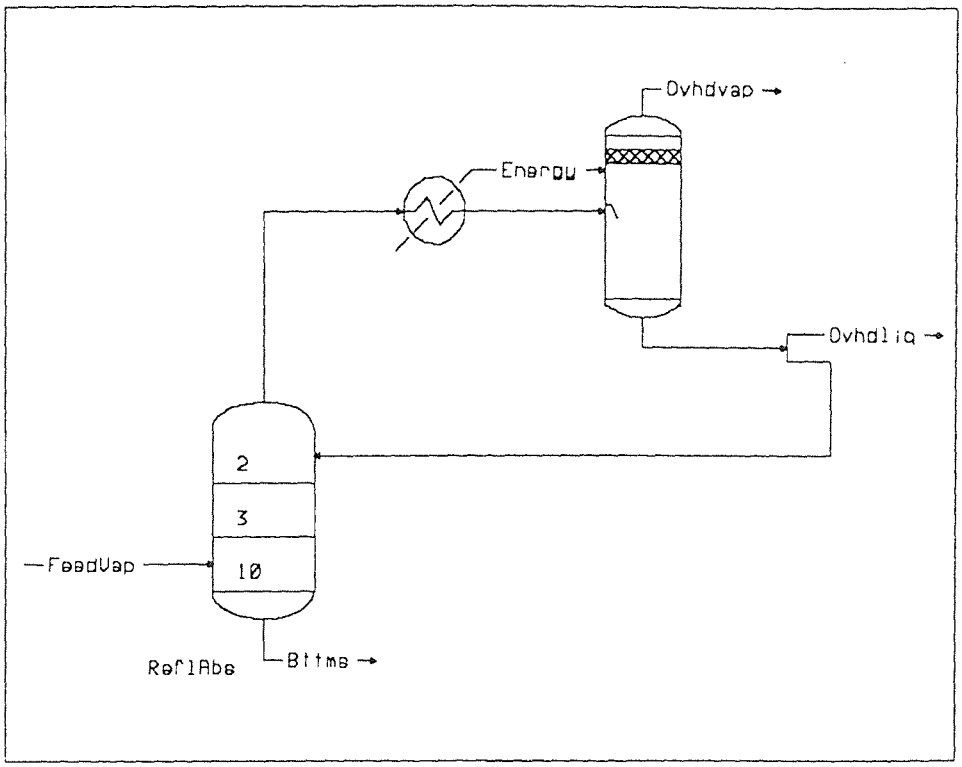
Liquid Leaving From Each Stage

**** Physical Properties ****

Stage No	Mole Wt	Flow Rates lb/hr	Flow Rates USGPM	Density lb/ft3	Reduced Temp	Reduced Press
1	371.36	1.395E+06	3574.890	48.69	0.533	0.001
2	485.01	2.611E+06	7436.924	43.78	0.653	0.003
3	509.08	3.319E+06	9775.355	42.34	0.685	0.004
4	519.03	3.542E+06	10571.275	41.78	0.697	0.005
5	526.15	3.615E+06	10881.040	41.42	0.706	0.006
6	534.10	3.621E+06	10970.547	41.15	0.712	0.007
7	544.66	3.596E+06	10954.298	40.94	0.718	0.009
8	558.39	3.574E+06	10939.691	40.74	0.724	0.010
9	574.29	3.587E+06	11030.608	40.55	0.730	0.011
10	590.07	248482.94	767.986	40.34	0.735	0.013

3.1.3 Refluxed Absorber Column (continued)

Step	Action
89	Press the <**F10**> key;
90	Press the <**Esc**> key until you are back at the Main Menu.
91	Highlight the letters **PFD** and then press the <**Enter**> key.
	The screen will then appear as shown below:



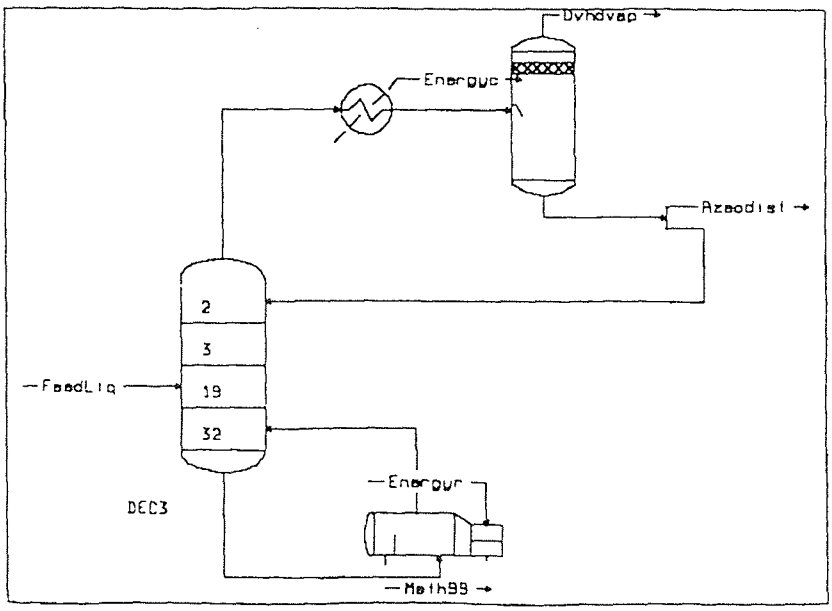
Step	Action
	Getting back to the Main Menu.
92	Press the <**Esc**> key until you reach the Main Menu.
93	Do you want to continue adding other unit operations to this refluxed absorber column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.1.4 Distillation Column

Objective - This exercise is an example of a distillation column. The purpose of the distillation column is to separate different components from a feed stream using a specified number of contact stages. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
This exercise is an example of how to separate a feed (*FeedLiq*) of 1424 kg-mols/hr of methanol and 337 kg-mols/hr of acetone into a liquid overhead (*Azeodist*) and a bottoms (*Meth99*). The *Azeodist* stream contained 108 kg-mols/hr of methanol and 319 kg-mols/hr of acetone. The distillate composition is near the azeotrope. The *Meth99* stream contained 1316 kg-mols/hr of methanol and 18 kg-mols/hr of acetone, or 99% methanol on a molar basis.
Technical Example Reference: Reference 5 - Problem # PD 9604 supplied by Dr. Roche of the NJIT Chemical Engineering Dept.
Other References: Refs. 1 and 2.

Directions - Pages 79 through 92 outline the execution of a distillation column example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.
Follow the Action Step instructions below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

A flow diagram of this unit operation, called *DEC3*, is shown below:



3.1.4 Distillation Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Activity_Models** and then press the <**Enter**> key;
4	Highlight the word **Margules** and then press the <**Enter**> key;
5	Highlight the word **Virial** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
6	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methanol** and then press the <**Enter**> key; Highlight the word **Acetone** and then press the <**Enter**> key.
7	Press the <**Insert**> key;
	The screen shown on the following page listing Association and Solvation Parameters will then appear.

3.1.4 Distillation Column (continued)

```
═══════ Association and Solvation Parameters ═══════
    Enter a value or Press Ins to Exit,
                 Methanol     Acetone
Methanol           1.6297       1.0000
Acetone            1.0000       0.8999
```

Step	Action
8	Press the <**Insert**> key;
	The following screen listing Aij Interaction Parameters will then appear:

```
═══════ Aij Interaction Parameters ═══════
 HOT KEYS   F1_Help   F2_Menu   S_Switch-Matrices   A_UnifacVLE
            H_Henry's Coeff     L_UnifacLLE     C_UnifacLLE_All
            I_j immiscible in i           B_all immiscible in i
               Methanol     Acetone
Methanol         ---          0.6121
Acetone          0.5769       ---
```

Step	Action
9	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the feed stream, FeedLiq.
10	Highlight the word **Specify** and then press the <**Enter**> key;
11	Highlight the word **Stream** and then press the <**Enter**> key;
12	Type the word **FeedLiq** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the FeedLiq stream in ℃.
13	Type the number **40** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the FeedLiq stream in kPa.
14	Type the number **274.8** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the FeedLiq stream as unknown by typing the letter "x".
15	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mass fractions of each component in the FeedLiq stream.
16	Highlight the word **Mass_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
═══════ Stream Mass Fractions ═══════

Methanol  _____________   Acetone  _____________
```

3.1.4 Distillation Column (continued)

Step	Action
	Selecting the components in the FeedLiq stream.
17	*Enter the following mass fractions beside each component in the FeedLiq stream:* After the word, Methanol, type the number **0.7** in the blank and then press the <**Enter**> key; After the word, Acetone, type the number **0.3** in the blank;
	The screen will now appear as shown below:

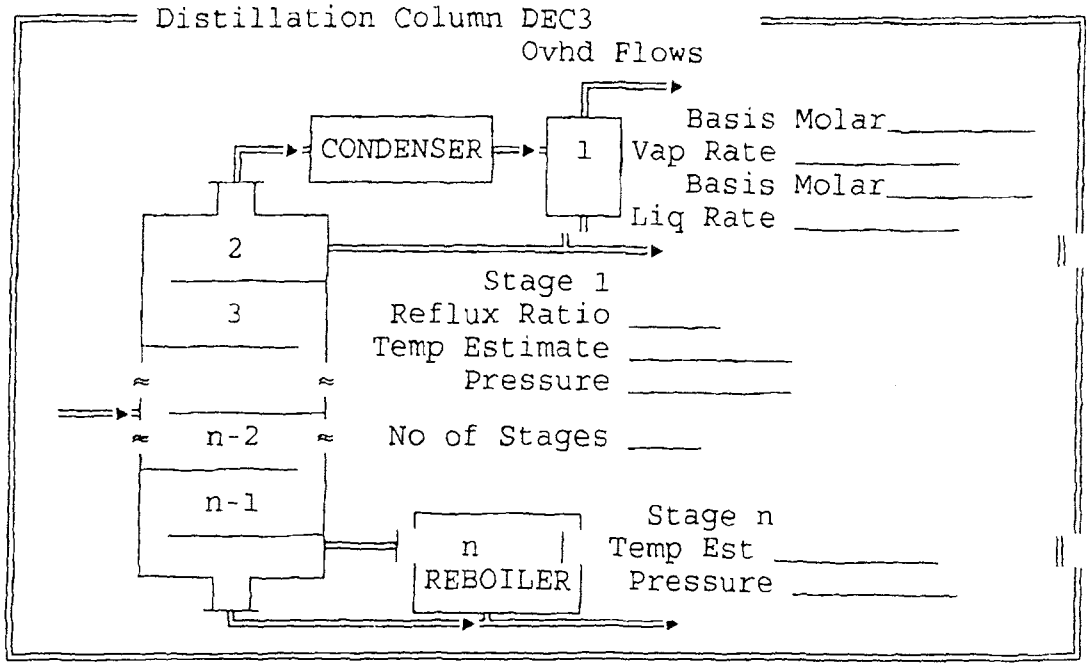
```
═══════════ Stream Mass Fractions ═══════════

 Methanol    0.7_____________     Acetone    0.3_____________
```

Step	Action
18	Press the <**Insert**> key;
19	Highlight the word **Worksheet** and then press the <**Enter**> key;
20	*Highlight the space under the FeedLiq title for the Mass Flow in kg/h.* Type the number **65200** and then press the <**Enter**> key;
	The following screen will then appear:

```
═══════════════════ Streams ═══════════════════

                  New Value =                 kg/h
Stream              FeedLiq       ---         ---       ---
Vapour_Frac          0.0000       ---         ---       ---
Temperature         40.0000*      ---         ---       ---
Pressure           274.8000*      ---         ---       ---
Flow              1761.1619        ---         ---       ---
Mass_Flow        65200.0000*       ---         ---       ---
LiqVol_Flow         82.1164        ---         ---       ---
Energy_Flow   -4.36607E+07         ---         ---       ---
```

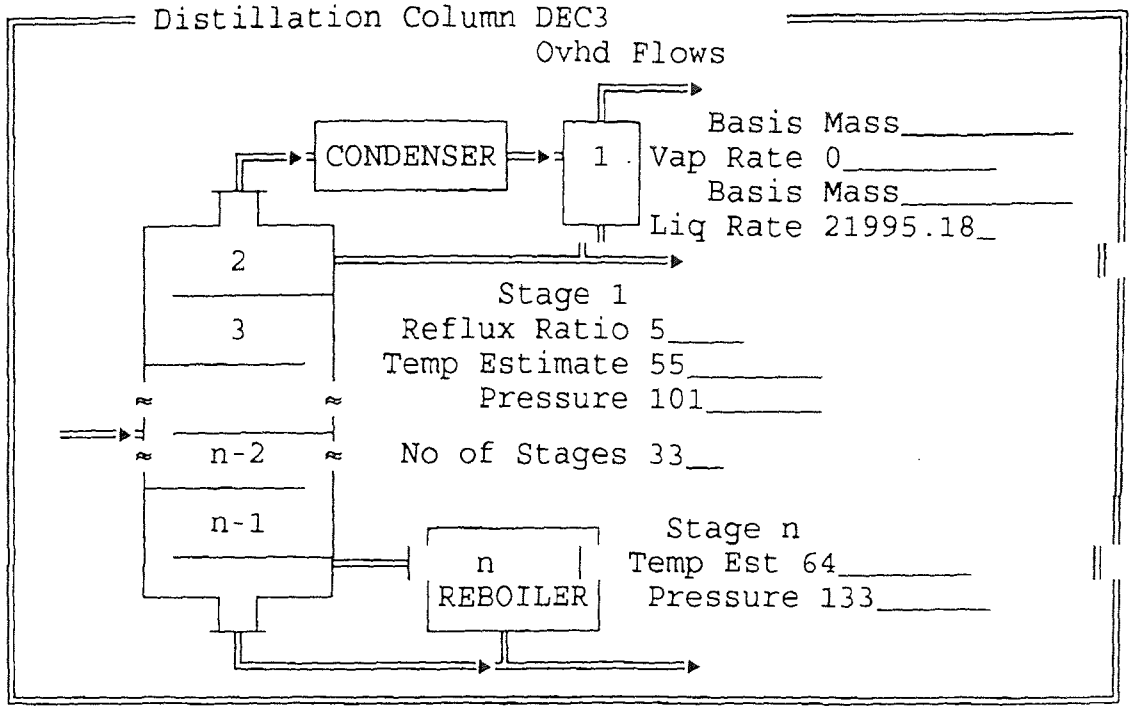
Step	Action
21	Press the <**Insert**> key;
	Specifying the type of operation we want to perform on the FeedLiq stream.
22	Type the words **DEC3 column** and then press the <**Enter**> key;
23	Highlight the word **Distillation** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.1.4 Distillation Column (continued)

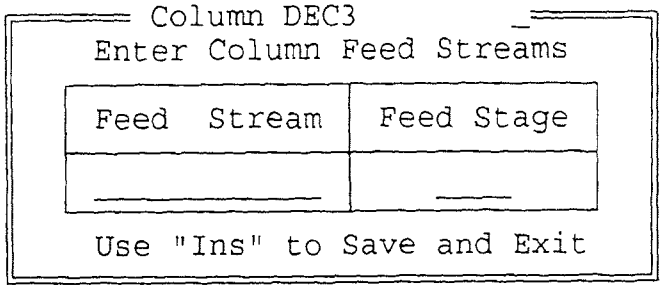


Step	Action
	Specifying the known data for the distillation column.
24	Press the <**Delete**> key until the word Molar is deleted; then type the word **Mass** in its place and then press the <**Enter**> key.
	Specifying the Vapor Overhead Rate in kilograms per hour, kg/hr.
25	Type the number **0** and then press the <**Enter**> key;
26	Press the <**Delete**> key until the word Molar is deleted; then type the word **Mass** in its place and then press the <**Enter**> key.
	Specifying the Liquid Overhead Rate in kg/hr.
27	Type the number **21995.18** and then press the <**Enter**> key;
	Specifying the Reflux Ratio.
28	Type the number **5** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 1 in °C.
29	Type the number **55** and then press the <**Enter**> key;
	Specifying the Pressure of Stage 1 in kilopascals, kPa.
30	Type the number **101** and then press the <**Enter**> key;
	Specifying the Number of Stages in the Distillation Column.
31	Type the number **33** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of Stage 33 in °C.
32	Type the number **64** and then press the <**Enter**> key;
	Specifying the Pressure of Stage33 in kPa
33	Type the number **133**;
	The screen will then appear as shown on the following page.

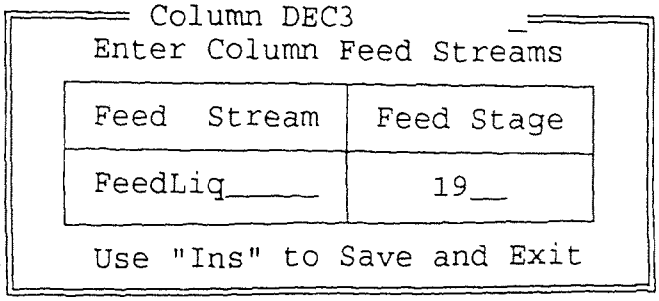
3.1.4 Distillation Column (continued)



Step	Action
34	Press the <**Insert**> key.
	The following screen for specifying the name of the FeedLiq stream and the stage at which it enters the Distillation column will then appear:

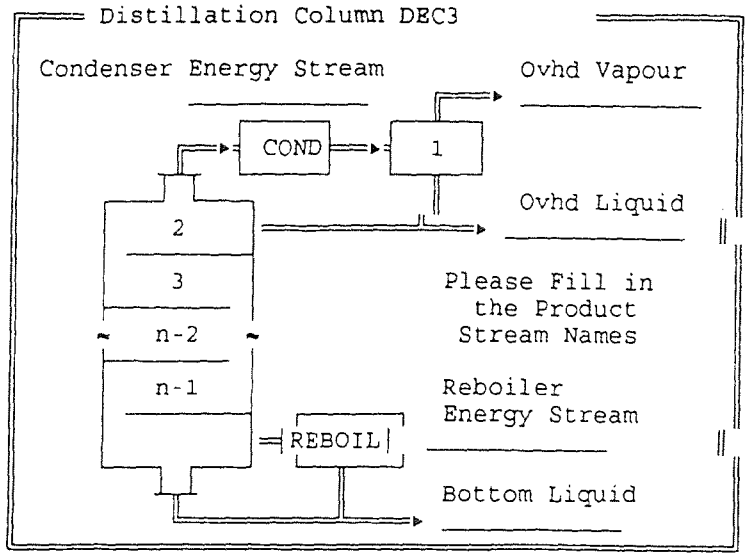


Step	Action
	Specifying at what stage the FeedLiq stream enters the Distillation Column.
35	Type the word **FeedLiq** and then press the <**Enter**> key.
36	Type the number **19**.
	The following screen will then appear:

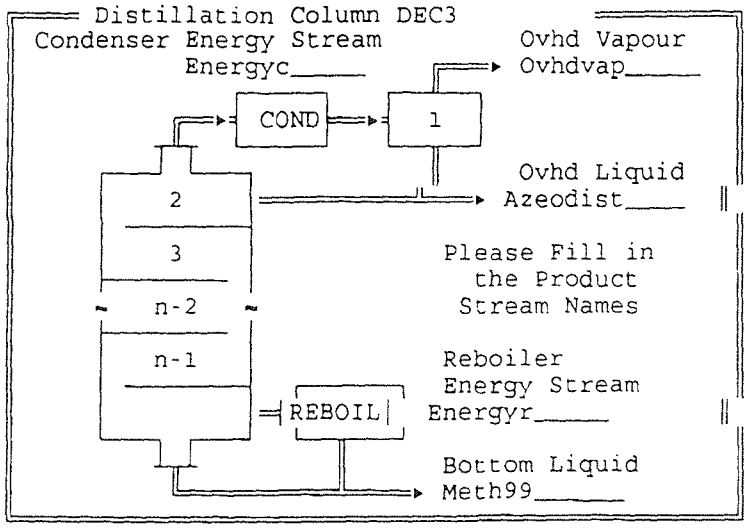


3.1.4 Distillation Column (continued)

Step	Action
37	Press the <**Insert**> key;
	The following screen will then appear:



Step	Action
	Specifying the names of the streams going into and out of the distillation column.
38	Type the word **Energyc** and then press the <**Enter**> key.
39	Type the word **Ovhdvap** and then press the <**Enter**> key.
40	Type the word **Azeodist** and then press the <**Enter**> key.
41	Type the word **Energyr** and then press the <**Enter**> key.
42	Type the word **Meth99**.
	The screen should then appear as shown below:



3.1.4 Distillation Column (continued)

Step	Action
43	Press the <**Insert**> key.

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in nonconvergence of a column calculation which leads to frustration with an input data error.

Step	Action
	Running the Distillation Column program.
44	Highlight the word **Run** and then press the <**Enter**> key.
45	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:

The various options available for the column, after you have finished step 45 are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Input* - Input data is printed.
b) *Feeds* - Feed composition and conditions are printed.
c) *Stages* - The temperature, pressure, liquid and vapor flow rates, any feed or drawoffs of each stage are reported, along with the duty of the first and last stage.
d) *Products* - The temperature, pressure, composition, and total flow rate of the overhead and bottom product streams are printed.
e) *Physical_Props* - the molecular weight, flow rate, density, reduced temperature and pressure are reported for each stage.
f) *Transport_Props* - The vapor and liquid dynamic viscosity and thermal conductivity are printed, along with the liquid surface tension.
g) *Exchanger_Profiles* - The condenser and reboiler heating curve data is printed.
h) *Composition* - The composition profile of selected components in the liquid and vapor phase are printed.
i) *Efficiencies* - The efficiency of each stage is printed.
j) *Pumparound_info* - If a pumparound is used, the information can be printed.
k) *All* - all of the information from a to j above will be printed.
l) *Graph* - Temperature, flowrates, mole fractions or key ratios can be printed in graphical form.
m) *SI* - The current output will be printed in metric units.
n) *Field* - The current output will be printed in Field (or English units).
o) *User* - The current output will be printed in user-defined units.
p) *Comp_Fractions* - The output will be printed on a mole, mass, or volume fractional basis.
q) *Comp_Flows* - The output will be printed as mole, mass or volume flows.
r) *Printer* - The printer will be toggled on. Selecting "Printer" once more will toggle the printer off.
s) *File* - The printout will be saved in a file.
t) *Mole* - The output will be printed on a mole basis.
u) *Mass* - The output will be printed on a mass basis.
v) *LiqVolume* - The output will be printed on a standard ideal liquid volume basis.
w) *Title* - Input a title which will be on all printouts.

3.1.4 Distillation Column (continued)

Print Options (continued):

x) *Boiling_Pt_Curves* - The True Boiling Point (TBP), D86, or Specific Gravity boiling point curves will be printed out.

y) *Cold_Properties* - The Research Octane Number (RON), Pour Point, and Flash Point sill be printed.

z) *User_Props* - If properties have been supplied by the user, these values will be printed out.

Step	Action
	Specifying the stream compositions in mole flow instead of mole fractions.
46	Highlight the word **Comp_Flows** and then press the **<Enter>** key.
47	Press the **<Esc>** key;
48	Highlight the word **Print** and then press the **<Enter>** key.
49	Highlight the word **Feeds** and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
50	Press the **<F10>** key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

**** Column Feeds ****

Feed Stream Name Enters on stage	FeedLiq 19
Vapour Fraction	0.0000
Temperature - C	40.00
Pressure - kPa	274.80
Flowrate - kgmole/h	1761.16
Enthalpy - kJ/h	-43660764.3
Methanol - kgmole/h	1424.3850
Acetone - kgmole/h	336.7769

3.1.4 Distillation Column (continued)

Step	Action
51	Press the <**F10**> key;
52	Highlight the word **Print** and then press the <**Enter**> key.

The various print options are shown on pages 85 - 86.

Step	Action
53	Highlight the word **Products** and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
54	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

**** Products ****

Leaving from stage Product Phase Assigned to Stream Name	1 Liquid Azeodist	33 Liquid Meth99
Temperature - C Pressure - kPa Methanol - kgmole/h Acetone - kgmole/h	55.30 101.00 108.232 318.989	71.11 133.00 1316.153 17.788
Total Flow - kgmole/h	427.22	1333.94

3.1.4 Distillation Column (continued)

Step	Action
55	Press the <**F10**> key;
56	Highlight the word **Size** and then press the <**Enter**> key.
57	Highlight the word **Auto-Section** and then press the <**Enter**> key.
	The screen will then appear as follows:

Auto-Section Information

Tower Internals: valve_tray	
Area Tolerance 0.60	When the ratio between the current calc'd area and either of min/max previous areas for the section exceeds this tol, a new DIAM section is started. Higher, more sections; Lower, fewer sections.
NFP Diam Factor 0.15	When a new number of flow paths will result in a diameter difference >= Diam Factor * old diameter, a new NFP Section is started. Not required for packed columns. Lower, more sections; Higher, fewer sections.

Step	Action
	Specifying a Sieve Tray instead of a Valve Tray.
58	Press the <**Delete**> key until the valve in valve_tray is deleted. Then type in the word sieve to make the word now sieve_tray.
	The screen will then appear as shown below:

Auto-Section Information

Tower Internals: sieve_tray	
Area Tolerance 0.60	When the ratio between the current calc'd area and either of min/max previous areas for the section exceeds this tol, a new DIAM section is started. Higher, more sections; Lower, fewer sections.
NFP Diam Factor 0.15	When a new number of flow paths will result in a diameter difference >= Diam Factor * old diameter, a new NFP Section is started. Not required for packed columns. Lower, more sections; Higher, fewer sections.

3.1.4 Distillation Column (continued)

Step	Action
59	Press the <Insert> key.
	The screen will then appear as follows:

```
                    Sieve Tray Input

                        Section: 1__________

          System Factor: 1.00
  Number of Flow Paths: __   (leave blank for maximum)

                        Tray spacing: 609.600 mm
                      Max DC backup:  50.000 %
                       Max flooding:  85.000 %
  DC Clear: 38.100  mm  Max Δp/tray: 203.200 mm  liq

     Weir: Straight            DC Type: Vertical
  Weir Ht: 50.800 mm         Tray Thick:   3.175 mm
  Loading: 71.535 m3/h-m__    Hole Diam:   4.763 mm
                            Hole Spacing:  12.700 mm

  Material: Carbon_Steel____   Tray Diam: _______ m_
                                       (specify only if rating)
```

Step	Action
60	Press the <Insert> key.
	The following screen will appear:

```
                  Shell Sizing Information

                    Section Name: 1__________

                       Head Type: Ellipsoidal__

                   Shell Material: Carbon_Steel____

                  Corrosion Allow:  6.350  mm

                Joint Efficiency:  0.850

                   Height Factor:  1.000

                    Design Conditions
                  (default: 120 % of max P-T)

                      Pressure: _______ kPa___
                   Temperature: _______ C_____
```

3.1.4 Distillation Column (continued)

Step	Action
61	Press the <**Insert**> key;
62	Highlight the word **Print** and then press the <**Enter**> key.

The print options available under the Sizing calculations are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Summary* - A summary of the calculations will be printed out.
b) *Detailed* - A table of detailed information, including Section performance, dimensions, orifice information, downcomer dimensions, downcomer and weir information, shell information and uninstalled cost estimates will be printed out.
c) *One_Tray* - Detailed information for one tray will be printed out.

There are also options available to:
1) have the output printed in metric (*SI*), *Field* or *User*-defined units.
2) have the material printed to the screen also printed to the *printer*.
3) have the printout saved by selecting *File*.

Step	Action
63	Highlight the word **Detailed** and then press the <**Enter**> key.
64	Highlight the word **Section-1** and then press the <**Enter**> key.
	Pressing the <F10> key to get the menu off of the screen in order to see the data on the screen underneath it.
65	Press the <**F10**> key;
	The screen will then appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.1.4 Distillation Column (continued)

SIEVE TRAY SECTION NAME: Section_1 MODE: Design STAGES: 2 - 32

SIEVE TRAY SECTION PERFORMANCE

		Specified	Max Calculated	Occurs on Tray
System Factor		1.000*		
Flooding	%	85.000*	72.602	2
DC Backup	% trayspace	50.000*	34.748	19
Weir Loading	m3/h-m	71.535*	72.514	19
DeltaP/Tray	mm liq	203.200*	69.333	2
Total DeltaP	kPa		14.523	

SECTION DIMENSIONS

Diameter	3.962	m
Area	12.331	m2
Active Area	10.315	m2
Avg DC Area	1.008	m2
Tray Spacing	609.600*	mm
Height Fact	1.000*	
Sect Height	18.898	m

ORIFICE INFORMATION

Hole Area	1.316	m2
Hole Diam	4.763*	mm
Hole spacing	12.700*	mm
Est #holes	73851	
Tray Thick	3.175*	mm

DC DIMENSIONS

	Side	Centre	O.C.	O.S.
Width (mm)				
top	539.8	0.0	0.0	0.0
btm	539.8	0.0	0.0	0.0
Length (m)				
top	2.72	0.00	0.00	0.00
btm	2.72	0.00	0.00	0.00
Area (m2)				
top	1.01	0.00	0.00	0.00
btm	1.01	0.00	0.00	0.00

DC/WEIR INFORMATION

Flow Paths	1	
Flow Length	2882.900	mm
Flow Width	3577.834	mm
Tot Weir Lng	2.718	m
DC Clearance	38.100*	mm
Weir Height	50.800*	mm
DC Type	Vertical*	
Side Weir Type	Straight*	
Side Weir Lng	2.718	m
Relief Area	0.00	m2

SHELL INFORMATION

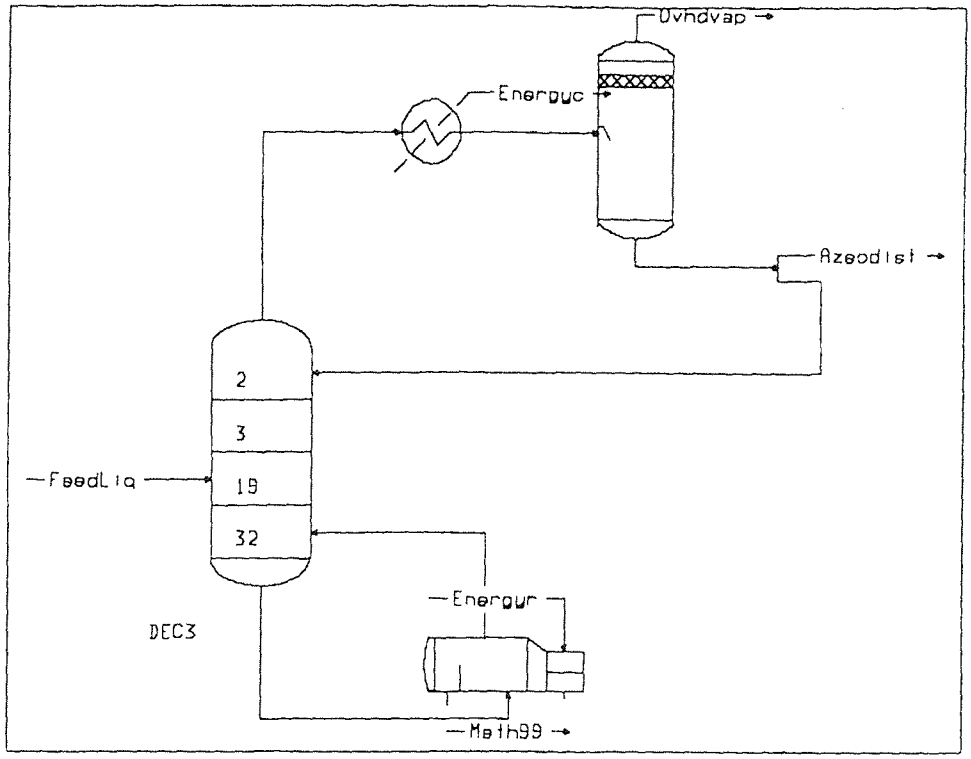
Material	Carbon_Steel*		Dsgn Pressure	159.000 kPa
Head Type	Ellipsoidal*		Dsgn Temp	139.963 C
Corrosion Al.	6.350*	mm	Joint Eff	0.850*
Shell Thickness			Cylinder Wt.	23557.590 kg
top	12.700	mm	Head Wt.(x2)	2477.672 kg
bottom	12.700	mm		
head	12.700	mm	Shell Weight	26035.261 kg

UNINSTALLED COST ESTIMATES

Shell Cost	124600.000	$ US (May '91)
P & L Cost	31200.000	$ US (May '91)
Tray Cost	104300.000	$ US (May '91)
Total Cost	260100.000	$ US (May '91)

3.1.4 Distillation Column (continued)

Step	Action
66	Press the <**F10**> key;
67	Press the <**Esc**> key until you are back at the Main Menu.
68	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



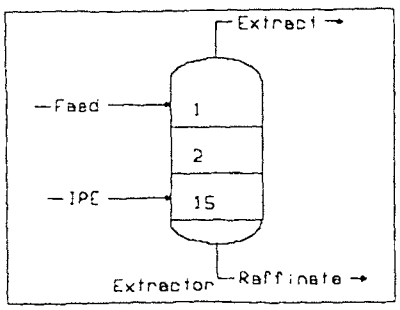
Step	Action
	Getting back to the Main Menu.
69	Press the <**Esc**> key until you reach the Main Menu.
70	Do you want to continue adding other unit operations to this distillation column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.1.5 Liquid/Liquid Extraction Column

Objective - This exercise is an example of an Extraction (Liquid-Liquid) Column. The purpose of the extraction column is to separate different components from a feed stream(s) using a specified number of contact stages. One or more of the feed stream(s) components is more soluble in another stream, and therefore that component will be transferred between streams. This case is an example of a liquid-liquid extraction, where all streams are in the liquid state. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
The three components in the feed streams for this example are: acetic acid, isopropyl ether and water. One feed stream, *IPE*, is all isopropyl ether, whereas the other feed stream , *Feed*, contains 31 mole % acetic acid and 69 mole % water. Two product streams emerge from the extraction column. The bottoms product stream, *Raffinate*, contains 99.4 mole % water, while the overhead product stream, *Extract*, contains all of the acetic acid, most of the isopropyl ether and some of the water in the system. These results show that the acetic acid was extracted from the water and into the isopropyl ether solvent.
Technical Example Reference: Reference 6 - "Principles of Unit Operations," (Illustration 5.1, page 45), by Alan S. Foust, et.al., John Wiley & Sons, Inc.,1960.
Other References: The specific model parameters in Kelvin for the UNIQUAC model (A_{ij}, A_{ji}, q_i and r_i) for the three components in this model (Isopropyl Ether, Acetic Acid and Water) were obtained from the following source: Reference 7 - "Liquid-Liquid Equilibrium Data Collection, Ternary Systems", Chemistry Data Series, Vol. V, Part 2, by J.M. Sorensen and W. Arlt, Published by DECHEMA, 6000 Frankfurt/Main, Federal Republic of Germany, p. 284, 1980. Refs. 1 and 2.

Directions - Pages 94 through 112 outline the execution of a Liquid-Liquid Extraction Column example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.
Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.**<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Extractor*, is shown below:



3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in SectionV). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Activity-Models** and then press the <**Enter**> key;
4	Highlight the word **UNIQUAC** and then press the <**Enter**> key;
5	Highlight the word **Ideal_Gas** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed streams.
6	*Highlight the following component name under the "Component Selection" Section and press the <Enter key so that the name then appears in the "Selected" column.* Highlight the word **Hypothetical** and press the <**Enter**> key.
	Acetic Acid will be specified as a hypothetical because HYSIM doesn't contain information in its data bank for the A_{ij} information needed, and so that the Q and P parameters can be specified for the three component system: Acetic Acid, Isopropyl Ether and Water. Isopropyl Ether will also be specified as a Hypothetical because it is not apart of the component list.

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
7	Highlight the letter **HC** and then press the <**Enter**> key;
	The screen shown below will then appear:

```
Hypothetical Component Information

Name: _____          Chemical Formula: _____

Boiling Point [C_]          : ___
LiqDensity (@ 15C) [kg/m3_] : ___
Molecular Weight            : ___

Critical Temperature [C_]   : ___
Critical Pressure [kPa___]  : ___
Critical Volume [m3/kgmol]  : ___
Acentric Factor             : ___
Acentric Factor  Wsrk       : ___
Charact. Volume [m3/kgmol]  : ___
Dipole Moment [debye]       : ___

  Vapour Pressure [deg K, kPa]
ANTA: _____  ANTD: _____
ANTB: _____  ANTE: _____
ANTC: _____  ANTF: _____
TMIN: _____  TMAX: _____
Viscosity Coeff A: _____
Viscosity Coeff B: _____

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal = _____ kJ/kg__
       + _____ * T
       + _____ * T^2
       + _____ * T^3
       + _____ * T^4
       + _____ * T^5
Entropy Coeff: _____
Cavett Param.: _____

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____ kJ/kgmol
       + _____ * T
       + _____ * T^2
Heat Form (@ 25 C): _____
Heat Comb (@ 25 C): _____
Radius Gyration [Ang]: _____
```

Step	Action
	Specifying Hypothetical Component Information.
8	Type the name **AceticAcid** and then press the <**Enter**> key;
9	Type the chemical formula **C2H4O2** and then press the <**Enter**> key;
	Specifying the Boiling Point in °C.
10	Type the number **118.00** and then press the <**Enter**> key;
11	Press the <**Enter**> key;
	Specifying the Molecular Weight.
12	Type the number **60.00** and then press the <**Enter**> key;
13	Press the <**Insert**> key;
	The screen shown below will then appear:

```
None                Dynamic              Kinematic
None viscosities will be calculated via an equation
 What type of viscosity curve do you wish to input ?
>
```

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
	Specifying that component viscosities should be calculated via an equation.
14	Highlight the word **None** and then press the **<Enter>** key;
	Changing the q_i and r_i parameters.
15	Type the number **2.072** and then press the **<Enter>** key;
16	Type the number **2.2024**.
	The screen will then appear as shown below:

```
═══════ Parameters for Uniquac Models ═══════
            Component Name:  AceticAcid __

     Uniquac Q Parameter        : 2.072_____
     Uniquac R Parameter        : 2.2024____
```

Step	Action
17	Press the **<Insert>** key;
	The screen shown below will then appear:

```
═══════ Hypothetical Component Information ═══════
      Are The Component Calculations Satisfactory: Yes_____
Name: AceticAcid                  Chemical Formula: C2H4O2
──────────────────────────────────────────────────────────
Boiling Point [C_]          :    118.00
LiqDensity (@ 15 ) [kg/m3_] :    752.46
Molecular Weight            :     60.00

Critical Temperature [C_]   :    300.95
Critical Pressure [kPa___]  :   2931.81
Critical Volume [m3/kgmol]  :     0.423
Acentric Factor             :   0.34126
Acentric Factor  Wsrk       :   0.34126
Charact. Volume [m3/kgmol]  :   0.23938
Dipole Moment [debye]       :      0.00

  Vapour Pressure [deg K, kPa]
ANTA:  5.57998e+01  ANTD: -5.79141e+00
ANTB: -6.51012e+03  ANTE:  8.79802e-18
ANTC:  0.00000e+00  ANTF:  6.00000e+00
TMIN:       118.000 TMAX:       300.948
Viscosity Coeff A:        -0.00603
Viscosity Coeff B:        -0.24743

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal =  1.0921140e+02 kJ/kg__
        +  6.8330309e-03 * T
        +  2.8484359e-03 * T^2
        + -6.9381542e-07 * T^3
        +  0.0000000e+00 * T^4
        +  0.0000000e+00 * T^5
Entropy Coeff:        1.0000000
Cavett Param.:          0.26829

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _______________ kJ/kgmol
       + _______________ * T
       + _______________ * T^2
Heat Form (@ 25 C): _____________
Heat Comb (@ 25 C): _____________
Radius Gyration [Ang]:    2.7599
```

Hypothetical Compounds - HYSIM will calculate the critical properties from either the Bergman Cavett or Lee-Kesler Correlation, depending on the API and Normal Boiling Point supplied. Other component types such as Amines, Alcohols, etc. will have critical properties determined by Joback's modification of Lydersen's group contribution method.

3.1.5 Liquid/Liquid Extraction Column (continued)

Hypothetical Compounds (continued):

The Enthalpy coefficients are for the following fifth order ideal enthalpy equation:

$H = A + BT + CT^2 + DT^3 + ET^4 + FT^5$

where: T = Absolute Temperature (K or R)
H = Enthalpy = BTU/lb-R or kJ/Kg-K

For solids, the enthalpy data should be entered. If HYSIM generates the coefficients, it will use the Cavett correlations for hydrocarbons, solids or miscellaneous substances; the Joback group contribution method will be used for all other substances.

Reference: Passut, C.A. and Danner, R.P., *I.E.C. Proc. Des. & Dev.*, 11, p. 543 (1972).

The Gibbs Free Energy will be calculated using the following equation:

$G^o = A + BT + CT^2$

where: T = Absolute Temperature = K or R

G^o = kJ/kgmole-K or Btu/lbmole-R

If the hypothetical is a Hydrocarbon or if a UNIFAC structure is not specified, no Gibbs coefficients will be calculated.

The modified Antoine vapor pressure model coefficients are calculated for the following equation:

$\ln(P_{vap}) = ANTA + (ANTB/(T+ANTC)) + ANTD(\ln(T)) + ANTE(T)^{ANTF}$

The viscosity coefficients, Theta A and Theta B, are used in the viscosity prediction models. Three viscosity models are available in HYSIM: the modified Ely and Hanley model, Twu's model and the modified Letsou-Stiel correlation.

Step	Action
18	Press the **<Insert>** key;
	The screen shown on the following page will then appear.

3.1.5 Liquid/Liquid Extraction Column (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
AceticAcid	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

↓Search by SYNONYM

F1 - Help, F4 - Flip Srch, F5 - Exam, F6 - Move,
F3 - Menu, PRESS INSERT TO SUBMIT F8 - Change

Step	Action
	Selecting the components in the feed streams.
19	*Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column.* Highlight the word **Hypothetical** and press the **<Enter>** key.
	Isopropyl Ether will be specified as a Hypothetical component because it is not apart of the component list.
20	Highlight the word **Ether** and then press the **<Enter>** key.
	The screen on the following page will then appear.

3.1.5 Liquid/Liquid Extraction Column (continued)

```
Hypothetical Component Information

Name: _____   Chemical Formula: _____

Boiling Point [C_]          : __
LiqDensity (@ 15C) [kg/m3_] : __
Molecular Weight            : __

Critical Temperature [C_]   : __
Critical Pressure [kPa___]  : __
Critical Volume [m3/kgmol]  : __
Acentric Factor             : __
Acentric Factor  Wsrk       : __
Charact. Volume [m3/kgmol]  : __
Dipole Moment [debye]       : __

  Vapour Pressure [deg K, kPa]
ANTA: _____   ANTD: ____
ANTB: _____   ANTE: ____
ANTC: _____   ANTF: ____
TMIN: _____   TMAX: ____
Viscosity Coeff A: ____
Viscosity Coeff B: ____

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal = _____ kJ/kg___
       + _____ * T
       + _____ * T^2
       + _____ * T^3
       + _____ * T^4
       + _____ * T^5
Entropy Coeff: _____
Cavett Param.: _____

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____ kJ/kgmol
       + _____ * T
       + _____ * T^2
Heat Form (@ 25 C): _____
Heat Comb (@ 25 C): _____
Radius Gyration [Ang]: _____
```

Step	Action
	Specifying Hypothetical Component Information.
21	Type the name **IPEther** and then press the <**Enter**> key;
22	Type the chemical formula **C6H14O** and then press the <**Enter**> key;
	Specifying the Boiling Point in ℃.
23	Type the number **69.00** and then press the <**Enter**> key;
24	Press the <**Enter**> key;
	Specifying the Molecular Weight.
25	Type the number **102.00** and then press the <**Enter**> key;
26	Press the <**Insert**> key;
	The screen shown on the following page will then appear.

3.1.5 Liquid/Liquid Extraction Column (continued)

```
CH3                 CH2                 CH                  C
CH2=CH              CH=CH               CH2=C               CH=C
C=C                 ACH                 AC                  ACCH3
ACCH2               ACCH                OH                  CH3OH
H2O                 ACOH                CH3CO               CH2CO
CHO                 CH3COO              CH2COO              HCOO
CH3O                CH2O                CH-O                FCH2O          ↓
CH3  Subgroup No. 1  Main Group 1 (2,2,4-Trimethylpentane)
Enter the subgroup type you wish to add or remove  q to quit
>
```

```
                C6                    IsopropylEth Unifac Structure
                C7
                C8
                C9
                C10
                C11
                C12
── ▼ ─ ↓ ──────── ▼ ─ ↓ ──Searc
 F1 - Help, F3 - Menu, F4 - Fli
                          PRESS I
```

Step	Action
27	Type the letter **q** and then press the **<Enter>** key;
	Specifying that component viscosities should be calculated via an equation.
28	Highlight the word **None** and then press the **<Enter>** key;
	The following screen will then appear:

```
        Parameters for Uniquac Models
            Component Name:  IPEther    __

   Uniquac Q Parameter        :   4.9360_____
   Uniquac R Parameter        :   5.8486_____
```

Step	Action
	Changing the q_i and r_i parameters.
29	Type the number **4.088** and then press the **<Enter>** key;
30	Type the number **4.7421**;
	The screen will then appear as follows:

```
        Parameters for Uniquac Models
            Component Name:  IPEther    __

   Uniquac Q Parameter        : 4.088_________
   Uniquac R Parameter        : 4.7421________
```

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
31	Press the <Insert> key;
	The screen will then appear as follows:

```
═══════════ Hypothetical Component Information ═══════════
   Are The Component Calculations Satisfactory: Yes_____
Name: IPEther                    Chemical Formula: C6H14O
──────────────────────────────────────────────────────────
Boiling Point [C_]          :     69.00
LiqDensity (@ 15 )[kg/m3_]  :    702.28
Molecular Weight            :    102.00

Critical Temperature [C_]   :    239.77
Critical Pressure [kPa___]  :   3185.54
Critical Volume [m3/kgmol]  :      0.356
Acentric Factor             :    0.27656
Acentric Factor  Wsrk       :    0.27656
Charact. Volume [m3/kgmol]  :    0.41230
Dipole Moment [debye]       :      0.00

  Vapour Pressure [deg K, kPa]
ANTA:  4.85694e+01  ANTD: -4.87945e+00
ANTB: -5.30459e+03  ANTE:  1.57758e-17
ANTC:  0.00000e+00  ANTF:  6.00000e+00
TMIN:       69.000  TMAX:       239.772
Viscosity Coeff A:          0.40899
Viscosity Coeff B:          0.48110

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal =  1.0939278e+02 kJ/kg___
       +  8.5511814e-02 * T
       +  2.8297170e-03 * T^2
       + -6.7709155e-07 * T^3
       +  0.0000000e+00 * T^4
       +  0.0000000e+00 * T^5
Entropy Coeff:        1.0000000
Cavett Param.:         0.27073

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____ kJ/kgmol
       + _____ * T
       + _____ * T^2
Heat Form (@ 25 C): _____
Heat Comb (@ 25 C): _____
Radius Gyration [Ang]:    4.0410
```

Step	Action
32	Press the <Insert> key;
	The screen will then appear as follows:

```
═══════════ COMPONENT SELECTION ═══════════
 Selected  |  Synonym  |  Name  |  Formula  |  Criteria
 ─ ▲ ─ ↑   |  ─ ▲ ─ ↑  |
AceticAcid | OIL       | OIL                | ALL
IPEther    | HYPOTHETICAL | HYPOTHETICAL    | HC
           | C1        | Methane    | CH4   | SOLID
           | C2        | Ethane     | C2H6  | MISC
           | C3        | Propane    | C3H8  | AMINE
           | i-C4      | i-Butane   | C4H10 | ALCOHOL
           | n-C4      | n-Butane   | C4H10 | KETONE
           | i-C5      | i-Pentane  | C5H12 | ALDEHYDE
           | n-C5      | n-Pentane  | C5H12 | ESTER
           | C6        | n-Hexane   | C6H14 | CARBACID
           | C7        | n-Heptane  | C7H16 | HALOGEN
           | C8        | n-Octane   | C8H18 | NITRILE
           | C9        | n-Nonane   | C9H20 | PHENOL
           | C10       | n-Decane   | C10H22| ETHER
           | C11       | n-C11      | C11H24| USER
           | C12       | n-C12      | C12H26|
 ─ ▼ ─ ↓   | ─ ▼ ─ ↓ ──Search by SYNONYM──
 F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
                PRESS INSERT TO SUBMIT
```

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
	Selecting the components in the feed streams.
33	*Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following component:* Highlight the formula **H2O** and then press the **<Enter>** key;
	The screen should then appear as follows:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
AceticAcid	1-DecaneThiol	1Decanethiol	C10H22S	ALL
IPEther	1-UndecaneThiol	1Undecathiol	C11H24S	HC
H2O	1-DodecaneThiol	1Dodecathiol	C12H26S	SOLID
	1-TetradecaThiol	1Ttrdecthiol	C14H30S	MISC
	1-OctadecaThiol	1OctadcThiol	C18H38S	AMINE
	ThioNaphthene	ThioNaphtene	C8H6S	ALCOHOL
	NH3	Ammonia	NH3	KETONE
	H2	Hydrogen	H2	ALDEHYDE
	H2O2	H2O2	H2O2	ESTER
	D2O	D2O	D2O	CARBACID
	He	Helium	He	HALOGEN
	Argon	Argon	Ar	NITRILE
	N2	Nitrogen	N2	PHENOL
	O2	Oxygen	O2	ETHER
	Ozone	Ozone	O3	USER
	HCl	HCl	HCl	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
34	Press the **<Insert>** key;
	The following screen will then appear:

Aij Interaction Parameters

HOT KEYS F1_Help F2_Menu S_Switch-Matrices A_UnifacVLE
H_Henry's Coeff L_UnifacLLE C_UnifacLLE_All
I_j immiscible in i B_all immiscible in i

	AceticAcid	IPEther	H2O
AceticAcid	---	---	---
IPEther	---	---	---
H2O	---	---	---

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
	Specifying the Aij Interaction Parameters.
35	*Place the cursor at blank for the Acetic Acid row and the IPEther column and then:* Type the number **46.8580** and then press the <**Enter**> key;
36	*Place the cursor at blank for the Acetic Acid row and the H2O column and then:* Type the number **-37.7850** and then press the <**Enter**> key;
37	*Place the cursor at blank for the IPEther row and the Acetic Acid column and then:* Type the number **-161.2300** and then press the <**Enter**> key;
38	*Place the cursor at blank for the IPEther row and the H2O column and then:* Type the number **154.6200** and then press the <**Enter**> key;
39	*Place the cursor at blank for the H2O row and the Acetic Acid column and then:* Type the number **-203.2900** and then press the <**Enter**> key;
40	*Place the cursor at blank for the H2O row and the IPEther column and then:* Type the number **571.5000** and then press the <**Enter**> key;
	The following screen will then appear:

Aij Interaction Parameters

```
 HOT KEYS    F1_Help    F2_Menu    S_Switch-Matrices    A_UnifacVLE
             H_Henry's Coeff       L_UnifacLLE      C_UnifacLLE_All
             I_j immiscible in i              B_all immiscible in i
                 AceticAcid    IPEther        H2O
AceticAcid         ---           46.8580      -37.7850
IPEther         -161.2300         ---         154.6200
H2O             -203.2900       571.5000       ---
```

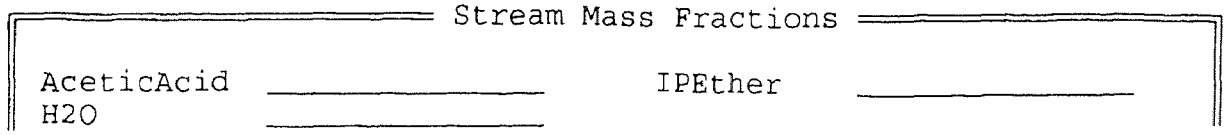
Step	Action
41	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

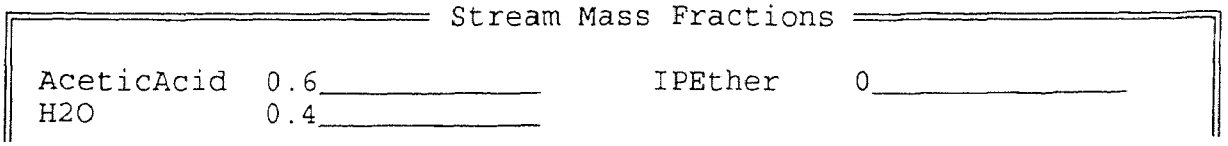
Step	Action
	Specifying the conditions of the Feed streams, Feed and IPE.
42	Highlight the word **Specify** and then press the <**Enter**> key;
43	Highlight the word **Stream** and then press the <**Enter**> key;
44	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in ℃.
45	Type the number **22.2** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in kPa.
46	Type the number **101** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream as unknown by typing the letter "x".
47	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
	Specifying that the composition of each component in the Feed stream will be given as mass fractions.
48	Highlight the word **Mass_Fractions** after the prompt (>) and then press the <**Enter**> key;
	The screen will appear as shown below:



Step	Action
	Selecting the components in the Feed stream.
49	*Enter the following mass fractions beside each component in the Feed stream:* After the word, AceticAcid, type the number **0.6** in the blank and then press the <**Enter**> key; After the word, IPEther, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.4** in the blank;
	The screen will now appear as shown below:



Step	Action
50	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream, IPE.
51	Highlight the word **Specify** and then press the <**Enter**> key;
52	Highlight the word **Stream** and then press the <**Enter**> key;
53	Type the word **IPE** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the IPE stream in °C.
54	Type the number **22.2** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the IPE stream in kPa.
55	Type the number **206.1** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the IPE stream as unknown (x) by typing the letter "x".
56	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the IPE stream will be given as mass fractions.
57	Highlight the word **Mass_Fractions** after the prompt (>) and then press the <**Enter**> key;
	The screen will appear as shown on the following page.

3.1.5 Liquid/Liquid Extraction Column (continued)

Stream Mass Fractions

AceticAcid _____ IPEther _____
H2O _____

Step	Action
	Selecting the components in the IPE stream.
58	*Enter the following mass fractions beside each component in the IPE stream:* After the word, AceticAcid, type the number **0** in the blank and then press the <**Enter**> key; After the word, IPEther, type the number **1** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0** in the blank;
	The screen will now appear as shown below:

Stream Mass Fractions

AceticAcid 0_____ IPEther 1_____
H2O 0_____

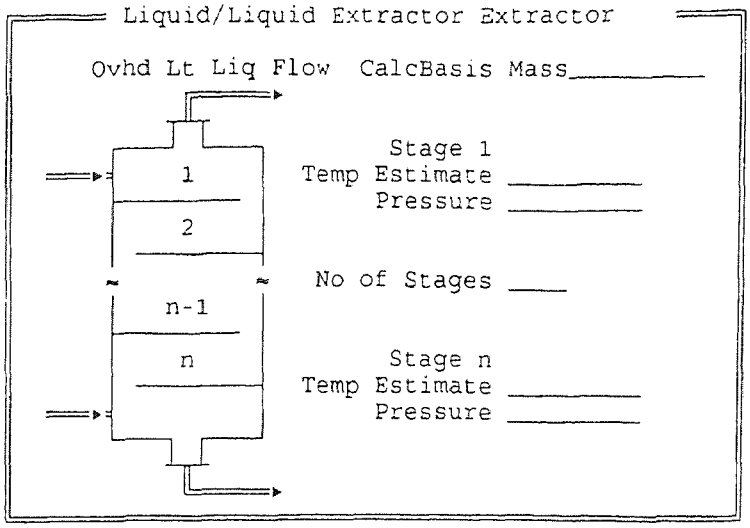
Step	Action
59	Press the <**Insert**> key;
	Specifying the Mass flow rate of streams Feed and IPE in kg/hr.
60	Highlight the word **Worksheet** and then press the <**Enter**> key;
61	*Highlight the space under the Feed title for the Mass Flow in kg/hr.* Type the number **909.1** and then press the <**Enter**> key;
62	*Highlight the space under the IPE title for the Mass Flow in kg/hr.* Type the number **1363.6** and then press the <**Enter**> key;
	The screen shown below will then appear:

Streams

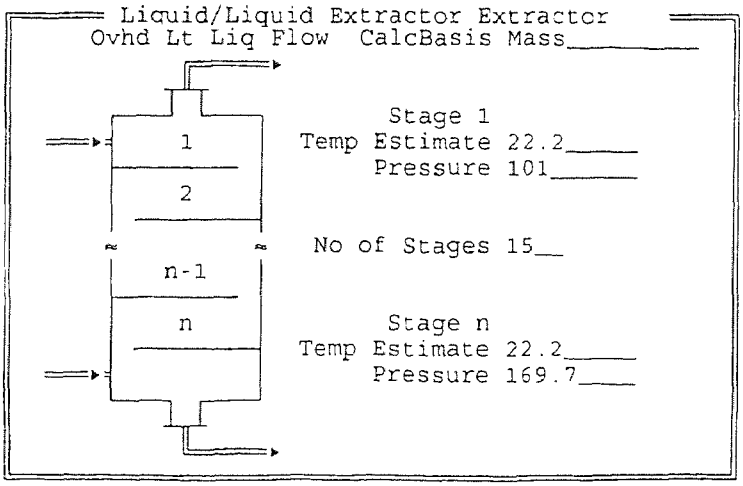
	New Value =		kg/h	
Stream	Feed	IPE	---	---
Vapour_Frac	0.0000	0.0000	---	---
Temperature	22.2000*	22.2000*	---	---
Pressure	101.0000*	206.1000*	---	---
Flow	29.2763	13.3686	---	---
Mass_Flow	909.1000*	1363.6000*	---	---
LiqVol_Flow	1.0893	1.9417	---	---
Energy_Flow	-850024.3585	94378.4111	---	---

Step	Action
63	Press the <**Insert**> key;
64	Type the word **Extractor** and then press the <**Enter**> key;
65	Highlight the word **Column** and then press the <**Enter**> key;
66	Highlight the word **Extraction** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page

3.1.5 Liquid/Liquid Extraction Column (continued)

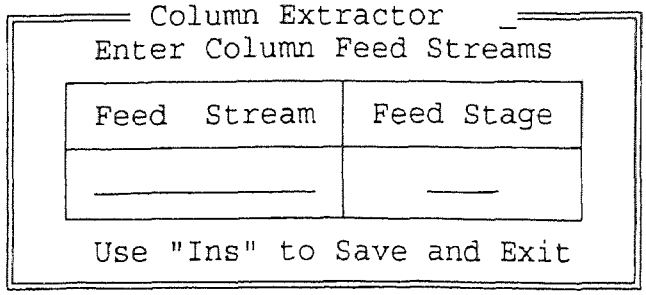


Step	Action
	Specifying the known data for the extraction column.
67	Press the **<Enter>** key;
	Specifying the Temperature Estimate of Stage 1 in °C.
68	Type the number **22.2** and then press the **<Enter>** key;
	Specifying the Pressure of Stage 1 in kPa.
69	Type the number **101** and then press the **<Enter>** key;
	Specifying the Number of Stages in the Extraction Column.
70	Type the number **15** and then press the **<Enter>** key;
	Specifying the Temperature Estimate of Stage 15 in °C.
71	Type the number **22.2** and then press the **<Enter>** key;
	Specifying the Pressure of Stage 15 in kPa.
72	Type the number **169.7**;
	The screen will then appear as shown below:

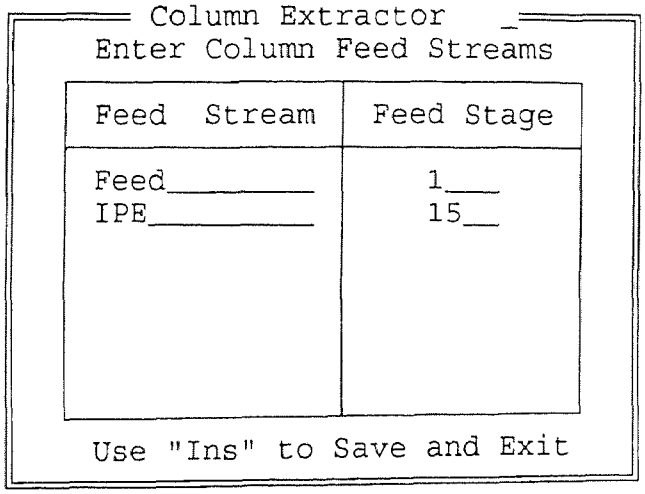


3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
73	Press the <**Insert**> key.
	The following screen for specifying the names of the feed streams and the stage at which they enter the Extraction column will then appear:

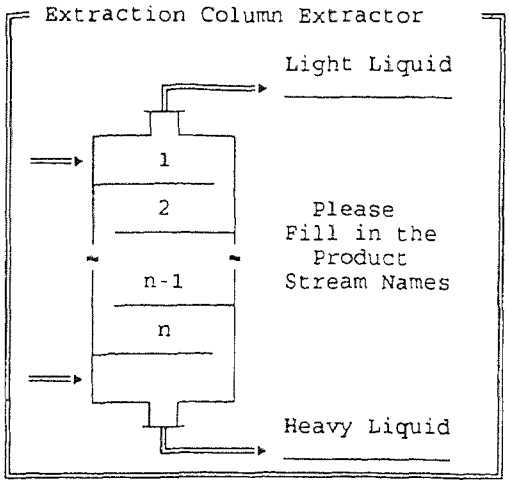


Step	Action
	Specifying at what stage the feed streams enter the Extraction Column.
74	Type the word **Feed** and then press the <**Enter**> key.
75	Type the number 1 and then press the <**Enter**> key.
76	Type the word **IPE** and then press the <**Enter**> key.
77	Type the number **15**.
	The following screen will then appear:

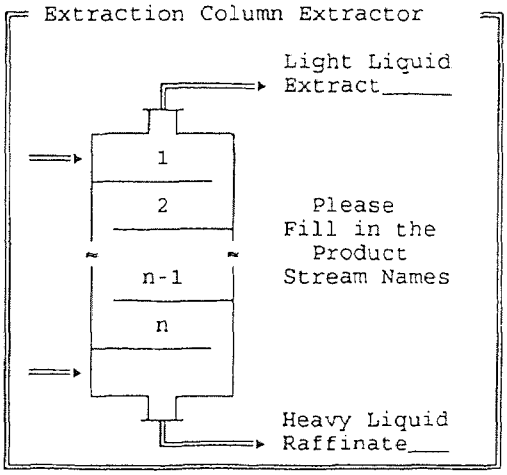


Step	Action
78	Press the <**Insert**> key;
	The screen will then appear as shown on the following page.

3.1.5 Liquid/Liquid Extraction Column (continued)



Step	Action
	Specifying the names of the streams going out of the Extraction Column.
79	Type the word **Extract** and then press the **<Enter>** key.
80	Type the word **Raffinate**.
	The screen should then appear as shown below:



Step	Action
81	Press the **<Insert>** key.

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in nonconvergence of a column calculation which leads to frustration with an input data error.

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
	Running the Extraction Column program.
82	Highlight the word **Run** and then press the **<Enter>** key.
83	Highlight the word **Print** and then press the **<Enter>** key.

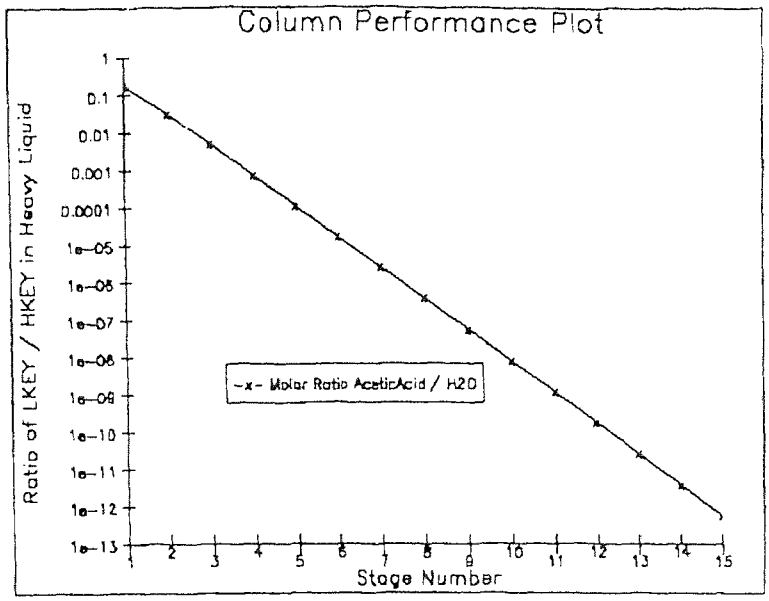
Print Options:

The various options available for the column, after you have finished step 83 are as follows: (Highlight the option you select below with the arrow keys, and then press the <Enter> key to select that option).

a) *Input* - Input data is printed.
b) *Feeds* - Feed composition and conditions are printed.
c) *Stages* - The temperature, pressure, liquid and vapor flow rates, any feed or drawoffs of each stage are reported, along with the duty of the first and last stage.
d) *Products* - The temperature, pressure, composition, and total flow rate of the overhead and bottom product streams are printed.
e) *Physical_Props* - The molecular weight, flow rate, density, reduced temperature and pressure are reported for each stage.
f) *Transport_Props* - The vapor and liquid dynamic viscosity and thermal conductivity are printed, along with the liquid surface tension.
g) *Exchanger_Profiles* - The condenser and reboiler heating curve data is printed.
h) *Composition* - The composition profile of selected components in the liquid and vapor phase are printed.
i) *Efficiencies* - The efficiency of each stage is printed.
j) *Pumparound_info* - If a pumparound is used, the information can be printed.
k) *All* - All of the information from a to j above will be printed.
l) *Graph* - Temperatures, flowrates, mole fractions or key ratios can be printed in graphical form.
m) *SI* - The current output will be printed in metric units.
n) *Field* - The current output will be printed in Field (or English units).
o) *User* - The current output will be printed in user-defined units.
p) *Comp_Fractions* - The output will be printed on a mole, mass, or volume fractional basis.
q) *Comp_Flows* - The output will be printed as mole, mass or volume flows.
r) *Printer* - The printer will be toggled on. Selecting "Printer" once more will toggle the printer off.
s) *File* - The printout will be saved in a file.
t) *Mole* - The output will be printed on a mole basis.
u) *Mass* - The output will be printed on a mass basis.
v) *LiqVolume* - The output will be printed on a standard ideal liquid volume basis.
w) *Title* - Input a title which will be on all printouts.
x) *Boiling_Pt_Curves* - The True Boiling Point (TBP), D86, or Specific Gravity boiling point curves will be printed out.
y) *Cold_Properties* - The Research Octane Number (RON), Pour Point, and Flash Point will be printed.
z) *User_Props* - If properties have been supplied by the user, these values will be printed out.

3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
84	Highlight the word **Graph** and then press the <**Enter**> key.
85	Highlight the word **Key_Ratios** and then press the <**Enter**> key.
86	Highlight the word **AceticAcid** and then press the <**Enter**> key.
87	Highlight the formula **H2O** and then press the <**Enter**> key.
88	Highlight the word **Plot** and then press the <**Enter**> key.
	The screen will then appear as shown below:



Step	Action
89	Press the <**Esc**> key five times until you are back at the Main Menu.
	Looking at the stream compositions resulting from the run.
90	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

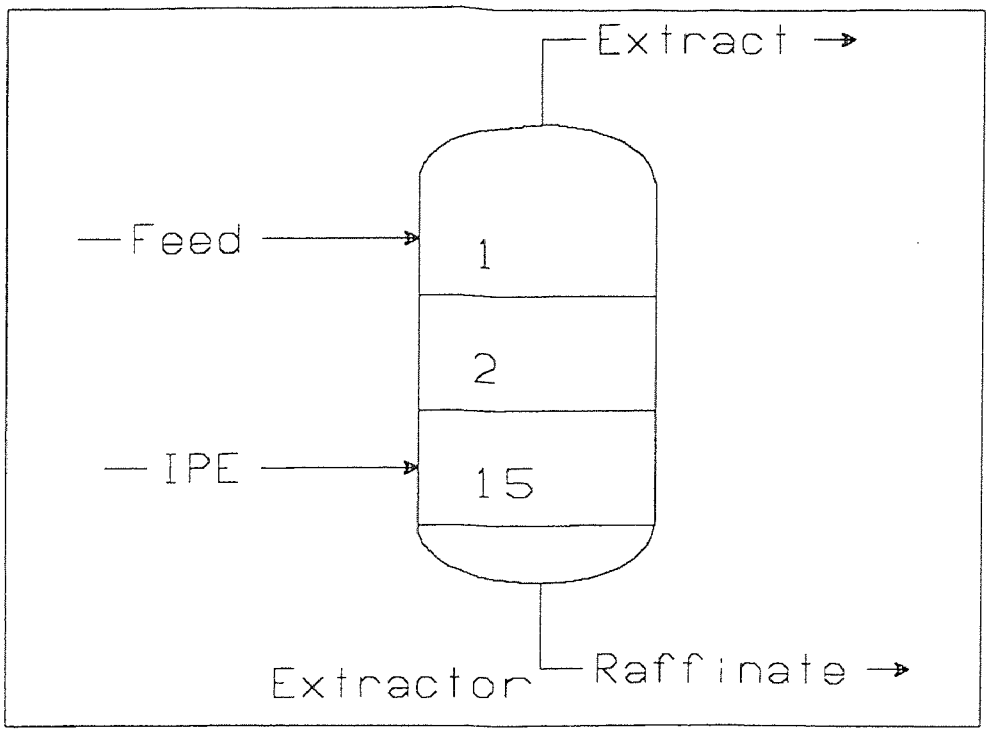
3.1.5 Liquid/Liquid Extraction Column (continued)

Step	Action
91	Highlight the word **Streams** and then press the <**Enter**> key.
92	Highlight the word **All** and then press the <**Enter**> key.
93	Highlight the dash symbol - and then press the <**Enter**> key.
	The menu on the screen can be temporarily taken off the screen, so that the underlying data can be viewed by pressing the <F10> key.
94	Press the <**F10**> key;
	The screen will then appear as shown below:

Stream		Feed	IPE	Extract	Raffinate
Description					
Vapour frac.		0.0000	0.0000	0.0000	0.0000
Temperature	C	22.2000*	22.2000*	22.1770	22.2466
Pressure	kPa	101.0000*	206.1000*	101.0000	169.7000
Molar Flow	kgmole/h	29.2763	13.3686	40.4775	2.1674
Mass Flow	kg/h	909.1000*	1363.6000*	2232.6035	40.0963
LiqVol Flow	m3/h	1.0893	1.9417	2.9902	0.0407
Enthalpy	kJ/h	-850024.3585	94378.4111	-680704.3377	-75055.8909
Density	kg/m3	844.3116	696.1990	772.2279	1002.8477
Mole Wt.		31.0524	102.0000	55.1567	18.4993
Spec. Heat	kJ/kg-C	3.0760	2.0329	2.4201	4.1201
Therm Cond	W/m-K	0.4327	0.1241	0.2961	0.6031
Viscosity	cP	0.7764	0.2860	0.4323	0.9308
Z Factor		0.0015	0.0123	0.0029	0.0013
Sur Tension	dyne/cm	57.1666	18.1236	43.4661	72.2610
Std Density	kg/m3	850.1712	702.7983	778.8751	1008.3014
AceticAcid	mole frac.	0.3105*	0.0000*	0.2246	0.0000
IPEther	mole frac.	0.0000*	1.0000*	0.3300	0.0058
H2O	mole frac.	0.6895*	0.0000*	0.4454	0.9942

Step	Action
	The menu can be put back on the screen by pressing the <F10> key.
95	Press the <**F10**> key;
96	Highlight the letters **PFD** and then press the <**Enter**> key.
	The screen shown on the following page will then appear.

3.1.5 Liquid/Liquid Extraction Column (continued)



Step	Action
	Getting back to the Main Menu.
97	Press the <Esc> key until you reach the Main Menu.
98	Do you want to continue adding other unit operations to this extraction column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.1.6 Component Fractionator Column

Objective - This exercise is an example of a fractionator column, where the component separation (in terms of the overhead product) has been specified. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

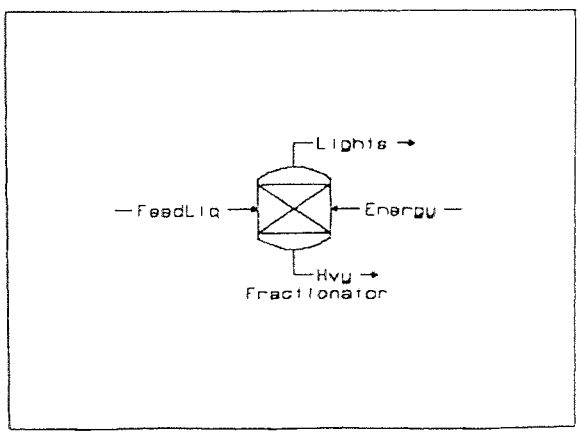
In this example, the feed stream, named *FeedLiq*, contains seven different hydrocarbons: ethane, propane, i-butane, n-butane, i-pentane, n-pentane and n-hexane. The fraction of each component in the feed going overhead is specified, along with the composition, flow rate and conditions of the *FeedLiq* stream. The vapor fraction and the pressure of the overhead stream, named *Lights*, and the bottoms product stream, named *Hvy*, were also specified. HYSIM then calculated the rest of the composition and conditions of each stream, as shown on page 118.
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-40 to 7-42.
Other References: Refs. 1 & 2.

The component fractionator column is very useful for speeding the convergence of a recycle loop containing distillation columns. If the recycle loop iteration calculation includes rigorous distillation column calculations, then the convergence is slow and may lead to the nonconvergence of a column as the recycle loop changes its feedrate. The frustration involved with this type of situation can be avoided by replacing rigorous columns with fractionators until approximate recycle rates and column feeds are established. These rates and feeds, which are very close to the actual values, are then used with the recycle calculation containing rigorous column calculations.

Directions - Pages 114 through 122 outline the execution of a component fractionator column. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Fractionator*, is shown below:



3.1.6 Component Fractionator Column (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word **i-Butane** and then press the <**Enter**> key; Highlight the word **n-Butane** and then press the <**Enter**> key; Highlight the word **i-Pentane** and then press the <**Enter**> key; Highlight the word **n-Pentane** and then press the <**Enter**> key; Highlight the word **n-Hexane** and then press the <**Enter**> key;
	The following screen on the following page will then appear.

3.1.6 Component Fractionator Column (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Ethane	OIL	OIL		ALL
Propane	HYPOTHETICAL	HYPOTHETICAL		HC
i-Butane	C1	Methane	CH4	SOLID
n-Butane	C7	n-Heptane	C7H16	MISC
i-Pentane	C8	n-Octane	C8H18	AMINE
n-Pentane	C9	n-Nonane	C9H20	ALCOHOL
n-Hexane	C10	n-Decane	C10H22	KETONE
	C11	n-C11	C11H24	ALDEHYDE
	C12	n-C12	C12H26	ESTER
	C13	n-C13	C13H28	CARBACID
	C14	n-C14	C14H30	HALOGEN
	C15	n-C15	C15H32	NITRILE
	C16	n-C16	C16H34	PHENOL
	C17	n-C17	C17H36	ETHER
	C18	n-C18	C18H38	USER
	C19	n-C19	C19H40	

Search by SYNONYM

F1 - Help, F4 - Flip Srch, F5 - Exam, F6 - Move,
F3 - Menu, PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;
	The following screen will then appear:

```
Work_Sheet          Specify          Operation        Print
PFD                 Remove           Store            New
Ignore              Restore          Hold             Go
Utility             Size             Report           Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system (kg, kPa, °C,etc.) to field units (lb, psia, °F,etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;

3.1.6 Component Fractionator Column (continued)

Step	Action
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the FeedLiq stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **FeedLiq** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the FeedLiq stream in °F.
14	Type the number **200** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the FeedLiq stream in psia.
15	Type the number **500** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the FeedLiq stream in lb-mols/hr.
16	Type the number **1000** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the FeedLiq stream will be given in mole fractions.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

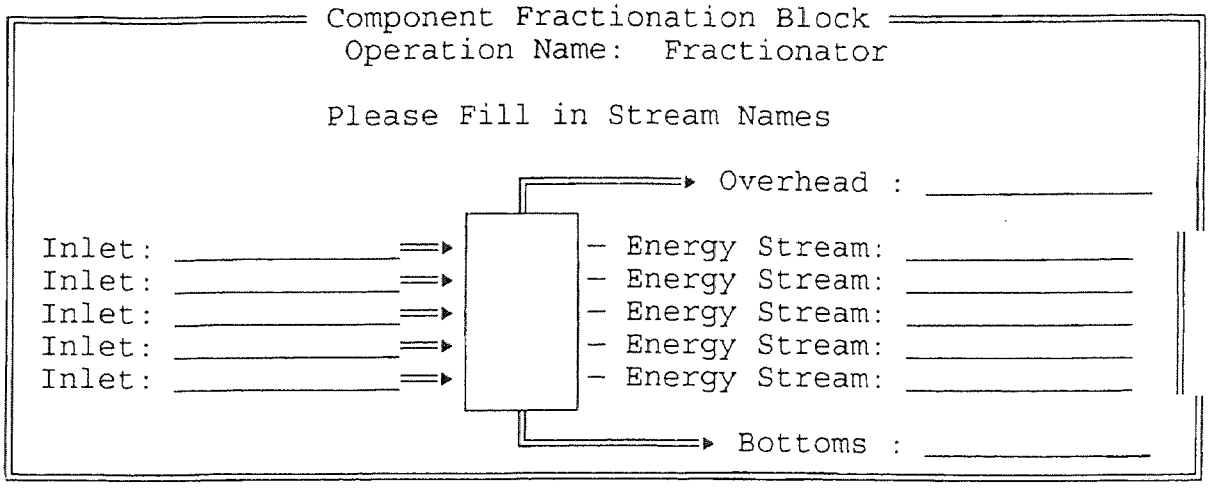
```
                    Stream Mole Fractions

Ethane      _____________________     Propane     _____________________
i-Butane    _____________________     n-Butane    _____________________
i-Pentane   _____________________     n-Pentane   _____________________
n-Hexane    _____________________
```

Step	Action
	Selecting the components in the FeedLiq stream.
18	*Enter the following mole fractions beside each component in the FeedLiq stream:* After the word, Ethane, type the number **0.0148** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.7315** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0681** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.1462** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0173** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0150** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0071** in the blank;
	The screen will now appear as shown below:

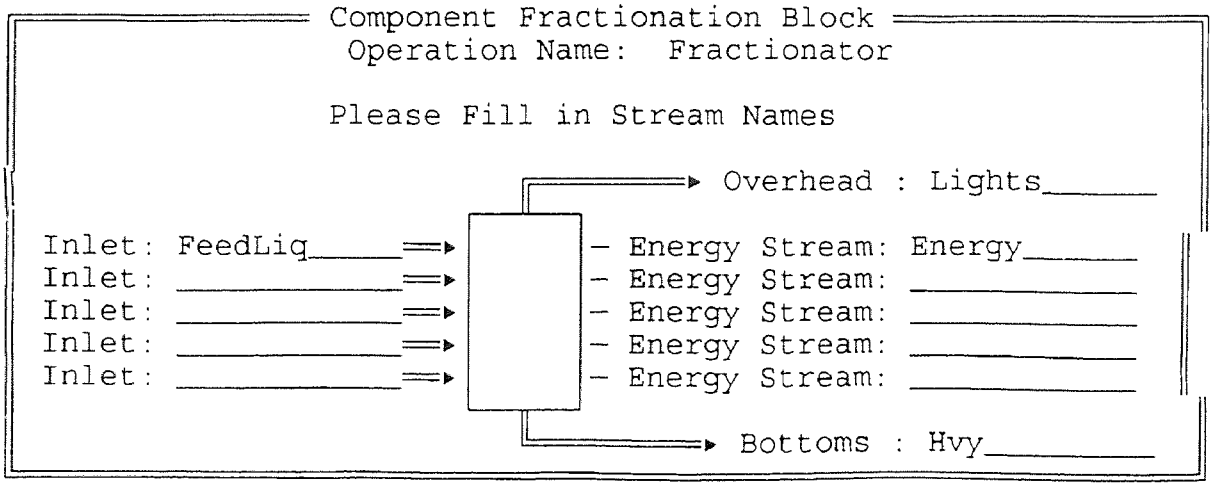
```
                    Stream Mole Fractions

Ethane      0.0148_____________     Propane     0.7315_____________
i-Butane    0.0681_____________     n-Butane    0.1462_____________
i-Pentane   0.0173_____________     n-Pentane   0.0150_____________
n-Hexane    0.0071_____________
```

3.1.6 Component Fractionator Column (continued)

Step	Action
19	Press the <**Insert**> key;
	Specifying the type of operation we want to perform on the FeedLiq stream.
20	Highlight the word **Operation** and then press the <**Enter**> key;
21	Type the word **Fractionator** and then press the <**Enter**> key;
22	Highlight the word **Fractionate** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the stream names for the component fractionator column.
23	Type the word **FeedLiq** and then place the cursor in the blank to the right of the Overhead label and then press the **left mouse key**;
24	Type the word **Lights** and then press the <**Enter**> key;
25	Type the word **Hvy** and then press the <**Enter**> key;
26	Type the word **Energy** and then press the <**Enter**> key;
	The screen will then appear as shown below:



3.1.6 Component Fractionator Column (continued)

Step	Action
27	Press the <**Insert**> key.
	The following screen for specifying the fraction of each component in the FeedLiq stream going overhead will then appear:

```
═══ Fraction of Feed going Overhead ═══

   Ethane      _____________      Propane     _____________
   i-Butane    _____________      n-Butane    _____________
   i-Pentane   _____________      n-Pentane   _____________
   n-Hexane    _____________
```

Step	Action
	Specifying the fraction of each component in the FeedLiq stream which will be going overhead in the Lights *stream.*
28	Type the number **1.000** and then press the <**Enter**> key.
29	Type the number **0.980** and then press the <**Enter**> key.
30	Type the number **0.020** and then press the <**Enter**> key.
31	Type the number **0.005** and then press the <**Enter**> key.
32	Type the number **0.001** and then press the <**Enter**> key.
33	Type the number **0.000** and then press the <**Enter**> key.
34	Type the number **0.000**.
	The following screen will then appear:

```
═══ Fraction of Feed going Overhead ═══

   Ethane      1.000_____________      Propane     0.980_____________
   i-Butane    0.020_____________      n-Butane    0.005_____________
   i-Pentane   0.001_____________      n-Pentane   0.000_____________
   n-Hexane    0.000_____________
```

Step	Action
35	Press the <**Insert**> key;
36	Highlight the word **Worksheet** and then press the <**Enter**> key;
	The screen will then appear as shown below:

```
═══ Streams ═══

                  New Value =
Stream             FeedLiq        Energy          Lights           Hvy
Vapour_Frac         0.0000        2.0000*          ---              ---
Temperature       200.0000*       0.0000*          ---              ---
Pressure          500.0000*       0.0000*          ---              ---
Flow             1000.0000*       0.0000*        733.7803         266.2197
Mass_Flow       48100.3030        0.0000*      32179.7539       15920.5501
LiqVol_Flow      6242.8582        0.0000*       4372.4888        1870.3690
Energy_Flow 4.01751E+06           ---             ---              ---
```

3.1.6 Component Fractionator Column (continued)

Step	Action
	Specifying the pressure (psia) and the Vapor Fraction of the Lights and Hvy streams.
37	*Move the cursor until it is in the column for the Lights stream and in the row for the Vapor Frac.* Type the number **1** and then press the **<Enter>** key.
38	*Move the cursor until it is in the column for the Lights stream and in the row for the pressure.* Type the number **100** and then press the **<Enter>** key.
39	*Move the cursor until it is in the column for the Hvy stream and in the row for the Vapor Frac.* Type the number **0** and then press the **<Enter>** key.
40	*Move the cursor until it is in the column for the Hvy stream and in the row for the pressure.* Type the number **103** and then press the **<Enter>** key.
	The screen should then appear as shown below:

Streams

Stream	New Value = FeedLiq	Energy	psia Lights	Hvy
Vapour_Frac	0.0000	2.0000*	1.0000*	0.0000*
Temperature	200.0000*	0.0000*	54.4899	141.6560
Pressure	500.0000*	0.0000*	100.0000*	103.0000*
Flow	1000.0000*	0.0000*	733.7803	266.2197
Mass_Flow	48100.3030	0.0000*	32179.7539	15920.5501
LiqVol_Flow	6242.8582	0.0000*	4372.4888	1870.3690
Energy_Flow	4.01751E+06	636054.5675	4.28622E+06	367344.1037

Step	Action
	Getting back to the Main Menu.
41	Press the **<Esc>** key.
42	Highlight the word **Print** and then press the **<Enter>** key.

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) Oil_Input - Lists inputted information on an oil.

3.1.6 Component Fractionator Column (continued)

Step	Action
43	Highlight the word **Streams** and then press the <**Enter**> key.
44	Highlight the word **All** and then press the <**Enter**> key.
45	Highlight the symbol - and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
46	Press the <**F10**> key;
	The screen will then appear as shown below:

Stream Description		FeedLiq	Energy	Lights	Hvy
Vapour frac.		0.0000	2.0000*	1.0000*	0.0000*
Temperature	F	200.0000*	0.0000*	54.4899	141.6560
Pressure	psia	500.0000*	0.0000*	100.0000*	103.0000*
Molar Flow	lbmole/hr	1000.0000*	0.0000*	733.7803	266.2197
Mass Flow	lb/hr	48100.3030	0.0000*	32179.7539	15920.5501
LiqVol Flow	barrel/day	6242.8582	0.0000*	4372.4888	1870.3690
Enthalpy	Btu/hr	4.01751E+06	636054.5675	4.28622E+06	367344.1037
Density	lb/ft3	23.8751	0.0000	0.9236	33.0017
Mole Wt.		48.1003	0.0000	43.8548	59.8023
Spec. Heat	Btu/lb-F	1.1003	---	0.4251	0.6458
Therm Cond	Btu/hr-ft-F	0.0327	---	0.0100	0.0464
Viscosity	cP	0.0579	---	0.0082	0.1245
Z Factor		0.1423	---	0.8605	0.0289
Sur Tension	dyne/cm	1.3362	---	---	7.7534
Std Density	lb/ft3	33.1813	---	---	36.5203
Ethane	mole frac.	0.0148*	0.0000*	0.0202	0.0000
Propane	mole frac.	0.7315*	0.0000*	0.9770	0.0550
i-Butane	mole frac.	0.0681*	0.0000*	0.0019	0.2507
n-Butane	mole frac.	0.1462*	0.0000*	0.0010	0.5464
i-Pentane	mole frac.	0.0173*	0.0000*	0.0000	0.0649
n-Pentane	mole frac.	0.0150*	0.0000*	0.0000	0.0563
n-Hexane	mole frac.	0.0071*	0.0000*	0.0000	0.0267

NOTE: It is useful to print out all of the inputted process data to check for accuracy. Incorrect data entries can result in nonconvergence of a column calculation which leads to frustration with an input data error.

Step	Action
47	Press the <**F10**> key;
48	Highlight the word **Print** and then press the <**Enter**> key.

The various print options can be found on page 119.

Step	Action
49	Highlight the word **Spec_Sheets** and then press the <**Enter**> key.
50	Highlight the word **Operations** and then press the <**Enter**> key.

3.1.6 Component Fractionator Column (continued)

Step	Action
51	Highlight the word **Fractionator** and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
52	Press the **<F10>** key.
	Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down. The screen will then appear as seen below:

HYSIM COMPONENT FRACTIONATE SPECIFICATION

HYSIM Version C2.53 Date 96/09/23
Case Name: Time 10:41:56

Operation Name: Fractionator
Operation Note:

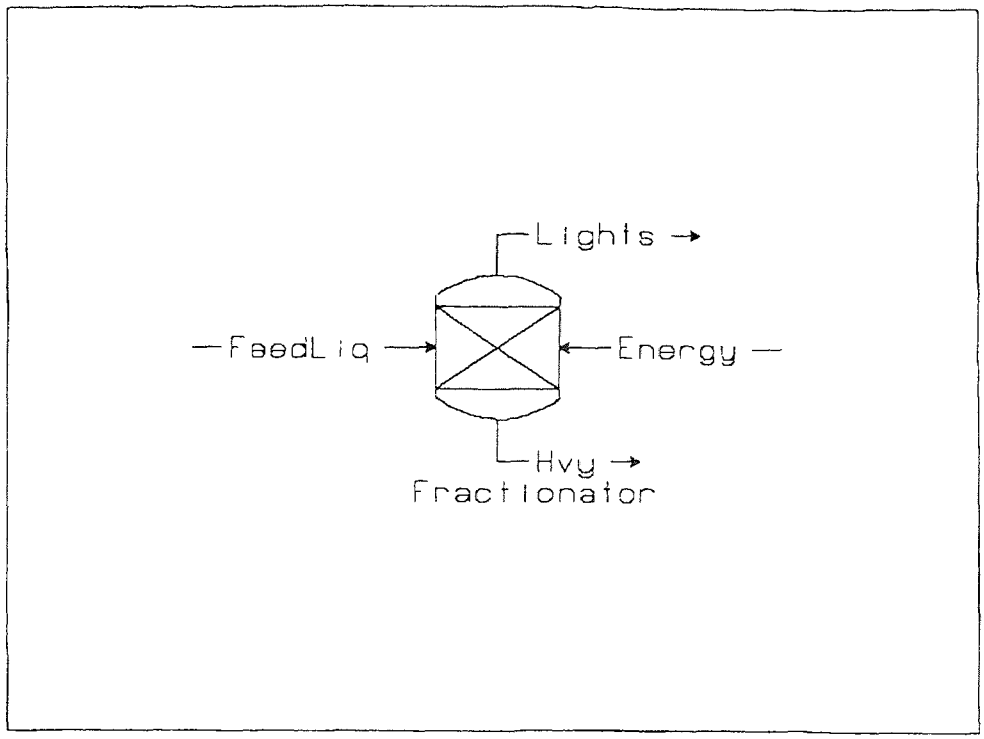
Process Feed Streams	From Operation		Flow Rate	
FeedLiq	---	---	1000.0000	lbmole/hr
---	---	---	---	lbmole/hr
---	---	---	---	lbmole/hr
---	---	---	---	lbmole/hr
---	---	---	---	lbmole/hr
Energy Streams				
Energy	---	---	636054.5675	Btu/hr
---	---	---	---	Btu/hr
---	---	---	---	Btu/hr
---	---	---	---	Btu/hr
---	---	---	---	Btu/hr
	To Operation			
Overhead Lights	---	---	733.7803	lbmole/hr
Bottoms Hvy	---	---	266.2197	lbmole/hr

Overhead Properties		Bottoms Properties	
Vapour Frac	1.0000	Vapour frac	0.0000
Temperature	54.4899 F	Temperature	141.6560 F
Pressure	100.0000 psia	Pressure	103.0000 psia
Density	0.9236 lb/ft3	Density	33.0017 lb/ft3
Std Density	31.5427 lb/ft3	Std Density	36.5203 lb/ft3
Mol Weight	43.8548	Mol Weight	59.8023
Viscosity	0.0082 cP	Viscosity	0.1245 cP
Therm Cond	0.0100 Btu/hr-ft-F	Therm Cond	0.0464 Btu/hr-ft-F

Component	Mole Fract Ovhd	Feed Moles	Overhead Moles	Bottoms Moles
Ethane	1.0000	14.8000	14.8000	0.0000
Propane	0.9800	731.5000	716.8700	14.6300
i-Butane	0.0200	68.1000	1.3620	66.7380
n-Butane	0.0050	146.2000	0.7310	145.4690
i-Pentane	0.0010	17.3000	0.0173	17.2827
n-Pentane	0.0000	15.0000	0.0000	15.0000
n-Hexane	0.0000	7.1000	0.0000	7.1000

3.1.6 Component Fractionator Column (continued)

Step	Action
53	Press the <**F10**> key;
54	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:

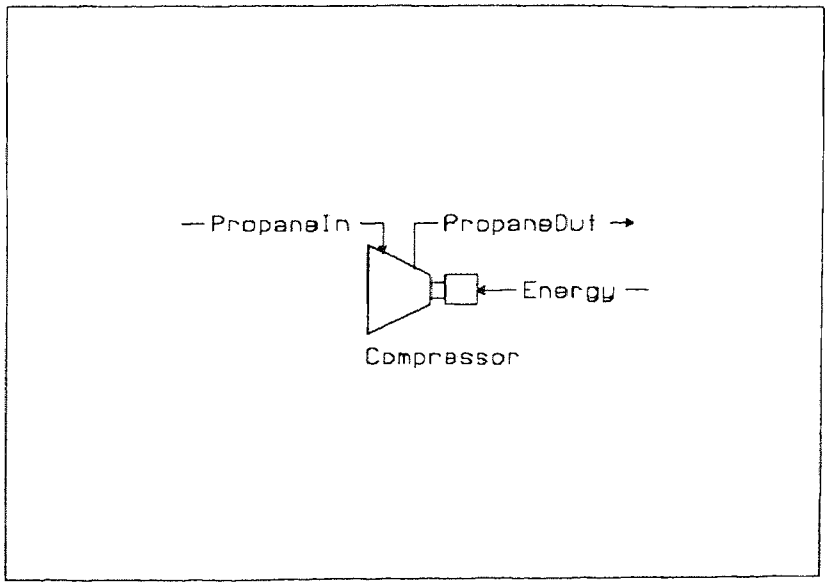


Step	Action
	Getting back to the Main Menu.
55	Press the <**Esc**> key until you reach the Main Menu.
56	Do you want to continue adding other unit operations to this component fractionator column? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

Objective- This exercise is an example of a compressor/expander calculation. The purpose of the compressor/expander unit operation is to compress or expand a gaseous or vapor stream either adiabatically (Q = 0) or polytropically. A polytropic process is one that is not an adiabatic process and is also not an isothermal process. This example can be modified by specifying another property package and/or other components, compositions and stream conditions.
In this example, the inlet stream, *PropaneIn*, is compressed from an inlet pressure of 44.1 psia to an outlet stream pressure of 248.5 psia, using a Compressor. HYSIM is used to calculate the related properties of the streams.
Technical Example Reference: Reference 1 - HYSIM Tutorial in the Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.
Other References: Refs. 1 & 2.

Directions: Pages 124 through 130 outline the execution of a compressor/expander example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.
Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Compressor*, is shown below:



Step	Action
1	Are you at the Start-Up Menu of HYSIM?(The Start-Up Menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream, named PropaneIn.
4	Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows: Highlight the word **Propane** and then press the <**Enter**> key;
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default SI or metric units (e.g. kg, °C, kPa, etc.) to field units (e.g. lb, °F, psia, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;

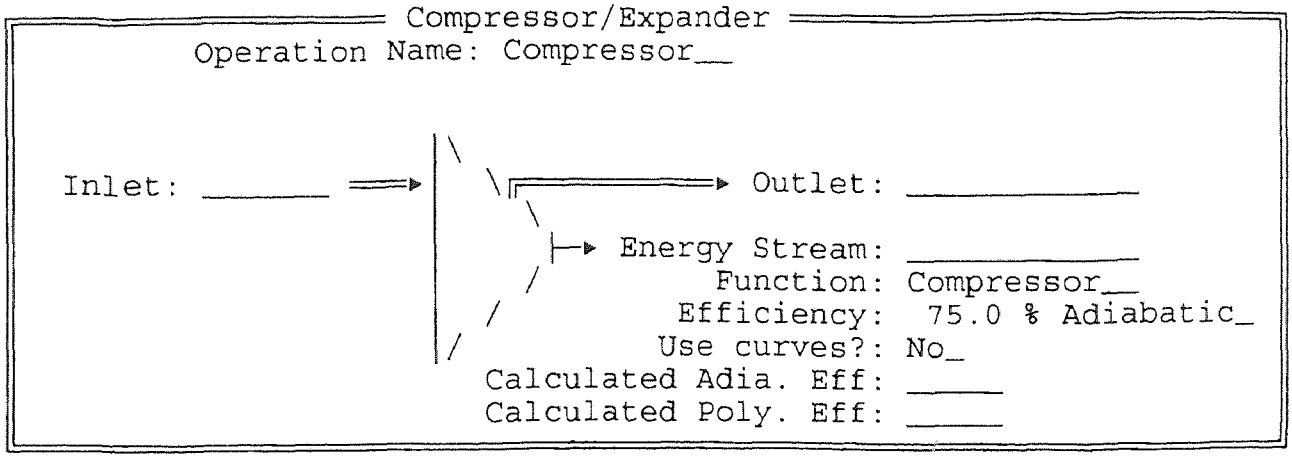
Step	Action
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the conditions of the feed stream, PropaneIn.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **PropaneIn** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of stream PropaneIn in °F.
14	Type the number **7.4** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of stream PropaneIn in psia.
15	Type the number **44.1** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the flow rate of stream PropaneIn is unknown by typing an "x".
16	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
17	Highlight the words **Mole_Flows** and then press the <**Enter**> key;
	The screen will then appear as follows:

```
Stream Molar Flows

Propane      _____________
```

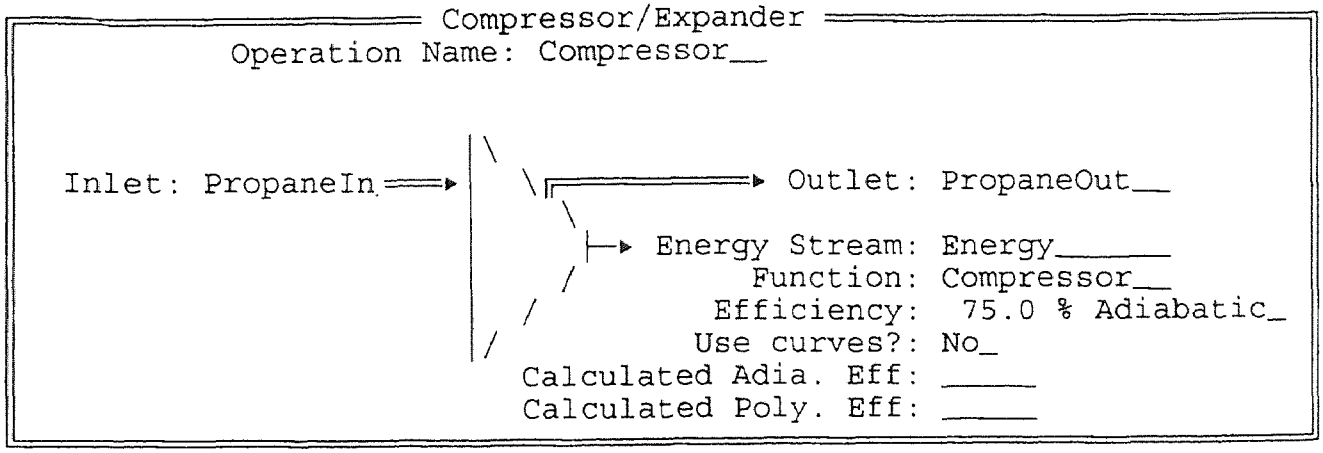
Step	Action
	Specifying the individual molar flows of each component.
18	*Enter the following molar flow(lb-mols/hr) beside each component in the PropaneIn stream:* After the word, Propane, type the number **5.66** in the blank;
	The screen should now appear as follows:

```
Stream Molar Flows

Propane      5.66_____________
```

Step	Action
19	Press the <**Insert**> key;
	HYSIM will next ask you if the total molar flow it calculated from adding up the individual component flows (5.6600 lb-mols/hr) is correct.
20	Highlight the word **Yes** and then press the <**Enter**> key;
	Specifying the type of operation.
21	Highlight the word **Operation** and then press the <**Enter**> key;
22	Type the word **Compressor** and then press the <**Enter**> key;
23	Highlight the word **Comp/Expander** and then press the <**Enter**> key;
	The screen shown on the following page will then appear.



Step	Action
	Naming the inlet and outlet streams.
24	Type the letter **PropaneIn** in the blank and then press the <**Enter**> key;
25	Type the letter **PropaneOut** in the blank and then press the <**Enter**> key;
26	Type the letter **Energy** in the blank;
	The screen should now appear as follows:



Step	Action
27	Press the <**Insert**> key;
28	Highlight the word **Worksheet** and then press the <**Enter**> key;
29	*Use the arrow keys to highlight the space (place the cursor over the blank) for the Pressure of stream,* PropaneOut in psia. Type the number **248.5** and then press the <**Enter**> key;
30	Press the <**Esc**> key until you are back at the Main Menu;

Step	Action
31	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:
The various print options available are as follows:
a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.
b) *Operations* - The different unit operations will be printed out.
c) *Spec_Sheets* - the specifications sheets will be printed out.
d) *Hypotheticals* - Hypothetical component information will be printed out.
e) *Format* - Specifies the format of the printout.
f) *Cost* - Lists costs of the run, if a royalty is being charged.
g) *File* - Saves results in a file.
h) *Printer* - Toggles on a printer.
i) *Cases* - Lists the stored files.
j) *Description* - Prints case description.
k) *Oil_Input* - Lists inputted information on an oil.

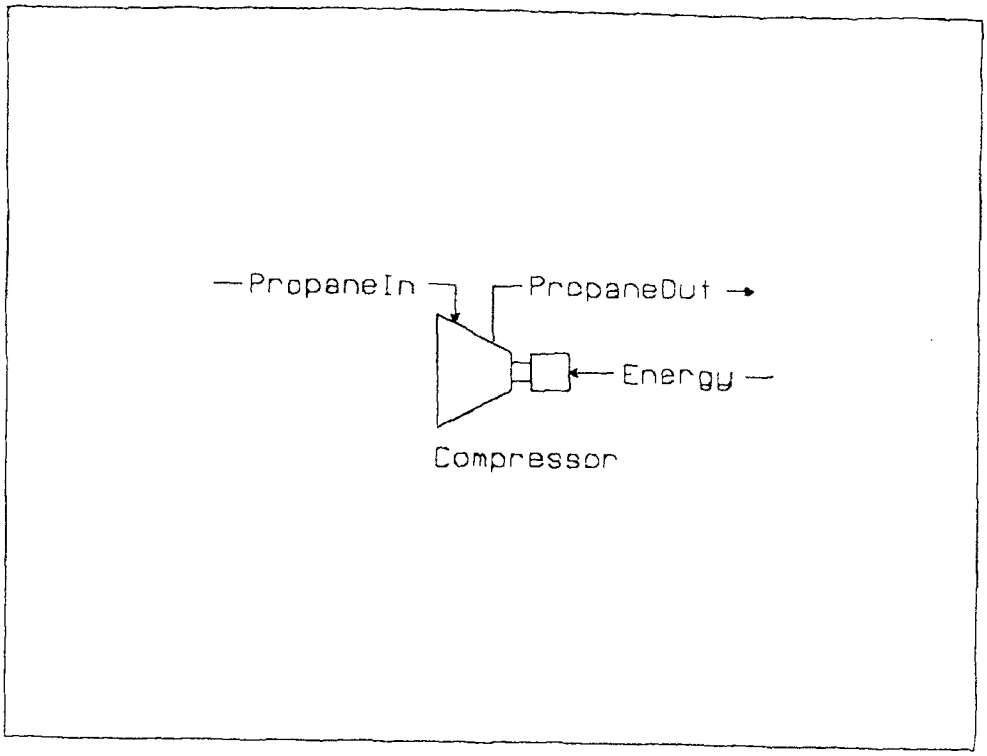
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
32	Highlight the word **Streams** and then press the <**Enter**> key;
	Looking at the calculated data for all of the streams.
33	Highlight the word **Summary** and then press the <**Enter**> key;
34	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
35	Press the <**F10**> key;
	The screen will appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream_Summary

*** Feed ***				
Stream Name		PropaneIn	PropaneOut	Energy
Vapour_Frac		1.0000	1.0000	---
Temperature	F	7.4000*	155.4053	---
Pressure	psia	44.1000*	248.5000*	---
Flow	lbmole/hr	5.6600*	5.6600	---
Mass_Flow	lb/hr	249.5890	249.5890	---
LiqVol_Flow	barrel/day	33.7296	33.7296	---
Mole_Weight		44.0970	44.0970	---
Energy	Btu/hr	29889.4688	41462.9570	11573.4873
Molar_Enthal	Btu/lbmole	5280.7715	7325.5366	---
Entropy	Btu/lbmole-F	33.8745	34.7210	---
Mass_Cp	Btu/lb-F	0.3798	0.5220	---
Mass_Density	lb/ft3	0.4201	2.1339	---
Z_Factor		0.9235	0.7780	---
*** Vapour ***				
Flow	lbmole/hr	5.6600	5.6600	---
Mass_Flow	lb/hr	249.5890	249.5890	---
Std_Gas_Flow	MMSCFD	0.0515	0.0515	---
Act_Gas_Flow	ACFM	9.9011	1.9495	---
Mole_Weight		44.0970	44.0970	---
Energy	Btu/hr	29889.4688	41462.9570	11573.4873
Molar_Enthal	Btu/lbmole	5280.7715	7325.5366	---
Entropy	Btu/lbmole-F	33.8745	34.7210	---
Mass_Cp	Btu/lb-F	0.3798	0.5220	---
Mass_Density	lb/ft3	0.4201	2.1339	---
Air_SG	rel_to_air	1.5225	1.5225	---
Z_Factor		0.9235	0.7780	---
Thermal_Cond	Btu/hr-ft-F	0.0083	0.0141	---
Viscosity	cP	0.0072	0.0103	---
*** Light Liquid ***				
Flow	lbmole/hr	0.0000	0.0000	---
Mass_Flow	lb/hr	0.0000	0.0000	---
LiqVol_Flow	barrel/day	0.0000	0.0000	---
Volume_Flow	barrel/day	0.0000	0.0000	---
Mole_Weight		---	---	---
Energy	Btu/hr	0.0000	0.0000	---
Molar_Enthal	Btu/lbmole	---	---	---
Entropy	Btu/lbmole-F	---	---	---
Mass_Cp	Btu/lb-F	---	---	---
Mass_Density	lb/ft3	---	---	---
Mass_Density	SG_H2O60api	---	---	---
UOPK_(dry)		---	---	---
Z_Factor		---	---	---
Thermal_Cond	Btu/hr-ft-F	---	---	---
Viscosity	cP	---	---	---
*** Heavy Liquid ***				
Flow	lbmole/hr	0.0000	0.0000	---
Mass_Flow	lb/hr	0.0000	0.0000	---
LiqVol_Flow	barrel/day	0.0000	0.0000	---

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
36	Press the **<F10>** key;
37	Highlight the letters **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
38	Press the **<Esc>** key until you reach the Main Menu;
39	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 127.

Step	Action
40	Highlight the word **Spec-Sheets** and then press the **<Enter>** key;
41	Highlight the word **Operations** and then press the **<Enter>** key;
42	Highlight the word **Compressor** and then press the **<Enter>**key;
	The screen will appear as shown on the following page. Repeat steps 35 and 36, using the <F10>, <Page Up> and <Page Down> keys in order to see the printout on the screen.
43	Do you want to continue adding other unit operations to this compressor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

HYSIM COMPRESSOR SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/09/24
Case Name: Time 10:23:30
Operation Name: Compressor
Operation Note:

Suction Side : PropaneIn

From Operation --- - ---

Suction Properties at Operating Conditions

Temperature	7.4000 F	Vap Z Factor	0.9235
Pressure	44.1000 psia	Ideal Cp/Cv	1.1345
Mass Frac vap	1.0000		
Mol Weight	44.0970	Flow Rates	249.5890 lb/hr
			0.0515 MMSCFD
Density	0.4201 lb/ft3		9.9011 ACFM

Discharge Side : PropaneOut

To Operation --- - ---

Discharge Properties at Operating Conditions

Temperature	155.4053 F	Vap Z Factor	0.7780
Pressure	248.5000 psia	Ideal Cp/Cv	1.0944
Mass Frac Vap	1.0000		
Mol Weight	44.0970	Diff Press	204.4000 psi
		Comp Ratio	5.6349
Density	2.1339 lb/ft3	Flow Rate	1.9495 ACFM

Driver :

Energy Stream Energy
Energy Required 11573.4876 Btu/hr
4.5485 hp

Adiabatic Head	27053.38 ft	Adiabatic Efficiency	75.00 %
Polytropic Head	28178.89 ft	Polytropic Efficiency	78.12 %

User Supplied Curves

Volumetric_Flow		Head		Efficiency	
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%
---	ACFM	---	ft	---	%

This section contains examples of the following five different types of heat exchangers:

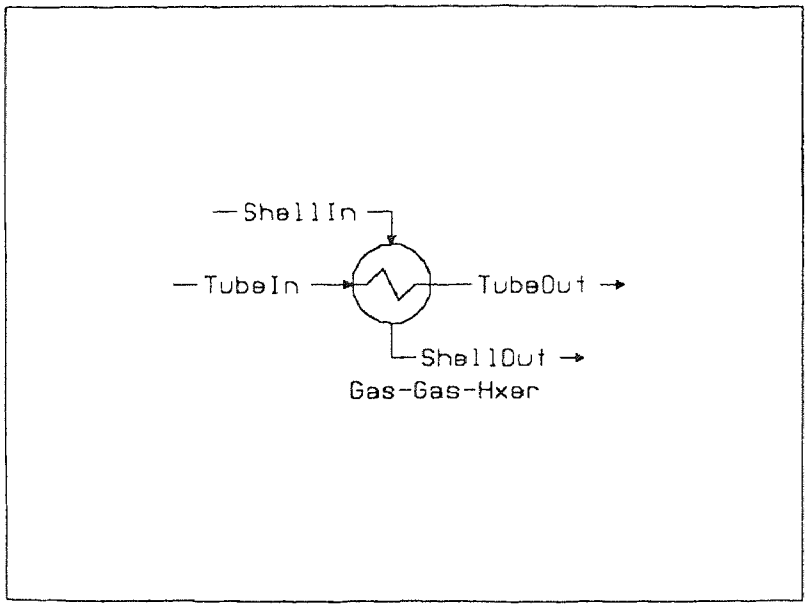
3.3.1 Shell and Tube Type Heat Exchanger - Simple

Objective - This exercise is an example of a simple, shell and tube type, gas-gas heat exchanger calculation. The purpose of the gas-gas heat exchanger is to heat one gaseous stream, with the heat lost when another stream is cooled. In this case, the stream gaining the heat is on the shell side, and the stream being cooled is on the tube side. This example can be modified by specifying another property package and/or components, compositions and feed conditions.
In this example a gaseous feed stream, *ShellIn*, gets heated in the shell side of a simple, gas-gas heat exchanger, from 12.8 to 50.0 °F; the other gaseous feed stream, *TubeIn*, gets cooled in the tubeside from 60.5 °F to 32.7 °F.
Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, in the Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.
Other References: Refs. 1 & 2.

Directions: Pages 133 through 141 outline the execution of a simple, shell and tube type heat exchanger example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g. <Esc>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Gas-Gas-Hxer*, is shown below:



3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

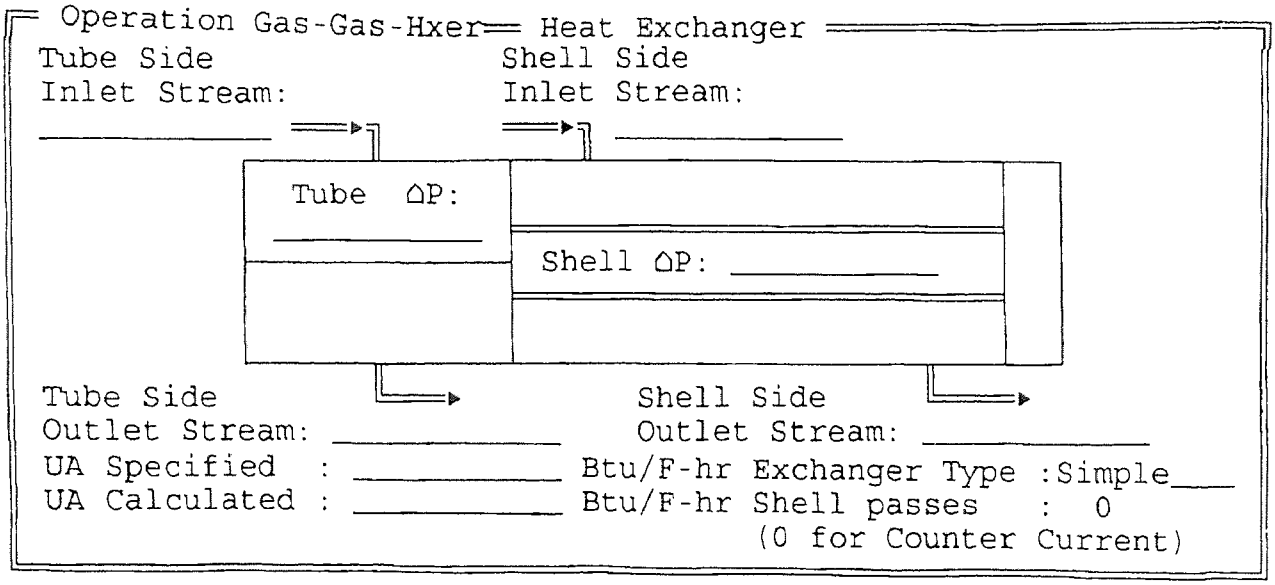
Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word **i-Butane** and then press the <**Enter**> key; Highlight the word **n-Butane** and then press the <**Enter**> key; Highlight the word **i-Pentane** and then press the <**Enter**> key; Highlight the word **n-Pentane** and then press the <**Enter**> key; Highlight the word **n-Hexane** and then press the <**Enter**> key; Highlight the word **n-Heptane** and then press the <**Enter**> key; Highlight the word **n-Octane**;

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
5	Press the <**Insert**> key;

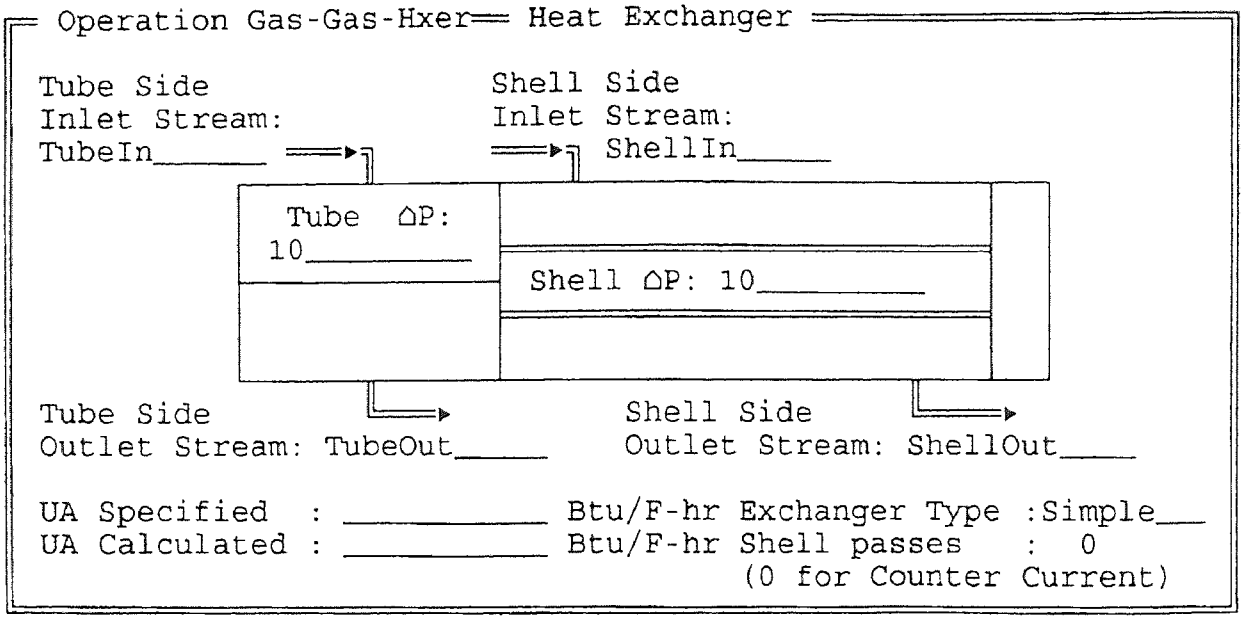
NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the type of operation we want to perform.
11	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "Gas-Gas-Hxer").
12	Type the word **Gas-Gas-Hxer** and then press the <**Enter**> key;
13	Highlight the word **Heat Exchanger** and then press the <**Enter**> key;
	The following diagram of the heat exchanger process will appear:



3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
	Naming the streams.
14	Type the name **TubeIn** and then press the <**Enter**> key;
15	Type the name **TubeOut** and then press the <**Enter**> key;
16	Type the name **ShellIn** and then press the <**Enter**> key;
17	Type the name **ShellOut** and then press the <**Enter**> key;
	Specifying the Tubeside Pressure Drop in psi.
18	Type the number **10** and then press the <**Enter**> key;
	Specifying the Shellside Pressure Drop in psi.
19	Type the number **10** and then press the <**Enter**> key;
	Leave the UA unspecified and the exchanger type and # of Shell passes as is currently displayed on the heat exchanger diagram.
20	Press the <**Enter**> key two times;
	The screen should now appear as follows:



Step	Action
	Getting back to the Main Menu.
21	Press the <**Insert**> key;
	Specifying the conditions of the feed streams.
22	Highlight the word **Specify** and then press the <**Enter**> key;
23	Highlight the word **Stream** and then press the <**Enter**> key;
24	Highlight the word **TubeIn** and then press the <**Enter**> key;
	Specifying the temperature of the TubeIn stream as unknown, by typing an "x".
25	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
	Specifying the pressure of the TubeIn stream in psia.
26	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of the TubeIn stream in lb-mols/hr.
27	Type the number **69.64** after the prompt (>) and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
28	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
29	*Enter the following mole fractions beside each component in the TubeIn stream:* After the word, Methane, type the number **0.7988** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1339** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0325** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0153** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0104** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0044** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0030** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0013** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0003** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0001** in the blank;
	The screen should now appear as follows:

Stream Mole Fractions

Methane	0.7988	Ethane	0.1339
Propane	0.0325	i-Butane	0.0153
n-Butane	0.0104	i-Pentane	0.0044
n-Pentane	0.0030	n-Hexane	0.0013
n-Heptane	0.0003	n-Octane	0.0001

Step	Action
30	Press the <**Insert**> key;
31	Highlight the word **Specify** and then press the <**Enter**> key;
32	Highlight the word **Stream** and then press the <**Enter**> key;
33	Highlight the word **ShellIn** and then press the <**Enter**> key;
	Specifying the conditions of the ShellIn stream. (Specify that the temperature is unknown by typing an "x").
34	Type the letter **x** and then press the <**Enter**> key;
	Specifying the pressure of the ShellIn stream in psia.
35	Type the number **580** and then press the <**Enter**> key;
	Specifying the molar flow rate of stream ShellIn in lb-mols hr.
36	Type the number **66.6** and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
37	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
38	*Enter the following mole fractions beside each component in the ShellIn stream:* After the word, Methane, type the number **0.8237** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1304** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0272** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0101** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0059** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0016** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0009** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0002** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0000** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0000** in the blank;
	The screen should now appear as follows:

Stream Mole Fractions

Methane	0.8237	Ethane	0.1304
Propane	0.0272	i-Butane	0.0101
n-Butane	0.0059	i-Pentane	0.0016
n-Pentane	0.0009	n-Hexane	0.0002
n-Heptane	0.0000	n-Octane	0.0000

Step	Action
39	Press the <**Insert**> key;
40	Highlight the word **Worksheet** and then press the <**Enter**> key;
	The screen should now appear as follows:

Streams

Stream	New Value = TubeIn	TubeOut	ShellIn	ShellOut
Vapour_Frac	---	---	---	---
Temperature	---	---	---	---
Pressure	600.0000*	590.0000	580.0000*	570.0000
Flow	69.6400*	69.6400	66.6000*	66.6000
Mass_Flow	1424.5420	1424.5420	1296.2150	1296.2150
LiqVol_Flow	289.2200	289.2200	271.2278	271.2278
Energy_Flow	---	---	---	---

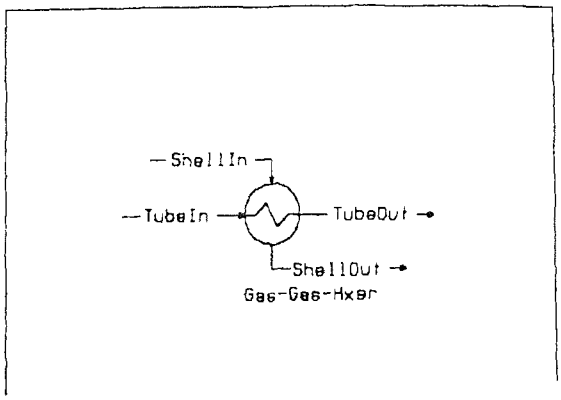
Step	Action
41	Highlight the *Vapour_Frac.* blank under the *TubeIn* stream title and type the number 1.0. Then press the <**Enter**> key;
42	Highlight the *Vapour_Frac.* blank under the *ShellIn* stream title and type the number 1.0. Then press the <**Enter**> key;
43	Highlight the *Temperature* blank under the *ShellOut* stream title and type the number **50.0**. Then press the <**Enter**> key;
	The screen will than appear as shown on the following page.

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Streams

Stream	New Value = TubeIn	TubeOut	F ShellIn	ShellOut
Vapour_Frac	1.0000*	0.9813	1.0000*	1.0000
Temperature	60.4964	32.7162	12.8210	50.0000*
Pressure	600.0000*	590.0000	580.0000*	570.0000
Flow	69.6400*	69.6400	66.6000*	66.6000
Mass_Flow	1424.5420	1424.5420	1296.2150	1296.2150
LiqVol_Flow	289.2200	289.2200	271.2278	271.2278
Energy_Flow	273649.1393	244139.1538	223800.6134	253310.5949

Step	Action
	Getting back to the Main Menu.
44	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the current Process Flow Diagram (PFD).
45	Highlight the letters **PFD** and then press the <**Enter**> key;
	The following figure will then appear:



Step	Action
	Getting back to the Main Menu..
46	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the Gas-Gas Heat Exchanger Specification Sheets.
47	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies format of the printout.

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Print Options (continued):

f) *Cost* - Lists costs of the run, if a royalty is being charged.
g) *File* - Saves results in a file.
h) *Printer* - Toggles on a printer.
i) *Cases* - Lists the stored files.
j) *Description* - Prints case description.
k) *Oil Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
48	Highlight the word **Spec-Sheets** and then press the **<Enter>** key;
49	Highlight the word **Operations** and then press the **<Enter>** key;
50	Highlight the word **Gas-Gas-Hxer** and then press the **<Enter>** key;
	The Specification Sheets on the following pages will appear on the screen. Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
51	Press the **<F10>** key;
	The screen will appear as shown below and on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

HYSIM HEAT EXCHANGER SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/09/25
Case Name: Time 14:51:22

Operation Name: Gas-Gas-Hxer
Note:

Performance

Duty	29509.9848 Btu/hr	LMTD	14.6984 F
weighted LMTD	14.3427 F	UA	2007.7049 Btu/F-hr
weighted UA	2057.4976 Btu/F-hr	FT Factor	1.0000
		Shell Passes	0.

Duties Btu/hr	Hot Side	Cold Side
Vapour	0.0019	29509.9811
Two Phase	29509.9830	0.0000
Liquid	0.0000	0.0000

Inlet	Hot Side	Cold Side
Stream Name	TubeIn	ShellIn
From Operation	---	---
Mass frac vap	1.0000	1.0000
Temperature F	60.4964	12.8210
Pressure psia	600.0000	580.0000
Mass flow lb/hr	1424.5420	1296.2150
Molar flow lbmole/hr	69.6400	66.6000

Outlet	Hot Side	Cold Side
Stream Name	TubeOut	ShellOut
To Operation	---	---
Mass frac vap	0.9577	1.0000
Temperature F	32.7162	50.0000
Pressure psia	590.0000	570.0000

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Fluid Properties	Hot Side		Cold Side	
	Liquid	Vapour	Liquid	Vapour
Ref Temp 1 F	32.7162	32.7162	---	12.8210
Ref Pres 1 psia	590.0000	590.0000	---	580.0000
Heat Cap Btu/lb-F	0.5870	0.6023	---	0.6144
Viscosity cP	0.1375	0.0115	---	0.0111
Therm Cond Btu/hr-ft-F	0.0587	0.0184	---	0.0178
Density lb/ft3	33.2787	2.7347	---	2.7794
Mole Wt	46.2083	19.9648	---	19.4627
Z Factor		0.8152		0.8010
Ref Temp 2 F	60.4964	60.4964	---	50.0000
Ref Pres 2 psia	600.0000	600.0000	---	570.0000
Heat Cap Btu/lb-F	0.5728	0.5899	---	0.5862
Viscosity cP	0.1598	0.0120	---	0.0116
Therm Cond Btu/hr-ft-F	0.0573	0.0192	---	0.0190
Density lb/ft3	34.9454	2.6266	---	2.3855
Mole Wt	54.2800	20.4558	---	19.4627
Z Factor		0.8371		0.8503

Heat Curve Hot Side			Heat Curve Cold Side		
Duty Btu/hr	Temp F	Mass Fct Vap	Duty Btu/hr	Temp F	Mass Fct Vap
29511.6509	60.50	1.0000	29509.9811	50.00	1.0000
22125.2861	52.88	0.9927	22132.4854	40.54	1.0000
14755.0082	45.82	0.9827	14754.9906	31.17	1.0000
7377.5318	39.14	0.9708	7377.4953	21.92	1.0000
0.0521	32.72	0.9577	-0.6258	12.82	1.0000

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
52	Press the **<F10>** key;
	Looking at the compositions of the streams.
53	Highlight the **Print** key and then press the **<Enter>** key;

The various print options are given on pages 138-139.

3.3.1 Shell and Tube Type Heat Exchanger - Simple (continued)

Step	Action
54	Highlight the word **Streams** and then press the <**Enter**> key;
55	Highlight the word **All** and then press the <**Enter**> key;
56	Highlight the dash symbol - and then press the <**Enter**> key;
	The following streams will appear on the screen:

Stream Description		TubeIn	TubeOut	ShellIn	ShellOut
Vapour frac.		1.0000*	0.9813	1.0000*	1.0000
Temperature	F	60.4964	32.7162	12.8210	50.0000*
Pressure	psia	600.0000*	590.0000	580.0000*	570.0000
Molar Flow	lbmole/hr	69.6400*	69.6400	66.6000*	66.6000
Mass Flow	lb/hr	1424.5420	1424.5420	1296.2150	1296.2150
LiqVol Flow	barrel/day	289.2200	289.2200	271.2278	271.2278
Enthalpy	Btu/hr	273649.1393	244139.1538	223800.6134	253310.5949
Density	lb/ft3	2.6266	2.8450	2.7794	2.3855
Mole Wt.		20.4558	20.4558	19.4627	19.4627
Spec. Heat	Btu/lb-F	0.5899	0.6016	0.6144	0.5862
Therm Cond	Btu/hr-ft-F	0.0192	---	0.0178	0.0190
Viscosity	cP	0.0120	---	0.0111	0.0116
Z Factor		0.8371	---	0.8010	0.8503
Sur Tension	dyne/cm	---	---	---	---
Std Density	lb/ft3	---	---	---	---
Methane	mole frac.	0.7988*	0.7988	0.8237*	0.8237
Ethane	mole frac.	0.1339*	0.1339	0.1304*	0.1304
Propane	mole frac.	0.0325*	0.0325	0.0272*	0.0272
i-Butane	mole frac.	0.0153*	0.0153	0.0101*	0.0101
n-Butane	mole frac.	0.0104*	0.0104	0.0059*	0.0059
i-Pentane	mole frac.	0.0044*	0.0044	0.0016*	0.0016
n-Pentane	mole frac.	0.0030*	0.0030	0.0009*	0.0009
n-Hexane	mole frac.	0.0013*	0.0013	0.0002*	0.0002
n-Heptane	mole frac.	0.0003*	0.0003	0.0000*	0.0000
n-Octane	mole frac.	0.0001*	0.0001	0.0000*	0.0000

Step	Action
57	Do you want to continue adding other unit operations to this simple, shell and tube heat exchanger? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.3.2 Shell and Tube Type Heat Exchanger - Rate

Objective - This exercise is an example of a heat exchanger rating calculation. This example will use a shell and tube type heat exchanger with cooling water on the tubeside and a distillation column bottoms product being cooled on the shellside. This example can be modified by specifying another property package and/or components, compositions and feed conditions.

In this example, the shell and tube type heat exchanger is rated. The distillation column bottoms steam, called *BottomsIn*, is composed of Hydrocarbons. The following physical data was supplied to HYSIM for this problem: tubeside fouling, number of tubes per shell, tube length, tube outside diameter, tube pitch, shell side fouling, % area of the baffle cut, baffle spacing, plus stream composition and condition data. After supplying this data, HYSIM calculated the shell area, the tube and shell coefficients, the log mean temperature difference (LMTD), and the duty.

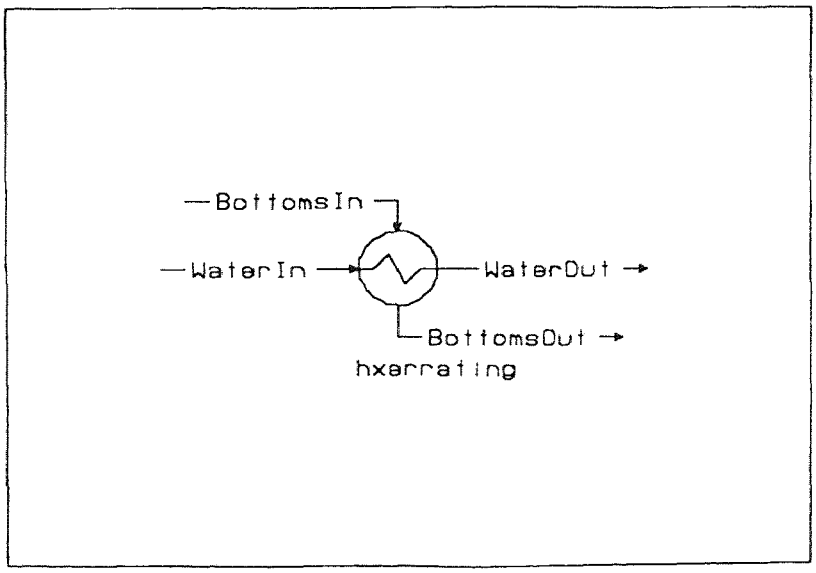
Technical Example Reference: Reference 3 - Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants," Volume 3, Example 10-6, Second Edition, Gulf Publishing Co., Houston, Texas, 1984, page 87.

Other References: Refs. 1 and 2.

Directions: Pages 143 through 154 outline the execution of a shell and tube type heat exchanger rating example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *hxerrating*, is shown below:



3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
2	Highlight the word **Configuration** and then press the <**Enter**> key;
3	Highlight the word **Units** and then press the <**Enter**> key;
4	Highlight the word **Field** and then press the <**Enter**> key;
5	Press the <**Esc**> key;
	Starting with a new case.
6	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
7	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed streams.
8	*Highlight the following component names under the "Component Selection" section and press the <Enter> key so that the names then appear in the "Selected" column, as follows:* Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Hypothetical** and then press the <**Enter**> key;
	The screen on the following page will then appear.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

```
HC                  Solid               Misc                Amine
Alcohol             Ketone              Aldehyde            Ester
CarbAcid            Halogen             Nitrile             Phenol
Ether
HC  HC-HC interaction parameters will be calculated and assigned
What is the component type?
>
```

Step	Action
9	Highlight the initials **HC** and then press the <**Enter**> key;
	The following screen will then appear:

```
                Hypothetical Component Information

  Name: _____________     Chemical Formula: _____________

  Boiling Point [F_]          :_      Ideal Enthalpy Coefficients
  LiqDensity (@ 60F)[lb/ft3]  :_      (Mass Basis - Ideal gas @ 0 K)
  Molecular Weight            :_      Hideal = _____________ Btu/lb__
                                              + _____________ * T
  Critical Temperature [F_]   :_              + _____________ * T^2
  Critical Pressure [psia__]  :_              + _____________ * T^3
  Critical Volume [ft3/lbmo]  :_              + _____________ * T^4
  Acentric Factor             :_              + _____________ * T^5
  Acentric Factor  Wsrk       :_      Entropy Coeff: _____________
  Charact. Volume [ft3/lbmo]  : _     Cavett Param.: _____________
  Dipole Moment [debye]       : _
                                      Ideal Gas Gibbs Free Energy
    Vapour Pressure [deg K, kPa]      (Molar Basis - Ideal gas @ 25 C)
  ANTA: _____________  ANTD: ____     Gibbs  = _____________ Btu/lbmo
  ANTB: _____________  ANTE: ____             + _____________ * T
  ANTC: _____________  ANTF: ____             + _____________ * T^2
  TMIN: _____________  TMAX: ___      Heat Form (@ 25 C): _____________
  Viscosity Coeff A: _____________    Heat Comb (@ 25 C): _____________
  Viscosity Coeff B: _____________    Radius Gyration [Ang]: _____________
```

Step	Action
10	Type the word **Bottoms** and then press the <**Enter**> key two times;
	Specifying the Boiling Point of the Bottoms in °F.
11	Type the number **280.4** and then press the <**Enter**> key;
	Specifying the density of the Bottoms in pounds per cubic foot (lb ft^3).
12	Type the number **48.4** and then press the <**Enter**> key;
	Specifying that you do not wish to input viscosity curve data.
13	Press the <**Insert**> key;
14	Highlight the word **None** and then press the <**Enter**> key.
	The screen on the following page will then appear.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Hypothetical Component Information

Are The Component Calculations Satisfactory: Yes_____

Name: Bottoms Chemical Formula: Bottoms

Boiling Point [F_]	280.40	Ideal Enthalpy Coefficients	
LiqDensity (@ 60) [lb/ft3]	48.40	(Mass Basis - Ideal gas @ 0 K)	
Molecular Weight	126.17	Hideal =	5.0150538e+01 Btu/lb__
		+	-8.7622401e-03 * T
Critical Temperature [F_]	615.22	+	3.7898889e-04 * T^2
Critical Pressure [psia__]	405.83	+	-5.1654688e-08 * T^3
Critical Volume [ft3/lbmo]	7.321	+	0.0000000e+00 * T^4
Acentric Factor	0.36914	+	0.0000000e+00 * T^5
Acentric Factor Wsrk	0.36914	Entropy Coeff:	0.2388459
Charact. Volume [ft3/lbmo]	7.98218	Cavett Param.:	0.26723
Dipole Moment [debye]	0.00		
		Ideal Gas Gibbs Free Energy	
Vapour Pressure [deg K, kPa]		(Molar Basis - Ideal gas @ 25 C)	
ANTA: 5.87938e+01 ANTD:	-6.16521e+00	Gibbs = _____	Btu/lbmo
ANTB: -7.03156e+03 ANTE:	7.21300e-18	+ _____	* T
ANTC: 0.00000e+00 ANTF:	6.00000e+00	+ _____	* T^2
TMIN: 280.400 TMAX:	615.219	Heat Form (@ 25 C):	_____
Viscosity Coeff A:	0.04464	Heat Comb (@ 25 C):	_____
Viscosity Coeff B:	-0.25202	Radius Gyration [Ang]:	4.5055

Hypothetical Compounds - HYSIM will calculate the critical properties from either the Bergman Cavett or Lee-Kesler Correlation, depending on the API and Normal Boiling Point supplied. Other component types such as Amines, Alcohols, etc. will have critical properties determined by Joback's modification of Lydersen's group contribution method.

The Enthalpy coefficients are for the following fifth order ideal enthalpy equation:

$H = A + BT + CT^2 + DT^3 + ET^4 + FT^5$

where: T = Absolute Temperature (K or R)

H = Enthalpy = BTU/lb-R or kJ/Kg-K

For solids, the enthalpy data should be entered. If HYSIM generates the coefficients, it will use the Cavett correlations for hydrocarbons, solids or miscellaneous substances; the Joback group contribution method will be used for all other substances.

Reference: Passut, C.A. and Danner, R.P., I.E.C. Proc. Des. & Dev., 11, p. 543 (1972).

The Gibbs Free Energy will be calculated using the following equation:

$G^o = A + BT + CT^2$

where: T = Absolute Temperature = K or R

G^o = kJ/kgmole-K or Btu/lbmole-R

If the hypothetical is a Hydrocarbon or if a UNIFAC structure is not specified, no Gibbs coefficients will be calculated.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Hypothetical Compounds (continued):

The modified Antoine vapor pressure model coefficients are calculated for the following equation:

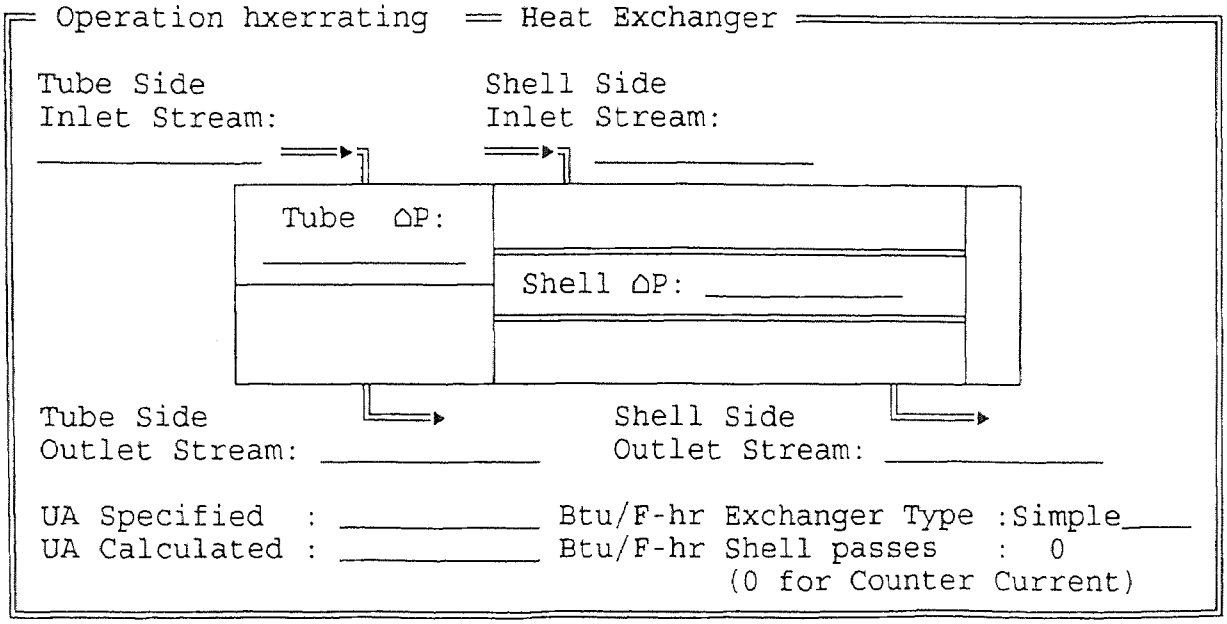
$\ln(P_{vap}) = ANTA + (ANTB/(T+ANTC)) + ANTD\ (\ln(T)) + ANTE\ (T)^{ANTF}$

The viscosity coefficients, Theta A and Theta B, are used in the viscosity prediction models. Three viscosity models are available in HYSIM: the modified Ely and Hanley model, Twu's model and the modified Letsou-Stiel correlation.

Step	Action
15	Press the <**Insert**> key two times;

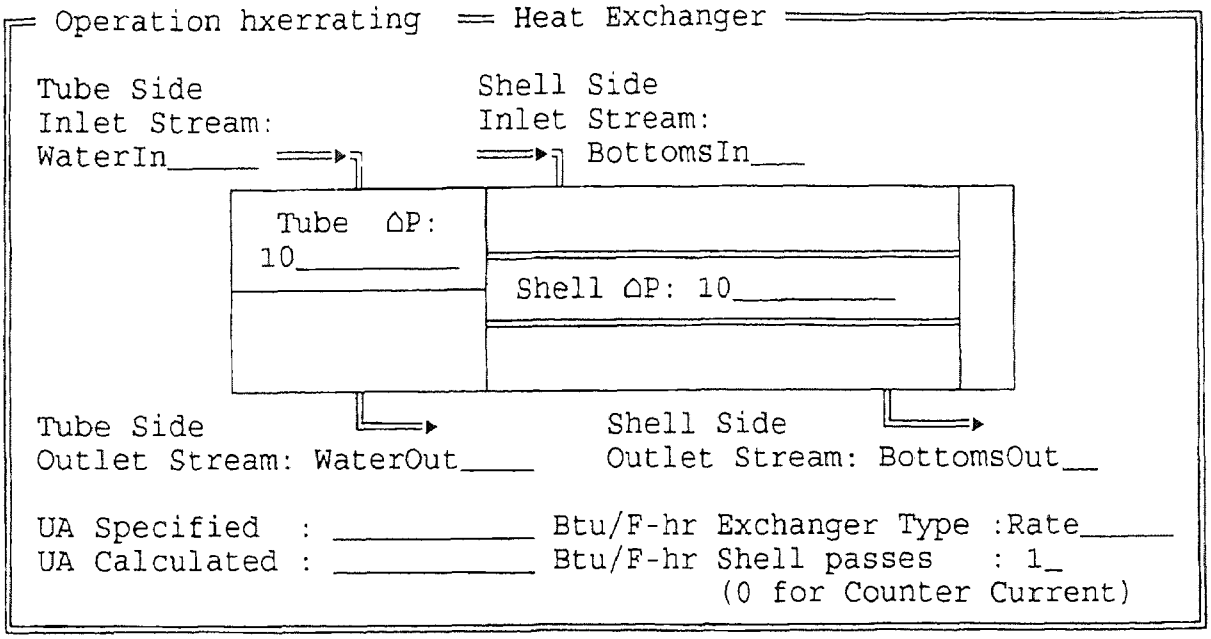
NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the type of operation we want to perform.
16	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "hxerrating").
17	Type the word **hxerrating** and then press the <**Enter**> key;
18	Highlight the words **Heat Exchanger** and then press the <**Enter**> key;
	The diagram of the heat exchanger process shown below will then appear:



3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Step	Action
	Naming the streams.
19	Type the name **WaterIn** and then press the <**Enter**> key;
20	Type the name **WaterOut** and then press the <**Enter**> key;
21	Type the name **BottomsIn** and then press the <**Enter**> key;
22	Type the name **BottomsOut** and then press the <**Enter**> key;
23	*Specifying the Tubeside Pressure Drop in psi.*
24	Type the number **10** in the blank and then press the <**Enter**> key;
	Specifying the Shellside Pressure Drop in psi.
25	Type the number **10** in the blank and then press the <**Enter**> key;
	Leave the UA unspecified.
26	Press the <**Enter**> key;
	Specifying the Exchanger Type.
27	Press the <**F2**> key and then highlight the word **Rate** and press the <**Enter**> key;
	Specifying the number of Shell passes.
28	Type the number **1**;
	The screen should now appear as shown below:



Step	Action
29	Press the <**Insert**> key;
	The screen shown on the following page will then appear.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

```
Simplified Heat Exchanger Geometry - Rating

E changer (Tema) Type A_ E_ U_

TUBE SIDE DATA                          SHELL SIDE DATA
Tube Passes/Shell     2                 Shell Series    1
Fouling           0.00000 F-hr-ft2/Bt   Shell Parallel  1
Tubes Per Shell _______                 Fouling      0.00000 F-hr-ft2/Bt
Tube Data                               Baffle Data
 Length            20.000 ft            Type          Single___
 O.D.               0.750 in            Orientation   Vertical__
 Thickness          0.090 in            Cut (% Area)      20.000
 Pitch              0.938 in            Spacing       __________ in
 Orientation    Horizontal
 Layout Angle   30_

Any of the following parameters left BLANK will be calculated by HYSIM

TUBE SIDE                               SHELL SIDE
Transfer Coeff __________ Btu/hr-ft2-   Transfer Coeff _____ Btu/hr-ft2-
Press. Drop    __________ psi           Press. Drop    _____ psi
                                        Shell Dia.     _____ in
                                        Area           _____ ft2
```

Step	Action
	Specifying the Heat Exchanger Geometry - Rating.
30	Press the <**Enter**> key four times;
	Specifying the Tubeside fouling in F-hr-ft^2/Btu.
31	Type the number **0.001** and then press the <**Enter**> key;
	Specifying the number of tubes per shell.
32	Type the number **44.0** and then press the <**Enter**> key;
	Specifying the Tube Length (ft).
33	Type the number **8.0** and then press the <**Enter**> key;
	Specifying the O.D. (Outside Diameter in inches).
34	Type the number **1.00** and then press the <**Enter**> key;
35	Press the <**Enter**> key one time;
	Specifying the Tube Pitch in inches.
36	Type the number **1.25** and then press the <**Enter**> key;
37	Press the <**Enter**> key four times;
	Specifying the Shell Side fouling in F-hr-ft^2/Btu.
38	Type the number **0.002** and then press the <**Enter**> key;
39	Press the <**Enter**> key two times;
	Specifying the % Area of the Baffle which is cut.(Usually 20 to near 50 %, Reference: Ludwig, E., Applied Process Design for Chemical and Petrochemical Plants, Vol.3,1983, p.23).

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Step	Action
40	Type the number **25** and then press the <**Enter**> key;
	Specifying the Baffle Spacing (in).(Note:Allowance must be made for baffle thickness. Also the number of spaces must be odd so that the inlet is on the top and the outlet is on the bottom.)
41	Type the number **5.5** and then press the <**Enter**> key;
	The screen should then appear as follows:

```
═══════ Simplified Heat Exchanger Geometry - Rating ═══════

Exchanger (Tema) Type A_ E_ U_

TUBE SIDE DATA                          SHELL SIDE DATA
Tube Passes/Shell    2                  Shell Series    1
Fouling          0.001_____ F-hr-ft2/BtShell Parallel  1
Tubes Per Shell 44.0___                 Fouling   0.002_____ F-hr-ft2/Bt
Tube Data                               Baffle Data
 Length          8.0_______ ft           Type          Single____
 O.D.            1.00______ in           Orientation   Vertical__
 Thickness            0.090 in           Cut (% Area)  25________
 Pitch           1.25______ in           Spacing       5.5_______ in
 Orientation     Horizontal
 Layout Angle    30_

Any of the following parameters left BLANK will be calculated by HYSIM

TUBE SIDE                               SHELL SIDE
Transfer Coeff __________ Btu/hr-ft2-   Transfer Coeff ______Btu/hr-ft2-
Press. Drop    __________ psi           Press. Drop    ______psi
                                        Shell Dia.     ______in
                                        Area           ______ft2
```

Step	Action
42	Press the <**Insert**> key;
	Specifying the conditions of the feed streams.
43	Highlight the word **Specify** and then press the <**Enter**> key;
44	Highlight the word **Stream** and then press the <**Enter**> key;
45	Highlight the word **WaterIn** and then press the <**Enter**> key;
	Specifying the temperature of the "WaterIn" stream in °F.
46	Type the number **90** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the "WaterIn" stream in psia.
47	Type the number **64.7** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of stream "WaterIn" in lb-mols/hr as unknown by typing the letter "x".
48	Type the letter **x** and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
49	Highlight the word **Mass_Fractions** and then press the <**Enter**> key;

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Step	Action
50	*Enter the following mass fractions beside each component in the "WaterIn" stream:* After the formula, H2O, type the number **1.0** in the blank and then press the **<Enter>** key; After the word, Bottoms, type the number **0.0** in the blank;
	The screen should now appear as follows:

```
                    Stream Mass Fractions

H2O          1.0_____________        Bottoms     0.0_____________
```

Step	Action
51	Press the **<Insert>** key;
52	Highlight the word **Specify** and then press the **<Enter>** key;
53	Highlight the word **Stream** and then press the **<Enter>** key;
54	Highlight the word **BottomsIn** and then press the **<Enter>** key;
	Specifying the conditions of the "BottomsIn" stream.
	Specifying the temperature of the "BottomsIn" stream in °F.
55	Type the number **176.0** and then press the **<Enter>** key;
	Specifying the pressure of the "BottomsIn" stream in psia.
56	Type the number **29.7** and then press the **<Enter>** key;
	Specifying the molar flow rate of stream "BottomsIn" in lb-mols/hr as unknown by typing the letter "x".
57	Type the letter **x** and then press the **<Enter>** key;
	Specifying the basis you wish to use when specifying the compositions.
58	Highlight the word **Mass_Fractions** and then press the **<Enter>** key;
59	*Enter the following mass fractions beside each component in the "BottomsIn" stream:* After the formula, H2O, type the number **0.0** in the blank and then press the **<Enter>** key; After the word, Bottoms, type the number **1.0** in the blank;
	The screen should now appear as follows:

```
                    Stream Mass Fractions

H2O          0.0_____________        Bottoms     1.0_____________
```

Step	Action
60	Press the **<Insert>** key;
61	Highlight the word **Worksheet** and then press the **<Enter>** key;
	The screen should now appear as shown on the following page.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Streams

Stream	New Value = WaterIn	WaterOut	BottomsIn	BottomsOut
Vapour_Frac	0.0000	---	0.0000	---
Temperature	90.0000*	---	176.0000*	---
Pressure	64.7000*	---	29.7000*	---
Flow	---	---	---	---
Mass_Flow	---	---	---	---
LiqVol_Flow	---	---	---	---
Energy_Flow	---	---	---	---

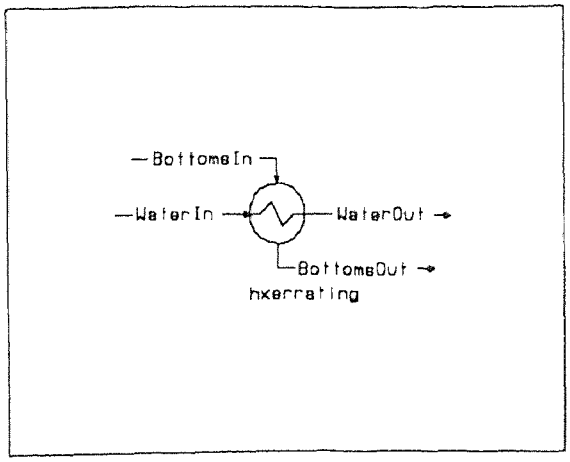
Step	Action
62	Highlight the *Mass Flow* (lb/hr) blank under the *WaterIn* stream title and type the number **144000**. Then press the <**Enter**> key;
63	Highlight the *Mass Flow* (lb/hr) blank under the *BottomsIn* stream title and type the number **37000**. Then press the <**Enter**> key;
	The screen will than appear as shown below:

Streams

Stream	New Value = WaterIn	WaterOut	lb/hr BottomsIn	BottomsOut
Vapour_Frac	0.0000	0.0000	0.0000	0.0000
Temperature	90.0000*	94.1947	176.0000*	142.2612
Pressure	64.7000*	59.7031	29.7000*	27.7017
Flow	7993.2945	7993.2945	293.2437	293.2437
Mass_Flow	144000.0025*	144000.0025	36999.9999*	36999.9999
LiqVol_Flow	9879.9851	9879.9863	3267.7893	3267.7893
Energy_Flow	-1.16639E+08	-1.16019E+08	1.85868E+06	1.23838E+06

Step	Action
	Getting back to the Main Menu.
64	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the current Process Flow Diagram (PFD).
65	Highlight the letters **PFD** and then press the <**Enter**> key;
	The figure shown below will then appear as shown on the following page.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)



Step	Action
	Getting back to the Main Menu.
66	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the Heat Exchanger Specification Sheet.
67	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - the different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
68	Highlight the word **Spec_Sheets** and then press the <**Enter**> key;
69	Highlight the word **Operations** and then press the <**Enter**> key;
70	Highlight the word **hxerrating** and then press the <**Enter**> key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
71	Press the <**F10**> key;
	The screen will appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

HYSIM HEAT EXCHANGER SPECIFICATION SHEET

Operation Name: hxerrating
Note:
HYSIM Version C2.53
Case Name:

Input

Exchanger (Tema) Type AEU

TUBE SIDE DATA			SHELL SIDE DATA		
Tube Passes	2.0		Shell Ser	1.0	
Fouling	0.00100	F-hr-ft2/Btu	Shell Para	1.0	
Tubes/Shell	44.0		Fouling	0.00200	F-hr-ft2/Btu
Tube Data			Baffle Data		
Length	8.0000	ft	Type	Single	
O.D.	1.0000	in	Orient	Vertical	
Thickness	0.0900	in	Cut(% Area)	25.00	
Pitch	1.2500	in	Spacing	5.5000	in
Orient	Horizontal				
Layout Ang	30.0000	Deg			
Trans Coeff	---	Btu/hr-ft2-F	Trans Coeff	---	Btu/hr-ft2-F
Press. Drop	---	psi	Press. Drop	---	psi
			Shell Dia.	---	in
			Area	---	ft2

Performance

Duty	620298.7110	Btu/hr	LMTD	65.9337	F
Wtd LMTD	66.0416	F	UA	9459.9163	Btu/F-hr
Wtd UA	9392.5490	Btu/F-hr	FT Factor	0.9945	
Tube Coeff	1533.6458	Btu/hr-ft2-F	Shell Passes	1.0	
Shell Coeff	190.3665	Btu/hr-ft2-F	Shell Area	92.1536	ft2
Shell Dia	10.3560	in			

Duties Btu/hr	Shell Side	Tube Side
Vapour	0.0000	0.0000
Two Phase	0.0000	0.0000
Liquid	620298.7110	620294.1496

Inlet		Shell Side	Tube Side
Stream Name		BottomsIn	WaterIn
From Operation		---	---
Mass frac vap		0.0000	0.0000
Temperature	F	176.0000	90.0000
Pressure	psia	29.7000	64.7000
Mass Rate	lb/hr	36999.9999	144000.0025
Flow Rate	lbmole/hr	293.2437	7993.2945

Outlet		Shell Side	Tube Side
Stream Name		BottomsOut	WaterOut
To Operation		---	---
Mass frac vap		0.0000	0.0000
Temperature	F	142.2612	94.1947
Pressure	psia	27.7017	59.7031

Heat Curve Shell Side			Heat Curve Tube Side		
Duty Btu/hr	Temp F	Mass Fct Vap	Duty Btu/hr	Temp F	Mass Fct Vap
620298.7110	176.00	0.0000	620314.7054	94.19	0.0000
465224.0480	167.69	0.0000	465220.5826	93.15	0.0000
310149.3555	159.30	0.0000	310146.8971	92.10	0.0000
155064.7997	150.83	0.0000	155073.3153	91.05	0.0000
-6.7056	142.26	0.0000	-0.4136	90.00	0.0000

3.3.2 Shell and Tube Type Heat Exchanger - Rate (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
72	Press the **<F10>** key;
	Looking at the compositions of the streams.
73	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found in page 152.

Step	Action
74	Highlight the word **Streams** and then press the **<Enter>** key;
75	Highlight the word **All** and then press the **<Enter>** key;
76	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
77	Press the **<F10>** key;
	The screen will appear as shown below: Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream Description		WaterIn	WaterOut	BottomsIn	BottomsOut
Vapour frac.		0.0000	0.0000	0.0000	0.0000
Temperature	F	90.0000*	94.1947	176.0000*	142.2612
Pressure	psia	64.7000*	59.7031	29.7000*	27.7017
Molar Flow	lbmole/hr	7993.2945	7993.2945	293.2437	293.2437
Mass Flow	lb/hr	144000.0025*	144000.0025	36999.9999*	36999.9999
LiqVol Flow	barrel/day	9879.9851	9879.9863	3267.7893	3267.7893
Enthalpy	Btu/hr	-1.16639E+08	-1.16019E+08	1.85868E+06	1.23838E+06
Density	lb/ft3	62.5541	62.4430	44.9985	46.0166
Mole Wt.		18.0151	18.0151	126.1749	126.1749
Spec. Heat	Btu/lb-F	1.0302	1.0303	0.5070	0.4866
Therm Cond	Btu/hr-ft-F	0.3590	0.3608	0.0659	0.0684
Viscosity	cP	0.7606	0.7250	0.3629	0.4353
Z Factor		0.0032	0.0029	0.0122	0.0118
Sur Tension	dyne/cm	70.8481	70.4429	18.6817	20.4503
Std Density	lb/ft3	63.3284	63.3284	48.4000	48.4000
H2O	mole frac.	1.0000*	1.0000	0.0000*	0.0000
Bottoms	mole frac.	0.0000*	0.0000	1.0000*	1.0000

Step	Action
78	Press the **<F10>** key;
79	Do you want to continue adding other unit operations to this heat exchanger? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.3.3 Single Sided Heat Exchanger - Heater

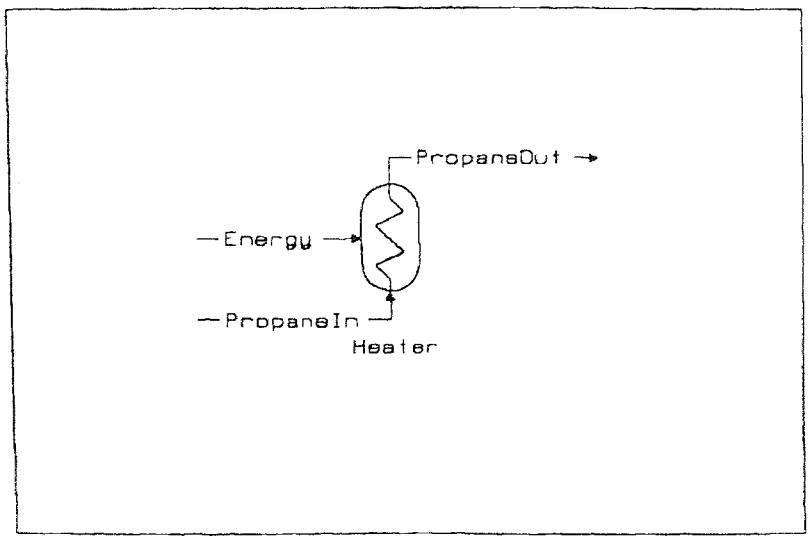
Objective - This exercise is an example of a single sided heat exchanger (unit name: *Heater*) calculation. The purpose of the single sided heat exchanger is to heat one process inlet stream using a fired heater (furnace). This example can be modified by specifying another property package and/or components, compositions and feed conditions.

In this example of a Single Sided Heat Exchanger, the feed stream, called *PropaneIn*, is heated from 90 °F to an outlet temperature of 115 °F in stream *PropaneOut*. The energy needed, 4625 Btu/hr, must be supplied by an external source.
Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, in the Hyprotech's HYSIM User Guide, Version C2.50, March 1994, pages 3-98 to 3-128.
Other References: Refs. 1 & 2.

Directions: Pages 156 through 162 outline the execution of a heater example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside < > brackets (e.g. <**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Heater*, is shown below:



3.3.3 Single Sided Heat Exchanger - Heater (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

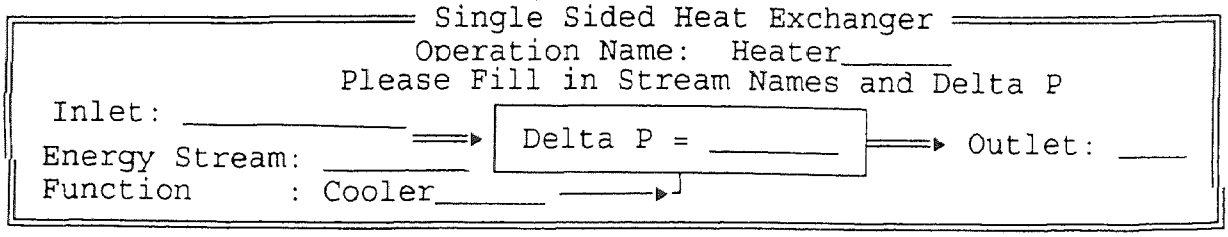
F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

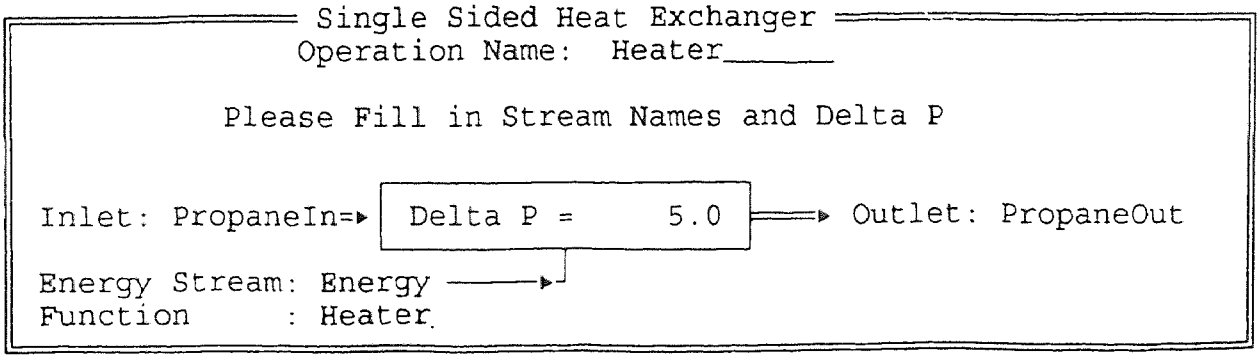
Step	Action
	Selecting the components in the feed stream.
4	*Highlight the following component name under the "Component Selection" section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Propane** and then press the <**Enter**> key;
5	Press the <**Insert**> key;

3.3.3 Single Sided Heat Exchanger - Heater (continued)

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C,etc.) to field units (lb, psia, °F,etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the type of operation we want to perform.
11	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "Heater").
12	Type the word **Heater** and then press the <**Enter**> key;
13	Highlight the words **Cooler/Heater** and then press the <**Enter**> key;
	The following diagram of the single-sided heat exchanger process will appear:



Step	Action
	Naming the streams.
14	Type the word **PropaneIn** in the blank and then press the <**Enter**> key;
15	Type the word **PropaneOut** in the blank and then press the <**Enter**> key;
16	Type the word **Energy** in the blank and then press the <**Enter**> key;
	Specifying the function of the heat exchanger as a Heater and not a Cooler (the Default Entry).
17	Press the <**Delete**> key until the word Cooler is deleted. Then type in the word **Heater** and press the <**Enter**> key;
	Specifying the change in pressure (Δ P) over the heat exchanger in psi.
18	Type **5.0** in the blank.
	The screen should now appear as shown below:



3.3.3 Single Sided Heat Exchanger - Heater (continued)

Step	Action
	Getting back to the Main Menu.
19	Press the <**Insert**> key;
	Specifying the conditions of the feed stream, PropaneIn.
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Type the word **PropaneIn** and then press the <**Enter**> key;
	Specifying the temperature of the PropaneIn stream °F.
23	Type the number **90.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the PropaneIn stream in psia.
24	Type the number **248.5** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of PropaneIn stream in lb-mols/hr.
25	Type the number **5.7** after the prompt (>) and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
26	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
27	*Enter the following molar flows beside each component in the PropaneIn stream:* After the word, Propane, type the number **1.0** in the blank;
	The screen should now appear as follows:

```
Stream Mole Fractions

Propane      1.0_____________
```

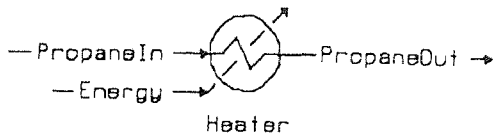
Step	Action
28	Press the <**Insert**> key;
29	Highlight the word **Worksheet** and then press the <**Enter**> key;
30	Place the cursor in the PropaneOut column and the Temperature row, and then type the number 115 and press the <**Enter**> key;
	The screen should now appear as shown on the following page.

3.3.3 Single Sided Heat Exchanger - Heater (continued)

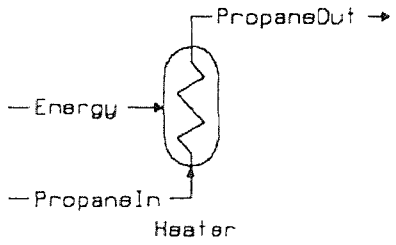
Streams

Stream	New Value = PropaneIn	PropaneOut	Energy	---
Vapour_Frac	0.0000	0.0000	2.0000*	---
Temperature	90.0000*	115.0000*	0.0000*	---
Pressure	248.5000*	243.5000	0.0000*	---
Flow	5.7000*	5.7000	0.0000*	---
Mass_Flow	251.3529	251.3529	0.0000*	---
LiqVol_Flow	33.9680	33.9680	0.0000*	---
Energy_Flow	538.4943	5163.2748	4624.7805	---

Step	Action
	Getting back to the Main Menu.
31	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the current Process Flow Diagram (PFD).
32	Highlight the letters **PFD** and then press the <**Enter**> key;
	The following figure will appear:



Step	Action
	Specifying a different type of heat exchanger icon on the PFD.
33	Move the mouse until the cross-hatches on the screen are over the heater and then press the **left mouse key**. (A box will appear around the heater.)
34	Press the <**I**> key.
35	Place the crosshatch (using the mouse) over the first icon (First column, first row) and press the **left mouse key**.
	The PFD will then appear as shown below:



3.3.3 Single Sided Heat Exchanger - Heater (continued)

Step	Action
	Getting back to the Main Menu.
36	Press the **<Esc>** key until you reach the Main Menu;
	Looking at the Heater Heat Exchanger Specification Sheets.
37	Highlight the word **Print** and then press the **<Enter>** key;

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
38	Highlight the word **Spec-Sheets** and then press the **<Enter>** key;
39	Highlight the word **Operations** and then press the **<Enter>** key;
40	Highlight the word **Heater** and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
41	Press the **<F10>** key;
	The screen will appear as seen below and on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

```
═══ HYSIM COOLER / HEATER SPECIFICATION SHEET ═══
HYSIM  Version     C2.53                          Date 96/09/27
Case Name:                                        Time  8:58:29

Operation Name: Heater
Operation Note:

═══ Phase Duties ═══ Process Side ═══ Total Duty ═══
Vapour                  0.0000 Btu/hr  4624.7805 Btu/hr
Two Phase               0.0000 Btu/hr
Liquid               4624.7805 Btu/hr
```

3.3.3 Single Sided Heat Exchanger - Heater (continued)

Inlet	Process Side	
Stream Name	PropaneIn	
From Operation	---	
Mass Frac Vap	0.0000	
Temperature	90.0000 F	
Pressure	248.5000 psia	
Mass Flow	251.3529 lb/hr	
Flow	5.7000 lbmole/hr	

Outlet	Process Side	
Stream Name	PropaneOut	
To Operation	---	
Mass Frac Vap	0.0000	
Temperature	115.0000 F	
Pressure	243.5000 psia	

Fluid Properties	Process Side	
	Liquid	Vapour
Reference Temp 1	90.0000 F	-- F
Reference Press 1	248.5000 psia	--- psia
Heat Capacity	0.6992 Btu/lb-F	--- Btu/lb-F
Viscosity	0.0935 cP	--- cP
Thermal Conductivity	0.0524 Btu/hr-ft-F	--- Btu/hr-ft-F
Density	30.1906 lb/ft3	--- lb/ft3
Molecular Weight	44.0970	---
Z Factor		---
Reference Temp 2	115.0000 F	--- F
Reference Press 2	243.5000 psia	--- psia
Heat Capacity	0.7778 Btu/lb-F	--- Btu/lb-F
Viscosity	0.0813 cP	--- cP
Thermal Conductivity	0.0477 Btu/hr-ft-F	--- Btu/hr-ft-F
Density	28.5438 lb/ft3	--- lb/ft3
Molecular Weight	44.0970	---
Z Factor		---

Process Heat Curve		
Duty Btu/hr	Temperature F	Mass Frac Vap
4624.7795	115.0000	0.0000
3468.5852	109.0051	0.0000
2312.3338	102.8340	0.0000
1156.0073	96.4957	0.0000
-0.0018	90.0000	0.0000

3.3.3 Single Sided Heat Exchanger - Heater (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
42	Press the **<F10>** key;
	Looking at the compositions of the streams.
43	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 160.

Step	Action
44	Highlight the word **Streams** and then press the **<Enter>** key;
45	Highlight the word **All** and then press the **<Enter>** key;
46	Highlight the dash symbol - and then press the **<Enter>** key;
	The streams will appear as shown below. Repeat Steps 41-42 in order to see the results on the screen.

Stream		PropaneIn	PropaneOut	Energy
Description				
Vapour frac.		0.0000	0.0000	2.0000*
Temperature	F	90.0000*	115.0000*	0.0000*
Pressure	psia	248.5000*	243.5000	0.0000*
Molar Flow	lbmole/hr	5.7000*	5.7000	0.0000*
Mass Flow	lb/hr	251.3529	251.3529	0.0000*
LiqVol Flow	barrel/day	33.9680	33.9680	0.0000*
Enthalpy	Btu/hr	538.4943	5163.2748	4624.7805
Density	lb/ft3	30.1906	28.5438	0.0000
Mole Wt.		44.0970	44.0970	0.0000
Spec. Heat	Btu/lb-F	0.6992	0.7778	---
Therm Cond	Btu/hr-ft-F	0.0524	0.0477	---
Viscosity	cP	0.0935	0.0813	---
Z Factor		0.0615	0.0610	---
Sur Tension	dyne/cm	6.0614	4.5073	---
Std Density	lb/ft3	31.6435	31.6435	---
Propane	mole frac.	1.0000*	1.0000	0.0000*

Step	Action
47	Do you want to continue adding other unit operations to this heater? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.3.4 Single Sided Heat Exchanger - Cooler

Objective - This exercise is an example of a single sided heat exchanger (unit name: *Cooler*) calculation using HYSIM. The purpose of the single sided heat exchanger is to cool one inlet feed stream, using an air-fin exchanger. This example can be modified by specifying another property package and/or components, compositions and feed conditions.

In this example, the feed stream to the cooler, called *PropaneIn*, is cooled from an inlet temperature of 155.3 °F to an outlet temperature of 120 °F in stream *PropaneOut*. The energy lost from the inlet stream is 4525 Btu/hr.

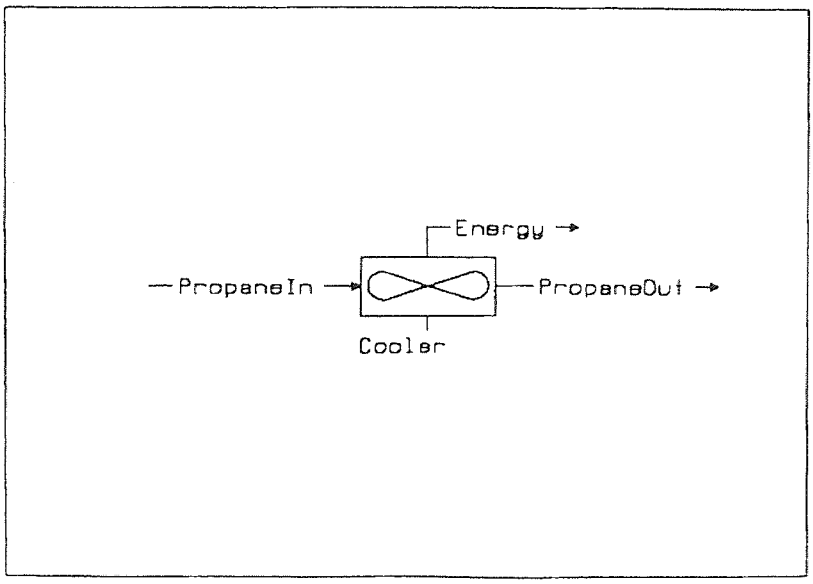
Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, in the Hyprotech's User Guide, Version C2.50, March 1994, pages 3-98 to 3-128.

Other References: Refs. 1 & 2.

Directions: Pages 164 through 170 outline the execution of a cooler example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys ($\leftarrow$,$\rightarrow$,$\uparrow$, or $\downarrow$ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Cooler*, is shown below:



3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

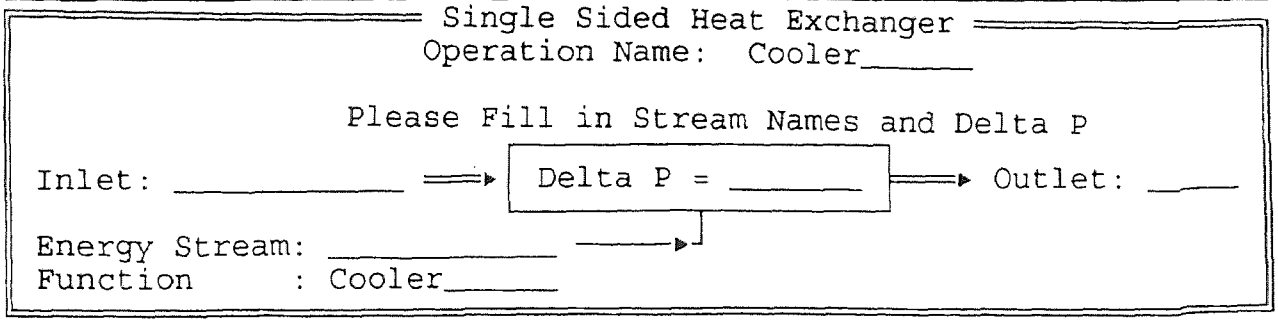
F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight the following component name under the "Component Selection" section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Propane** and then press the <**Enter**> key;
5	Press the <**Insert**> key;

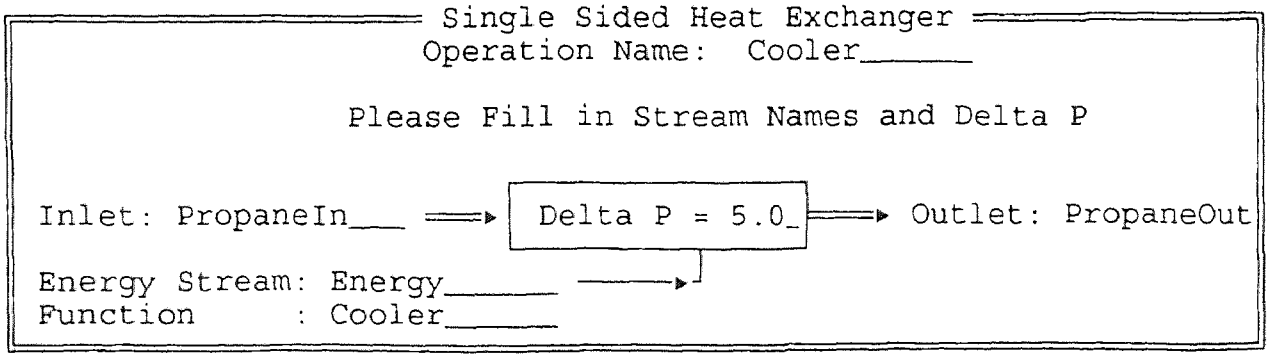
NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the type of operation we want to perform.
11	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "Cooler").
12	Type the word **Cooler** and then press the <**Enter**> key;
13	Highlight the words **Cooler/Heater** and then press the <**Enter**> key;
	The following diagram of the single-sided heat exchanger process will appear:



Step	Action
	Naming the streams.
14	Type the word **PropaneIn** in the blank and then press the <**Enter**> key;
15	Type the word **PropaneOut** in the blank and then press the <**Enter**> key;
16	Type the word **Energy** in the blank and then press the <**Enter**> key;
17	Press the <**Enter**> key;
	Specifying the change in pressure (ΔP) over the heat exchanger in psi.
18	Type **5.0** in the blank;
	The screen should now appear as shown below:



3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Step	Action
	Getting back to the Main Menu.
19	Press the <**Insert**> key;
	Specifying the conditions of thePropaneIn stream.
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Highlight the word **PropaneIn** and then press the <**Enter**> key;
	Specifying the temperature of the PropaneIn stream in °F.
23	Type the number **155.3** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the PropaneIn stream in psia.
24	Type the number **248.5** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of PropaneIn stream in lb-mols/hr.
25	Type the number **5.7** after the prompt (>) and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
26	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
27	*Enter the following molar flows beside the one component in the PropaneIn stream:* After the word, Propane, type the number **1.0** in the blank;
	The screen should now appear as follows:

```
═══════════ Stream Mole Fractions ═══════════

Propane      1.0_____________
```

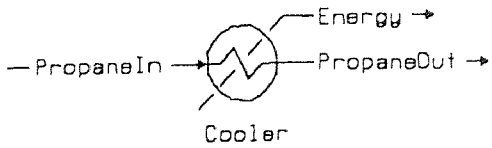
Step	Action
28	Press the <**Insert**> key;
29	Highlight the word **Worksheet** and then press the <**Enter**> key;
30	Place the cursor in the PropaneOut column and the Temperature row and then type the number **120** and press the <**Enter**> key;
	The screen should now appear as shown on the following page.

3.3.4 Single Sided Heat Exchanger - Cooler (continued)

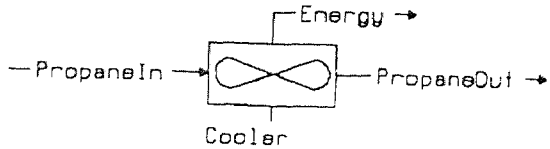
Streams

Stream	New Value = PropaneIn	PropaneOut	Energy	---
Vapour_Frac	1.0000	1.0000	2.0000*	---
Temperature	155.3000*	120.0000*	0.0000*	---
Pressure	248.5000*	243.5000	0.0000*	---
Flow	5.7000*	5.7000	0.0000*	---
Mass_Flow	251.3529	251.3529	0.0000*	---
LiqVol_Flow	33.9680	33.9680	0.0000*	---
Energy_Flow	41742.1678	37217.5937	4524.5743	---

Step	Action
	Getting back to the Main Menu.
31	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the current Process Flow Diagram (PFD).
32	Highlight the letter **PFD** and then press the <**Enter**> key;
	The following figure will appear:



Step	Action
	Specifying a different type of heat exchanger icon on the PFD.
33	Move the mouse until the cross-hatches on the screen are over the cooler and then press the **left mouse key**. (A box will appear around the cooler.)
34	Press the <**I**> key.
35	Place the crosshatch (using the mouse) over the first icon (First column, first row) which represents an aerial cooler and press the **left mouse key**.
	The following PFD will then appear on the screen:



3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Step	Action
	Getting back to the Main Menu.
36	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the Cooler Heat Exchanger Specification Sheets.
37	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
38	Highlight the word **Spec-Sheets** and then press the <**Enter**> key;
39	Highlight the word **Operations** and then press the <**Enter**> key;
40	Highlight the word **Cooler** and then press the <**Enter**> key;
	Pressing the <F10> key will get the main menu off of the screen in enabling you to see the data on the screen underneath it.
41	Press the <**F10**> key;
	The screen will appear as shown below and on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

```
═══ HYSIM COOLER / HEATER SPECIFICATION SHEET ═══
HYSIM  Version      C2.53                    Date 96/09/27
Case Name:                                   Time 12:28:13

Operation Name: Cooler
Operation Note:

═══ Phase Duties ═══ Process Side ═══ Total Duty ═══
Vapour              4524.5743 Btu/hr   4524.5743 Btu/hr
Two Phase              0.0000 Btu/hr
Liquid                 0.0000 Btu/hr
```

3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Inlet	Process Side	
Stream Name	PropaneIn	
From Operation	---	
Mass Frac Vap	1.0000	
Temperature	155.3000 F	
Pressure	248.5000 psia	
Mass Flow	251.3529 lb/hr	
Flow	5.7000 lbmole/hr	

Outlet	Process Side	
Stream Name	PropaneOut	
To Operation	---	
Mass Frac Vap	1.0000	
Temperature	120.0000 F	
Pressure	243.5000 psia	

Fluid Properties		Process Side	
		Liquid	Vapour
Reference Temp 1	---	F	120.0000 F
Reference Press 1	---	psia	243.5000 psia
Heat Capacity	---	Btu/lb-F	0.5308 Btu/lb-F
Viscosity	---	cP	0.0098 cP
Thermal Conductivity	---	Btu/hr-ft-F	0.0130 Btu/hr-ft-F
Density	---	lb/ft3	2.3727 lb/ft3
Molecular Weight	---		44.0970
Z Factor			0.7275
Reference Temp 2	---	F	155.3000 F
Reference Press 2	---	psia	248.5000 psia
Heat Capacity	---	Btu/lb-F	0.5220 Btu/lb-F
Viscosity	---	cP	0.0103 cP
Thermal Conductivity	---	Btu/hr-ft-F	0.0141 Btu/hr-ft-F
Density	---	lb/ft3	2.1346 lb/ft3
Molecular Weight	---		44.0970
Z Factor			0.7779

Process Heat Curve		
Duty Btu/hr	Temperature F	Mass Frac Vap
4524.5747	155.3000	1.0000
3393.4309	146.4538	1.0000
2262.4827	137.6121	1.0000
1131.1459	128.7860	1.0000
-0.0000	120.0000	1.0000

3.3.4 Single Sided Heat Exchanger - Cooler (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
42	Press the **<F10>** key;
	Looking at the compositions of the streams.
43	Highlight the **Print** key and then press the **<Enter>** key;

The various print options can be found on page 168.

Step	Action
44	Highlight the word **Streams** and then press the **<Enter>** key;
45	Highlight the word **All** and then press the **<Enter>** key;
46	Highlight the dash symbol - and then press the **<Enter>** key;
	The streams will appear as shown below. Repeat Steps 41-42 in order to see the results on the screen.

Stream Description		PropaneIn	PropaneOut	Energy
Vapour frac.		1.0000	1.0000	2.0000*
Temperature	F	155.3000*	120.0000*	0.0000*
Pressure	psia	248.5000*	243.5000	0.0000*
Molar Flow	lbmole/hr	5.7000*	5.7000	0.0000*
Mass Flow	lb/hr	251.3529	251.3529	0.0000*
LiqVol Flow	barrel/day	33.9680	33.9680	0.0000*
Enthalpy	Btu/hr	41742.1678	37217.5937	4524.5743
Density	lb/ft3	2.1346	2.3727	0.0000
Mole Wt.		44.0970	44.0970	0.0000
Spec. Heat	Btu/lb-F	0.5220	0.5308	---
Therm Cond	Btu/hr-ft-F	0.0141	0.0130	---
Viscosity	cP	0.0103	0.0098	---
Z Factor		0.7779	0.7275	---
Sur Tension	dyne/cm	---	---	---
Std Density	lb/ft3	---	---	---
Propane	mole frac.	1.0000*	1.0000	0.0000*

Step	Action
47	Do you want to continue adding other unit operations to this cooler? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.3.5 LNG (Multi-Pass) Heat Exchanger

Objective - This exercise is an example of a multi-pass heat exchanger (or an LNG heat exchanger) calculation using HYSIM. The purpose of the LNG heat exchanger (cold box) is to solve heat and material balances for multiple process inlet and outlet streams, specifying sufficient information for the system. This example can be modified by specifying another property package and/or components, compositions and feed/outlet conditions.

This example of a multi-pass heat exchanger, shows a heat exchanger which has four inlet streams, *WarmIn1*, *WarmIn2*, *ColdIn3*, and *ColdIn4*, and four product streams, *ColdOut1*, *ColdOut2*, *WarmOut3*, and *WarmOut4*. (The stream representing the energy-in is called *Sinkloss* and the stream representing the energy-out is *Srceloss*). The composition, flowrate and other conditions of the inlet streams are given, as well as certain temperature specifications of various streams in relation to one another. The temperature, as well as other conditions of the outlet streams are calculated by HYSIM.

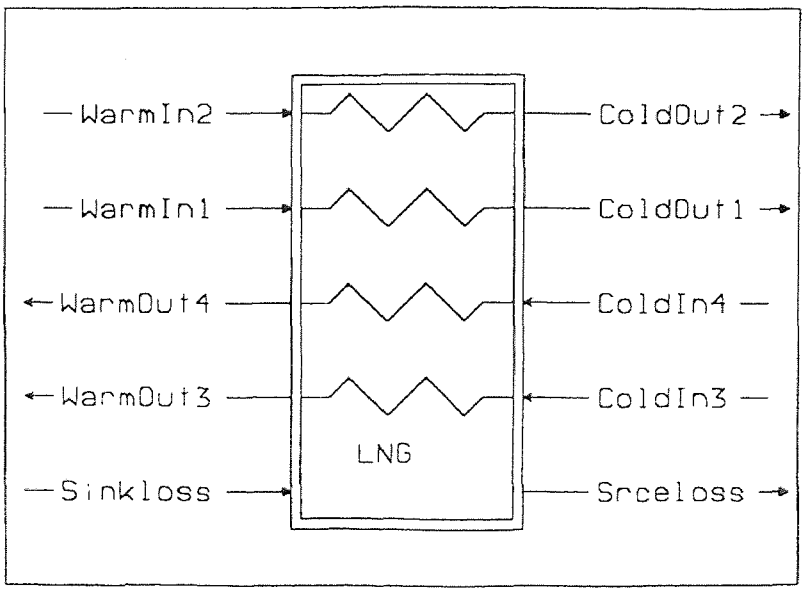
Technical Example Reference: Reference 2 - Hyprotech's "HYSIM Special Features and Applications Guide," Version C2.50, March 1994, pages GP-77 to GP-82.

Other References: Refs. 1 & 2.

Directions: Pages 172 through 186 outline the execution of a LNG Multi-Pass heat exchanger example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the Action Step instructions below. The menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action Column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column. Supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *LNG*, is shown below:



3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V) • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed streams.
4	*Highlight each of the following component names under the "Component Selection" section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word i-**Butane** and then press the <**Enter**> key Highlight the word n-**Butane** and then press the <**Enter**> key; Highlight the word i-**Pentane** and then press the <**Enter**> key; Highlight the word n-**Pentane** and then press the <**Enter**> key;
	The screen on the following page will then appear.

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	OIL	OIL		ALL
Ethane	HYPOTHETICAL	HYPOTHETICAL		HC
Propane	C6	n-Hexane	C6H14	SOLID
i-Butane	C7	n-Heptane	C7H16	MISC
n-Butane	C8	n-Octane	C8H18	AMINE
i-Pentane	C9	n-Nonane	C9H20	ALCOHOL
n-Pentane	C10	n-Decane	C10H22	KETONE
	C11	n-C11	C11H24	ALDEHYDE
	C12	n-C12	C12H26	ESTER
	C13	n-C13	C13H28	CARBACID
	C14	n-C14	C14H30	HALOGEN
	C15	n-C15	C15H32	NITRILE
	C16	n-C16	C16H34	PHENOL
	C17	n-C17	C17H36	ETHER
	C18	n-C18	C18H38	USER
	C19	n-C19	C19H40	

Search by SYNONYM

F1 - Help, F4 - Flip Srch, F5 - Exam, F6 - Move,
F3 - Menu, PRESS INSERT TO SUBMIT F8 - Change

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Getting back to the Main Menu.
5	Press the <**Insert**> key;
	Specifying the type of operation we want to perform.
6	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "LNG").
7	Type the letters **LNG** and then press the <**Enter**> key;
8	Highlight the letters **LNG** and then press the <**Enter**> key;
	The following spreadsheet for listing stream names and other information for the LNG heat exchanger process will appear:

LNG Exchanger - Exchanger Passes

Operation Name: LNG_____

Inlet Stream	Outlet Stream	Energy Stream	Pres. Drop [kPa]____	Pass UA [kJ/C-h]___	Hot or Cold

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Specifying the Inlet Stream Name.
9	Type the name **WarmIn1** and then press the <**Enter**> key;
	Specifying the Outlet Stream Name.
10	Type the name **ColdOut1** and then press the <**Enter**> key two times;
	Specifying the Pressure Drop in kPa.
11	Type the number **100** and then press the <**Enter**> key two times;
	Specifying whether WarmIn1 is the Hot or Cold stream, as compared to ColdOut1.
12	Type the word **Hot** and then press the <**Enter**> key;
	Specifying the Inlet Stream Name.
13	Type the name **WarmIn2** and then press the <**Enter**> key;
	Specifying the Outlet Stream Name.
14	Type the name **ColdOut2** and then press the <**Enter**> key two times;
	Specifying the Pressure Drop in kPa.
15	Type the number **10** and then press the <**Enter**> key two times;
	Specifying whether WarmIn2 is the Hot or Cold stream, as compared to ColdOut2.
16	Type the word **Hot** and then press the <**Enter**> key;
	Specifying the Inlet Stream Name.
17	Type the name **ColdIn3** and then press the <**Enter**> key;
	Specifying the Outlet Stream Name.
18	Type the name **WarmOut3** and then press the <**Enter**> key two times;
	Specifying the Pressure Drop in kPa.
19	Type the number **50** and then press the <**Enter**> key two times
	Specifying whether WarmIn1 is the Hot or Cold stream, as compared to ColdOut1.
20	Type the word **Cold** and then press the <**Enter**> key;
	Specifying the Inlet Stream Name.
21	Type the name **ColdIn4** and then press the <**Enter**> key;
	Specifying the Outlet Stream Name.
22	Type the name **WarmOut4** and then press the <**Enter**> key two times;
	Specifying the Pressure Drop in kPa.
23	Type the number **5** and then press the <**Enter**> key two times;
	Specifying whether ColdIn4 is the Hot or Cold stream, as compared to WarmOut4.
24	Type the word **Cold**;
	The following table will then appear:

LNG Exchanger - Exchanger Passes

Operation Name: LNG_____

Inlet Stream	Outlet Stream	Energy Stream	Pres. Drop [kPa]____	Pass UA [kJ/C-h]___	Hot or Cold
WarmIn1_____	ColdOut1_____	_____	100_____	_____	Hot_
WarmIn2_____	ColdOut2_____	_____	10_____	_____	Hot_
ColdIn3_____	WarmOut3_____	_____	50_____	_____	Cold
ColdIn4_____	WarmOut4_____	_____	5_____	_____	old_

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
25	Press the <**Insert**> key;
	The following screen will then appear:

```
                    LNG Exchanger - Specifications
Operation Name: LNG_________

UA: _______________ kJ/C-h___      Min temp approach: _______ C
Heat leak stream: _____________    Heat loss stream: _________
Heat leak fraction: 0.0000         Heat loss fraction: 0.0000

Number of intervals: 1             Locate phase changes: Yes_
Convergence tolerance: 1.000e-04   Composite method: Pinch___

Temperature specifications
Stream Temp   = Stream Temp   + Constant   [C]
_____________________________________________
WarmOut4____  = WarmOut3____  +          0.000
ColdOut2____  = ColdOut1____  +          0.000
              =               +
              =               +
              =               +
              =               +
              =               +
              =               +
```

Step	Action
26	Press the <**Enter**> key two times;
	Specifying the name of the heat leak stream.
27	Type the name **Sinkloss** and then press the <**Enter**> key;
	Specifying the name of the heat loss stream.
28	Type the name **Srceloss** and then press the <**Enter**> key;
	Specifying the heat leak fraction.
29	Type the number **0.0001** and then press the <**Enter**> key;
	Specifying the heat loss fraction.
30	Type the number **0.0005** and then press the <**Enter**> key;
	Specifying the number of intervals.
31	Type the number **20** and then press the <**Enter**> key;
32	Press the <**Enter**> key three times;
33	Type the name **ColdOut1** and then press the <**Enter**> key;
34	Type the name **ColdIn3** and then press the <**Enter**> key;
35	Type the number **15** and then press the <**Enter**> key;

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Giving Stream Temperature Specifications.
36	Type the name **WarmIn2** and then press the <**Enter**> key;
37	Type the name **WarmOut3** and then press the <**Enter**> key;
38	Type the number **2** and then press the <**Enter**> key;
39	Type the name **WarmIn2** and then press the <**Enter**> key;
40	Type the name **ColdOut2** and then press the <**Enter**> key;
41	Type the number **5**;
	The screen will then appear as follows:

```
═══════ LNG Exchanger - Specifications ═══════
Operation Name: LNG_________

UA: _____________ kJ/C-h___     Min temp approach: _______ C
Heat leak stream: Sinkloss____  Heat loss stream: Srceloss
Heat leak fraction: 0.0001____  Heat loss fraction: 0.0005

Number of intervals: 20__       Locate phase changes: Yes_
Convergence tolerance: 1.000e-04 Composite method: Pinch___

Temperature specifications
Stream Temp   = Stream Temp   + Constant   [C]
_____________________________________________
ColdOut1____ = ColdIn3_____ +  15__________
WarmIn2_____ = WarmOut3____ +  2___________
WarmIn2_____ = ColdOut2____ +  5___________
             =              +
```

Step	Action
	Getting back to the Main Menu.
42	Press the <**Insert**> key;
	Specifying the conditions of the feed stream, WarmIn1.
43	Highlight the word **Specify** and then press the <**Enter**> key;
44	Highlight the word **Stream** and then press the <**Enter**> key;
45	Highlight the word **WarmIn1** and then press the <**Enter**> key;
	Specifying the temperature of the WarmIn1 stream in °C.
46	Type the number **20** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the WarmIn1 stream in kPa.
47	Type the number **5000** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of stream WarmIn1 in kg-mols/hr.
48	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
49	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen should now appear as shown on the following page.

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

```
Stream Mole Fractions

Methane  _____________    Ethane   _____________
Propane  _____________    i-Butane _____________
n-Butane _____________    i-Pentane _____________
n-Pentane _____________
```

Step	Action
50	*Enter the following molar flows beside each component in the WarmIn1 stream.* After the word, Methane, type the number **0.5386** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1538** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0769** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0692** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0615** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0538** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0462** in the blank;
	The screen should now appear as follows:

```
Stream Mole Fractions

Methane   0.5386_____    Ethane    0.1538_____
Propane   0.0769_____    i-Butane  0.0692_____
n-Butane  0.0615_____    i-Pentane 0.0538_____
n-Pentane 0.0462_____
```

Step	Action
51	Press the <**Insert**> key;
52	Highlight the word **Specify** and then press the <**Enter**> key;
53	Highlight the word **Stream** and then press the <**Enter**> key;
54	Highlight the word **WarmIn2** and then press the <**Enter**> key;
	Specifying the Temperature of the WarmIn2 stream in °C.
55	Type the number **30** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the Pressure in kPa of the WarmIn2 stream
56	Type the number **5000** after the prompt (>) and then press the <**Enter**> key;

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Specifying the molar flow rate of WarmIn2 in kg-mols/hr.
57	Type the number **50** after the prompt (>) and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
58	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen should now appear as follows:

```
═══════════ Stream Mole Fractions ═══════════

Methane    _____________    Ethane     _____________
Propane    _____________    i-Butane   _____________
n-Butane   _____________    i-Pentane  _____________
n-Pentane  _____________
```

Step	Action
59	*Enter the following molar flows beside each component in the WarmIn2 stream:* After the word, Methane, type the number **0.95** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.05** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0** in the blank;
	The screen should now appear as follows:

```
═══════════ Stream Mole Fractions ═══════════

Methane    0.95_____________    Ethane     0.05_____________
Propane    0_____________       i-Butane   0_____________
n-Butane   0_____________       i-Pentane  0_____________
n-Pentane  0_____________
```

Step	Action
60	Press the <**Insert**> key;
61	Highlight the word **Specify** and then press the <**Enter**> key;
62	Highlight the word **Stream** and then press the <**Enter**> key;
63	Highlight the word **ColdIn3** and then press the <**Enter**> key;

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Specifying that the Temperature of the ColdIn3 stream in °C is unknown by typing an "x".
64	Type the letter **x** and then press the **<Enter>** key;
	Specifying the Pressure of the ColdIn3 stream in kilopascals (kPa).
65	Type the number **2000** and then press the **<Enter>** key;
	Specifying the molar flow rate of ColdIn3 in kg-mols/hr.
66	Type the number **75** and then press the **<Enter>** key;
	Specifying the basis you wish to use when specifying the compositions.
67	Highlight the word **Mole_Fractions** and then press the **<Enter>** key;
	The screen should now appear as follows:

```
                    Stream Mole Fractions

Methane     _____________________    Ethane      _____________________
Propane     _____________________    i-Butane    _____________________
n-Butane    _____________________    i-Pentane   _____________________
n-Pentane   _____________________
```

Step	Action
68	*Enter the following molar flows beside each component in the ColdIn3 stream:* After the word, Methane, type the number **0.95** in the blank and then press the **<Enter>** key; After the word, Ethane, type the number **0.05** in the blank and then press the **<Enter>** key, After the word, Propane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Pentane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Pentane, type the number **0** in the blank;
	The screen should now appear as follows:

```
                    Stream Mole Fractions

Methane     0.95_____________    Ethane      0.05_____________
Propane     0_____________       i-Butane    0_____________
n-Butane    0_____________       i-Pentane   0_____________
n-Pentane   0_____________
```

Step	Action
69	Press the **<Insert>** key,
70	Highlight the word **Specify** and then press the **<Enter>** key;
71	Highlight the word **Stream** and then press the **<Enter>** key;
72	Highlight the word **ColdIn4** and then press the **<Enter>** key;
	Specifying that the Temperature of the ColdIn4 stream in °C is unknown by typing an "x".
73	Type the letter **x** and then press the **<Enter>** key;

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Specifying the Pressure of the ColdIn4 stream in kilopascals (kPa).
74	Type the number **250** and then press the **<Enter>** key;
	Specifying the molar flow rate of ColdIn4 in kg-mols/hr is unknown by typing an "x".
75	Type the letter **x** and then press the **<Enter>** key;
	Specifying the basis you wish to use when specifying the compositions.
76	Highlight the word **Mole_Fractions** and then press the **<Enter>** key;
	The screen should now appear as follows:

```
═══════ Stream Mole Fractions ═══════

Methane    _____________    Ethane     _____________
Propane    _____________    i-Butane   _____________
n-Butane   _____________    i-Pentane  _____________
n-Pentane  _____________
```

Step	Action
77	*Enter the following molar flows beside each component in the ColdIn4 stream:* After the word, Methane, type the number **0.02** in the blank and then press the **<Enter>** key; After the word, Ethane, type the number **0.98** in the blank and then press the **<Enter>** key; After the word, Propane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Butane, type the number **0** in the blank and then press the **<Enter>** key; After the word, i-Pentane, type the number **0** in the blank and then press the **<Enter>** key; After the word, n-Pentane, type the number **0** in the blank;
	The screen should now appear as follows:

```
═══════ Stream Mole Fractions ═══════

Methane    0.02_____________    Ethane     0.98_____________
Propane    0_____________       i-Butane   0_____________
n-Butane   0_____________       i-Pentane  0_____________
n-Pentane  0_____________
```

Step	Action
	Getting back to the Main Menu.
78	Press the **<Insert>** key;
79	Highlight the word **Worksheet** and then press the **<Enter>** key;
	Specifying the known vapor fraction of various streams.
80	*Place the cursor under the column for the ColdIn3 stream and at the Vapour frac. row using the arrow keys.* Type the number **1** and then press the **<Enter>** key;
81	*Place the cursor under the column for the ColdIn4 stream and at the Vapour frac. row using the arrow keys.* Type the number **0** and then press the **<Enter>** key;

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
82	*Place the cursor under the column for the WarmOut4 stream and at the Vapour frac. row using the arrow keys.* Type the number **1** and then press the <**Enter**> key;
	The following screen will then appear as shown below:

Streams

Stream	New Value = WarmIn1	ColdOut1	WarmIn2	ColdOut2
Vapour_Frac	0.5734	0.0000	1.0000	1.0000
Temperature	20.0000*	-72.2132	30.0000*	24.9986
Pressure	5000.0000*	4900.0000	5000.0000*	4990.0000
Flow	100.0000*	100.0000	50.0000*	50.0000
Mass_Flow	3146.8423	3146.8423	837.2125	837.2125
LiqVol_Flow	7.3362	7.3362	2.7566	2.7566
Energy_Flow	525029.5898	-497964.9902	467546.3867	456869.5313

Stream	ColdIn3	WarmOut3	ColdIn4	WarmOut4
Vapour_Frac	1.0000*	1.0000	0.0000*	1.0000*
Temperature	-87.2127	27.9990	-79.1307	-70.9851
Pressure	2000.0000*	1950.0000	250.0000*	245.0000
Flow	75.0000*	75.0000	47.8685	47.8685
Mass_Flow	1255.8187	1255.8187	1425.9722	1425.9722
LiqVol_Flow	4.1349	4.1349	4.0172	4.0172
Energy_Flow	396088.5132	739452.6123	-348854.1076	341039.7848

Attached to LNG

Step	Action
83	Press the <**Esc**> key;
84	Highlight the word **Operation** and then press the <**Enter**> key;
85	Highlight the letters **LNG** and then press the <**Enter**> key;
86	Highlight the word **Change** and then press the <**Enter**> key;
87	Press the <**Insert**> key;
88	Press the <**Enter**> key;
	Specifying the Minimum Temperature approach in ℃.
89	Type the number **2** and then press the <**Enter**> key;
90	Press the <↓> key 11 times;
	Deleting the second row relating streams WarmIn2 and WarmOut3.
91	Press the **space bar** 5 times until the entire row is deleted;
	Changing the constant in the relationship between WarmIn2 and ColdOut2.
92	Press the <**Enter**> key 3 times;
93	Type the number **3**;
	The screen should then appear as shown on the following page.

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

LNG Exchanger - Specifications

Operation Name: LNG

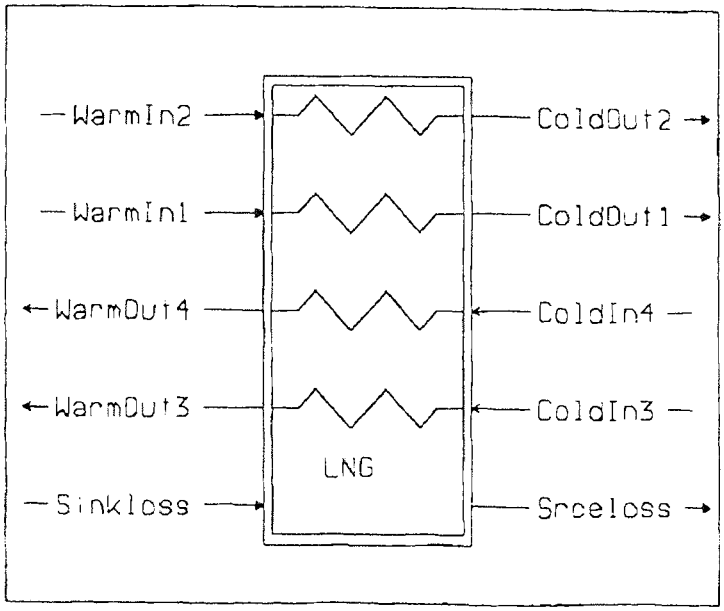
UA: kJ/C-h
Min temp approach: 2 C
Heat leak stream: Sinkloss
Heat loss stream: Srceloss
Heat leak fraction: 0.0001
Heat loss fraction: 0.0005

Number of intervals: 20
Locate phase changes: Yes
Convergence tolerance: 1.000e-04
Composite method: Pinch

Temperature specifications

Stream Temp	=	Stream Temp	+	Constant [C]
ColdOut1	=	ColdIn3	+	15.000
	=		+	
WarmIn2	=	ColdOut2	+	3
	=		+	
	=		+	
	=		+	
	=		+	
	=		+	

Step	Action
94	Press the <**Insert**> key;
	Looking at the current Process Flow Diagram (PFD).
95	Highlight the letters **PFD** and then press the <**Enter**> key;
	The figure shown below will then appear.



3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Getting back to the Main Menu.
96	Press the <**Esc**> key;
	Looking at the LNG Heat Exchanger Results.
97	Highlight the word **Operation** and then press the <**Enter**> key;
98	Highlight the letters **LNG** and then press the <**Enter**> key;
99	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Input* - The inputted information will be printed out.
b) *Results* - A summary of results sheet will be printed out.
c) *Curves* - Heat exchanger duty, temperature or UA profile curves be printed out.
d) *DegFree* - The degrees of freedom will be printed out.
e) *Spread sheet* - Toggles between display and spreadsheet.
f) *Printer* - Toggles the printer on.
g) *File* - Saves results in a file.
h) *SI* - Prints results in SI (the International System) or metric units.
i) *Field* - Prints results in Field (or English) units.
j) *User* - Prints results in User supplied units.
k) *Quit* - Leave the menu.

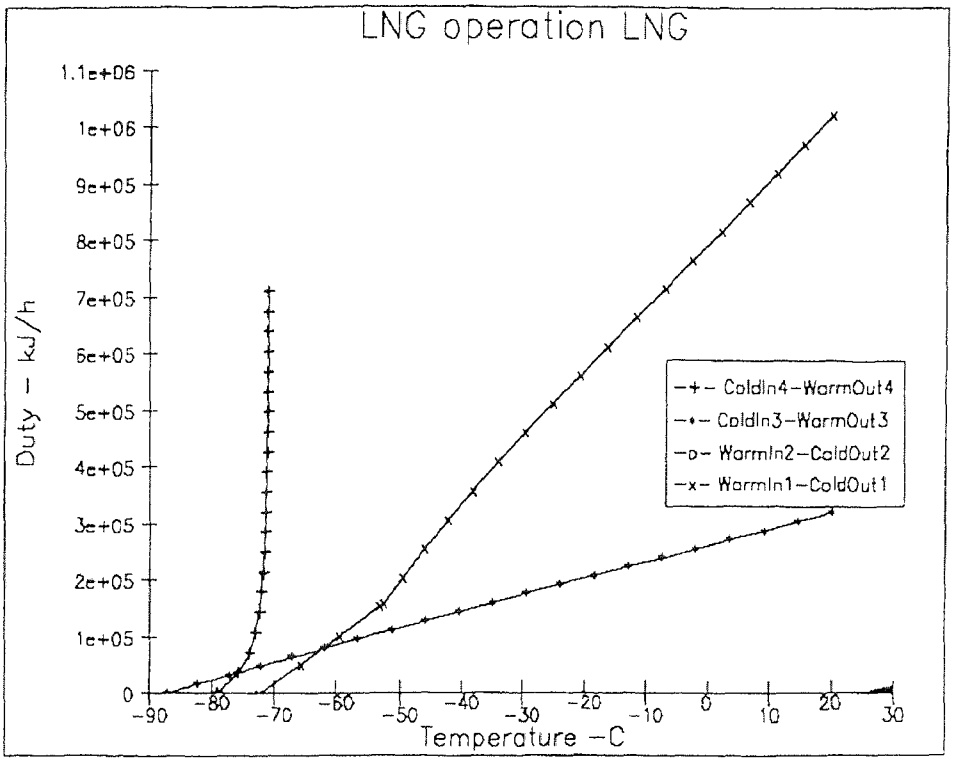
NOTE. It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
100	Highlight the word **Results** and then press the <**Enter**> key;
	Pressing the <F10> key will get the Main Menu off of the screen, enabling you to see the data on the screen underneath it.
101	Press the <**F10**> key;
	The screen will appear as shown below:

```
LNG Operation LNG

Results:

Hot Side Duty =              1.02935E+06 kJ/h
Heat Loss =                      514.680 kJ/h
Cold Side Duty =             1.02894E+06 kJ/h
Heat Leak =                      102.895 kJ/h
UA =                             41953.2 kJ/C-h
Effective MTD =                  24.5310 C
Min dT =                          2.0000 C


   Inlet       Inlet Outlet     Outlet      Flow     Duty     Pass UA
   Stream    Temp [C]Stream    Temp [C] [kgmole/h] [kJ/h]    [kJ/C-h]
-------------------------------------------------------------------
WarmIn1         20.000 ColdOut1 -72.212  100.00-1.0229E+06   41329.
WarmIn2         30.000 ColdOut2  27.000  50.000    -6364.9   624.25
ColdIn3        -87.213 WarmOut3  20.003  75.000 3.1998E+05   18274.
ColdIn4        -79.131 WarmOut4 -70.985  49.191 7.0895E+05   23680.
```

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
102	Press the **<F10>** key;
	Looking at the compositions of the streams.
103	Press the **<Esc>** key;
104	Highlight the word **Plot** and then press the **<Enter>** key;
105	Highlight the word **Temperature** and then press the **<Enter>** key;
106	Highlight the word **Duty** and then press the **<Enter>** key;
107	Highlight the word **Passes** and then press the **<Enter>** key;
	The graph shown below will then appear:



Step	Action
108	Press the **<Esc>** key;
109	Highlight the word **Quit** and then press the **<Enter>** key;
110	Highlight the word **Quit** and then press the **<Enter>** key;
	Getting back to the Main Menu.
111	Highlight the word **Print** and then press the **<Enter>** key;

Print Options:

The various print options available are as follows:

a) *Streams*- The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Print Options (continued):

c) *Spec_Sheets* - The specifications sheets will be printed out.
d) *Hypotheticals* - Hypothetical component information will be printed out.
e) *Format* - Specifies the format of the printout.
f) *Cost* - Lists costs of the run, if a royalty is being charged.
g) *File* - Saves results in a file.
h) *Printer* - Toggles on a printer.
i) *Cases* - Lists the stored files.
j) *Description* - Prints case description.
k) *Oil_Input* - Lists inputted information on an oil.

Step	Action
112	Highlight the word **Streams** and then press the <**Enter**> key;
113	Highlight the word **All** and then press the <**Enter**> key;
114	Highlight the symbol - and then press the <**Enter**> key;
	Pressing the <F10> key will get the Main Menu off of the screen, enabling you to see the data on the screen underneath it.
115	Press the <**F10**> key;
	The following screen below and on the following page will then appear:

Stream		WarmIn1	ColdOut1	WarmIn2	ColdOut2
Description					
Vapour frac.		0.5734	0.0000	1.0000	1.0000
Temperature	C	20.0000*	-72.2132	30.0000*	26.9986
Pressure	kPa	5000.0000*	4900.0000	5000.0000*	4990.0000
Molar Flow	kgmole/h	100.0000*	100.0000	50.0000*	50.0000
Mass Flow	kg/h	3146.8423	3146.8423	837.2125	837.2125
LiqVol Flow	m3/h	7.3362	7.3362	2.7566	2.7566
Enthalpy	kJ/h	525029.5898	-497964.9902	467546.3867	461181.4941
Density	kg/m3	121.1219	514.7614	37.0933	37.5423
Mole Wt.		31.4684	31.4684	16.7442	16.7442
Spec. Heat	kJ/kg-C	2.6560	2.4373	2.5702	2.5736
Therm Cond	W/m-K	---	0.0841	0.0383	0.0379
Viscosity	cP	---	0.1413	0.0125	0.0124
Z Factor		---	0.1793	0.8955	0.8918
Sur Tension	dyne/cm	---	9.1015	---	---
Std Density	kg/m3	---	---	---	---
Methane	mole frac.	0.5386*	0.5386	0.9500*	0.9500
Ethane	mole frac.	0.1538*	0.1538	0.0500*	0.0500
Propane	mole frac.	0.0769*	0.0769	0.0000*	0.0000
i-Butane	mole frac.	0.0692*	0.0692	0.0000*	0.0000
n-Butane	mole frac.	0.0615*	0.0615	0.0000*	0.0000
i-Pentane	mole frac.	0.0538*	0.0538	0.0000*	0.0000
n-Pentane	mole frac.	0.0462*	0.0462	0.0000*	0.0000
Stream		ColdIn3	WarmOut3	ColdIn4	WarmOut4
Description					
Vapour frac.		1.0000*	1.0000	0.0000*	1.0000*
Temperature	C	-87.2127	20.0025	-79.1307	-70.9851
Pressure	kPa	2000.0000*	1950.0000	250.0000*	245.0000
Molar Flow	kgmole/h	75.0000*	75.0000	49.1913	49.1913
Mass Flow	kg/h	1255.8187	1255.8187	1465.3789	1465.3789
LiqVol Flow	m3/h	4.1349	4.1349	4.1282	4.1282

3.3.5 LNG (Multi-Pass) Heat Exchanger (continued)

Enthalpy	kJ/h	396088.5132	716077.1484	-358494.6862	350464.4147
Density	kg/m3	27.6522	14.0812	529.9079	4.6134
Mole Wt.		16.7442	16.7442	29.7894	29.7894
Spec. Heat	kJ/kg-C	2.6565	2.3226	2.4395	1.4967
Therm Cond	W/m-K	0.0212	0.0339	0.1482	0.0125
Viscosity	cP	0.0079	0.0114	0.1447	0.0065
Z Factor		0.7834	0.9513	0.0087	0.9412
Sur Tension	dyne/cm	---	---	14.1132	---
Std Density	kg/m3	---	---	351.1792	---
Methane	mole frac.	0.9500*	0.9500	0.0200*	0.0200
Ethane	mole frac.	0.0500*	0.0500	0.9800*	0.9800
Propane	mole frac.	0.0000*	0.0000	0.0000*	0.0000
i-Butane	mole frac.	0.0000*	0.0000	0.0000*	0.0000
n-Butane	mole frac.	0.0000*	0.0000	0.0000*	0.0000
i-Pentane	mole frac.	0.0000*	0.0000	0.0000*	0.0000
n-Pentane	mole frac.	0.0000*	0.0000	0.0000*	0.0000

Stream Description		Sinkloss	Srceloss
Vapour frac.		2.0000*	2.0000*
Temperature	C	0.0000*	0.0000*
Pressure	kPa	0.0000*	0.0000*
Molar Flow	kgmole/h	0.0000*	0.0000*
Mass Flow	kg/h	0.0000*	0.0000*
LiqVol Flow	m3/h	0.0000*	0.0000*
Enthalpy	kJ/h	102.8948	514.6797
Density	kg/m3	0.0000	0.0000
Mole Wt.		0.0000	0.0000
Spec. Heat	kJ/kg-C	---	---
Therm Cond	W/m-K	---	---
Viscosity	cP	---	---
Z Factor		---	---
Sur Tension	dyne/cm	---	---
Std Density	kg/m3	---	---
Methane	mole frac.	0.0000*	0.0000*
Ethane	mole frac.	0.0000*	0.0000*
Propane	mole frac.	0.0000*	0.0000*
i-Butane	mole frac.	0.0000*	0.0000*
n-Butane	mole frac.	0.0000*	0.0000*
i-Pentane	mole frac.	0.0000*	0.0000*
n-Pentane	mole frac.	0.0000*	0.0000*

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
116	Press the **<F10>** key;
117	Do you want to continue adding other unit operations to this LNG (multi-pass) heat exchanger? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

Objective- This exercise is an example of a mixer calculation. The purpose of the mixer unit operation is to combine two or more streams, and then to obtain the properties of the combined outlet stream. This example can be modified by specifying another property package and/or other components, compositions and stream conditions.

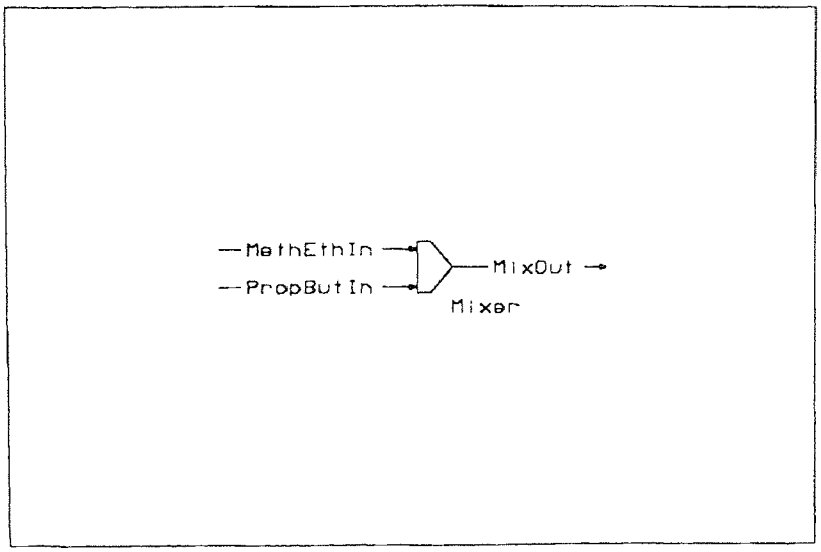
In this example, two feed streams (*MethEthIn* and *PropButIn*) are mixed resulting in one product stream, *MixOut*. The temperature, pressure, mass flow and composition of streams *MethEthIn* and *PropButIn* are specified and HYSIM calculates the conditions of product stream, *MixOut*. (If the inlet stream pressures are not the same, HYSIM will assign the lowest pressure of the inlet streams to the outlet stream).

References: Refs. 1 and 2.

Directions: Pages 188 through 193 outline the execution of an adiabatic mixer example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Mixer*, is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed streams.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word **i-Butane**;
5	Press the <**Insert**> key;

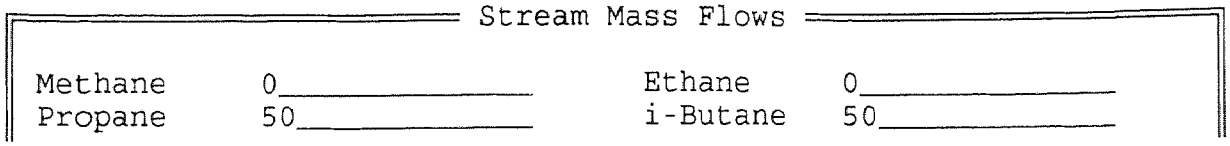
NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the conditions of the Feed stream "MethEthIn".
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the letter **MethEthIn** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of stream "MethEthIn" in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of stream "MethEthIn" in psia.
15	Type the number **25** after the prompt (>) and then press the <**Enter**> key;
	Typing an "x" to leave the flow rate of the stream "MethEthIn" unspecified at this point.
16	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying the composition of stream "MethEthIn".
17	Highlight the words **Mass_Flows** and then press the <**Enter**> key;
	Specifying the individual mass flows of each component.
18	*Enter the following mass flow beside each component in the feed stream "MethEthIn" in lb/hr:* After the word, Methane, type the number **50** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **50** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0** in the blank;
	The screen should now appear as follows:

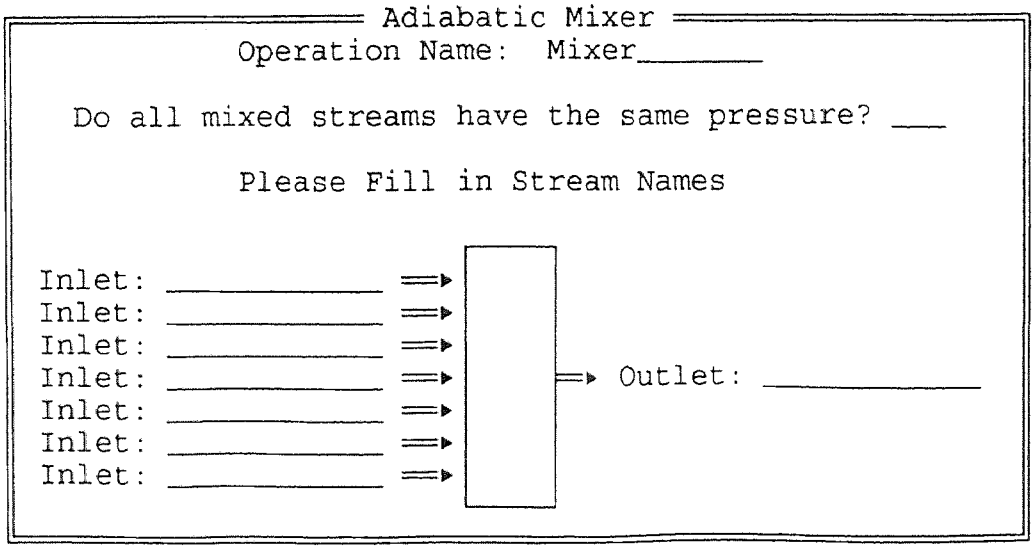
```
                    Stream Mass Flows

Methane     50_____________        Ethane     50_____________
Propane     0______________        i-Butane   0______________
```

Step	Action
19	Press the <**Insert**> key;
	HYSIM will next ask you if the total mass flow (100.0000 lb/hr) it calculated from adding up the individual component flows is correct.
20	Highlight the word **Yes** and then press the <**Enter**> key;
	Specifying the conditions of the Feed stream "PropButIn".
21	Highlight the word **Specify** and then press the <**Enter**> key;
22	Highlight the word **Stream** and then press the <**Enter**> key;
23	Type the letter **PropButIn** after the prompt (>) and then press the <**Enter**> key;

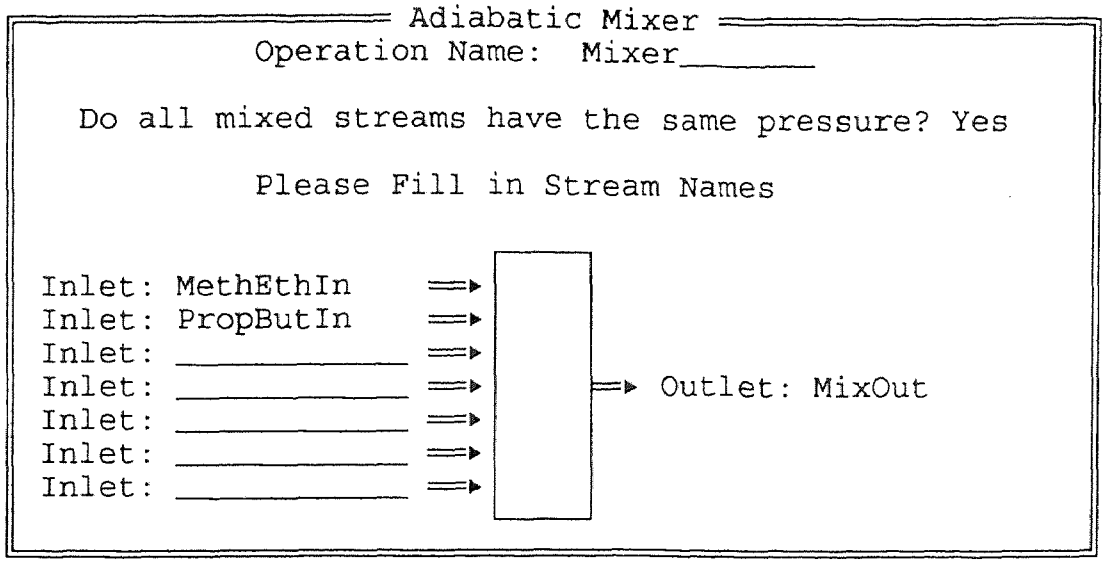
Step	Action
	Specifying the temperature of stream "PropButIn" in °F.
24	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of stream "PropButIn" in psia.
25	Type the number **25** after the prompt (>) and then press the <**Enter**> key;
	Typing an "x" to leave the flow rate of the stream "PropButIn" unspecified at this point.
26	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
27	Highlight the words **Mass_Flows** and then press the <**Enter**> key;
28	*Enter the following mass flow (lb/hr) beside each component in the feed stream, PropButIn:* After the word, Methane, type the number **0** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **50** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **50** in the blank;
	The screen should now appear as follows:



Step	Action
29	Press the <**Insert**> key;
	HYSIM will next ask you if the total mass flow (100.0000 lb/hr) it calculated from adding up the individual component flows is correct.
30	Highlight the word **Yes** and then press the <**Enter**> key;
	Specifying the type of operation.
31	Highlight the word **Operation** and then press the <**Enter**> key;
32	Type the word **Mixer** and then press the <**Enter**> key;
33	Highlight the word **Mixer** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Answering the question: "Do all streams have the same pressure?"
34	Type the word **Yes** and then press the <**Enter**> key;
	Naming the outlet and inlet streams.
35	Type the letter **MixOut** in the blank and then press the <**Enter**> key;
36	Type the letter **MethEthIn** in the blank and then press the <**Enter**> key;
37	Type the letter **PropButIn** in the blank;
	The screen should now appear as follows:



Step	Action
38	Press the <**Insert**> key;
39	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

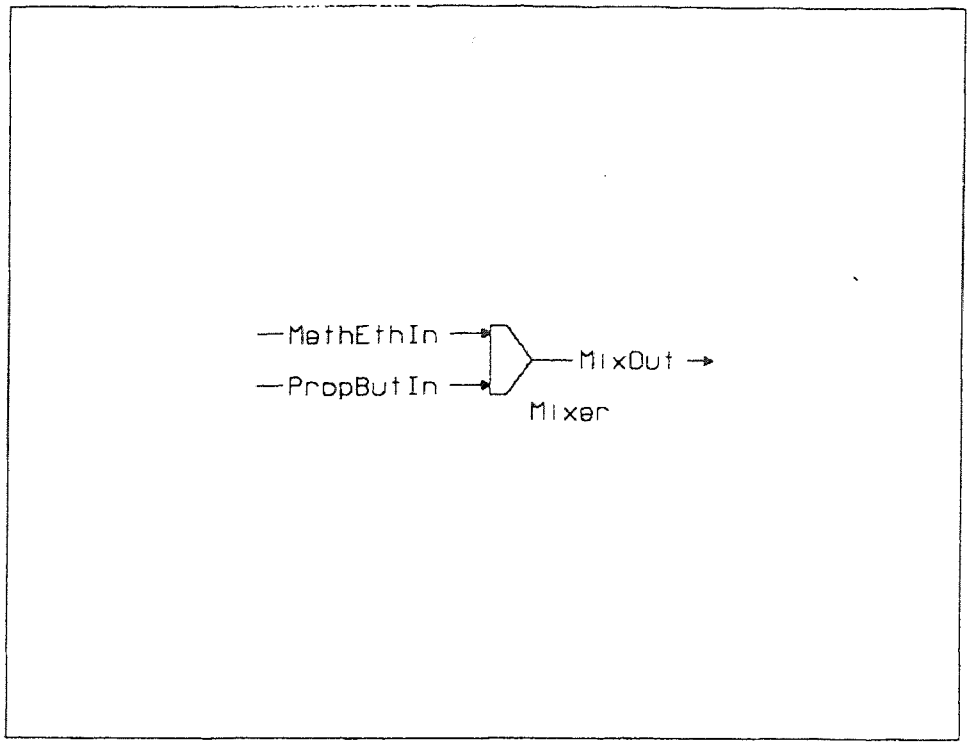
k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
40	Highlight the word **Streams** and then press the **<Enter>** key;
41	Highlight the word **All** and then press the **<Enter>** key;
	Looking at the calculated data for all of the streams.
42	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
43	Press the **<F10>** key;
	The screen will appear as follows:

Stream		MethEthIn	PropButIn	MixOut
Description				
Vapour frac.		1.0000	1.0000	1.0000
Temperature	F	60.0000*	60.0000*	59.4689
Pressure	psia	25.0000*	25.0000*	25.0000
Molar Flow	lbmole/hr	4.7794	1.9941	6.7735
Mass Flow	lb/hr	100.0000*	100.0000*	200.0000
LiqVol Flow	barrel/day	21.0608	12.8493	33.9101
Enthalpy	Btu/hr	21076.4835	13263.3572	34339.8414
Density	lb/ft3	0.0945	0.2338	0.1344
Mole Wt.		20.9230	50.1481	29.5267
Spec. Heat	Btu/lb-F	0.4739	0.3988	0.4354
Therm Cond	Btu/hr-ft-F	0.0160	0.0092	0.0135
Viscosity	cP	0.0104	0.0077	0.0098
Z Factor		0.9926	0.9615	0.9860
Sur Tension	dyne/cm	---	---	---
Std Density	lb/ft3	---	---	---
Methane	mole frac.	0.6521*	0.0000*	0.4601
Ethane	mole frac.	0.3479*	0.0000*	0.2455
Propane	mole frac.	0.0000*	0.5686*	0.1674
i-Butane	mole frac.	0.0000*	0.4314*	0.1270

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
44	Press the **<F10>** key;
45	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
46	Press the **<Esc>** key until you reach the Main Menu;
47	Do you want to continue adding other unit operations to this Mixer? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

Objective- This exercise is an example of a pump calculation. The pump unit operation changes the pressure of an inlet stream by accomplishing mechanical work. The HYSIM pump operation only deals with liquid streams and performs an overall energy balance to determine the required work. The unit operation will calculate conditions of the inlet and outlet streams if enough variables are specified. This example can be modified by specifying another property package and/or other components, compositions and stream conditions.

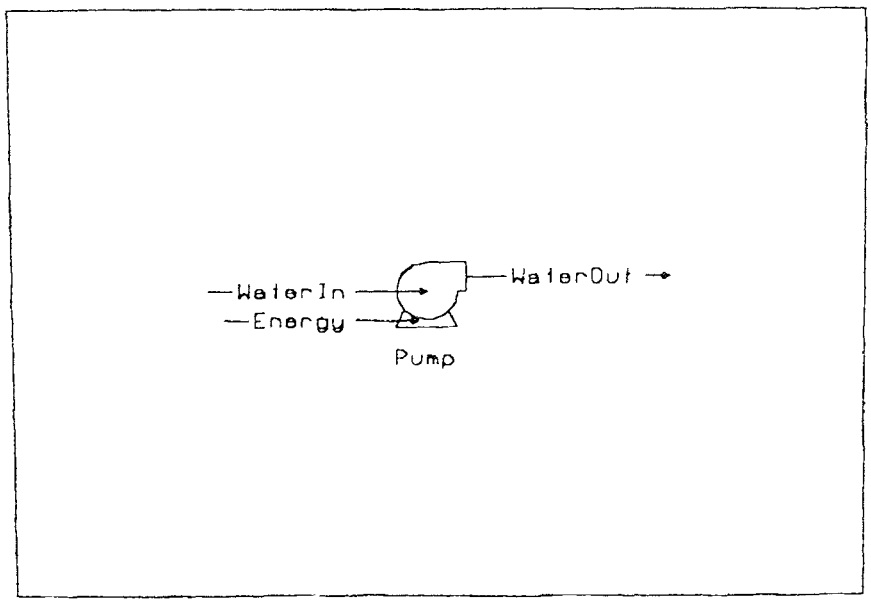
In this example, a liquid feed stream, *WaterIn*, composed of only water at a pressure of 14.7 psia is pumped, with the resultant pump product stream, *WaterOut*, having a pressure of 100 psia.

Technical Example Reference: Reference 3 - Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Volume I, Second Edition, Gulf Publishing Co., 1984.
Other References: Refs. 1 and 2.

Directions: Pages 195 through 202 outline the execution of a pump for liquids example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Pump*, is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Steam** and then press the <**Enter**> key;
4	Highlight the word **ASME-Steam** and then press the <**Enter**> key
	The following screen will appear:

```
                    COMPONENT SELECTION
 Selected  |  Synonym              Name        Formula  |  Criteria
 ——▲—↑——   |  ——▲—↑——————————————————————————————————  |  ————————
           |  H2O                  H2O         H2O      |  ALL
           |  Dihydrogen_Oxide     H2O         H2O      |  HC
           |  Ice                  H2O         H2O      |  SOLID
           |  Water                H2O         H2O      |  MISC
           |                                            |  AMINE
           |                                            |  ALCOHOL
           |                                            |  KETONE
           |                                            |  ALDEHYDE
           |                                            |  ESTER
           |                                            |  CARBACID
           |                                            |  HALOGEN
           |                                            |  NITRILE
           |                                            |  PHENOL
           |                                            |  ETHER
           |                                            |  USER
 ——▼—↓——   |  ——▼—↓——Search by SYNONYM————————————————————————
 F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
                        PRESS INSERT TO SUBMIT   F8 - Change
```

Step	Action
	Selecting the components in the feed stream.
5	Highlight the following component synonym under the "Component Selection" Section and press the <Enter> key so that the synonym then appears in the "selected" column, as follows: Highlight the word **Water** and then press the <**Enter**> key;
6	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

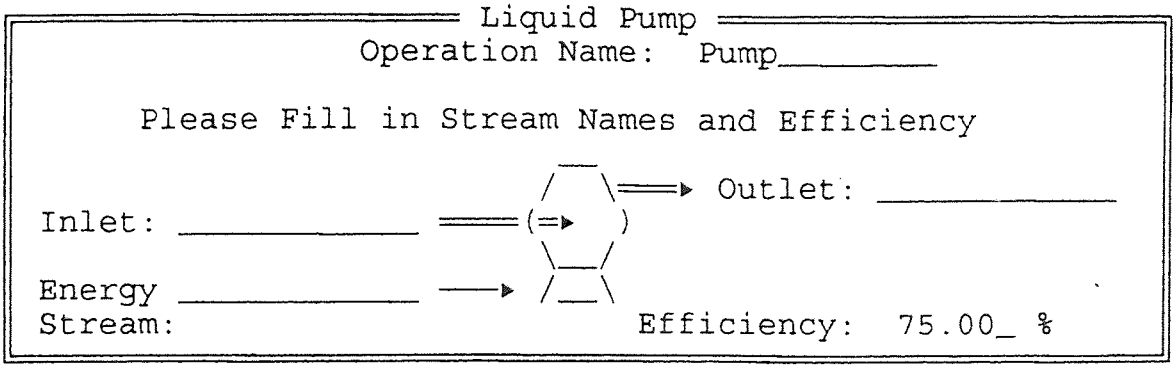
Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, °C, kPa, etc.) to field units. (lb, °F, psia, etc.)
7	Highlight the word **Utility** and then press the <**Enter**> key;
8	Highlight the word **Configuration** and then press the <**Enter**> key;
9	Highlight the word **Units** and then press the <**Enter**> key;
10	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
11	Press the <**Esc**> key;
	Specifying the conditions of the Feed stream "WaterIn".
12	Highlight the word **Specify** and then press the <**Enter**> key;
13	Highlight the word **Stream** and then press the <**Enter**> key;
14	Type the letter **WaterIn** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of stream "WaterIn" in °F.
15	Type the number **85** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of stream "WaterIn" in psia units.
16	Type the number **14.7** after the prompt (>) and then press the <**Enter**> key;
	Typing an "x" to leave stream flow of the stream "WaterIn" unspecified at this point.
17	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
18	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The screen will then appear as follows:

```
═══════════ Stream Mole Fractions ═══════════

H2O                  _______
```

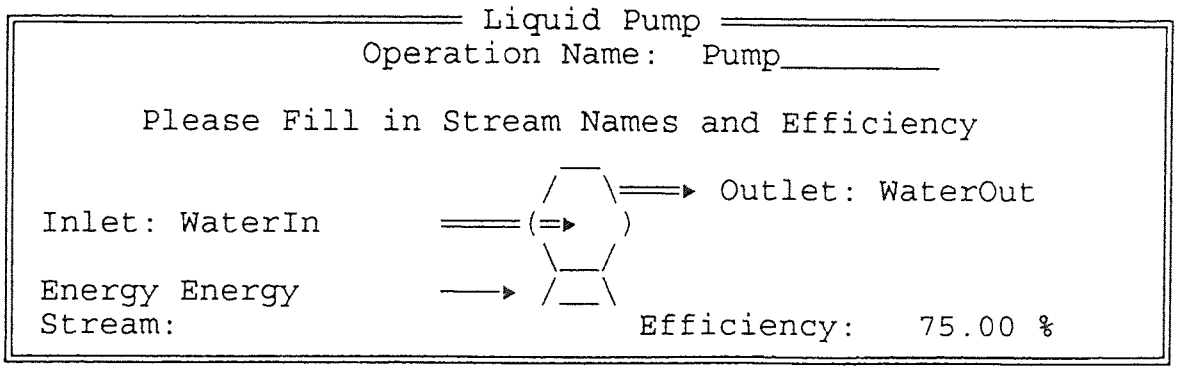
Step	Action
	Specifying the individual molar flows of each component.
19	*Enter the following molar flow beside each component in the feed stream, WaterIn:* After the formula, H2O, type the number **1.00** in the blank;
	The screen should now appear as follows:

```
═══════════ Stream Mole Fractions ═══════════

H2O                  1.00___
```

Step	Action
20	Press the <**Insert**> key;
	Specifying the type of operation.
21	Highlight the word **Operation** and then press the <**Enter**> key;
22	Type the word **Pump** and then press the <**Enter**> key;
23	Highlight the word **Pump** and then press the <**Enter**> key;
	The following screen will appear:



Step	Action
	Naming the inlet and outlet streams.
24	Type the letter **WaterIn** in the blank and then press the <**Enter**> key;
25	Type the letter **WaterOut** in the blank and then press the <**Enter**> key;
26	Type the letter **Energy** in the blank;
	The screen should now appear as follows:



Step	Action
27	Press the <**Insert**> key;
28	Highlight the word **Worksheet** and then press the <**Enter**> key;
29	*Use the arrow keys to highlight the space for the Pressure of stream "WaterOut" in psia units.* Type the number **100.0** and then press the <**Enter**> key;
30	*Use the arrow keys to highlight the space for the LiqVol-Flow of stream "WaterIn" in gallons/minute (GPM) units.* Press the <**F2**> key; Highlight the word **GPM** and then type the number **300** . Finally, press the <**Enter**> key;
31	Press the <**Esc**> key until you are back at the Main Menu;

Step	Action
32	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

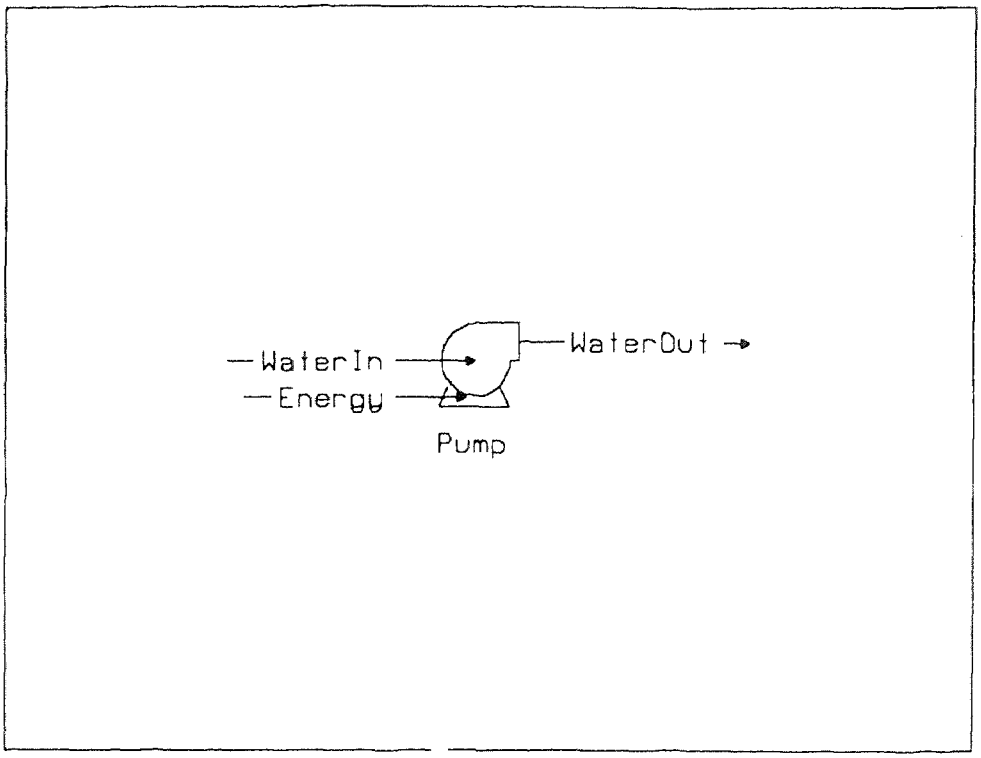
k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
33	Highlight the word **Streams** and then press the <**Enter**> key;
	Looking at the calculated data for all of the streams.
34	Highlight the word **All** and then press the <**Enter**> key;
35	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
36	Press the <**F10**> key;
	The screen will appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream Description		WaterIn	WaterOut	Energy
Vapour frac.		0.0000	0.0000	2.0000*
Temperature	F	85.0000*	85.1080	0.0000*
Pressure	psia	14.7000*	100.0000*	0.0000*
Molar Flow	lbmole/hr	8320.9667	8320.9667	0.0000*
Mass Flow	lb/hr	149903.0515	149903.0515	0.0000*
LiqVol Flow	barrel/day	10285.0000*	10285.0000	0.0000*
Enthalpy	Btu/hr	7.95694E+06	8.00770E+06	50757.9645
Density	lb/ft3	62.1564	62.1716	0.0000
Mole Wt.		18.0151	18.0151	0.0000
Spec. Heat	Btu/lb-F	0.9983	0.9979	---
Therm Cond	Btu/hr-ft-F	0.3568	0.3568	---
Viscosity	cP	0.8068	0.8058	---
Z Factor		0.0007	0.0050	---
Sur Tension	dyne/cm	71.3302	71.3198	---
Std Density	lb/ft3	62.3567	62.3567	---
H2O	mole frac.	1.0000*	1.0000	0.0000*

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
37	Press the **<F10>** key;
38	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
39	Press the **<Esc>** key until you reach the Main Menu;
40	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 198.

Step	Action
41	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
42	Highlight the word **Operations** and then press the **<Enter>** key;
43	Highlight the word **Pump** and then press the **<Enter>** key;
	The screen will appear as shown on the following page. Repeat steps 36 and 37, using the <F10>, <Page Up> and <Page Down> keys in order to see the printout on the screen.

HYSIM PUMP SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/09/30
Case Name: Time 18:33:06

Operation Name: Pump
Operation Note:

Suction Side : WaterIn

From operation --- — ---

Suction Properties at Operating Conditions

Temperature	85.0000 F		Flow Rates	149903.0515 lb/hr
Pressure	14.7000 psia			300.6830 USGPM
Mass Frac Vap	0.0000			0.0190 m3/s
Mol Weight	18.0151			
Density	62.1564 lb/ft3			
	0.9977 SG_H2O60			
Viscosity	0.8068 cP			

Discharge Side : WaterOut

To operation --- — ---

Discharge Properties at Operating Conditions

Temperature	85.1080 F	Diff Press	85.3000 psi
Pressure	100.0000 psia	Diff Head	197.5585 ft
Mass Frac Vap	0.0000	Comp Ratio	6.8027
Density	62.1716 lb/ft3	Vol. Rate	300.6096 USGPM
	0.9979 SG_H2O60		0.0190 m3/s

Driver :

Energy Stream	Energy
Energy Required	50757.9645 Btu/hr
	19.9483 hp
Therm Efficiency	75.0000 %

NOTES :

Step	Action
44	Highlight the word **Size** and then press the <**Enter**> key;
45	Highlight the word **Pipe_Size** and then press the <**Enter**> key;
46	Highlight the letter **WaterIn** and then press the <**Enter**> key;
47	Highlight the word **Press_Drop** and then press the <**Enter**> key;
	Specifying the Pipe Diameter. Nominal or actual Inside Diameter (ID) in inches.
48	Type the number **6.0** and then press the <**Enter**> key;
	Entering the Pipe Schedule.
49	Type the number **40** and then press the <**Enter**> key;
	The screen will appear as shown below. Repeat steps 36 and 37, using the <F10>, <Page Up> and <Page Down> keys in order to see the printout on the screen.

Pressure Drop Calculation for stream WaterIn

Stream Properties

Phase	Viscosity cP	Flowrate lb/hr	Velocity ft/s	Density lb/ft3
Liquid	0.8068	149904.4106	3.3392	62.1563

Pipe Parameters

Reynolds Number	Friction Factor	Pipe Dia. in	Schedule	Press Drop Psi/100 ft
1.93E+05	0.017841	6.065	Std.	0.263925

Step	Action
50	Highlight the word **Size** and then press the <**Enter**> key;
51	Highlight the word **Pipe_Size** and then press the <**Enter**> key;
52	Highlight the letter **WaterOut** and then press the <**Enter**> key;
53	Highlight the word **Press_Drop** and then press the <**Enter**> key;
	Specifying the Pipe Diameter, Nominal or actual Inside Diameter (ID) in inches.
54	Type the number **4.0** and then press the <**Enter**> key;
	Entering the Pipe Schedule.
55	Type the number **40** and then press the <**Enter**> key;
	The screen will appear as shown below. Repeat steps 36 and 37, using the <F10>, <Page Up> and <Page Down> keys in order to see the printout on the screen.

Pressure Drop Calculation for stream WaterOut

Stream Properties

Phase	Viscosity cP	Flowrate lb/hr	Velocity ft/s	Density lb/ft3
Liquid	0.8058	149904.4106	7.5761	62.1715

Pipe Parameters

Reynolds Number	Friction Factor	Pipe Dia. in	Schedule	Press Drop Psi/100 ft
2.91E+05	0.018054	4.026	Std.	2.071683

Step	Action
56	Do you want to continue adding other unit operations to this Pump? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

This section contains examples of the following five different types of reactors:

3.6.1 Stoichiometric Reactor

Objective- This exercise is an example of a stoichiometric reactor calculation. The purpose of the stoichiometric reactor unit operation is to compute the output stream given the input stream, reaction stoichiometry, reaction conditions and conversion information. The chemical equations used in this example are as follows:

Reaction #1 $CH_4 + H_2O \rightarrow CO + 3H_2$

Reaction #2 $CO + H_2O \rightarrow CO_2 + H_2$

Reaction #3 $CH_4 \rightarrow C(s) + 2H_2$

This example can be modified by specifying another property package and/or other reactions, components, compositions and stream conditions.

In this stoichiometric matrix reactor, the stoichiometric equations for the three chemical reactions taking place inside the reactor are given to HYSIM, along with the percentage conversion of each of the base components of each reaction. The flow rate, composition and conditions of the feed stream are also specified. From this information, HYSIM can calculate the composition and condition of the outlet stream.

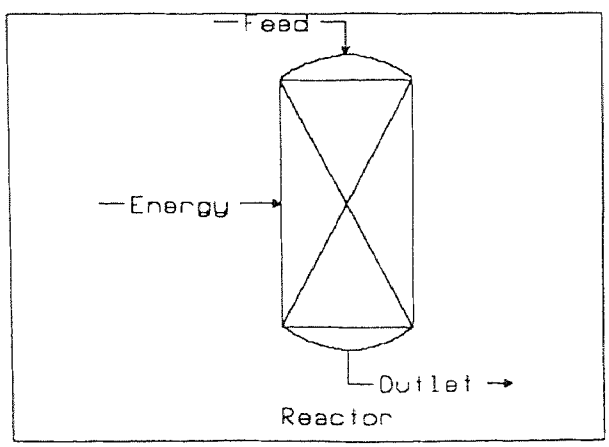
Technical Example Reference: Reference 1 - Hyprotech HYSIM User's Guide,Version C2.50, pp.7-66 to 7-72.

Other References: Refs. 1 & 2.

Directions: Pages 205 through 214 outlined the execution of a stoichiometric reactor example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the student, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Reactor*, is shown below:



3.6.1 Stoichiometric Reactor (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Hydrogen** and then press the <**Enter**> key; Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Argon** and then press the <**Enter**> key; Highlight the formula **CO** and then press the <**Enter**> key; Highlight the formula **CO2** and then press the <**Enter**> key; Highlight the word **Carbon** and then press the <**Enter**> key.
	The screen on the following page will then appear.

3.6.1 Stoichiometric Reactor (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	NO2	NO2	NO2	ALL
Hydrogen	N2O	N2O	N2O	HC
H2O	N2O4	N2O4	N2O4	SOLID
Argon	SO2	SO2	SO2	MISC
CO	SO3	SO3	SO3	AMINE
CO2	Sulphur_Rhombic	S_Rhombic	S	ALCOHOL
Carbon	Sulphur_Monoclinic	S_Monoclinic	S	KETONE
	Sulphur_Amorphous	S_Amorphous	S	ALDEHYDE
	Sulphur_Liq_150	S_Liq_150	S	ESTER
	Sulphur_Liq_190	S_Liq_190	S	CARBACID
	Sulphur_Liq_280	S_Liq_280	S	HALOGEN
	Sulphur_Vapour	S_Vapour	S	NITRILE
	H2S	H2S	H2S	PHENOL
	CarbonOxiSulphide	COS	COS	ETHER
	CarbondiSulphide	CS2	CS2	USER
	di-M-Sulphide	diM-Sulphide	C2H6S	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the type of operation.
6	Highlight the word **Operation** and then press the <**Enter**> key;
7	Type the word **Reactor** after the prompt (>) and then press the <**Enter**> key;
8	Highlight the word **Reactor** and then press the <**Enter**> key;
	The following screen will then appear:

General Reactor

Please fill in reactor type, stream names, etc.

Operation Name: Reactor_____

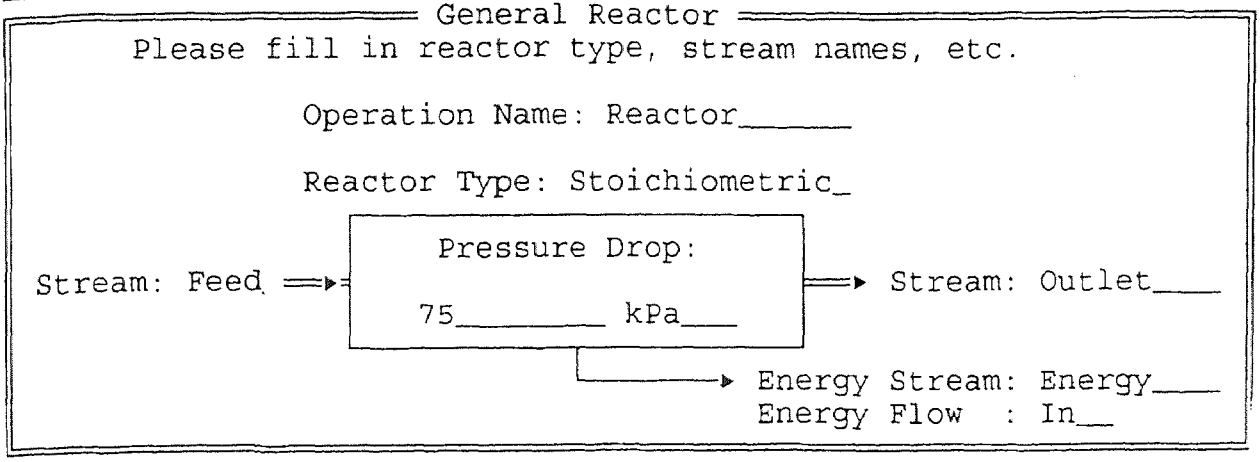
Reactor Type: Stoichiometric_

Stream: _____ ⟹ Pressure Drop: _____ kPa___ ⟹ Stream: __

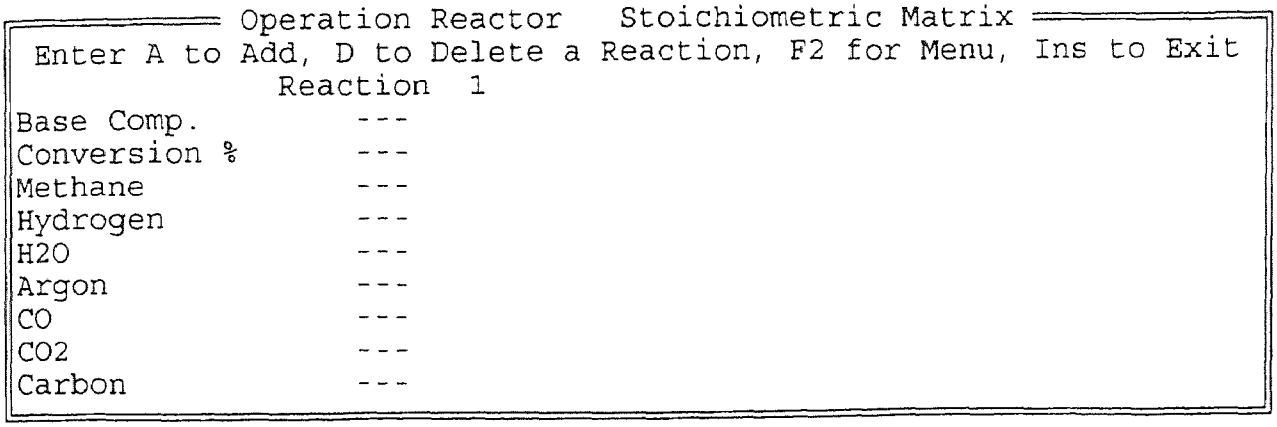
Energy Stream: __
Energy Flow : In

3.6.1 Stoichiometric Reactor (continued)

Step	Action
	Specifying that the reactor type should be left as Stoichiometric.
9	Press the <**Enter**> key;
	Specifying the stream names.
10	Type the word **Feed** in the blank and then press the <**Enter**> key;
11	Type the word **Outlet** in the blank and then press the <**Enter**> key;
12	Type the word **Energy** in the blank and then press the <**Enter**> key two times;
	Specifying the pressure drop in kPa units.
13	Type the number **75** in the blank.
	The screen should now appear as follows:



Step	Action
14	Press the <**Insert**> key;
	The following screen will then appear:



Step	Action
	Reaction 1 specifications.
	Specifying the base component, as Methane.
15	Press the <**F2**> and then highlight the word **Methane** and then press the <**Enter**> key;

3.6.1 Stoichiometric Reactor (continued)

Step	Action
	Specifying the % conversion of Reaction 1.
16	Press the <↓> and then type the number 77 and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients of Reaction 1.
17	Type the number **-1** and then press the <**Enter**> key;
18	Type the number **3** and then press the <**Enter**> key;
19	Type the number **-1** and then press the <**Enter**> key;
20	Type the number **0** and then press the <**Enter**> key;
21	Type the number **1** and then press the <**Enter**> key;
22	Type the number **0** and then press the <**Enter**> key;
23	Type the number **0** and then press the <**Enter**> key;
24	Press the letter **a**;
	Reaction 2 specifications.
	Specifying the base component, as CO.
25	Press the <↑> enough times until the pointer is at the blank space for the Base Comp. of Reaction 2.
26	Press the <**F2**> and then highlight the formula **CO** and then press the <**Enter**> key;
	Specifying the % conversion of Reaction 2.
27	Press the <↓> and then type the number **55** and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients of Reaction 2.
28	Type the number **0** and then press the <**Enter**> key;
29	Type the number **1** and then press the <**Enter**> key;
30	Type the number **-1** and then press the <**Enter**> key;
31	Type the number **0** and then press the <**Enter**> key;
32	Type the number **-1** and then press the <**Enter**> key;
33	Type the number **1** and then press the <**Enter**> key;
34	Type the number **0** and then press the <**Enter**> key;
35	Press the letter **a**;
	Reaction 3 specifications.
	Specifying the base component, as Methane.
36	Press the <↑> key enough times until the pointer is at the blank space for the Base Comp. of Reaction 3.
37	Press the <**F2**> key and then highlight the word **Methane** and then press the <**Enter**> key;
	Specifying the % conversion of Reaction 3.
38	Press the <↓> key and then type the number **1** and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients of Reaction 3.
39	Type the number **-1** and then press the <**Enter**> key;
40	Type the number **2** and then press the <**Enter**> key;
41	Type the number **0** and then press the <**Enter**> key;
42	Type the number **0** and then press the <**Enter**> key;
43	Type the number **0** and then press the <**Enter**> key;
44	Type the number **0** and then press the <**Enter**> key;

3.6.1 Stoichiometric Reactor (continued)

Step	Action
45	Type the number **1** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation Reactor Stoichiometric Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

	Reaction 1	Reaction 2	Reaction 3
Base Comp.	Methane	CO	Methane
Conversion %	77.000	55.000	1.000
Methane	-1.000	---	-1.000
Hydrogen	3.000	1.000	2.000
H2O	-1.000	-1.000	---
Argon	---	---	---
CO	1.000	-1.000	---
CO2	---	1.000	---
Carbon	---	---	1.000

Step	Action
46	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream.
47	Highlight the word **Specify** and then press the <**Enter**> key;
48	Highlight the word **Stream** and then press the <**Enter**> key;
49	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying the Temperature of the Feed in °C.
50	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
51	Type the number **1500** after the prompt (>) and then press the <**Enter**> key;
	Specifying the Flow in kg-mols/hr.
52	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
53	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The following screen will then appear:

Stream Mole Fractions

Methane	_____	Hydrogen	_____
H2O	_____	Argon	_____
CO	_____	CO2	_____
Carbon	_____		

3.6.1 Stoichiometric Reactor (continued)

Step	Action
54	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.45** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.54** in the blank and then press the <**Enter**> key; After the word, Argon, type the number **0.01** in the blank and then press the <**Enter**> key; After the formula, CO, type the number **0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0** in the blank;
	The screen should now appear as follows:

Stream Mole Fractions

Methane	0.45	Hydrogen	0
H2O	0.54	Argon	0.01
CO	0	CO2	0
Carbon	0		

Step	Action
55	Press the <**Insert**> key;
	Specifying the temperature (°C) and pressure (kPa) of the Outlet stream.
56	Highlight the word **Worksheet** and then press the <**Enter**> key;
57	*Use the arrow keys to move the pointer to the blank space for the Temperature of the Outlet stream.* Type the number **600** and then press the <**Enter**> key;
	The following screen will appear:

Streams

	New Value =		C	
Stream	Feed	Outlet	Energy	---
Vapour_Frac	1.0000	0.9974	2.0000*	---
Temperature	600.0000*	600.0000*	0.0000*	---
Pressure	1500.0000*	1425.0000	0.0000*	---
Flow	100.0000*	170.2000	0.0000*	---
Mass_Flow	1734.6940	1734.7194	0.0000*	---
LiqVol_Flow	3.4152	5.7065	0.0000*	---
Energy_Flow	3.45557E+06	4.53503E+06	7.06083E+06	---

Step	Action
58	Press the <**Esc**> key;
59	Highlight the word **Print** and then press the <**Enter**> key;

3.6.1 Stoichiometric Reactor (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - the different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves the results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
60	Highlight the word **Streams** and then press the **<Enter>** key;
61	Highlight the word **All** and then press the **<Enter>** key;
	Looking at the calculated data for all of the streams.
62	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
63	Press the **<F10>** key;
	The screen will appear as follows. Use the <Page Up> and <Page Down> keys to view the entire text.

Stream Description		Feed	Outlet	Energy
Vapour frac.		1.0000	0.9974	2.0000*
Temperature	C	600.0000*	600.0000*	0.0000*
Pressure	kPa	1500.0000*	1425.0000	0.0000*
Molar Flow	kgmole/h	100.0000*	170.2000	0.0000*
Mass Flow	kg/h	1734.6940	1734.7194	0.0000*
LiqVol Flow	m3/h	3.4152	5.7065	0.0000*
Enthalpy	kJ/h	3.45557E+06	4.53503E+06	7.06083E+06
Density	kg/m3	3.5867	1.9997	0.0000
Mole Wt.		17.3469	10.1922	0.0000
Spec. Heat	kJ/kg-C	3.0043	3.3907	---
Therm Cond	W/m-K	0.1040	---	---
Viscosity	cP	0.0267	---	---
Z Factor		0.9993	---	---
Sur Tension	dyne/cm	---	---	---
Std Density	kg/m3	---	---	---
Methane	mole frac.	0.4500*	0.0582	0.0000*
Hydrogen	mole frac.	0.0000*	0.7280	0.0000*
H2O	mole frac.	0.5400*	0.0017	0.0000*
Argon	mole frac.	0.0100*	0.0059	0.0000*
CO	mole frac.	0.0000*	0.0916	0.0000*
CO2	mole frac.	0.0000*	0.1120	0.0000*
Carbon	mole frac.	0.0000*	0.0026	0.0000*

3.6.1 Stoichiometric Reactor (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
64	Press the **<F10>** key;
65	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 211.

Step	Action
66	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
67	Highlight the word **Operations** and then press the **<Enter>** key;
68	Highlight the word **Reactor** and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
69	Press the **<F10>** key;
	The screen will appear as shown below and on the following page. Use the <Page Up> and <Page Down> keys to view the entire text.

HYSIM STOICHIOMETRIC REACTOR SPECIFICATION — Page 1 of 2

HYSIM Version C2.53 — Date 96/07/12

Case Name: — Time 12:45:06

Operation Name: Reactor

Operation Note:

Stream		Operation	Flowrate
Inlet: Feed	from	---	100.0000 kgmole/h
			1734.6940 kg/h
Outlet: Outlet	to	---	170.2000 kgmole/h
			1734.7194 kg/h
Energy: Energy	to	---	7.06083E+06 kJ/h

Inlet Properties at Operating Conds		Outlet Properties at Operating Conds	
Vapour Frac	1.0000	Vapour Frac	0.9974
Temperature	600.0000 C	Temperature	600.0000 C
Pressure	1500.0000 kPa	Pressure	1425.0000 kPa
Density	3.5867 kg/m3	Density	1.9997 kg/m3
Std Density	517.5597 kg/m3	Std Density	--- kg/m3
Mol Weight	17.3469	Mol Weight	10.1922
Viscosity	0.0267 cP	Viscosity	--- cP
Therm Cond	0.1040 W/m-K	Therm Cond	--- W/m-K

Component	Hform @ 298 K (kJ/kgmole)	Inlet Flowrate (kgmole/h)	Outlet Flowrate (kgmole/h)
Methane	-74900.0000	45.0000	9.9000
Hydrogen	0.0000	0.0000	123.9075
H2O	-241000.0000	54.0000	0.2925
Argon	0.0000	1.0000	1.0000
CO	-110590.0000	0.0000	15.5925
CO2	-393790.0000	0.0000	19.0575
Carbon	0.0000	0.0000	0.4500

3.6.1 Stoichiometric Reactor (continued)

HYSIM STOICHIOMETRIC REACTOR SPECIFICATION — Page 2 of 2

Case Name: Date 96/07/12
Operation Name: Reactor Time 12:45:06

Reaction 1	Base Component		% Conversion
	Methane		77.00
Reactants	-1.000 Methane	+ -1.000 H2O	
Products	3.000 Hydrogen	+ 1.000 CO	
Reaction 2	Base Component		% Conversion
	CO		55.00
Reactants	-1.000 H2O	+ -1.000 CO	
Products	1.000 Hydrogen	+ 1.000 CO2	
Reaction 3	Base Component		% Conversion
	Methane		1.00
Reactants	-1.000 Methane		
Products	2.000 Hydrogen	+ 1.000 Carbon	
Reaction 4	Base Component		% Conversion

Reactants			---
Products			---
Reaction 5	Base Component		% Conversion

Reactants			---
Products			---
Reaction 6	Base Component		% Conversion

Reactants			---
Products			---
Reaction 7	Base Component		% Conversion

Reactants			---
Products			---
Reaction 8	Base Component		% Conversion

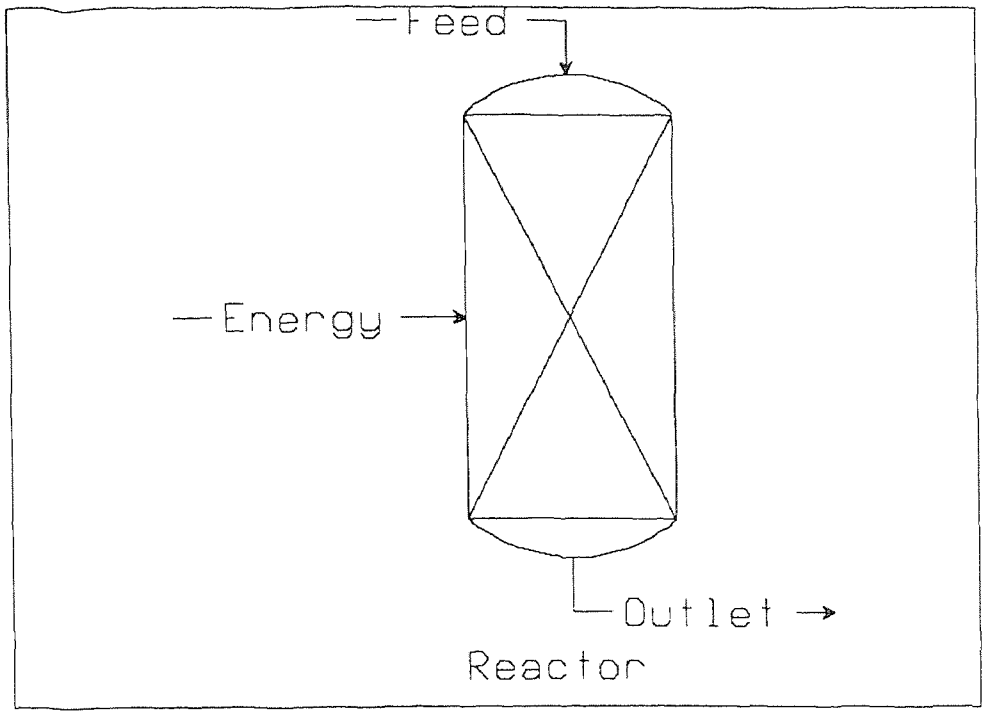
Reactants			---
Products			---
Reaction 9	Base Component		% Conversion

Reactants			---
Products			---
Reaction 10	Base Component		% Conversion

Reactants			---
Products			---

3.6.1 Stoichiometric Reactor (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
70	Press the **<F10>** key;
71	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
72	Press the **<Esc>** key until you reach the Main Menu;
73	Do you want to continue adding other unit operations to this reactor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.6.2 Equilibrium Reactor

Objective- This exercise is an example of an equilibrium reactor calculation. The purpose of the equilibrium reactor unit operation is to compute the output stream given the input stream, reaction stoichiometry, reaction conditions and equilibrium constants. The equilibrium reactor calculation assumes that the outlet stream is in a state of equilibrium. The chemical equations used in this example are as follows:

Reaction #1 $CH_4 + H_2O \rightarrow CO + 3H_2$

Reaction #2 $CO + H_2O \rightarrow CO_2 + H_2$

Reaction #3 $CH_4 \rightarrow C(s) + 2H_2$

This example can be modified by specifying another property package and/or other reactions, components and conditions.

In this example, the stoichiometric matrix of three chemical reaction equations is specified, along with the equilibrium constants for each equation. The composition, conditions and flow rate of the feed stream, along with the conditions of the outlet stream are also given. From this information HYSIM calculates the composition of the outlet stream.

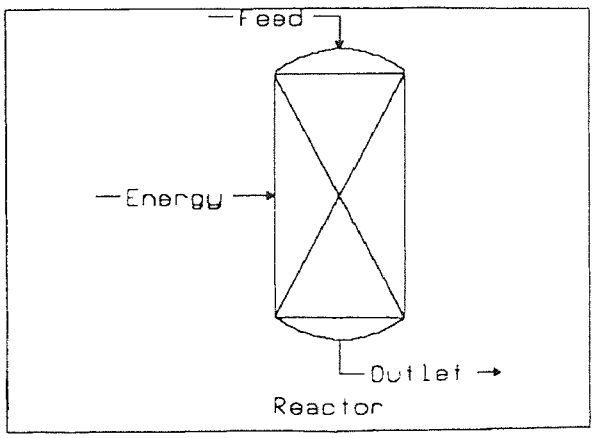
Technical Example Reference: Reference 1 - Hyprotech HYSIM User's Guide,Version C2.50, pages 7-66 to 7-76.

Other References: Refs. 1 & 2.

Directions: Pages 216 through 224 outline the execution of an equilibrium reactor example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Reactor*, is shown below:



3.6.2 Equilibrium Reactor (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows: Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Hydrogen** and then press the <**Enter**> key; Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Argon** and then press the <**Enter**> key; Highlight the formula **CO** and then press the <**Enter**> key; Highlight the formula **CO2** and then press the <**Enter**> key; Highlight the word **Carbon** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.6.2 Equilibrium Reactor (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	N2O	N2O	N2O	ALL
Hydrogen	N2O4	N2O4	N2O4	HC
H2O	SO2	SO2	SO2	SOLID
Argon	SO3	SO3	SO3	MISC
CO	Sulphur_Rhombic	S_Rhombic	S	AMINE
CO2	Sulphur_Monoclinic	S_Monoclinic	S	ALCOHOL
Carbon	Sulphur_Amorphous	S_Amorphous	S	KETONE
	Sulphur_Liq_150	S_Liq_150	S	ALDEHYDE
	Sulphur_Liq_190	S_Liq_190	S	ESTER
	Sulphur_Liq_280	S_Liq_280	S	CARBACID
	Sulphur_Vapour	S_Vapour	S	HALOGEN
	H2S	H2S	H2S	NITRILE
	CarbonOxiSulphide	COS	COS	PHENOL
	CarbondiSulphide	CS2	CS2	ETHER
	di-M-Sulphide	diM-Sulphide	C2H6S	USER
	di-M-Sulfoxide	diMSulfoxide	C2H6OS	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the type of operation.
6	Highlight the word **Operation** and then press the <**Enter**> key;
7	Type the word **Reactor** after the prompt (>) and then press the <**Enter**> key;
8	Highlight the word **Reactor** and then press the <**Enter**> key;
	The following screen will then appear:

General Reactor

Please fill in reactor type, stream names, etc.

Operation Name: Reactor_____

Reactor Type: Stoichiometric_

Stream:_____ ==> Pressure Drop: _____ kPa___ ==> Stream: _____

Energy Stream: _____
Energy Flow : In_

3.6.2 Equilibrium Reactor (continued)

Step	Action
	Specifying that the reactor type should be Equilibrium.
9	Press the **<F2>** key and highlight the word **Equilibrium** and then press the **<Enter>** key;
	Specifying the stream names.
10	Type the word **Feed** in the blank and then press the **<Enter>** key;
11	Type the word **Outlet** in the blank and then press the **<Enter>** key;
12	Type the word **Energy** in the blank and then press the **<Enter>** key two times;
	Specifying the pressure drop in kPa units.
13	Type the number 75 in the blank.
	The screen should now appear as follows:

```
                    General Reactor
        Please fill in reactor type, stream names, etc.

                  Operation Name: Reactor_____

                  Reactor Type: Equilibrium____

                       Pressure Drop:
Stream: Feed_____ ==>                          ==> Stream: Outlet_
                       75_________ kPa___

                                    ---------> Energy Stream: Energy_
                                               Energy Flow  : In__
```

Step	Action
14	Press the **<Insert>** key;
	The following screen will then appear:

```
        Operation Reactor   Stoichiometric Matrix
 Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit
                Reaction  1
Basis              Activity
Basis Unit           ---
Equil.Const.         ---
EquilConst-A         ---
EquilConst-B         ---
Approach [C]         ---
Methane              ---
Hydrogen             ---
H2O                  ---
Argon                ---
CO                   ---
CO2                  ---
Carbon               ---
```

3.6.2 Equilibrium Reactor (continued)

Step	Action
	Reaction 1 specifications.
	Specifying the basis for the equilibrium constant for Reaction 1.
15	Press the <**F2**> key and then highlight the word **Activity** and then press the <**Enter**> key;
	Specifying the equilibrium constant for Reaction 1.
16	Press the <↓> key two times and then type the number **4.5e+01** and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients for Reaction 1.
17	Press the <↓> key three times and then type the number **-1** and then press the <**Enter**> key;
18	Type the number **3** and then press the <**Enter**> key;
19	Type the number **-1** and then press the <**Enter**> key;
20	Type the number **0** and then press the <**Enter**> key;
21	Type the number **1** and then press the <**Enter**> key;
22	Type the number **0** and then press the <**Enter**> key;
23	Type the number **0** and then press the <**Enter**> key;
24	Press the letter **a**;
	Reaction 2 specifications.
	Specifying the basis for the equilibrium constant for Reaction 2.
25	Press the <↑> enough times until the pointer is at the Basis of Reaction 2 block.
26	Press the <**F2**> and then highlight the word **Activity** and then press the <**Enter**> key;
	Specifying the equilibrium constant for Reaction 2.
27	Press the <↓> two times and then type the number **2.4e+00** and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients for Reaction 2.
28	Press the <↓> key three times and then type the number **0** and then press the <**Enter**> key;
29	Type the number **1** and then press the <**Enter**> key;
30	Type the number **-1** and then press the <**Enter**> key;
31	Type the number **0** and then press the <**Enter**> key;
32	Type the number **-1** and then press the <**Enter**> key;
33	Type the number **1** and then press the <**Enter**> key;
34	Type the number **0** and then press the <**Enter**> key;
35	Press the letter **a**;
	Reaction 3 specifications.
	Specifying the basis for the equilibrium constant for Reaction 3.
36	Press the <↑> key enough times until the pointer is at the Basis of Reaction 3 block.
37	Press the <**F2**> key and then highlight the word **Activity** and then press the <**Enter**> key;
	Specifying the equilibrium constant for Reaction 3.
38	Press the <↓> key two times and then type the number **1.0e-03** and then press the <**Enter**> key;
	Specifying the stoichiometric coefficients for Reaction 3.
39	Press the <↓> key three times and then type the number **-1** and then press the <**Enter**> key;
40	Type the number **2** and then press the <**Enter**> key;
41	Type the number **0** and then press the <**Enter**> key;
42	Type the number **0** and then press the <**Enter**> key;

3.6.2 Equilibrium Reactor (continued)

Step	Action
43	Type the number **0** and then press the <**Enter**> key;
44	Type the number **0** and then press the <**Enter**> key;
45	Type the number **1** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation Reactor Stoichiometric Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

Basis	Reaction 1 Activity	Reaction 2 Activity	Reaction 3 Activity
Basis Unit	---	---	---
Equil.Const.	4.5000e+01	2.4000e+00	1.0000e-03
EquilConst-A	---	---	---
EquilConst-B	---	---	---
Approach [C]	---	---	---
Methane	-1.000	---	-1.000
Hydrogen	3.000	1.000	2.000
H2O	-1.000	-1.000	---
Argon	---	---	---
CO	1.000	-1.000	---
CO2	---	1.000	---
Carbon	---	---	1.000

Step	Action
46	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream.
47	Highlight the word **Specify** and then press the <**Enter**> key;
48	Highlight the word **Stream** and then press the <**Enter**> key;
49	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying the Temperature of the Feed in °C.
50	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
51	Type the number **1500** after the prompt (>) and then press the <**Enter**> key;
	Specifying the Flow in kg-mols/hr.
52	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
53	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Stream Mole Fractions

Methane	_____	Hydrogen	_____
H2O	_____	Argon	_____
CO	_____	CO2	_____
Carbon	_____		

3.6.2 Equilibrium Reactor (continued)

Step	Action
54	*Enter the following mole fractions beside each component in the feed stream:* After the word, Methane, type the number **0.45** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.54** in the blank and then press the <**Enter**> key; After the word, Argon, type the number **0.01** in the blank and then press the <**Enter**> key; After the formula, CO, type the number **0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0** in the blank;
	The screen should now appear as follows:

Stream Mole Fractions

Methane	0.45	Hydrogen	0
H2O	0.54	Argon	0.01
CO	0	CO2	0
Carbon	0		

Step	Action
55	Press the <**Insert**> key;
	Specifying the temperature (°C) and pressure (kPa) of the Outlet stream.
56	Highlight the word **Worksheet** and then press the <**Enter**> key;
57	*Use the arrow keys to move the pointer to the blank space for the Temperature of the Outlet stream* Type the number **600** and then press the <**Enter**> key;
	The following screen will appear:

Streams

	New Value =		C	
Stream	Feed	Outlet	Energy	---
Vapour_Frac	1.0000	1.0000	2.0000*	---
Temperature	600.0000*	600.0000*	0.0000*	---
Pressure	1500.0000*	1425.0000	0.0000*	---
Flow	100.0000*	138.0683	0.0000*	---
Mass_Flow	1734.6940	1734.7084	0.0000*	---
LiqVol_Flow	3.4152	4.6335	0.0000*	---
Energy_Flow	3.45557E+06	4.04095E+06	3.90694E+06	---

Step	Action
58	Press the <**Esc**> key;
59	Highlight the word **Print** and then press the <**Enter**> key;

3.6.2 Equilibrium Reactor (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - the different unit operations will be printed out.

c) *Spec Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - specifies format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
60	Highlight the word **Streams** and then press the **<Enter>** key;
61	Highlight the word **All** and then press the **<Enter>** key;
	Looking at the calculated data for all of the streams.
62	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it. Use the <Page Down> and <Page Up> keys to view the entire text.
63	Press the **<F10>** key;
	The screen will appear as follows:

Stream Description		Feed	Outlet	Energy
Vapour frac.		1.0000	1.0000	2.0000*
Temperature	C	600.0000*	600.0000*	0.0000*
Pressure	kPa	1500.0000*	1425.0000	0.0000*
Molar Flow	kgmole/h	100.0000*	138.0683	0.0000*
Mass Flow	kg/h	1734.6940	1734.7084	0.0000*
LiqVol Flow	m3/h	3.4152	4.6335	0.0000*
Enthalpy	kJ/h	3.45557E+06	4.04095E+06	3.90694E+06
Density	kg/m3	3.5867	2.4603	0.0000
Mole Wt.		17.3469	12.5641	0.0000
Spec. Heat	kJ/kg-C	3.0043	3.2062	---
Therm Cond	W/m-K	0.1040	0.1768	---
Viscosity	cP	0.0267	0.0257	---
Z Factor		0.9993	1.0024	---
Sur Tension	dyne/cm	---	---	---
Std Density	kg/m3	---	---	---
Methane	mole frac.	0.4500*	0.1881	0.0000*
Hydrogen	mole frac.	0.0000*	0.4800	0.0000*
H2O	mole frac.	0.5400*	0.1868	0.0000*
Argon	mole frac.	0.0100*	0.0072	0.0000*
CO	mole frac.	0.0000*	0.0714	0.0000*
CO2	mole frac.	0.0000*	0.0665	0.0000*
Carbon	mole frac.	0.0000*	0.0000	0.0000*

3.6.2 Equilibrium Reactor (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
64	Press the **<F10>** key;
65	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 222.

Step	Action
66	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
67	Highlight the word **Operations** and then press the **<Enter>** key;
68	Highlight the word **Reactor** and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
69	Press the **<F10>** key;
	The screen will appear as shown below and on the following page. Use the <Page Down> and <Page Up> keys to view the entire text.

HYSIM EQUILIBRIUM REACTOR SPECIFICATION — Page 1 of 3

HYSIM Version C2.53 — Date 96/07/12

Case Name: — Time 14:36:34

Operation Name: Reactor

Operation Note:

	Stream		Operation	Flowrate
Inlet:	Feed	from	---	100.0000 kgmole/h
				1734.6940 kg/h
Outlet:	Outlet	to	---	138.0683 kgmole/h
				1734.7084 kg/h
Energy:	Energy	to	---	3.90694E+06 kJ/h

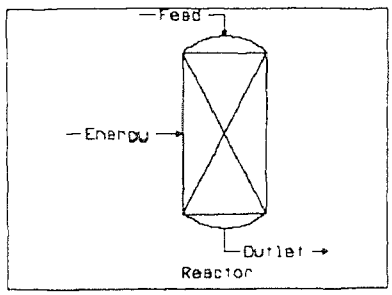
Inlet Properties at Operating Conds		Outlet Properties at Operating Conds	
Vapour Frac	1.0000	Vapour Frac	1.0000
Temperature	600.0000 C	Temperature	600.0000 C
Pressure	1500.0000 kPa	Pressure	1425.0000 kPa
Density	3.5867 kg/m3	Density	2.4603 kg/m3
Std Density	517.5597 kg/m3	Std Density	--- kg/m3
Mol Weight	17.3469	Mol Weight	12.5641
Viscosity	0.0267 cP	Viscosity	0.0257 cP
Therm Cond	0.1040 W/m-K	Therm Cond	0.1768 W/m-K

Component	Hform @ 298 K (kJ/kgmole)	Inlet Flowrate (kgmole/h)	Outlet Flowrate (kgmole/h)
Methane	-74900.0000	45.0000	25.9659
Hydrogen	0.0000	0.0000	66.2785
H2O	-241000.0000	54.0000	25.7898
Argon	0.0000	1.0000	1.0000
CO	-110590.0000	0.0000	9.8581
CO2	-393790.0000	0.0000	9.1761
Carbon	0.0000	0.0000	0.0000

3.6.2 Equilibrium Reactor (continued)

```
= HYSIM EQUILIBRIUM REACTOR SPECIFICATION ========== Page 2 of 3 =

 Case Name:                                          Date 96/07/12
 Operation Name: Reactor                             Time 14:36:34

 Reaction  1     Equil. Const.     EqConst_A  EqConst_B     Temp. Appr.
                 4.500e+01           ---        ---           ---
                 Basis: Activities
 Reactants -1.000 Methane       + -1.000 H2O
 Products  3.000 Hydrogen     + 1.000 CO

 Reaction  2     Equil. Const.     EqConst_A  EqConst_B     Temp. Appr.
                 2.400e+00           ---        ---           ---
                 Basis: Activities
 Reactants -1.000 H2O           + -1.000 CO
 Products  1.000 Hydrogen     + 1.000 CO2

 Reaction  3     Equil. Const.     EqConst_A  EqConst_B     Temp. Appr.
                 1.000e-03           ---        ---           ---
                 Basis: Activities
 Reactants -1.000 Methane
 Products  2.000 Hydrogen     + 1.000 Carbon
```

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
70	Press the **<F10>** key;
71	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
72	Press the **<Esc>** key until you reach the Main Menu;
73	Do you want to continue adding other unit operations to this reactor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.6.3 Gibbs Reactor

Objective- This exercise is an example of a Gibbs reactor calculation. The purpose of the Gibbs reactor unit operation is to compute the output stream given the input stream, reaction conditions and the assumption that the outlet stream is at equilibrium and the Gibbs free energy is therefore at a minimum at equilibrium. The chemical equations used in this example are as follows:

Reaction #1 $CH_4 + H_2O \rightarrow CO + 3H_2$

Reaction #2 $CO + H_2O \rightarrow CO_2 + H_2$

Reaction #3 $CH_4 \rightarrow C(s) + 2H_2$

This example can be modified by specifying another property package and/or other reactions, components, compositions and stream conditions.

In this example, the components in the feed stream are specified, along with the atomic matrix of each component and the overall flow rate. The conditions of the feed and product streams are also specified. HYSIM then calculates the composition of the outlet stream.

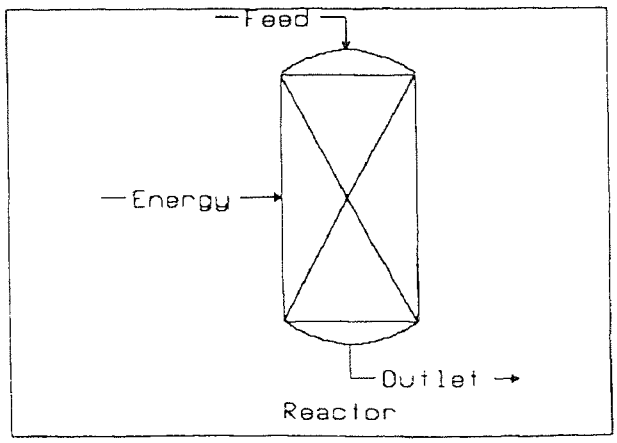
Technical Example Reference: Reference 1- Hyprotech HYSIM User's Guide,Version C2.50, pp.7-66 to 7-78.

Other References: Refs. 1 & 2.

Directions: Pages 226 through 233 outline the execution of a Gibbs type reactor example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions below in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Reactor*, is shown below:



3.6.3 Gibbs Reactor (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Hydrogen** and then press the <**Enter**> key; Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Argon** and then press the <**Enter**> key; Highlight the formula **CO** and then press the <**Enter**> key; Highlight the formula **CO2** and then press the <**Enter**> key; Highlight the word **Carbon** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.6.3 Gibbs Reactor (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	HI	HI	HI	ALL
Hydrogen	NitricOxide	NO	NO	HC
H2O	NO2	NO2	NO2	SOLID
Argon	N2O	N2O	N2O	MISC
CO	N2O4	N2O4	N2O4	AMINE
CO2	SO2	SO2	SO2	ALCOHOL
Carbon	SO3	SO3	SO3	KETONE
	Sulphur_Rhombic	S_Rhombic	S	ALDEHYDE
	Sulphur_Monoclinic	S_Monoclinic	S	ESTER
	Sulphur_Amorphous	S_Amorphous	S	CARBACID
	Sulphur_Liq_150	S_Liq_150	S	HALOGEN
	Sulphur_Liq_190	S_Liq_190	S	NITRILE
	Sulphur_Liq_280	S_Liq_280	S	PHENOL
	Sulphur_Vapour	S_Vapour	S	ETHER
	H2S	H2S	H2S	USER
	CarbonOxiSulphide	COS	COS	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the type of operation.
6	Highlight the word **Operation** and then press the <**Enter**> key;
7	Type the word **Reactor** after the prompt (>) and then press the <**Enter**> key;
8	Highlight the word **Reactor** and then press the <**Enter**> key;
	The following screen will then appear:

General Reactor

Please fill in reactor type, stream names, etc.

Operation Name: Reactor_____

Reactor Type: Stoichiometric_

Stream: _____ ==▸ Pressure Drop: _____ kPa___ ==▸ Stream: __

▸ Energy Stream: __
Energy Flow : In

Step	Action
	Specifying that the reactor type should be Gibbs.
9	Press the <**F2**> key and highlight the word **Gibbs_Reactor** and then press the <**Enter**> key;

3.6.3 Gibbs Reactor (continued)

Step	Action
	Specifying the stream names.
10	Type the word **Feed** in the blank and then press the <**Enter**> key;
11	Type the word **Outlet** in the blank and then press the <**Enter**> key;
12	Type the word **Energy** in the blank and then press the <**Enter**> key two times;
	Specifying the pressure in kilopascals (kPa) units.
13	Type the number 75 in the blank.
	The screen should now appear as follows:

```
                    General Reactor
        Please fill in reactor type, stream names, etc.

                Operation Name: Reactor_____

                Reactor Type: Gibbs_Reactor__

                      Pressure Drop:
Stream: Feed_____ ==>|                    |==> Stream: Outlet
                     |  75_______ kPa___  |
                     |____________________|
                                  |
                                  |--------> Energy Stream: Energy
                                             Energy Flow  : In__
```

Step	Action
14	Press the <**Insert**> key;
	The following screen will then appear:

```
          Operation Reactor   Gibbs Atomic Matrix
    Enter I to make component Inert,  Ins to Exit,
                        C            H            O            Ar  →
Methane              1.0000       4.0000       ---          ---
Hydrogen             ---          2.0000       ---          ---
H2O                  ---          2.0000        1.0000      ---
Argon                ---          ---          ---           1.0000
CO                    1.0000      ---           1.0000      ---
CO2                   1.0000      ---           2.0000      ---      →
Carbon                1.0000      ---          ---          ---
```

Step	Action
	Specifying the Product Flow Rate of Methane in kgmoles/hr. (You must move the screen to the right by using the right arrow (→) key, to display the Prod. Flow column because the entire spreadsheet could not fit on the screen).
15	Press the <→> key until the pointer is at the blank space for the Prod. Flow of Methane and then type the number **10** and press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.6.3 Gibbs Reactor (continued)

Operation Reactor Gibbs Atomic Matrix

Enter I to make component Inert, Ins to Exit,

	H	O	Ar	Prod Flow
Methane	4.0000	---	---	10.0000
Hydrogen	2.0000	---	---	---
H2O	2.0000	1.0000	---	---
Argon	---	---	1.0000	---
CO	---	1.0000	---	---
CO2	---	2.0000	---	---
Carbon	---	---	---	---

Step	Action
16	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream.
17	Highlight the word **Specify** and then press the <**Enter**> key;
18	Highlight the word **Stream** and then press the <**Enter**> key;
19	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying the Temperature of the Feed in °C.
20	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
21	Type the number **1500** after the prompt (>) and then press the <**Enter**> key;
	Specifying the Flow in kg-mols/hr.
22	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions in the Feed stream.
23	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The following screen will then appear:

Stream Mole Fractions

Methane _____ Hydrogen _____

H2O _____ Argon _____

CO _____ CO2 _____

Carbon _____

Step	Action
24	*Enter the following mole fractions beside each component in the feed stream:* After the word, Methane, type the number **0.45** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.54** in the blank and then press the <**Enter**> key; After the word, Argon, type the number **0.01** in the blank and then press the <**Enter**> key; After the formula, CO, type the number **0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0** in the blank;
	The screen should now appear as shown on the following page.

3.6.3 Gibbs Reactor (continued)

Stream Mole Fractions

Methane	0.45	Hydrogen	0
H2O	0.54	Argon	0.01
CO	0	CO2	0
Carbon	0		

Step	Action
25	Press the <**Insert**> key;
	Specifying the temperature (°C) and pressure (kPa) of the Outlet stream.
26	Highlight the word **Worksheet** and then press the <**Enter**> key;
27	*Use the arrow keys to move the pointer to the blank space for the Temperature of the Outlet stream.* Type the number **600** and then press the <**Enter**> key;
	The following screen will appear:

Streams

Stream	New Value = Feed	Outlet	C Energy	---
Vapour_Frac	1.0000	1.0000	2.0000*	---
Temperature	600.0000*	600.0000*	0.0000*	---
Pressure	1500.0000*	1425.0000	0.0000*	---
Flow	100.0000*	170.0000	0.0000*	---
Mass_Flow	1734.6940	1734.7233	0.0000*	---
LiqVol_Flow	3.4152	5.3763	0.0000*	---
Energy_Flow	3.45557E+06	4.49503E+06	7.53958E+06	---

Step	Action
28	Press the <**Esc**> key;
29	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - the different unit operations will be printed out.

c) *Spec_Sheets* - the specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

3.6.3 Gibbs Reactor (continued)

Step	Action
30	Highlight the word **Streams** and then press the **<Enter>** key;
31	Highlight the word **All** and then press the **<Enter>** key;
	Looking at the calculated data for all of the streams.
32	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
33	Press the **<F10>** key;
	The screen will appear as follows. Press the <Page Up> and <Page Down> keys to view the entire text.

Stream Description		Feed	Outlet	Energy
Vapour frac.		1.0000	1.0000	2.0000*
Temperature	C	600.0000*	600.0000*	0.0000*
Pressure	kPa	1500.0000*	1425.0000	0.0000*
Molar Flow	kgmole/h	100.0000*	170.0000	0.0000*
Mass Flow	kg/h	1734.6940	1734.7233	0.0000*
LiqVol Flow	m3/h	3.4152	5.3763	0.0000*
Enthalpy	kJ/h	3.45557E+06	4.49503E+06	7.53958E+06
Density	kg/m3	3.5867	1.9971	0.0000
Mole Wt.		17.3469	10.2043	0.0000
Spec. Heat	kJ/kg-C	3.0043	3.3279	---
Therm Cond	W/m-K	0.1040	0.2132	---
Viscosity	cP	0.0267	0.0267	---
Z Factor		0.9993	1.0030	---
Sur Tension	dyne/cm	---	---	---
Std Density	kg/m3	---	---	---
Methane	mole frac.	0.4500*	0.0588	0.0000*
Hydrogen	mole frac.	0.0000*	0.6605	0.0000*
H2O	mole frac.	0.5400*	0.0689	0.0000*
Argon	mole frac.	0.0100*	0.0059	0.0000*
CO	mole frac.	0.0000*	0.1630	0.0000*
CO2	mole frac.	0.0000*	0.0428	0.0000*
Carbon	mole frac.	0.0000*	0.0000	0.0000*

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
34	Press the **<F10>** key;
35	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 230.

3.6.3 Gibbs Reactor (continued)

Step	Action
36	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
37	Highlight the word **Operations** and then press the **<Enter>** key;
38	Highlight the word **Reactor** and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
39	Press the **<F10>** key;
	The screen will appear as shown below. Press the <Page Up> and <Page Down> keys to view the entire text.

HYSIM GIBBS REACTOR SPECIFICATION

HYSIM Version C2.53 Date 96/07/15
Case Name: Time 10:07:37

Operation Name: Reactor
Operation Note:

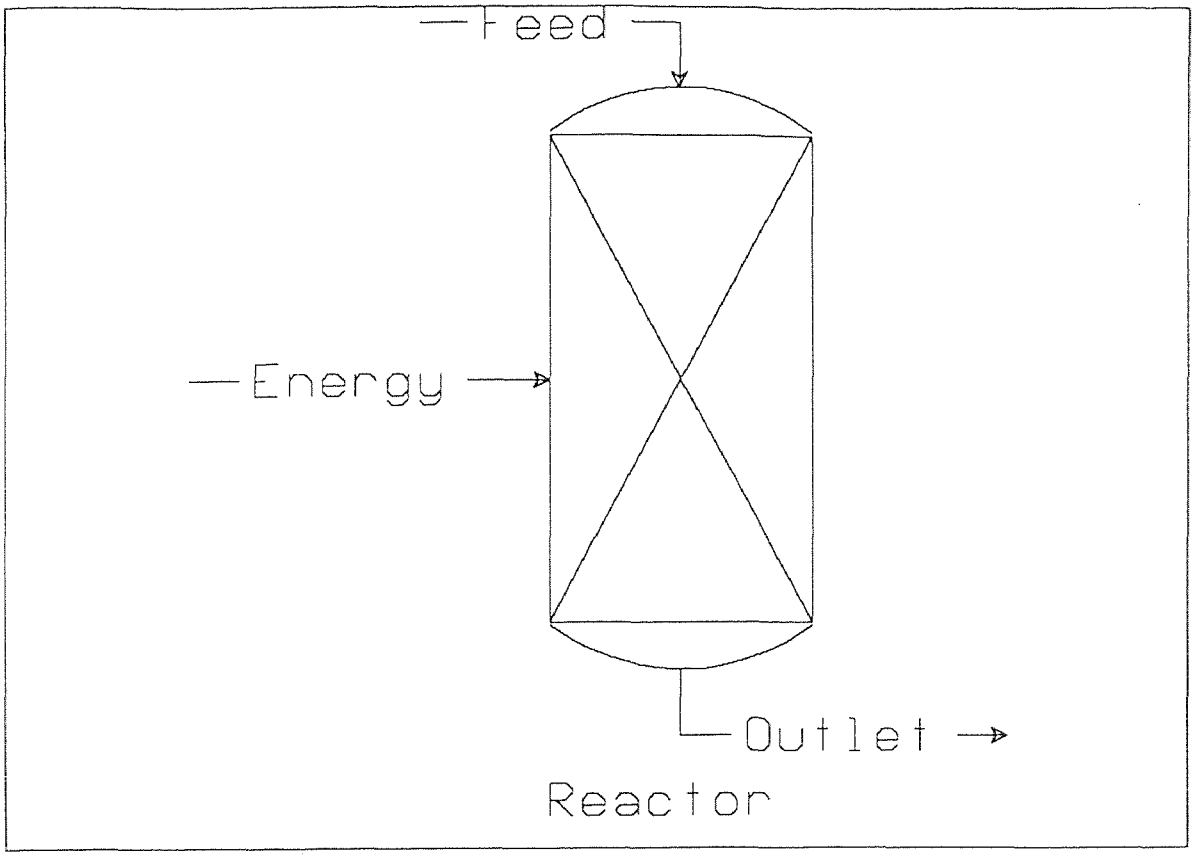
Stream		Operation	Flowrate
Inlet: Feed	from	---	100.0000 kgmole/h
			1734.6940 kg/h
Outlet: Outlet	to	---	170.0000 kgmole/h
			1734.7233 kg/h
Energy: Energy	to	---	7.53958E+06 kJ/h

Inlet Properties at Operating Conds		Outlet Properties at Operating Conds	
Vapour Frac	1.0000	Vapour Frac	1.0000
Temperature	600.0000 C	Temperature	600.0000 C
Pressure	1500.0000 kPa	Pressure	1425.0000 kPa
Density	3.5867 kg/m3	Density	1.9971 kg/m3
Std Density	517.5597 kg/m3	Std Density	--- kg/m3
Mol Weight	17.3469	Mol Weight	10.2043
Viscosity	0.0267 cP	Viscosity	0.0267 cP
Therm Cond	0.1040 W/m-K	Therm Cond	0.2132 W/m-K

Component	Hform @ 298 K (kJ/kgmole)	Inlet Flowrate (kgmole/h)	Outlet Flowrate (kgmole/h)
Methane	-74900.0000	45.0000	10.0000
Hydrogen	0.0000	0.0000	112.2819
H2O	-241000.0000	54.0000	11.7181
Argon	0.0000	1.0000	1.0000
CO	-110590.0000	0.0000	27.7181
CO2	-393790.0000	0.0000	7.2819
Carbon	0.0000	0.0000	0.0000
---	---	---	---

3.6.3 Gibbs Reactor (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
40	Press the **<F10>** key;
41	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
42	Press the **<Esc>** key until you reach the Main Menu;
43	Do you want to continue adding other unit operations to this reactor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.6.4 Continuously Stirred Tank Reactor (CSTR)

Objective- This exercise is an example of a Continuous Stirred-Tank Reactor (CSTR) calculation. The purpose of the CSTR unit operation is to compute the output stream given the input stream, reaction stoichiometry, reactor volume or space-time, and rate constant (k) or Arrhenius' law parameters: frequency factor (k_0) and activation energy (E) information. The Arrhenius' law is:

$k = k_0 e^{-E/RT}$, where R = the universal gas constant, and T = the absolute temperature.

The chemical equations used in this example are as follows:

Reaction #1 $CH_4 + H_2O \rightarrow CO + 3H_2$

Reaction #2 $CO + H_2O \rightarrow CO_2 + H_2$

Reaction #3 $CH_4 \rightarrow C(s) + 2H_2$

This example can be modified by specifying another property package and/or other reactions, components, compositions and stream conditions.

In this example, the reactor volume and dead space are specified. The stoichiometric matrix of the three different chemical reaction equations is also given to the HYSIM program, along with either the rate constants or the frequency factor and activation energy data for each chemical reaction. The conditions, molar flow rate, and composition of the feed, as well as the conditions of the outlet stream are also specified. With all of this data, HYSIM will then calculate the composition of the outlet stream.

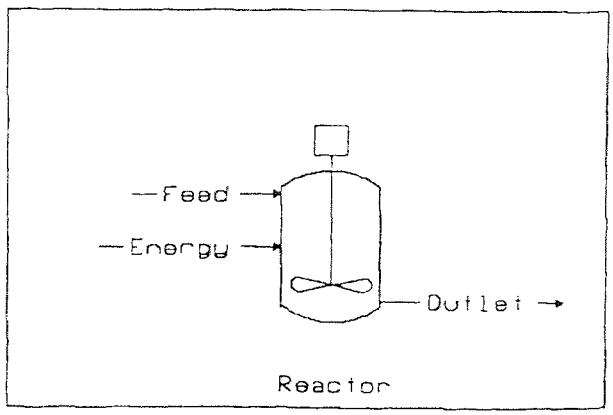
Technical Example Reference: Reference 1 - HYSIM User's Guide,Version C2.50, pp.7-66 to 7-83.

Other References: Refs. 1 & 2.

Directions: Pages 235 through 247 outline the execution of a Continuously Stirred Tank Reactor (CSTR) example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Reactor*, is shown below:



3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Hydrogen** and then press the <**Enter**> key; Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Argon** and then press the <**Enter**> key; Highlight the formula **CO** and then press the <**Enter**> key; Highlight the formula **CO2** and then press the <**Enter**> key; Highlight the word **Carbon** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	HI	HI	HI	ALL
Hydrogen	NitricOxide	NO	NO	HC
H2O	NO2	NO2	NO2	SOLID
Argon	N2O	N2O	N2O	MISC
CO	N2O4	N2O4	N2O4	AMINE
CO2	SO2	SO2	SO2	ALCOHOL
Carbon	SO3	SO3	SO3	KETONE
	Sulphur_Rhombic	S_Rhombic	S	ALDEHYDE
	Sulphur_Monoclinic	S_Monoclinic	S	ESTER
	Sulphur_Amorphous	S_Amorphous	S	CARBACID
	Sulphur_Liq_150	S_Liq_150	S	HALOGEN
	Sulphur_Liq_190	S_Liq_190	S	NITRILE
	Sulphur_Liq_280	S_Liq_280	S	PHENOL
	Sulphur_Vapour	S_Vapour	S	ETHER
	H2S	H2S	H2S	USER
	CarbonOxiSulphide	COS	COS	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default metric units (kg, kPa, °C,etc.) to field units (lb,psia, °F,etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and press the <**Enter**> key and then press the <**Esc**> key;
	Specifying the type of operation.
10	Highlight the word **Operation** and then press the <**Enter**> key;
11	Type the word **Reactor** after the prompt (>) and then press the <**Enter**> key;
12	Highlight the word **Reactor** and then press the <**Enter**> key;
	The following screen will then appear:

General Reactor

Please fill in reactor type, stream names, etc.

Operation Name: Reactor_____

Reactor Type: Stoichiometric_

Stream: _____ ⟹ Pressure Drop: _____ psi___ ⟹ Stream: __

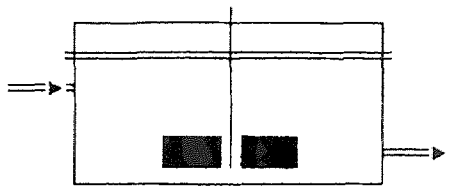
Energy Stream: __
Energy Flow : In

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Specifying that the reactor type should be a CSTR.
13	Press the <**F2**> key and highlight the word **CSTReactor** and then press the <**Enter**> key;
	Specifying the stream names.
14	Type the word **Feed** in the blank and then press the <**Enter**> key;
15	Type the word **Outlet** in the blank and then press the <**Enter**> key;
16	Type the word **Energy** in the blank and then press the <**Enter**> key two times;
	Specifying the pressure drop across the CSTR in psi.
17	Type the number **10.9**.
	The screen should now appear as follows:

```
                    General Reactor
        Please fill in reactor type, stream names, etc.

                Operation Name: Reactor_____

                Reactor Type: CSTReactor_____

                      Pressure Drop:
Stream: Feed____ ==>                          ==> Stream: Outlet_
                      10.9_____ psi___
                                  |
                                  |-------> Energy Stream: Energy_
                                            Energy Flow  : In__
```

Step	Action
18	Press the <**Insert**> key;
	The following screen will then appear:

```
            Continuous Stirred Tank Reactor

            Operation Name: Reactor_____

                    

                  Specify only ONE of
                Volume/Space-Time (*)

                  Volume: _____ ft3      *
              Space-Time: _____ seconds  *
              Dead Space: 0.0_____
                 LiqVolFrac: _____
          Initialize from
                  Stream: _____
```

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Specifying the reactor volume in cubic feet (ft^3).
19	Type the number 17697.6 and then press the <Insert> key;
	The following screen will then appear:

```
═══ Operation Reactor  Stoichiometric Matrix ═══
 Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit
              Reaction  1
Phase              Overall
Methane            ---
Hydrogen           ---
H2O                ---
Argon              ---
CO                 ---
CO2                ---
Carbon             ---
```

Step	Action
	Specifying the stoichiometric coefficients for each of the seven chemical reactants (negative integer) and products (positive integer) of each of the three reactions on page 234
	Reaction 1 stoichiometric coefficients.
20	Press the <↓> key one time and then type the number -1 and then press the <Enter> key;
21	Type the number 3 and then press the <Enter> key;
22	Type the number -1 and then press the <Enter> key;
23	Type the number 0 and then press the <Enter> key;
24	Type the number 1 and then press the <Enter> key;
25	Type the number 0 and then press the <Enter> key;
26	Type the number 0 and then press the <Enter> key;
	Pressing an "a" to add another column to the table.
27	Press the letter a;
	Reaction 2 stoichiometric coefficients.
28	Press the <↑> key enough times until the pointer is at the blank space for the component Methane of Reaction 2.
29	Type the number 0 and then press the <Enter> key;
30	Type the number 1 and then press the <Enter> key;
31	Type the number -1 and then press the <Enter> key;
32	Type the number 0 and then press the <Enter> key;
33	Type the number -1 and then press the <Enter> key;
34	Type the number 1 and then press the <Enter> key;
35	Type the number 0 and then press the <Enter> key;
36	Press the letter a;

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Reaction 3 stoichiometric coefficients.
37	Press the <↑> key enough times until the pointer is at the blank space for the component Methane of Reaction 3.
38	Type the number **-1** and then press the **<Enter>** key;
39	Type the number **2** and then press the **<Enter>** key;
40	Type the number **0** and then press the **<Enter>** key;
41	Type the number **0** and then press the **<Enter>** key;
42	Type the number **0** and then press the **<Enter>** key;
43	Type the number **0** and then press the **<Enter>** key;
44	Type the number **1** and then press the **<Enter>** key;
	The screen will then appear as shown below:

Operation Reactor Stoichiometric Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

	Reaction 1	Reaction 2	Reaction 3
Phase	Overall	Overall	Overall
Methane	-1.000	---	-1.000
Hydrogen	3.000	1.000	2.000
H2O	-1.000	-1.000	---
Argon	---	---	---
CO	1.000	-1.000	---
CO2	---	1.000	---
Carbon	---	---	1.000

Step	Action
45	Press the **<Insert>** key;
	Reaction 1 specifications.
	Specifying the rate constant for reaction 1.
46	Type the number **7.2e+02** and then press the **<Enter>** key ;
	Specifying the units of the rate constant for reaction 1 as lb-mols/cubic foot-hour.
47	Press the <↓> key two times and then press the **<F2>** key; and then highlight the **lbmole/ft3-hr** unit and then press the **<Enter>** key;
	Specifying the base component (reaction rate basis) for reaction 1 as Methane.
48	Press the <↓> key one time and then press the **<F2>** key; and highlight the word **Methane** and then press the **<Enter>** key;
	Specifying that the units of the basis (molar concentration is used in calculating the rate) are expressed in lb-mols/cubic foot.
49	Press the <↓> key two times and then press the **<F2>** key; and then highlight the **lbmole/ft3** unit and then press the **<Enter>** key;

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Specifying the order of the reaction. The two reactants in reaction 1 are Methane and H2O, and their coefficients are 1, so they have an order of one. The rest of the components have a zero order.
50	Press the <↓> key one time and then type the number **1** and press the <**Enter**> key;
51	Type the number **0** and then press the <**Enter**> key;
52	Type the number **1** and then press the <**Enter**> key;
53	Type the number **0** and then press the <**Enter**> key;
54	Type the number **0** and then press the <**Enter**> key;
55	Type the number **0** and then press the <**Enter**> key;
56	Type the number **0** and then press the <**Enter**> key;
57	Press the <→> key once until the cursor is in the reaction 2 column;
	Reaction 2 specifications.
	Specifying the frequency factor for reaction 2.
58	Press the <↑> key enough times until the pointer is at the blank space for the Freq. Factor of reaction 2.
59	Type the number **4.7e+03** and then press the <**Enter**> key;
	Specifying the Activation Energy for Reaction 2.
60	Type the number **7.8e+04** and then press the <**Enter**> key;
	Specifying the rate constant units in lb-mols/cubic foot-hour.
61	Press the <**F2**> key; and then highlight the **lbmole/ft3-hr** unit and then press the <**Enter**> key;
	Specifying the base component (reaction rate basis) for reaction 2 as Carbon Monoxide (CO).
62	Press the <↓> key one time and then press the <**F2**> key; and highlight the formula **CO** and then press the <**Enter**> key;
	Specifying that the units of the basis (molar concentration is used in calculating the rate) are expressed in lb-mols/cubic foot.
63	Press the <↓> two times and then press the <**F2**> key; and then highlight the **lbmole/ft3** unit and then press the <**Enter**> key;
	Specifying the order of the reaction. The two reactants in reaction 2 are H2O and CO, and their coefficients are 1, so they have an order of one. The rest of the components have a zero order.
64	Press the <↓> key one time and then type the number **0** and press the <**Enter**> key;
65	Type the number **0** and then press the <**Enter**> key;
66	Type the number **1** and then press the <**Enter**> key;
67	Type the number **0** and then press the <**Enter**> key;
68	Type the number **1** and then press the <**Enter**> key;
69	Type the number **0** and then press the <**Enter**> key;
70	Type the number **0** and then press the <**Enter**> key;
71	Press the <→> key one time until the cursor is in the column for Reaction 3;

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Reaction 3 specifications.
	Specifying the rate constant for reaction 3.
72	Press the <↑> key enough times until the pointer is at the blank space for the rate constant of Reaction 3.
73	Type the number **1.6e+00** and then press the <**Enter**> key;
	Specifying the rate constant units in lb-mols/cubic foot-hour.
74	Press the <↓> key two times and press the <**F2**> key; and then highlight the **lbmole/ft3-hr** unit and press the <**Enter**> key;
	Specifying the base component (reaction rate basis) for reaction 3 as Methane.
75	Press the <↓> key one time and then press the <**F2**> key; and highlight the word **Methane** and then press the <**Enter**> key;
	Specifying that the units of the basis (molar concentration is used in calculating the rate) are expressed in lb-mols/cubic foot.
76	Press the <↓> key two times and then press the <**F2**> key; and then highlight the **lbmole/ft3** unit and then press the <**Enter**> key;
	Specifying the order of the reaction. The only reactant in reaction 3 is Methane, and the coefficient is 1, so it has an order of one. The rest of the components have a zero order.
77	Press the <↓> key one time and then type the number 1 and press the <**Enter**> key;
78	Type the number **0** and then press the <**Enter**> key;
79	Type the number **0** and then press the <**Enter**> key;
80	Type the number **0** and then press the <**Enter**> key;
81	Type the number **0** and then press the <**Enter**> key;
82	Type the number **0** and then press the <**Enter**> key;
83	Type the number **0** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation Reactor Rate Constant/Order Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

	Reaction 1	Reaction 2	Reaction 3
Rate Const.	7.2000e+02	---	1.6000e+00
Freq. Factor	---	4.7000e+03	---
Actv. Energy	---	7.8000e+04	---
Rate Unit	lbmole/ft3-h	lbmole/ft3-h	lbmole/ft3-h
Base Comp.	Methane	CO	Methane
Basis	MolarConc	MolarConc	MolarConc
Basis Unit	lbmole/ft3	lbmole/ft3	lbmole/ft3
Methane	1.000	---	1.000
Hydrogen	---	---	---
H2O	1.000	1.000	---
Argon	---	---	---
CO	---	1.000	---
CO2	---	---	---
Carbon	---	---	---

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
84	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream.
85	Highlight the word **Specify** and then press the <**Enter**> key;
86	Highlight the word **Stream** and then press the <**Enter**> key;
87	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying the Temperature of the Feed in °F.
88	Type the number **1112** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
89	Type the number **218.3** after the prompt (>) and then press the <**Enter**> key;
	Specifying the Flow in lb-mols/hr.
90	Type the number **220** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions in the feed stream.
91	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The following screen will then appear:

```
                    Stream Mole Fractions

Methane  _____________________     Hydrogen  _____________________
H2O      _____________________     Argon     _____________________
CO       _____________________     CO2       _____________________
Carbon   _____________________
```

Step	Action
92	*Enter the following mole fractions beside each component in the feed stream:* After the word, Methane, type the number **0.45** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.54** in the blank and then press the <**Enter**> key; After the word, Argon, type the number **0.01** in the blank and then press the <**Enter**> key; After the formula, CO, type the number **0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0** in the blank;
	The screen should now appear as follows:

```
                    Stream Mole Fractions

Methane  0.45_____________     Hydrogen  0_____________________
H2O      0.54_____________     Argon     0.01__________________
CO       0_____________________ CO2       0_____________________
Carbon   0_____________________
```

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
93	Press the <**Insert**> key;
	Specifying the temperature (°F) of the Outlet stream.
94	Highlight the word **Worksheet** and then press the <**Enter**> key;
95	*Use the arrow keys to move the pointer to the blank space for the Temperature of the Outlet stream.* Type the number **1112** and then press the <**Enter**> key;
	The following screen will appear:

Streams

	New Value =		F	
Stream	Feed	Outlet	Energy	---
Vapour_Frac	1.0000	0.9160	2.0000*	---
Temperature	1112.0000*	1112.0000*	0.0000*	---
Pressure	218.3000*	207.4000	0.0000*	---
Flow	220.0000*	360.4430	0.0000*	---
Mass_Flow	3816.3265	3816.3596	0.0000*	---
LiqVol_Flow	514.4725	674.8822	0.0000*	---
Energy_Flow	3.26838E+06	4.01913E+06	4.98404E+06	---

Step	Action
96	Press the <**Esc**> key;
97	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
98	Highlight the word **Streams** and then press the <**Enter**> key;
99	Highlight the word **All** and then press the <**Enter**> key;
	Looking at the calculated data for all of the streams.
100	Highlight the dash symbol - and then press the <**Enter**> key;

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
101	Press the **<F10>** key;
	The screen will appear as follows. Use the <Page Up> and <Page Down> keys to view the entire text.

Stream Description		Feed	Outlet	Energy
Vapour frac.		1.0000	0.9160	2.0000*
Temperature	F	1112.0000*	1112.0000*	0.0000*
Pressure	psia	218.3000*	207.4000	0.0000*
Molar Flow	lbmole/hr	220.0000*	360.4430	0.0000*
Mass Flow	lb/hr	3816.3265	3816.3596	0.0000*
LiqVol Flow	barrel/day	514.4725	674.8822	0.0000*
Enthalpy	Btu/hr	3.26838E+06	4.01913E+06	4.98404E+06
Density	lb/ft3	0.2247	0.1418	0.0000
Mole Wt.		17.3469	10.5880	0.0000
Spec. Heat	Btu/lb-F	0.7176	0.7755	---
Therm Cond	Btu/hr-ft-F	0.0601	---	---
Viscosity	cP	0.0267	---	---
Z Factor		0.9993	---	---
Sur Tension	dyne/cm	---	---	---
Std Density	lb/ft3	---	---	---
Methane	mole frac.	0.4500*	0.0798	0.0000*
Hydrogen	mole frac.	0.0000*	0.5004	0.0000*
H2O	mole frac.	0.5400*	0.2188	0.0000*
Argon	mole frac.	0.0100*	0.0061	0.0000*
CO	mole frac.	0.0000*	0.1108	0.0000*
CO2	mole frac.	0.0000*	0.0000	0.0000*
Carbon	mole frac.	0.0000*	0.0840	0.0000*

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
102	Press the **<F10>** key;
103	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 243.

Step	Action
104	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
105	Highlight the word **Operations** and then press the **<Enter>** key;
106	Highlight the word **Reactor** and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
107	Press the **<F10>** key;
	The screen will appear as shown on the following two pages. Use the <Page Up> and <Page Down> keys to view the entire text.

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

HYSIM STIRRED TANK REACTOR SPECIFICATION — Page 1 of 3

HYSIM Version C2.53 — Date 96/10/21

Case Name: — Time 9:22:16

Operation Name: Reactor

Operation Note:

	Stream		Operation	Flowrate
Inlet:	Feed	from	---	220.0000 lbmole/hr
				3816.3265 lb/hr
Outlet:	Outlet	to	---	360.4430 lbmole/hr
				3816.3596 lb/hr
Energy:	Energy	to	---	4.98404E+06 Btu/hr

Inlet Properties at Operating Conds		Outlet Properties at Operating Conds	
Vapour Frac	1.0000	Vapour Frac	0.9160
Temperature	1112.0000 F	Temperature	1112.0000 F
Pressure	218.3000 psia	Pressure	207.4000 psia
Density	0.2247 lb/ft3	Density	0.1418 lb/ft3
Std Density	32.2511 lb/ft3	Std Density	--- lb/ft3
Mol Weight	17.3469	Mol Weight	10.5880
viscosity	0.0267 cP	viscosity	--- cP
therm cond	0.0601 Btu/hr-ft-F	therm cond	--- Btu/hr-ft-F

Component	Hform @ 298 K (Btu/lbmole)	Inlet Flowrate (lbmole/hr)	Outlet Flowrate (lbmole/hr)
Methane	-32201.2027	99.0000	28.7785
Hydrogen	0.0000	0.0000	180.3811
H2O	-103611.3466	118.8000	78.8619
Argon	0.0000	2.2000	2.2000
CO	-47545.1403	0.0000	39.9381
CO2	-169299.2207	0.0000	0.0000
Carbon	0.0000	0.0000	30.2834
---	---	---	---
---	---	---	---
---	---	---	---
---	---	---	---
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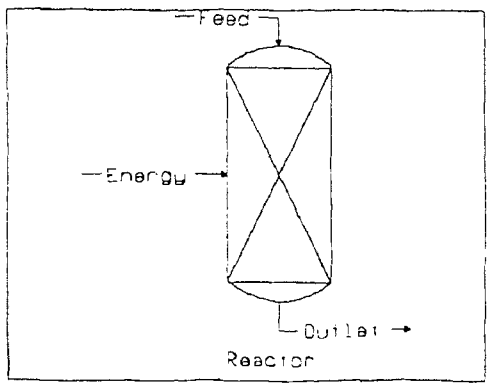
---	---	---	---
---	---	---	---
---	---	---	---

3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

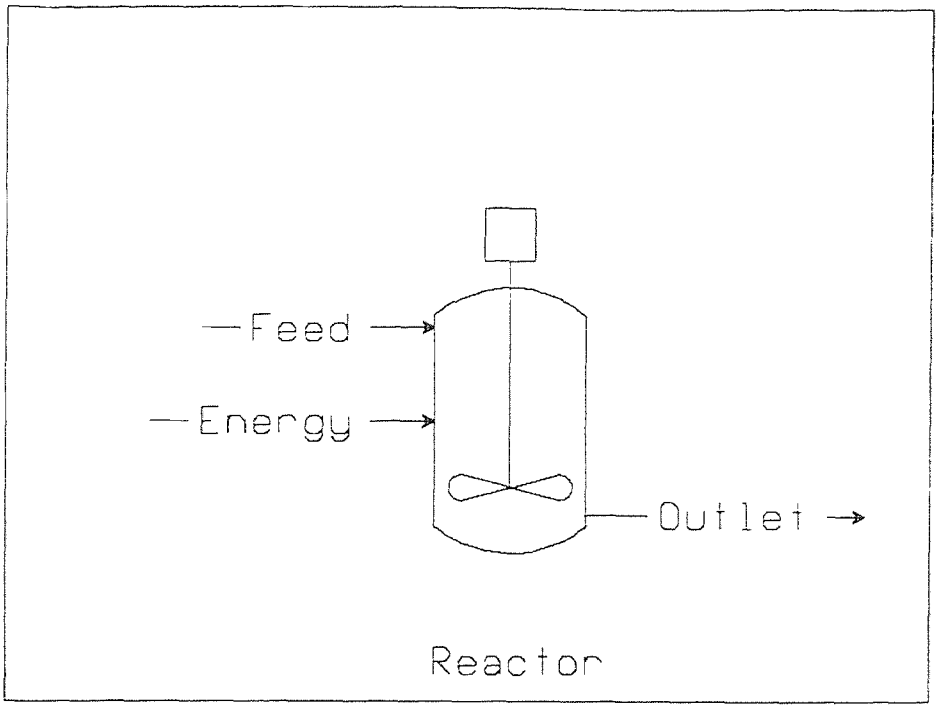
```
HYSIM STIRRED TANK REACTOR SPECIFICATION                    Page 2 of 3
Case Name:                                                  Date 96/10/21
Operation Name: Reactor                                     Time  9:22:16

Dimensions

    Volume    17697.5996 ft3
Space-Time       ---        seconds     Dead-Space Frac        0.0000

Reaction  1      Rate Const.     Pre-Expon. Factor     Activ. Energy
                 7.200e+02             ---                  ---
                 Rxn Phase: Overall          Base Comp.: Methane
Basis      MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders     Methane      1.000 H2O          1.000
Reactants  -1.000 Methane       + -1.000 H2O
Products   3.000 Hydrogen      + 1.000 CO

Reaction  2      Rate Const.     Pre-Expon. Factor     Activ. Energy
                     ---           4.700e+03           1.814e+05
                 Rxn Phase: Overall          Base Comp.: CO
Basis      MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders     H2O          1.000 CO           1.000
Reactants  -1.000 H2O           + -1.000 CO
Products   1.000 Hydrogen      + 1.000 CO2

Reaction  3      Rate Const.     Pre-Expon. Factor     Activ. Energy
                 1.600e+00             ---                  ---
                 Rxn Phase: Overall          Base Comp.: Methane
Basis      MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders     Methane      1.000
Reactants  -1.000 Methane
Products   2.000 Hydrogen      + 1.000 Carbon
```

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
108	Press the **<F10>** key;
109	Highlight the letters **PFD** and then press the **<Enter>** key;
	The following screen will appear:



3.6.4 Continuously Stirred Tank Reactor (CSTR) (continued)

Step	Action
	Specifying a different type of reactor icon on the PFD.
110	Move the mouse until the cross-hatches on the screen are over the reactor and then press the **left mouse key**. (A box will appear around the reactor).
111	Press the <**I**> key;
112	Place the crosshatch (using the mouse) over the second icon (first row, second column) which represents a continuously stirred tank reactor (CSTR) and press the **left mouse key**.
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
113	Press the <**Esc**> key until you reach the Main Menu;
114	Do you want to continue adding other unit operations to this reactor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.6.5 Plug Flow Reactor (PFR)

Objective- This exercise is an example of a Plug Flow Reactor (PFR) calculation. The purpose of the PFR unit operation is to compute the output stream given the input stream, reaction stoichiometry, reactor length and diameter (space time may be substituted for one of these two variables). The rate constant (k) or Arrhenius' law parameters, frequency factor (k_0) and activation energy (E), are also required. The Arrhenius' law is : $k = k_0 e^{-E/RT}$, where R = the universal gas constant and T = the absolute temperature. The chemical equations used in this example are as follows:

Reaction #1 $CH_4 + H_2O \rightarrow CO + 3H_2$

Reaction #2 $CO + H_2O \rightarrow CO_2 + H_2$

Reaction #3 $CH_4 \rightarrow C(s) + 2H_2$

This example can be modified by specifying another property package and/or other reactions, components, compositions and stream conditions.

In this example, the reactor diameter and length are specified, along with the stoichiometric matrix of the three chemical reaction equations taking place inside the reactor. The reaction rate constant or the frequency factor/Activation energy are also specified for each reaction. The composition and molar flow of the feed is also given, along with the conditions of the feed and outlet streams. HYSIM then calculates the composition of the outlet stream.

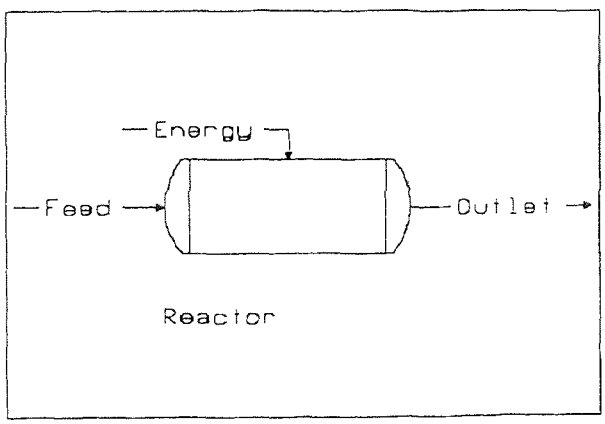
Technical Example Reference: Reference 1 - Hyprotech HYSIM User's Guide,Version C2.50, pp.7-66 to 7-89.

Other References: Refs. 1 & 2.

Directions: Pages 249 through 261 outline the execution of a Plug Flow Reactor (PFR) example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Reactor*, is shown below:



3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	Highlight each of the following component names under the "Component Selection" Section (use the arrow or Page Up/Down keys) and press the <Enter> key so that the name then appears in the "selected" column, as follows: Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Hydrogen** and then press the <**Enter**> key; Highlight the formula **H2O** and then press the <**Enter**> key; Highlight the word **Argon** and then press the <**Enter**> key; Highlight the formula **CO** and then press the <**Enter**> key; Highlight the formula **CO2** and then press the <**Enter**> key; Highlight the word **Carbon** and then press the <**Enter**> key;
	The screen shown on the following page will then appear.

3.6.5 Plug Flow Reactor (PFR) (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	HI	HI	HI	ALL
Hydrogen	NitricOxide	NO	NO	HC
H2O	NO2	NO2	NO2	SOLID
Argon	N2O	N2O	N2O	MISC
CO	N2O4	N2O4	N2O4	AMINE
CO2	SO2	SO2	SO2	ALCOHOL
Carbon	SO3	SO3	SO3	KETONE
	Sulphur_Rhombic	S_Rhombic	S	ALDEHYDE
	Sulphur_Monoclinic	S_Monoclinic	S	ESTER
	Sulphur_Amorphous	S_Amorphous	S	CARBACID
	Sulphur_Liq_150	S_Liq_150	S	HALOGEN
	Sulphur_Liq_190	S_Liq_190	S	NITRILE
	Sulphur_Liq_280	S_Liq_280	S	PHENOL
	Sulphur_Vapour	S_Vapour	S	ETHER
	H2S	H2S	H2S	USER
	CarbonOxiSulphide	COS	COS	

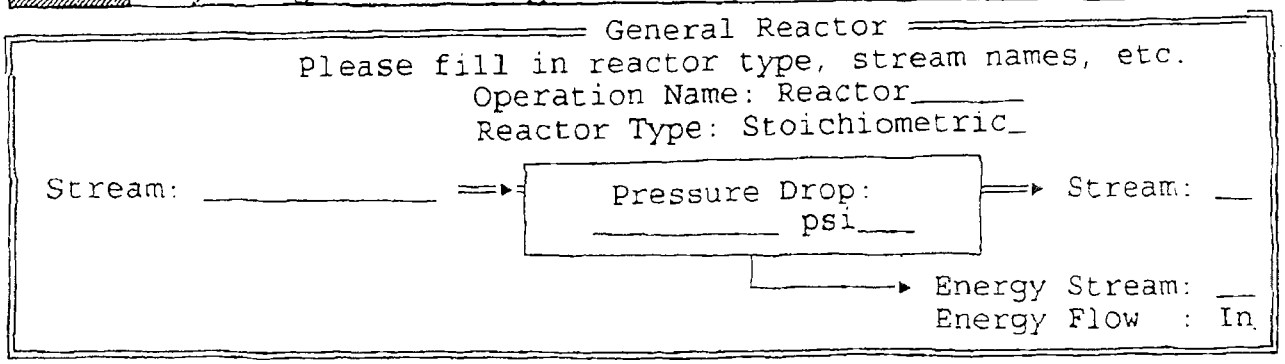
Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the **<Insert>** key.

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the **<Enter>** key;
7	Highlight the word **Configuration** and then press the **<Enter>** key;
8	Highlight the word **Units** and then press the **<Enter>** key;
9	Highlight the word **Field** and then press the **<Enter>** key;
10	Press the **<Esc>** key;
	Specifying the type of operation.
11	Highlight the word **Operation** and then press the **<Enter>** key;
12	Type the word **Reactor** after the prompt (>) and then press the **<Enter>** key;
13	Highlight the word **Reactor** and then press the **<Enter>** key;
	The following screen will then appear:



3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Specifying that the reactor type should be a PFR.
14	Press the <**F2**> key and highlight the word **PFReactor** and then press the <**Enter**> key;
	Specifying the stream names.
15	Type the word **Feed** in the blank and then press the <**Enter**> key;
16	Type the word **Outlet** in the blank and then press the <**Enter**> key;
17	Type the word **Energy** in the blank and then press the <**Enter**> key two times;
	Specifying the pressure drop across the PFR in psi.
18	Type the number **11**.
	The screen should now appear as follows:

```
                    General Reactor
          Please fill in reactor type, stream names, etc.
                    Operation Name: Reactor_____

                    Reactor Type: PFReactor_____

Stream: Feed_____ ==>|  Pressure Drop:  |==> Stream: Outlet
                     |  11_____ psi___  |
                     |_____>  Energy Stream: Energy
                            Energy Flow  : In__
```

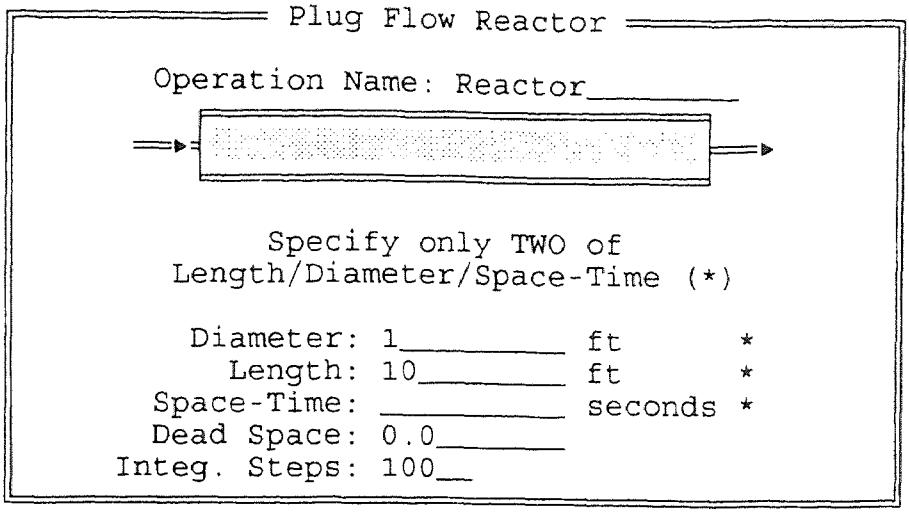
Step	Action
19	Press the <**Insert**> key;
	The following screen will then appear:

```
                    Plug Flow Reactor

          Operation Name: Reactor_____

          ==>|                                  |==>

               Specify only TWO of
          Length/Diameter/Space-Time (*)

            Diameter: _____ ft       *
              Length: _____ ft       *
          Space-Time: _____ seconds  *
          Dead Space: 0.0_____
        Integ. Steps: 100__
```

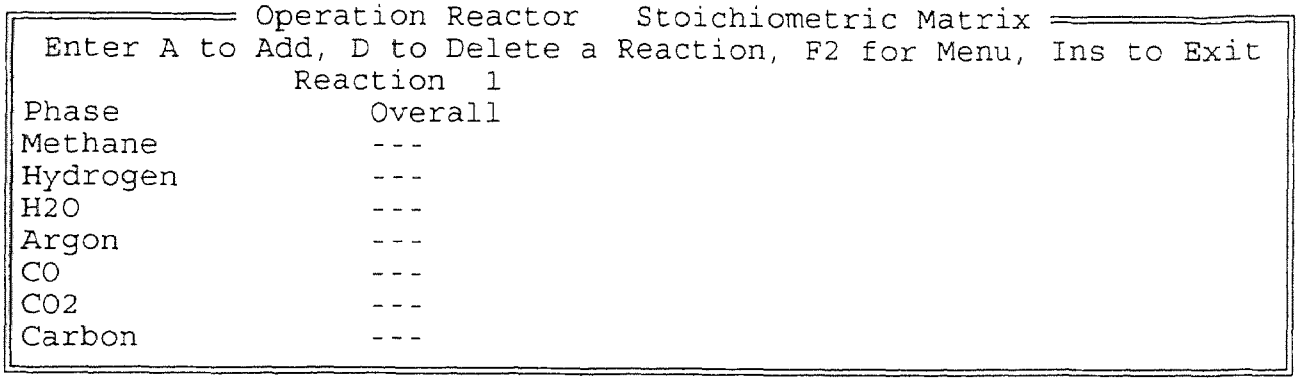
Step	Action
	Specifying the reactor diameter and length in feet (ft).
20	Type the number 1 and then press the <**Enter**> key;

3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
21	Type the number 10 and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
22	Press the <**Insert**> key;
	The following screen will then appear:



Step	Action
	Specifying the stoichiometric coefficients for each of the seven chemical reactants (negative integer) and products (positive integer) of each of the three reactions on page 248.
	Reaction 1 stoichiometric coefficients.
23	Press the <↓> key one time and then type the number -1 and press the <**Enter**> key;
24	Type the number 3 and then press the <**Enter**> key;
25	Type the number -1 and then press the <**Enter**> key;
26	Type the number 0 and then press the <**Enter**> key;
27	Type the number 1 and then press the <**Enter**> key;
28	Type the number 0 and then press the <**Enter**> key;
29	Type the number 0 and then press the <**Enter**> key;

3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Pressing an "a" to add another column to the table.
30	Press the letter **a**;
	Reaction 2 stoichiometric coefficients..
31	Press the <↑> key enough times until the pointer is at the blank space for the component Methane of Reaction 2.
32	Type the number **0** and then press the <**Enter**> key;
33	Type the number **1** and then press the <**Enter**> key;
34	Type the number **-1** and then press the <**Enter**> key;
35	Type the number **0** and then press the <**Enter**> key;
36	Type the number **-1** and then press the <**Enter**> key;
37	Type the number **1** and then press the <**Enter**> key;
38	Type the number **0** and then press the <**Enter**> key;
39	Press the letter **a**;
	Reaction 3 stoichiometric coefficients.
40	Press the <↑> key enough times until the pointer is at the blank space for the component Methane of Reaction 3.
41	Type the number **-1** and then press the <**Enter**> key;
42	Type the number **2** and then press the <**Enter**> key;
43	Type the number **0** and then press the <**Enter**> key;
44	Type the number **0** and then press the <**Enter**> key;
45	Type the number **0** and then press the <**Enter**> key;
46	Type the number **0** and then press the <**Enter**> key;
47	Type the number **1** and then press the <**Enter**> key;
	The screen shown below will then appear:

Operation Reactor Stoichiometric Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

	Reaction 1	Reaction 2	Reaction 3
Phase	Overall	Overall	Overall
Methane	-1.000	---	-1.000
Hydrogen	3.000	1.000	2.000
H2O	-1.000	-1.000	---
Argon	---	---	---
CO	1.000	-1.000	---
CO2	---	1.000	---
Carbon	---	---	1.000

Step	Action
48	Press the <**Insert**> key;
	Reaction 1 specifications.
	Specifying the rate constant for reaction 1.
49	Type the number **7.2e+02** and then press the <**Enter**> key ;

3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Specifying the base component (reaction rate basis) for reaction 1 as Methane.
50	Press the <↓> key three times and then press the <**F2**> key; and highlight the word **Methane** and then press the <**Enter**> key;
	Specifying the order of the reaction. The two reactants in reaction 1 are Methane and H2O. and their coefficients are 1, so they have an order of one. The rest of the components have a zero order.
51	Press the <↓> key three times and then type the number **1** and then press the <**Enter**> key;
52	Type the number **0** and then press the <**Enter**> key;
53	Type the number **1** and then press the <**Enter**> key;
54	Type the number **0** and then press the <**Enter**> key;
55	Type the number **0** and then press the <**Enter**> key;
56	Type the number **0** and then press the <**Enter**> key;
57	Type the number **0** and then press the <**Enter**> key;
58	Press the <→> key once until the cursor is in the reaction 2 column;
	Reaction 2 specifications.
	Specifying the frequency factor for reaction 2.
59	Press the <↑> key enough times until the pointer is at the blank space for the Freq. Factor of reaction 2.
60	Type the number **4.7e+03** and then press the <**Enter**> key ;
	Specifying the Activation Energy for reaction 2.
61	Type the number **7.8e+04** and then press the <**Enter**> key ;
	Specifying the base component (reaction rate basis) for reaction 2 as Carbon Monoxide (CO).
62	Press the <↓> key one time and then press the <**F2**> key; and highlight the formula **CO** and then press the <**Enter**> key;
	Specifying the order of the reaction. The two reactants in reaction 2 are H2O and CO, and their coefficients are 1, so they have an order of one. The rest of the components have a zero order.
63	Press the <↓> key three times and then type the number **0** and then press the <**Enter**> key;
64	Type the number **0** and then press the <**Enter**> key;
65	Type the number **1** and then press the <**Enter**> key;
66	Type the number **0** and then press the <**Enter**> key;
67	Type the number **1** and then press the <**Enter**> key;
68	Type the number **0** and then press the <**Enter**> key;
69	Type the number **0** and then press the <**Enter**> key;
70	Press the <→> key one time until the cursor is in the column for reaction 3;
	Reaction 3 specifications.
	Specifying the rate constant for reaction 3.
71	Press the <↑> key enough times until the pointer is at the blank space for the rate constant of Reaction 3.
72	Type the number **1.6e+00** and then press the <**Enter**> key;

3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Specifying the base component (reaction rate basis) for reaction 3 as Methane.
73	Press the <↓> key three times and then press the <**F2**> key; and highlight the word **Methane** and then press the <**Enter**> key;
	Specifying the order of the reaction. The only reactant in reaction 3 is Methane, and the coefficient is 1, so it has an order of one. The rest of the components have a zero order.
74	Press the <↓> key three times and then type the number **1** and then press the <**Enter**> key;
75	Type the number **0** and then press the <**Enter**> key;
76	Type the number **0** and then press the <**Enter**> key;
77	Type the number **0** and then press the <**Enter**> key;
78	Type the number **0** and then press the <**Enter**> key;
79	Type the number **0** and then press the <**Enter**> key;
80	Type the number **0** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation Reactor Rate Constant/Order Matrix

Enter A to Add, D to Delete a Reaction, F2 for Menu, Ins to Exit

	Reaction 1	Reaction 2	Reaction 3
Rate Const.	7.2000e+02	---	1.6000e+00
Freq. Factor	---	4.7000e+03	---
Actv. Energy	---	7.8000e+04	---
Rate Unit	lbmole/ft3-h	lbmole/ft3-h	lbmole/ft3-h
Base Comp.	Methane	CO	Methane
Basis	MolarConc	MolarConc	MolarConc
Basis Unit	lbmole/ft3	lbmole/ft3	lbmole/ft3
Methane	1.000	---	1.000
Hydrogen	---	---	---
H2O	1.000	1.000	---
Argon	---	---	---
CO	---	1.000	---
CO2	---	---	---
Carbon	---	---	---

Step	Action
81	Press the <**Insert**> key;
	Specifying the conditions of the Feed stream.
82	Highlight the word **Specify** and then press the <**Enter**> key;
83	Highlight the word **Stream** and then press the <**Enter**> key;
84	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying the Temperature of the Feed in °F.
85	Type the number **1112** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
86	Type the number **218** after the prompt (>) and then press the <**Enter**> key;

3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Specifying the Flow in lb-mols/hr.
87	Type the number **220.46** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying the compositions of the feed stream.
88	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Stream Mole Fractions

Methane		Hydrogen	
H2O		Argon	
CO		CO2	
Carbon			

Step	Action
89	*Enter the following mole fractions beside each component in the feed stream:* After the word, Methane, type the number **0.45** in the blank and then press the <**Enter**> key; After the word, Hydrogen, type the number **0** in the blank and then press the <**Enter**> key; After the formula, H2O, type the number **0.54** in the blank and then press the <**Enter**> key; After the word, Argon, type the number **0.01** in the blank and then press the <**Enter**> key; After the formula, CO, type the number **0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0** in the blank;
	The screen should now appear as follows:

Stream Mole Fractions

Methane	0.45	Hydrogen	0
H2O	0.54	Argon	0.01
CO	0	CO2	0
Carbon	0		

Step	Action
90	Press the <**Insert**> key;
	Specifying the temperature (°F) and pressure (psia) of the Outlet stream.
91	Highlight the word **Worksheet** and then press the <**Enter**> key;
92	*Use the arrow keys to move the pointer to the blank space for the Temperature of the Outlet stream.* Type the number **1112** and then press the <**Enter**> key;
	The screen will appear as shown on the following page.

3.6.5 Plug Flow Reactor (PFR) (continued)

Streams

Stream	New Value = Feed	Outlet	F Energy	---
Vapour_Frac	1.0000	0.9997	2.0000*	---
Temperature	1112.0000*	1112.0000*	0.0000*	---
Pressure	218.0000*	207.0000	0.0000*	---
Flow	220.4600*	221.0374	0.0000*	---
Mass_Flow	3824.3063	3824.3063	0.0000*	---
LiqVol_Flow	515.5482	516.3485	0.0000*	---
Energy_Flow	3.27523E+06	3.27899E+06	24041.9421	---

Step	Action
93	Press the <**Esc**> key;
94	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
95	Highlight the word **Streams** and then press the <**Enter**> key;
96	Highlight the word **All** and then press the <**Enter**> key;
	Looking at the calculated data for all of the streams.
97	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it. Use the <Page Up> and <Page Down> keys to view the entire text.
98	Press the <**F10**> key;
	The screen will appear as shown on the following page.

3.6.5 Plug Flow Reactor (PFR) (continued)

Stream		Feed	Outlet	Energy
Description				
Vapour frac.		1.0000	0.9997	2.0000*
Temperature	F	1112.0000*	1112.0000*	0.0000*
Pressure	psia	218.0000*	207.0000	0.0000*
Molar Flow	lbmole/hr	220.4600*	221.0374	0.0000*
Mass Flow	lb/hr	3824.3063	3824.3063	0.0000*
LiqVol Flow	barrel/day	515.5482	516.3485	0.0000*
Enthalpy	Btu/hr	3.27523E+06	3.27899E+06	24041.9421
Density	lb/ft3	0.2244	0.2125	0.0000
Mole Wt.		17.3469	17.3016	0.0000
Spec. Heat	Btu/lb-F	0.7176	0.7176	---
Therm Cond	Btu/hr-ft-F	0.0601	---	---
Viscosity	cP	0.0267	---	---
Z Factor		0.9993	---	---
Sur Tension	dyne/cm	---	---	---
Std Density	lb/ft3	---	---	---
Methane	mole frac.	0.4500*	0.4475	0.0000*
Hydrogen	mole frac.	0.0000*	0.0036	0.0000*
H2O	mole frac.	0.5400*	0.5376	0.0000*
Argon	mole frac.	0.0100*	0.0100	0.0000*
CO	mole frac.	0.0000*	0.0010	0.0000*
CO2	mole frac.	0.0000*	0.0000	0.0000*
Carbon	mole frac.	0.0000*	0.0003	0.0000*

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
99	Press the **<F10>** key;
100	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 257.

Step	Action
101	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
102	Highlight the word **Operations** and then press the **<Enter>** key;
103	Highlight the word **Reactor** and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
104	Press the **<F10>** key;
	The screen will appear as shown on the following two pages. Use the <Page Up> and <Page Down> keys to view the entire text.

3.6.5 Plug Flow Reactor (PFR) (continued)

HYSIM PLUG FLOW REACTOR SPECIFICATION — Page 1 of 3
HYSIM Version C2.53 — Date 96/10/09
Case Name: — Time 10:50:14

Operation Name: Reactor
Operation Note:

	Stream		Operation	Flowrate
Inlet:	Feed	from	---	220.4600 lbmole/hr
				3824.3063 lb/hr
Outlet:	Outlet	to	---	221.0374 lbmole/hr
				3824.3063 lb/hr
Energy:	Energy	to	---	24041.9421 Btu/hr

Inlet Properties at Operating Conds			Outlet Properties at Operating Conds		
Vapour Frac	1.0000		Vapour Frac	0.9997	
Temperature	1112.0000	F	Temperature	1112.0000	F
Pressure	218.0000	psia	Pressure	207.0000	psia
Density	0.2244	lb/ft3	Density	0.2125	lb/ft3
Std Density	32.2511	lb/ft3	Std Density	32.0190	lb/ft3
Mol Weight	17.3469		Mol Weight	17.3016	
Viscosity	0.0267	cP	Viscosity	---	cP
Therm Cond	0.0601	Btu/hr-ft-F	Therm Cond	---	Btu/hr-ft-F

Component	Hform @ 298 K (Btu/lbmole)	Inlet Flowrate (lbmole/hr)	Outlet Flowrate (lbmole/hr)
Methane	-32201.2027	99.2070	98.9183
Hydrogen	0.0000	0.0000	0.7950
H2O	-103611.3466	119.0484	118.8308
Argon	0.0000	2.2046	2.2046
CO	-47545.1403	0.0000	0.2176
CO2	-169299.2207	0.0000	0.0000
Carbon	0.0000	0.0000	0.0711
---	---	---	---
---	---	---	---
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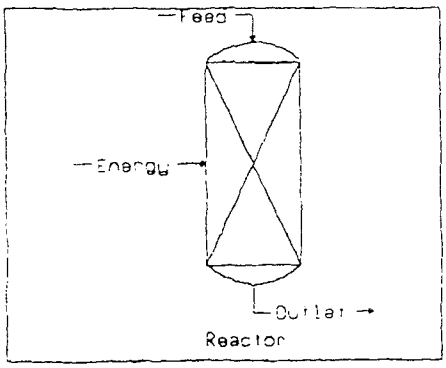
---	---	---	---

3.6.5 Plug Flow Reactor (PFR) (continued)

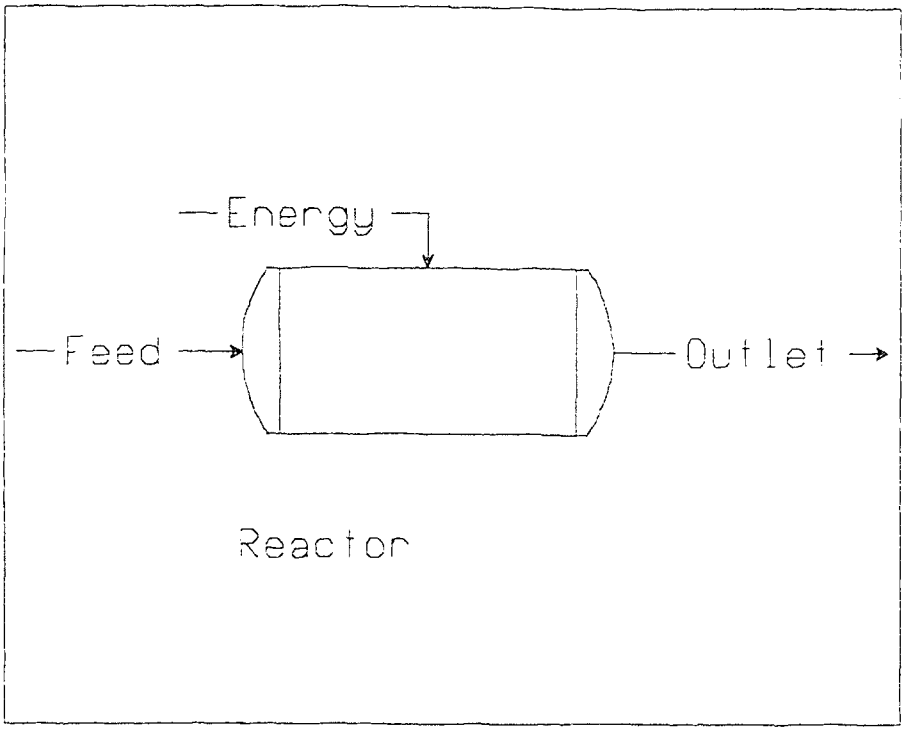
```
HYSIM PLUG FLOW REACTOR SPECIFICATION                    Page 2 of 3

Case Name:                                               Date 96/10/09
Operation Name: Reactor                                  Time 10:50:14

Dimensions

  Diameter        1.0000 ft                    Length      10.0000 ft
Space-Time         ---       seconds      Dead-Space Frac    0.0000

Reaction  1     Rate Const.     Pre-Expon. Factor    Activ. Energy
                7.200e+02            ---                  ---
                Rxn Phase: Overall        Base Comp.: Methane
Basis     MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders    Methane      1.000 H2O          1.000
Reactants -1.000 Methane       + -1.000 H2O
Products  3.000 Hydrogen     + 1.000 CO

Reaction  2     Rate Const.     Pre-Expon. Factor    Activ. Energy
                   ---             4.700e+03          1.814e+05
                Rxn Phase: Overall        Base Comp.: CO
Basis     MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders    H2O          1.000 CO           1.000
Reactants -1.000 H2O           + -1.000 CO
Products  1.000 Hydrogen     + 1.000 CO2

Reaction  3     Rate Const.     Pre-Expon. Factor    Activ. Energy
                1.600e+00            ---                  ---
                Rxn Phase: Overall        Base Comp.: Methane
Basis     MolarConcs in lbmole/ft3   yield reaction rate in lbmole/ft3-hr
Orders    Methane      1.000
Reactants -1.000 Methane
Products  2.000 Hydrogen     + 1.000 Carbon
```

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu
105	Press the **<F10>** key;
106	Highlight the letters **PFD** and then press the **<Enter>** key;
	The following screen will appear:



3.6.5 Plug Flow Reactor (PFR) (continued)

Step	Action
	Specifying a different type of reactor icon on the PFD.
107	Move the mouse until the cross-hatches on the screen are over the reactor and then press the **left mouse key**. (A box will appear around the reactor).
108	Press the <**I**> key;
109	Place the crosshatch (using the mouse) over the third icon (first row, third column) which represents a plug flow reactor (PFR) and then press the **left mouse key**.
	The following screen will then appear:



Step	Action
	Getting back to the Main Menu.
110	Press the <**Esc**> key until you reach the Main Menu;
111	Do you want to continue adding other unit operations to this reactor? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

This section contains examples of the following seven different types of separators:

3.7.1 Two-Phase Separator

Objective - This exercise is an example of a two-phase separator calculation. The purpose of the two-phase separator unit operation is to phase separate a liquid and vapor stream. The HYSIM program will calculate the amount of vapor and liquid in equilibrium at the separator's outlet if the composition, temperature and pressure of the feed stream are supplied. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, the feed components, composition and conditions are specified. HYSIM then separates the product stream into separate liquid and vapor streams.

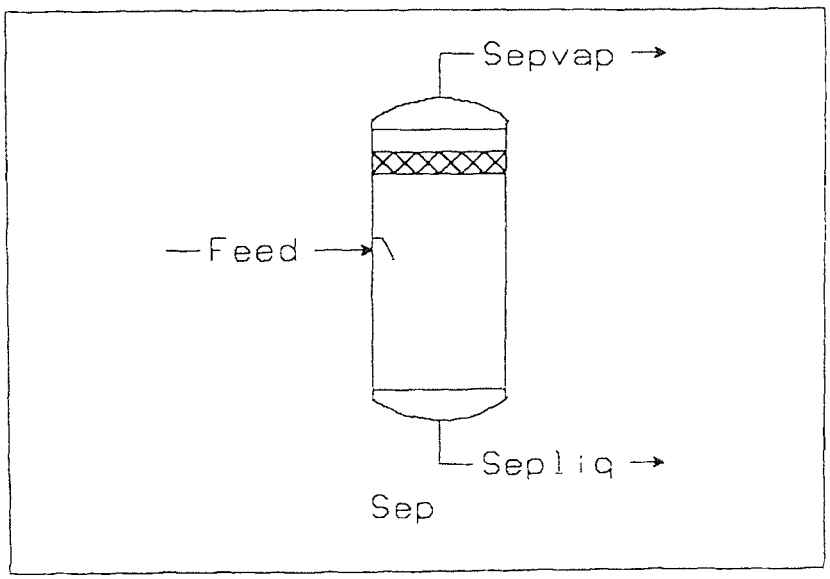
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Interactive Tutorial, Version C2.50, March 1994, pages 3-98 to 3-128.

Other References: Refs. 1 & 2.

Directions: Pages 264 through 269 outline the execution of a Two-Phase Separator example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the " escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Sep*, is shown below:



3.7.1 Two-Phase Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the Feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word **i-Butane** and then press the <**Enter**> key; Highlight the word **n-Butane** and then press the <**Enter**> key; Highlight the word **i-Pentane** and then press the <**Enter**> key; Highlight the word **n-Pentane** and then press the <**Enter**> key Highlight the word **n-Hexane** and then press the <**Enter**> key; Highlight the word **n-Heptane** and then press the <**Enter**> key; Highlight the word **n-Octane** and then press the <**Enter**> key, followed by the <**Insert**> key.

3.7.1 Two-Phase Separator (continued)

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
5	Highlight the word **Utility** and then press the <**Enter**> key;
6	Highlight the word **Configuration** and then press the <**Enter**> key;
7	Highlight the word **Units** and then press the <**Enter**> key;
8	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
9	Press the <**Esc**> key;
	Specifying the conditions of the Feed stream.
10	Highlight the word **Specify** and then press the <**Enter**> key;
11	Highlight the word **Stream** and then press the <**Enter**> key;
12	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in °F.
13	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in psia.
14	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Typing an "x" to leave the molar flow of the feed unspecified at this point.
15	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual molar flows (lb-mols/hr) of each component in the Feed stream.
16	Type the word **Mole-Flows** after the prompt (>) and then press the <**Enter**> key;
	The following screen will appear:

```
                    Stream Molar Flows

Methane     _____________      Ethane      _____________
Propane     _____________      i-Butane    _____________
n-Butane    _____________      i-Pentane   _____________
n-Pentane   _____________      n-Hexane    _____________
n-Heptane   _____________      n-Octane    _____________
```

3.7.1 Two-Phase Separator (continued)

Step	Action
17	*Enter the following molar flows (lb-mols hr) beside each component in the feed stream:* After the word, Methane, type the number 70 in the blank and then press the <**Enter**> key; After the word, Ethane, type the number 20 in the blank and then press the <**Enter**> key; After the word, Propane, type the number 10 in the blank and then press the <**Enter**> key; After the word, *i*-Butane, type the number 9 in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number 8 in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number 7 in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number 6 in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number 7 in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number 4 in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number 3 in the blank;
	The screen will then appear as shown below

Stream Molar Flows

Methane	70	Ethane	20
Propane	10	i-Butane	9
n-Butane	8	i-Pentane	7
n-Pentane	6	n-Hexane	7
n-Heptane	4	n-Octane	3

Step	Action
18	Press the <**Insert**> key;
	HYSIM will next ask you if the total molar flow it calculated from adding up the individual component flows (144.0000 lb-mols hr) is correct
19	Highlight the word **Yes** and then press the <**Enter**> key;
	Looking at the conditions in the program for the feed stream.
20	Highlight the word **Print** and then press the <**Enter**> key;

Print Options

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

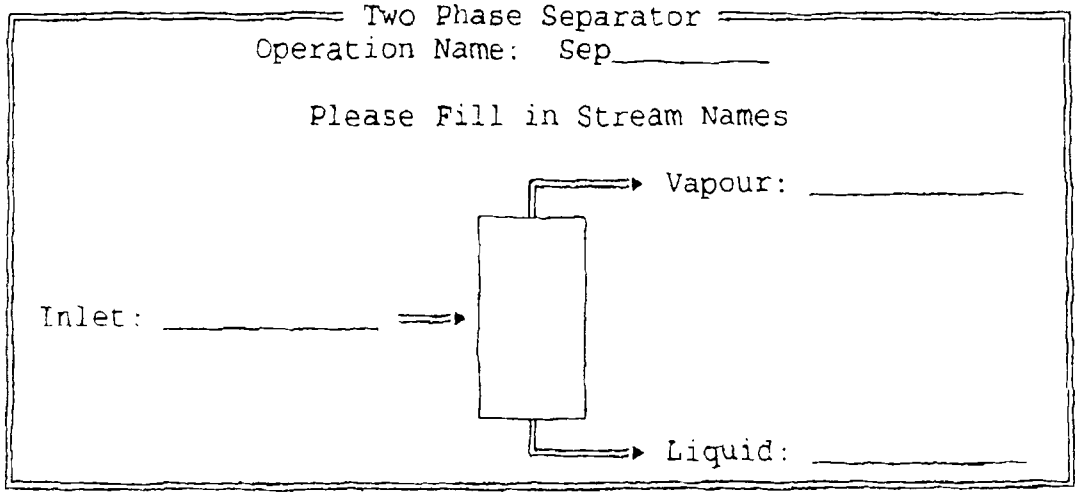
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

3.7.1 Two-Phase Separator (continued)

Step	Action
21	Highlight the word **Streams** and then press the <**Enter**> key.
22	Highlight the word **Conditions** and then press the <**Enter**> key.
23	Highlight the word **Feed** and then press the <**Enter**> key.
	The following conditions will then appear on the screen for the feed stream

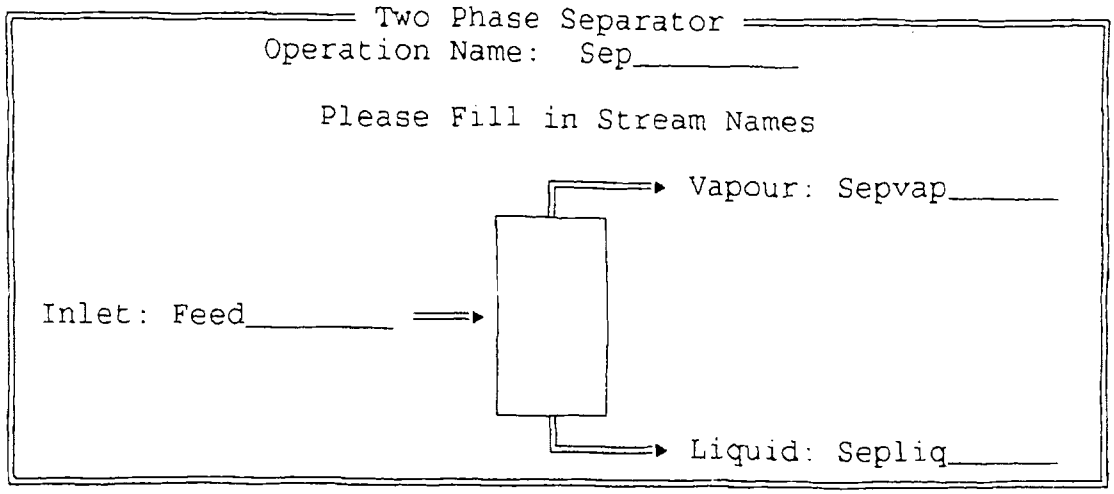
Stream		Feed
Vapour frac.		0.4836
Temperature	F	60.0000*
Pressure	psia	600.0000*
Molar Flow	lbmole/hr	144.0000*
Mass Flow	lb/hr	5438.2035
LiqVol Flow	barrel/day	788.6378
Enthalpy	Btu/hr	231865.6189

Step	Action
	Specifying the type of operation we want to perform on the feed stream.
24	Highlight the word **Operation** and then press the <**Enter**> key.
	Typing a name for the operation (We will call it "Sep").
25	Type the word **Sep** and then press the <**Enter**> key.
26	Highlight the word **Separator** and then press the <**Enter**> key.
	The following diagram of the separator process will appear:



3.7.1 Two-Phase Separator (continued)

Step	Action
	Naming the streams.
27	Type **Feed** in the blank and then press the <**Enter**> key.
28	Type **Sepliq** in the blank and then press the <**Enter**> key.
29	Type **Sepvap** in the blank;
	The screen should now appear as follows:



Step	Action
	Looking at the conditions of all of the streams.
30	Press the <**Enter**> key.
31	Highlight the word **Print** and then press the <**Enter**> key.

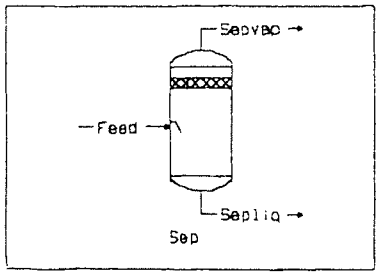
The various print options can be found on page 266.

Step	Action
32	Highlight the word **Streams** and then press the <**Enter**> key.
33	Highlight the word **All** and then press the <**Enter**> key.
34	Highlight the dash symbol - and then press the <**Enter**> key.
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
35	Press the <**F10**> key;
	The screen will then appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.1 Two-Phase Separator (continued)

Stream		Feed	Sepliq	Sepvap
Description				
Vapour frac.		0.4836	0.0000	1.0000
Temperature	F	60.0000*	60.0000	60.0000
Pressure	psia	600.0000*	600.0000	600.0000
Molar Flow	lbmole/hr	144.0000*	74.3626	69.6374
Mass Flow	lb/hr	5438.2035	4013.7623	1424.4413
LiqVol Flow	barrel/day	788.6378	499.4297	289.2080
Enthalpy	Btu/hr	231865.6189	-41348.8026	273214.4039
Density	lb/ft3	8.2828	34.8685	2.6308
Mole Wt.		37.7653	53.9755	20.4551
Spec. Heat	Btu/lb-F	0.5779	0.5736	0.5901
Therm Cond	Btu/hr-ft-F	---	0.0572	0.0192
Viscosity	cP	---	0.1585	0.0119
Z Factor		---	0.1665	0.8365
Sur Tension	dyne/cm	---	9.8719	---
Std Density	lb/ft3	---	34.8684	---
Methane	mole frac.	0.4861*	0.1933	0.7988
Ethane	mole frac.	0.1389*	0.1435	0.1339
Propane	mole frac.	0.0694*	0.1040	0.0325
i-Butane	mole frac.	0.0625*	0.1067	0.0153
n-Butane	mole frac.	0.0556*	0.0979	0.0104
i-Pentane	mole frac.	0.0486*	0.0900	0.0044
n-Pentane	mole frac.	0.0417*	0.0779	0.0030
n-Hexane	mole frac.	0.0486*	0.0929	0.0013
n-Heptane	mole frac.	0.0278*	0.0535	0.0003
n-Octane	mole frac.	0.0208*	0.0403	0.0001

Step	Action
36	Press the <**F10**> key;
	Looking at the current process flow diagram (PFD).
37	Highlight the abbreviation **PFD** and then press the <**Enter**> key;
	The following figure will appear:



Step	Action
	Getting back to the Main Menu.
38	Press the <**Esc**> key until you reach the Main Menu.
39	Do you want to continue adding other unit operations to this separator? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.7.2 Three-Phase Separator

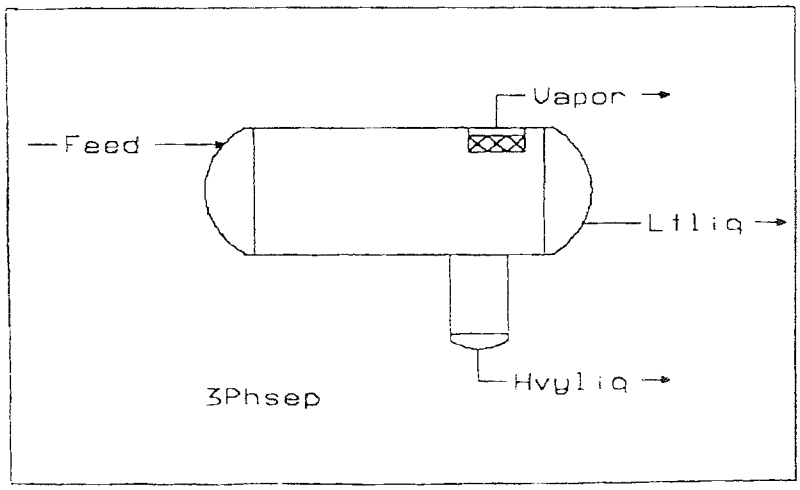
Objective - This exercise is an example of a three-phase separator calculation. The purpose of the three-phase separator unit operation is to phase separate a system consisting of a vapor and two immiscible liquid phases into three streams from a single feed stream. An example of such a system would be one consisting of a gas, oil and water mixture. The HYSIM program will calculate the amount of gas, oil and liquid at the separator's outlet if the composition, temperature and pressure of the feed stream are supplied. This example can be modified by specifying another property package and/or other components, compositions and feed conditions

In this example, a *Feed* stream containing water, oil and gas is separated into three different streams: *Vapor*, *Ltliq* and *Hvyliq*. The *Vapor* stream contains mainly gas, the *Ltliq* stream contains mainly oil and the *Hvyliq* stream contains mainly water.
Technical Example Reference: Reference 8 - Surface Production Operations, Volume 1, "Design of Oil-Handling Systems and Facilities," by Ken Arnold and Maurice Stewart, 1986, Gulf Publishing Co., Book Division, Houston, Texas, Example 5-1, pages 144-146.
Other References: Refs. 1 and 2.

Directions: Pages 271 through 282 outline the execution of a Three-Phase Separator example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the " escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *3Phsep*, is shown below:



3.7.2 Three-Phase Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V) • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C,etc.) to field units (lb, psia, °F,etc.).
2	Highlight the word **Configuration** and then press the <**Enter**> key;
3	Highlight the word **Units** and then press the <**Enter**> key;
4	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu
5	Press the <**Esc**> key;
	Starting with a new case.
6	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
7	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

3.7.2 Three-Phase Separator (continued)

Step	Action
	Selecting the components in the feed stream.
8	*Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Hypothetical** and then press the **<Enter>** key;
	Specifying that the hypothetical component is a Hydrocarbon (HC).
9	Highlight the initials **HC** and then press the **<Enter>** key;
	The screen will then appear as shown below:

```
═══════ Hypothetical Component Information ═══════

Name: _________          Chemical Formula: _____________

Boiling Point [F_]          : __
LiqDensity (@ 60F)[lb/ft3]  : __
Molecular Weight            : __

Critical Temperature [F_]   : __
Critical Pressure [psia__]  : __
Critical Volume [ft3/lbmo]  : __
Acentric Factor             : __
Acentric Factor  Wsrk       : __
Charact. Volume [ft3/lbmo]  : __
Dipole Moment [debye]       : __

  Vapour Pressure [deg K, kPa]
ANTA: _____________  ANTD: _____
ANTB: _____________  ANTE: _____
ANTC: _____________  ANTF: _____
TMIN: _____________  TMAX: _____
Viscosity Coeff A: _____________
Viscosity Coeff B: _____________

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal = _____________ Btu/lb__
       + _____________ * T
       + _____________ * T^2
       + _____________ * T^3
       + _____________ * T^4
       + _____________ * T^5
Entropy Coeff: _____________
Cavett Param.: _____________

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____________ Btu/lbmo
       + _____________ * T
       + _____________ * T^2
Heat Form (@ 25 C): _____________
Heat Comb (@ 25 C): _____________
Radius Gyration [Ang]: _________
```

Step	Action
10	Type the word **Oil** and then press the **<Enter>** key two times;
	Specifying the Boiling Point of the Oil in °F.
11	Type the number **336** and then press the **<Enter>** key;
	Specifying the Density of the Oil in lb/cubic foot at 60°F.
12	Type the number **54.4** and then press the **<Enter>** key;
	The screen will then appear as shown on the following page.

3.7.2 Three-Phase Separator (continued)

Hypothetical Component Information

Name: Oil_____ Chemical Formula: _____

Boiling Point [F_] : 336_	Ideal Enthalpy Coefficients
LiqDensity (@ 60F) [lb/ft3] : 54.4	(Mass Basis - Ideal gas @ 0 K)
Molecular Weight : ____	Hideal = _____ Btu/lb__
	+ _____ * T
Critical Temperature [F_] : ____	+ _____ * T^2
Critical Pressure [psia__] : ____	+ _____ * T^3
Critical Volume [ft3/lbmo] : ____	+ _____ * T^4
Acentric Factor : ____	+ _____ * T^5
Acentric Factor Wsrk : ____	Entropy Coeff: _____
Charact. Volume [ft3/lbmo] : ____	Cavett Param.: _____
Dipole Moment [debye] : ____	
	Ideal Gas Gibbs Free Energy
Vapour Pressure [deg K, kPa]	(Molar Basis - Ideal gas @ 25 C)
ANTA: _____ ANTD: _____	Gibbs = _____ Btu/lbmo
ANTB: _____ ANTE: _____	+ _____ * T
ANTC: _____ ANTF: _____	+ _____ * T^2
TMIN: _____ TMAX: _____	Heat Form (@ 25 C): _____
Viscosity Coeff A: _____	Heat Comb (@ 25 C): _____
Viscosity Coeff B: _____	Radius Gyration [Ang]: _____

Hypothetical Compounds - HYSIM will calculate the critical properties from either the Bergman Cavett or Lee-Kesler Correlation, depending on the API and Normal Boiling Point supplied. Other component types such as Amines, Alcohols, etc. will have critical properties determined by Joback's modification of Lydersen's group contribution method.

The Enthalpy coefficients are for the following fifth order ideal enthalpy equation:

$H = A + BT + CT^2 + DT^3 + ET^4 + FT^5$

where: T = Absolute Temperature (K or R)

H = Enthalpy = BTU/lb-R or kJ/Kg-K

For solids, the enthalpy data should be entered. If HYSIM generates the coefficients, it will use the Cavett correlations for hydrocarbons, solids or miscellaneous substances; the Joback group contribution method will be used for all other substances.

Reference: Passut, C.A. and Danner, R.P., I.E.C. Proc. Des. & Dev., 11, p. 543 (1972).

The Gibbs Free Energy is calculated using the following equation: $G^o = A + BT + CT^2$

where: T = Absolute Temperature = K or R

G^o = kJ/kgmole-K or Btu/lbmole-R

If the hypothetical is a Hydrocarbon or if a UNIFAC structure is not specified, no Gibbs coefficients will be calculated.

The modified Antoine vapor pressure model coefficients are calculated for the following equation: $\ln (P_{vap}) = ANTA + (ANTB/(T+ANTC)) + ANTD(\ln(T)) + ANTE(T)^{ANTF}$

The viscosity coefficients, Theta A and Theta B, are used in the viscosity prediction models. Three viscosity models are available in HYSIM: the modified Ely and Hanley model, Twu's model and the modified Letsou-Stiel correlation.

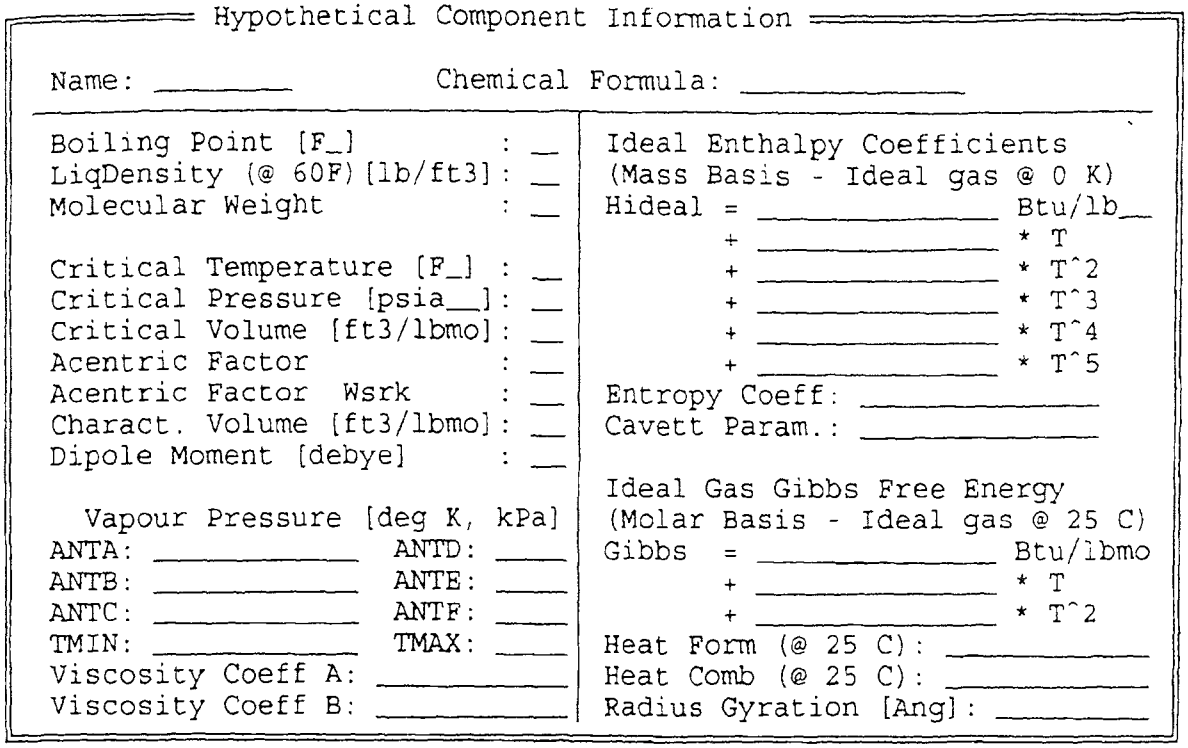
3.7.2 Three-Phase Separator (continued)

Step	Action
	Selecting the components in the feed stream.
13	Press the <**Insert**> key;
	Specifying that the viscosity will be calculated via an equation.
14	Highlight the word **None** and then press the <**Enter**> key;
	The screen will then appear as shown below:

```
═══════════ Hypothetical Component Information ═══════════
   Are The Component Calculations Satisfactory: Yes_____
Name: Oil                        Chemical Formula: Oil
──────────────────────────────────────────────────────────
Boiling Point [F_]          :    336.00
LiqDensity (@ 60 )[lb/ft3]  :     54.40
Molecular Weight            :    135.76

Critical Temperature [F_]   :    706.00
Critical Pressure [psia__]  :    479.48
Critical Volume [ft3/lbmo]  :     6.664
Acentric Factor             :   0.39470
Acentric Factor  Wsrk       :   0.39470
Charact. Volume [ft3/lbmo]  :   7.87490
Dipole Moment [debye]       :      0.00

  Vapour Pressure [deg K, kPa]
ANTA:  6.22775e+01  ANTD: -6.53562e+00
ANTB: -7.90473e+03  ANTE:  4.59697e-18
ANTC:  0.00000e+00  ANTF:  6.00000e+00
TMIN:      336.000  TMAX:      705.998
Viscosity Coeff A:          0.07769
Viscosity Coeff B:         -0.19384

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)
Hideal =  9.0459282e+01 Btu/lb__
       + -8.3169436e-02 * T
       +  3.8270973e-04 * T^2
       + -5.3501511e-08 * T^3
       +  0.0000000e+00 * T^4
       +  0.0000000e+00 * T^5
Entropy Coeff:       0.2388459
Cavett Param.:         0.26623

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _______________ Btu/lbmo
       + _______________ * T
       + _______________ * T^2
Heat Form (@ 25 C): _____________
Heat Comb (@ 25 C): _____________
Radius Gyration [Ang]:    4.5580
```

Step	Action
15	Press the <**Insert**> key;
16	*Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Hypothetical** and then press the <**Enter**> key;
	Specifying that the hypothetical component is a Hydrocarbon (HC).
17	Highlight the initials **HC** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.7.2 Three-Phase Separator (continued)



Step	Action
18	Type the word **Gas** and then press the <**Enter**> key two times;
	Specifying the Boiling Point of the Gas in °F.
19	Type the number **-162** and then press the <**Enter**> key two times;
	Specifying the Molecular Weight of the Gas.
20	Type the number **17.4** and then press the <**Enter**> key;
21	Press the <**Insert**> key;
22	Highlight the word **None** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

3.7.2 Three-Phase Separator (continued)

Hypothetical Component Information

Are The Component Calculations Satisfactory: Yes_____

Name: Gas Chemical Formula: Gas

Boiling Point [F_]	-162.00		
LiqDensity (@ 60) [lb/ft3]	12.49		
Molecular Weight	17.40		
Critical Temperature [F_]	59.85		
Critical Pressure [psia__]	914.46		
Critical Volume [ft3/lbmo]	1.795		
Acentric Factor	-0.01115		
Acentric Factor Wsrk	-0.01115		
Charact. Volume [ft3/lbmo]	3.67030		
Dipole Moment [debye]	0.00		
Vapour Pressure [deg K, kPa]			
ANTA:	2.47857e+01	ANTD:	-1.70192e+00
ANTB:	-1.89849e+03	ANTE:	3.16074e-16
ANTC:	0.00000e+00	ANTF:	6.00000e+00
TMIN:	-162.000	TMAX:	59.852
Viscosity Coeff A:	0.48877		
Viscosity Coeff B:	0.58826		

Ideal Enthalpy Coefficients
(Mass Basis - Ideal gas @ 0 K)

Hideal = 5.9871802e+04 Btu/lb__
+ -7.0655866e+00 * T
+ 2.8194943e-04 * T^2
+ -3.4896171e-09 * T^3
+ 0.0000000e+00 * T^4
+ 0.0000000e+00 * T^5

Entropy Coeff: 0.2388459
Cavett Param.: 0.28049

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)

Gibbs = _____ Btu/lbmo
+ _____ * T
+ _____ * T^2

Heat Form (@ 25 C): _____
Heat Comb (@ 25 C): _____
Radius Gyration [Ang]: 2.8197

Step	Action
23	Press the **<Insert>** key;
	Use the <Page Down> and <↓> arrow keys to locate the formula H2O in the Component Selection Column. The Component list is very long.
24	Highlight the formula **H2O** and then press the **<Enter>** key;
	The screen shown on the following page will then appear.

3.7.2 Three-Phase Separator (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Oil	Muriatic_Acid	HCl	HCl	ALL
Gas	Hydrogen_Fluoride	HF	HF	HC
H2O	Anhydrous_hydrofluor	HF	HF	SOLID
	Hydrogen_Bromide	HBr	HBr	MISC
	Hydrogen_Iodide	HI	HI	AMINE
	Carbon_Monoxide	CO	CO	ALCOHOL
	Carbonic_Oxide	CO	CO	KETONE
	Exhaust_Gas	CO	CO	ALDEHYDE
	Carbon_Dioxide	CO2	CO2	ESTER
	Carbonic_Acid_Gas	CO2	CO2	CARBACID
	Carbonic_Anhydride	CO2	CO2	HALOGEN
	Hydrogen_Sulphide	H2S	H2S	NITRILE
	Hydrogen_Sulfide	H2S	H2S	PHENOL
	Stink_Damp	H2S	H2S	ETHER
	Sulfuretted_Hydrogen	H2S	H2S	USER
	Hydrogen_Cyanide	HCN	HCN	

Search by SYNONYM

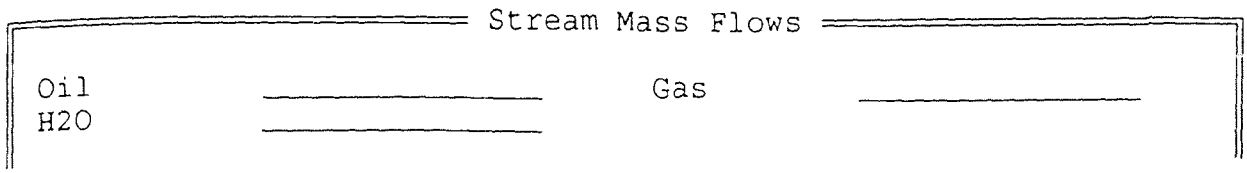
F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
25	Press the <**Insert**> key;

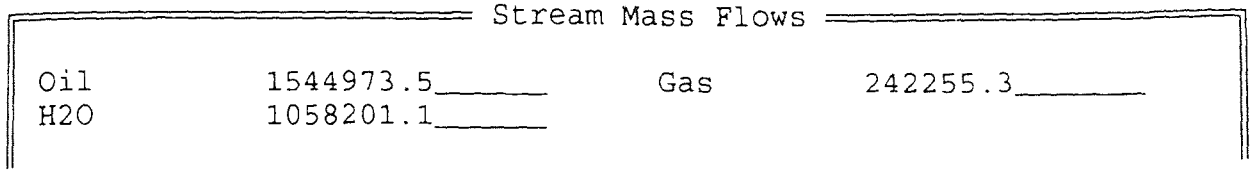
NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
26	Highlight the word **Specify** and then press the <**Enter**> key;
27	Highlight the word **Stream** and then press the <**Enter**> key;
28	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in °F.
29	Type the number **90** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in psia.
30	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the molar flow of the Feed stream is unspecified at this point by typing an "x".
31	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mass flows in lb/hr of each component.
32	Type the word **Mass_Flows** after the prompt (>) and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

3.7.2 Three-Phase Separator (continued)



Step	Action
33	*Enter the following mass flows in lb hr beside each component in the feed stream:* After the word, Oil, type the number **1544973.5** in the blank and then press the **<Enter>** key; After the word, Gas, type the number **242255.3** in the blank and then press the **<Enter>** key; After the formula, H2O, type the number **1058201.1** in the blank;
	The screen will then appear as shown below:



Step	Action
34	Press the **<Insert>** key;
	HYSIM will next ask you if the total mass flow it calculated from adding up the individual component flows or 2845429.9000 lb/hr is correct.
35	Highlight the word **Yes** and then press the **<Enter>** key;
	Looking at the conditions in the program for the feed stream.
36	Highlight the word **Print** and then press the **<Enter>** key;

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

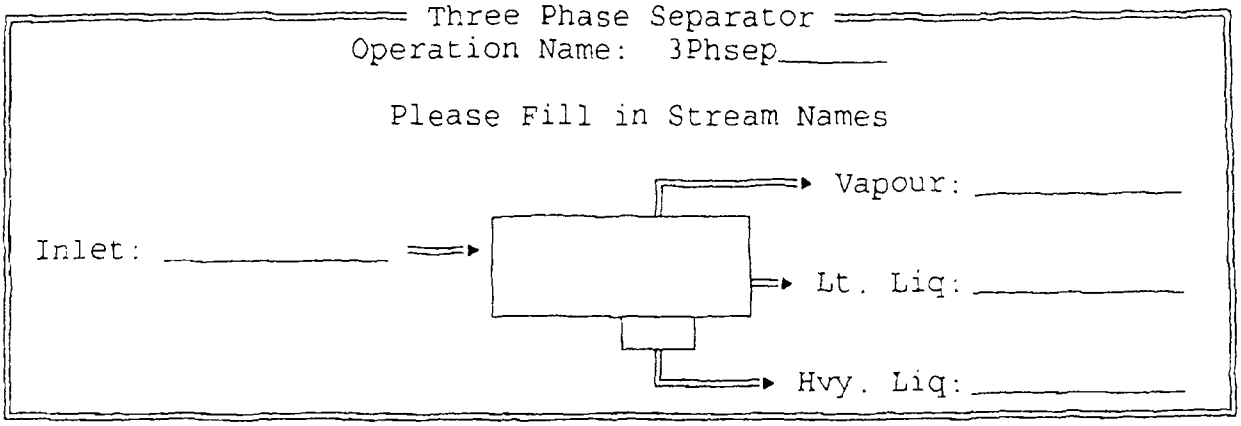
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

3.7.2 Three-Phase Separator (continued)

Step	Action
37	Highlight the word **Streams** and then press the <**Enter**> key.
38	Highlight the word **Conditions** and then press the <**Enter**> key.
39	Highlight the word **Feed** and then press the <**Enter**> key.
	The following conditions will then appear on the screen for the Feed stream:

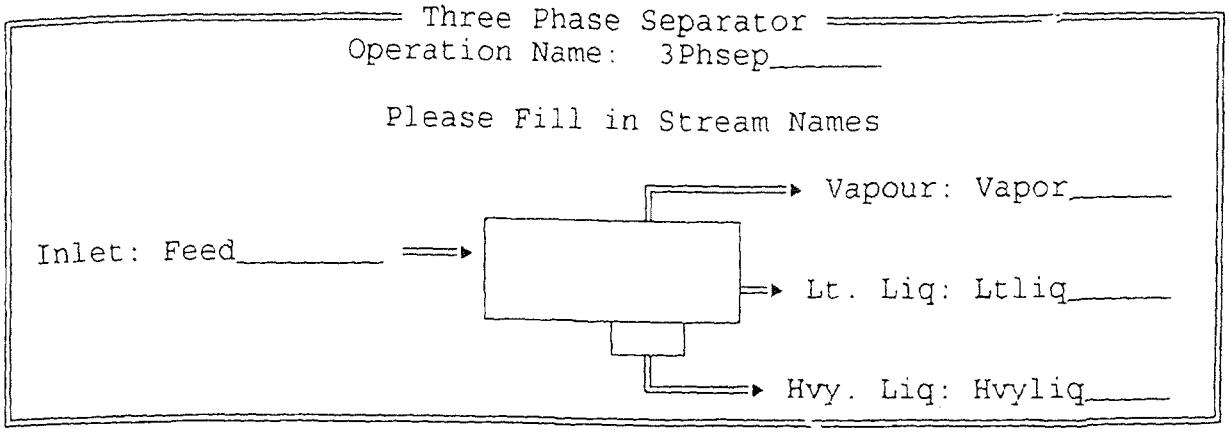
Stream		Feed
Vapour frac.		0.1525
Temperature	F	90.0000*
Pressure	psia	100.0000*
Molar Flow	lbmole/hr	84042.8484
Mass Flow	lb/hr	2.84542E+06*
LiqVol Flow	barrel/day	276944.0831
Enthalpy	Btu/hr	1.27230E+10

Step	Action
	Specifying the type of operation we want to perform on the Feed stream.
40	Highlight the word **Operation** and then press the <**Enter**> key.
	Typing a name for the operation. (We will call it "3Phsep").
41	Type the word **3Phsep** and then press the <**Enter**> key.
42	Highlight the word **Separator_3** and then press the <**Enter**> key.
	The following diagram of the separator process will appear:



Step	Action
	Naming the streams
43	Type **Feed** in the blank and then press the <**Enter**> key.
44	Type **Ltliq** in the blank and then press the <**Enter**> key.
45	Type **Vapor** in the blank and then press the <**Enter**> key.
46	Type **Hvyliq** in the blank.
	The screen should now appear as shown on the following page.

3.7.2 Three-Phase Separator (continued)



Step	Action
	Looking at the conditions of all of the streams.
47	Press the <**Enter**> key;
48	Highlight the word **Print** and then press the <**Enter**> key;

The various print options can be found on page 278.

Step	Action
49	Highlight the word **Streams** and then press the <**Enter**> key;
50	Highlight the word **All** and then press the <**Enter**> key;
51	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key in order to get the current menu off of the screen, to allow viewing of the data underneath the menu.
52	Press the <**F10**> key;
	The following information will now appear as shown below:

Stream Description		Feed	Ltliq	Vapor	Hvyliq
Vapour frac.		0.1525	0.0000	1.0000	0.0000
Temperature	F	90.0000*	90.0000	90.0000	90.0000
Pressure	psia	100.0000*	100.0000	100.0000	100.0000
Molar Flow	lbmole/hr	84042.8484	12581.0903	12820.2614	58641.4945
Mass Flow	lb/hr	2.84542E+06*	1.56473E+06	224259.3525	1.05643E+06
LiqVol Flow	barrel/day	276944.0831	128471.9874	75989.1469	72482.9304
Enthalpy	Btu/hr	1.27230E+10	1.16881E+09	1.24098E+10	-8.55598E+08
Density	lb/ft3	3.6645	50.7463	0.3077	62.5588
Mole Wt.		33.8569	124.3722	17.4926	18.0151
Spec. Heat	Btu/lb-F	0.0175	0.2894	-6.6493	1.0301
Therm Cond	Btu/hr-ft-F	---	0.0625	0.0005	0.3590
Viscosity	cP	---	0.5963	0.0096	0.7606
Z Factor		---	0.0415	0.9637	0.0049
Sur Tension	dyne/cm	---	27.2962	---	70.8481
Std Density	lb/ft3	---	51.6133	---	63.3284
Oil	mole frac.	0.1354*	0.9038	0.0007	0.0000
Gas	mole frac.	0.1657*	0.0956	0.9922	0.0000
H2O	mole frac.	0.6989*	0.0006	0.0071	1.0000

3.7.2 Three-Phase Separator (continued)

Step	Action
53	Press the <F10> key;
	Looking at the conditions of all of the streams.
54	Highlight the word **Print** and then press the <Enter> key;

The various print options can be found on page 278.

Step	Action
55	Highlight the word **Spec_Sheets** and then press the <Enter> key;
56	Highlight the word **Operations** and then press the <Enter> key;
57	Highlight the name **3Phsep** and then press the <Enter> key;
	Pressing the <F10> key in order to get the current menu off of the screen, to allow viewing of the specification sheets underneath the menu.
58	Press the <F10> key;
	The information as shown below and on the following page will then appear on the screen. Use the <Page Up>, <Page Down> and Arrow keys (←, ↑, →, or ↓) to view the entire sheet.

HYSIM VESSEL SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/10/23
Case Name Time 9:19:09

Operation Name: 3Phsep
Operation Note:

Stream		Operation		Flowrate	
Inlet:	Feed	from	--- ---	2.84542E+06	lb/hr
Vapour:	Vapor	to	--- ---	224259.3525	lb/hr
HC Liquid:	Ltliq	to	--- ---	1.56473E+06	lb/hr
Hvy Liquid:	Hvyliq	to	--- ---	1.05643E+06	lb/hr

Inlet Properties at Operating Conds		Inlet Mixed Liquid Properties	
Temperature	90.0000 F	Density	54.9263 lb/ft3
Pressure	100.0000 psia	Spec. Grav.	0.8816 SG_H2O60
Mass Frac Vap	0.0788	Mol. Weight	36.8025
Density	3.6645 lb/ft3	Surface Tens.	63.1549 dyne/cm
Mol. Weight	33.8569	Viscosity	2.1316 cP

Vapour Outlet Properties	
Density	0.3077 lb/ft3
Mol. Weight	17.4926
Z Factor	0.9637
Viscosity	0.0096 cP

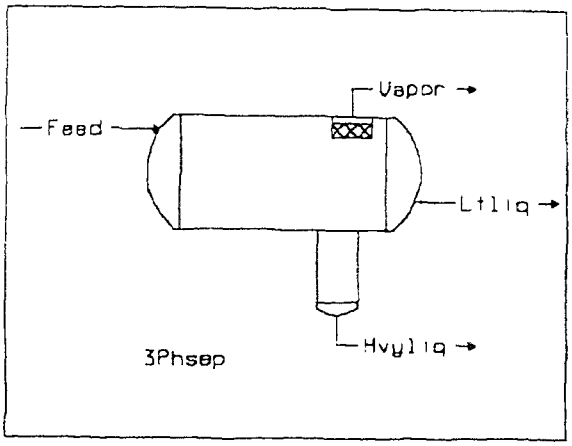
3.7.2 Three-Phase Separator (continued)

Hydrocarbon Liquid Outlet Properties		
Density	50.7463	lb/ft3
Spec. Grav.	0.8145	SG_H2O60
Mol. Weight	124.3722	
Surface Tens.	27.2962	dyne/cm
Viscosity	0.5963	cP

Heavy Liquid Outlet Properties		
Density	62.5588	lb/ft3
Spec. Grav.	1.0041	SG_H2O60
Mol. Weight	18.0151	
Surface Tens.	70.8481	dyne/cm
Viscosity	0.7606	cP

NOTES :

Step	Action
59	Press the <**F10**> key;
	Looking at the current process flow diagram (PFD).
60	Highlight the abbreviation **PFD** and then press the <**Enter**> key;
	The figure shown below will then appear.



Step	Action
	Getting back to the Main Menu.
61	Press the <**Esc**> key until you reach the Main Menu.
62	Do you want to continue adding other unit operations to this three phase separator? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

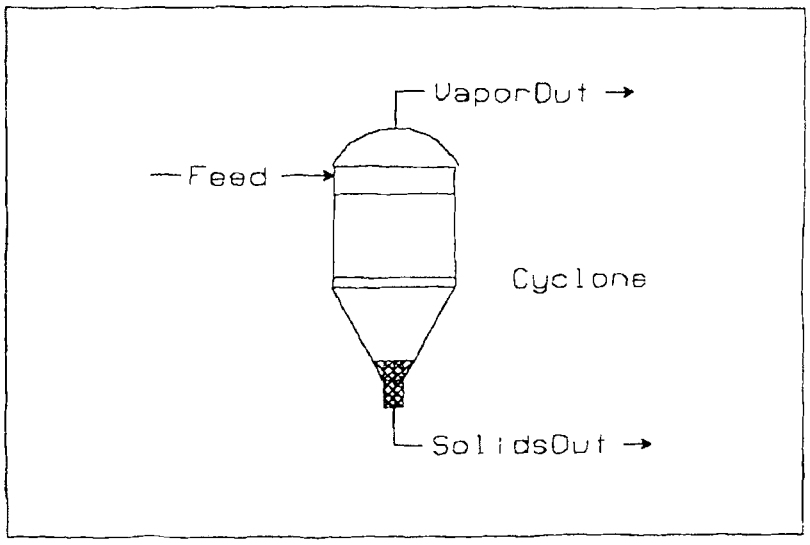
3.7.3 Cyclone Solids Separator

Objective - This exercise is an example of a Cyclone Solid Separation calculation. The purpose of the Cyclone operation is to separate solids (larger than 5 microns) from a gaseous feed stream. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
In this example, the feed stream contains nitrogen, oxygen and a solid catalyst. The cyclone solid separator in this example is 85% efficient in separating the solid catalyst from the feed stream.
Technical Reference Example: Reference 2 - HYSIM Special Features and Applications Guide, pages 2-20 to 2-25.
Other References: Refs. 1 and 2.

Directions - Pages 284 through 296 outline the execution of a cyclone solids separator example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Cyclone*, is shown below



3.7.3 Cyclone Solids Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **PR_Options** and then press the <**Enter**> key;
4	Highlight the word **PRSV** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
5	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Nitrogen** and then press the <**Enter**> key; Highlight the word **Oxygen** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

3.7.3 Cyclone Solids Separator (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Nitrogen	Xenon	Xenon	Xe	ALL
Oxygen	Ozone	Ozone	O3	HC
	Cl2	Cl2	Cl2	SOLID
	HCl	HCl	HCl	MISC
	F2	F2	F2	AMINE
	HF	HF	HF	ALCOHOL
	Br2	Bromine	Br2	KETONE
	HBr	HBr	HBr	ALDEHYDE
	I2	Iodine	I2	ESTER
	HI	HI	HI	CARBACID
	NitricOxide	NO	NO	HALOGEN
	NO2	NO2	NO2	NITRILE
	N2O	N2O	N2O	PHENOL
	N2O4	N2O4	N2O4	ETHER
	SO2	SO2	SO2	USER
	SO3	SO3	SO3	

Search by SYNONYM

F1 - Help, F4 - Flip Srch, F5 - Exam, F6 - Move,
F3 - Menu, PRESS INSERT TO SUBMIT F8 - Change

Step	Action
	Specifying the solid component of the feed stream.
6	Highlight the word **SOLID** under the "Criteria" column heading and then press the <Enter> key;
	The following screen will then appear.

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Nitrogen	HYPOTHETICAL	HYPOTHETICAL		ALL
Oxygen	Sulphur_Rhombic	S_Rhombic	S	HC
	Sulphur_Monoclinic	S_Monoclinic	S	SOLID
	Sulphur_Amorphous	S_Amorphous	S	MISC
	Carbon	Carbon	C	AMINE
	Urea	Urea	CH4N2O	ALCOHOL
	Silver	Silver	Ag	KETONE
	Beryllium	Beryllium	Be	ALDEHYDE
	Bismuth	Bismuth	Bi	ESTER
	Calcium	Calcium	Ca	CARBACID
	S_Rhombic	S_Rhombic	S	HALOGEN
	S_Monoclinic	S_Monoclinic	S	NITRILE
	S_Amorphous	S_Amorphous	S	PHENOL
	2-Phenyl-1-Propene	Beryllium	Be	ETHER
	Sulfur	S_Rhombic	S	USER
	Brimstone	S_Rhombic	S	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

3.7.3 Cyclone Solids Separator (continued)

Step	Action
7	Highlight the word **Hypothetical** under the "COMPONENT SELECTION" Column and then press the <**Enter**> key;
	The following screen will then appear:

```
HC                  Solid               Misc                Amine
Alcohol             Ketone              Aldehyde            Ester
CarbAcid            Halogen             Nitrile             Phenol
Ether
HC  HC-HC interaction parameters will be calculated and assigned
What is the component type?
>
```

Step	Action
8	Highlight the word **Solid** and then press the <**Enter**> key;
	The following screen will then appear:

```
Solid Hypothetical Component Information

Name: _____        Chemical Formula: _____

Solid Density     [kg/m3__] : ___        Coal Analysis
Molecular Weight            : ___          Carbon: _____ %
Average Diameter  [mm_____] : ___        Hydrogen: _____ %
Sphericity                  : ___        Nitrogen: _____ %
Area/Unit Volume  [m2/m3__] : ___          Oxygen: _____ %
                                           Sulphur: _____ %
Specific Heat Coefficents                 Chlorine: _____ %
(Mass Basis - solid @ 25 C)
Cp     = _____ kJ/kg-K_   Heat of Formation and Combustion
       + _____ * T        (Molar Basis - Ideal gas @ 25 C)
       + _____ * T^2      Heat Formation : _____
       + _____ * T^3      Heat Combustion: _____
       + _____ * T^4

  Vapour Pressure [deg K, kPa]   Ideal Gas Gibbs Free Energy
ANTA: _____  ANTD: _____         (Molar Basis - Ideal gas @ 25 C)
ANTB: _____  ANTE: _____         Gibbs  = _____ kJ/kgmol
ANTC: _____  ANTF: _____                + _____ * T
TMIN: _____  TMAX: _____                + _____ * T^2
```

3.7.3 Cyclone Solids Separator (continued)

Step	Action
9	Type the word **Catalyst** and then press the <**Enter**> key two times;
	Specifying the Solid Density of the Catalyst in kg/m^3.
10	Type the number **2995.5** and then press the <**Enter**> key;
	Specifying the Molecular Weight of the Catalyst.
11	Type the number **100** and then press the <**Enter**> key;
	Specifying the Average Diameter of the Catalyst Particle in millimeters (mm).
12	Type the number **0.006** and then press the <**Enter**> key;
	Specifying the Sphericity of the Catalyst Particle.
13	Type the number **0.9**;
	The following screen will then appear:

```
═══════ Solid Hypothetical Component Information ═══════

Name: Catalyst____          Chemical Formula: _____________

Solid Density     [kg/m3__]: 2995.5      Coal Analysis
Molecular Weight           : 100___      Carbon: _______ %
Average Diameter [mm_____]: 0.006_      Hydrogen: _______ %
Sphericity                 : 0.9___     Nitrogen: _______ %
Area/Unit Volume [m2/m3__]: _______      Oxygen: _______ %
                                         Sulphur: _______ %
Specific Heat Coefficents                Chlorine: _______ %
(Mass Basis - solid @ 25 C)
Cp    = _______________ kJ/kg-K_     Heat of Formation and Combustion
      + _______________ * T          (Molar Basis - Ideal gas @ 25 C)
      + _______________ * T^2        Heat Formation : _____________
      + _______________ * T^3        Heat Combustion: _____________
      + _______________ * T^4

  Vapour Pressure [deg K, kPa]       Ideal Gas Gibbs Free Energy
ANTA: _____________ ANTD: _______    (Molar Basis - Ideal gas @ 25 C)
ANTB: _____________ ANTE: _______    Gibbs = _______________ kJ/kgmol
ANTC: _____________ ANTF: _______          + _______________ * T
TMIN: _____________ TMAX: _______          + _______________ * T^2
```

Step	Action
14	Press the <**Insert**> key.
	The screen will then appear as shown on the following page.

3.7.3 Cyclone Solids Separator (continued)

```
Solid Hypothetical Component Information
  Are The Component Calculations Satisfactory: Yes_____
Name: Catalyst                  Chemical Formula: Catalyst

Solid Density     [kg/m3__]:  2995.500
Molecular Weight            :   100.000
Average Diameter  [mm_____]:6.0000e-03
Sphericity                  :   0.90000
Area/Unit Volume  [m2/m3__]:  1.67e+05

Specific Heat Coefficents
(Mass Basis - solid @ 25 C)
Cp     = -3.0217652e+00 kJ/kg-K_
       +  6.0891764e-03 * T
       + -2.6071865e-06 * T^2
       +  0.0000000e+00 * T^3
       +  0.0000000e+00 * T^4

  Vapour Pressure [deg K, kPa]
ANTA:  1.00000e+00  ANTD:  0.00000e+00
ANTB:  0.00000e+00  ANTE:  0.00000e+00
ANTC:  0.00000e+00  ANTF:  0.00000e+00
TMIN: _____________ TMAX: _____________

     Coal Analysis
   Carbon:  0.0000 %
 Hydrogen:  0.0000 %
 Nitrogen:  0.0000 %
   Oxygen:  0.0000 %
  Sulphur:  0.0000 %
 Chlorine:  0.0000 %

Heat of Formation and Combustion
(Molar Basis - Ideal gas @ 25 C)
Heat Formation : _____________
Heat Combustion: _____________

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____________ kJ/kgmol
       + _____________ * T
       + _____________ * T^2
```

Step	Action
15	Press the <**Insert**> key;
	The following screen will then appear:

```
                    COMPONENT SELECTION
  Selected  |  Synonym              Name            Formula |  Criteria
 ---------- | ---------- ---------- ---------- ---------- | ----------
Nitrogen    | HYPOTHETICAL          HYPOTHETICAL            | ALL
Oxygen      | Sulphur_Rhombic       S_Rhombic       S       | HC
Catalyst    | Sulphur_Monoclinic    S_Monoclinic    S       | SOLID
            | Sulphur_Amorphous     S_Amorphous     S       | MISC
            | Carbon                Carbon          C       | AMINE
            | Urea                  Urea            CH4N2O  | ALCOHOL
            | Silver                Silver          Ag      | KETONE
            | Beryllium             Beryllium       Be      | ALDEHYDE
            | Bismuth               Bismuth         Bi      | ESTER
            | Calcium               Calcium         Ca      | CARBACID
            | S_Rhombic             S_Rhombic       S       | HALOGEN
            | S_Monoclinic          S_Monoclinic    S       | NITRILE
            | S_Amorphous           S_Amorphous     S       | PHENOL
            | 2-Phenyl-1-Propene    Beryllium       Be      | ETHER
            | Sulfur                S_Rhombic       S       | USER
            | Brimstone             S_Rhombic       S       |
 ---------- | ---------- ---------- ---------- ---------- | ----------
                                  Search by SYNONYM
 F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
                      PRESS INSERT TO SUBMIT    F8 - Change
```

3.7.3 Cyclone Solids Separator (continued)

Step	Action
16	Press the <**Insert**> key;
	The following screen will then appear:

```
Interaction Parameters
   Enter H for all k(j,HC),  Ins to Exit,
                Nitrogen     Oxygen       Catalyst
Nitrogen          ---         -0.0120       ---
Oxygen          -0.0120       ---           ---
Catalyst          ---         ---           ---
```

Step	Action
17	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
18	Highlight the word **Specify** and then press the <**Enter**> key;
19	Highlight the word **Stream** and then press the <**Enter**> key;
20	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature in ℃ of the Feed.
21	Type the number **25** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
22	Type the number **101** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in kg-mols/hour.
23	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Feed.
24	Highlight the word **Mole_Fractions** after the prompt (>) and then press the <**Enter**> key;
	The screen will appear as shown below:

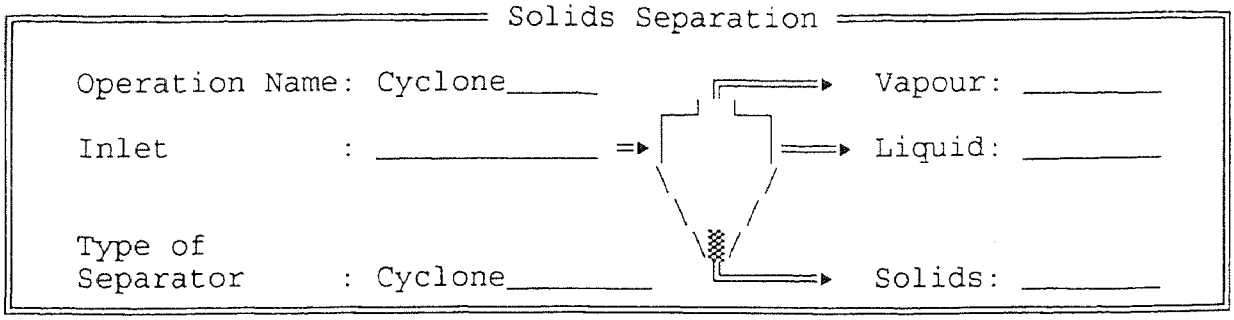
```
Stream Mole Fractions

Nitrogen  _____________    Oxygen  _____________
Catalyst  _____________
```

Step	Action
	Entering the mole-fractions of the components in the Feed stream.
25	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Nitrogen, type the number **0.782** in the blank and then press the <**Enter**> key; After the word, Oxygen, type the number **0.208** in the blank and then press the <**Enter**> key; After the word, Catalyst, type the number **0.01**;
	The screen will now appear as shown below.

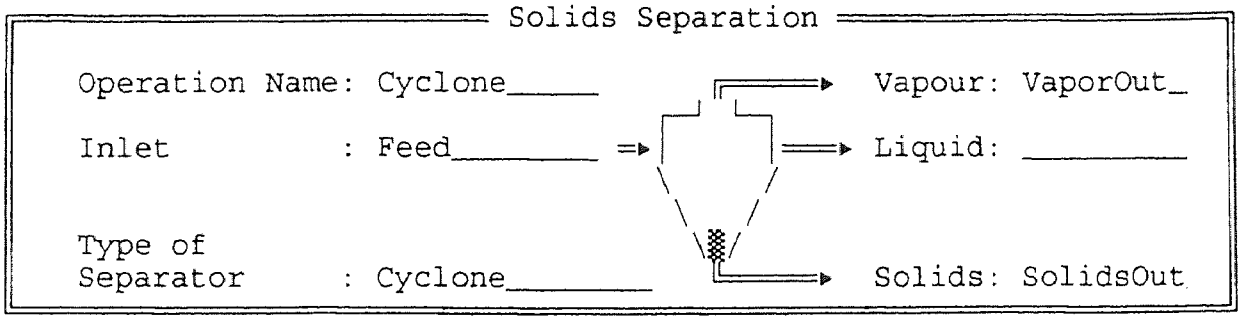
```
Stream Mole Fractions

Nitrogen  0.782_____________    Oxygen  0.208_____________
Catalyst  0.01_____________
```

3.7.3 Cyclone Solids Separator (continued)

Step	Action
26	Press the <**Insert**> key;
27	Highlight the word **Operation** and then press the <**Enter**> key;
28	Type the word **Cyclone** and then press the <**Enter**> key;
29	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



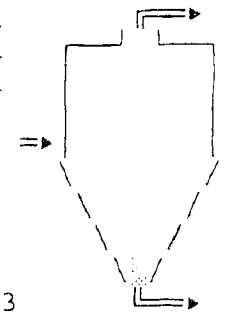
Step	Action
	Specifying the names of the streams entering and leaving the Cyclone.
30	Type the word **Feed** and then press the <**Enter**> key;
31	Type the word **VaporOut** and then press the <**Enter**> key;
32	Press the <**Enter**> key;
33	Type the word **SolidsOut** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
34	Press the <**Insert**> key;
	The screen will then appear as shown on the following page.

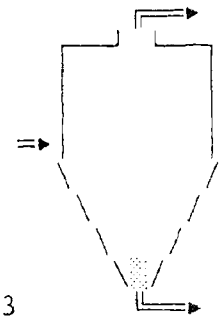
3.7.3 Cyclone Solids Separator (continued)

```
Solids Separation - Cyclone Initial Parameters

Operation Name          : Cyclone_____
Configuration           : Efficiency__
Efficiency Method       : Lapple______

Objective                                  =>
  Efficiency            : _______ %
  Solid Name            : ___________
     -or-
  Particle Diameter     : _______ mm
  Particle Density      : _______ kg/m3

Maximum Diameter        :    5.00 m
Minimum Diameter        :    0.30 m
Maximum Pressure Drop   :   15.00 kPa
```



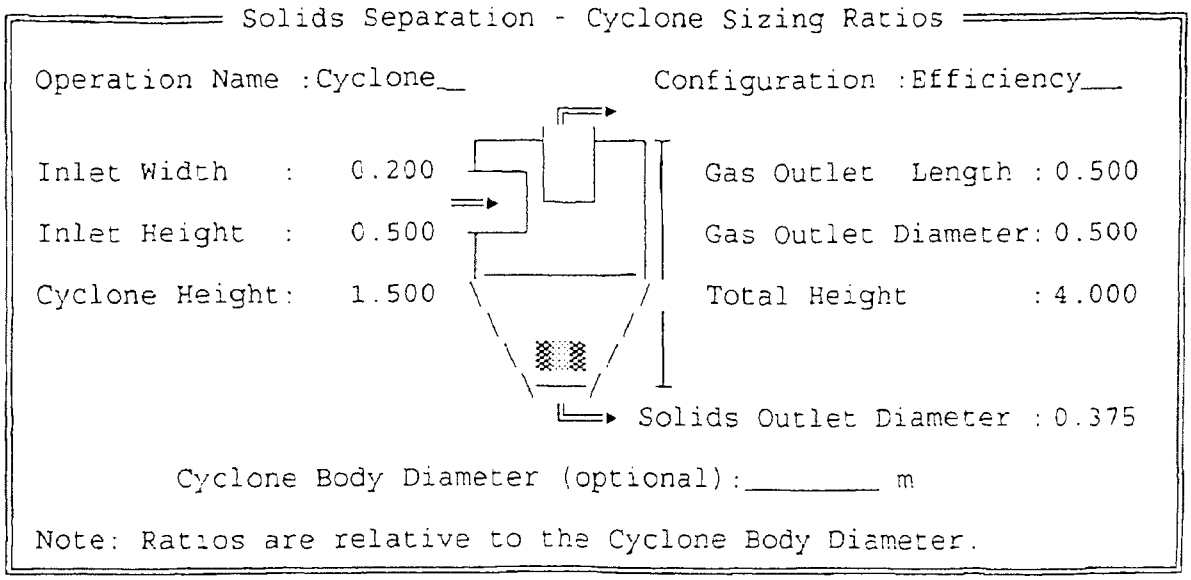
Step	Action
	Specifying the Configuration for the Cyclone. The configuration can either be high efficiency or high output. We will leave it in the HYSIM default mode of high efficiency.
35	Press the <**Enter**> key.
	Specifying the Efficiency Method of either Lapple (HYSIM default mode) or Leith Licht. The Leith Licht efficiency method is more rigorous than the Lapple method.
36	Press the <**Delete**> key until the word Lapple is deleted; then press the <**F2**> key and highlight the word **Leith/Licht**; then press the <**Enter**> key.
	Specifying the cyclone efficiency as a percentage (%).
37	Type the number **85** and then press the <**Enter**> key;
	Specifying the name of the solid that will be separated by the cyclone.
38	Type the word **Catalyst** and then press the <**Enter**> key;
	The screen will then appear as shown below.

```
Solids Separation - Cyclone Initial Parameters

Operation Name          : Cyclone_____
Configuration           : Efficiency__
Efficiency Method       : Leith/Licht_

Objective                                  =>
  Efficiency            : 85_____ %
  Solid Name            : Catalyst____
     -or-
  Particle Diameter     : _______ mm
  Particle Density      : _______ kg/m3

Maximum Diameter        :    5.00 m
Minimum Diameter        :    0.30 m
Maximum Pressure Drop   :   15.00 kPa
```



3.7.3 Cyclone Solids Separator (continued)

Step	Action
39	Press the <**Insert**> key.
	The following screen defining the dimensional sizing ratios of the separator will then appear.



Step	Action
40	Press the <**Insert**> key.
	Printing Results from the Cyclone HYSIM run.
41	Highlight the word **Print** and then press the <**Enter**> key.

Print Options:

The various print options available are as follows:

a) *Streams* - the conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files

j) *Description* - Prints case description.

k) *Oil Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

3.7.3 Cyclone Solids Separator (continued)

Step	Action
42	Highlight the word **Streams** and then press the <**Enter**> key.
43	Highlight the word **All** and then press the <**Enter**> key.
44	Highlight the dash symbol - and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
45	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream		Feed	VaporOut	SolidsOut
Description				
Vapour frac.		0.9900	0.9985	0.0000
Temperature	C	25.0000*	25.0000	25.0000
Pressure	kPa	101.0000*	99.7838	99.7838
Molar Flow	kgmole/h	100.0000*	99.1500	0.8500
Mass Flow	kg/h	2956.2166	2871.2134	85.0033
LiqVol Flow	m3/h	3.3351	3.3067	0.0284
Enthalpy	kJ/h	701221.3867	833663.4135	-132432.3115
Density	kg/m3	1.2173	1.1681	2995.5000
Mole Wt.		29.5622	28.9583	100.0000
Spec. Heat	kJ/kg-C	0.9278	0.9979	0.0100
Therm Cond	W/m-K	---	---	---
Viscosity	cP	---	---	---
Z Factor		---	---	0.0013
Sur Tension	dyne/cm	---	---	---
Std Density	kg/m3	---	---	2995.5000
Nitrogen	mole frac.	0.7820*	0.7887	0.0000
Oxygen	mole frac.	0.2080*	0.2098	0.0000
Catalyst	mole frac.	0.0100*	0.0015	1.0000

Step	Action
46	Press the <**F10**> key;
47	Highlight the word **Print** and then press the <**Enter**> key.

The various print options can be found on page 292.

Step	Action
48	Highlight the word **Spec_Sheets** and then press the <**Enter**> key.
49	Highlight the word **Operations** and then press the <**Enter**> key.
50	Highlight the word **Cyclone** and then press the <**Enter**> key.
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
51	Press the <**F10**> key;
	The screen will then appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.3 Cyclone Solids Separator (continued)

HYSIM CYCLONE SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/10/04
Case Name: Time 13:20:22
Operation Name: Cyclone
Operation Note:

Stream		Operation			Flowrate
Inlet:	Feed	from	---	---	2956.2166 kg/h
					100.0000 kgmole/h
Solids:	SolidsOut	to	---	---	85.0033 kg/h
					0.8500 kgmole/h
Vapour:	VaporOut	to	---	---	2871.2134 kg/h
					99.1500 kgmole/h

Inlet Properties

Temperature	25.0000	C
Pressure	101.0000	kPa
Mass Frac Vapour	0.9662	
Mass Frac Solid	0.0338	
Density	1.2173	kg/m3
Spec. Grav.	0.0012	SG_H2O60
Mol. Weight	29.56	

Vapour Outlet Properties

Density	1.17	kg/m3
Mol. Weight	28.9583	
Z factor	---	

Solids Outlet Properties

Density	2995.5000	kg/m3
Spec. Grav.	3.0015	SG_H2O60ap
Mol. Weight	100.0000	

Solids Outlet Efficiencies

Solid1	Catalyst	85.00	%
Solid2	---	---	%
Solid3	---	---	%
Solid4	---	---	%
Solid5	---	---	%
Solid6	---	---	%
Overall Efficiency		85.00	%

Objective Sizing Parameters

Efficiency	85.0000	%
Diameter	6.000E-06	m
Density	2995.5000	kg/m3

Cyclone Sizing Parameters

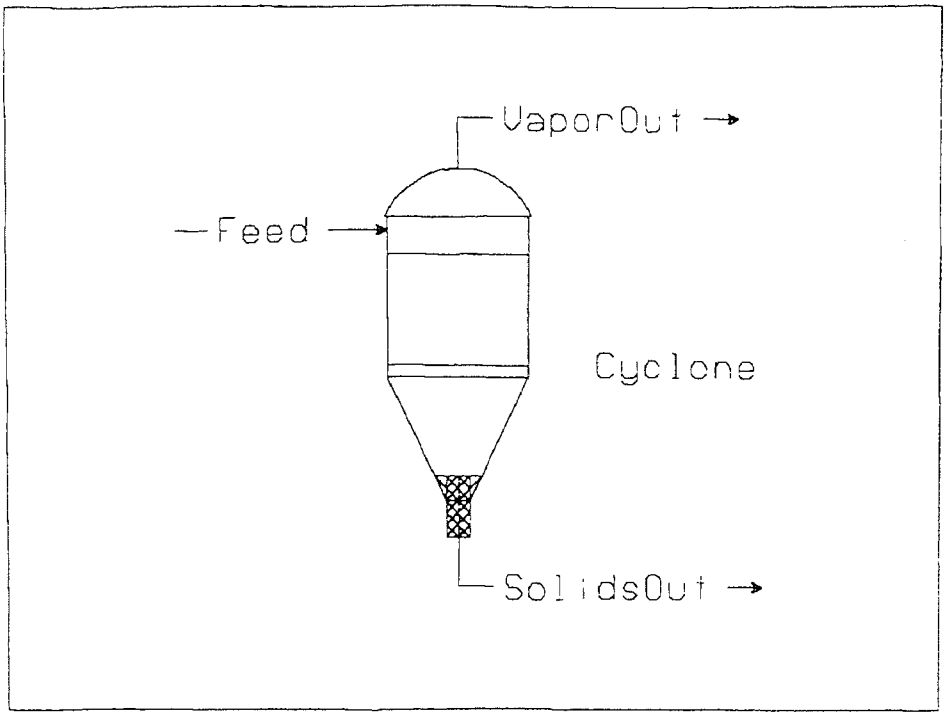
Efficiency Type LEITH
Configuration High Efficiency

Diameter	0.6110	m
Cyclone Height	0.9164	m
Total Height	2.4438	m
Cyclones in Parallel	1.0	
Inlet duct		
Height	0.3055	m
Width	0.1222	m
Overflow		
Height	0.3055	m
Diameter	0.3055	m
Underflow		
Diameter	0.2291	m

NOTES :

3.7.3 Cyclone Solids Separator (continued)

Step	Action
52	Press the <**F10**> key;
53	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
	Getting back to the Main Menu.
54	Press the <**Esc**> key until you reach the Main Menu.
	Sizing the Cyclone.
55	Highlight the word **Size** and then press the <**Enter**> key;
56	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
57	Highlight the word **Cyclone** and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it
58	Press the <**F10**> key;
	The screen will then appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.3 Cyclone Solids Separator (continued)

Cyclone Sizing	
Operation Name	Cyclone
Configuration	High Efficiency
Efficiency Type	Leith
Diameter	0.6101 m
Cyclone Height	0.9152 m
Total Height	2.4405 m
Cyclones In Parallel	1.0000
Pressure Drop	1.2228 kPa
Inlets and Outlets	
Inlet Duct: Height	0.3051 m
Width	0.1220 m
Overflow : Height	0.3051 m
Diameter	0.3051 m
Underflow : Diameter	0.2288 m
Objective Sizing Parameters	
Efficiency	85.0000 %
Particle Diameter	6.000E-06 m
Particle Density	2995.5000 kg/m3
Achieved Solids Separation Efficiencies	
Catalyst	85.0381 %
Note: Changes done in this utility will not appear in the actual operation.	

Step	Action
59	Press the <**F10**> key;
60	Highlight the word **Quit** and then press the <**Enter**> key;
61	Do you want to continue adding other unit operations to this cyclone? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.7.4 Bag-House Filter Solids Separator

Objective - This exercise is an example of a Bag-House Filter Solid Separation calculation. The purpose of the Bag-House Filter operation is to separate solids from a gaseous feed stream. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

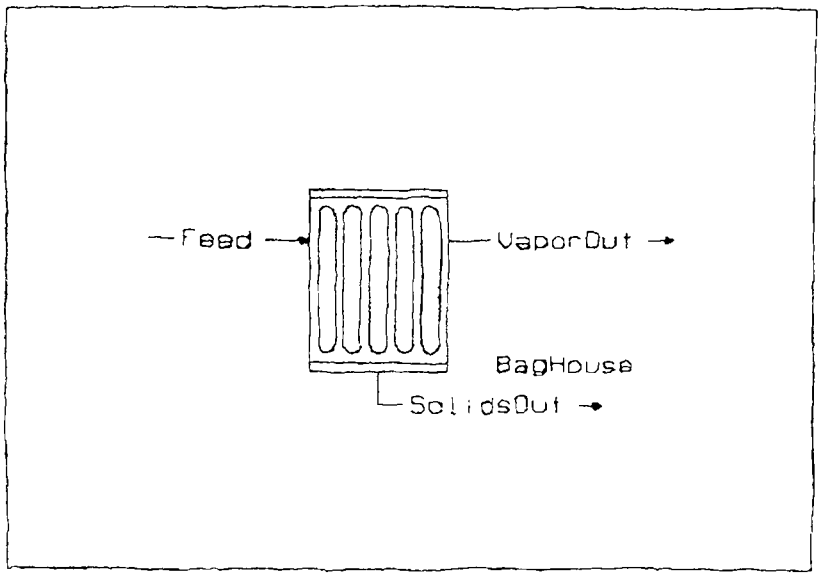
In this example, a feed stream consists of nitrogen, oxygen and solid catalyst. The bag-house filter separator is used to separate the solid catalyst from the nitrogen and oxygen in the feed stream

Technical Reference Example Reference 1 - HYSIM User's Guide, page 7-118 Reference 2 - HYSIM Special Features and Applications Guide, pages 2-20 to 2-25.
Other References: Refs. 1 and 2.

Directions - Pages 298 through 307 outline the execution of a bag-house filter solids separator example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g. <Esc>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *BagHouse*, is shown below.



3.7.4 *Bag-House Filter Solids Separator (continued)*

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package
3	Highlight the word **PR_Options** and then press the <**Enter**> key;
4	Highlight the word **PRSV** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream
5	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components.* Highlight the word **Nitrogen** and then press the <**Enter**> key. Highlight the word **Oxygen** and then press the <**Enter**> key.
	The screen on the following page will then appear.

3.7.4 Bag-House Filter Solids Separator (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Nitrogen	1-C19#	1-Nonadecyn	C19H36	ALL
Oxygen	1-C20#	1-Eicosyne	C10H38	HC
	NH3	Ammonia	NH3	SOLID
	Deuterium-eq	Deuterium-eq	D2	MISC
	H2	Hydrogen	H2	AMINE
	H2O	H2O	H2O	ALCOHOL
	H2O2	H2O2	H2O2	KETONE
	D2O	D2O	D2O	ALDEHYDE
	He	Helium	He	ESTER
	Neon	Neon	Ne	CARBACID
	Argon	Argon	Ar	HALOGEN
	Krypton	Krypton	Kr	NITRILE
	Xenon	Xenon	Xe	PHENOL
	Ozone	Ozone	O3	ETHER
	Cl2	Cl2	Cl2	USER
	HCl	HCl	HCl	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
	Specifying the solid component of the feed stream.
6	Highlight the word **SOLID** under the "Criteria" column heading and then press the <**Enter**> key.
	The following screen will then appear.

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Nitrogen	HYPOTHETICAL	HYPOTHETICAL		ALL
Oxygen	Sulphur_Rhombic	S_Rhombic	S	HC
	Sulphur_Monoclinic	S_Monoclinic	S	SOLID
	Sulphur_Amorphous	S_Amorphous	S	MISC
	Carbon	Carbon	C	AMINE
	Urea	Urea	CH4N2O	ALCOHOL
	Silver	Silver	Ag	KETONE
	Beryllium	Beryllium	Be	ALDEHYDE
	Bismuth	Bismuth	Bi	ESTER
	Calcium	Calcium	Ca	CARBACID
	S_Rhombic	S_Rhombic	S	HALOGEN
	S_Monoclinic	S_Monoclinic	S	NITRILE
	S_Amorphous	S_Amorphous	S	PHENOL
	2-Phenyl-1-Propene	Beryllium	Be	ETHER
	Sulfur	S_Rhombic	S	USER
	Brimstone	S_Rhombic	S	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
7	Highlight the word **Hypothetical** under the "COMPONENT SELECTION" Column and then press the <**Enter**> key;
	The following screen will then appear:

```
HC                  Solid               Misc                Amine
Alcohol             Ketone              Aldehyde            Ester
CarbAcid            Halogen             Nitrile             Phenol
Ether
HC  HC-HC interaction parameters will be calculated and assigned
What is the component type?
>
```

Step	Action
8	Highlight the word **Solid** and then press the <**Enter**> key;
	The following screen will then appear:

```
Solid Hypothetical Component Information

Name: __                    Chemical Formula: _____________

Solid Density     [kg/m3__] : __        Coal Analysis
Molecular Weight            : __          Carbon: _____ %
Average Diameter  [mm_____] : __        Hydrogen: _____ %
Sphericity                  : __        Nitrogen: _____ %
Area/Unit Volume  [m2/m3__] : __          Oxygen: _____ %
                                          Sulphur: _____ %
Specific Heat Coefficents                 Chlorine: _____ %
(Mass Basis - solid @ 25 C)
Cp    = _____________ kJ/kg-K     Heat of Formation and Combustion
      + _____________ * T         (Molar Basis - Ideal gas @ 25 C)
      + _____________ * T^2       Heat Formation : _____________
      + _____________ * T^3       Heat Combustion: _____________
      + _____________ * T^4

  Vapour Pressure [deg K, kPa]    Ideal Gas Gibbs Free Energy
ANTA: _____________ ANTD: _____   (Molar Basis - Ideal gas @ 25 C)
ANTB: _____________ ANTE: _____   Gibbs  = _____________ kJ/kgmol
ANTC: _____________ ANTF: _____         + _____________ * T
TMIN: _____________ TMAX: _____         + _____________ * T^2
```

Step	Action
9	Type the word **Catalyst** and then press the <**Enter**> key two times;
	Specifying the Solid Density of the Catalyst in kg/m^3.
10	Type the number **2995.5** and then press the <**Enter**> key;

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
	Specifying the Molecular Weight of the Catalyst.
11	Type the number **100** and then press the <**Enter**> key;
	Specifying the Average Diameter of the Catalyst Particle in millimeters, mm.
12	Type the number **0.006** and then press the <**Enter**> key,
	Specifying the Sphericity of the Catalyst Particle.
13	Type the number **0.9**;
	The following screen will then appear:

```
═══════ Solid Hypothetical Component Information ═══════

Name: Catalyst_              Chemical Formula: _____________

Solid Density     [kg/m3__] : 2995.5   |     Coal Analysis
Molecular Weight            : 100___   |   Carbon: _______ %
Average Diameter  [mm_____] : 0.006    |  Hydrogen: _______ %
Sphericity                  : 0.9__    |  Nitrogen: _______ %
Area/Unit Volume  [m2/m3__] : _____    |    Oxygen: _______ %
                                       |   Sulphur: _______ %
Specific Heat Coefficents              |  Chlorine: _______ %
(Mass Basis - solid @ 25 C)            |
Cp    = _____________ kJ/kg-K_         | Heat of Formation and Combustion
      + _____________ * T              | (Molar Basis - Ideal gas @ 25 C)
      + _____________ * T^2            | Heat Formation : _____________
      + _____________ * T^3            | Heat Combustion: _____________
      + _____________ * T^4            |
                                       |
  Vapour Pressure [deg K, kPa]         | Ideal Gas Gibbs Free Energy
ANTA: _____________ ANTD: _______      | (Molar Basis - Ideal gas @ 25 C)
ANTB: _____________ ANTE: _______      | Gibbs = _____________ kJ/kgmol
ANTC: _____________ ANTF: _______      |       + _____________ * T
TMIN: _____________ TMAX: _______      |       + _____________ * T^2
```

Step	Action
14	Press the <**Insert**> key;
	The screen will then appear as shown on the following page

3.7.4 Bag-House Filter Solids Separator (continued)

```
Solid Hypothetical Component Information
   Are The Component Calculations Satisfactory: Yes_____
Name: Catalyst                  Chemical Formula: Catalyst

Solid Density     [kg/m3__] :   2995.500
Molecular Weight            :    100.000
Average Diameter  [mm_____] : 6.0000e-03
Sphericity                  :    0.90000
Area/Unit Volume  [m2/m3__] :   1.67e+05

Specific Heat Coefficents
(Mass Basis - solid @ 25 C)
Cp     = -3.0217652e+00 kJ/kg-K_
       +  6.0891764e-03 * T
       + -2.6071865e-06 * T^2
       +  0.0000000e+00 * T^3
       +  0.0000000e+00 * T^4

  Vapour Pressure [deg K, kPa]
ANTA:  1.00000e+00  ANTD:  0.00000e+00
ANTB:  0.00000e+00  ANTE:  0.00000e+00
ANTC:  0.00000e+00  ANTF:  0.00000e+00
TMIN: _____________ TMAX: _____________

      Coal Analysis
   Carbon:  0.0000 %
 Hydrogen:  0.0000 %
 Nitrogen:  0.0000 %
   Oxygen:  0.0000 %
  Sulphur:  0.0000 %
 Chlorine:  0.0000 %

Heat of Formation and Combustion
(Molar Basis - Ideal gas @ 25 C)
Heat Formation : _____________
Heat Combustion: _____________

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____________ kJ/kgmol
       + _____________ * T
       + _____________ * T^2
```

Step	Action
15	Press the <Insert> key;
	The following screen will then appear:

```
COMPONENT SELECTION
  Selected   |  Synonym              Name              Formula | Criteria
 ------------|-------------------------------------------------|----------
Nitrogen     | HYPOTHETICAL          HYPOTHETICAL              | ALL
Oxygen       | Sulphur_Rhombic       S_Rhombic         S       | HC
Catalyst     | Sulphur_Monoclinic    S_Monoclinic      S       | SOLID
             | Sulphur_Amorphous     S_Amorphous       S       | MISC
             | Carbon                Carbon            C       | AMINE
             | Urea                  Urea              CH4N2O  | ALCOHOL
             | Silver                Silver            Ag      | KETONE
             | Beryllium             Beryllium         Be      | ALDEHYDE
             | Bismuth               Bismuth           Bi      | ESTER
             | Calcium               Calcium           Ca      | CARBACID
             | S_Rhombic             S_Rhombic         S       | HALOGEN
             | S_Monoclinic          S_Monoclinic      S       | NITRILE
             | S_Amorphous           S_Amorphous       S       | PHENOL
             | 2-Phenyl-1-Propene    Beryllium         Be      | ETHER
             | Sulfur                S_Rhombic         S       | USER
             | Brimstone             S_Rhombic         S       |
 ------------|-------------------------------------------------|----------
             |                    Search by SYNONYM
 F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
                      PRESS INSERT TO SUBMIT  F8 - Change
```

Step	Action
16	Press the <Insert> key;
	The following screen will then appear:

```
Interaction Parameters
  Enter H for all k(j,HC),  Ins to Exit,
                Nitrogen      Oxygen        Catalyst
Nitrogen          ---         -0.0120         ---
Oxygen          -0.0120         ---           ---
Catalyst          ---           ---           ---
```

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
17	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
18	Highlight the word **Specify** and then press the <**Enter**> key;
19	Highlight the word **Stream** and then press the <**Enter**> key;
20	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed in °C.
21	Type the number **25** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
22	Type the number **101** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in kg-mols/hr.
23	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Feed.
24	Highlight the word **Mole_Fractions** after the prompt (>) and then press the <**Enter**> key.
	The screen will appear as shown below:

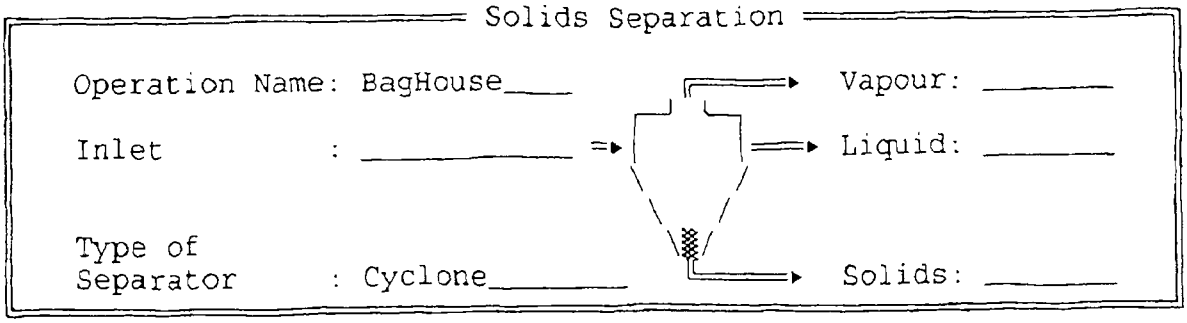
```
═══════ Stream Mole Fractions ═══════

Nitrogen  _____________   Oxygen  _____________
Catalyst  _____________
```

Step	Action
	Entering the mole-fractions of the components in the Feed stream.
25	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Nitrogen, type the number **0.782** in the blank and then press the <**Enter**> key; After the word, Oxygen, type the number **0.208** in the blank and then press the <**Enter**> key; After the word, Catalyst, type the number **0.01**;
	The screen will now appear as shown below.

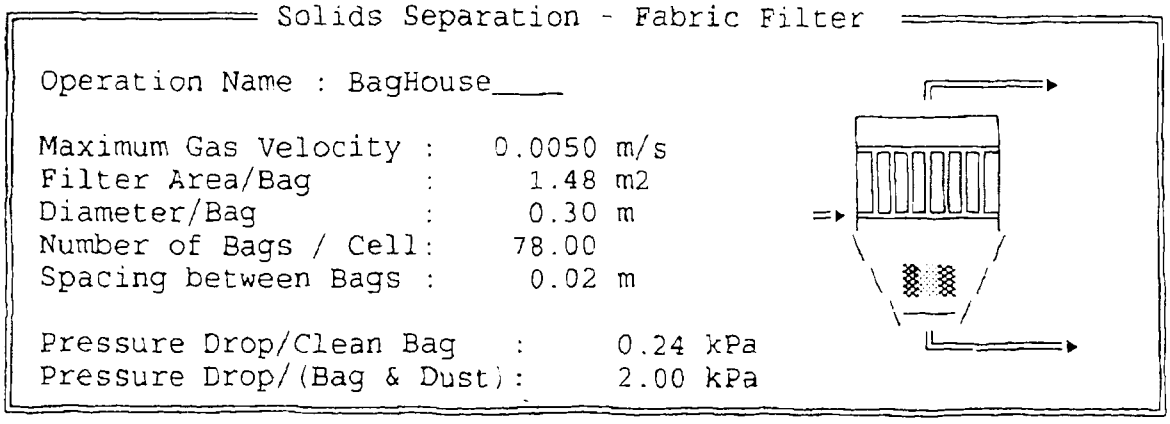
```
═══════ Stream Mole Fractions ═══════

Nitrogen  0.782_____________   Oxygen  0.208_____________
Catalyst  0.01_____________
```

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
26	Press the <**Insert**> key;
27	Highlight the word **Operation** and then press the <**Enter**> key;
28	Type the word **BagHouse** and then press the <**Enter**> key;
29	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below



Step	Action
	Specifying the names of the streams entering and leaving the Bag-House Filter.
30	Type the word **Feed** and then press the <**Enter**> key;
31	Type the word **VaporOut** and then press the <**Enter**> key ;
32	Press the <**Enter**> key;
33	Type the word **SolidsOut** and then press the <**Enter**> key
	Specifying that the solids separator will be a Bag-House Filter type.
34	Press the <**Delete**> key until the word Cyclone is deleted; then press the <**F2**> key. Highlight the word **Bag_Filter** and then press the <**Enter**> key
	The following screen will then appear



Step	Action
35	Press the <**Insert**> key
	Printing Results from the Bag-House Filter HYSIM run
36	Highlight the word **Print** and then press the <**Enter**> key.

3.7.4 Bag-House Filter Solids Separator (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
37	Highlight the word **Streams** and then press the **<Enter>** key.
38	Highlight the word **All** and then press the **<Enter>** key.
39	Highlight the dash symbol - and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
40	Press the **<F10>** key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream Description		Feed	VaporOut	SolidsOut
Vapour frac.		0.9900	1.0000	0.0000
Temperature	C	25.0000*	25.0000	25.0000
Pressure	kPa	101.0000*	99.0000	99.0000
Molar Flow	kgmole/h	100.0000*	99.0044	0.9956
Mass Flow	kg/h	2956.2166	2856.6567	99.5600
LiqVol Flow	m3/h	3.3351	3.3018	0.0332
Enthalpy	kJ/h	701221.3867	856348.5349	-155111.2420
Density	kg/m3	1.2173	1.1530	2995.5000
Mole Wt.		29.5622	28.8538	100.0000
Spec. Heat	kJ/kg-C	0.9278	1.0103	0.0100
Therm Cond	W/m-K	---	---	---
Viscosity	cP	---	---	---
Z Factor		---	---	0.0013
Sur Tension	dyne/cm	---	---	---
Std Density	kg/m3	---	---	2995.5000
Nitrogen	mole frac.	0.7820*	0.7899	0.0000
Oxygen	mole frac.	0.2080*	0.2101	0.0000
Catalyst	mole frac.	0.0100*	0.0000	1.0000

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
41	Press the <**F10**> key;
42	Highlight the word **Print** and then press the <**Enter**> key.

The various print options can be found on page 305.

Step	Action
43	Highlight the word **Spec_Sheets** and then press the <**Enter**> key.
44	Highlight the word **Operations** and then press the <**Enter**> key.
45	Highlight the word **BagHouse** and then press the <**Enter**> key.
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
46	Press the <**F10**> key;
	The screen will then appear as seen below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

HYSIM BAGHOUSE FABRIC FILTER SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/10/04
Case Name: Time 14:29:47

Operation Name: BagHouse
Operation Note:

Stream		Operation			Flowrate	
Inlet:	Feed	from	---	---	2956.2166	kg/h
					100.0000	kgmole/h
Solids:	SolidsOut	to	---	---	99.5600	kg/h
					0.9956	kgmole/h
Vapour:	VaporOut	to	---	---	2856.6567	kg/h
					99.0044	kgmole/h

Inlet Properties		
Temperature	25.0000	C
Pressure	101.0000	kPa
Mass Frac Vap	0.9662	
Mass Frac Solid	0.0338	
Density	1.2173	kg/m3
Spec Grav	0.0012	SG_H2O60
Mol Weight	29.5622	

Vapour Outlet Properties		
Density	1.1530	kg/m3
Mol Weight	28.8538	
Z Factor	---	

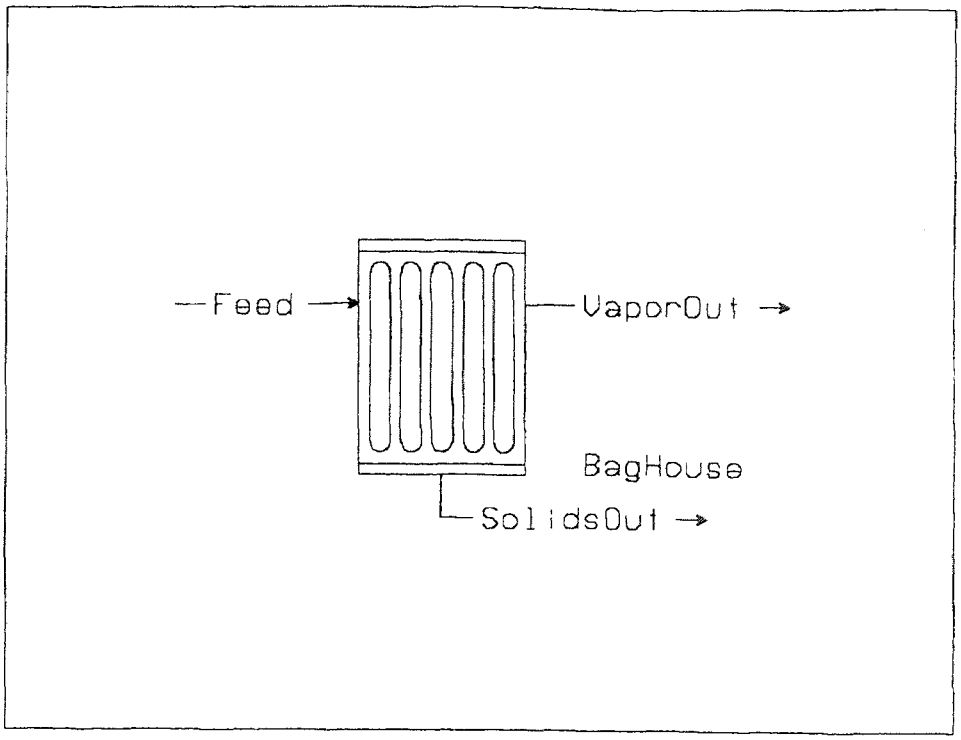
Solids Outlet Properties		
Density	2995.5000	kg/m3
Spec Grav	3.0015	SG_H2O60ap
Mol Weight	100.0000	

Baghouse Sizing Parameters		
Cells in Use	2.0000	
Bags / Cell	78.0000	
Spacing	0.0200	m
Floor Area	28.3842	m2
Bag Information		
Diameter	0.3000	m
Area	1.4800	m2
Pressure Drop		
Overall	2.0000	kPa
Clean Bag	0.2400	kPa
Gas Velocity	0.0050	m/s

NOTES :

3.7.4 Bag-House Filter Solids Separator (continued)

Step	Action
47	Press the <**F10**> key;
48	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
49	Press the <**Esc**> key;
50	Do you want to continue adding other unit operations to this bag house filter? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

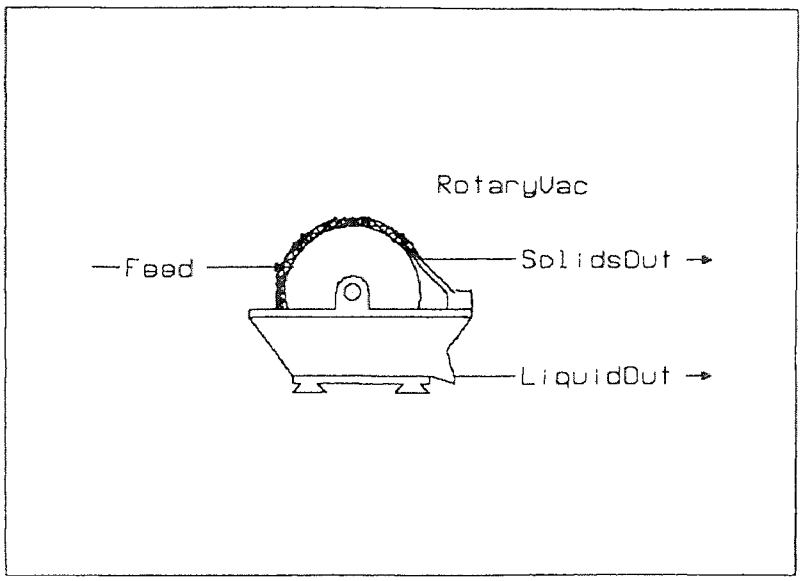
3.7.5 Rotary-Vacuum Filter Solids Separator

Objective - This exercise is an example of a Rotary-Vacuum Filter Solid Separation calculation. The purpose of the Rotary-Vacuum Filter operation is to separate solids from a liquid feed stream. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
In this example, the feed stream consists of water and solid carbon. The rotary vacuum filter is used to separate the water and the solid carbon, into a liquid and solids stream.
Technical Reference Example: Reference 1 - HYSIM User's Guide, pages 7-119 to 7-120.
Reference 2 - HYSIM Special Features and Applications Guide, pages 2-20 to 2-25.
Other References: Refs. 1 and 2.

Directions - Pages 309 through 316 outline the execution of a Rotary-Vacuum Filter example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *RotaryVac*, is shown below:



3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V) • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key.
	Selecting a Property Package.
3	Highlight the word **Peng_Robinson** and then press the <**Enter**> key.
	The following screen will appear.

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight the following component name under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following component:* Highlight the formula **H2O** and then press the <**Enter**> key.
	The screen on the following page will then appear.

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
H2O	H2	Hydrogen	H2	ALL
	He	Helium	He	HC
	Neon	Neon	Ne	SOLID
	Argon	Argon	Ar	MISC
	Krypton	Krypton	Kr	AMINE
	Xenon	Xenon	Xe	ALCOHOL
	N2	Nitrogen	N2	KETONE
	O2	Oxygen	O2	ALDEHYDE
	Ozone	Ozone	O3	ESTER
	Cl2	Cl2	Cl2	CARBACID
	HCl	HCl	HCl	HALOGEN
	F2	F2	F2	NITRILE
	HF	HF	HF	PHENOL
	Br2	Bromine	Br2	ETHER
	HBr	HBr	HBr	USER
	I2	Iodine	I2	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
	Specifying the solid component of the feed stream.
5	Highlight the word **SOLID** under the "Criteria" column heading and then press the <**Enter**> key;
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
H2O	HYPOTHETICAL	HYPOTHETICAL		ALL
	Sulphur_Rhombic	S_Rhombic	S	HC
	Sulphur_Monoclinic	S_Monoclinic	S	SOLID
	Sulphur_Amorphous	S_Amorphous	S	MISC
	Carbon	Carbon	C	AMINE
	S_Rhombic	S_Rhombic	S	ALCOHOL
	S_Monoclinic	S_Monoclinic	S	KETONE
	S_Amorphous	S_Amorphous	S	ALDEHYDE
	Sulfur	S_Rhombic	S	ESTER
	Brimstone	S_Rhombic	S	CARBACID
	Colloidal_Sulfur	S_Rhombic	S	HALOGEN
	Flowers_of_Sulfur	S_Rhombic	S	NITRILE
	Precipitated_Sulfur	S_Rhombic	S	PHENOL
				ETHER
				USER

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Step	Action
6	Highlight the word **Carbon** under the "COMPONENT SELECTION" Column and then press the <**Enter**> key;
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
H2O	HYPOTHETICAL	HYPOTHETICAL		ALL
Carbon	Sulphur_Rhombic	S_Rhombic	S	HC
	Sulphur_Monoclinic	S_Monoclinic	S	SOLID
	Sulphur_Amorphous	S_Amorphous	S	MISC
	S_Rhombic	S_Rhombic	S	AMINE
	S_Monoclinic	S_Monoclinic	S	ALCOHOL
	S_Amorphous	S_Amorphous	S	KETONE
	Sulfur	S_Rhombic	S	ALDEHYDE
	Brimstone	S_Rhombic	S	ESTER
	Colloidal_Sulfur	S_Rhombic	S	CARBACID
	Flowers_of_Sulfur	S_Rhombic	S	HALOGEN
	Precipitated_Sulfur	S_Rhombic	S	NITRILE
				PHENOL
				ETHER
				USER

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
7	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
8	Highlight the word **Specify** and then press the <**Enter**> key;
9	Highlight the word **Stream** and then press the <**Enter**> key;
10	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the Feed temperature in °C.
11	Type the number **25** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
12	Type the number **101** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in kg-mols/hour.
13	Type the number **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed stream will be specified in mole fractions.
14	Highlight the word **Mole_Fractions** after the prompt (>) and then press the <**Enter**> key;
	The screen will appear as shown below:

Stream Mole Fractions

H2O _____ Carbon _____

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Step	Action
	Specifying the mole-fractions of the components in the Feed stream.
15	*Enter the following mole fractions beside each component in the Feed stream:* After the formula, H2O, type the number **0.75** in the blank and then press the <**Enter**> key; After the word, Carbon, type the number **0.25** in the blank;
	The screen will now appear as shown below:

```
═══════════ Stream Mole Fractions ═══════════

H2O          0.75_____________    Carbon     0.25_____________
```

Step	Action
16	Press the <**Insert**> key;
17	Highlight the word **Operation** and then press the <**Enter**> key;
18	Type the word **RotaryVac** and then press the <**Enter**> key;
19	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:

```
═══════════ Solids Separation ═══════════

Operation Name: RotaryVac____                    Vapour: _______

Inlet         : _____________ =>                 Liquid: _______

Type of
Separator     : Cyclone_______                   Solids: _______
```

Step	Action
	Specifying the names of the streams entering and leaving the Rotary-Vacuum Filter Solids Separator..
20	Type the word **Feed** and then press the <**Enter**> key;
21	Press the <**Enter**> key;
22	Type the word **LiquidOut** and then press the <**Enter**> key;
23	Type the word **SolidsOut** and then press the <**Enter**> key.
	Specifying that the solids separator will be a Rotary-Vacuum Filter type.
24	Press the <**Delete**> key until the word Cyclone is deleted; then press the <**F2**> key. Highlight the word **Rotary_Filter**;
25	Press the <**Enter**> key;
	The screen will then appear as shown on the next page.

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

```
═══════════ Solids Separation - Rotary Vacuum Filter ═══════════

Operation Name: RotaryVac___

Operation Parameter                          Filter Size
 Pressure Drop:      10.00 kPa                Radius ____ m
 Cycle Time   :     300 00 seconds            Width  ____ m
 Dewatering   :      45 00 % of Cycle
 Submergence  : _________ % of Cycle
 Solid Mass Frac. of final Cake: _________

Cake Properties
 Thickness  :     0.0500 m          Irreducible Sat: 0.33
 Porosity   :      40.00 %          Permeability   :_____ m3/s2

 Filtration Resistance: 5.0000e+09 m/kg        OR
                                     s         ==
 Filtration Resistance(m/kg) = α * ΔP

 ΔP = Pressure Drop Across Cake (kPa____ )
 α  = Cake Resistance Constant   : _________
 s  = Cake Compressibility Factor: _________
```

Step	Action
26	Press the <Insert> key.
27	Highlight the word **Worksheet** and then press the <Enter> key.
28	*Highlight the blank space under the "LiquidOut" stream column heading and the "Flow" row heading and type the following flow rate in kg-mols/hr.* Type the number 75 and then press the <Enter> key
	The following screen will then appear

```
═══════════ Streams ═══════════

                New Value =                          kgmole/h
Stream             Feed          LiquidOut          SolidsOut      ---
Vapour_Frac      0.0000            0.0000             0.0000       ---
Temperature     25.0000*          25.0000            25.0000       ---
Pressure       101.0000*          91.0000            91.0000       ---
Flow           100.0000*          75.0000*           25.0000       ---
Mass_Flow     1651.4026        1351.1326             300.2700      ---
LiqVol_Flow      1.5367            1.3539             0.1829       ---
Energy_Flow -2.56188E+06      -2.58812E+06       26225.2350        ---
```

Step	Action
29	Press the <Esc> key
	Printing Results from the Rotary Vacuum Filter HYSIM run
30	Highlight the word **Print** and then press the <Enter> key

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec Sheets* - the specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
31	Highlight the word **Streams** and then press the <**Enter**> key.
32	Highlight the word **All** and then press the <**Enter**> key.
33	Highlight the dash symbol - and then press the <**Enter**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
34	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream Description		Feed	LiquidOut	SolidsOut
Vapour frac.		0.0000	0.0000	0.0000
Temperature	C	25.0000*	25.0000	25.0000
Pressure	kPa	101.0000*	91.0000	91.0000
Molar Flow	kgmole/h	100.0000*	75.0000*	25.0000
Mass Flow	kg/h	1651.4026	1351.1326	300.2700
LiqVol Flow	m3/h	1.5367	1.3539	0.1829
Enthalpy	kJ/h	-2.56188E+06	-2.58812E+06	26225.2350
Density	kg/m3	1083.5153	1007.3623	1642.0600
Mole Wt.		16.5140	18.0151	12.0108
Spec. Heat	kJ/kg-C	3.6573	4.3135	0.7050
Therm Cond	W/m-K	---	0.6110	---
Viscosity	cP	---	0.8904	---
Z Factor		---	0.0007	0.0003
Sur Tension	dyne/cm	72.0995	72.0995	---
Std Density	kg/m3	1090.5804	1014.8360	1642.0601
H2O	mole frac.	0.7500*	1.0000	0.0000
Carbon	mole frac.	0.2500*	0.0000	1.0000

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Step	Action
35	Press the <**F10**> key;
36	Highlight the word **Print** and then press the <**Enter**> key.

The various print options can be found on page 314.

Step	Action
37	Highlight the word **Spec_Sheets** and then press the <**Enter**> key.
38	Highlight the word **Operations** and then press the <**Enter**> key.
39	Highlight the word **RotaryVac** and then press the <**Enter**> key.
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
40	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

HYSIM ROTARY VACUUM FILTER SPECIFICATION SHEET

HYSIM Version C2.53 Date

Case Name: Time 15:22:37

Operation Name: RotaryVac

Operation Note:

Stream		Operation		Flowrate	
Inlet: Feed	from	---	---	1651.4026	kg/h
				100.0000	kgmole/h
Solids: SolidsOut	to	---	---	300.2700	kg/h
				25.0000	kgmole/h
Vapour: LiquidOut	to	---	---	1351.1326	kg/h
				75.0000	kgmole/h

Inlet Properties at Operating Conds

Temperature	25.0000	C
Pressure	101.0000	kPa
Mass Frac Vap	0.0000	
Mass Frac Solid	0.1818	
Density	1083.5154	kg/m3
Spec Grav	1.0857	SG_H2O60
Mol Weight	16.5140	

Liquid Outlet Properties

Density	1007.3622	kg/m3
Spec Grav	1.0094	SG_H2O60
Mol Weight	18.0151	
Surface Ten	72.0995	dyne/cm
Viscosity	0.8904	cP

Solids Outlet Properties

Density	1642.0601	kg/m3
Specific gr	1.6454	SG_H2O60ap
Mol weight	12.0108	

Filter Cake Properties

Thickness	0.0500	m
Porosity	40.00	%
Solids Mass Fraction	1.00	
Permeability	2.029E-13	m3/s2
| Cake Resistance		
Specific	---	m/kg
Actual	5.000E+09	m/kg
Compressibility Factor	---	

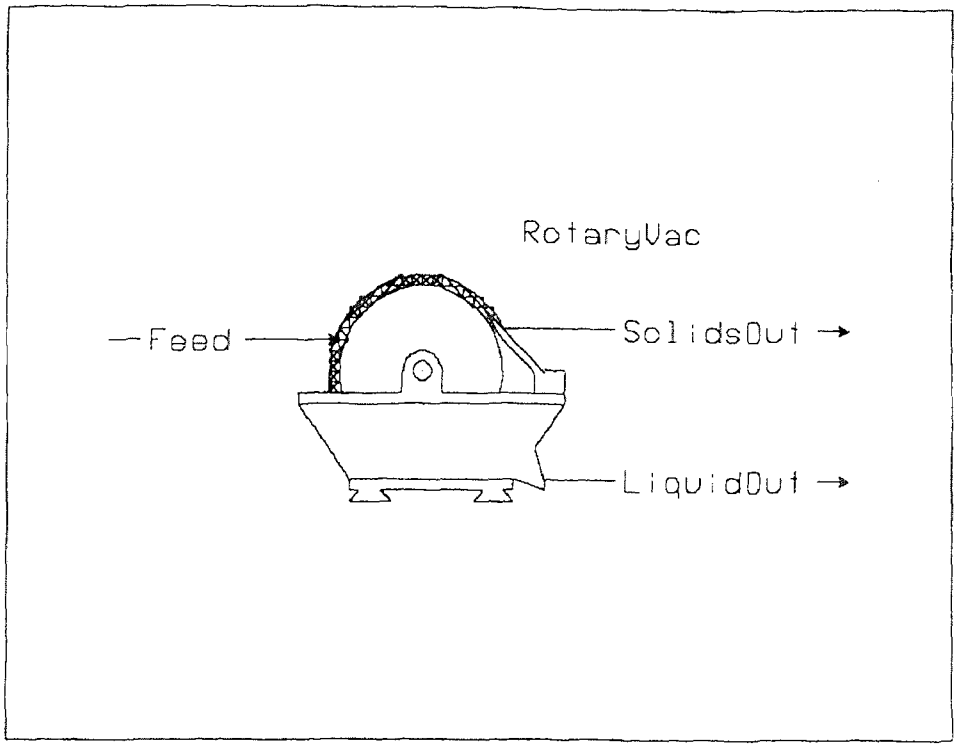
Rotary Filter Operating Parameters

Pressure Drop	10.0000	kPa
Cycle Time	300.0000	second
Submergence	---	%
Radius	---	m
Width	---	m

NOTES :

3.7.5 Rotary-Vacuum Filter Solids Separator (continued)

Step	Action
41	Press the <**F10**> key;
42	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
43	Press the <**Esc**> key;
44	Do you want to continue adding other unit operations to this rotary-vacuum filter? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

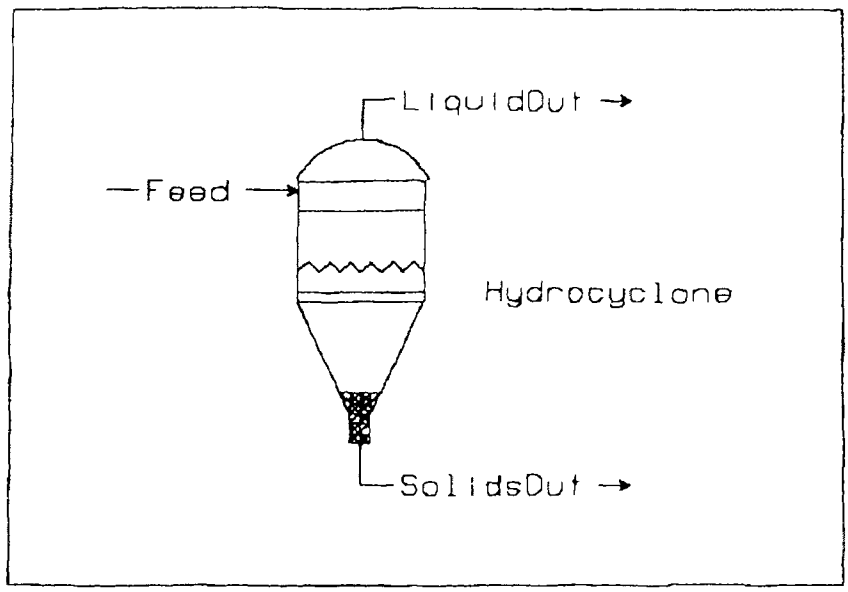
3.7.6 Hydrocyclone Solids Separator

Objective - This exercise is an example of a Hydrocyclone Solid Separation calculation. The purpose of the Hydrocyclone operation is to separate solids from a liquid feed stream. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.
In this example, the feed stream consists of water and solid catalyst, and the hydrocyclone has a 95% efficiency in separating the solid catalyst from the water in the feed stream.
Technical Reference Example: Reference 1 - HYSIM User's Guide, page 7-120. Reference 2 - HYSIM Special Features and Applications Guide, pages 2-20 to 2-25.
Other References: Refs. 1 and 2.

Directions - Pages 318 through 330 outline the execution of a Hydrocyclone example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.**<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Hydrocyclone*, is shown below:



3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng_Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the component in the feed stream.
4	*Highlight the following component chemical formula under the "Component Selection" Section and press the <Enter> key so that the formula then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following component:* Highlight the formula **H2O** and then press the <**Enter**> key;
	The screen on the following page will then appear.

3.7.6 Hydrocyclone Solids Separator (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
H2O	1-C18#	1-Octadecyne	C18H34	ALL
	1-C19#	1-Nonadecyn	C19H36	HC
	1-C20#	1-Eicosyne	C10H38	SOLID
	NH3	Ammonia	NH3	MISC
	Deuterium-eq	Deuterium-eq	D2	AMINE
	H2	Hydrogen	H2	ALCOHOL
	He	Helium	He	KETONE
	Neon	Neon	Ne	ALDEHYDE
	Argon	Argon	Ar	ESTER
	Krypton	Krypton	Kr	CARBACID
	Xenon	Xenon	Xe	HALOGEN
	N2	Nitrogen	N2	NITRILE
	O2	Oxygen	O2	PHENOL
	Ozone	Ozone	O3	ETHER
	Cl2	Cl2	Cl2	USER
	HCl	HCl	HCl	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
	Specifying the solid component of the feed stream
5	Highlight the word **SOLID** under the "Criteria" column heading and then press the <Enter> key;
	The following screen will then appear

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
H2O	HYPOTHETICAL	HYPOTHETICAL		ALL
	Sulphur_Rhombic	S_Rhombic	S	HC
	Sulphur_Monoclinic	S_Monoclinic	S	SOLID
	Sulphur_Amorphous	S_Amorphous	S	MISC
	Carbon	Carbon	C	AMINE
	S_Rhombic	S_Rhombic	S	ALCOHOL
	S_Monoclinic	S_Monoclinic	S	KETONE
	S_Amorphous	S_Amorphous	S	ALDEHYDE
	Sulfur	S_Rhombic	S	ESTER
	Brimstone	S_Rhombic	S	CARBACID
	Colloidal_Sulfur	S_Rhombic	S	HALOGEN
	Flowers_of_Sulfur	S_Rhombic	S	NITRILE
	Precipitated_Sulfur	S_Rhombic	S	PHENOL
				ETHER
				USER

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
6	Highlight the word **Hypothetical** under the "COMPONENT SELECTION" Column and then press the <**Enter**> key;
	The following screen will then appear:

```
HC                  Solid               Misc                Amine
Alcohol             Ketone              Aldehyde            Ester
CarbAcid            Halogen             Nitrile             Phenol
Ether
HC  HC-HC interaction parameters will be calculated and assigned
What is the component type?
>
```

Step	Action
7	Highlight the word **Solid** and then press the <**Enter**> key;
	The following screen will then appear:

```
Solid Hypothetical Component Information

Name: __                    Chemical Formula: _____________

Solid Density     [kg/m3__] : __        Coal Analysis
Molecular Weight            : __          Carbon: _______ %
Average Diameter  [mm_____] : __        Hydrogen: _______ %
Sphericity                  : __        Nitrogen: _______ %
Area/Unit Volume  [m2/m3__] : __          Oxygen: _______ %
                                          Sulphur: _______ %
Specific Heat Coefficents                 Chlorine: _______ %
(Mass Basis - solid @ 25 C)
Cp    = _____________ kJ/kg-K.    Heat of Formation and Combustion
      + _____________ * T         (Molar Basis - Ideal gas @ 25 C)
      + _____________ * T^2       Heat Formation : _____________
      + _____________ * T^3       Heat Combustion: _____________
      + _____________ * T^4

  Vapour Pressure [deg K, kPa]    Ideal Gas Gibbs Free Energy
ANTA: _____________ ANTD: _____   (Molar Basis - Ideal gas @ 25 C)
ANTB: _____________ ANTE: _____   Gibbs  = _____________ kJ/kgmol
ANTC: _____________ ANTF: _____         + _____________ * T
TMIN: _____________ TMAX: _____         + _____________ * T^2
```

Step	Action
8	Type the word **Catalyst** and then press the <**Enter**> key two times;
	Specifying the Solid Density of the Catalyst in kilograms per cubic meter (kg/m^3).
9	Type the number **2995.5** and then press the <**Enter**> key;

3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
	Specifying the Molecular Weight of the Catalyst.
10	Type the number **100** and then press the **<Enter>** key;
	Specifying the Average Diameter of the Catalyst Particle in millimeters (mm).
11	Type the number **0.06** and then press the **<Enter>** key;
	Specifying the Sphericity of the Catalyst Particle.
12	Type the number **0.9**;
	The following screen will then appear:

```
═══════ Solid Hypothetical Component Information ═══════

Name: Catalyst              Chemical Formula: _____________

Solid Density     [kg/m3__]: 2995.5
Molecular Weight           : 100___
Average Diameter  [mm_____]: 0.06_
Sphericity                 : 0.9__
Area/Unit Volume  [m2/m3__]: _____

Specific Heat Coefficents
(Mass Basis - solid @ 25 C)
Cp    = _________________ kJ/kg-K_
      + _________________ * T
      + _________________ * T^2
      + _________________ * T^3
      + _________________ * T^4

   Vapour Pressure [deg K, kPa]
ANTA: _____________  ANTD: _______
ANTB: _____________  ANTE: _______
ANTC: _____________  ANTF: _______
TMIN: _____________  TMAX: _______

      Coal Analysis
   Carbon: _______ %
 Hydrogen: _______ %
 Nitrogen: _______ %
   Oxygen: _______ %
  Sulphur: _______ %
 Chlorine: _______ %

Heat of Formation and Combustion
(Molar Basis - Ideal gas @ 25 C)
Heat Formation : _____________
Heat Combustion: _____________

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs = _________________ kJ/kgmol
      + _________________ * T
      + _________________ * T^2
```

Step	Action
13	Press the **<Insert>** key;
	The screen will then appear as shown on the following page.

3.7.6 Hydrocyclone Solids Separator (continued)

```
═══════ Solid Hypothetical Component Information ═══════
   Are The Component Calculations Satisfactory: Yes_____
Name: Catalyst                  Chemical Formula: Catalyst
──────────────────────────────────────────────────────────
Solid Density     [kg/m3__]:  2995.500
Molecular Weight           :   100.000
Average Diameter [mm_____]:6.0000e-02
Sphericity                 :   0.90000
Area/Unit Volume [m2/m3__]:  1.67e+04

Specific Heat Coefficents
(Mass Basis - solid @ 25 C)
Cp     = -3.0217652e+00 kJ/kg-K_
       +  6.0891764e-03 * T
       + -2.6071865e-06 * T^2
       +  0.0000000e+00 * T^3
       +  0.0000000e+00 * T^4

  Vapour Pressure [deg K, kPa]
ANTA:  1.00000e+00  ANTD:  0.00000e+00
ANTB:  0.00000e+00  ANTE:  0.00000e+00
ANTC:  0.00000e+00  ANTF:  0.00000e+00
TMIN: _____________ TMAX: _____________

     Coal Analysis
  Carbon:  0.0000 %
Hydrogen:  0.0000 %
Nitrogen:  0.0000 %
  Oxygen:  0.0000 %
 Sulphur:  0.0000 %
Chlorine:  0.0000 %

Heat of Formation and Combustion
(Molar Basis - Ideal gas @ 25 C)
Heat Formation : _____________
Heat Combustion: _____________

Ideal Gas Gibbs Free Energy
(Molar Basis - Ideal gas @ 25 C)
Gibbs  = _____________ kJ/kgmol
       + _____________ * T
       + _____________ * T^2
```

Step	Action
14	Press the <**Insert**> key;
	The following screen will then appear:

```
═══════ COMPONENT SELECTION ═══════
 Selected  |  Synonym              Name              Formula | Criteria
 ─ ▲ ─ ↑   |  ▲ ─ ↑                                        |
H2O        | HYPOTHETICAL          HYPOTHETICAL              | ALL
Catalyst   | Sulphur_Rhombic       S_Rhombic         S       | HC
           | Sulphur_Monoclinic    S_Monoclinic      S       | SOLID
           | Sulphur_Amorphous     S_Amorphous       S       | MISC
           | Carbon                Carbon            C       | AMINE
           | S_Rhombic             S_Rhombic         S       | ALCOHOL
           | S_Monoclinic          S_Monoclinic      S       | KETONE
           | S_Amorphous           S_Amorphous       S       | ALDEHYDE
           | Sulfur                S_Rhombic         S       | ESTER
           | Brimstone             S_Rhombic         S       | CARBACID
           | Colloidal_Sulfur      S_Rhombic         S       | HALOGEN
           | Flowers_of_Sulfur     S_Rhombic         S       | NITRILE
           | Precipitated_Sulfur   S_Rhombic         S       | PHENOL
           |                                                  | ETHER
           |                                                  | USER
 ─ ▼ ─ ↓   |  ▼ ─ ↓ ──Search by SYNONYM                       |
 F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
                    PRESS INSERT TO SUBMIT   F8 - Change
```

3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
15	Press the <Insert> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
16	Highlight the word **Specify** and then press the <Enter> key;
17	Highlight the word **Stream** and then press the <Enter> key;
18	Type the word **Feed** after the prompt (>) and then press the <Enter> key;
	Specifying the Feed temperature in ℃.
19	Type the number **25** after the prompt (>) and then press the <Enter> key;
	Specifying the pressure of the Feed in kilopascals (kPa).
20	Type the number **101** after the prompt (>) and then press the <Enter> key;
	Specifying the flow of the Feed stream in kg-mols/hour.
21	Type the number **100** after the prompt (>) and then press the <Enter> key;
	Specifying that the composition of each component in the Feed stream will be specified in mole fractions.
22	Highlight the word **Mole_Fractions** after the prompt (>) and then press the <Enter> key;
	The screen will appear as shown below:

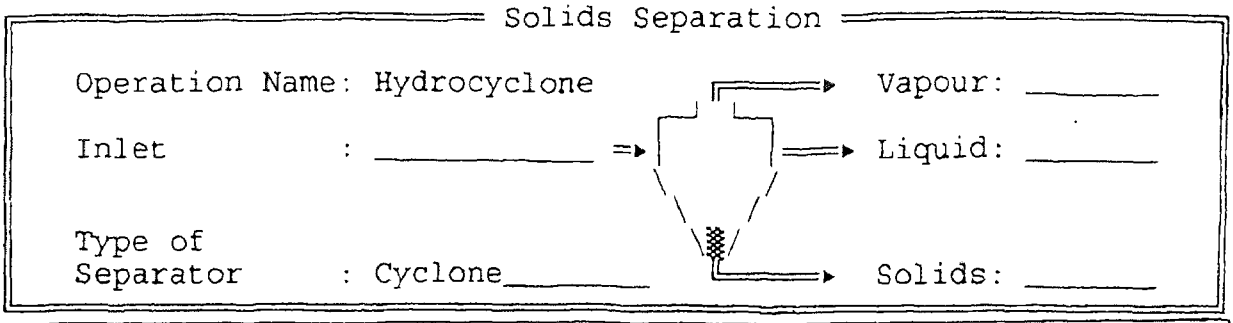
```
═══════════ Stream Mole Fractions ═══════════

H2O  _____________  Catalyst  _____________
```

Step	Action
	Entering the mole-fractions of the components in the Feed stream.
23	*Enter the following mole fractions beside each component in the Feed stream.* After the formula, H2O, type the number **0.95** in the blank and then press the <Enter> key; After the word, Catalyst, type the number **0.05** in the blank;
	The screen will now appear as shown below:

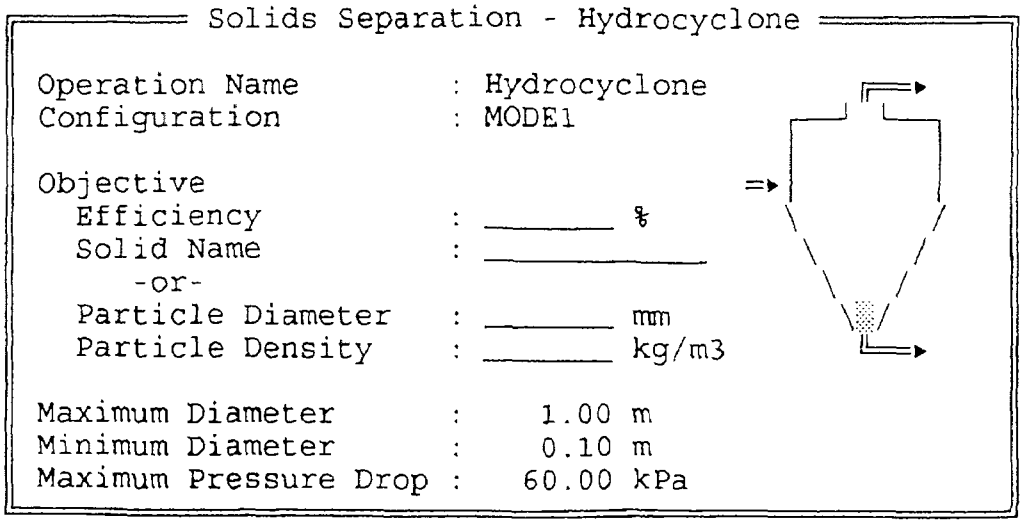
```
═══════════ Stream Mole Fractions ═══════════

H2O  0.95_____________  Catalyst  0.05_____________
```

Step	Action
24	Press the <Insert> key;
25	Highlight the word **Operation** and then press the <Enter> key;
26	Type the word **Hydrocyclone** and then press the <Enter> key;
27	Highlight the word **Solid_Separator** and then press the <Enter> key;
	The screen will then appear as shown on the following page.

3.7.6 Hydrocyclone Solids Separator (continued)



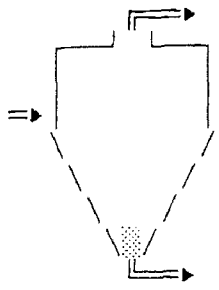
Step	Action
	Specifying the names of the streams entering and leaving the Hydrocyclone.
28	Type the word **Feed** and then press the <**Enter**> key.
29	Press the <**Enter**> key.
30	Type the word **LiquidOut** and then press the <**Enter**> key.
31	Type the word **SolidsOut** and then press the <**Enter**> key.
32	Press the <**Delete**> key until the word "Cyclone" is deleted and then press the <**F2**> key. Highlight the word **Hydrocyclone** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
	Specifying the Configuration for the Hydrocyclone. The configuration can either be Mode1 or Mode2. We will leave it in the HYSIM default mode of Mode1.
33	Press the <**Enter**> key.
	Specifying the Hydrocyclone efficiency in percentage (%).
34	Type the number **95** and then press the <**Enter**> key.
	Specifying the name of the solid that will be separated by the Hydrocyclone.
35	Type the word **Catalyst** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

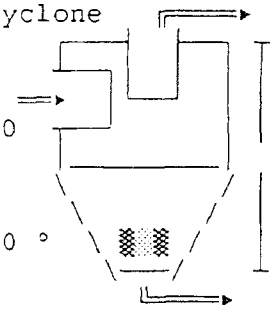
3.7.6 Hydrocyclone Solids Separator (continued)

```
Solids Separation - Hydrocyclone

Operation Name          : Hydrocyclone
Configuration           : MODE1

Objective
  Efficiency            : 95_____ %
  Solid Name            : Catalyst____
     -or-
  Particle Diameter     : _______ mm
  Particle Density      : _______ kg/m3

Maximum Diameter        :    1.00 m
Minimum Diameter        :    0.10 m
Maximum Pressure Drop   :   60.00 kPa
```



Step	Action
36	Press the <Insert> key.
	The following screen defining the dimensional sizing ratios of the Hydrocyclone will then appear:

```
Solids Separation - Hydrocyclone Sizing Ratios

Operation Name : Hydrocyclone          Overflow Length    :0.4000
Configuration  : MODE1                 Overflow Diameter  :0.1250
Inlet Diameter :  0.1430               Total Height       :4.0000
Included Angle :  9.0000 °             Underflow Diameter :0.1000

          Cyclone Body Diameter (Length): _______ m

Note: Sizing Ratios are relative to the Cyclone Body Diameter.
```



Step	Action
37	Press the <Insert> key.
	Printing Results from the Hydrocyclone HYSIM run
38	Highlight the word **Print** and then press the <Enter> key

3.7.6 Hydrocyclone Solids Separator (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
39	Highlight the word **Streams** and then press the **<Enter>** key.
40	Highlight the word **All** and then press the **<Enter>** key.
41	Highlight the dash symbol - and then press the **<Enter>** key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
42	Press the **<F10>** key.
	The screen will then appear as seen below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Stream Description		Feed	LiquidOut	SolidsOut
Vapour frac.		0.0000	0.0000	0.0000
Temperature	C	25.0000*	25.0000	25.0000
Pressure	kPa	101.0000*	98.7904	98.7904
Molar Flow	kgmole/h	100.0000*	63.6156	36.3844
Mass Flow	kg/h	2211.4346	1166.5896	1044.8450
LiqVol Flow	m3/h	1.8818	1.1522	0.7296
Enthalpy	kJ/h	-4.05726E+06	-2.22566E+06	-1.83160E+06
Density	kg/m3	1185.2228	1021.9364	1442.5752
Mole Wt.		22.1143	18.3381	28.7169
Spec. Heat	kJ/kg-C	3.0131	4.1899	1.6991
Therm Cond	W/m-K	---	---	---
Viscosity	cP	---	---	---
Z Factor		---	---	---
Sur Tension	dyne/cm	72.0995	72.0995	72.0995
Std Density	kg/m3	1193.2210	1029.4599	1450.9188
H2O	mole frac.	0.9500*	0.9961	0.8695
Catalyst	mole frac.	0.0500*	0.0039	0.1305

3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
43	Press the <**F10**> key;
44	Highlight the word **Print** and then press the <**Enter**> key.

The various print options can be found on page 326.

Step	Action
45	Highlight the word **Spec_Sheets** and then press the <**Enter**> key.
46	Highlight the word **Operations** and then press the <**Enter**> key.
47	Highlight the word **Hydrocyclone** and then press the <**Enter**> key.
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
48	Press the <**F10**> key;
	The screen will then appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.6 Hydrocyclone Solids Separator (continued)

HYSIM HYDROCYCLONE SPECIFICATION SHEET

HYSIM Version C2.53 — Date 96/10/10
Case Name: — Time 8:47:11
Operation Name: Hydrocyclone
Operation Note:

	Stream	Operation			Flowrate
Inlet:	Feed	from	---	---	2211.4346 kg/h 100.0000 kgmole/h
Solids:	SolidsOut	to	---	---	1044.8450 kg/h 36.3844 kgmole/h
Liquid:	LiquidOut	to	---	---	1166.5896 kg/h 63.6156 kgmole/h

Inlet Properties at Operating Conds

Temperature	25.0000	C
Pressure	101.0000	kPa
Mass Frac Vap	0.0000	
Mass Frac Solid	0.2261	
Density	1185.2228	kg/m3
Spec Grav	1.1876	SG_H2O60
Mol Weight	22.11	

Liquid Outlet Properties

Density	1021.9364	kg/m3
Spec Grav	1.0240	SG_H2O60
Mol Weight	18.34	
Surface Ten	---	dyne/cm
Viscosity	---	cP

Solids Outlet Properties

Density	1442.5752	kg/m3
Spec Grav	1.4455	SG_H2O60
Mol Weight	28.72	

Solids Outlet Efficiencies

Solid1	Catalyst	94.99 %
Solid2	---	--- %
Solid3	---	--- %
Solid4	---	--- %
Solid5	---	--- %
Solid6	---	--- %
Overall Efficiency		94.99 %

Objective Sizing Parameters

Efficiency	95.0000	%
Diameter	5.999E-05	m
Density	2995.5000	kg/m3

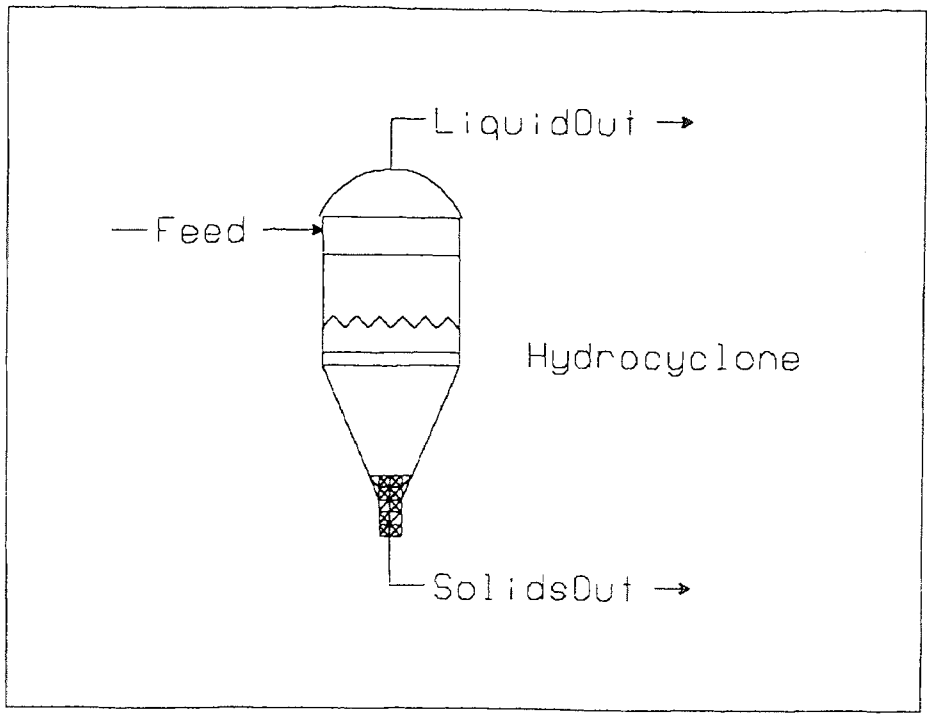
Cyclone Sizing Parameters

Configuration	MODEl	
Diameter	0.2382	m
Height	0.9528	m
Cyclones in Parallel	1.0	
Inlet Duct		
Diameter	0.0341	m
Overflow		
Height	0.0953	m
Diameter	0.0298	m
Underflow		
Diameter	0.0238	m
Included Angle	9.0000	Degrees

NOTES :

3.7.6 Hydrocyclone Solids Separator (continued)

Step	Action
49	Press the <**F10**> key;
50	Highlight the letters **PFD** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
	Getting back to the Main Menu.
51	Press the <**Esc**> key until you reach the Main Menu.
	Sizing the Hydrocyclone.
52	Highlight the word **Size** and then press the <**Enter**> key;
53	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
54	Highlight the word **Hydrocyclone** and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
55	Press the <**F10**> key;
	The screen will then appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.6 Hydrocyclone Solids Separator (continued)

Hydrocyclone Sizing	
Operation Name	Hydrocyclone
Configuration	MODE 1
Diameter	0.2390 m
Included Angle	9.0000 Degrees
Total Height	0.9561 m
Cyclones In Parallel	1.0000
Pressure Drop	2.1822 kPa
Inlets and Outlets	
Inlet Diameter	0.0342 m
Overflow : Height	0.0956 m
Diameter	0.0299 m
Underflow : Diameter	0.0239 m
Objective Sizing Parameters	
Efficiency	95.0000 %
Particle Diameter	5.999E-05 m
Particle Density	2995.5000 kg/m3
Achieved Solids Separation Efficiencies	
Catalyst	94.7309 %
Note: Changes done in this utility will not appear in the actual operation.	

Step	Action
56	Press the <**F10**> key;
57	Highlight the word **Quit** and then press the <**Enter**> key;
58	Do you want to continue adding other unit operations to this Hydrocyclone? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

3.7.7 Simple Solids Separator

Objective - This exercise is an example of a simple separator calculation. The purpose of the simple separator unit operation is to separate the liquid and vapor into two streams from a single feed stream, and to divide the solids in the feed stream between the outlet liquid and vapor streams. The fraction of solids in the outlet streams and the fraction of liquids in the solid product must be known by the user, (use only for an existing operation) and must be specified to the HYSIM program. The user must first verify that the solid material balances over the inlet and outlet streams. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, the feed stream contains ten different hydrocarbons and one solid, brimstone or rhombic sulfur (S_Rhombic). The solid rhombic sulfur is separated from the hydrocarbons in the simple separator with an efficiency of 92.2%.

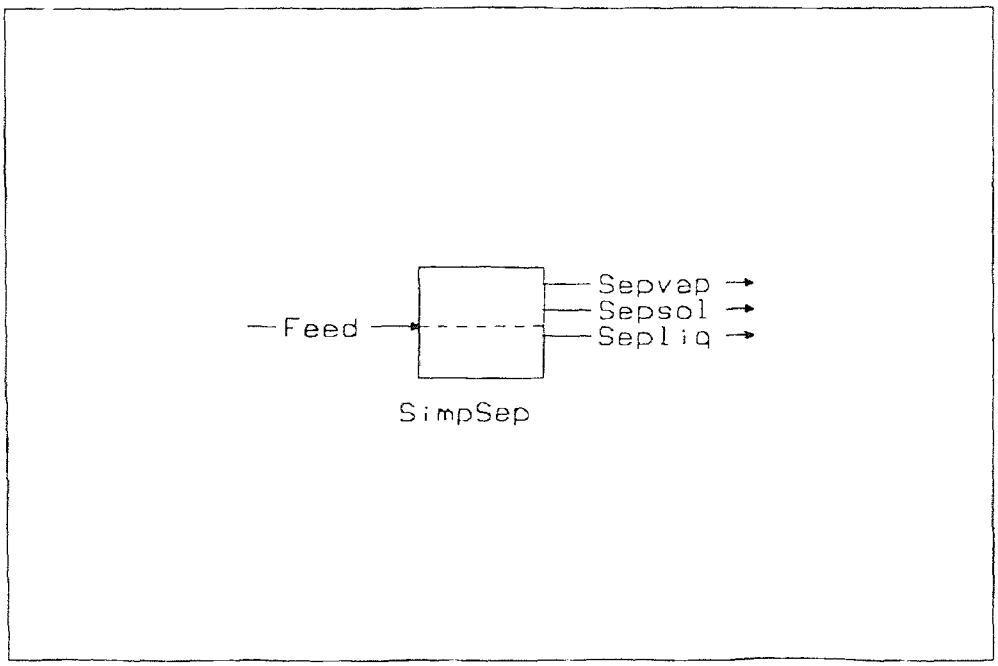
Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.

Other References: Refs. 1 & 2.

Directions: Pages 332 through 340 outline the execution of a Simple Separator example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the required word on the menu changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

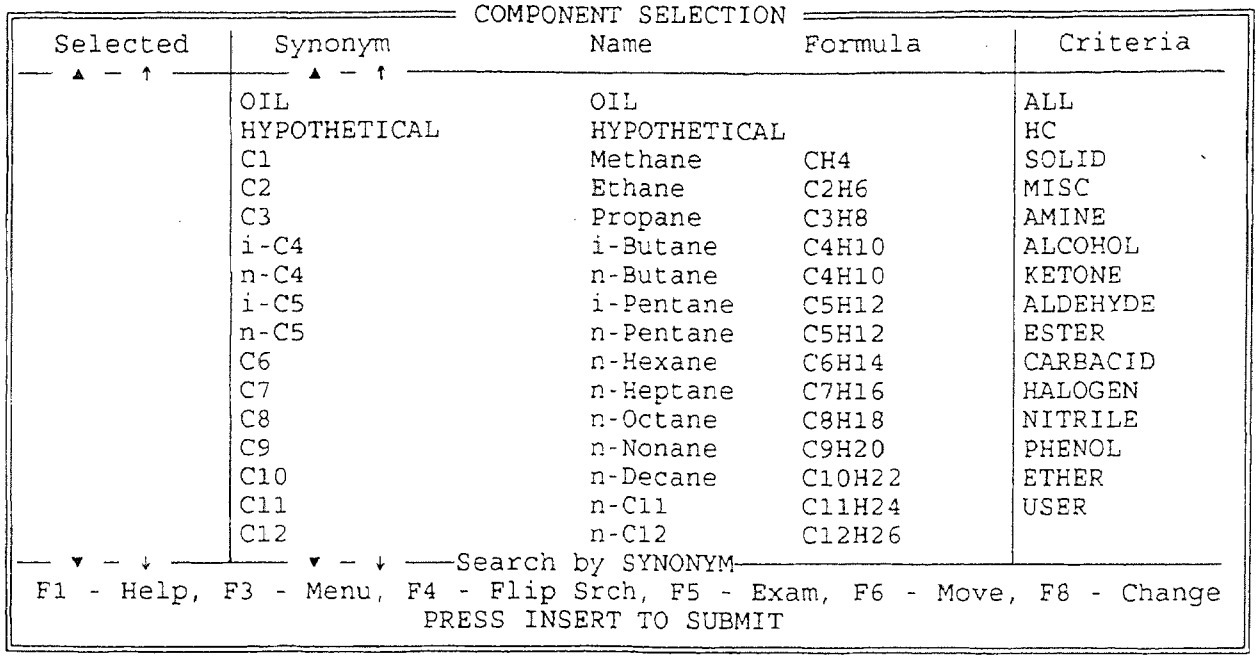
Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "escape" key have additionally been placed inside < > brackets (e.g. <**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *SimpSep*, is shown below:



3.7.7 Simple Solids Separator (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:



3.7.7 Simple Solids Separator (continued)

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key;
	Highlight the following component name under the "Criteria" Section and press the <Enter> key so that the "Component Selection" menu will contain solids, as follows:
5	Highlight the word **SOLID** and then press the **<Enter>** key;
	Highlight the following component synonym under the "Component Selection" Section and press the <Enter> key so that the component name, S_Rhombic, then appears in the "selected" column, as follows:
6	Highlight the word **Brimstone** and then press the **<Enter>** key;
7	Press the **<Insert>** key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default metric units (kg, kPa, °C,etc.) to field units (lb, psia, °F,etc.).
8	Highlight the word **Utility** and then press the **<Enter>** key;
9	Highlight the word **Configuration** and then press the **<Enter>** key;
10	Highlight the word **Units** and then press the **<Enter>** key;
11	Highlight the word **Field** and then press the **<Enter>** key;
	Getting back to the Main Menu.
12	Press the **<Esc>** key;
	Specifying the conditions of the Feed stream.
13	Highlight the word **Specify** and then press the **<Enter>** key;
14	Highlight the word **Stream** and then press the **<Enter>** key;
15	Type the word **Feed** after the prompt (>) and then press the **<Enter>** key;
	Specifying the temperature of the Feed stream in °F.
16	Type the number 60 after the prompt (>) and then press the **<Enter>** key;
	Specifying the pressure of the Feed stream in psia.
17	Type the number 600 after the prompt (>) and then press the **<Enter>** key;

3.7.7 Simple Solids Separator (continued)

Step	Action
	Typing the molar flow of the feed in lb-mols/hr.
18	Type the number **144.0** after the prompt (>) and then press the **<Enter>** key;
	Specifying that the composition of each component in the Feed will be specified in mass fractions.
19	Highlight the word **Mass-Fractions** after the prompt (>) and then press the **<Enter>** key;
	The following screen will appear:

Stream Mass Fractions

Methane		Ethane	
Propane		i-Butane	
n-Butane		i-Pentane	
n-Pentane		n-Hexane	
n-Heptane		n-Octane	
S_Rhombic			

Step	Action
20	*Enter the following mass fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, Ethane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, Propane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, i-Butane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, n-Butane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, i-Pentane, type the number **0.09** in the blank and then press the **<Enter>** key, After the word, n-Pentane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, n-Hexane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, n-Heptane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, n-Octane, type the number **0.09** in the blank and then press the **<Enter>** key; After the word, S_Rhombic, type the number **0.10** in the blank;
	The screen will then appear as shown below.

Stream Mass Fractions

Methane	0.09	Ethane	0.09
Propane	0.09	i-Butane	0.09
n-Butane	0.09	i-Pentane	0.09
n-Pentane	0.09	n-Hexane	0.09
n-Heptane	0.09	n-Octane	0.09
S_Rhombic	0.1		

Step	Action
21	Press the **<Insert>** key;
	Looking at the conditions in the program for the Feed stream.
22	Highlight the word **Print** and then press the **<Enter>** key;

3.7.7 Simple Solids Separator (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Print* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil Input* - Lists inputted information on an oil.

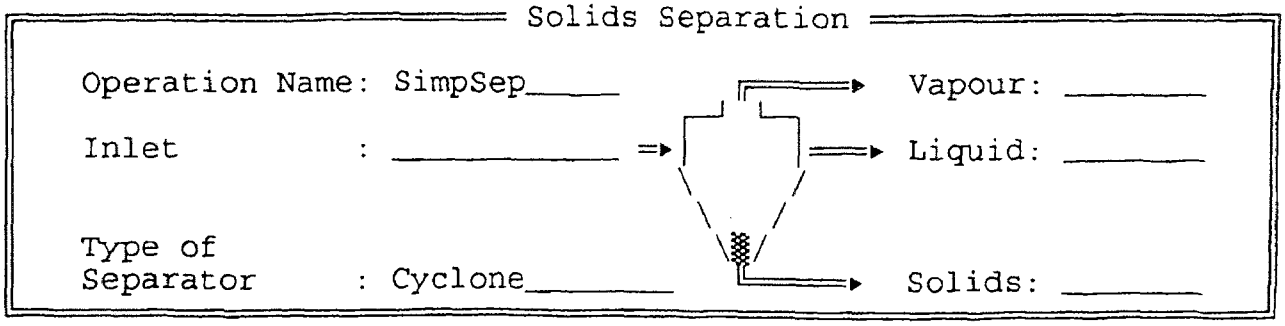
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
23	Highlight the word **Streams** and then press the <**Enter**> key;
24	Highlight the word **Conditions** and then press the <**Enter**> key;
25	Highlight the word **Feed** and then press the <**Enter**> key;
	The following conditions will then appear on the screen for the Feed stream:

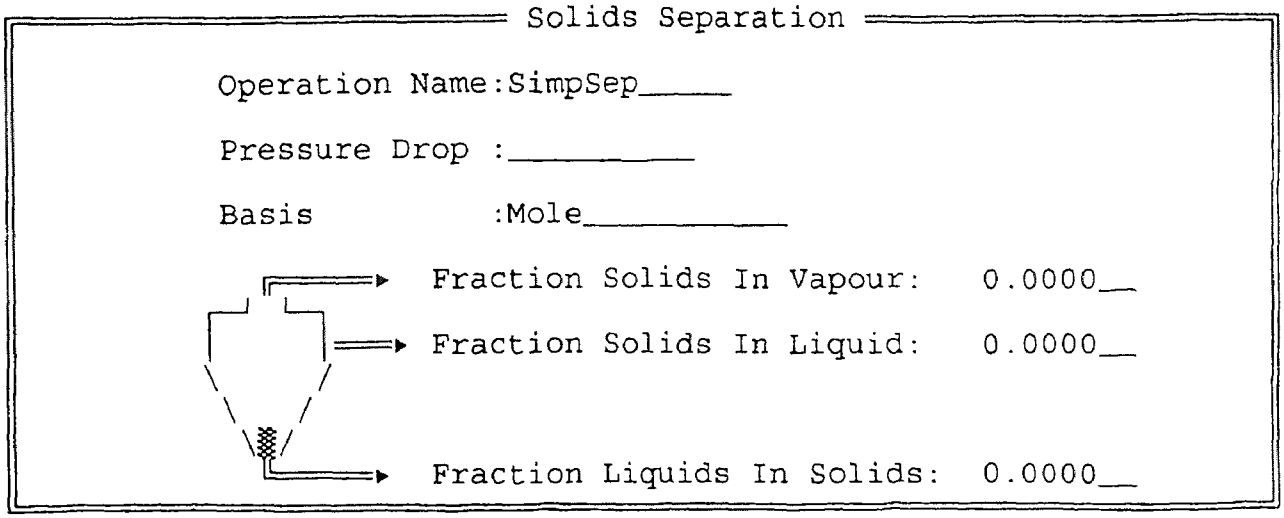
Stream		Feed
Vapour frac.		0.1541
Temperature	F	60.0000*
Pressure	psia	600.0000*
Molar Flow	lbmole/hr	144.0000*
Mass Flow	lb/hr	6520.4151
LiqVol Flow	barrel/day	792.8311
Enthalpy	Btu/hr	77443.4267

Step	Action
	Specifying the type of operation we want to perform on the feed stream.
26	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "SimpSep").
27	Type the word **SimpSep** and then press the <**Enter**> key;
28	Highlight the word **Solid_Separator** and then press the <**Enter**> key;
	The diagram of the separator process will appear as shown on the following page.

3.7.7 Simple Solids Separator (continued)

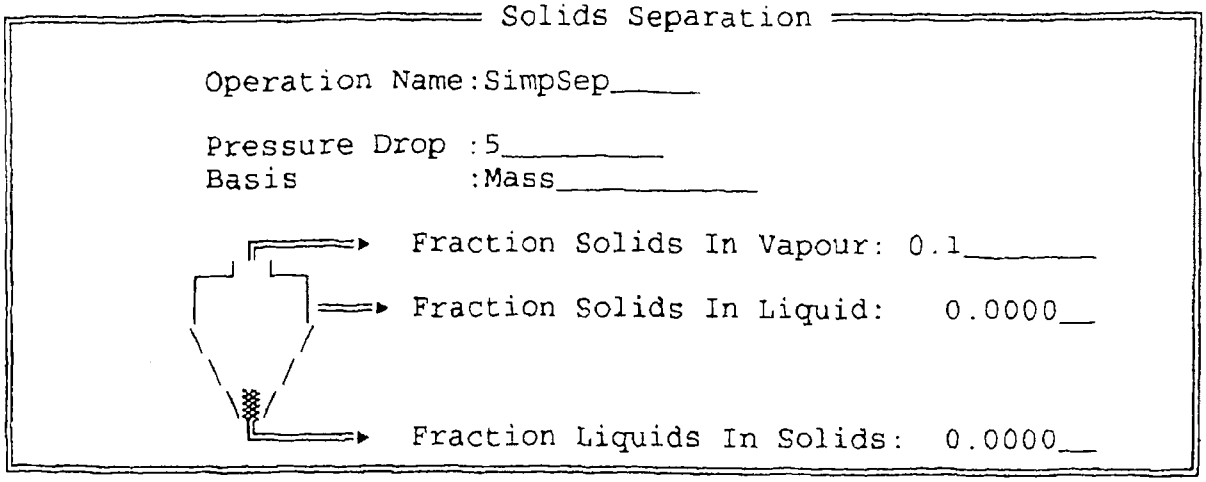


Step	Action
	Naming the streams.
29	Type the word **Feed** in the blank and then press the <**Enter**> key;
30	Type the name **Sepvap** in the blank and then press the <**Enter**> key;
31	Type the name **Sepliq** in the blank and then press the <**Enter**> key;
32	Type the name **Sepsol** in the blank and then press the <**Enter**> key;
33	Press the <**F2**> key and highlight the name **Simple_Sep** and then press the <**Enter**> key;
	The screen should now appear as follows:



Step	Action
	Specifying the Pressure Drop (psi) in the Simple Separator.
34	Type the number **5** in the blank and then press the <**Enter**> key;
35	Type the word **Mass** and then press the <**Enter**> key;
36	Type the number **0.1** and then press the <**Enter**> key;
	The screen should now appear as shown on the following page.

3.7.7 Simple Solids Separator (continued)



Step	Action
	Looking at the conditions of all of the streams.
37	Press the **<Insert>** key;
38	Highlight the word **Print** and then press the **<Enter>** key;

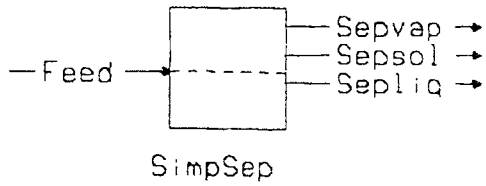
The various print options can be found on page 335

Step	Action
39	Highlight the word **Streams** and then press the **<Enter>** key;
40	Highlight the word **All** and then press the **<Enter>** key;
41	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
42	Press the **<F10>** key;
	The information will now appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

3.7.7 Simple Solids Separator (continued)

Stream		Feed	Sepvap	Sepliq	Sepsol
Description					
Vapour frac.		0.1541	0.9329	0.0030	0.0000
Temperature	F	60.0000*	60.0000	60.0000	60.0000
Pressure	psia	600.0000*	595.0000	595.0000	595.0000
Molar Flow	lbmole/hr	144.0000*	23.7899	101.4717	18.7385
Mass Flow	lb/hr	6520.4151	511.7355	5407.8117	600.8679
LiqVol Flow	barrel/day	792.8311	94.7378	678.2167	19.8766
Enthalpy	Btu/hr	77443.4267	90452.0555	-50850.5057	38486.7913
Density	lb/ft3	19.6190	2.9506	34.2279	129.2216
Mole Wt.		45.2807	21.5107	53.2938	32.0660
Spec. Heat	Btu/lb-F	0.5412	0.5513	0.5766	0.2091
Therm Cond	Btu/hr-ft-F	---	---	---	---
Viscosity	cP	---	---	---	---
Z Factor		---	---	---	0.0265
Sur Tension	dyne/cm	---	---	---	---
Std Density	lb/ft3	---	---	---	129.2216
Methane	mole frac.	0.2540*	0.7270	0.1900	0.0000
Ethane	mole frac.	0.1355*	0.1392	0.1597	0.0000
Propane	mole frac.	0.0924*	0.0360	0.1227	0.0000
i-Butane	mole frac.	0.0701*	0.0131	0.0964	0.0000
n-Butane	mole frac.	0.0701*	0.0097	0.0972	0.0000
i-Pentane	mole frac.	0.0565*	0.0037	0.0793	0.0000
n-Pentane	mole frac.	0.0565*	0.0029	0.0795	0.0000
n-Hexane	mole frac.	0.0473*	0.0009	0.0669	0.0000
n-Heptane	mole frac.	0.0407*	0.0003	0.0576	0.0000
n-Octane	mole frac.	0.0357*	0.0001	0.0506	0.0000
S_Rhombic	mole frac.	0.1412*	0.0671	0.0000	1.0000

Step	Action
	Getting back to the Main Menu.
43	Press the <**F10**> key;
	Looking at the current Process Flow Diagram (PFD).
44	Highlight the abbreviation **PFD** and then press the <**Enter**> key;
	The following figure will appear.



3.7.7 Simple Solids Separator (continued)

Step	Action
	Looking at the conditions of all of the streams.
45	Press the <**Esc**> key;
46	Highlight the word **Print** and then press the <**Enter**> key;

The various print options can be found on page 335.

Step	Action
47	Highlight the word **Spec_Sheets** and then press the <**Enter**> key;
48	Highlight the word **Operations** and then press the <**Enter**> key;
49	Highlight the name **SimpSep** and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
50	Press the <**F10**> key;
	The information will now appear as shown below and on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

HYSIM SOLID SEPARATOR SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/10/10
Case Name: Time 10:24:09

Operation Name: SimpSep
Operation Note:

Stream		Operation	Flowrate	
Inlet:	Feed	from ---	6520.4151	lb/hr
			144.0000	lbmole/hr
Solids:	Sepsol	to ---	600.8679	lb/hr
			18.7385	lbmole/hr
Vapour:	Sepvap	to ---	511.7355	lb/hr
			23.7899	lbmole/hr
Liquid:	Sepliq	to ---	5407.8117	lb/hr
			101.4717	lbmole/hr

Inlet Properties			Outlet Conditions	
Temperature	60.0000	F	Temperature	60.0000 F
Pressure	600.0000	psia	Pressure	595.0000 psia
Mass Frac Vapour	0.0706			
Mass Frac Solid	0.1000			
Density	19.6190	lb/ft3		
Spec Grav	0.3149	SG_H2O60		
Mol Weight	45.2807			

3.7.7 Simple Solids Separator (continued)

Vapour Outlet Properties			Liquid Outlet Properties		
Density	2.9506	lb/ft3	Density	34.2279	lb/ft3
			Spec Grav	0.5494	SG_H2O60
Mol Weight	21.5107		Mol Weight	53.2938	
Z Factor	---		Surface Ten	---	dyne/cm
			Viscosity	---	cP

Solids Outlet Properties		
Density	129.2216	lb/ft3
Spec Grav	2.0741	SG_H2O60ap
Mol Weight	32.0660	

Solids Outlet Efficiencies		
Solid1 S_Rhombic	92.15	%
Solid2 ---	---	%
Solid3 ---	---	%
Solid4 ---	---	%
Solid5 ---	---	%
Solid6 ---	---	%
Overall Efficiency	92.15	%

NOTES :

Step	Action
	Getting back to the Main Menu.
51	Press the <F10> key;
52	Do you want to continue adding other unit operations to this simple separator? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

CHAPTER 4

OTHER OPERATIONS IN HYSIM

Chapter 4 contains examples of the following four types of Piping and Fittings in Section 4.1, plus sections on: Section 4.2 - *Mass and Mole Balances*, Section 4.3 - *Set Controllers*, Section 4.4 - *Adjust Controllers*, Section 4.5 - *Recycle*, and Section 4.6 - *Data Recorders*.

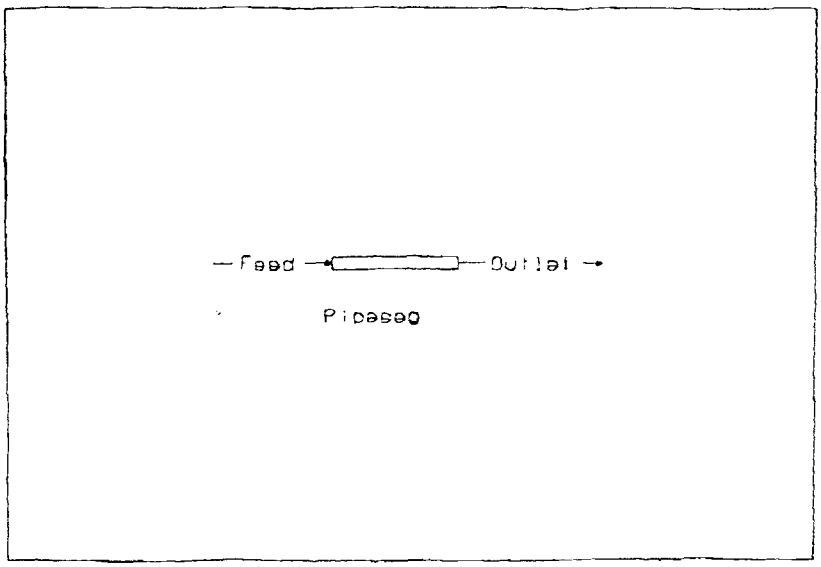
4.1.1 Pipeline Segments (Single/Two/Three Phase)

Objective - This exercise is an example of a Pipeline Segment calculation. The purpose of these calculations are to take a stream whose composition, flowrate and other processing conditions (such as pipe diameter, length, elevation gain, temperature, and absolute pipe roughness) are known and calculate the pressure drop for the pipeline segment. The pipeline segment can contain one or more phases. This example can be modified by specifying another property package and/or other components, compositions, feed and processing conditions. In this example, a feed stream containing ten different hydrocarbons, nitrogen and carbon dioxide enters a pipeline segment. The conditions and composition of this inlet stream are specified, along with the pipe diameter, length, elevation gain, ambient temperature, heat transfer coefficient and absolute roughness of the pipe. HYSIM calculated the pressure drop to be 226.2 psi.
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-58 to 7-63.
Other References: Refs. 1 & 2

Directions: Pages 343 through 350 outline the execution of a Pipeline Segment example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the keys to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Pipeseg*, is shown below:



4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key.
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section (use the <↓> and <Page Down> keys as needed) and then press the <Enter> key so that the name then appears in the "selected" column, as follows:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key; Highlight the word **Nitrogen** and then press the **<Enter>** key; Highlight the formula **CO2**;
	The following screen will then appear.

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	Cl2	Cl2	Cl2	ALL
Ethane	HCl	HCl	HCl	HC
Propane	F2	F2	F2	SOLID
i-Butane	HF	HF	HF	MISC
n-Butane	Br2	Bromine	Br2	AMINE
i-Pentane	HBr	HBr	HBr	ALCOHOL
n-Pentane	I2	Iodine	I2	KETONE
n-Hexane	HI	HI	HI	ALDEHYDE
n-Heptane	NitricOxide	NO	NO	ESTER
n-Octane	NO2	NO2	NO2	CARBACID
Nitrogen	N2O	N2O	N2O	HALOGEN
CO2	N2O4	N2O4	N2O4	NITRILE
	SO2	SO2	SO2	PHENOL
	SO3	SO3	SO3	ETHER
	CO	CO	CO	USER
	Sulphur_Rhombic	S_Rhombic	S	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

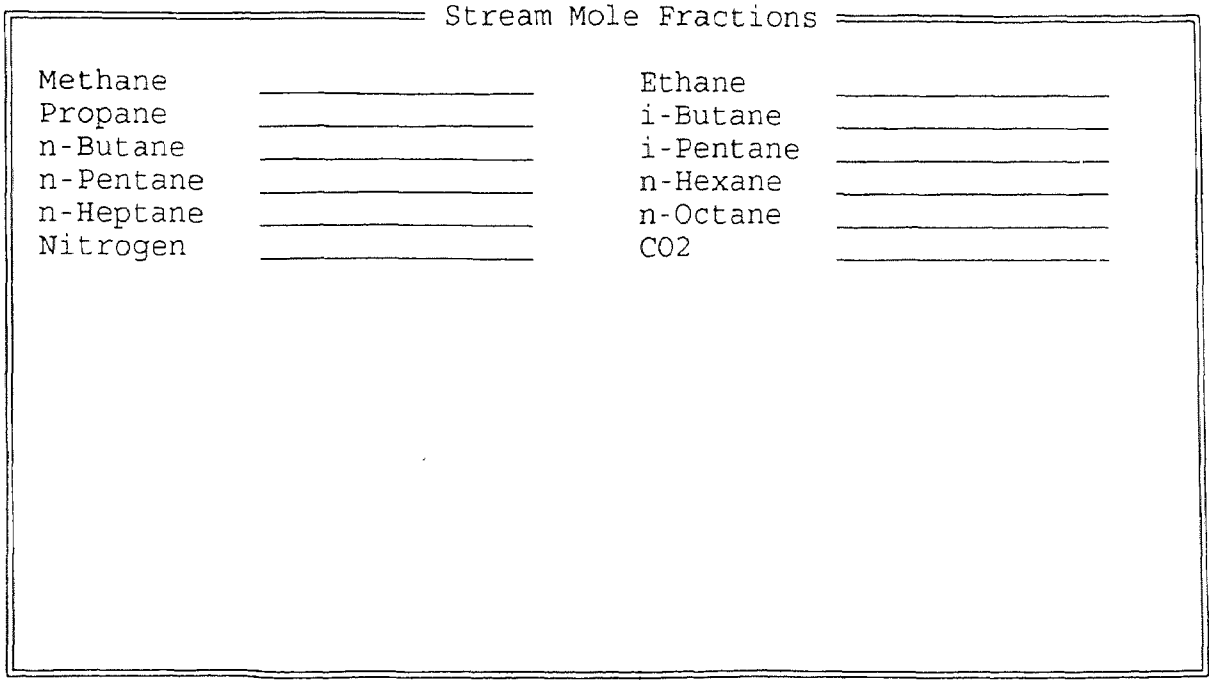
Step	Action
5	Press the **<Insert>** key;
	Changing the units from the HYSIM default SI or metric units (kg, °C, kPa, etc.) to field units (lb, °F, psia, etc.).
6	Highlight the word **Utility** and then press the **<Enter>** key;

4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

Step	Action
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in psia.
15	Type the number **1000** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow of the feed in lb-mols/hr.
16	Type the number **1317.6565** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual molar fractions of each component.
17	Highlight the word **Mole-Fractions** after the prompt (>) and then press the <**Enter**> key;
	The following screen will appear:



4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

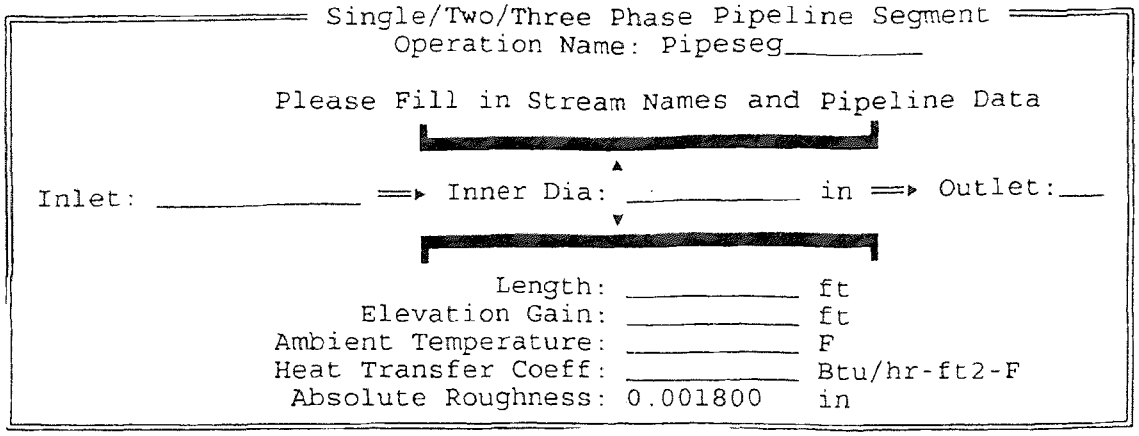
Step	Action
18	*Enter the following mole fractions beside each component in the feed stream:* After the word, Methane, type the number **0.9122** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0496** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0148** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0026** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0020** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0010** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0006** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0001** in the blank and then press the <**Enter**> key;; After the word, Nitrogen, type the number **0.0149** in the blank and then press the <**Enter**> key; After the word, CO2, type the number **0.0020** in the blank;
	The screen should now appear as shown below:

Stream Mole Fractions

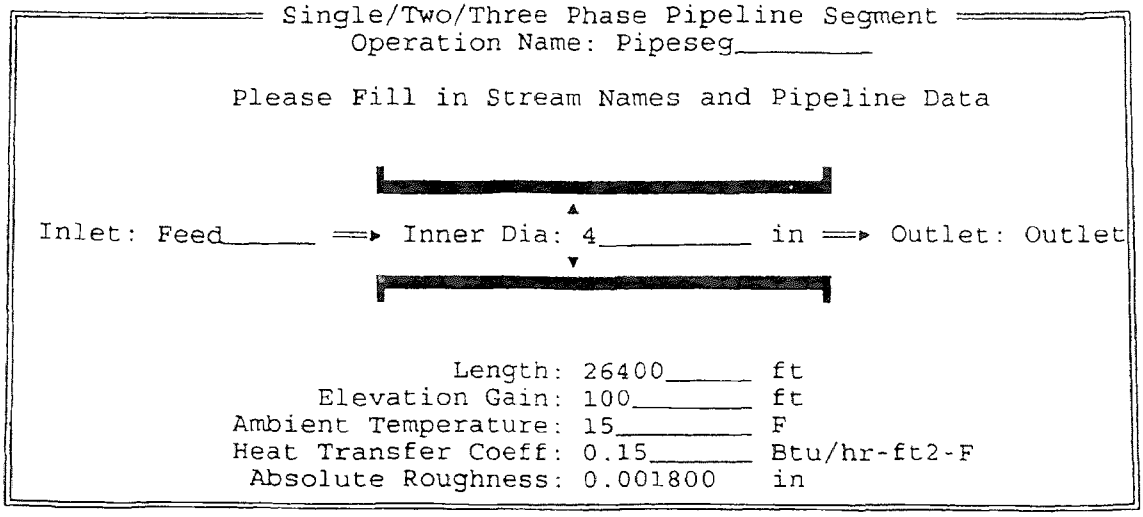
Methane	0.9122	Ethane	0.0496
Propane	0.0148	i-Butane	0.0026
n-Butane	0.0020	i-Pentane	0.0010
n-Pentane	0.0006	n-Hexane	0.0001
n-Heptane	0.0001	n-Octane	0.0001
Nitrogen	0.0149	CO2	0.0020

Step	Action
19	Press the <**Insert**> key;
20	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Operation "Pipeseg".
21	Type the word **Pipeseg** and then press the <**Enter**> key;
	Specifying the type of operation you wish to perform.
22	Highlight the word **Pipe_Segment** and then press the <**Enter**> key;
	The following screen will then appear as shown on the following page.

4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)



Step	Action
	Specifying the Stream Names.
23	Type the word **Feed** and then press the <**Enter**> key;
24	Type the word **Outlet** and then press the <**Enter**> key;
	Specifying the Actual Inner Diameter of the Pipe Segment in inches.
25	Type the number **4** and then press the <**Enter**> key;
	Specifying the Pipe Segment Length in Feet.
26	Type the number **26400** and then press the <**Enter**> key;
	Specifying the Elevation Gain in feet.
27	Type the number **100** and then press the <**Enter**> key;
	Specifying the Ambient Temperature in °F.
28	Type the number **15** and then press the <**Enter**> key;
	Specifying the Heat Transfer Coefficient in Btu/hr-ft^2-F so HYSIM can calculate the energy exchanged between the fluid in the pipe and the environment.
29	Type the number **0.15** and then press the <**Enter**> key;
	The following screen will then appear:



4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

Step	Action
30	Press the **<Insert>** key;
	Printing out all of the stream information.
31	Highlight the word **Print** and then press the **<Enter>** key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
32	Highlight the word **Streams** and then press the **<Enter>** key;
33	Highlight the word **All** and then press the **<Enter>** key;
34	Highlight the dash symbol - and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
35	Press the **<F10>** key;
	The screen will appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

Stream Description		Feed	Outlet
Vapour frac.		1.0000	1.0000
Temperature	F	60.0000*	36.8501
Pressure	psia	1000.0000*	773.8243
Molar Flow	lbmole/hr	1317.6565*	1317.6565
Mass Flow	lb/hr	23318.2006	23318.2006
LiqVol Flow	barrel/day	5023.8275	5023.8275
Enthalpy	Btu/hr	4.71991E+06	4.58705E+06
Density	lb/ft3	3.8568	3.0879
Mole Wt.		17.6967	17.6967
Spec. Heat	Btu/lb-F	0.6601	0.6312
Therm Cond	Btu/hr-ft-F	0.0222	0.0202
Viscosity	cP	0.0130	0.0120
Z Factor		0.8228	0.8323
Sur Tension	dyne/cm	---	---
Std Density	lb/ft3	---	---
Methane	mole frac.	0.9122*	0.9122
Ethane	mole frac.	0.0496*	0.0496
Propane	mole frac.	0.0148*	0.0148
i-Butane	mole frac.	0.0026*	0.0026
n-Butane	mole frac.	0.0020*	0.0020
i-Pentane	mole frac.	0.0010*	0.0010
n-Pentane	mole frac.	0.0006*	0.0006
n-Hexane	mole frac.	0.0001*	0.0001
n-Heptane	mole frac.	0.0001*	0.0001
n-Octane	mole frac.	0.0001*	0.0001
Nitrogen	mole frac.	0.0149*	0.0149
CO2	mole frac.	0.0020*	0.0020

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
36	Press the **<F10>** key;
	Printing the Specification Sheets for the Pipe Segment Operation.
37	Highlight the word **Print** and then press the **<Enter>** key;

The various print options can be found on page 348.

Step	Action
38	Highlight the word **Spec_Sheets** and then press the **<Enter>** key;
39	Highlight the word **Operations** and then press the **<Enter>** key;
40	Highlight the word **Pipeseg** and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
41	Press the **<F10>** key;
	The screen will appear as shown on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

4.1.1 Pipeline Segments (Single/Two/Three Phase) (continued)

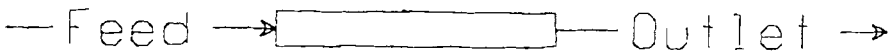
HYSIM PIPESEG OPERATION

HYSIM Version C2.53 Date 96/07/11
Case Name Time 14:14:23

Operation Name: Pipeseg
Operation Note:

Pipe Segment Inlet Stream	Feed
Pipe Segment Outlet Stream	Outlet
Inside Diameter	4.0000 in
Length	26399.9999 ft
Elevation Gain	100.0000 ft
Ambient Temperature	15.0000 F
Heat Transfer Coeff.	0.1500 Btu/hr-ft2-F
Absolute Roughness	0.0018 in
Pressure Drop	226.1757 psi

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
42	Press the **<F10>** key;
	Looking at the Process Flow Diagram (PFD) for the Pipe Segment Operation
43	Highlight the letters **PFD** and then press the **<Enter>** key;
	The PFD shown below will appear on the screen.



Pipeseg

Step	Action
44	Press the **<Esc>** key;
45	Do you want to continue with other unit operations? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

4.1.2 Tees (Adiabatic)

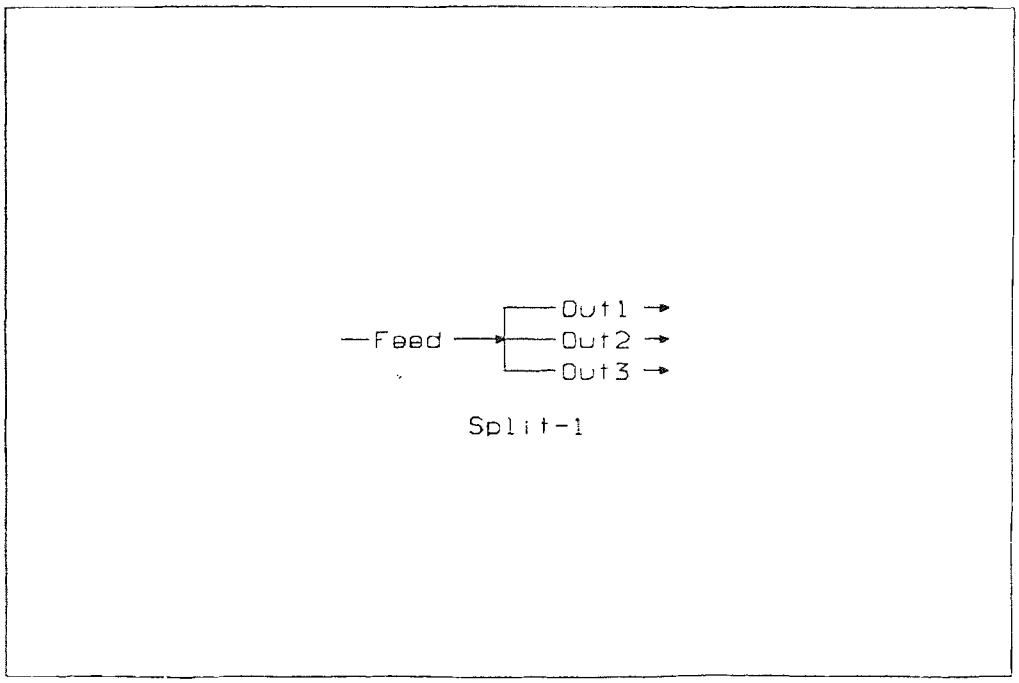
Objective- This exercise is an example of an adiabatic tee calculation. The purpose of the tee unit operation is to divide or split a feed stream into two or more streams, and then obtain the properties of these streams. The percentage of the split, either on a mass, molar or liquid volume basis, into the outlet streams must be specified. If all but one of the outlet streams are specified, HYSIM will calculate the other stream by difference. This example can be modified by specifying another property package and/or other components, compositions and stream conditions.

In this example, an adiabatic tee separates the feed stream, consisting of methane and ethane, into three outlet streams. The set operations are used to set one outlet stream at 30 % of the feed and another at 40 % of the feed. The third outlet stream is then 30 % of the feed by mass balance. The three outlet streams are at the same temperature, pressure and composition as the inlet stream, but only vary in the amount of total mass flow.
References: Refs. 1 and 2.

Directions: Pages 352 through 358 outline the execution of an adiabatic tee example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the required word on the menu changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to by typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside the < > brackets (e.g. **<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Split-1*, is shown below:



4.1.2 Tees (Adiabatic) (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the Feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "selected" column, as follows.* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key;
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

4.1.2 Tees (Adiabatic) (continued)

Step	Action
	Specifying the conditions of the Feed stream.
6	Highlight the word **Specify** and then press the <**Enter**> key;
7	Highlight the word **Stream** and then press the <**Enter**> key;
8	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature in ℃.
9	Type the number **10** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure in kilopascals (kPa).
10	Type the number **101** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate in kg-mols/hr of the stream, "Feed".
11	Type the letter **100** after the prompt (>) and then press the <**Enter**> key;
	Specifying the units of flow to use when specifying compositions.
12	Highlight the words **Mole_Fractions** and then press the <**Enter**> key;
	The screen will then appear as shown below:

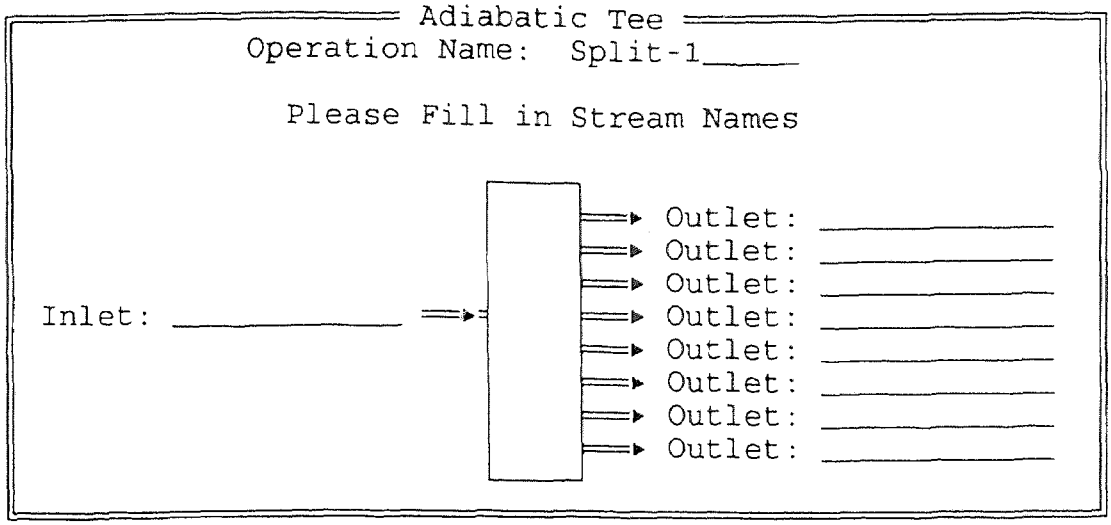
```
═══════ Stream Mole Fractions ═══════

Methane _____________  Ethane _____________
```

Step	Action
	Specifying the individual mole fractions of each component.
13	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.5** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.5** in the blank;
	The screen should now appear as follows:

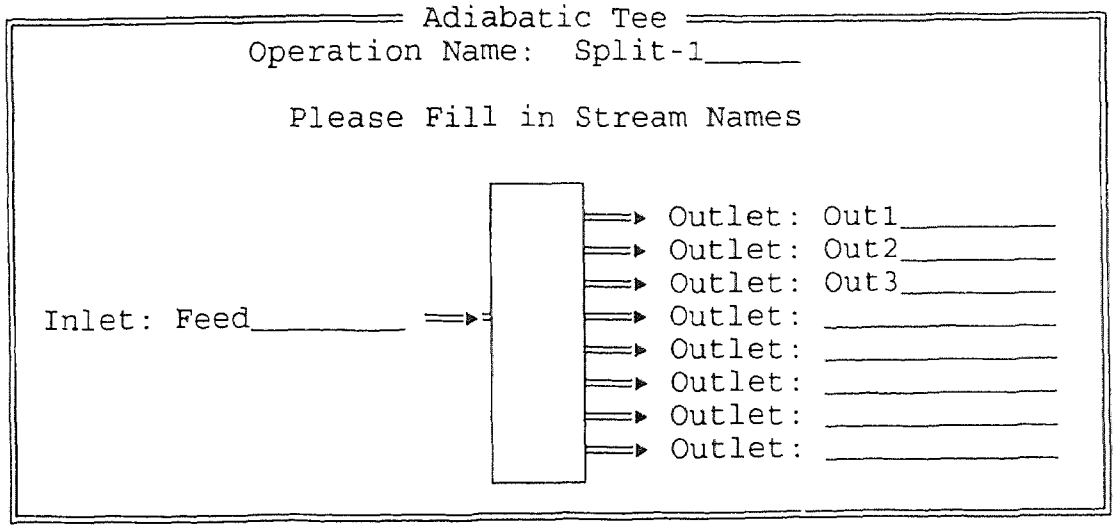
```
═══════ Stream Mole Fractions ═══════

Methane   0.5_____________  Ethane   0.5_____________
```

Step	Action
14	Press the <**Insert**> key;
	Specifying the type of operation.
15	Highlight the word **Operation** and then press the <**Enter**> key;
16	Type the word **Split-1** and then press the <**Enter**> key;
17	Highlight the word **Tee** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

4.1.2 Tees (Adiabatic) (continued)



Step	Action
	Naming the outlet and inlet streams.
18	Type the word **Feed** in the blank and then press the <**Enter**> key;
19	Type the word **Out1** in the blank and then press the <**Enter**> key;
20	Type the word **Out2** in the blank and then press the <**Enter**> key;
21	Type the word **Out3** in the blank;
	The screen should now appear as follows:



Step	Action
22	Press the <**Insert**> key;
	Specifying the type of operation.
23	Highlight the word **Operation** and then press the <**Enter**> key;
24	Type the word **Setflow** and then press the <**Enter**> key;
25	Highlight the word **Set** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

4.1.2 Tees (Adiabatic) (continued)

Set/Controller Block

Operation Name: Setflow___

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
_____ of	_____	= 1.0000___ *	_____	+ 0.0000_

Step	Action
26	Press the <**F2**> key;
	Specifying the controlled variable for setting the percentage of the feed stream.
27	Highlight the word **Mass_flow** and then press the <**Enter**> key;
28	Press the <**F2**> key;
	Specifying the controlled stream which will be set at a percentage of the feed stream.
29	Highlight the word **Out1** and then press the <**Enter**> key;
	Specifying the fraction (Multiplier) of the Feed stream, which composes the mass flow of the Out1 stream.
30	Press the <**Delete**> key until the 1.0000 Multiplier is deleted.
31	Type the number **0.3** and then press the <**Enter**> key;
32	Press the <**F2**> key;
	Specifying the independent stream, or the stream from which a certain percentage will compose stream Out1.
33	Highlight the word **Feed** and then press the <**Enter**> key;
	The following screen will appear:

Set/Controller Block

Operation Name: Setflow___

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Mass_flow_ of Out1_____		= 0.3_____ *	Feed_____	+ 0.0000_

Step	Action
34	Press the <**Insert**> key;
	Specifying the type of operation.
35	Highlight the word **Operation** and then press the <**Enter**> key;
36	Type the word **Setflow2** and then press the <**Enter**> key;
37	Highlight the word **Set** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

4.1.2 Tees (Adiabatic) (continued)

Set/Controller Block

Operation Name: Setflow2__

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
_____ of	_____	= 1.0000___ *	_____	+ 0.0000_

Step	Action
38	Press the <**F2**> key;
	Specifying the controlled variable for setting the percentage of the feed stream.
39	Highlight the word **Mass_flow** and then press the <**Enter**> key;
40	Press the <**F2**> key;
	Specifying the controlled stream which will be set at a percentage of the feed stream.
41	Highlight the word **Out2** and then press the <**Enter**> key;
	Specifying the fraction (Multiplier) of the Feed stream, which composes the mass flow of the Out2 stream.
42	Press the <**Delete**> key until the 1.0000 Multiplier is deleted.
43	Type the number **0.4** and then press the <**Enter**> key;
44	Press the <**F2**> key;
	Specifying the independent stream, which contains a certain percentage of stream Out2.
45	Highlight the word **Feed** and then press the <**Enter**> key;
	The following screen will appear:

Set/Controller Block

Operation Name: Setflow2__

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Mass_flow_ of	Out2_____	= 0.4_____ *	Feed_____	+ 0.0000_

Step	Action
46	Press the <**Insert**> key;
47	Highlight the word **Print** and then press the <**Enter**> key;

4.1.2 Tees (Adiabatic) (continued)

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil Input* - Lists inputted information on an oil.

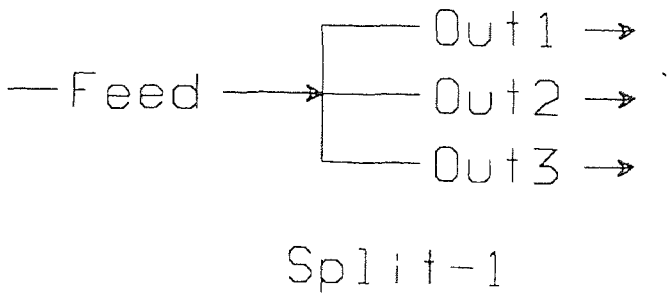
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
48	Highlight the word **Streams** and then press the <**Enter**> key;
49	Highlight the word **All** and then press the <**Enter**> key;
	Looking at the calculated data for all of the streams.
50	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
51	Press the <**F10**> key;
	The screen will appear as follows:

Stream		Feed	Out3	Out2	Out1
Description					
Vapour frac.		1.0000	1.0000	1.0000	1.0000
Temperature	C	10.0000*	10.0000	10.0000	10.0000
Pressure	kPa	101.0000*	101.0000	101.0000	101.0000
Molar Flow	kgmole/h	100.0000*	30.0000	40.0000	30.0000
Mass Flow	kg/h	2305.6401	691.6919	922.2560	691.6921
LiqVol Flow	m3/h	6.9063	2.0719	2.7625	2.0719
Enthalpy	kJ/h	1.03014E+06	309042.4412	412056.6406	309042.5198
Density	kg/m3	0.9948	0.9948	0.9948	0.9948
Mole Wt.		23.0564	23.0564	23.0564	23.0564
Spec. Heat	kJ/kg-C	1.8859	1.8859	1.8859	1.8859
Therm Cond	W/m-K	0.0250	0.0250	0.0250	0.0250
Viscosity	cP	0.0099	0.0099	0.0099	0.0099
Z Factor		0.9943	0.9943	0.9943	0.9943
Sur Tension	dyne/cm	---	---	---	---
Std Density	kg/m3	---	---	---	---
Methane	mole frac.	0.5000*	0.5000	0.5000	0.5000
Ethane	mole frac.	0.5000*	0.5000	0.5000	0.5000

4.1.2 Tees (Adiabatic) (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
52	Press the **<F10>** key;
53	Highlight the word **PFD** and then press the **<Enter>** key;
	The following screen will appear:



Step	Action
	Getting back to the Main Menu.
54	Press the **<Esc>** key until you reach the Main Menu;
55	Do you want to continue adding other unit operations to this Adiabatic Tee? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

4.1.3 Valves (Adiabatic)

Objective - This exercise is an example of an adiabatic valve calculation. The purpose of the valve operation is to perform a material and energy balance over the valve for the inlet and outlet streams. The composition and flow rate of the inlet or outlet stream must be specified. Three of the four variables (inlet temperature and pressure, and outlet temperature and pressure) must be specified and the other variable will be determined by HYSIM. This example can be modified by specifying another property package and/or components, compositions and feed conditions).

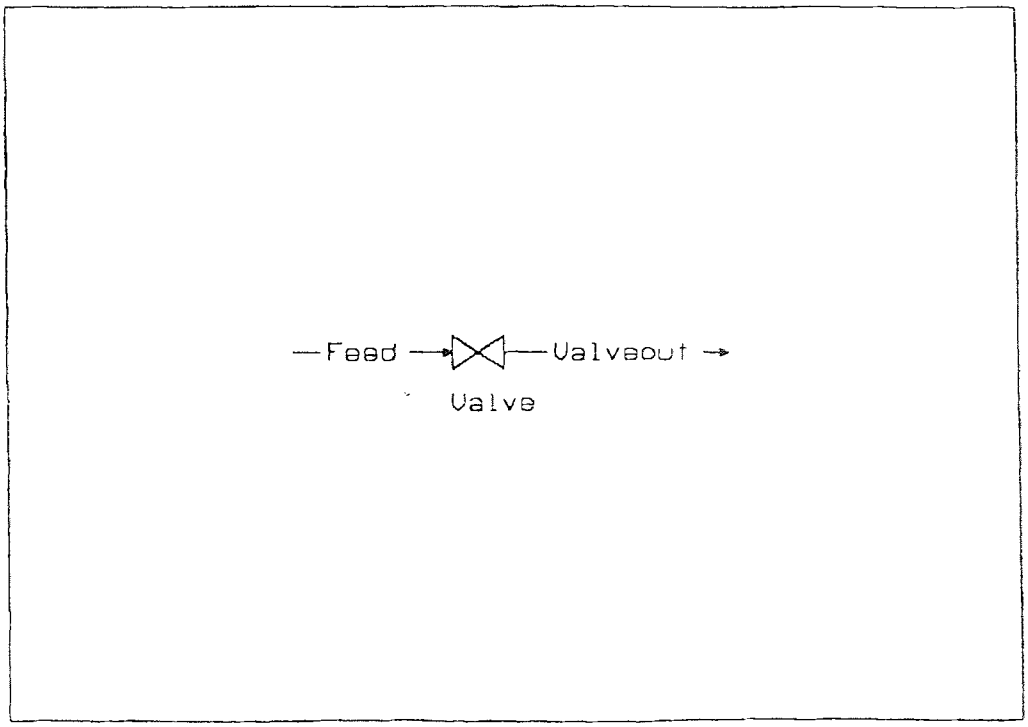
In this example, the feed stream to the valve contains only propane. The temperature, vapor fraction and flow rate of the feed stream is specified, along with the pressure of the outlet stream. With this information, HYSIM then calculates the rest of the conditions of the outlet stream.

Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.
Other References: Refs. 1 & 2.

Directions: Pages 360 through 365 outline the execution of an adiabatic valve example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g. <**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capitals and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Valve*, is shown below:



4.1.3 Valves (Adiabatic) (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

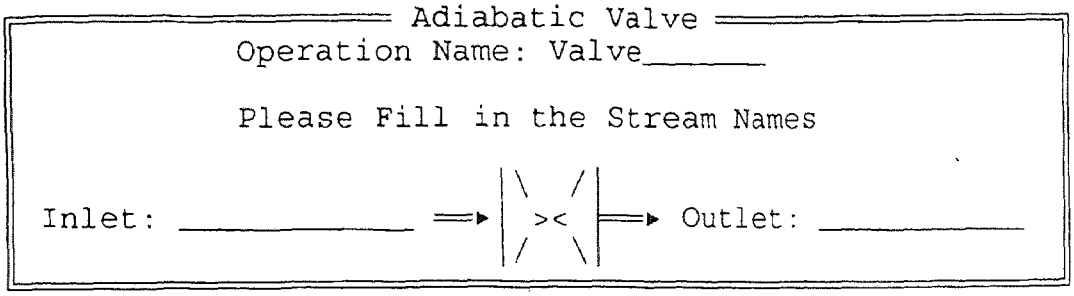
Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

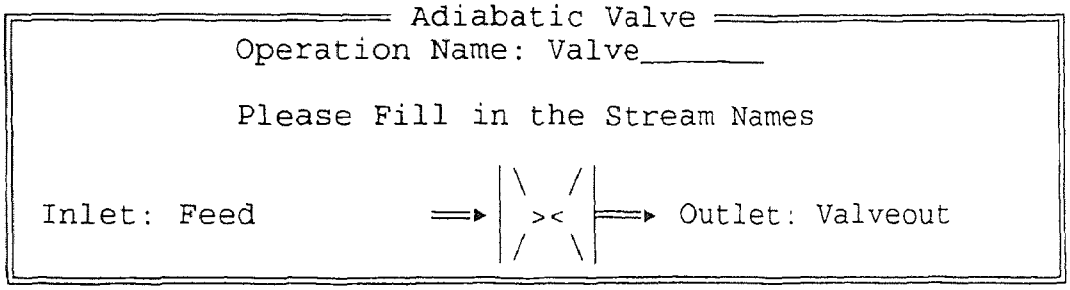
Step	Action
	Selecting the components in the Feed stream.
4	*Highlight the following component name under the "Component Selection" section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Propane** and then press the <**Enter**> key;
5	Press the <**Insert**> key;
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;

4.1.3 Valves (Adiabatic) (continued)

Step	Action
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the type of operation we want to perform.
11	Highlight the word **Operation** and then press the <**Enter**> key;
	Typing a name for the operation. (We will call it "Valve").
12	Type the word **Valve** and then press the <**Enter**> key;
13	Highlight the word **Valve** and then press the <**Enter**> key;
	The following diagram of the valve will appear:



Step	Action
	Naming the streams.
14	Type the word **Feed** in the blank and then press the <**Enter**> key;
15	Type the name **Valveout** in the blank;
	The screen should now appear as follows:



Step	Action
	Getting back to the Main Menu.
16	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
17	Highlight the word **Specify** and then press the <**Enter**> key;
18	Highlight the word **Stream** and then press the <**Enter**> key;
19	Highlight the word **Feed** and then press the <**Enter**> key;

4.1.3 Valves (Adiabatic) (continued)

Step	Action
	Specifying the Temperature of the Feed stream in °F.
20	Type the number **120** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the Pressure of the Feed stream in psia is unknown by typing an "x".
21	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the molar flow rate of Feed stream in lb-mols/hr.
22	Type the number **5.7** and then press the <**Enter**> key;
	Specifying the basis you wish to use when specifying the compositions.
23	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
24	After the word, Propane, type the number **1.0** in the blank;
	The screen should now appear as shown below:

Stream Mole Fractions

```
Propane      1.0_____________
```

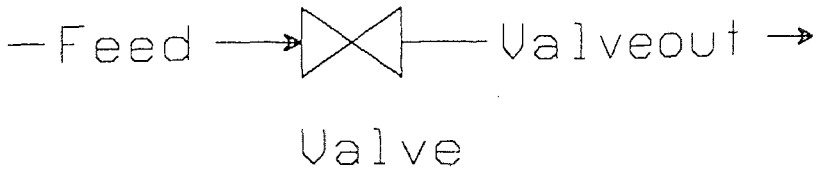
Step	Action
25	Press the <**Insert**> key;
26	Highlight the word **Worksheet** and then press the <**Enter**> key;
27	*Place the cursor in the blank under the column for the Stream name "Feed", and in the row labeled as Vapour frac.* Type the number **0** and then press the <**Enter**> key;
28	*Place the cursor in the blank under the column for the Stream name "Valveout", and in the row labeled as Pressure (psia).* Type the number **44.3** and then press the <**Enter**> key;
	The screen should now appear as follows:

Streams

	New Value =		psia	
Stream	Feed	Valveout	---	---
Vapour_Frac	0.0000*	0.4380	---	---
Temperature	120.0000*	7.5309	---	---
Pressure	243.5033	44.3000*	---	---
Flow	5.7000*	5.7000	---	---
Mass_Flow	251.3529	251.3529	---	---
LiqVol_Flow	33.9680	33.9680	---	---
Energy_Flow	6154.1805	6154.1805	---	---

Step	Action
	Getting back to the Main Menu.
29	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the current Process Flow Diagram (PFD).
30	Highlight the abbreviation **PFD** and then press the <**Enter**> key;
	The figure will then appear as shown on the following page.

4.1.3 Valves (Adiabatic) (continued)



Step	Action
	Getting back to the Main Menu.
31	Press the <**Esc**> key until you reach the Main Menu;
	Looking at the Adiabatic Valve Specification Sheets.
32	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:
The various print options available are as follows:
a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.
b) *Operations* - The different unit operations will be printed out.
c) *Spec_Sheets* - The specifications sheets will be printed out.
d) *Hypotheticals* - Hypothetical component information will be printed out.
e) *Format* - Specifies the format of the printout.
f) *Cost* - Lists costs of the run, if a royalty is being charged.
g) *File* - saves results in a file.
h) *Printer* - Toggles on a printer.
i) *Cases* - Lists the stored files.
j) *Description* - Prints case description.
k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
33	Highlight the word **Spec-Sheets** and then press the <**Enter**> key;
34	Highlight the word **Operations** and then press the <**Enter**> key;
35	Highlight the word **Valve** and then press the <**Enter**> key;
	Pressing the <F10> key will get the main menu off of the screen in enabling you to see the data on the screen underneath it.
36	Press the <**F10**> key;
	The screen will appear as seen on the following page. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

4.1.3 Valves (Adiabatic) (continued)

HYSIM VALVE SPECIFICATION

HYSIM Version C2.53 Date 96/07/11
Case Name: Time 16:00:31
Operation Name: Valve
Operation Note:

Stream		Operation	Flowrate
Inlet: Feed	from	---	5.7000 lbmole
			251.3529 lb/hr
Outlet: Valveout	to	---	

Inlet Properties			Outlet Properties		
Mass Frac Vap	0.0000		Mass frac vap	0.4380	
Temperature	120.0000	F	Temperature	7.5309	F
Pressure	243.5033	psia	Pressure	44.3000	psia
Density	28.1719	lb/ft3	Density	0.9486	lb/ft3
Specific gr	0.4522	SG_H2O60ap	Spec Grav	0.0152	SG_H2O60
Mol Weight	44.0970				
Viscosity	0.0790	cP	Viscosity	---	cP

Vapour Properties			Vapour Properties		
Mass Flow	0.0000	lb/hr	Mass flow	110.0888	lb/hr
Std Vol Flow	0.0000	MMSCFD	Std Vol Flow	0.0227	MMSCFD
Density	---	lb/ft3	Density	0.4221	lb/ft3
Mol Weight	---		Mol Weight	44.0970	
Viscosity	---	cP	Viscosity	0.0072	cP
Z Factor	---		Z Factor	0.9232	

Liquid Properties			Liquid Properties		
Mass flow	251.3529	lb/hr	Mass flow	141.2641	lb/hr
Density	28.1719	lb/ft3	Density	34.1335	lb/ft3
Spec Grav	0.4522	SG_H2O60api	Spec Grav	0.5479	SG_H2O60ap
Mol Weight	44.0970		Mol Weight	44.0970	
Viscosity	0.0790	cP	Viscosity	0.1457	cP

Hydrocarbon Liquid Properties			Hydrocarbon Liquid Properties		
Mass flow	251.3529	lb/hr	Mass flow	141.2641	lb/hr
Density	28.1719	lb/ft3	Density	34.1335	lb/ft3
Spec Grav	0.4522	SG_H2O60api	Spec Grav	0.5479	SG_H2O60ap
Mol Weight	44.0970		Mol Weight	44.0970	
Viscosity	0.0790	cP	Viscosity	0.1457	cP

Heavy Liquid Properties			Heavy Liquid Properties		
Mass Flow	0.0000	lb/hr	Mass Flow	0.0000	lb/hr
Density	---	lb/ft3	Density	---	lb/ft3
Spec Grav	---	SG_H2O60api	Spec Grav	---	SG_H2O60ap
Mol Weight	---		Mol Weight	---	
Viscosity	---	cP	Viscosity	---	cP

NOTES :

4.1.3 Valves (Adiabatic) (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
37	Press the **<F10>** key;
	Looking at the compositions of the streams.
38	Highlight the **Print** key and then press the **<Enter>** key;

The various print options can be found on page 363.

Step	Action
39	Highlight the word **Streams** and then press the **<Enter>** key;
40	Highlight the word **All** and then press the **<Enter>** key;
41	Highlight the dash symbol - and then press the **<Enter>** key;
	The screen will then appear as shown below. Use the <F10> key and the <Page Up> and <Page Down> keys as shown in Steps 36-37.

Stream		Feed	Valveout
Description			
Vapour frac.		0.0000*	0.4380
Temperature	F	120.0000*	7.5309
Pressure	psia	243.5033	44.3000*
Molar Flow	lbmole/hr	5.7000*	5.7000
Mass Flow	lb/hr	251.3529	251.3529
LiqVol Flow	barrel/day	33.9680	33.9680
Enthalpy	Btu/hr	6154.1805	6154.1805
Density	lb/ft3	28.1719	0.9486
Mole Wt.		44.0970	44.0970
Spec. Heat	Btu/lb-F	0.7996	0.4890
Therm Cond	Btu/hr-ft-F	0.0467	---
Viscosity	cP	0.0790	---
Z Factor		0.0613	---
Sur Tension	dyne/cm	4.2069	---
Std Density	lb/ft3	31.6435	---
Propane	mole frac.	1.0000*	1.0000

Step	Action
42	Do you want to continue adding other unit operations to this valve? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

4.1.4 Pipe Sizing and Pressure Drop Calculations

Objective - This exercise is an example of a pipe sizing and pressure drop calculations using HYSIM. The purpose of these calculations are to take a stream whose composition, flowrate and other processing conditions are known and calculate the pipe size needed given a certain pressure drop or vice versa. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, the feed stream contains ten different hydrocarbons. The temperature, pressure and molar flow rate of the feed stream is specified, along with the pipe diameter and schedule. HYSIM can then calculate the pressure drop. If the pressure drop and pipe schedule are specified, without the pipe diameter information, HYSIM will then calculate the pipe diameter.

The dimensionless friction factors used in this calculation by HYSIM were: 0.02253 for the liquid phase and 0.01948 for the vapor phase for the pressure drop calculation, and 0.02250 for the liquid phase and 0.02001 for the vapor phase for the pipe diameter calculation.

HYSIM uses the Darcy equation for single phase stream calculations. In this case the stream is two phase (vapor/liquid) and in the elongated bubble regime. HYSIM uses the pattern map of Mandhane, Gregory and Aziz to determine the flow regime and uses the Mandhane, et.al. modification #1 of the Lockhart-Martinelli model for predicting the pressure drop. (Ref. 2, pages 2-2 to 2-7)

Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.

Other References: Refs. 1 & 2.

Directions: Pages 367 through 373 outline the execution of Pipe Sizing and Pressure Drop Calculations. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←,→,↑, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the keys to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the " Escape" key have additionally been placed inside < > brackets (e.g. <Esc>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the Feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column, as follows:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key; Highlight the word **Propane** and then press the <**Enter**> key; Highlight the word **i-Butane** and then press the <**Enter**> key; Highlight the word **n-Butane** and then press the <**Enter**> key; Highlight the word **i-Pentane** and then press the <**Enter**> key; Highlight the word **n-Pentane** and then press the <**Enter**> key Highlight the word **n-Hexane** and then press the <**Enter**> key; Highlight the word **n-Heptane** and then press the <**Enter**> key; Highlight the word **n-Octane** and then press the <**Enter**> key;

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
5	Press the <**Insert**> key;

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Changing the units from the HYSIM default SI or metric units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.)
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
	Getting back to the Main Menu.
10	Press the <**Esc**> key;
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Typing an "x" to leave the molar flow of the feed unspecified at this point.
16	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed stream will be specified in molar flow rates (lb-mols/hr).
17	Highlight the word **Mole_Flows** after the prompt (>) and then press the <**Enter**> key;
	The following screen will appear:

```
Stream Molar Flows

Methane    _____          Ethane     _____
Propane    _____          i-Butane   _____
n-Butane   _____          i-Pentane  _____
n-Pentane  _____          n-Hexane   _____
n-Heptane  _____          n-Octane   _____
```

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
18	*Enter the following molar flows (lb-mols/hr) beside each component in the feed stream:* After the word, Methane, type the number **70** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **20** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **10** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **9** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **8** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **7** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **6** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **7** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **4** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **3** in the blank;
	The screen should now appear as shown below:

Stream Molar Flows

Methane	70	Ethane	20
Propane	10	i-Butane	9
n-Butane	8	i-Pentane	7
n-Pentane	6	n-Hexane	7
n-Heptane	4	n-Octane	3

Step	Action
19	Press the <**Insert**> key;
	HYSIM will next ask you if the total molar flow (144.0000 lb-mols/hr) it calculated from adding up the component flows is correct.
20	Highlight the word **Yes** and then press the <**Enter**> key;
	Looking at the conditions in the program for the feed stream.
21	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
22	Highlight the word **Streams** and then press the <**Enter**> key;
23	Highlight the word **All** and then press the <**Enter**> key;
24	Highlight the dash symbol - and then press the <**Enter**> key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
25	Press the <**F10**> key;
	The following conditions will then appear on the screen for the Feed stream. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down

Stream		Feed
Description		
Vapour frac.		0.4836
Temperature	F	60.0000*
Pressure	psia	600.0000*
Molar Flow	lbmole/hr	144.0000*
Mass Flow	lb/hr	5438.2035
LiqVol Flow	barrel/day	788.6378
Enthalpy	Btu/hr	231865.6189
Density	lb/ft3	8.2828
Mole Wt.		37.7653
Spec. Heat	Btu/lb-F	0.5779
Therm Cond	Btu/hr-ft-F	---
Viscosity	cP	---
Z Factor		---
Sur Tension	dyne/cm	---
Std Density	lb/ft3	---
Methane	mole frac.	0.4861*
Ethane	mole frac.	0.1389*
Propane	mole frac.	0.0694*
i-Butane	mole frac.	0.0625*
n-Butane	mole frac.	0.0556*
i-Pentane	mole frac.	0.0486*
n-Pentane	mole frac.	0.0417*
n-Hexane	mole frac.	0.0486*
n-Heptane	mole frac.	0.0278*
n-Octane	mole frac.	0.0208*

Step	Action
26	Press the <**F10**> key;
	Specifying that we want to perform a pipe-sizing operation on the Feed stream.
27	Highlight the word **Size** and then press the <**Enter**> key;
28	Highlight the word **Pipe-Size** and then press the <**Enter**> key;
29	Highlight the word **Feed** and then press the <**Enter**> key;
	Specifying a Pipe Diameter in order to obtain the related Pressure Drop in the Pipe in psia.
30	Highlight the word **Press_Drop** and then press the <**Enter**> key;

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
	Entering the Pipe Diameter (nominal or actual Inside Diameter) in inches.
31	Type the number **2.5** at the prompt (>) and then press the **<Enter>** key;
	Specifying the schedule of the pipe.
32	Type the number **40** after the prompt (>) and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
33	Press the **<F10>** key;
	The screen will appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Pressure Drop Calculation for stream Feed

Vapour-Liquid Flow Regime -- Elongated Bubble

Stream Properties

Phase	Viscosity cP	Flowrate lb/hr	Velocity ft/s	Density lb/ft3
Vapour	0.0119	1424.4542	4.4122	2.6307
	cP	lb/hr	ft/s	lb/ft3
Liquid	0.1585	4013.7984	0.9380	34.8684

Pipe Parameters

LIQUID			VAPOUR		
Reynolds Number	Friction Factor	Press Drop Psi/100 ft	Reynolds number	Friction Factor	Press Drop Psi/100 ft
63978.48	0.02253	0.03579	3.01E+05	0.01948	0.05170

Pipe Dia. in	Schedule	Total Pressure Drop Psi/100 ft
2.500	Std.	0.772434

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
34	Press the **<F10>** key;

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
	Specifying that we want to perform a pipe-sizing operation on the Feed stream.
35	Highlight the word **Size** and then press the **<Enter>** key;
36	Highlight the word **Pipe-Size** and then press the **<Enter>** key;
37	Highlight the word **Feed** and then press the **<Enter>** key;
	Specifying a Pressure Drop in order to obtain the related Pipe Diameter in inches.
38	Highlight the word **Diameter** and then press the **<Enter>** key;
	Entering the Pressure Drop in inches of Water per foot of pipe.
39	Type the number **1.0** at the prompt (>) and then press the **<Enter>** key;
	Specifying the schedule of the pipe.
40	Type the number **40** the prompt (>) and then press the **<Enter>** key;
	Pressing the <F10> key will get the Main Menu off of the screen in enabling you to see the data on the screen underneath it.
41	Press the **<F10>** key;
	The screen will appear as shown below. Use the <Page Up> and <Page Down> keys to scroll the screen text up and down.

Pipe Diameter Calculation for stream Feed

Vapour-Liquid Flow Regime -- Elongated Bubble

Stream Properties

Phase	Viscosity cP	Flowrate lb/hr	Velocity ft/s	Density lb/ft3
Vapour	0.0119	1424.4542	6.4544	2.6307
	cP	lb/hr	ft/s	lb/ft3
Liquid	0.1585	4013.7984	1.3722	34.8684

Pipe Parameters

LIQUID			VAPOUR		
Reynolds Number	Friction Factor	Press Drop Psi/100 ft	Reynolds number	Friction Factor	Press Drop Psi/100 ft
77381.00	0.02250	0.09252	3.64E+05	0.02001	0.13741

Pipe Dia. in	Schedule	Total Pressure Drop Psi/100 ft
2.067	Std.	2.026328

4.1.4 Pipe Sizing and Pressure Drop Calculations (continued)

Step	Action
	Pressing the <F10> key again, to get back to the Main Menu.
42	Press the **<F10>** key;
43	Do you want to continue with other unit operations? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual.

This section contains examples of the following two different types of material balances:

4.2.1 Mass Balance

Objective - This exercise is an example of the mass balance operation. This operation takes into account conservation of mass but not of energy, chemical species or moles. This operation should only be used with reactor unit operations. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, the inlet feed stream contains ten different hydrocarbons; whereas the outlet stream contains only one. The mass balance envelope insures that the mass flow in is equal to the mass flow out.

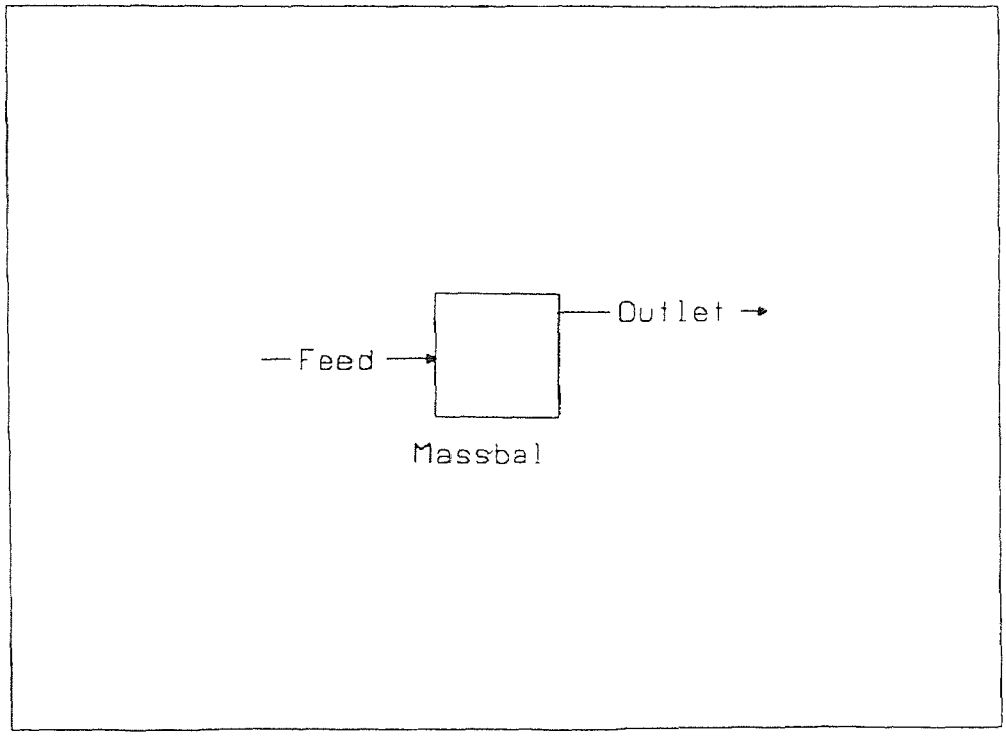
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-51 to 7-53.

Other References: Refs. 1 & 2.

Directions - Pages 376 through 383 outline the execution of a mass balance example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Massbal*, is shown below:



4.2.1 Mass Balance (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

4.2.1 Mass Balance (continued)

Step	Action
	Selecting the components in the Feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key;
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	OIL	OIL		ALL
Ethane	HYPOTHETICAL	HYPOTHETICAL		HC
Propane	C9	n-Nonane	C9H20	SOLID
i-Butane	C10	n-Decane	C10H22	MISC
n-Butane	C11	n-C11	C11H24	AMINE
i-Pentane	C12	n-C12	C12H26	ALCOHOL
n-Pentane	C13	n-C13	C13H28	KETONE
n-Hexane	C14	n-C14	C14H30	ALDEHYDE
n-Heptane	C15	n-C15	C15H32	ESTER
n-Octane	C16	n-C16	C16H34	CARBACID
	C17	n-C17	C17H36	HALOGEN
	C18	n-C18	C18H38	NITRILE
	C19	n-C19	C19H40	PHENOL
	C20	n-C20	C20H42	ETHER
	C21	n-C21	C21H44	USER
	C22	n-C22	C22H46	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the **<Insert>** key;
	The screen on the following page will then appear.

4.2.1 Mass Balance (continued)

```
Work_Sheet          Specify          Operation        Print
PFD                 Remove           Store            New
Ignore              Restore          Hold             Go
Utility             Size             Report           Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system (kPa, kg, °C, etc.) to field units (psia, lb, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in lb-mols/hr.
16	Type the number **100.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying the composition of each component in the Feed stream in mole fractions.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
                    Stream Mole Fractions

Methane     _____________      Ethane      _____________
Propane     _____________      i-Butane    _____________
n-Butane    _____________      i-Pentane   _____________
n-Pentane   _____________      n-Hexane    _____________
n-Heptane   _____________      n-Octane    _____________
```

4.2.1 Mass Balance (continued)

Step	Action
	Specifying the molar fractions of each component in the Feed stream.
18	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.9271** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0516** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0148** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0026** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0020** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0010** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0006** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0001** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0001** in the blank;
	The screen will now appear as shown below:

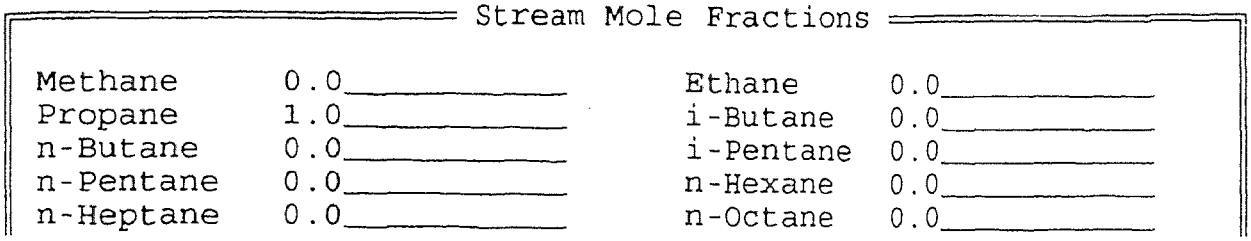
```
                    Stream Mole Fractions

 Methane     0.9271_________      Ethane      0.0516_________
 Propane     0.0148_________      i-Butane    0.0026_________
 n-Butane    0.0020_________      i-Pentane   0.0010_________
 n-Pentane   0.0006_________      n-Hexane    0.0001_________
 n-Heptane   0.0001_________      n-Octane    0.0001_________
```

Step	Action
19	Press the <**Insert**> key;
	Specifying the conditions of the Outlet stream.
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Type the word **Outlet** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature in °F of the Outlet stream as unknown by typing an "x".
23	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Outlet stream in psia as unknown by typing an "x".
24	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Outlet stream in lb-mols/hr as unknown by typing an "x".
25	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Outlet stream.
26	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

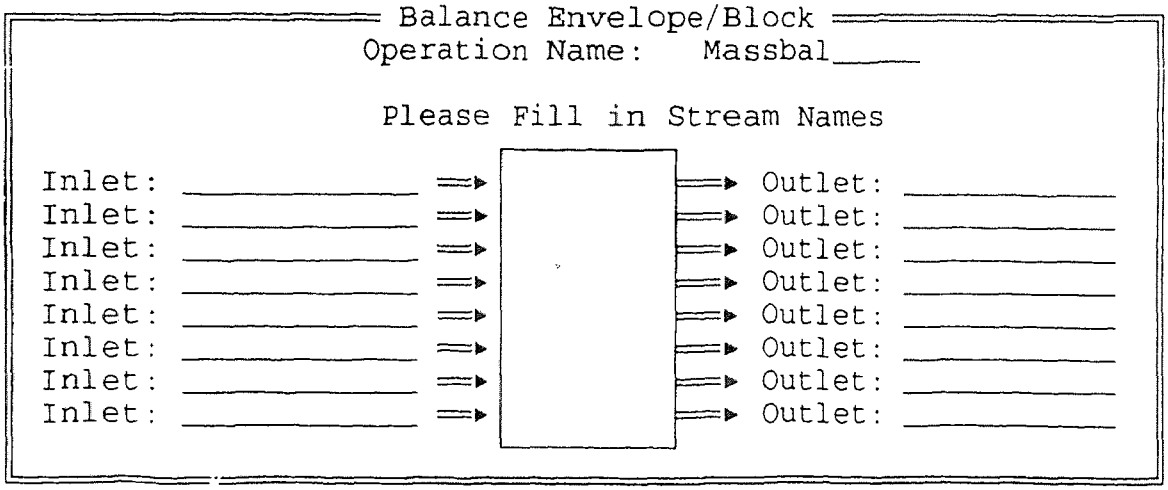
```
                    Stream Mole Fractions

 Methane     _________________    Ethane      _________________
 Propane     _________________    i-Butane    _________________
 n-Butane    _________________    i-Pentane   _________________
 n-Pentane   _________________    n-Hexane    _________________
 n-Heptane   _________________    n-Octane    _________________
```

4.2.1 Mass Balance (continued)

Step	Action
	Specifying the molar fractions of each component in the Outlet stream.
27	*Enter the following mole fractions beside each component in the Outlet stream:* After the word, Methane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **1.0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0** in the blank;
	The screen will now appear as shown below:

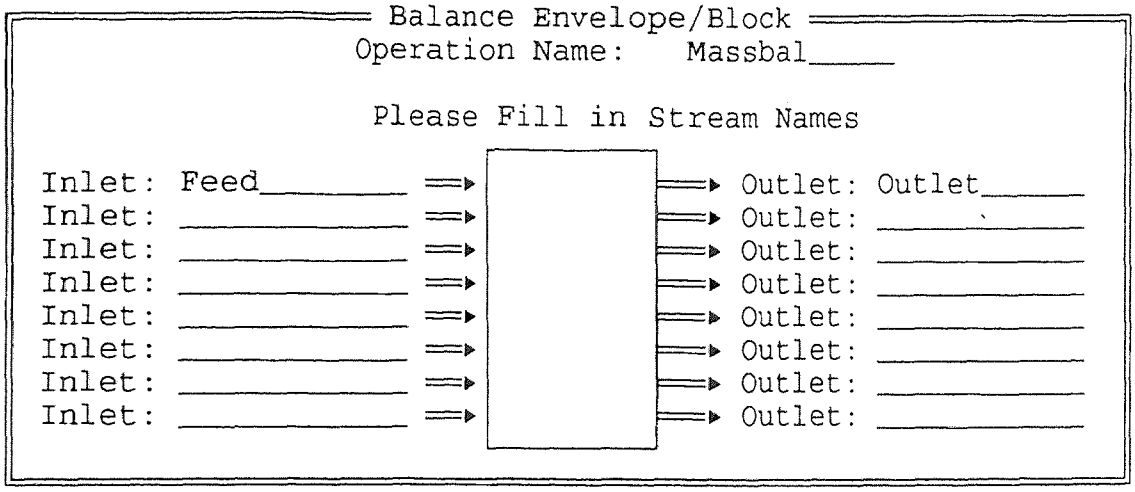


Step	Action
28	Press the <**Insert**> key;
29	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the unit operation as "Massbal".
30	Type the word **Massbal** and then press the <**Enter**> key;
31	Highlight the word **Mass_Balance** and then press the <**Enter**> key;
	The screen will then appear as shown below:



4.2.1 Mass Balance (continued)

Step	Action
	Specifying the inlet and outlet stream names into and out of the mass balance envelope.
32	Type the word **Feed** and then press the <**Enter**> key.
33	Use the mouse to move the cursor to the first Outlet blank and then click the **left mouse button**, and type the word **Outlet**.
	The following screen will then appear:



Step	Action
34	Press the <**Insert**> key.
35	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - specifies the format of the printout

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves the results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

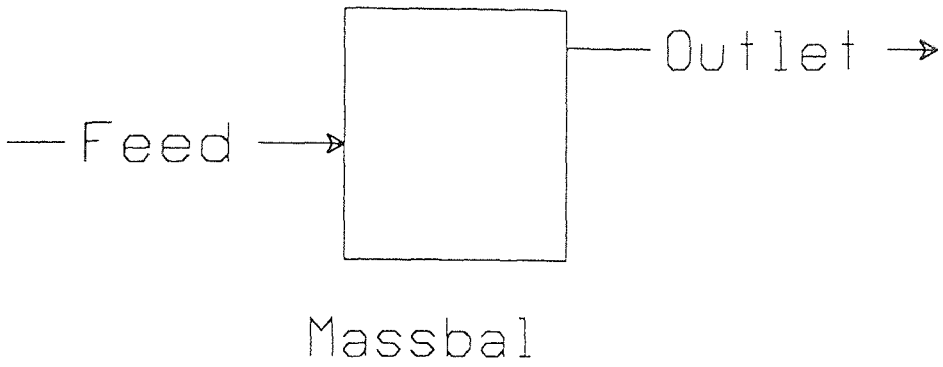
4.2.1 Mass Balance (continued)

Step	Action
36	Highlight the word **Streams** and then press the **<Enter>** key;
37	Highlight the word **All** and then press the **<Enter>** key;
38	Highlight the dash symbol - and then press the **<Enter>** key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
39	Press the **<F10>** key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

Stream Description		Feed	Outlet
Vapour frac.		1.0000	---
Temperature	F	60.0000*	---
Pressure	psia	600.0000*	---
Molar Flow	lbmole/hr	100.0000*	39.6637
Mass Flow	lb/hr	1749.0490	1749.0490
LiqVol Flow	barrel/day	383.6201	236.3677
Enthalpy	Btu/hr	385993.3533	---
Density	lb/ft3	2.1263	---
Mole Wt.		17.4905	44.0970
Spec. Heat	Btu/lb-F	0.5959	---
Therm Cond	Btu/hr-ft-F	0.0203	---
Viscosity	cP	0.0119	---
Z Factor		0.8850	---
Sur Tension	dyne/cm	---	---
Std Density	lb/ft3	---	---
Methane	mole frac.	0.9271*	0.0000*
Ethane	mole frac.	0.0516*	0.0000*
Propane	mole frac.	0.0148*	1.0000*
i-Butane	mole frac.	0.0026*	0.0000*
n-Butane	mole frac.	0.0020*	0.0000*
i-Pentane	mole frac.	0.0010*	0.0000*
n-Pentane	mole frac.	0.0006*	0.0000*
n-Hexane	mole frac.	0.0001*	0.0000*
n-Heptane	mole frac.	0.0001*	0.0000*
n-Octane	mole frac.	0.0001*	0.0000*

4.2.1 Mass Balance (continued)

Step	Action
40	Press the <**F10**> key;
	Looking at the PFD (Process Flow Diagram) for the mass balance.
41	Highlight the letters **PFD** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Getting back to the Main Menu.
42	Press the <**Esc**> key until you reach the Main Menu.
43	Do you want to continue adding other unit operations to this mass balance? • If Yes, turn to the pertinent section of this manual now; • I f No, turn to the "Exiting HYSIM" Section of this manual

4.2.2 Mole Balance

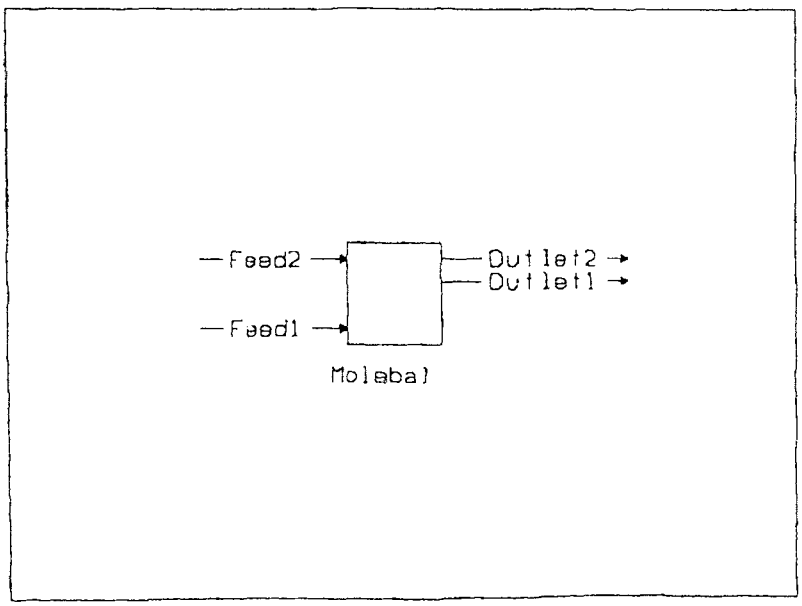
Objective - This exercise is an example of the mole balance operation. This operation takes into account conservation of moles but not of energy. This example can be modified by specifying another property package and/or other components, compositions and feed/outlet conditions.

In this example, there are two feed streams (*Feed1*, *Feed2*) and two outlet streams (*Outlet1* and *Outlet2*) to and from the mole balance envelope. The temperature, pressure and composition were specified for all four streams. The molar flow rate of *Feed1* and *Feed2* were also specified and then HYSIM calculated the mole flow rate of *Outlet1* and *Outlet2*.
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User 's Guide, Version C2.50, March 1994, pages 7-54 to 7-55.
Other References: Refs. 1 & 2.

Directions - Pages 385 through 392 outline the execution of a mole balance example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.**<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *Molebal*, is shown below:



4.2.2 Mole Balance (continued)

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the process.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

4.2.2 Mole Balance (continued)

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	OIL	OIL		ALL
Ethane	HYPOTHETICAL	HYPOTHETICAL		HC
	C3	Propane	C3H8	SOLID
	i-C4	i-Butane	C4H10	MISC
	n-C4	n-Butane	C4H10	AMINE
	i-C5	i-Pentane	C5H12	ALCOHOL
	n-C5	n-Pentane	C5H12	KETONE
	C6	n-Hexane	C6H14	ALDEHYDE
	C7	n-Heptane	C7H16	ESTER
	C8	n-Octane	C8H18	CARBACID
	C9	n-Nonane	C9H20	HALOGEN
	C10	n-Decane	C10H22	NITRILE
	C11	n-C11	C11H24	PHENOL
	C12	n-C12	C12H26	ETHER
	C13	n-C13	C13H28	USER
	C14	n-C14	C14H30	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;
	The following screen will then appear:

```
Work_Sheet          Specify             Operation           Print
PFD                 Remove              Store               New
Ignore              Restore             Hold                Go
Utility             Size                Report              Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system units (kPa, kg, °C, etc.) to field units (psia, lb, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;

4.2.2 Mole Balance (continued)

Step	Action
10	Press the <**Esc**> key.
	Specifying the conditions of the Feed1 stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed1** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed1 stream in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed1 stream in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed1 stream in lb-mols/hr.
16	Type the number **100.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed1 stream will be in mole fractions.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
═══════ Stream Mole Fractions ═══════

Methane  _____________  Ethane  _____________
```

Step	Action
	Specifying the molar fractions of each component in the Feed1 stream.
18	*Enter the following mole fractions beside each component in the Feed1 stream:* After the word, Methane, type the number **0.1** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.9** in the blank;
	The screen will now appear as shown below:

```
═══════ Stream Mole Fractions ═══════

Methane  0.1_____________  Ethane  0.9_____________
```

Step	Action
19	Press the <**Insert**> key;
	Specifying the conditions of the Feed2 stream.
20	Highlight the word **Specify** and then press the <**Enter**> key;
21	Highlight the word **Stream** and then press the <**Enter**> key;
22	Type the word **Feed2** after the prompt (>) and then press the <**Enter**> key;

4.2.2 Mole Balance (continued)

Step	Action
	Specifying the temperature of the Feed2 stream in °F.
23	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed2 stream in psia.
24	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed2 stream in lb-mols/hr.
25	Type the number **100.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed2 stream will be in mole fractions.
26	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
═══════ Stream Mole Fractions ═══════

Methane  _____________  Ethane  _____________
```

Step	Action
	Specifying the molar fractions of each component in the Feed2 stream.
27	*Enter the following mole fractions beside each component in the Feed2 stream:* After the word, Methane, type the number **0.5** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.5** in the blank;
	The screen will now appear as shown below:

```
═══════ Stream Mole Fractions ═══════

Methane  0.5_____________  Ethane  0.5_____________
```

Step	Action
28	Press the <**Insert**> key;
	Specifying the conditions of the Outlet1 stream.
29	Highlight the word **Specify** and then press the <**Enter**> key;
30	Highlight the word **Stream** and then press the <**Enter**> key;
31	Type the word **Outlet1** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Outlet1 stream in °F.
32	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Outlet1 stream in psia.
33	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Outlet1 stream in lb-mols/hr as unknown by typing an "x".
34	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Outlet1 stream.
35	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown on the following page.

4.2.2 Mole Balance (continued)

```
Stream Mole Fractions

Methane _____________   Ethane _____________
```

Step	Action
	Specifying the molar fractions of each component in the Outlet1 stream.
36	*Enter the following mole fractions beside each component in the Outlet1 stream:* After the word, Methane, type the number **0.35** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.65** in the blank;
	The screen will now appear as shown below:

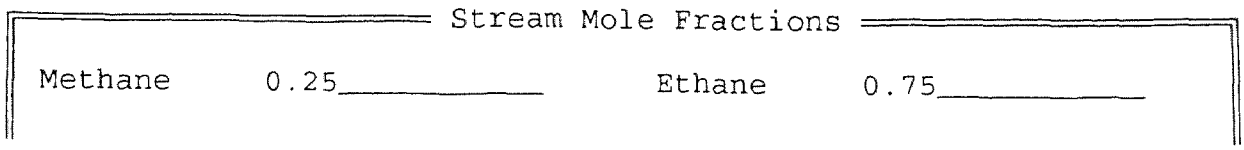
```
Stream Mole Fractions

Methane   0.35_____________   Ethane   0.65_____________
```

Step	Action
37	Press the <**Insert**> key;
	Specifying the conditions of the Outlet2 stream.
38	Highlight the word **Specify** and then press the <**Enter**> key;
39	Highlight the word **Stream** and then press the <**Enter**> key;
40	Type the word **Outlet2** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Outlet2 stream in °F.
41	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Outlet2 stream in psia.
42	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Outlet2 stream in lb-mols/hr as unknown by typing an "x".
43	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Outlet2 stream will be provided in a mole fraction form.
44	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

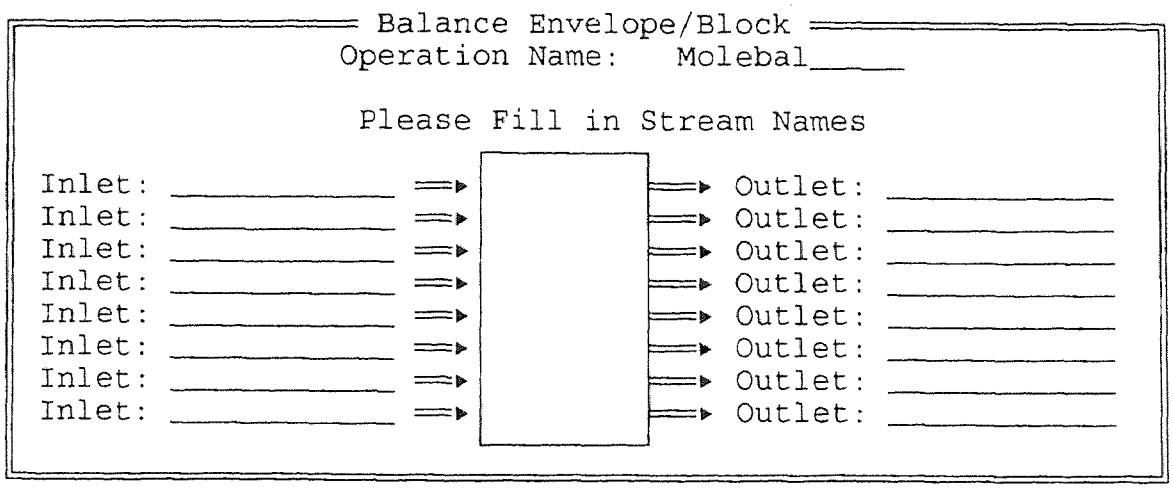
```
Stream Mole Fractions

Methane _____________   Ethane _____________
```

4.2.2 Mole Balance (continued)

Step	Action
	Specifying the molar fractions of each component in the Outlet2 stream.
45	*Enter the following mole fractions beside each component in the Outlet2 stream:* After the word, Methane, type the number **0.25** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.75** in the blank;
	The screen will now appear as shown below:

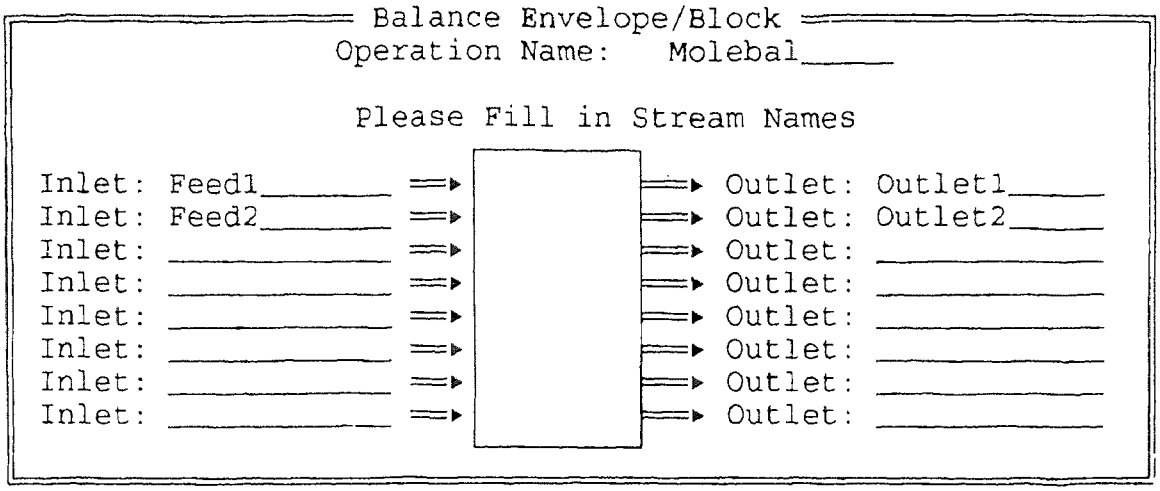


Step	Action
46	Press the <**Insert**> key;
47	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the unit operation as "Molebal".
48	Type the word **Molebal** and then press the <**Enter**> key;
49	Highlight the word **Mole_Balance** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the inlet and outlet stream names into and out of the mole balance envelope.
50	Type the word **Feed1** and then press the <**Enter**> key.
51	Type the word **Feed2** and then press the <**Enter**> key.
52	Use the mouse to move the cursor to the first Outlet blank and then click the **left mouse button**, and type the word **Outlet1** and then press the <**Enter**> key.
53	Type the word **Outlet2**.
	The following screen will then appear as shown on the following page.

4.2.2 Mole Balance (continued)



Step	Action
54	Press the <**Insert**> key.
55	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

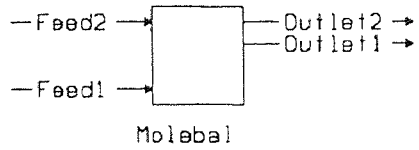
NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
56	Highlight the word **Streams** and then press the <**Enter**> key;
57	Highlight the word **All** and then press the <**Enter**> key;
58	Highlight the dash symbol - and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
59	Press the <**F10**> key;
	The screen will then appear as shown on the following page. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

4.2.2 Mole Balance (continued)

Stream		Feed1	Feed2	Outlet1	Outlet2
Description					
Vapour frac.		0.6901	1.0000	1.0000	1.0000
Temperature	F	60.0000*	60.0000*	60.0000*	60.0000*
Pressure	psia	600.0000*	600.0000*	600.0000*	600.0000*
Molar Flow	lbmole/hr	100.0000*	100.0000*	100.0000	100.0000
Mass Flow	lb/hr	2866.7201	2305.6400	2516.0452	2656.3148
LiqVol Flow	barrel/day	557.6812	472.8934	504.6889	525.8857
Enthalpy	Btu/hr	257239.0962	378479.1626	369481.4192	358936.7282
Density	lb/ft3	7.4294	3.2337	3.8576	4.4302
Mole Wt.		28.6672	23.0564	25.1604	26.5632
Spec. Heat	Btu/lb-F	1.2904	0.6073	0.6560	0.7325
Therm Cond	Btu/hr-ft-F	---	0.0178	0.0172	0.0170
Viscosity	cP	---	0.0117	0.0118	0.0120
Z Factor		---	0.7671	0.7017	0.6451
Sur Tension	dyne/cm	---	---	---	---
Std Density	lb/ft3	---	---	---	---
Methane	mole frac.	0.1000*	0.5000*	0.3500*	0.2500*
Ethane	mole frac.	0.9000*	0.5000*	0.6500*	0.7500*

Step	Action
60	Press the <**F10**> key;
	Looking at the PFD (Process Flow Diagram) for the mole balance.
61	Highlight the letters **PFD** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Getting back to the Main Menu.
62	Press the <**Esc**> key until you reach the Main Menu.
63	Do you want to continue adding other unit operations to this mole balance? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

Objective - This exercise is an example of the set operation. This Set operation is used to set a variable (such as the temperature) of a controlled stream equal to that of another independent stream multiplied by a certain multiplier and added to some offset value. This example can be modified by specifying another property package and/or other components, compositions and feed/outlet conditions.

In this example, the pressure, molar flow rate, and composition of both the feed and outlet stream are specified; the temperature of the feed stream is also given. The set operation is used to set the temperature of the outlet stream as the temperature of the feed stream plus 10°C. HYSIM then calculates the temperature of the outlet stream.

Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-113 to 7-114.

Other References: Refs. 1 & 2.

Directions - Pages 394 through 399 outlines the execution of a set/controller example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the process.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the <**Enter**> key; Highlight the word **Ethane** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	OIL	OIL		ALL
Ethane	HYPOTHETICAL	HYPOTHETICAL		HC
	C3	Propane	C3H8	SOLID
	i-C4	i-Butane	C4H10	MISC
	n-C4	n-Butane	C4H10	AMINE
	i-C5	i-Pentane	C5H12	ALCOHOL
	n-C5	n-Pentane	C5H12	KETONE
	C6	n-Hexane	C6H14	ALDEHYDE
	C7	n-Heptane	C7H16	ESTER
	C8	n-Octane	C8H18	CARBACID
	C9	n-Nonane	C9H20	HALOGEN
	C10	n-Decane	C10H22	NITRILE
	C11	n-C11	C11H24	PHENOL
	C12	n-C12	C12H26	ETHER
	C13	n-C13	C13H28	USER
	C14	n-C14	C14H30	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the <**Insert**> key;
	The following screen will then appear:

```
Work_Sheet          Specify          Operation          Print
PFD                 Remove           Store              New
Ignore              Restore          Hold               Go
Utility             Size             Report             Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying the conditions of the Feed stream.
6	Highlight the word **Specify** and then press the <**Enter**> key;
7	Highlight the word **Stream** and then press the <**Enter**> key;
8	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed stream in °C.
9	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed stream in kilopascals (kPa).
10	Type the number **600** after the prompt (>) and then press the <**Enter**> key;

Step	Action
	Specifying the flow of the Feed stream in kg-mols/hr.
11	Type the number **100.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed stream will be specified in mole fractions.
12	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
Stream Mole Fractions

Methane _____________   Ethane _____________
```

Step	Action
	Specifying the molar fractions of each component in the Feed stream.
13	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.5** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.5** in the blank;
	The screen will now appear as shown below:

```
Stream Mole Fractions

Methane  0.5_________   Ethane  0.5_________
```

Step	Action
14	Press the <**Insert**> key;
	Specifying the conditions of the Outlet stream.
15	Highlight the word **Specify** and then press the <**Enter**> key;
16	Highlight the word **Stream** and then press the <**Enter**> key;
17	Type the word **Outlet** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Outlet stream in ℃ as unknown by typing an "x".
18	Type the letter **x** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Outlet stream in kilopascals (kPa).
19	Type the number **700** after the prompt (>)and then press the <**Enter**> key;
	Specifying the flow of the Outlet stream in kg-mols/hr.
20	Type the number **100.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Outlet stream will be in mole fractions.
21	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
Stream Mole Fractions

Methane _____________   Ethane _____________
```

Step	Action
	Specifying the molar fractions of each component in the Outlet stream.
22	*Enter the following mole fractions beside each component in the Outlet stream:* After the word, Methane, type the number **0.5** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.5** in the blank;
	The screen will now appear as shown below:

Stream Mole Fractions

Methane 0.5 Ethane 0.5

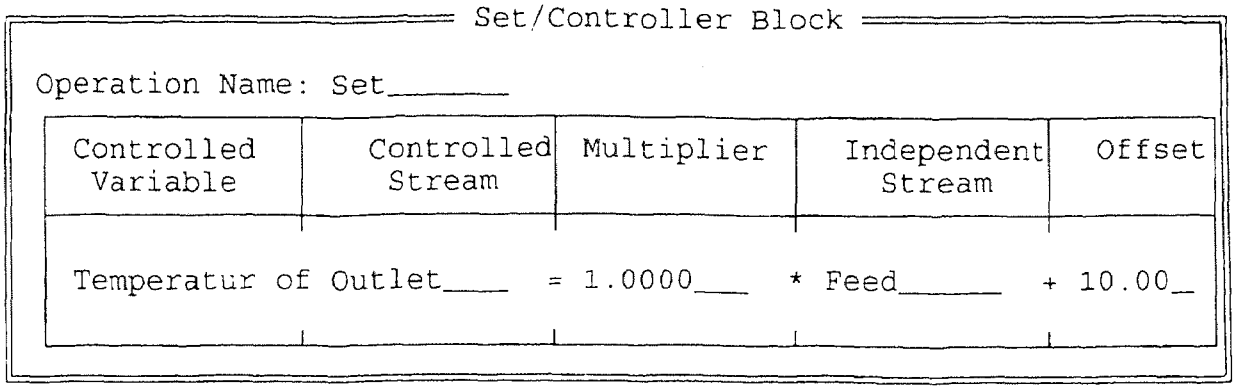
Step	Action
23	Press the <**Insert**> key;
24	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the set operation as "Set".
25	Type the word **Set** and then press the <**Enter**> key;
26	Highlight the word **Set** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Set/Controller Block

Operation Name: Set

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
	of	= 1.0000	*	+ 0.0000

Step	Action
	Specifying the controlled variable and stream, the multiplier, the independent stream and the offset value.
27	Type the word **Temperature** and then press the <**Enter**> key.
28	Type the word **Outlet** and then press the <**Enter**> key two times.
29	Type the word **Feed** and then press the <**Enter**> key.
30	Type the number **10.00**.
	The screen will then appear as shown on the following page.



Step	Action
31	Press the <**Insert**> key.
32	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves the results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
33	Highlight the word **Streams** and then press the <**Enter**> key;
34	Highlight the word **All** and then press the <**Enter**> key;
35	Highlight the dash symbol - and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
36	Press the <**F10**> key;
	The screen will then appear as shown on the following page.

Stream		Feed	Outlet
Description			
Vapour frac.		1.0000	1.0000
Temperature	C	60.0000*	70.0000
Pressure	kPa	600.0000*	700.0000*
Molar Flow	kgmole/h	100.0000*	100.0000*
Mass Flow	kg/h	2305.6401	2305.6401
LiqVol Flow	m3/h	6.9063	6.9063
Enthalpy	kJ/h	1.24192E+06	1.28744E+06
Density	kg/m3	5.0990	5.7828
Mole Wt.		23.0564	23.0564
Spec. Heat	kJ/kg-C	2.0828	2.1221
Therm Cond	W/m-K	0.0319	0.0333
Viscosity	cP	0.0117	0.0121
Z Factor		0.9795	0.9782
Sur Tension	dyne/cm	---	---
Std Density	kg/m3	---	---
Methane	mole frac.	0.5000*	0.5000*
Ethane	mole frac.	0.5000*	0.5000*

Step	Action
37	Press the <**F10**> key;
38	Do you want to continue adding other unit operations to this set operation? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

Objective - This exercise is an example of the Adjust/Controllers operation in HYSIM. This operation allows the HYSIM user to make a variable for one stream, called the dependent variable (e.g. the flowrate), dependent on a variable for another stream called the adjust variable (e.g. the temperature). The HYSIM user must specify the target value of the Dependent Variable and also the convergence criteria (Target Tolerance and Adjusted Variable step size). This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, a *Feed* stream containing ten different hydrocarbons is fed into a two phase separator, which separates the vapor and liquid product streams. The adjust operation is used to adjust the temperature of the feed stream until the flow rate of the liquid product stream, *Sepliq*, is equal to 100 lb-mols/hr.

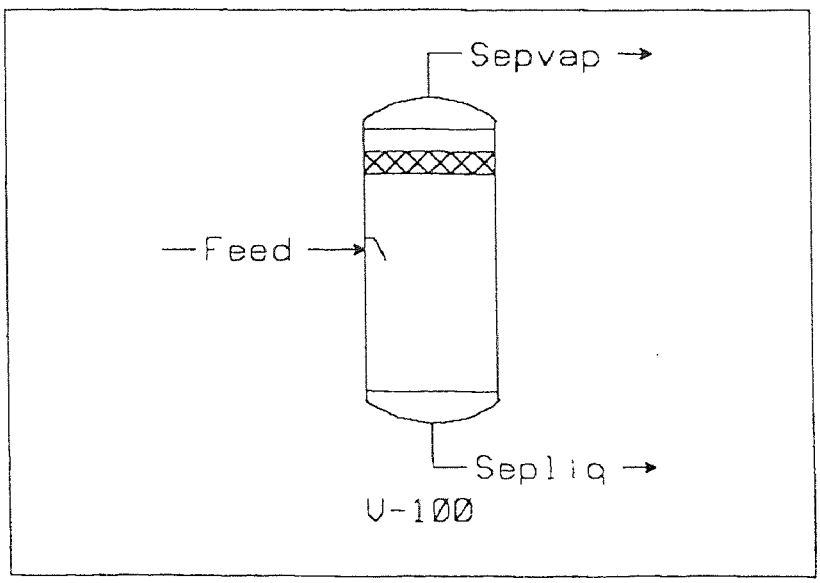
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-15 to 7-26.

Other References: Refs. 1 & 2.

Directions - Pages 401 through 411 outline the execution of an adjuster/controller example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.**<Esc>**) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this unit operation, called *V-100*, is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key;
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	OIL	OIL		ALL
Ethane	HYPOTHETICAL	HYPOTHETICAL		HC
Propane	C9	n-Nonane	C9H20	SOLID
i-Butane	C10	n-Decane	C10H22	MISC
n-Butane	C11	n-C11	C11H24	AMINE
i-Pentane	C12	n-C12	C12H26	ALCOHOL
n-Pentane	C13	n-C13	C13H28	KETONE
n-Hexane	C14	n-C14	C14H30	ALDEHYDE
n-Heptane	C15	n-C15	C15H32	ESTER
n-Octane	C16	n-C16	C16H34	CARBACID
	C17	n-C17	C17H36	HALOGEN
	C18	n-C18	C18H38	NITRILE
	C19	n-C19	C19H40	PHENOL
	C20	n-C20	C20H42	ETHER
	C21	n-C21	C21H44	USER
	C22	n-C22	C22H46	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move,
PRESS INSERT TO SUBMIT F8 - Change

Step	Action
5	Press the **<Insert>** key;
	The screen on the following page will then appear.

```
Work_Sheet          Specify             Operation       Print
PFD                 Remove              Store           New
Ignore              Restore             Hold            Go
Utility             Size                Report          Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system (kPa, kg, °C, etc.) to field units (psia, lb, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in lb-mols/hr.
16	Type the number **144.0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Feed will be given in mole fractions.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

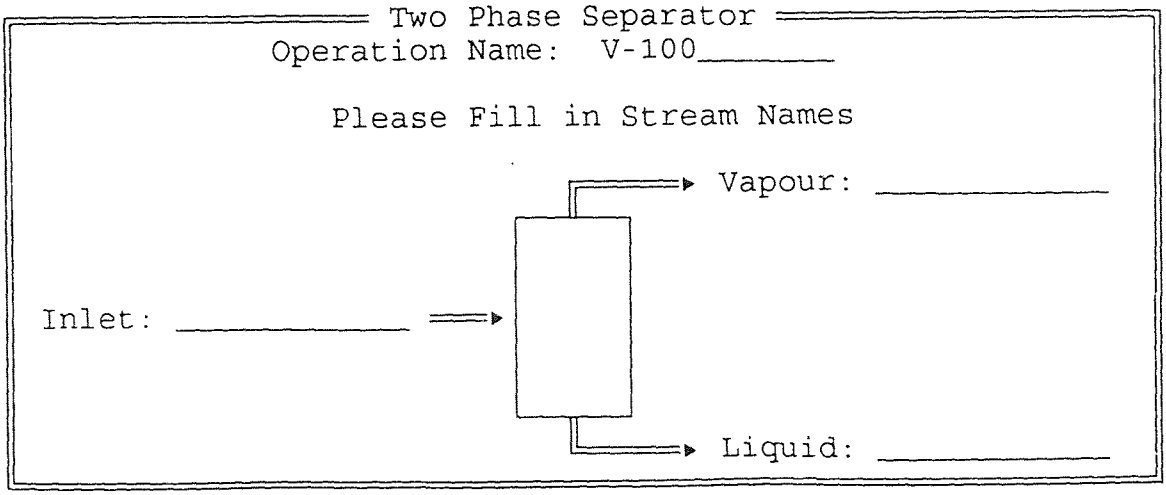
```
                    Stream Mole Fractions

Methane     _____________________    Ethane      _____________________
Propane     _____________________    i-Butane    _____________________
n-Butane    _____________________    i-Pentane   _____________________
n-Pentane   _____________________    n-Hexane    _____________________
n-Heptane   _____________________    n-Octane    _____________________
```

Step	Action
	Specifying the molar fractions of each component in the Feed stream.
18	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.4861** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1389** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0694** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0625** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0556** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0486** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0417** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0486** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0278** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0208** in the blank;
	The screen will now appear as shown below:

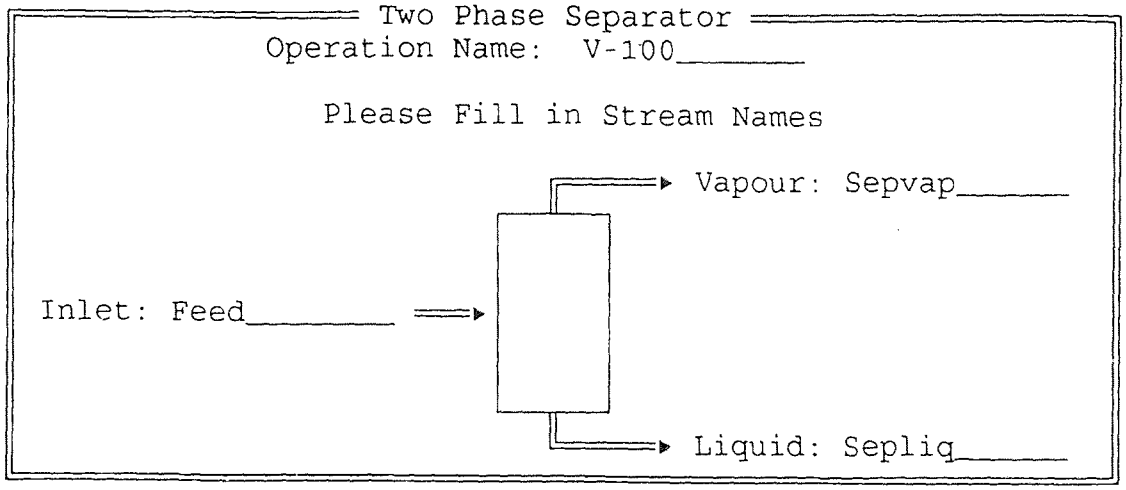
Stream Mole Fractions

Methane	0.4861	Ethane	0.1389
Propane	0.0694	i-Butane	0.0625
n-Butane	0.0556	i-Pentane	0.0486
n-Pentane	0.0417	n-Hexane	0.0486
n-Heptane	0.0278	n-Octane	0.0208

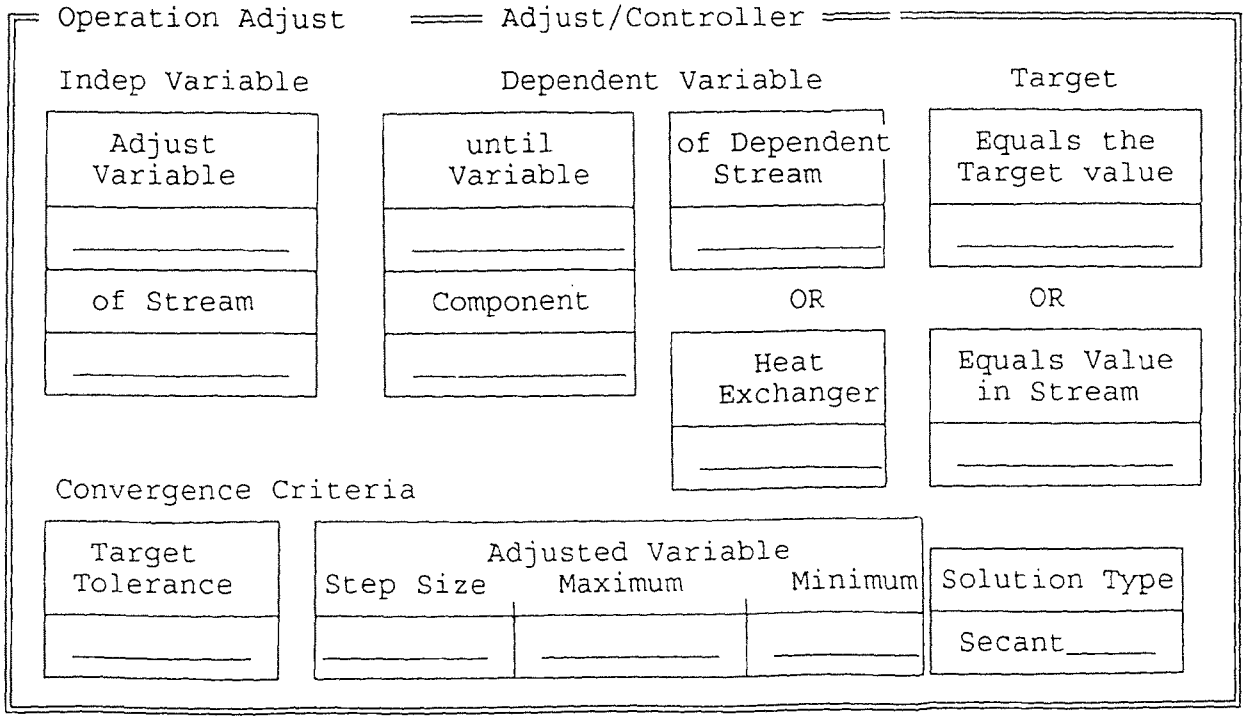
Step	Action
19	Press the <**Insert**> key;
20	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Separator as "V-100".
21	Type the name **V-100** and then press the <**Enter**> key;
22	Highlight the word **Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the inlet and outlet stream names into and out of Separator.
23	Type the word **Feed** and then press the <**Enter**> key.
24	Type the word **Sepliq** and then press the <**Enter**> key.
25	Type the word **Sepvap**.
	The following screen will then appear:



Step	Action
26	Press the <**Insert**> key;
27	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Adjust Operation as "Adjust".
28	Type the name **Adjust** and then press the <**Enter**> key;
29	Highlight the word **Adjust** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the Independent or Adjust Variable.
30	Type the word **Temperature** and then press the <**Enter**> key;
	Specifying the Stream name containing the Independent Variable to be adjusted.
31	Type the name **Feed** and then press the <**Enter**> key;
	Specifying the Dependent Variable.
32	Type the word **Flow** and then press the <**Enter**> key two times;
	Specifying the Stream name containing the Dependent Variable, for which a target value will be specified.
33	Type the name **Sepliq** and then press the <**Enter**> key two times;
	Specifying the Target value for the Flow Rate of stream Sepliq as 100.0000 lb-mols/hr.
34	Type the number **100.0000** and then press the <**Enter**> key two times;
	Specifying the converged tolerance of the dependent variable.
35	Type the number **1.0000** and then press the <**Enter**> key;
	Specifying the Step Size used to adjust the independent variable.
36	Type the number **20.000** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation Adjust — Adjust/Controller

Indep Variable

Adjust Variable
Temperature_
of Stream
Feed_____

Dependent Variable

until Variable
Flow_____
Component
_____

of Dependent Stream
Sepliq_____
OR
Heat Exchanger
_____

Target

Equals the Target value
100.0000____
OR
Equals Value in Stream
_____

Convergence Criteria

Target Tolerance
1.0000__

Adjusted Variable		
Step Size	Maximum	Minimum
20.000____	_____	_____

Solution Type
Secant_____

Step	Action
37	Press the <**Insert**> key.
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
38	Press the <**F10**> key;
	The screen will then appear as shown on the following page.

```
 Your selected components are
Methane         Ethane          Propane         i-Butane        n-Butane
i-Pentane       n-Pentane       n-Hexane        n-Heptane       n-Octane


Adjust Adjust   Iteration   1: Temperature of        60.000 F gives
 Flow of        74.366 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   2: Temperature of        80.000 F gives
 Flow of        68.700 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   3: Temperature of        40.000 F gives
 Flow of        80.188 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   4: Temperature of        20.000 F gives
 Flow of        86.376 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   5: Temperature of   1.9073E-06 F gives
 Flow of        93.248 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   6: Temperature of       -20.000 F gives
 Flow of        101.34 vs       100.00 lbmole/hr
Adjust Adjust   Iteration   7: Temperature of       -16.684 F gives
 Flow of        99.881 vs       100.00 lbmole/hr
Adjust Adjust Converged
```

Step	Action
39	Press the <**F10**> key;
40	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

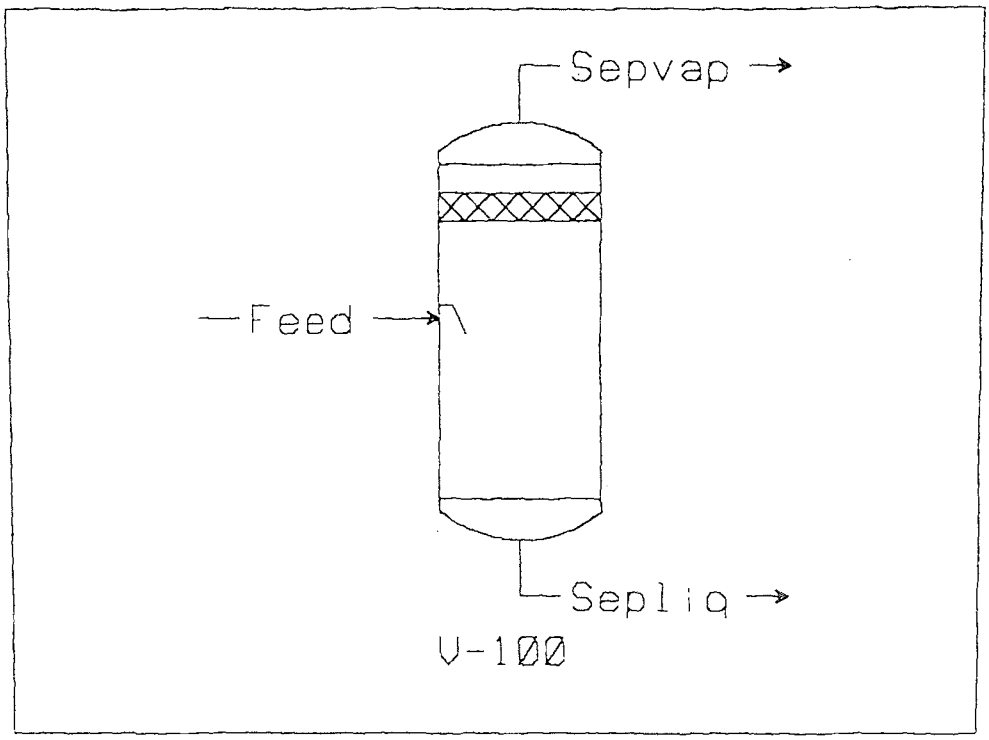
k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
41	Highlight the word **Streams** and then press the <**Enter**> key;
42	Highlight the word **All** and then press the <**Enter**> key;
43	Highlight the dash symbol - and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
44	Press the <**F10**> key;
	The screen will then appear as shown below. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

Stream Description		Feed	Sepliq	Sepvap
Vapour frac.		0.3064	0.0000	1.0000
Temperature	F	-16.6836*	-16.6836	-16.6836
Pressure	psia	600.0000*	600.0000	600.0000
Molar Flow	lbmole/hr	144.0000*	99.8812	44.1188
Mass Flow	lb/hr	5438.1809	4653.8385	784.3422
LiqVol Flow	barrel/day	788.6361	617.2932	171.3429
Enthalpy	Btu/hr	-73747.2829	-207126.4622	133379.1830
Density	lb/ft3	13.3722	35.6979	2.8386
Mole Wt.		37.7651	46.5938	17.7779
Spec. Heat	Btu/lb-F	0.5538	0.5378	0.6484
Therm Cond	Btu/hr-ft-F	---	0.0674	0.0175
Viscosity	cP	---	0.1879	0.0107
Z Factor		---	0.1647	0.7905
Sur Tension	dyne/cm	---	11.3211	---
Std Density	lb/ft3	---	31.8352	---
Methane	mole frac.	0.4861*	0.3011	0.9049
Ethane	mole frac.	0.1389*	0.1666	0.0762
Propane	mole frac.	0.0694*	0.0952	0.0111
i-Butane	mole frac.	0.0625*	0.0884	0.0039
n-Butane	mole frac.	0.0556*	0.0791	0.0024
i-Pentane	mole frac.	0.0486*	0.0697	0.0008
n-Pentane	mole frac.	0.0417*	0.0599	0.0005
n-Hexane	mole frac.	0.0486*	0.0700	0.0002
n-Heptane	mole frac.	0.0278*	0.0401	0.0000
n-Octane	mole frac.	0.0208*	0.0300	0.0000

Step	Action
45	Press the <**F10**> key;
	Looking at the PFD (Process Flow Diagram) for the Separator.
46	Highlight the letters **PFD** and then press the <**Enter**> key;
	The screen will then appear as shown on the following page.



Step	Action
47	Press the <**Esc**> key.
48	Highlight the word **Print** and then press the <**Enter**> key;

The various print options can be found on page 407.

Step	Action
49	Highlight the word **Spec_Sheets** and then press the <**Enter**> key;
50	Highlight the word **Operations** and then press the <**Enter**> key;
51	Highlight the name **V-100** and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it.
52	Press the <**F10**> key;
	The screen will then appear as shown on the next page Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

HYSIM VESSEL SPECIFICATION SHEET

HYSIM Version C2.53 Date 96/07/17
Case Name Time 13:42:55

Operation Name: V-100
Operation Note:

Stream		Operation			Flowrate	
Inlet:	Feed	from	---	---	5438.1809	lb/hr
Vapour:	Sepvap	to	---	---	784.3422	lb/hr
HC Liquid:	Sepliq	to	---	---	4653.8385	lb/hr
Hvy Liquid:	---	to	---	---	---	lb/hr

Inlet Properties at Operating Conds			Inlet Mixed Liquid Properties		
Temperature	-16.6836	F	Density	35.6979	lb/ft3
Pressure	600.0000	psia	Spec. Grav.	0.5730	SG_H2O60
Mass Frac Vap	0.1442		Mol. Weight	46.5938	
Density	13.3722	lb/ft3	Surface Tens.	11.3211	dyne/cm
Mol. Weight	37.7651		Viscosity	0.1879	cP

Vapour Outlet Properties		
Density	2.8386	lb/ft3
Mol. Weight	17.7779	
Z Factor	0.7905	
Viscosity	0.0107	cP

Hydrocarbon Liquid Outlet Properties		
Density	35.6979	lb/ft3
Spec. Grav.	0.5730	SG_H2O60
Mol. Weight	46.5938	
Surface Tens.	11.3211	dyne/cm
Viscosity	0.1879	cP

Heavy Liquid Outlet Properties		
Density	---	lb/ft3
Spec. Grav.	---	SG_H2O60
Mol. Weight	---	
Surface Tens.	---	dyne/cm
Viscosity	---	cP

NOTES :

Step	Action
53	Press the <F10> key;
54	Do you want to continue adding other operations to this adjust/controller operation? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

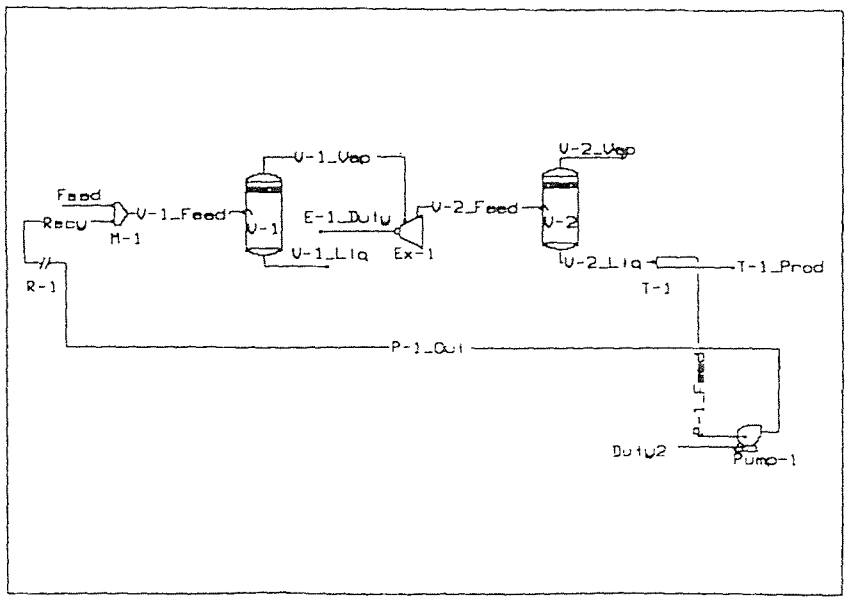
Objective - This exercise is an example of the single recycle stream operation in HYSIM. This operation allows the HYSIM user to recycle a stream used in a process. This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, a process is specified to HYSIM which includes a recycle stream, *Recy*. The *Feed* stream to the process is mixed with the Recy recycle steam in a mixer, *M-1*. The resultant product from this mixer, *V-1 Feed* stream is fed into a separator, *V-1*. The vapor product stream from the separator, *V-1 Vap*, is then fed into a expander, *Ex-1*. The outlet stream from the compressor, *V-2 Feed*, is then fed into another separator, *V-2*. The liquid product stream from the V-2 separator is then separated by half, into streams *T-1 Prod* and *P-1 Feed*, with the use of the tee operation, *T-1*. The P-1 Feed stream is then fed into a pump, *Pump-1*. The outlet stream from the pump, *P-1 Out*, is then recycled to the mixer, *M-1*.
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-90 to 7-108. (This section in the User's Guide should be consulted if multiple recycle streams are required).
Other References: Refs. 1 & 2.

Directions - Pages 413 through 431 outline the execution of a process with a recycle stream. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

A process flow diagram for this process containing a recycle, called *R-1*, is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected"column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key; Highlight the word **Nitrogen** and then press the **<Enter>** key; Highlight the formula **CO2** and then press the **<Enter>** key
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	Cl2	Cl2	Cl2	ALL
Ethane	HCl	HCl	HCl	HC
Propane	F2	F2	F2	SOLID
i-Butane	HF	HF	HF	MISC
n-Butane	Br2	Bromine	Br2	AMINE
i-Pentane	HBr	HBr	HBr	ALCOHOL
n-Pentane	I2	Iodine	I2	KETONE
n-Hexane	HI	HI	HI	ALDEHYDE
n-Heptane	NitricOxide	NO	NO	ESTER
n-Octane	NO2	NO2	NO2	CARBACID
Nitrogen	N2O	N2O	N2O	HALOGEN
CO2	N2O4	N2O4	N2O4	NITRILE
	SO2	SO2	SO2	PHENOL
	SO3	SO3	SO3	ETHER
	CO	CO	CO	USER
	Sulphur_Rhombic	S_Rhombic	S	

Search by SYNONYM

F1 - Help,F3 - Menu,F4 - Flip Srch, F5 - Exam,F6 - Move,F8 - Change

PRESS INSERT TO SUBMIT

Step	Action
5	Press the **<Insert>** key;
	The screen on the following page will then appear.

```
Work_Sheet          Specify             Operation          Print
PFD                 Remove              Store              New
Ignore              Restore             Hold               Go
Utility             Size                Report             Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system (kPa, kg, ℃, etc.) to field units (psia, lb, ℉, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed in ℉.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in lb-mols/hr.
16	Type the number **2635.3364** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Feed.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
                    Stream Mole Fractions

Methane     _____________      Ethane      _____________
Propane     _____________      i-Butane    _____________
n-Butane    _____________      i-Pentane   _____________
n-Pentane   _____________      n-Hexane    _____________
n-Heptane   _____________      n-Octane    _____________
Nitrogen    _____________      CO2         _____________
```

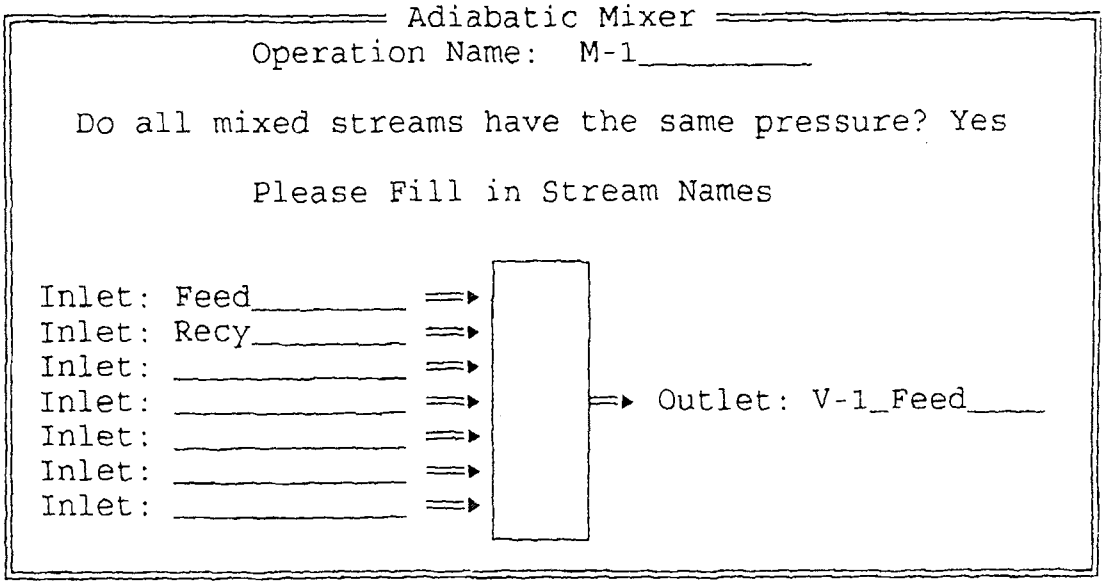
Step	Action
	Specifying the molar fractions of each component in the Feed stream.
18	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.4826** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1379** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0690** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0621** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0552** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0483** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0414** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0345** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0276** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0207** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **0.0069** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0138** in the blank;
	The screen will now appear as shown below:

```
═══════════ Stream Mole Fractions ═══════════

Methane     0.4826_____      Ethane      0.1379_____
Propane     0.0690_____      i-Butane    0.0621_____
n-Butane    0.0552_____      i-Pentane   0.0483_____
n-Pentane   0.0414_____      n-Hexane    0.0345_____
n-Heptane   0.0276_____      n-Octane    0.0207_____
Nitrogen    0.0069_____      CO2         0.0138_____
```

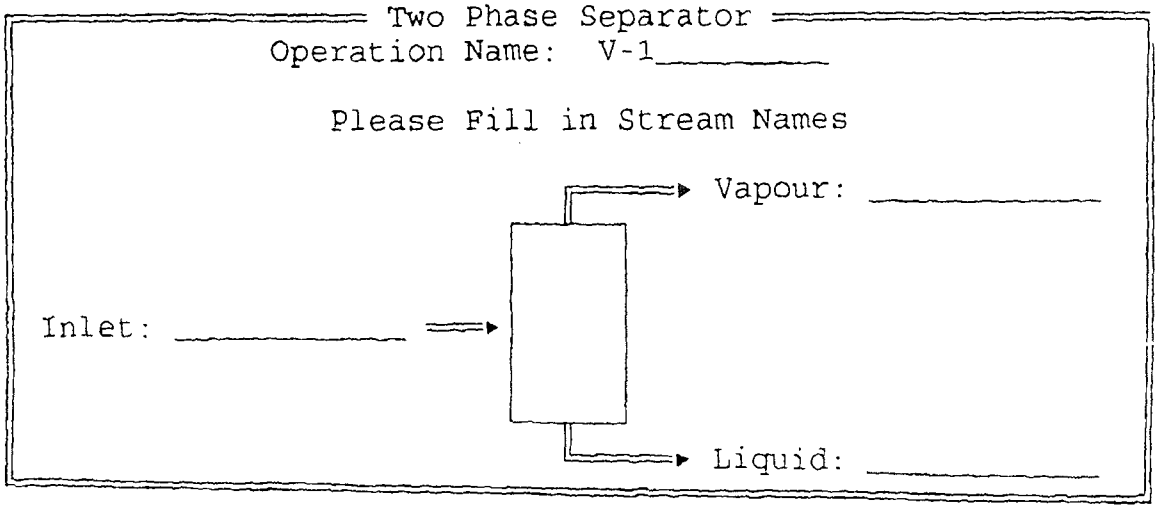
Step	Action
19	Press the <**Insert**> key;
20	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Mixer as "M-1".
21	Type the name **M-1** and then press the <**Enter**> key;
22	Highlight the word **Mixer** and then press the <**Enter**> key;
	The screen will then appear as shown below:

```
═══════════ Adiabatic Mixer ═══════════
          Operation Name:  M-1_____
  Do all mixed streams have the same pressure? ___

          Please Fill in Stream Names


Inlet: _____ ═══►
Inlet: _____ ═══►
Inlet: _____ ═══►
Inlet: _____ ═══►      ═══► Outlet: _____
Inlet: _____ ═══►
Inlet: _____ ═══►
Inlet: _____ ═══►
```

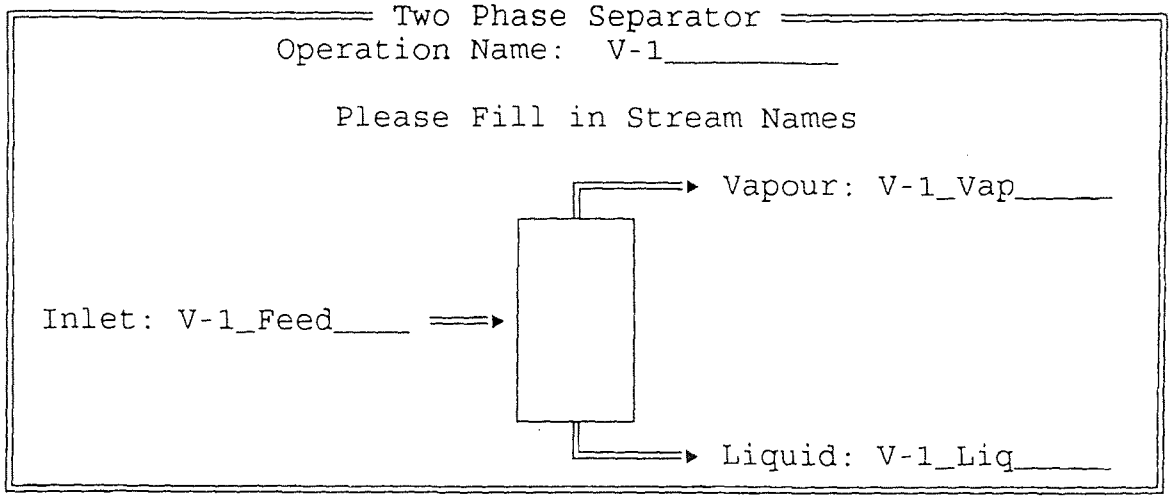
Step	Action
	Answering the question, "Do all mixed streams have the same pressure?"
23	Type the word **Yes** and then press the <**Enter**> key;
	Specifying the inlet and outlet stream names into and out of the Mixer, M-1.
24	Type the word **V-1_Feed** and then press the <**Enter**> key.
25	Type the word **Feed** and then press the <**Enter**> key.
26	Type the word **Recy**.
	The following screen will then appear:



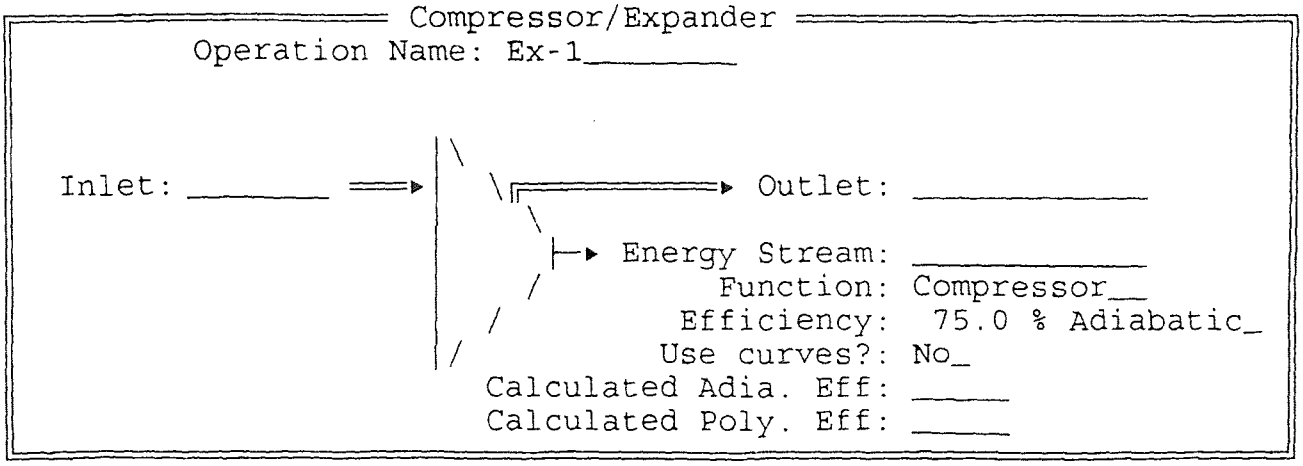
Step	Action
27	Press the <**Insert**> key;
28	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Separator as "V-1".
29	Type the name **V-1** and then press the <**Enter**> key;
30	Highlight the word **Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



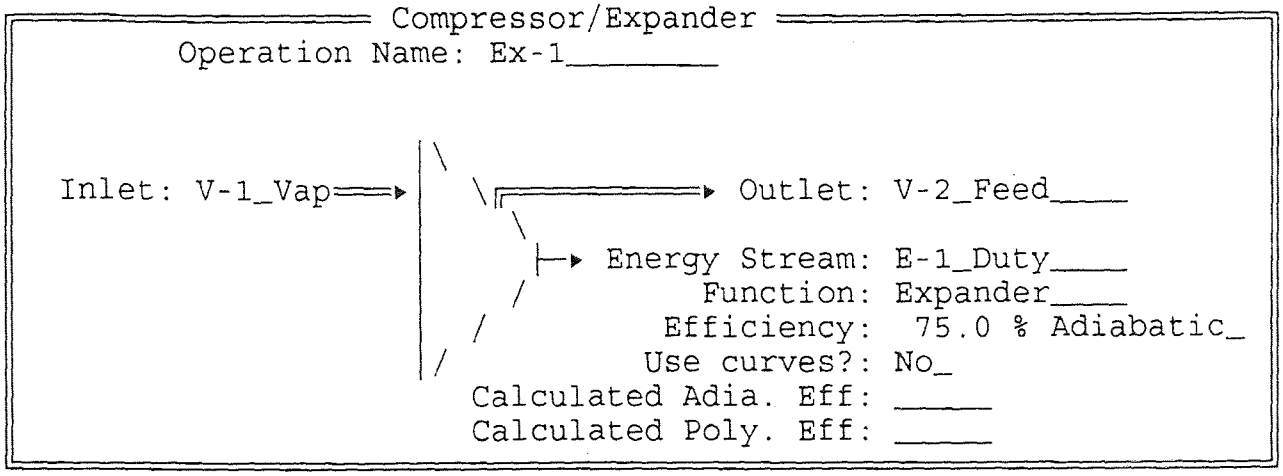
Step	Action
	Specifying the inlet and outlet stream names into and out of Separator, V-1.
31	Type the word **V-1_Feed** and then press the <**Enter**> key.
32	Type the word **V-1_Liq** and then press the <**Enter**> key.
33	Type the word **V-1_Vap**.
	The following screen will then appear:



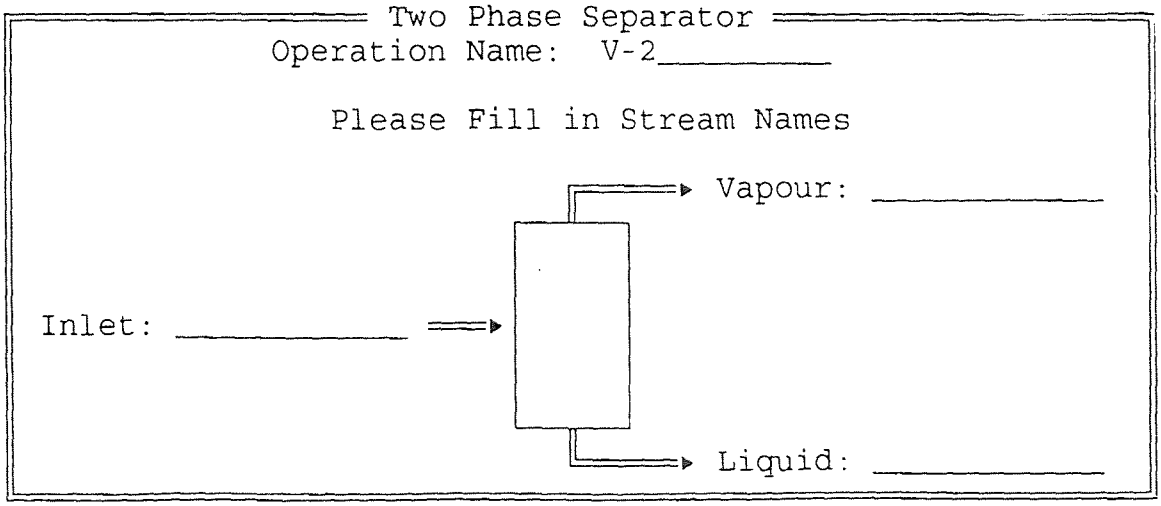
Step	Action
34	Press the <**Insert**> key;
35	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Expander as "Ex-1".
36	Type the name **Ex-1** and then press the <**Enter**> key;
37	Highlight the words **Comp/Expander** and then press the <**Enter**> key;
	The screen will then appear as shown below:



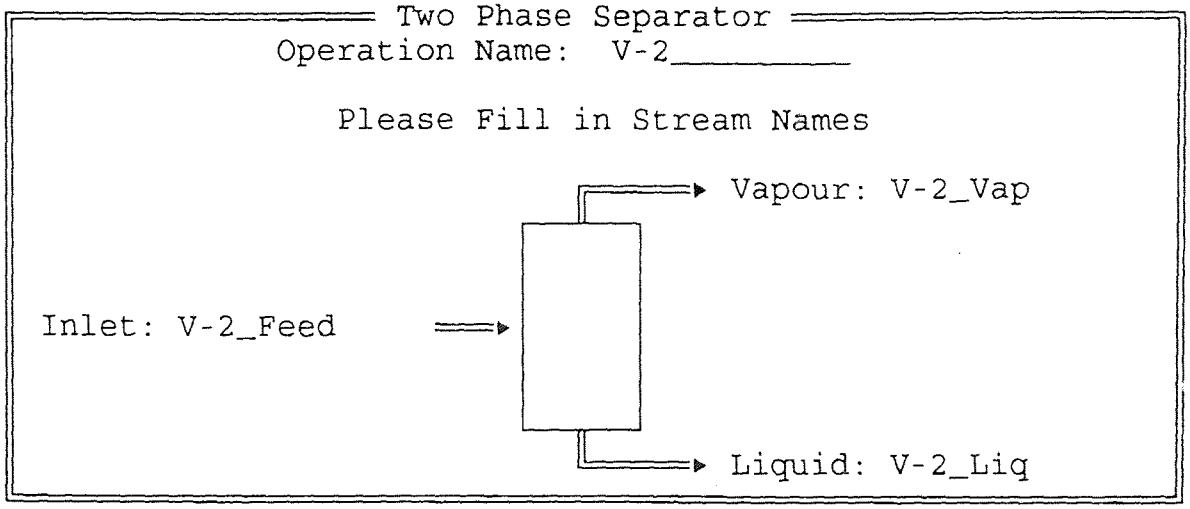
Step	Action
	Specifying the inlet and outlet stream names into and out of Expander, Ex-1.
38	Type the word **V-1_Vap** and then press the <**Enter**> key.
39	Type the word **V-2_Feed** and then press the <**Enter**> key.
40	Type the word **E-1_Duty** and then press the <**Enter**> key.
41	Press the <**F2**> key and highlight the word **Expander** and then press the <**Enter**> key;
	The following screen will then appear:



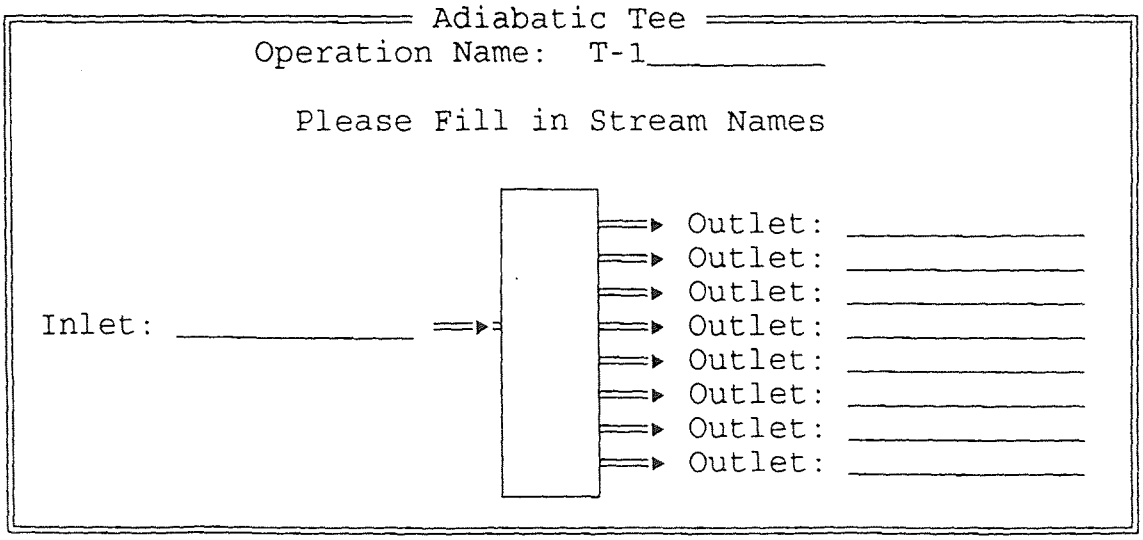
Step	Action
42	Press the <**Insert**> key and then highlight the word **Operation** and press the <**Enter**> key;
	Naming the second Separator as "V-2".
43	Type the name **V-2** and then press the <**Enter**> key;
44	Highlight the word **Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



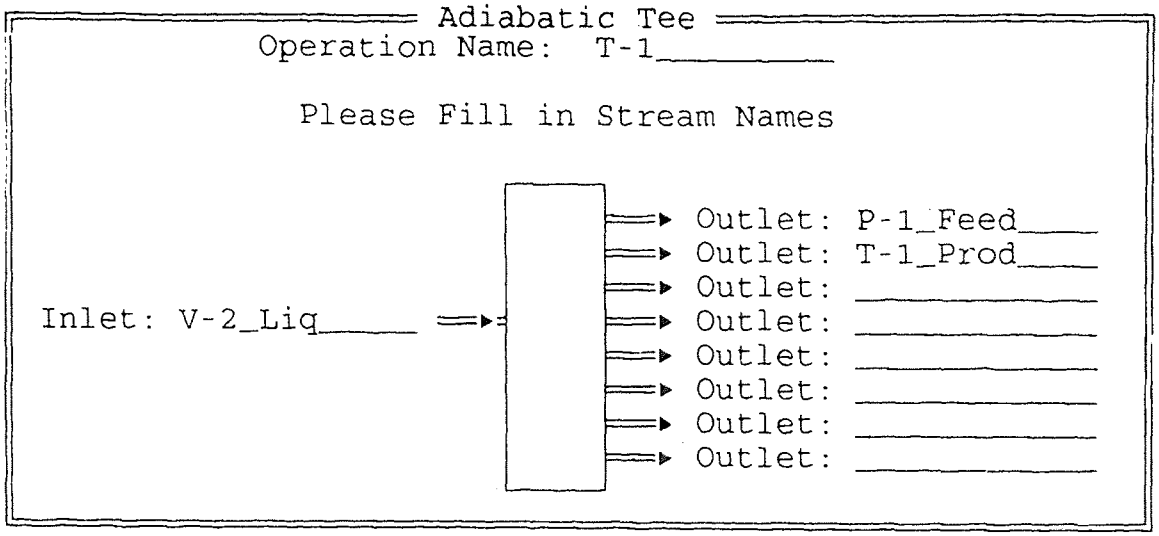
Step	Action
	Specifying the inlet and outlet stream names into and out of Separator. V-2.
45	Type the word **V-2_Feed** and then press the <**Enter**> key.
46	Type the word **V-2_Liq** and then press the <**Enter**> key.
47	Type the word **V-2_Vap**.
	The following screen will then appear:



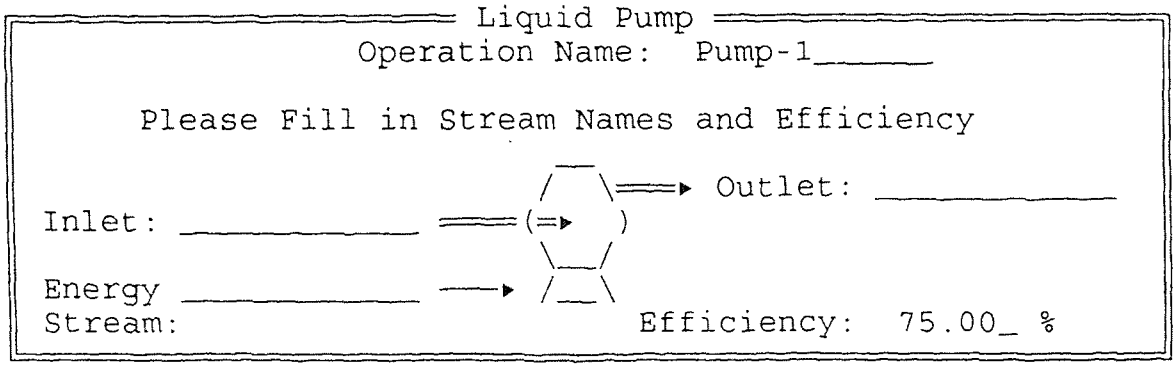
Step	Action
48	Press the <**Insert**> key;
49	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Tee as "T-1".
50	Type the name **T-1** and then press the <**Enter**> key;
51	Highlight the word **Tee** and then press the <**Enter**> key;
	The screen will then appear as shown below:



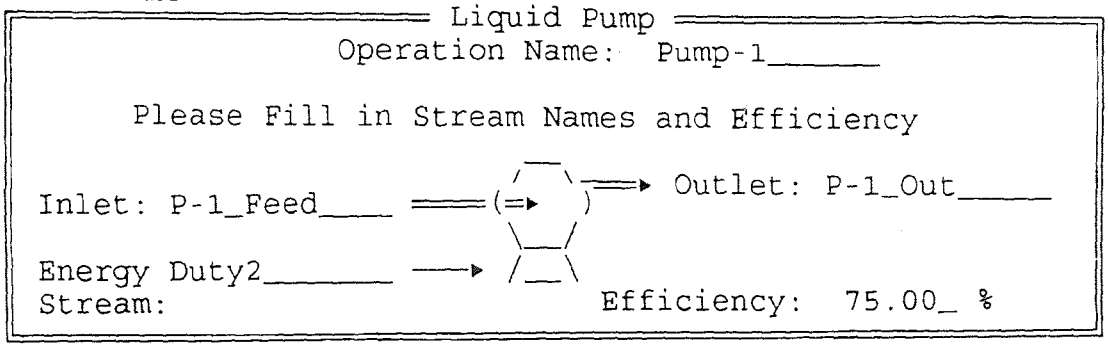
Step	Action
	Specifying the inlet and outlet stream names into and out of the Tee, T-1.
52	Type the word **V-2_Liq** and then press the <**Enter**> key.
53	Type the word **P-1_Feed** and then press the <**Enter**> key.
54	Type the word **T-1_Prod**.
	The following screen will then appear:



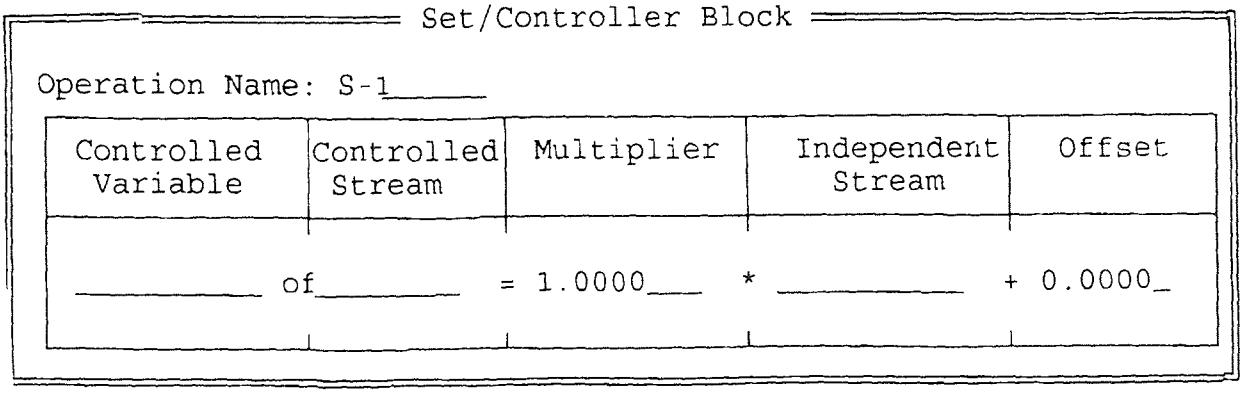
Step	Action
55	Press the <**Insert**> key;
56	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Pump as "Pump-1".
57	Type the name **Pump-1** and then press the <**Enter**> key;
58	Highlight the word **Pump** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the inlet and outlet stream names into and out of the Pump, Pump-1.
59	Type the word **P-1_Feed** and then press the <**Enter**> key.
60	Type the word **P-1_Out** and then press the <**Enter**> key.
61	Type the word **Duty2**.
	The following screen will then appear:



Step	Action
62	Press the <**Insert**> key;
63	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Set operation as "S-1".
64	Type the name **S-1** and then press the <**Enter**> key;
65	Highlight the word **Set** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the controlled variable.
66	Type the word **Flow** and then press the <**Enter**> key.
	Specifying the controlled stream name.
67	Type the word **P-1_Feed** and then press the <**Enter**> key.
	Specifying the Multiplier of the independent stream's flow rate.
68	Type the number **0.5** and then press the <**Enter**> key;
	Specifying the Independent stream name.
69	Type the word **V-2_Liq** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

Set/Controller Block

Operation Name:S-1_____

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Flow____	of P-1_Feed__	= 0.5_____	* V-2_Liq___	+ 0.0000_

Step	Action
70	Press the <**Insert**> key;
71	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Recycle operation as "R-1".
72	Type the name **R-1** and then press the <**Enter**> key;
73	Highlight the word **Recycle** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation R-1 _____Recycle Operation

Max Iters: 5 Type: Nested_____

Wegstein Count: 3__

Q Max: 0.00

Q Min: -20.00

Sensitivities

Phase Frac.	10.0	Flow	10.0
Temperature	10.0	Enthalpy	10.0
Pressure	10.0	Composition	10.0

Inlet Stream

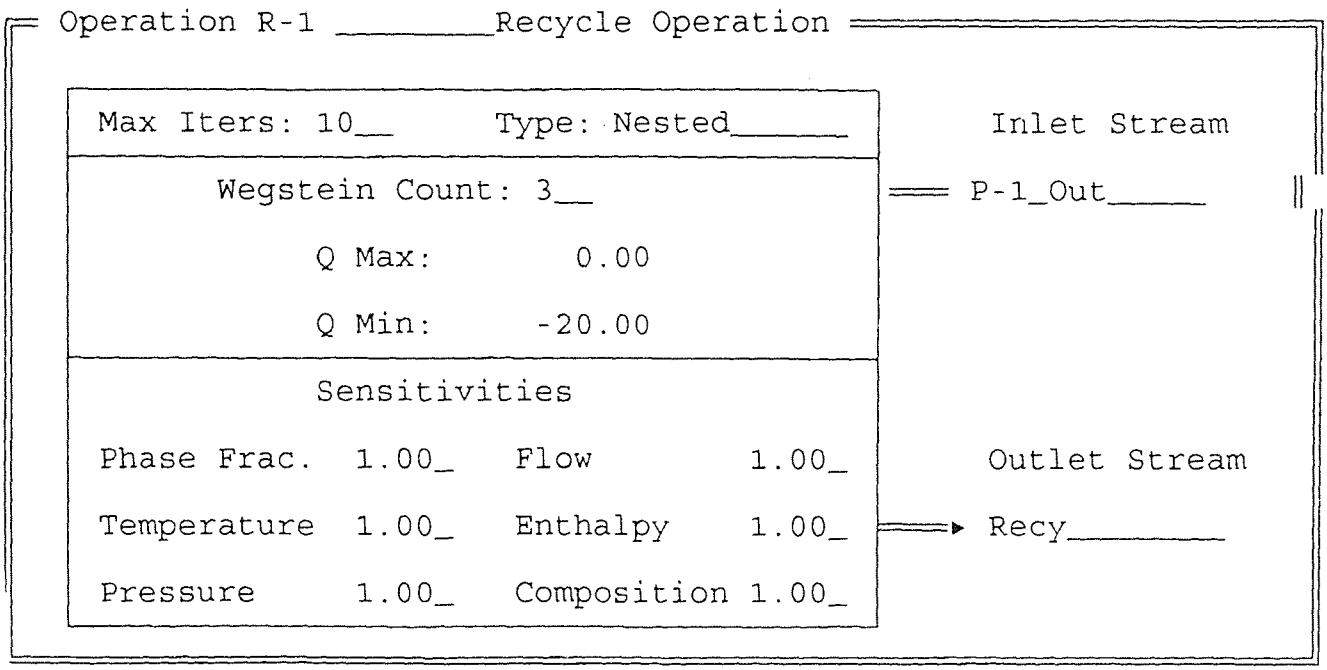
_____

Outlet Stream

_____

Step	Action
	Specifying the inlet stream name.
74	Type the word **P-1_Out** and then press the <**Enter**> key.
	Specifying the outlet stream name.
75	Type the word **Recy** and then press the <**Enter**> key.
	Specifying the maximum number of iterations.
76	Type the number **10** and then press the <**Enter**> key five times.

Step	Action
	Specifying the Sensitivity of the Phase Fraction.
77	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Temperature.
78	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Pressure.
79	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Flow.
80	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Enthalpy.
81	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Composition.
82	Type the number **1.00.**
	The following screen will then appear:



Step	Action
83	Press the <**Insert**> key;
	Specifying the Conditions and initial composition of the Recycle (Recy) stream.
84	Highlight the word **Specify** and then press the <**Enter**> key;
85	Highlight the word **Stream** and then press the <**Enter**> key;
86	Highlight the name **Recy** and then press the <**Enter**> key;

Step	Action
	Specifying the temperature in °F of the Recycle (Recy) stream.
87	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Recycle (Recy) stream in psia.
88	Type the number **600** after the prompt and then press the <**Enter**> key;
	Specifying the flow of the Recycle (Recy) stream in lb-mols/hr.
89	Type the number **0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Recycle (Recy) stream will be specified in mole fractions.
90	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
═══════════ Stream Mole Fractions ═══════════

Methane    _____________________   Ethane     _____________________
Propane    _____________________   i-Butane   _____________________
n-Butane   _____________________   i-Pentane  _____________________
n-Pentane  _____________________   n-Hexane   _____________________
n-Heptane  _____________________   n-Octane   _____________________
Nitrogen   _____________________   CO2        _____________________
```

Step	Action
	Specifying the molar fractions of each component in the Recycle (Recy) stream.
91	*Enter the following mole fractions beside each component in the Recycle (Recy) stream:* After the word, Methane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **1.0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0** in the blank;
	The screen will now appear as shown below:

```
═══════════ Stream Mole Fractions ═══════════

Methane    0.0_____________________   Ethane     0.0_____________________
Propane    0.0_____________________   i-Butane   0.0_____________________
n-Butane   0.0_____________________   i-Pentane  0.0_____________________
n-Pentane  0.0_____________________   n-Hexane   0.0_____________________
n-Heptane  0.0_____________________   n-Octane   0.0_____________________
Nitrogen   1.0_____________________   CO2        0.0_____________________
```

Step	Action
92	Press the <**Insert**> key.
93	Highlight the word **Worksheet** and then press the <**Enter**> key;
	Specifying the pressure of stream V-2_Feed in psia.
94	*Place the cursor in the blank for the pressure of the V-2_Feed stream by using the arrow and <Page Down> key, if necessary.* Type the number **300** and then press the <**Enter**> key;
	Specifying the pressure of stream P-1_Out in psia.
95	*Place the cursor in the blank for the pressure of the P-1_Out stream by using the arrow and <Page Down> key, if necessary.* Type the number **600** and then press the <**Enter**> key;
96	Press the <**Esc**> key;
97	Press the <**F10**> key;
	The screen on the following page will then appear saying that the Recycle has converged. (Use the <Page Up> and <Page down> keys to see the entire page).

```
 Your selected components are
Methane         Ethane          Propane         i-Butane        n-Butane
i-Pentane       n-Pentane       n-Hexane        n-Heptane       n-Octane
Nitrogen        CO2

 Recycle          R-1         Old              New          Iteration     0
Vapour_Frac                    1.000000         0.000000
Temperature                   60.000000        10.137188
Flow                           0.000000        14.463635
Mass_Flow                      0.000000       742.425423
LiqVol_Flow                    0.000000        94.401760
Energy_Flow                 3471.410034     -2140.748365
Methane                        0.000000         0.124708
Ethane                         0.000000         0.148791
Propane                        0.000000         0.144380
i-Butane                       0.000000         0.163109
n-Butane                       0.000000         0.149037
i-Pentane                      0.000000         0.114717
n-Pentane                      0.000000         0.089224
n-Hexane                       0.000000         0.039384
n-Heptane                      0.000000         0.013813
n-Octane                       0.000000         0.004229
Nitrogen                       1.000000         0.000553
CO2                            0.000000         0.008055
 Recycle          R-1         Old              New          Iteration     1
Temperature                   10.137188         9.917132
Flow                          14.463635        14.492113
LiqVol_Flow                   94.401760        94.525711
Energy_Flow                -2140.748995     -2143.008188
Methane                        0.124708         0.124924
Ethane                         0.148791         0.149032
Propane                        0.144380         0.144779
i-Butane                       0.163109         0.163560
n-Butane                       0.149037         0.149337
i-Pentane                      0.114717         0.114403
n-Pentane                      0.089224         0.088783
n-Hexane                       0.039384         0.038859
n-Heptane                      0.013813         0.013560
 Recycle          R-1         Old              New          Iteration     2
 Converged
```

Step	Action
98	Press the <**F10**> key;
99	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves the results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
100	Highlight the word **Streams** and then press the <**Enter**> key;
101	Highlight the word **All** and then press the <**Enter**> key;
102	Highlight the dash symbol - and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
103	Press the <**F10**> key;
	The screen will then appear as shown on the next two pages. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

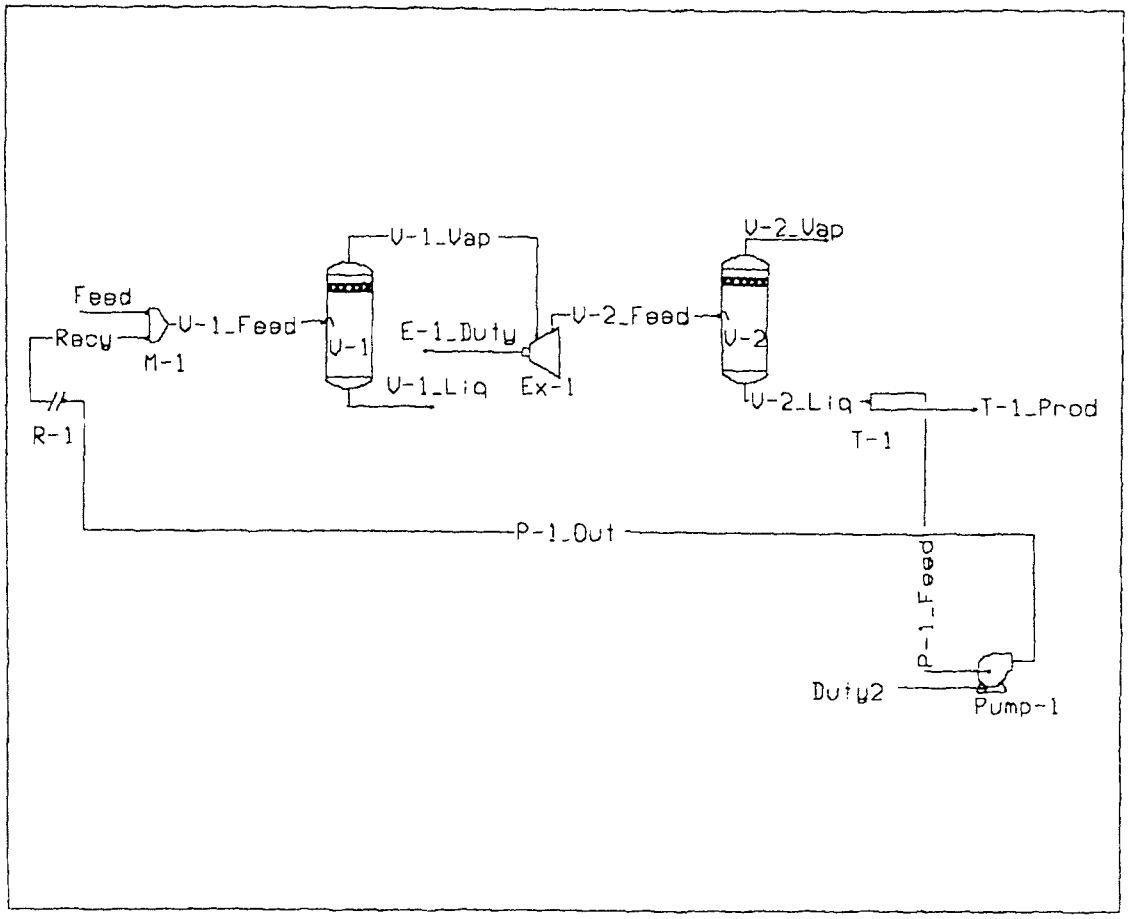
Stream Description		Feed	V-1_Feed	Recy	V-1_Liq
Vapour frac.		0.5096	0.5059	0.0000	0.0000
Temperature	F	60.0000*	59.7353	9.9171*	59.7353
Pressure	psia	600.0000*	600.0000	600.0000*	600.0000
Molar Flow	lbmole/hr	2635.3364*	2649.8286	14.4921*	1309.3618
Mass Flow	lb/hr	97838.3051	98581.2897	742.9799	70231.8087
LiqVol Flow	barrel/day	14187.2493	14281.7760	94.5257	8733.7169
Enthalpy	Btu/hr	4.55314E+06	4.52209E+06	-31057.0383	-720424.5001
Density	lb/ft3	7.8786	7.9411	36.4906	34.9180
Mole Wt.		37.1255	37.2029	51.2679	53.6382
Spec. Heat	Btu/lb-F	0.5731	0.5732	0.5322	0.5736
Therm Cond	Btu/hr-ft-F	---	---	0.0622	0.0568
Viscosity	cP	---	---	0.1897	0.1573
Z Factor		---	---	0.1673	0.1654
Sur Tension	dyne/cm	---	---	12.3051	9.7611
Std Density	lb/ft3	---	---	34.1186	34.9055
Methane	mole frac.	0.4826*	0.4806	0.1249*	0.1869
Ethane	mole frac.	0.1379*	0.1380	0.1490*	0.1431
Propane	mole frac.	0.0690*	0.0694	0.1448*	0.1065
i-Butane	mole frac.	0.0621*	0.0627	0.1636*	0.1106
n-Butane	mole frac.	0.0552*	0.0557	0.1493*	0.1017
i-Pentane	mole frac.	0.0483*	0.0487	0.1144*	0.0938
n-Pentane	mole frac.	0.0414*	0.0417	0.0888*	0.0811
n-Hexane	mole frac.	0.0345*	0.0345	0.0389*	0.0689
n-Heptane	mole frac.	0.0276*	0.0275	0.0136*	0.0554
n-Octane	mole frac.	0.0207*	0.0206	0.0041*	0.0416
Nitrogen	mole frac.	0.0069*	0.0069	0.0006*	0.0011
CO2	mole frac.	0.0138*	0.0138	0.0081*	0.0094

Stream Description		V-1_Vap	V-2_Feed	E-1_Duty	V-2_Liq
Vapour frac.		1.0000	0.9784	2.0000*	0.0000
Temperature	F	59.7353	7.3587	0.0000*	7.3587
Pressure	psia	600.0000	300.0000*	0.0000*	300.0000
Molar Flow	lbmole/hr	1340.4668	1340.4668	0.0000*	28.9853
Mass Flow	lb/hr	28349.4810	28349.4810	0.0000*	1485.9919
LiqVol Flow	barrel/day	5548.0591	5548.0591	0.0000*	189.0568
Enthalpy	Btu/hr	5.24250E+06	4.66977E+06	572727.6030	-65131.0662
Density	lb/ft3	2.7252	1.4498	0.0000	36.4856
Mole Wt.		21.1490	21.1490	0.0000	51.2672
Spec. Heat	Btu/lb-F	0.5723	0.5112	---	0.5345
Therm Cond	Btu/hr-ft-F	0.0189	---	---	0.0625
Viscosity	cP	0.0121	---	---	0.1920
Z Factor		0.8354	---	---	0.0841
Sur Tension	dyne/cm	---	---	---	12.4562
Std Density	lb/ft3	---	---	---	34.1183
Methane	mole frac.	0.7676	0.7676	0.0000*	0.1249
Ethane	mole frac.	0.1330	0.1330	0.0000*	0.1490
Propane	mole frac.	0.0332	0.0332	0.0000*	0.1448
i-Butane	mole frac.	0.0159	0.0159	0.0000*	0.1636
n-Butane	mole frac.	0.0108	0.0108	0.0000*	0.1493
i-Pentane	mole frac.	0.0046	0.0046	0.0000*	0.1144
n-Pentane	mole frac.	0.0031	0.0031	0.0000*	0.0888
n-Hexane	mole frac.	0.0010	0.0010	0.0000*	0.0389
n-Heptane	mole frac.	0.0003	0.0003	0.0000*	0.0136
n-Octane	mole frac.	0.0001	0.0001	0.0000*	0.0041
Nitrogen	mole frac.	0.0125	0.0125	0.0000*	0.0006
CO2	mole frac.	0.0180	0.0180	0.0000*	0.0081

Stream		V-2_Vap	T-1_Prod	P-1_Feed	P-1_Out
Description					
Vapour frac.		1.0000	0.0000	0.0000	0.0000
Temperature	F	7.3587	7.3587	7.3587	9.9155
Pressure	psia	300.0000	300.0000	300.0000	600.0000
Molar Flow	lbmole/hr	1311.4815	14.4926	14.4926	14.4926
Mass Flow	lb/hr	26863.4880	742.9959	742.9959	742.9959
LiqVol Flow	barrel/day	5359.0017	94.5284	94.5284	94.5284
Enthalpy	Btu/hr	4.73491E+06	-32565.5331	-32565.5331	-31058.1673
Density	lb/ft3	1.3767	36.4856	36.4856	36.4904
Mole Wt.		20.4833	51.2672	51.2672	51.2672
Spec. Heat	Btu/lb-F	0.5099	0.5345	0.5345	0.5322
Therm Cond	Btu/hr-ft-F	0.0157	0.0625	0.0625	0.0622
Viscosity	cP	0.0103	0.1920	0.1920	0.1897
Z Factor		0.8906	0.0841	0.0841	0.1673
Sur Tension	dyne/cm	---	12.4562	12.4562	12.3050
Std Density	lb/ft3	---	34.1183	34.1183	34.1183
Methane	mole frac.	0.7818	0.1249	0.1249	0.1249
Ethane	mole frac.	0.1326	0.1490	0.1490	0.1490
Propane	mole frac.	0.0307	0.1448	0.1448	0.1448
i-Butane	mole frac.	0.0126	0.1636	0.1636	0.1636
n-Butane	mole frac.	0.0077	0.1493	0.1493	0.1493
i-Pentane	mole frac.	0.0022	0.1144	0.1144	0.1144
n-Pentane	mole frac.	0.0012	0.0888	0.0888	0.0888
n-Hexane	mole frac.	0.0001	0.0389	0.0389	0.0389
n-Heptane	mole frac.	0.0000	0.0136	0.0136	0.0136
n-Octane	mole frac.	0.0000	0.0041	0.0041	0.0041
Nitrogen	mole frac.	0.0128	0.0006	0.0006	0.0006
CO2	mole frac.	0.0182	0.0081	0.0081	0.0081

Stream		Duty2
Description		
Vapour frac.		2.0000*
Temperature	F	0.0000*
Pressure	psia	0.0000*
Molar Flow	lbmole/hr	0.0000*
Mass Flow	lb/hr	0.0000*
LiqVol Flow	barrel/day	0.0000*
Enthalpy	Btu/hr	1507.3658
Density	lb/ft3	0.0000
Mole Wt.		0.0000
Spec. Heat	Btu/lb-F	---
Therm Cond	Btu/hr-ft-F	---
Viscosity	cP	---
Z Factor		---
Sur Tension	dyne/cm	---
Std Density	lb/ft3	---
Methane	mole frac.	0.0000*
Ethane	mole frac.	0.0000*
Propane	mole frac.	0.0000*
i-Butane	mole frac.	0.0000*
n-Butane	mole frac.	0.0000*
i-Pentane	mole frac.	0.0000*
n-Pentane	mole frac.	0.0000*
n-Hexane	mole frac.	0.0000*
n-Heptane	mole frac.	0.0000*
n-Octane	mole frac.	0.0000*
Nitrogen	mole frac.	0.0000*
CO2	mole frac.	0.0000*

Step	Action
104	Press the <**F10**> key;
	Looking at the PFD (Process Flow Diagram) for the Process.
105	Highlight the letters **PFD** and then press the <**Enter**> key;
	Pressing the <Home> key will reduce the PFD diagram to fit on the screen.
106	Press the <**Home**> key;
	A Process Flow Diagram (PFD) similar to the one below will then appear.



Step	Action
107	Press the <**Esc**> key.
108	Do you want to continue adding other unit operations to this recycle process? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

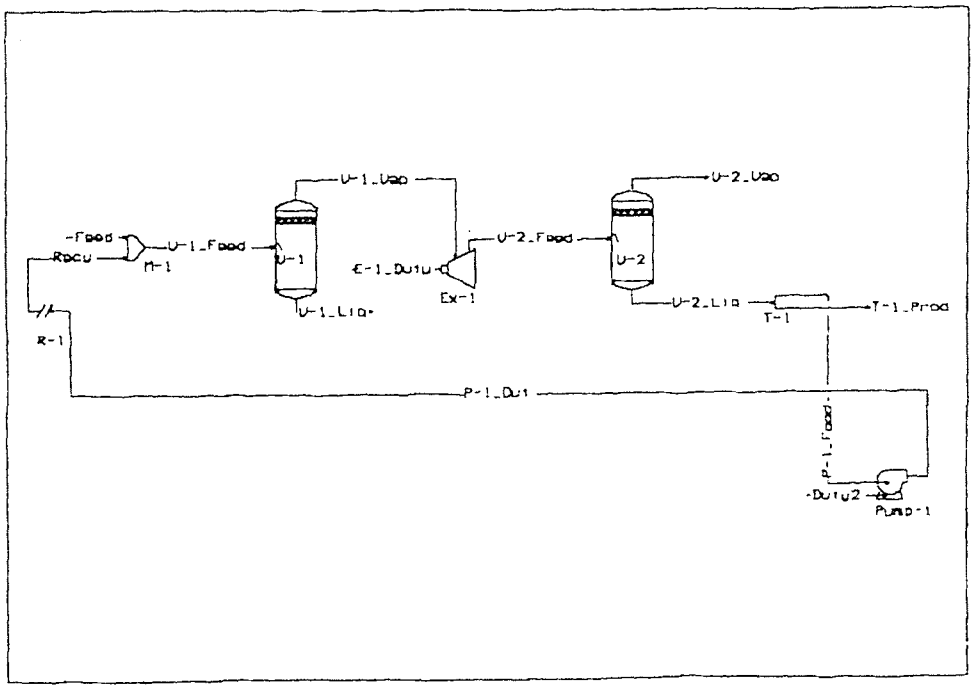
Objective - This exercise is an example of the single recycle stream operation in HYSIM, using a data recorder. The data recorder operation allows the HYSIM user to specify certain process variables to be recorded during calculations.
This recycle example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, a recycle process is used to show how the data recorder is utilized in HYSIM. The variables which are to be recorded for various streams are specified, e.g. the temperature of the recycle (*Recy*) stream. As HYSIM does its calculation iterations, the data recorder records the value of the variables which were specified for recording.
Technical Example Reference: Reference 1 - Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 7-90 to 7-108. The data recorder operation is described in the same User's Guide on pages 7-133 to 7-138. This section in the User's Guide should be consulted if multiple recycle streams are required.
Other References: Refs. 1 & 2.

Directions - Pages 433 through 453 outline the execution of a data recorder example. This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the cursor is over the required word on the menu, and that word then changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this process containing a data recorder is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the <**Enter**> key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the <**Enter**> key;
	The following screen will appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the Feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key; Highlight the word **Nitrogen** and then press the **<Enter>** key; Highlight the formula **CO2** and then press the **<Enter>** key
	The following screen will then appear:

COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
Methane	Cl2	Cl2	Cl2	ALL
Ethane	HCl	HCl	HCl	HC
Propane	F2	F2	F2	SOLID
i-Butane	HF	HF	HF	MISC
n-Butane	Br2	Bromine	Br2	AMINE
i-Pentane	HBr	HBr	HBr	ALCOHOL
n-Pentane	I2	Iodine	I2	KETONE
n-Hexane	HI	HI	HI	ALDEHYDE
n-Heptane	NitricOxide	NO	NO	ESTER
n-Octane	NO2	NO2	NO2	CARBACID
Nitrogen	N2O	N2O	N2O	HALOGEN
CO2	N2O4	N2O4	N2O4	NITRILE
	SO2	SO2	SO2	PHENOL
	SO3	SO3	SO3	ETHER
	CO	CO	CO	USER
	Sulphur_Rhombic	S_Rhombic	S	

Search by SYNONYM

F1 - Help,F3 - Menu,F4 - Flip Srch, F5 - Exam,F6 - Move,F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
5	Press the **<Insert>** key;
	The screen on the following page will then appear.

```
Work_Sheet          Specify             Operation       Print
PFD                 Remove              Store           New
Ignore              Restore             Hold            Go
Utility             Size                Report          Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system (kPa, kg, °C, etc.) to field units (psia, lb, °F, etc.).
6	Highlight the word **Utility** and then press the <**Enter**> key;
7	Highlight the word **Configuration** and then press the <**Enter**> key;
8	Highlight the word **Units** and then press the <**Enter**> key;
9	Highlight the word **Field** and then press the <**Enter**> key;
10	Press the <**Esc**> key.
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the <**Enter**> key;
12	Highlight the word **Stream** and then press the <**Enter**> key;
13	Type the word **Feed** after the prompt (>) and then press the <**Enter**> key;
	Specifying the temperature of the Feed in °F.
14	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Feed in psia.
15	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Feed stream in lb-mols/hr.
16	Type the number **2635.3364** after the prompt (>) and then press the <**Enter**> key;
	Specifying the individual mole fractions of each component in the Feed.
17	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

```
                    Stream Mole Fractions

Methane     _____________      Ethane      _____________
Propane     _____________      i-Butane    _____________
n-Butane    _____________      i-Pentane   _____________
n-Pentane   _____________      n-Hexane    _____________
n-Heptane   _____________      n-Octane    _____________
Nitrogen    _____________      CO2         _____________
```

Step	Action
	Specifying the molar fractions of each component in the Feed stream.
18	*Enter the following mole fractions beside each component in the Feed stream:* After the word, Methane, type the number **0.4826** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.1379** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0690** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0621** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0552** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0483** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0414** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0345** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0276** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0207** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **0.0069** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0138** in the blank;
	The screen will now appear as shown below:

Stream Mole Fractions

Methane	0.4826	Ethane	0.1379
Propane	0.0690	i-Butane	0.0621
n-Butane	0.0552	i-Pentane	0.0483
n-Pentane	0.0414	n-Hexane	0.0345
n-Heptane	0.0276	n-Octane	0.0207
Nitrogen	0.0069	CO2	0.0138

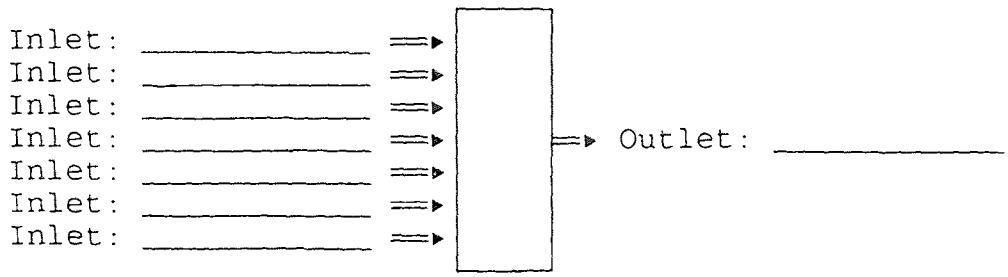
Step	Action
19	Press the <**Insert**> key;
20	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Mixer as "M-1".
21	Type the name **M-1** and then press the <**Enter**> key;
22	Highlight the word **Mixer** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Adiabatic Mixer

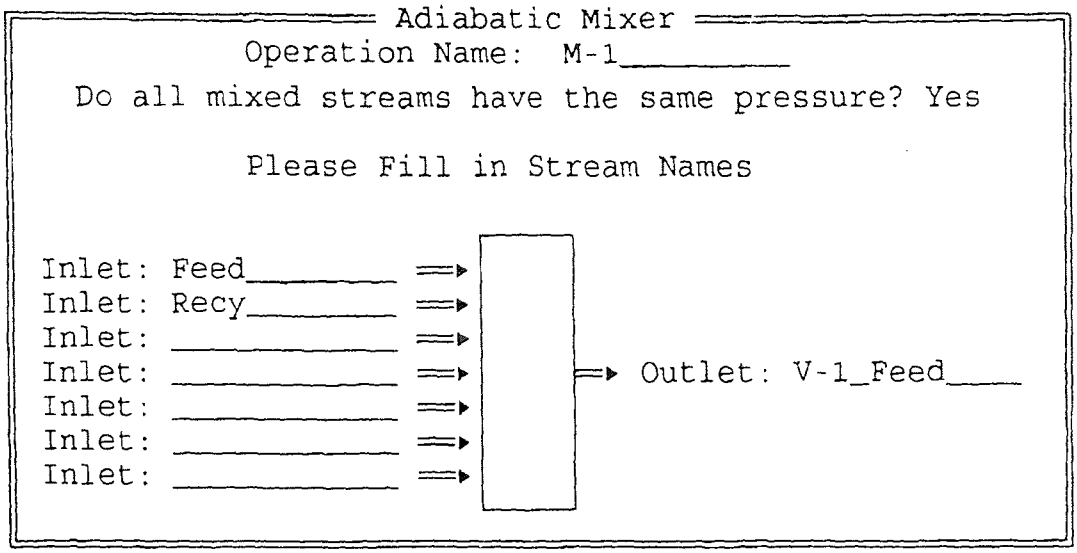
Operation Name: M-1

Do all mixed streams have the same pressure? ___

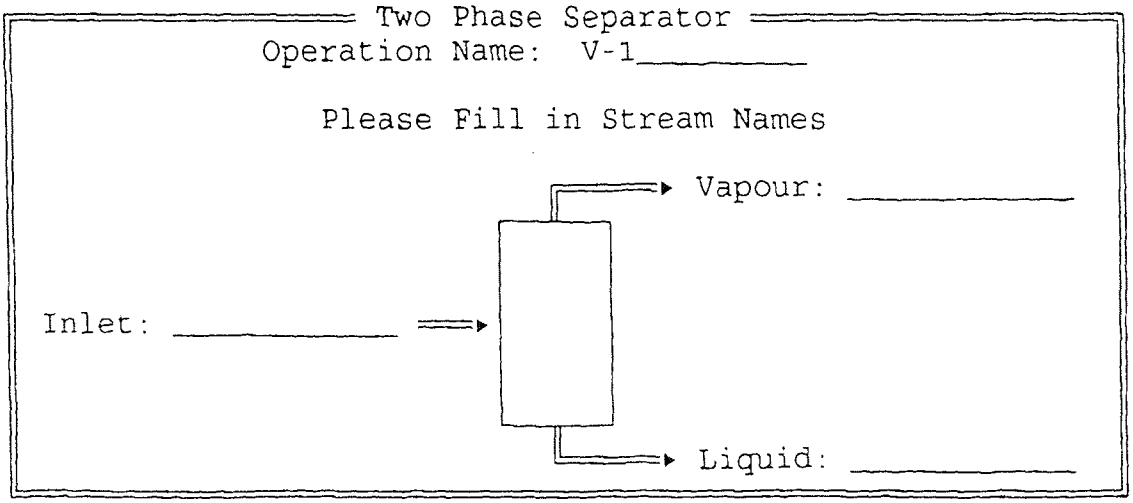
Please Fill in Stream Names



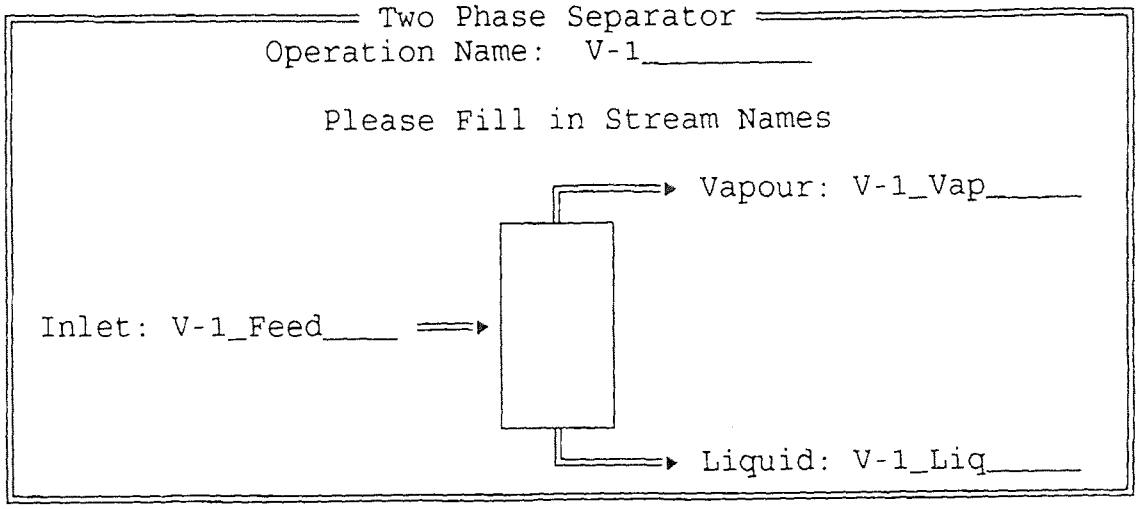
Step	Action
	Answering the question, "Do all mixed streams have the same pressure?"
23	Type the word **Yes** and then press the <**Enter**> key;
	Specifying the inlet and outlet stream names into and out of the Mixer M-1.
24	Type the word **V-1_Feed** and then press the <**Enter**> key.
25	Type the word **Feed** and then press the <**Enter**> key.
26	Type the word **Recy**.
	The following screen will then appear:



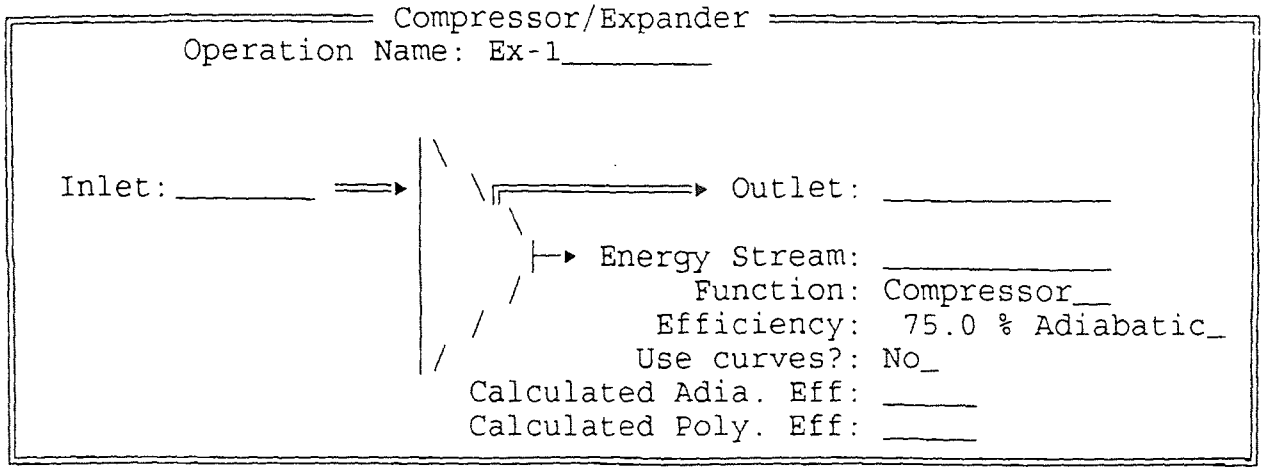
Step	Action
27	Press the <**Insert**> key;
28	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Separator as "V-1".
29	Type the name **V-1** and then press the <**Enter**> key;
30	Highlight the word **Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



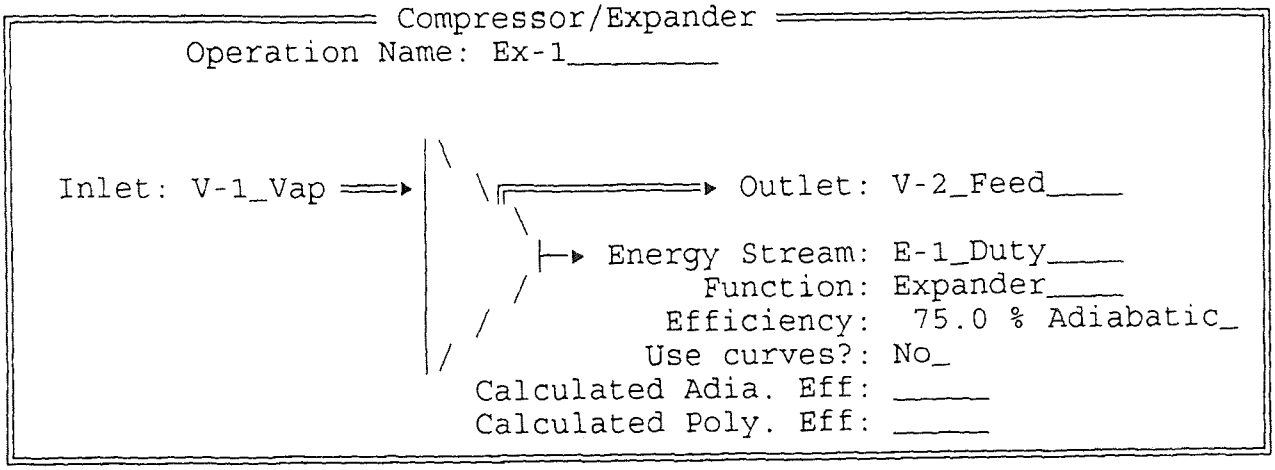
Step	Action
	Specifying the inlet and outlet stream names into and out of Separator, V-1.
31	Type the word **V-1_Feed** and then press the <**Enter**> key.
32	Type the word **V-1_Liq** and then press the <**Enter**> key.
33	Type the word **V-1_Vap**.
	The following screen will then appear:



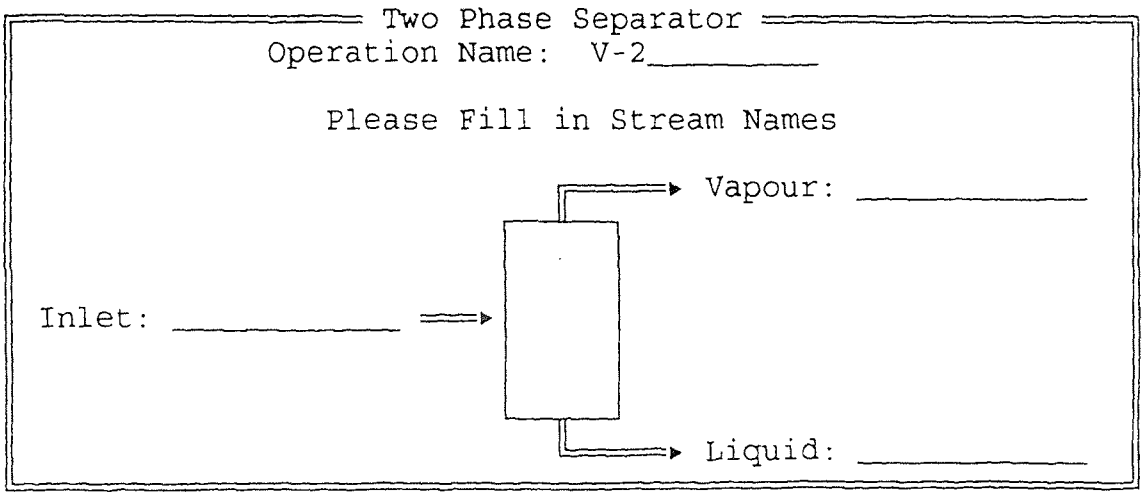
Step	Action
34	Press the <**Insert**> key;
35	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Expander as "Ex-1".
36	Type the name **Ex-1** and then press the <**Enter**> key;
37	Highlight the words **Comp/Expander** and then press the <**Enter**> key;
	The screen will then appear as shown below:



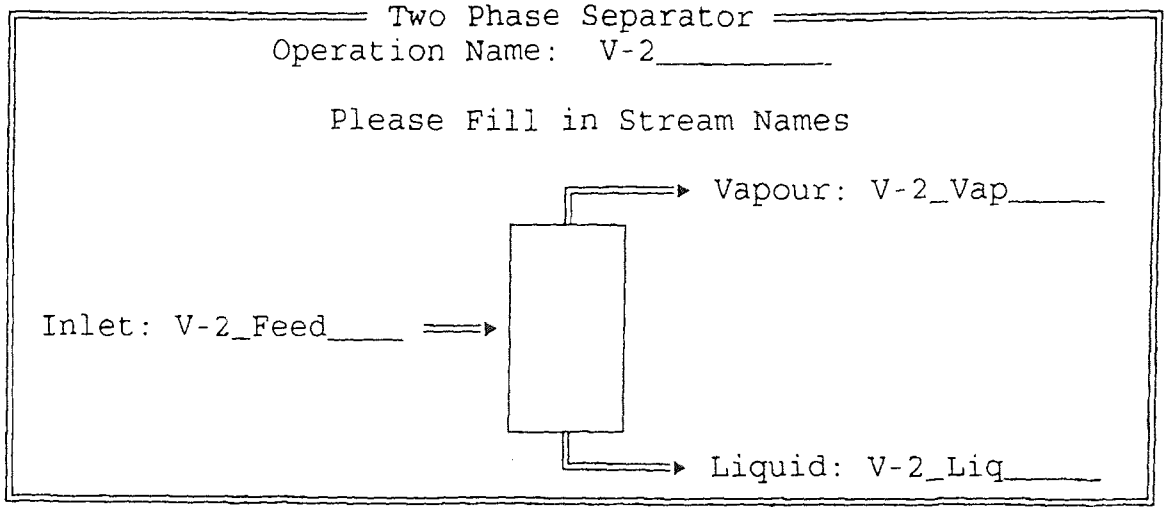
Step	Action
	Specifying the inlet and outlet stream names into and out of Expander, Ex-1.
38	Type the word **V-1_Vap** and then press the <**Enter**> key.
39	Type the word **V-2_Feed** and then press the <**Enter**> key.
40	Type the word **E-1_Duty** and then press the <**Enter**> key.
41	Press the <**F2**> key and highlight the word **Expander** and then press the <**Enter**> key.
	The following screen will then appear:



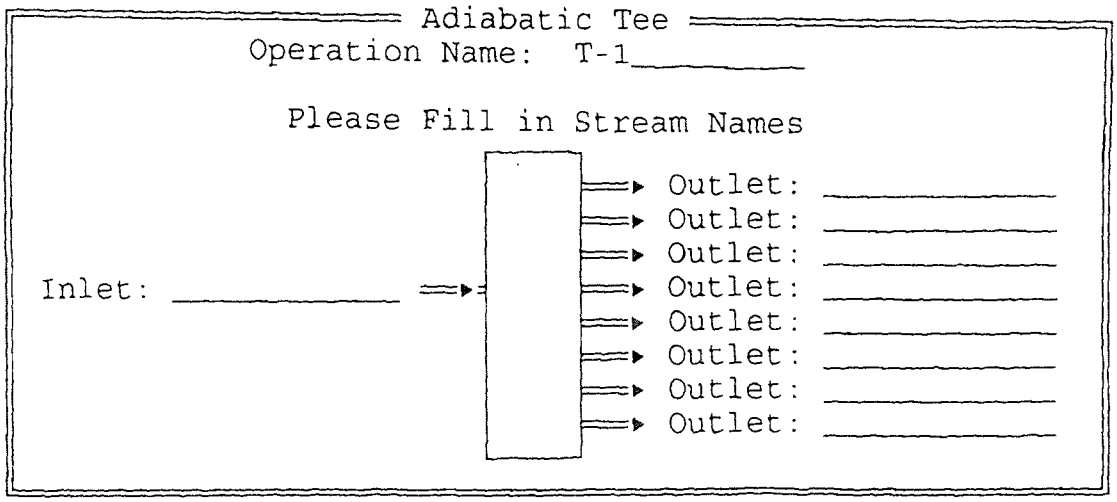
Step	Action
42	Press the <**Insert**> key and highlight the word **Operation** and then press the <**Enter**> key;
	Naming the second Separator as "V-2".
43	Type the name **V-2** and then press the <**Enter**> key;
44	Highlight the word **Separator** and then press the <**Enter**> key;
	The screen will then appear as shown below:



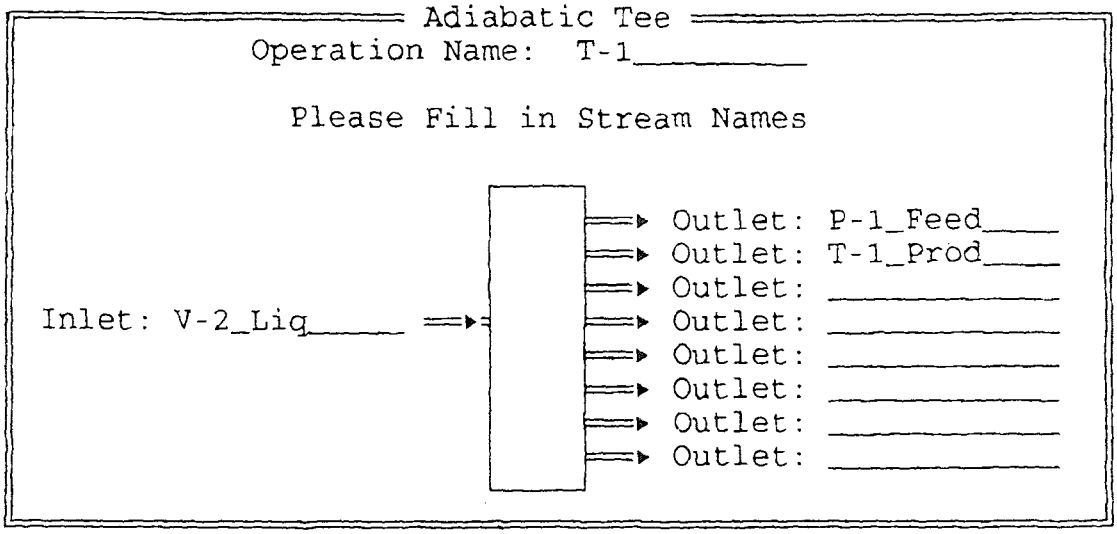
Step	Action
	Specifying the inlet and outlet stream names into and out of Separator, V-2.
45	Type the word **V-2_Feed** and then press the <**Enter**> key.
46	Type the word **V-2_Liq** and then press the <**Enter**> key.
47	Type the word **V-2_Vap**.
	The following screen will then appear:



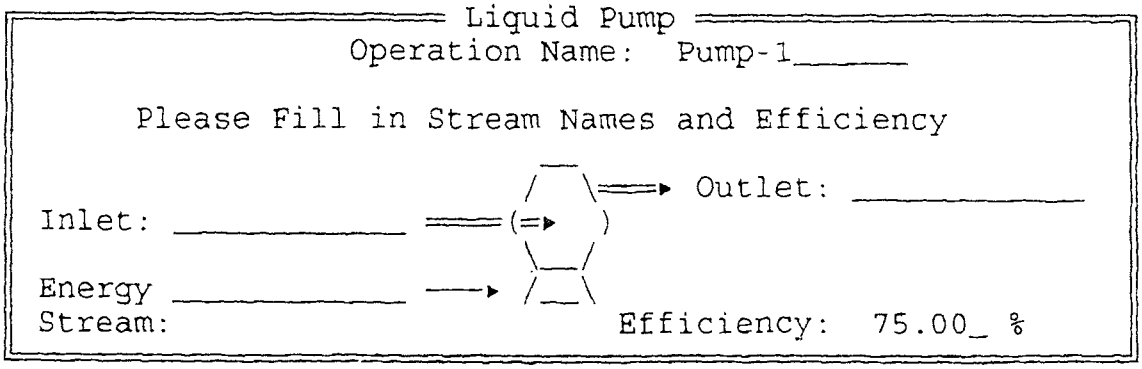
Step	Action
48	Press the <**Insert**> key;
49	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Tee as "T-1".
50	Type the name **T-1** and then press the <**Enter**> key;
51	Highlight the word **Tee** and then press the <**Enter**> key;
	The screen will then appear as shown below:



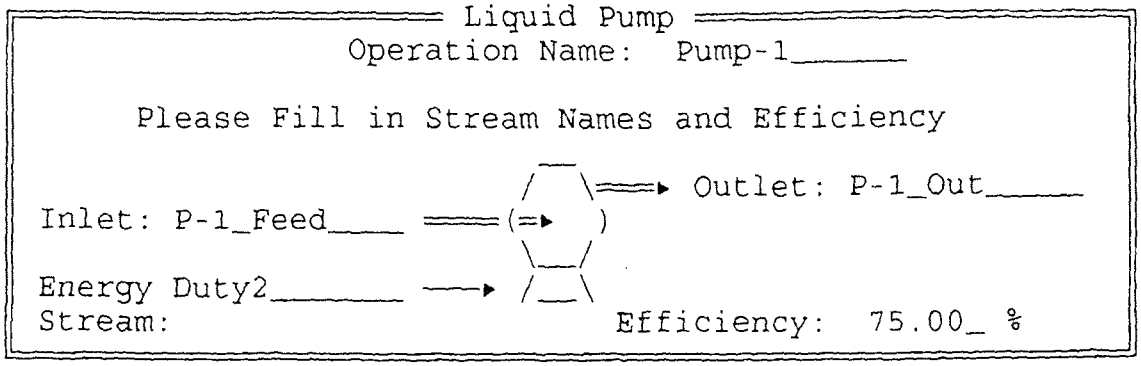
Step	Action
	Specifying the inlet and outlet stream names into and out of the Tee, T-1.
52	Type the word **V-2_Liq** and then press the <**Enter**> key.
53	Type the word **P-1_Feed** and then press the <**Enter**> key.
54	Type the word **T-1_Prod**.
	The following screen will then appear.



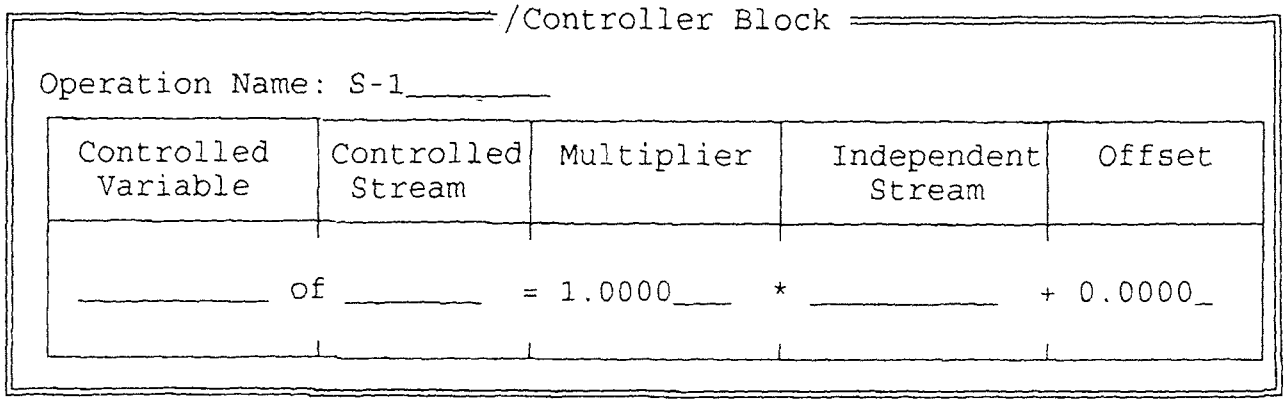
Step	Action
55	Press the <**Insert**> key;
56	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Pump as "Pump-1".
57	Type the name **Pump-1** and then press the <**Enter**> key;
58	Highlight the word **Pump** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the inlet and outlet stream names into and out of the Pump, Pump-1.
59	Type the word **P-1_Feed** and then press the <**Enter**> key.
60	Type the word **P-1_Out** and then press the <**Enter**> key.
61	Type the word **Duty2**.
	The screen will then appear as shown on the following page.



Step	Action
62	Press the <**Insert**> key;
63	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Set operation as "S-1".
64	Type the name **S-1** and then press the <**Enter**> key;
65	Highlight the word **Set** and then press the <**Enter**> key;
	The screen will then appear as shown below:



Step	Action
	Specifying the controlled variable.
66	Type the word **Flow** and then press the <**Enter**> key.
	Specifying the controlled stream name.
67	Type the word **P-1_Feed** and then press the <**Enter**> key.
	Specifying the Multiplier of the independent stream's flow rate.
68	Type the number **0.5** and then press the <**Enter**> key;
	Specifying the Independent stream name.
69	Type the word **V-2_Liq** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

Set/Controller Block

Operation Name: S-1_____

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Flow___	of P-1_Feed__	= 0.5_____	* V-2_Liq___	+ 0.0000_

Step	Action
70	Press the <**Insert**> key;
71	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Recycle operation as "R-1".
72	Type the name **R-1** and then press the <**Enter**> key;
73	Highlight the word **Recycle** and then press the <**Enter**> key;
	The screen will then appear as shown below:

Operation R-1 _____Recycle Operation

Max Iters: 5 Type: Nested_____

Wegstein Count: 3__

Q Max: 0.00

Q Min: -20.00

Sensitivities

Phase Frac.	10.0	Flow	10.0
Temperature	10.0	Enthalpy	10.0
Pressure	10.0	Composition	10.0

Inlet Stream

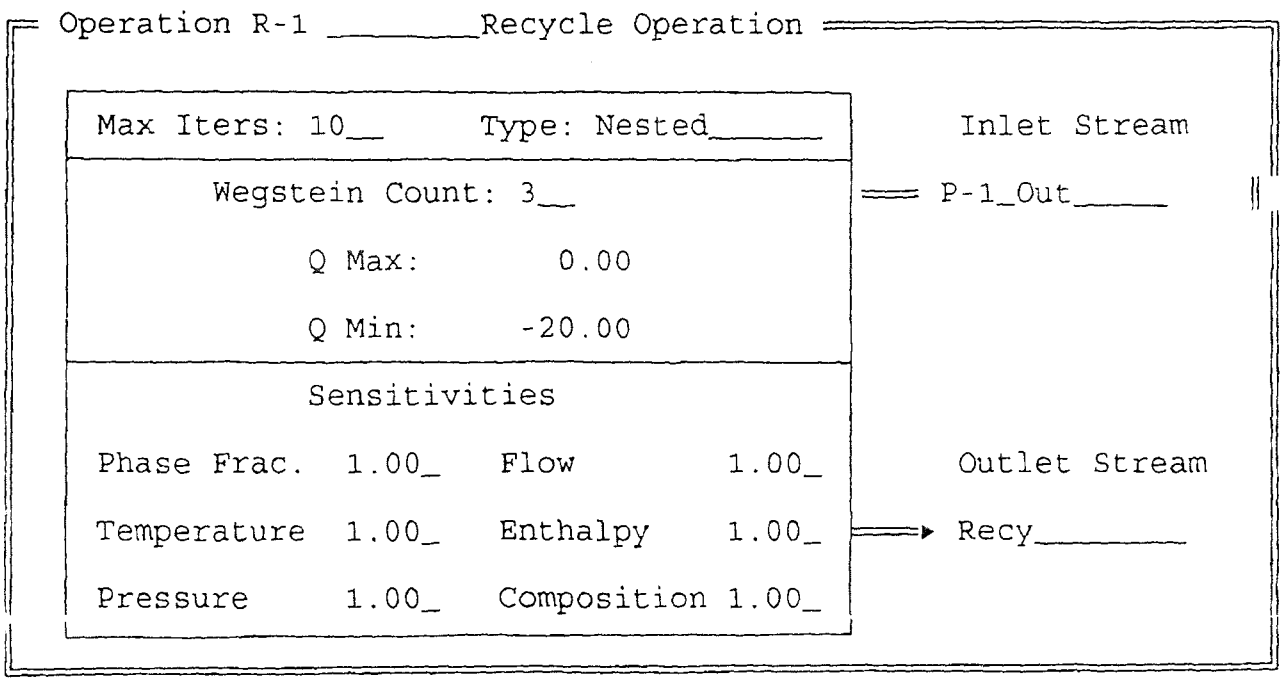
_____

Outlet Stream

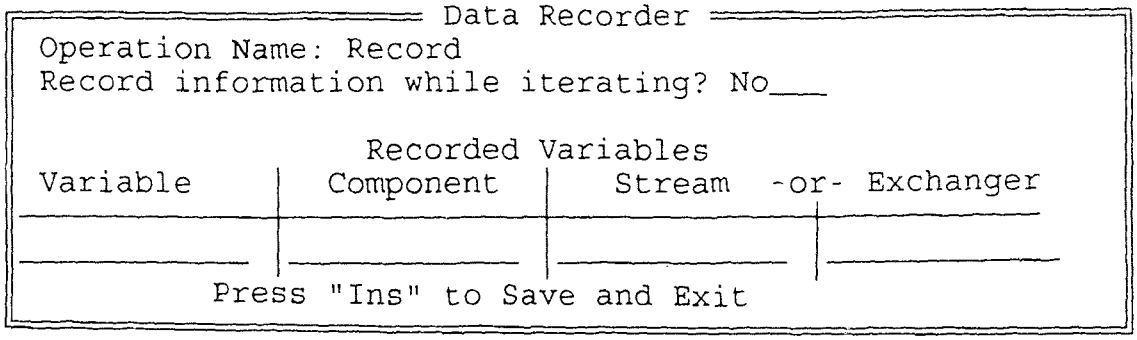
_____

Step	Action
	Specifying the inlet stream name.
74	Type the word **P-1_Out** and then press the <**Enter**> key.
	Specifying the outlet stream name.
75	Type the word **Recy** and then press the <**Enter**> key.

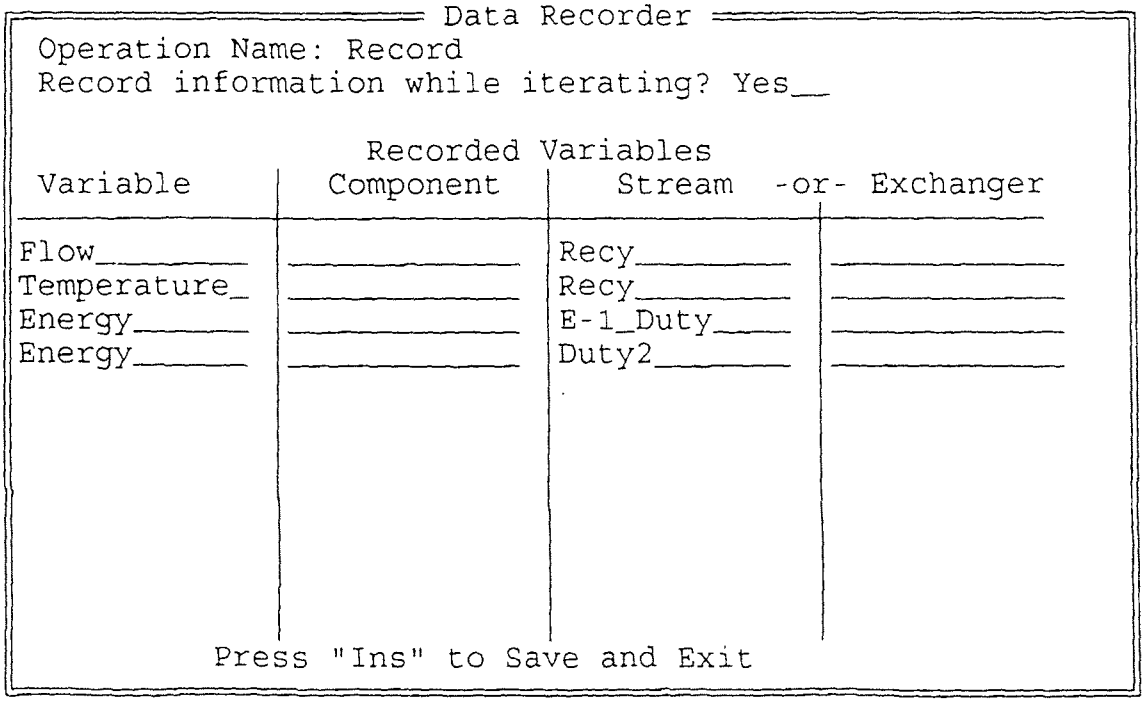
Step	Action
	Specifying the maximum number of iterations.
76	Type the number **10** and then press the <**Enter**> key five times.
	Specifying the Sensitivity of the Phase Fraction.
77	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Temperature.
78	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Pressure.
79	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Flow.
80	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Enthalpy.
81	Type the number **1.00** and then press the <**Enter**> key;
	Specifying the Sensitivity of the Composition.
82	Type the number **1.00.**
	The following screen will then appear:



Step	Action
83	Press the <**Insert**> key;
84	Highlight the word **Operation** and then press the <**Enter**> key;
	Naming the Data Recorder as "Record".
85	Type the word **Record** and then press the <**Enter**> key;
86	Highlight the word **Data_Recorder** and then press the <**Enter**> key;
	The screen on the following page will then appear.



Step	Action
	Specifying that the information should be recorded while iterating.
87	Type the word **Yes** and then press the <**Enter**> key;
	Specifying the type of information which should be recorded.
88	Type the word **Flow** and then press the <**Enter**> key two times;
89	Type the word **Recy** and then press the <**Enter**> key two times;
90	Type the word **Temperature** and then press the <**Enter**> key two times;
91	Type the word **Recy** and then press the <**Enter**> key two times;
92	Type the word **Energy** and then press the <**Enter**> key two times;
93	Type the word **E-1_Duty** and then press the <**Enter**> key two times;
94	Type the word **Energy** and then press the <**Enter**> key two times;
95	Type the word **Duty2**;
	The following screen will then appear:



Step	Action
96	Press the <**Insert**> key;
	Specifying the Conditions and initial composition of the Recycle (Recy) stream.
97	Highlight the word **Specify** and then press the <**Enter**> key;
98	Highlight the word **Stream** and then press the <**Enter**> key;
99	Highlight the name **Recy** and then press the <**Enter**> key;
	Specifying the temperature of the Recycle (Recy) stream in °F.
100	Type the number **60** after the prompt (>) and then press the <**Enter**> key;
	Specifying the pressure of the Recycle (Recy) stream in psia.
101	Type the number **600** after the prompt (>) and then press the <**Enter**> key;
	Specifying the flow of the Recycle (Recy) stream in lb-mols/hr.
102	Type the number **0** after the prompt (>) and then press the <**Enter**> key;
	Specifying that the composition of each component in the Recycle (Recy) stream will be given in mole fractions.
103	Highlight the word **Mole_Fractions** and then press the <**Enter**> key;
	The screen will appear as shown below:

Stream Mole Fractions

Methane	_____	Ethane	_____
Propane	_____	i-Butane	_____
n-Butane	_____	i-Pentane	_____
n-Pentane	_____	n-Hexane	_____
n-Heptane	_____	n-Octane	_____
Nitrogen	_____	CO2	_____

Step	Action
	Specifying the molar fractions of each component in the Recycle (Recy) stream.
104	*Enter the following mole fractions beside each component in the Recycle (Recy) stream:* After the word, Methane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Nitrogen, type the number **1.0** in the blank and then press the <**Enter**> key; After the formula, CO2, type the number **0.0** in the blank;
	The screen will now appear as shown on the following page.

Stream Mole Fractions

Methane	0.0	Ethane	0.0
Propane	0.0	i-Butane	0.0
n-Butane	0.0	i-Pentane	0.0
n-Pentane	0.0	n-Hexane	0.0
n-Heptane	0.0	n-Octane	0.0
Nitrogen	1.0	CO2	0.0

Step	Action
105	Press the **<Insert>** key.
106	Highlight the word **Worksheet** and then press the **<Enter>** key;
	Specifying the pressure of stream V-2_Feed in psia.
107	*Place the cursor in the blank for the pressure of the V-2_Feed stream by using the arrow and <Page Down> key, if necessary.* Type the number **300** and then press the **<Enter>** key;
	Specifying the pressure of stream P-1_Out in psia.
108	*Place the cursor in the blank for the pressure of the P-1_Out stream by using the arrow and <Page Down> key, if necessary.* Type the number **600** and then press the **<Enter>** key;
109	Press the **<Esc>** key;
110	Press the **<F10>** key;
	The screen on the following page will then appear saying that the Recycle has converged. (Use the <Page Up> and <Page down> keys to see the entire page).

```
 Your selected components are
Methane         Ethane     Propane         i-Butane        n-Butane
i-Pentane       n-Pentane  n-Hexane        n-Heptane       n-Octane
Nitrogen        CO2

 Recycle          R-1    Old               New          Iteration    0
Vapour_Frac                1.000000          0.000000
Temperature               60.000000         10.137188
Flow                       0.000000         14.463635
Mass_Flow                  0.000000        742.425423
LiqVol_Flow                0.000000         94.401760
Energy_Flow             3471.410034      -2140.748365
Methane                    0.000000          0.124708
Ethane                     0.000000          0.148791
Propane                    0.000000          0.144380
i-Butane                   0.000000          0.163109
n-Butane                   0.000000          0.149037
i-Pentane                  0.000000          0.114717
n-Pentane                  0.000000          0.089224
n-Hexane                   0.000000          0.039384
n-Heptane                  0.000000          0.013813
n-Octane                   0.000000          0.004229
Nitrogen                   1.000000          0.000553
CO2                        0.000000          0.008055
 Recycle          R-1    Old               New          Iteration    1
Temperature               10.137188          9.917132
Flow                      14.463635         14.492113
LiqVol_Flow               94.401760         94.525711
Energy_Flow            -2140.748995      -2143.008188
Methane                    0.124708          0.124924
Ethane                     0.148791          0.149032
Propane                    0.144380          0.144779
i-Butane                   0.163109          0.163560
n-Butane                   0.149037          0.149337
i-Pentane                  0.114717          0.114403
n-Pentane                  0.089224          0.088783
n-Hexane                   0.039384          0.038859
n-Heptane                  0.013813          0.013560
 Recycle          R-1    Old               New          Iteration    2
 Converged
```

Step	Action
111	Press the <**F10**> key;
112	Highlight the word **Print** and then press the <**Enter**> key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case description.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
113	Highlight the word **Streams** and then press the <**Enter**> key;
114	Highlight the word **All** and then press the <**Enter**> key;
115	Highlight the dash symbol - and then press the <**Enter**> key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the main menu off of the screen in order to see the data on the screen underneath it.
116	Press the <**F10**> key;
	The screen will then appear as shown on the next two pages. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

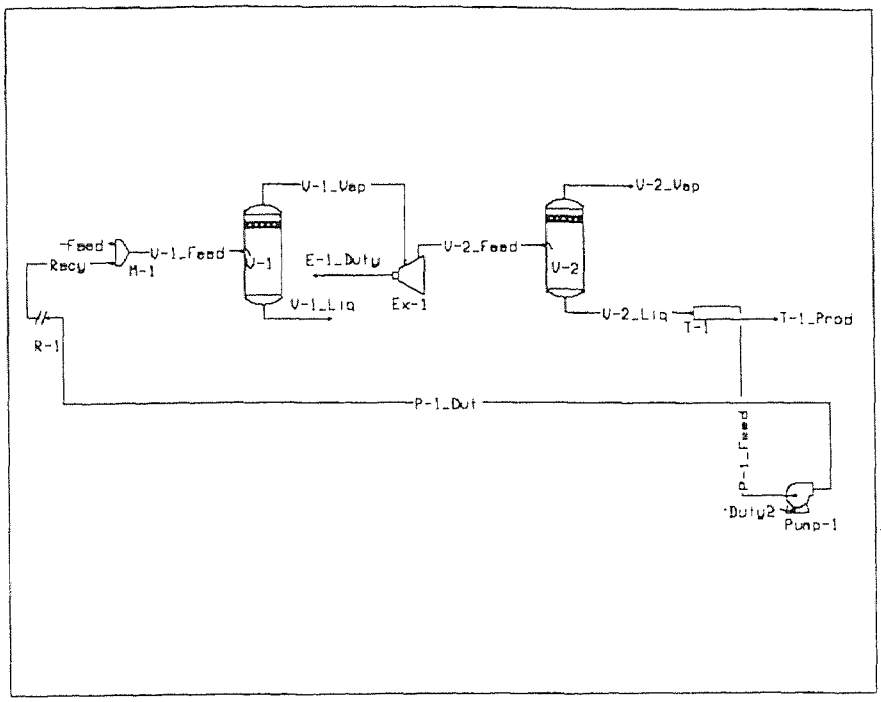
Stream		Feed	V-1_Feed	Recy	V-1_Liq
Description					
Vapour frac.		0.5096	0.5059	0.0000	0.0000
Temperature	F	60.0000*	59.7353	9.9171*	59.7353
Pressure	psia	600.0000*	600.0000	600.0000*	600.0000
Molar Flow	lbmole/hr	2635.3364*	2649.8286	14.4921*	1309.3618
Mass Flow	lb/hr	97838.3051	98581.2897	742.9799	70231.8087
LiqVol Flow	barrel/day	14187.2493	14281.7760	94.5257	8733.7169
Enthalpy	Btu/hr	4.55314E+06	4.52209E+06	-31057.0383	-720424.5001
Density	lb/ft3	7.8786	7.9411	36.4906	34.9180
Mole Wt.		37.1255	37.2029	51.2679	53.6382
Spec. Heat	Btu/lb-F	0.5731	0.5732	0.5322	0.5736
Therm Cond	Btu/hr-ft-F	---	---	0.0622	0.0568
Viscosity	cP	---	---	0.1897	0.1573
Z Factor		---	---	0.1673	0.1654
Sur Tension	dyne/cm	---	---	12.3051	9.7611
Std Density	lb/ft3	---	---	34.1186	34.9055
Methane	mole frac.	0.4826*	0.4806	0.1249*	0.1869
Ethane	mole frac.	0.1379*	0.1380	0.1490*	0.1431
Propane	mole frac.	0.0690*	0.0694	0.1448*	0.1065
i-Butane	mole frac.	0.0621*	0.0627	0.1636*	0.1106
n-Butane	mole frac.	0.0552*	0.0557	0.1493*	0.1017
i-Pentane	mole frac.	0.0483*	0.0487	0.1144*	0.0938
n-Pentane	mole frac.	0.0414*	0.0417	0.0888*	0.0811
n-Hexane	mole frac.	0.0345*	0.0345	0.0389*	0.0689
n-Heptane	mole frac.	0.0276*	0.0275	0.0136*	0.0554
n-Octane	mole frac.	0.0207*	0.0206	0.0041*	0.0416
Nitrogen	mole frac.	0.0069*	0.0069	0.0006*	0.0011
CO2	mole frac.	0.0138*	0.0138	0.0081*	0.0094

Stream		V-1_Vap	V-2_Feed	E-1_Duty	V-2_Liq
Description					
Vapour frac.		1.0000	0.9784	2.0000*	0.0000
Temperature	F	59.7353	7.3587	0.0000*	7.3587
Pressure	psia	600.0000	300.0000*	0.0000*	300.0000
Molar Flow	lbmole/hr	1340.4668	1340.4668	0.0000*	28.9853
Mass Flow	lb/hr	28349.4810	28349.4810	0.0000*	1485.9919
LiqVol Flow	barrel/day	5548.0591	5548.0591	0.0000*	189.0568
Enthalpy	Btu/hr	5.24250E+06	4.66977E+06	572727.6030	-65131.0662
Density	lb/ft3	2.7252	1.4498	0.0000	36.4856
Mole Wt.		21.1490	21.1490	0.0000	51.2672
Spec. Heat	Btu/lb-F	0.5723	0.5112	---	0.5345
Therm Cond	Btu/hr-ft-F	0.0189	---	---	0.0625
Viscosity	cP	0.0121	---	---	0.1920
Z Factor		0.8354	---	---	0.0841
Sur Tension	dyne/cm	---	---	---	12.4562
Std Density	lb/ft3	---	---	---	34.1183
Methane	mole frac.	0.7676	0.7676	0.0000*	0.1249
Ethane	mole frac.	0.1330	0.1330	0.0000*	0.1490
Propane	mole frac.	0.0332	0.0332	0.0000*	0.1448
i-Butane	mole frac.	0.0159	0.0159	0.0000*	0.1636
n-Butane	mole frac.	0.0108	0.0108	0.0000*	0.1493
i-Pentane	mole frac.	0.0046	0.0046	0.0000*	0.1144
n-Pentane	mole frac.	0.0031	0.0031	0.0000*	0.0888
n-Hexane	mole frac.	0.0010	0.0010	0.0000*	0.0389
n-Heptane	mole frac.	0.0003	0.0003	0.0000*	0.0136
n-Octane	mole frac.	0.0001	0.0001	0.0000*	0.0041
Nitrogen	mole frac.	0.0125	0.0125	0.0000*	0.0006
CO2	mole frac.	0.0180	0.0180	0.0000*	0.0081

Stream		V-2_Vap	T-1_Prod	P-1_Feed	P-1_Out
Description					
Vapour frac.		1.0000	0.0000	0.0000	0.0000
Temperature	F	7.3587	7.3587	7.3587	9.9155
Pressure	psia	300.0000	300.0000	300.0000	600.0000*
Molar Flow	lbmole/hr	1311.4815	14.4926	14.4926	14.4926
Mass Flow	lb/hr	26863.4880	742.9959	742.9959	742.9959
LiqVol Flow	barrel/day	5359.0017	94.5284	94.5284	94.5284
Enthalpy	Btu/hr	4.73491E+06	-32565.5331	-32565.5331	-31058.1673
Density	lb/ft3	1.3767	36.4856	36.4856	36.4904
Mole Wt.		20.4833	51.2672	51.2672	51.2672
Spec. Heat	Btu/lb-F	0.5099	0.5345	0.5345	0.5322
Therm Cond	Btu/hr-ft-F	0.0157	0.0625	0.0625	0.0622
Viscosity	cP	0.0103	0.1920	0.1920	0.1897
Z Factor		0.8906	0.0841	0.0841	0.1673
Sur Tension	dyne/cm	---	12.4562	12.4562	12.3050
Std Density	lb/ft3	---	34.1183	34.1183	34.1183
Methane	mole frac.	0.7818	0.1249	0.1249	0.1249
Ethane	mole frac.	0.1326	0.1490	0.1490	0.1490
Propane	mole frac.	0.0307	0.1448	0.1448	0.1448
i-Butane	mole frac.	0.0126	0.1636	0.1636	0.1636
n-Butane	mole frac.	0.0077	0.1493	0.1493	0.1493
i-Pentane	mole frac.	0.0022	0.1144	0.1144	0.1144
n-Pentane	mole frac.	0.0012	0.0888	0.0888	0.0888
n-Hexane	mole frac.	0.0001	0.0389	0.0389	0.0389
n-Heptane	mole frac.	0.0000	0.0136	0.0136	0.0136
n-Octane	mole frac.	0.0000	0.0041	0.0041	0.0041
Nitrogen	mole frac.	0.0128	0.0006	0.0006	0.0006
CO2	mole frac.	0.0182	0.0081	0.0081	0.0081

Stream		Duty2
Description		
Vapour frac.		2.0000*
Temperature	F	0.0000*
Pressure	psia	0.0000*
Molar Flow	lbmole/hr	0.0000*
Mass Flow	lb/hr	0.0000*
LiqVol Flow	barrel/day	0.0000*
Enthalpy	Btu/hr	1507.3658
Density	lb/ft3	0.0000
Mole Wt.		0.0000
Spec. Heat	Btu/lb-F	---
Therm Cond	Btu/hr-ft-F	---
Viscosity	cP	---
Z Factor		---
Sur Tension	dyne/cm	---
Std Density	lb/ft3	---
Methane	mole frac.	0.0000*
Ethane	mole frac.	0.0000*
Propane	mole frac.	0.0000*
i-Butane	mole frac.	0.0000*
n-Butane	mole frac.	0.0000*
i-Pentane	mole frac.	0.0000*
n-Pentane	mole frac.	0.0000*
n-Hexane	mole frac.	0.0000*
n-Heptane	mole frac.	0.0000*
n-Octane	mole frac.	0.0000*
Nitrogen	mole frac.	0.0000*
CO2	mole frac.	0.0000*

Step	Action
117	Press the <**F10**> key;
	Looking at the PFD (Process Flow Diagram) for the Process.
118	Highlight the letters **PFD** and then press the <**Enter**> key;
	Pressing the <Home> key will reduce the PFD diagram to fit on the screen.
119	Press the <**Home**> key;
	A Process Flow Diagram (PFD) similar to the one shown below will then appear.

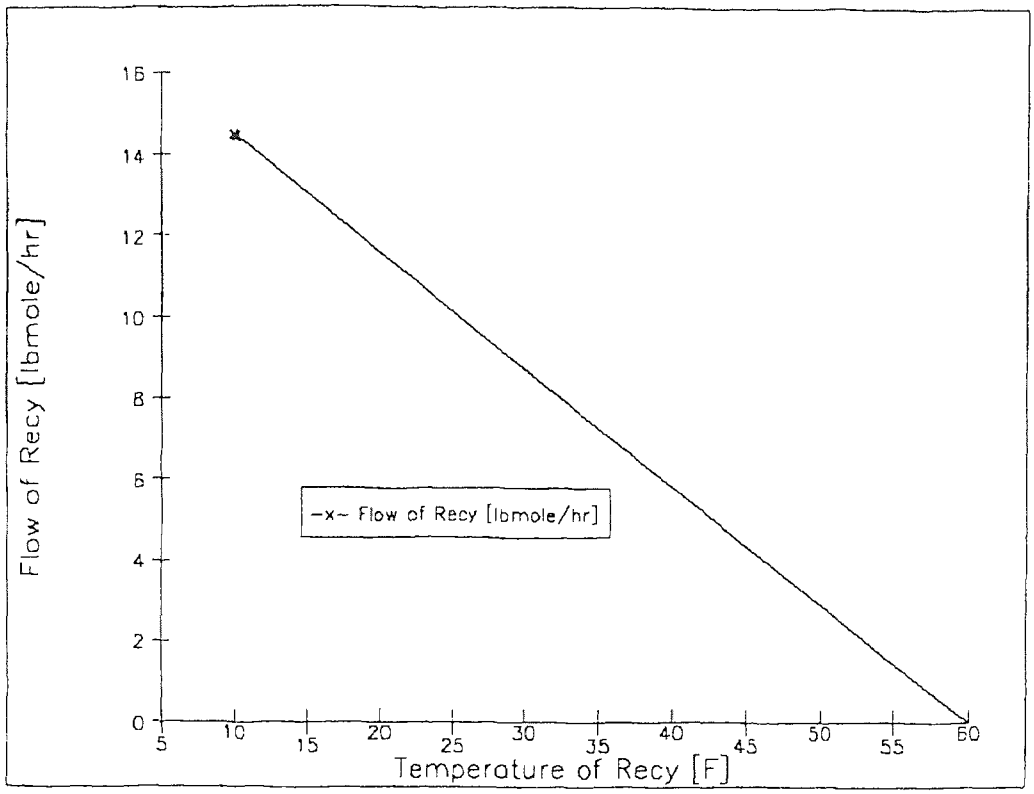


Step	Action
120	Press the <**Esc**> key.
	Looking at the data recorded by the data recorder during recycle iterations.
121	Highlight the word **Operation** and then press the <**Enter**> key;
122	Highlight the word **Record** and then press the <**Enter**> key;
123	Highlight the word **Print** and then press the <**Enter**> key;
	The following screen will then appear:

Data Recorder Record

Case	Flow Recy lbmole/hr	Temperature Recy F	Energy E-1_Duty Btu/hr	Energy Duty2 Btu/hr
1	0.000000	60.0000	574249.	1505.76
2	14.4636	10.1372	572732.	1507.33
3	14.4921	9.91713	572728.	1507.37

Step	Action
	Plotting the flow of the Recy stream vs. its temperature.
124	Highlight the word **Plot** and then press the **<Enter>** key;
	Specifying the Temperature of the Recy stream as the X-Variable.
125	Highlight the words **Recy_Temperature** and then press the **<Enter>** key;
	Specifying the Flow of the Recy stream as the Y-Variable.
126	Highlight the words **Recy_Flow** and then press the **<Enter>** key;
	Specifying that HYSIM should sort the data points.
127	Highlight the word **Yes** and then press the **<Enter>** key;
	The screen will then appear as shown below:



Step	Action
128	Press the **<Esc>** key;
129	Highlight the word **Quit** and then press the **<Enter>** key;
130	Do you want to continue adding other unit operations to this recycle process with a data recorder? • If Yes, turn to the pertinent section of this manual now; • If No, turn to the "Exiting HYSIM" Section of this manual

CHAPTER 5

COMBINING UNIT OPERATIONS INTO ONE PROCESS AND PFD

Objective - This exercise is an example of how to use the HYSIM program to combine unit operations into one process and PFD (Process Flow Diagram). This example can be modified by specifying another property package and/or other components, compositions and feed conditions.

In this example, separators, heat exchangers, a mixer, a set operation, a distillation column, a compressor, a cooler, and an adiabatic valve are combined into one flow process using HYSIM.

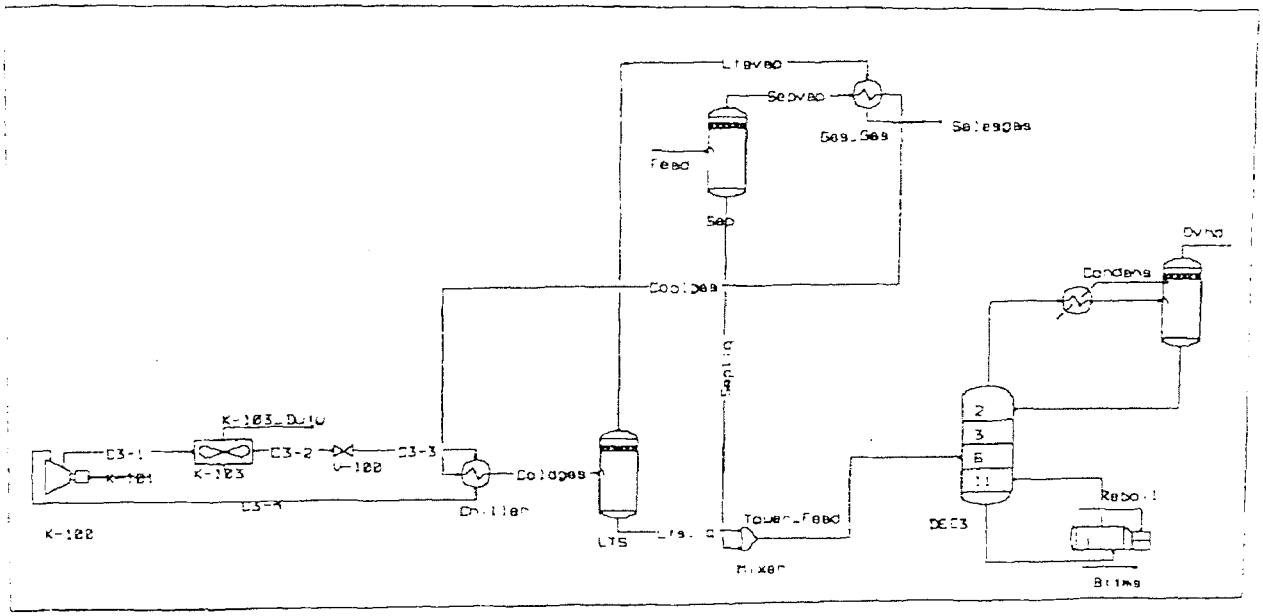
Technical Example Reference: Reference 1 - HYSIM Interactive Tutorial, Hyprotech's HYSIM User's Guide, Version C2.50, March 1994, pages 3-98 to 3-128.

Other References: Refs.1 & 2.

Directions - Pages 455 through 478 outline the combination of various unit operations into one process and process flow diagram (PFD). This exercise requires the user to take certain actions which specify highlighting pertinent words on the menu screens which will pop-up in HYSIM. Highlighting is accomplished by moving the arrow keys (←, ↑, →, or ↓ keys) until the required word on the menu changes color to indicate that it has been selected. Alternatively, the mouse can be used to highlight a menu item by moving the cursor over to the menu item with the mouse and then "clicking" on that item.

Follow the instructions in the Action column below. The HYSIM menu items to be highlighted and the words to be typed have been indicated in **boldtype** in the Action column. Function keys to be pressed by the user, such as the "Escape" key have additionally been placed inside < > brackets (e.g.<**Esc**>) in the Action column; supplemental comments are indicated in *italicized* print. Typing can be done in capital and/or small-case lettering, because they are recognized as the same in HYSIM.

The process flow diagram for this operation is shown below:



Step	Action
1	Are you at the start-up menu of HYSIM? (The start-up menu is described in Section V). • If Yes, proceed with Step 2. • If No, turn to the "Starting HYSIM" Section of this manual and follow the procedures before proceeding to Step 2.
	Starting with a new case.
2	Highlight the word **No** and then press the **<Enter>** key;
	Selecting a Property Package.
3	Highlight the word **Peng-Robinson** and then press the **<Enter>** key;
	The following screen will appear:

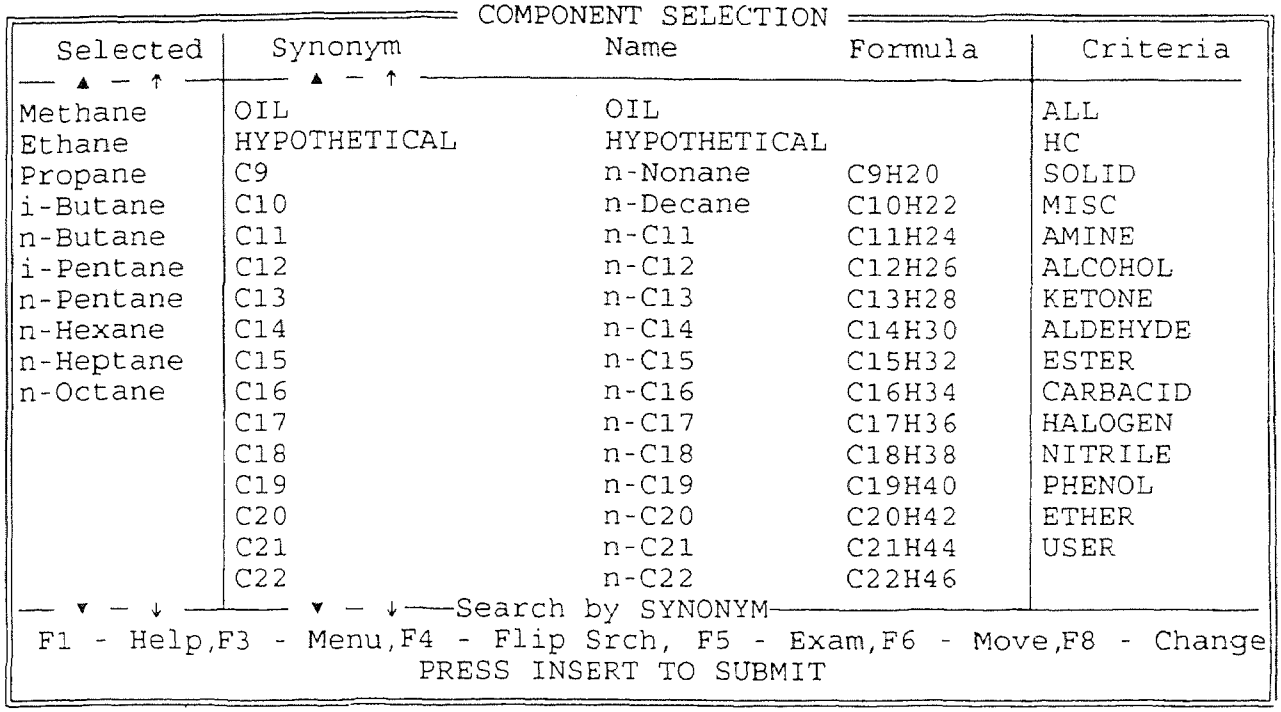
COMPONENT SELECTION

Selected	Synonym	Name	Formula	Criteria
	OIL	OIL		ALL
	HYPOTHETICAL	HYPOTHETICAL		HC
	C1	Methane	CH4	SOLID
	C2	Ethane	C2H6	MISC
	C3	Propane	C3H8	AMINE
	i-C4	i-Butane	C4H10	ALCOHOL
	n-C4	n-Butane	C4H10	KETONE
	i-C5	i-Pentane	C5H12	ALDEHYDE
	n-C5	n-Pentane	C5H12	ESTER
	C6	n-Hexane	C6H14	CARBACID
	C7	n-Heptane	C7H16	HALOGEN
	C8	n-Octane	C8H18	NITRILE
	C9	n-Nonane	C9H20	PHENOL
	C10	n-Decane	C10H22	ETHER
	C11	n-C11	C11H24	USER
	C12	n-C12	C12H26	

Search by SYNONYM

F1 - Help, F3 - Menu, F4 - Flip Srch, F5 - Exam, F6 - Move, F8 - Change
PRESS INSERT TO SUBMIT

Step	Action
	Selecting the components in the feed stream.
4	*Highlight each of the following component names under the "Component Selection" Section and press the <Enter> key so that the name then appears in the "Selected" column. This "Component Selection" List is very long. Use the <Page Down> and Arrow Keys to find the following components:* Highlight the word **Methane** and then press the **<Enter>** key; Highlight the word **Ethane** and then press the **<Enter>** key; Highlight the word **Propane** and then press the **<Enter>** key; Highlight the word **i-Butane** and then press the **<Enter>** key; Highlight the word **n-Butane** and then press the **<Enter>** key; Highlight the word **i-Pentane** and then press the **<Enter>** key; Highlight the word **n-Pentane** and then press the **<Enter>** key; Highlight the word **n-Hexane** and then press the **<Enter>** key; Highlight the word **n-Heptane** and then press the **<Enter>** key; Highlight the word **n-Octane** and then press the **<Enter>** key;
	The following screen will then appear:



Step	Action
5	Press the **<Insert>** key;
	The screen will then appear as shown on the following page.

```
Work_Sheet          Specify             Operation          Print
PFD                 Remove              Store              New
Ignore              Restore             Hold               Go
Utility             Size                Report             Toggle
Exit                ?
Work_Sheet streams in a spreadsheet format
Prop Pkg PR - SI Units   9879552
>
```

NOTE: On returning to the main menu after component selection, HYSIM will provide a list of the component selections. This is helpful in assessing component selections.

Step	Action
	Specifying that you want the units changed from the default metric system units (kg, kPa, °C, etc.) to field units (lb, psia, °F, etc.).
6	Highlight the word **Utility** and then press the **<Enter>** key;
7	Highlight the word **Configuration** and then press the **<Enter>** key;
8	Highlight the word **Units** and then press the **<Enter>** key;
9	Highlight the word **Field** and then press the **<Enter>** key;
10	Press the **<Esc>** key.
	Specifying the conditions of the Feed stream.
11	Highlight the word **Specify** and then press the **<Enter>** key;
12	Highlight the word **Stream** and then press the **<Enter>** key;
13	Type the word **Feed** after the prompt (>) and then press the **<Enter>** key;
	Specifying the temperature of the Feed in °F.
14	Type the number **60** after the prompt (>) and then press the **<Enter>** key;
	Specifying the pressure of the Feed in psia.
15	Type the number **600** after the prompt (>) and then press the **<Enter>** key;
	Specifying the flow of the Feed stream in lb-mols/hr as unknown.
16	Type the letter **x** after the prompt (>) and then press the **<Enter>** key;
	Specifying that the composition of each component in the Feed will be given in a molar flow rate.
17	Highlight the word **Mole_Flows** and then press the **<Enter>** key;
	The screen will appear as shown below:

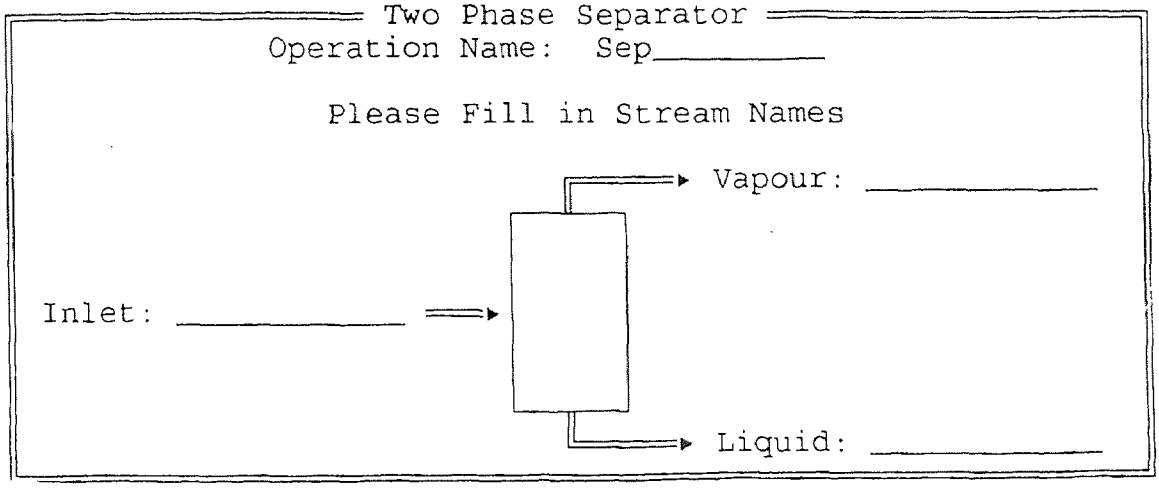
```
                    Stream Molar Flows

Methane   _____________________    Ethane    _____________________
Propane   _____________________    i-Butane  _____________________
n-Butane  _____________________    i-Pentane _____________________
n-Pentane _____________________    n-Hexane  _____________________
n-Heptane _____________________    n-Octane  _____________________
```

Step	Action
	Specifying the molar flow rates in lbmoles/hr of each component in the Feed stream.
18	*Enter the following mole flows beside each component in the Feed stream:* After the word, Methane, type the number **70** in the blank and then press the **<Enter>** key; After the word, Ethane, type the number **20** in the blank and then press the **<Enter>** key; After the word, Propane, type the number **10** in the blank and then press the **<Enter>** key; After the word, i-Butane, type the number **9** in the blank and then press the **<Enter>** key; After the word, n-Butane, type the number **8** in the blank and then press the **<Enter>** key; After the word, i-Pentane, type the number **7** in the blank and then press the **<Enter>** key; After the word, n-Pentane, type the number **6** in the blank and then press the **<Enter>** key; After the word, n-Hexane, type the number **7** in the blank and then press the **<Enter>** key; After the word, n-Heptane, type the number **4** in the blank and then press the **<Enter>** key; After the word, n-Octane, type the number **3** in the blank;
	The screen will now appear as shown below:

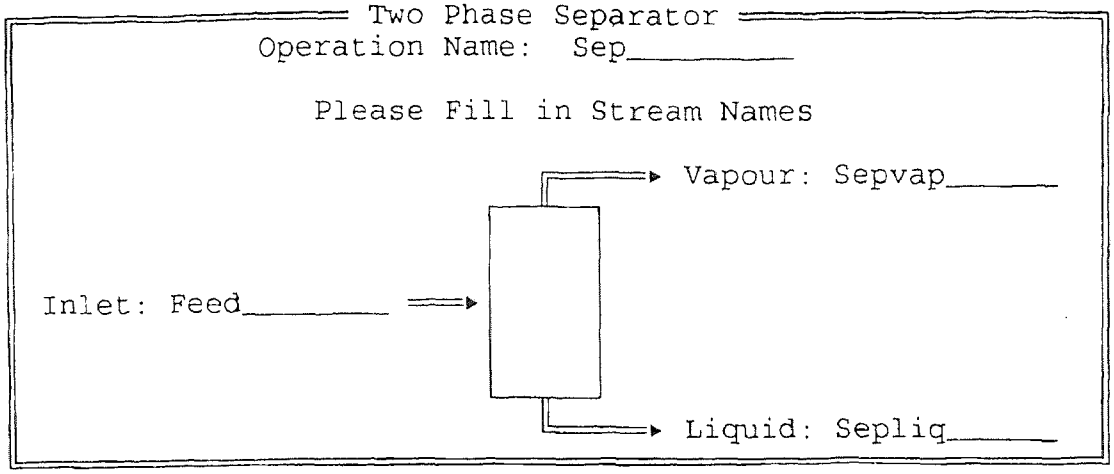
Stream Molar Flows

Methane	70	Ethane	20
Propane	10	i-Butane	9
n-Butane	8	i-Pentane	7
n-Pentane	6	n-Hexane	7
n-Heptane	4	n-Octane	3

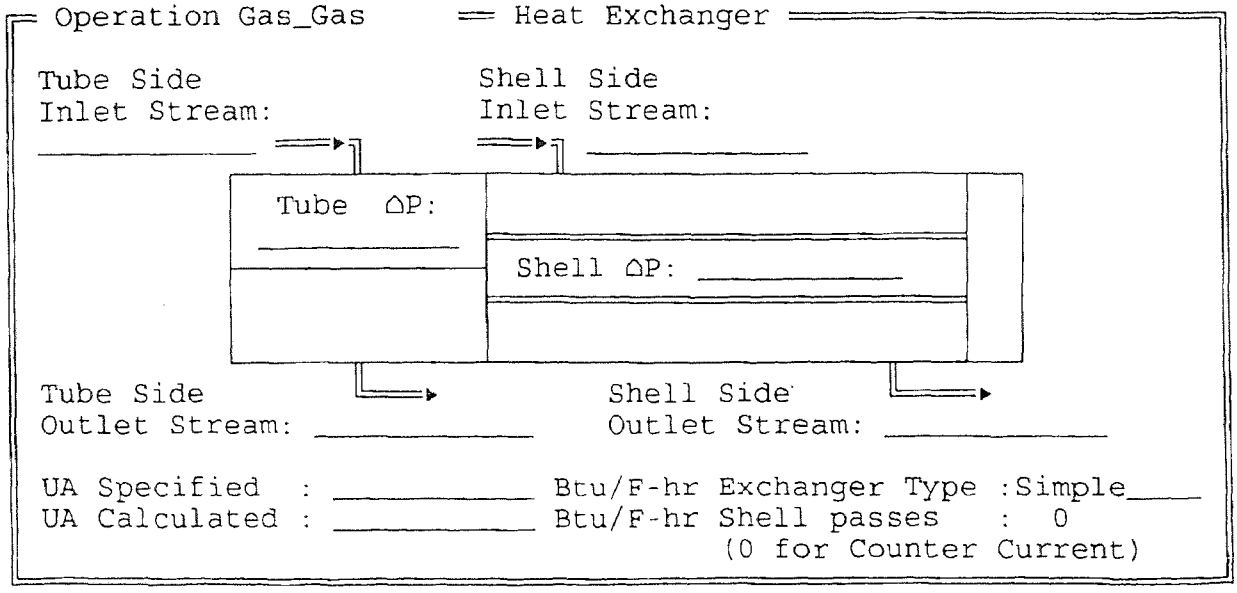
Step	Action
19	Press the **<Insert>** key;
	Specifying whether the total molar flow rate which HYSIM has calculated (144.0000 lb-mols/hr) is correct.
20	Highlight the word **Yes** and then press the **<Enter>** key;
	Specifying the type of operation we want to perform on the Feed stream.
21	Highlight the word **Operation** and then press the **<Enter>** key;
	Naming the first unit operation, (a separator), as "Sep".
22	Type the word **Sep** and then press the **<Enter>** key;
23	Highlight the word **Separator** and then press the **<Enter>** key;
	The screen will then appear as shown below:



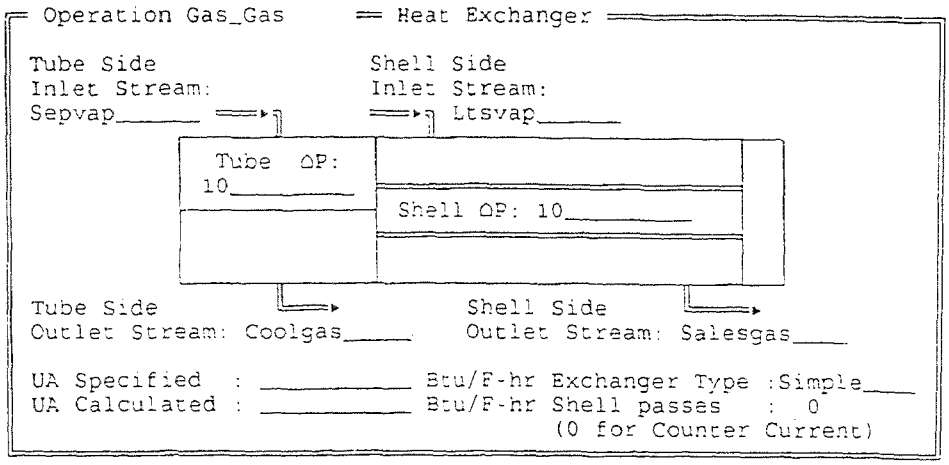
Step	Action
	Specifying the inlet and outlet stream names to and from the separator.
24	Type the word **Feed** and then press the <**Enter**> key.
25	Type the word **Sepliq** and then press the <**Enter**> key.
26	Type the word **Sepvap**.
	The following screen will then appear:



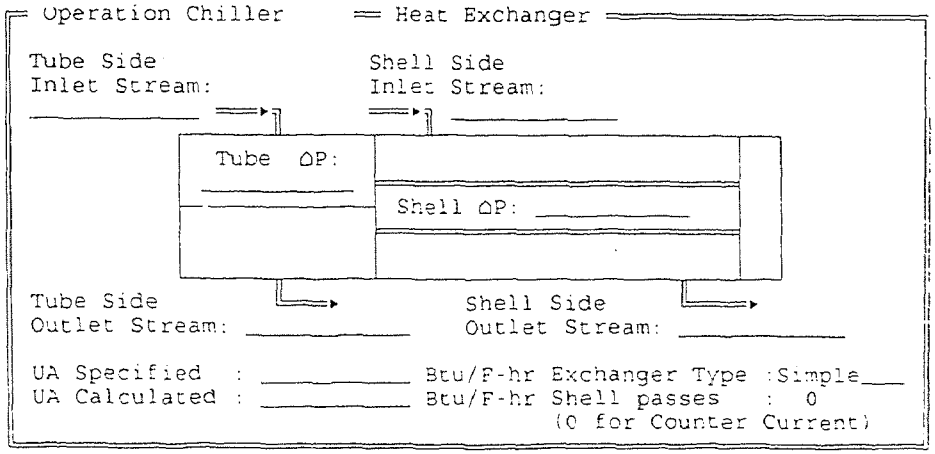
Step	Action
27	Press the <**Insert**> key;
	Naming the second unit operation (a gas/gas heat exchanger) as "Gas_Gas".
28	Highlight the word **Operation** and then press the <**Enter**> key.
29	Type the word **Gas_Gas** and then press the <**Enter**> key.
30	Highlight the word **Heat_Exchanger** and then press the <**Enter**> key.
	The screen should then appear as shown below:



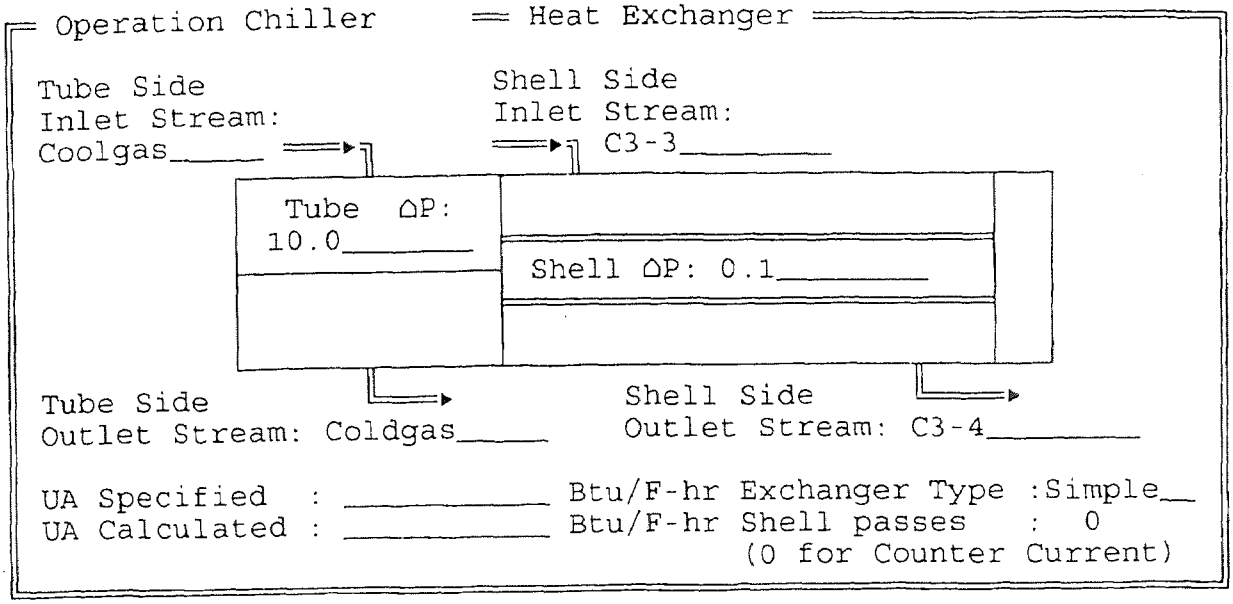
Step	Action
	Specifying the inlet and outlet stream names and the tube and shellside ΔP.
31	Type the word **Sepvap** and then press the <**Enter**> key;
32	Type the word **Coolgas** and then press the <**Enter**> key;
33	Type the word **Ltsvap** and then press the <**Enter**> key;
34	Type the word **Salesgas** and then press the <**Enter**> key;
35	Type the number **10** and then press the <**Enter**> key;
36	Type the number 10 and then press the <**Enter**> key;
	The screen should appear as shown below:



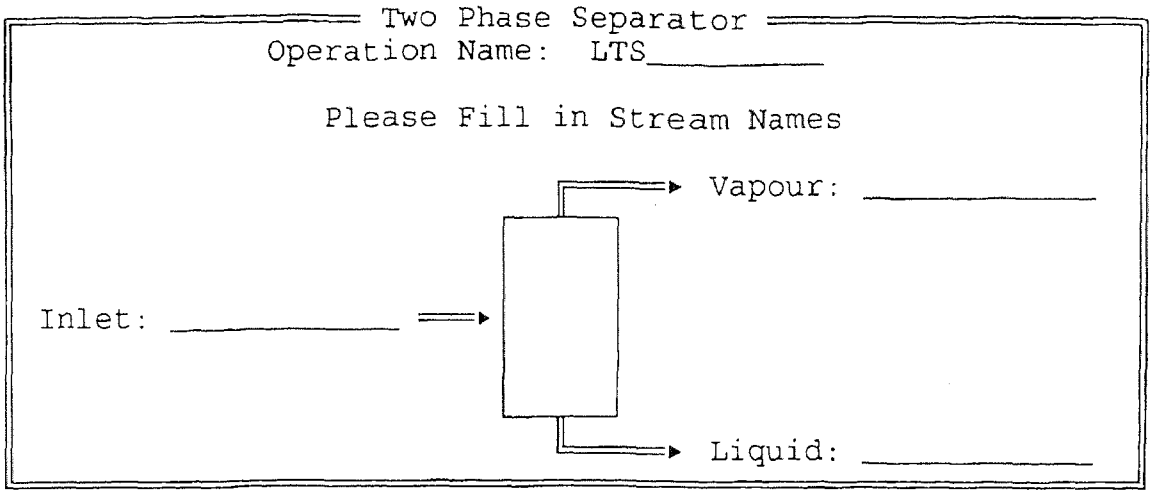
Step	Action
37	Press the <**Insert**> key.
	Naming the third unit operation (a heat exchanger) as "Chiller".
38	Highlight the word **Operation** and then press the <**Enter**> key.
39	Type the word **Chiller** and then press the <**Enter**> key.
40	Highlight the word **Heat_Exchanger** and then press the <**Enter**> key.
	The following screen will then appear:



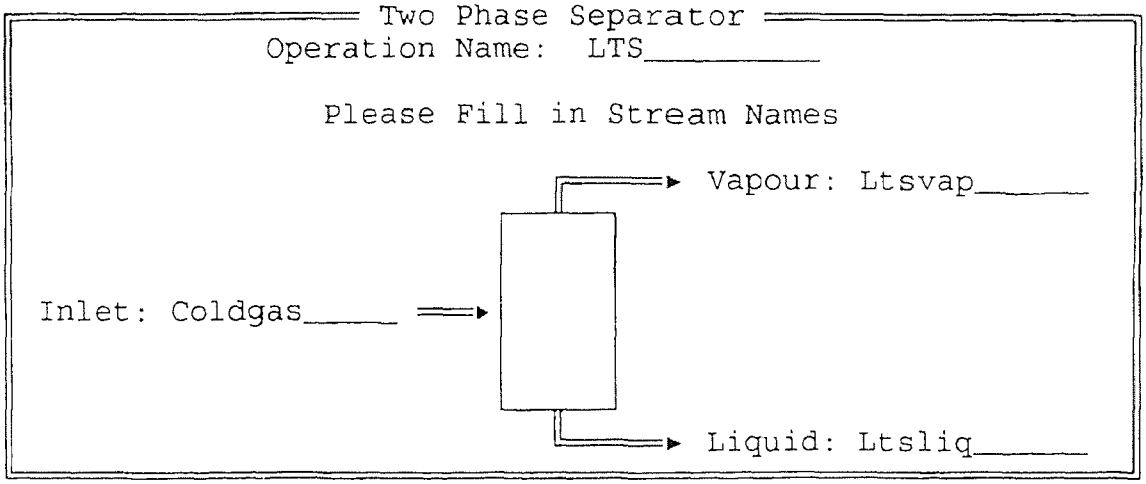
Step	Action
	Specifying the inlet and outlet stream names and the tube and shellside ΔP.
41	Type the word **Coolgas** and then press the **<Enter>** key;
42	Type the word **Coldgas** and then press the **<Enter>** key;
43	Type the word **C3-3** and then press the **<Enter>** key;
44	Type the word **C3-4** and then press the **<Enter>** key;
45	Type the number **10.0** and then press the **<Enter>** key;
46	Type the number **0.1** and then press the **<Enter>** key;
	The screen should appear as shown below:



Step	Action
47	Press the **<Insert>** key.
48	Highlight the word **Worksheet** and then press the **<Enter>** key;
	Specifying the temperature of the stream Coldgas in °F.
49	*Place the cursor using the arrow keys in the column for the Coldgas stream and the row for the Temperature.* Type the number **12.47** and then press the **<Enter>** key;
50	Press the **<Esc>** key;
	Naming the fourth unit operation (a separator) as "LTS".
51	Highlight the word **Operation** and then press the **<Enter>** key.
52	Type the letters **LTS** and then press the **<Enter>** key.
53	Highlight the word **Separator** and then press the **<Enter>** key.
	The screen will then appear as shown on the following page.



Step	Action
	Specifying the inlet and outlet stream names to and from the separator.
54	Type the word **Coldgas** and then press the <**Enter**> key.
55	Type the word **Ltsliq** and then press the <**Enter**> key.
56	Type the word **Ltsvap**.
	The following screen will then appear:



Step	Action
57	Press the <**Insert**> key;
	Setting the Temperature of stream Salesgas as 10°F lower than the Temperature of stream Sepvap.
58	Highlight the word **Operation** and then press the <**Enter**> key.
	Naming the Temperature Setting operation (Set) as "Delt".
59	Type the word **Delt** and then press the <**Enter**> key.
60	Highlight the word **Set** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.

Set/Controller Block

Operation Name: Delt___

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
_____	of _____	= 1.0000___	* _____	+ 0.0000_

Step	Action
61	Type the word **Temperature** and then press the <**Enter**> key.
62	Type the word **Salesgas** and then press the <**Enter**> key two times.
63	Type the word **Sepvap** and then press the <**Enter**> key.
64	Type the symbol and number **-10.0**.
	The following screen will then appear:

Set/Controller Block

Operation Name: Delt_____

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Temperatur	of Salesgas__	= 1.0000___	* Sepvap___	+ -10.0__

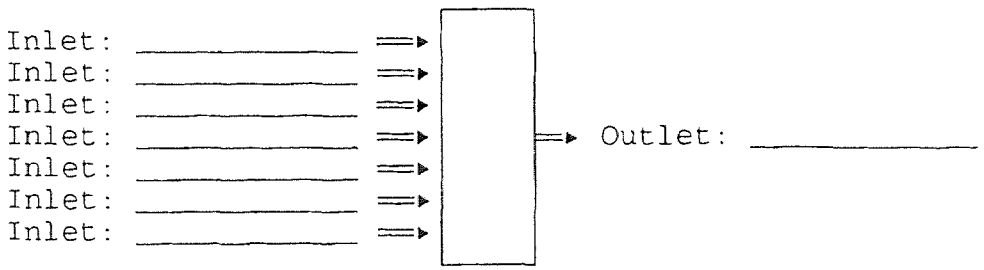
Step	Action
65	Press the <**Insert**> key;
	Naming the fifth unit operation (a mixer) as "Mixer".
66	Highlight the word **Operation** and then press the <**Enter**> key.
67	Type the word **Mixer** and then press the <**Enter**> key.
68	Highlight the word **Mixer** and then press the <**Enter**> key.
	The following screen will then appear:

Adiabatic Mixer

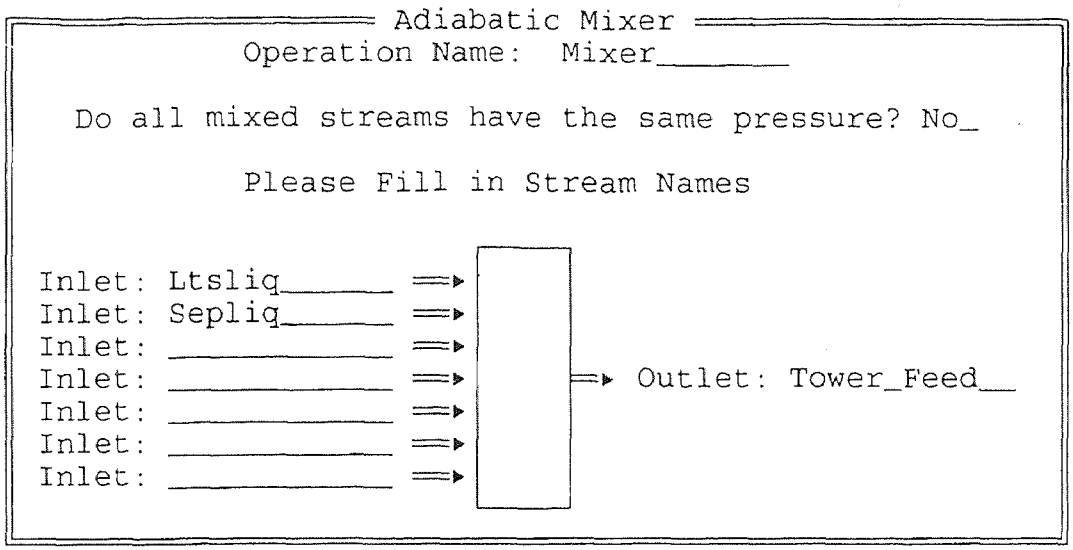
Operation Name: Mixer_____

Do all mixed streams have the same pressure? ___

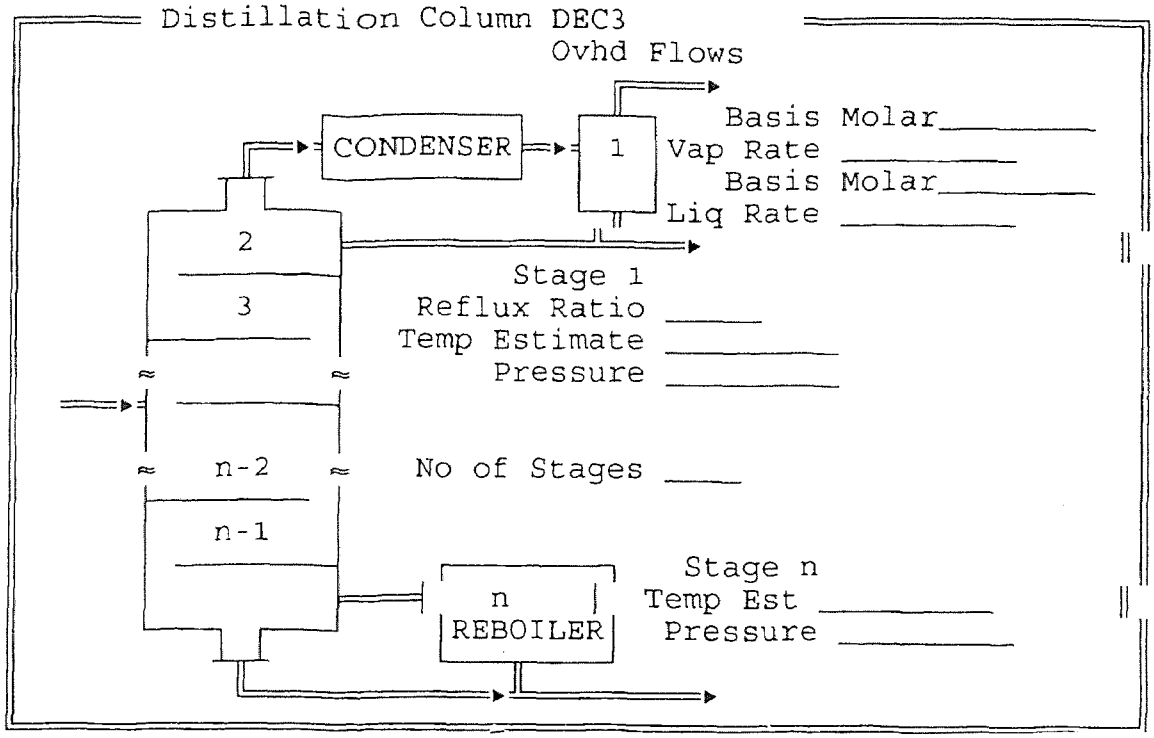
Please Fill in Stream Names



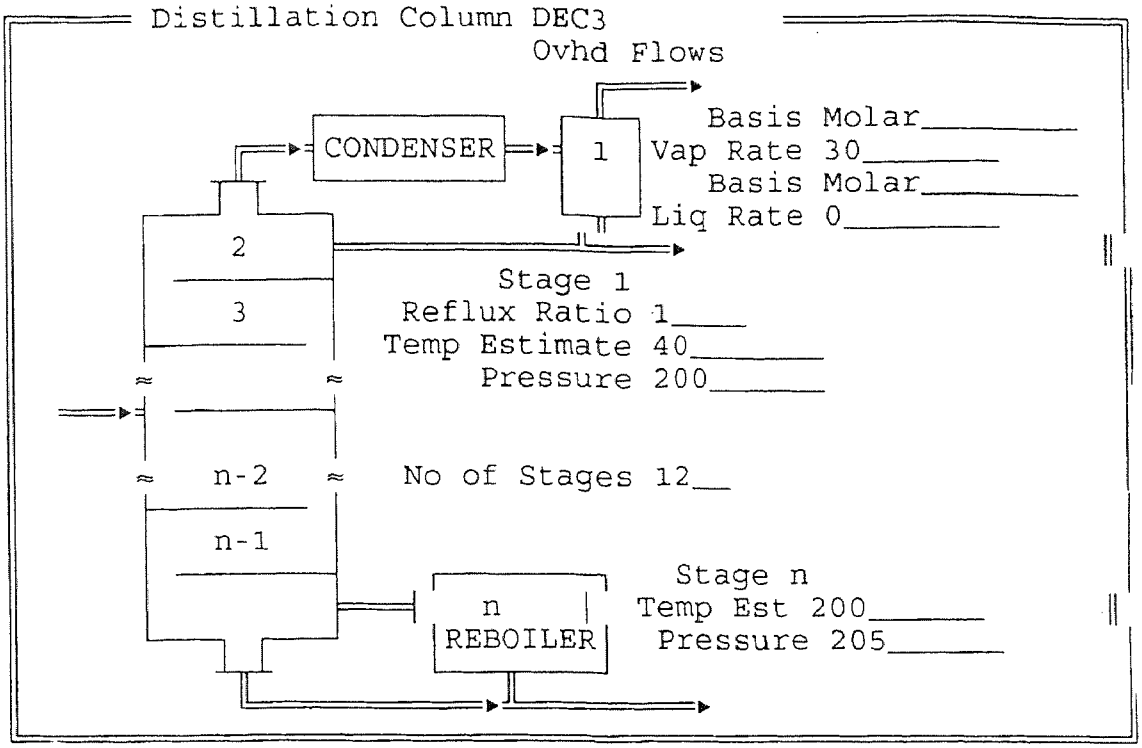
Step	Action
	Specifying whether all the mixed streams have the same pressure.
69	Type the word **No** and then press the <**Enter**> key.
	Specifying the inlet and outlet stream names to and from the Mixer.
70	Type the word **Tower_Feed** and then press the <**Enter**> key.
71	Type the word **Ltsliq** and then press the <**Enter**> key.
72	Type the word **Sepliq**.
	The following screen will then appear:



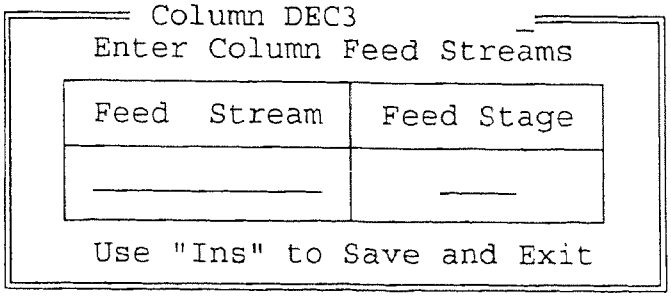
Step	Action
73	Press the <**Insert**> key;
74	Highlight the word **Worksheet** and then press the <**Enter**> key.
75	Press the <**Insert**> key;
	Naming the sixth unit operation (a distillation column) as "DEC3".
76	Type the word **DEC3** and then press the <**Enter**> key.
77	Highlight the word **Column** and then press the <**Enter**> key.
78	Highlight the word **Distillation** and then press the <**Enter**> key.
	The screen will then appear as shown on the following page.



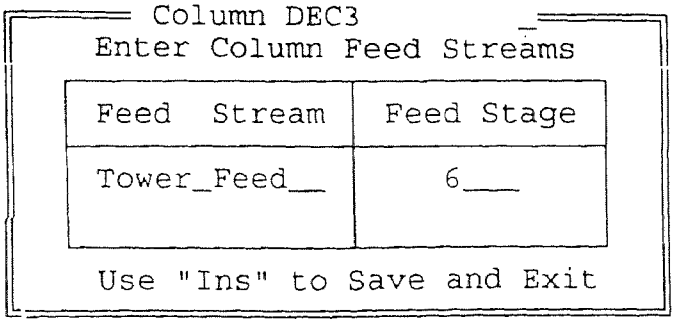
Step	Action
	Specifying the column flowrates on a molar basis.
79	Press the <**Enter**> key;
	Specifying the Vapor molar flow rate from stage 1 in lb-mols/hr.
80	Type the number **30** and then press the <**Enter**> key;
	Specifying the column flowrates on a molar basis.
81	Press the <**Enter**> key;
	Specifying the Liquid molar flow rate from stage 1 in lb-mols/hr.
82	Type the number **0** and then press the <**Enter**> key;
	Specifying the top stage reflux ratio.
83	Type the number **1** and then press the <**Enter**> key;
	Specifying the Temperature Estimate of the top stage in °F.
84	Type the number **40** and then press the <**Enter**> key;
	Specifying the Pressure Estimate of the top stage in psia.
85	Type the number **200** and then press the <**Enter**> key;
	Specifying the number of stages in the column.
86	Type the number **12** and then press the <**Enter**> key;
	Specifying the Temperature estimate of the bottom stage in °F.
87	Type the number **200** and then press the <**Enter**> key;
	Specifying the pressure estimate of the bottom stage in psia.
88	Type the number **205**;
	The screen should appear as shown on the following page.



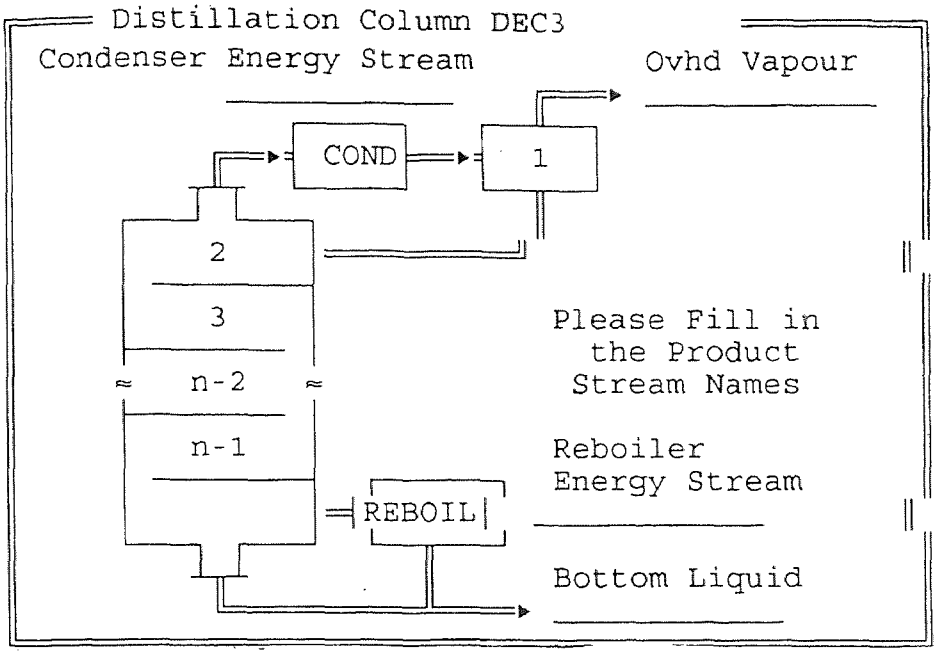
Step	Action
89	Press the <**Insert**> key;
	The following screen will then appear:



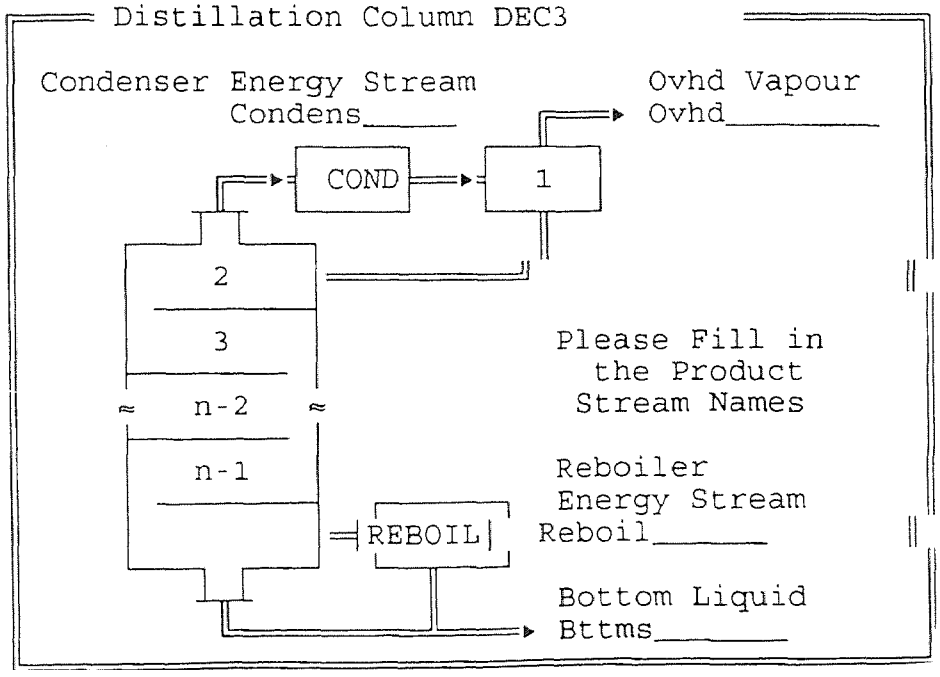
Step	Action
	Specifying that the Tower_Feed stream enters the DEC3 distillation column at stage number 6.
90	Type the word **Tower_Feed** and then press the <**Enter**> key.
91	Type the number **6**.
	The following screen will then appear:



Step	Action
92	Press the <**Insert**> key;
	The following screen will then appear:



Step	Action
	Specifying the outlet stream names from the DEC3 distillation column.
93	Type the word **Condens** and then press the <**Enter**> key.
94	Type the word **Ovhd** and then press the <**Enter**> key.
95	Type the word **Reboil** and then press the <**Enter**> key.
96	Type the word **Bttms**.
	The following screen will then appear:



Step	Action
97	Press the <**Insert**> key;
	Changing the flow specification to a mole fraction specification for the overhead flow (which is specification number 1).
98	Highlight the word **Change** and then press the <**Enter**> key.
99	Highlight the word **Specifications** and then press the <**Enter**> key.
100	Type the number **1** and then press the <**Enter**> key.
101	Highlight the word **Fractions** and then press the <**Enter**> key.
	Specifying that the Mole Fraction of Propane in the liquid product leaving stage 12 is 0.02.
102	Type the number **12** and then press the <**Enter**> key.
103	Highlight the word **Liquid** and then press the <**Enter**> key.
104	Highlight the word **Mole** and then press the <**Enter**> key.
105	Type the number **0.02** and then press the <**Enter**> key.
106	Highlight the word **Propane** and then press the <**Enter**> key.
	Running the DEC3 distillation column.
107	Highlight the word **Run** and then press the <**Enter**> key.
108	Press the <**Esc**> key three times until you get back to the Main Menu;
	Specifying the composition of stream C3-4.
109	Highlight the word **Specify** and then press the <**Enter**> key.
110	Highlight the word **Composition** and then press the <**Enter**> key.
111	Highlight the stream name **C3-4** and then press the <**Enter**> key.
112	Highlight the word **Mole_Fractions** and then press the <**Enter**> key.
	The following screen will then appear.

```
                    Stream Mole Fractions

Methane    _____________________    Ethane     _____________________
Propane    _____________________    i-Butane   _____________________
n-Butane   _____________________    i-Pentane  _____________________
n-Pentane  _____________________    n-Hexane   _____________________
n-Heptane  _____________________    n-Octane   _____________________
```

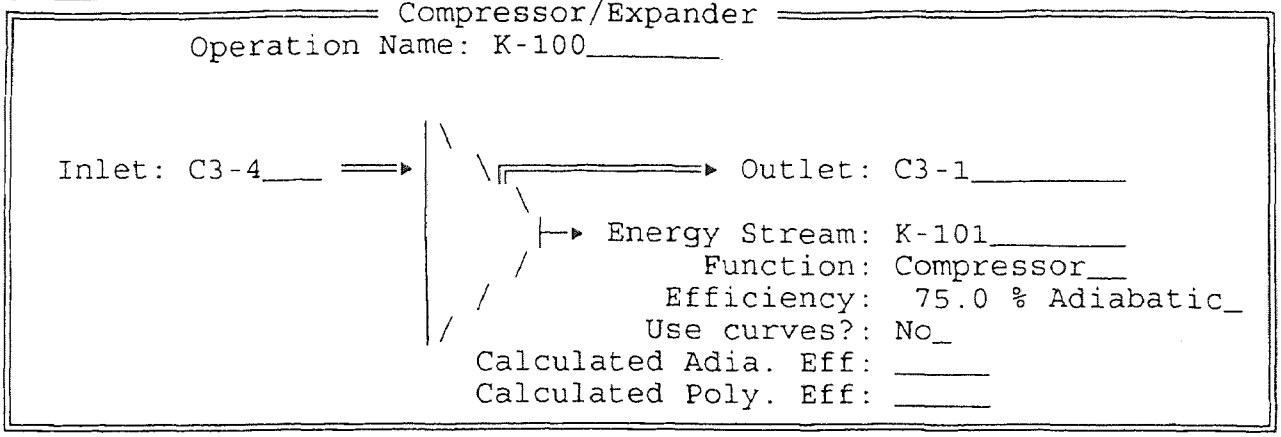
Step	Action
	Specifying the mole fractions of each component in the C3-4 stream.
113	*Enter the following mole fractions beside each component in the C3-4 stream:* After the word, Methane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Ethane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, Propane, type the number **1.0** in the blank and then press the <**Enter**> key; After the word, i-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Butane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, i-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Pentane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Hexane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Heptane, type the number **0.0** in the blank and then press the <**Enter**> key; After the word, n-Octane, type the number **0.0** in the blank;
	The screen will now appear as shown below:

```
═══════════ Stream Mole Fractions ═══════════

Methane     0.0_____________    Ethane      0.0_____________
Propane     1.0_____________    i-Butane    0.0_____________
n-Butane    0.0_____________    i-Pentane   0.0_____________
n-Pentane   0.0_____________    n-Hexane    0.0_____________
n-Heptane   0.0_____________    n-Octane    0.0_____________
```

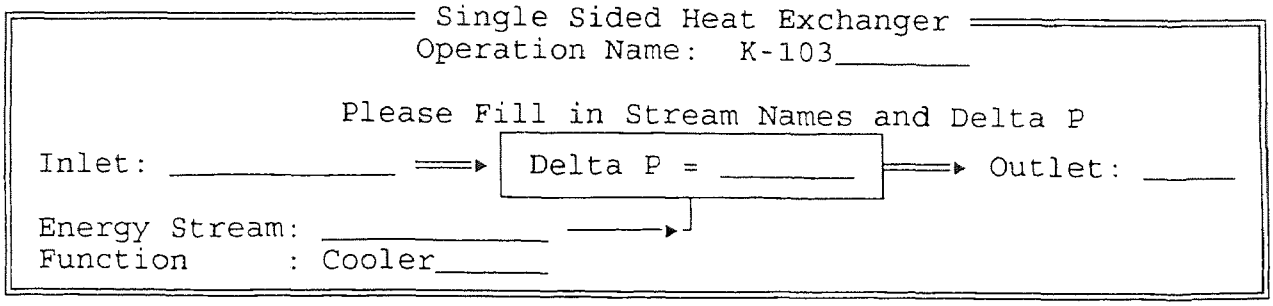
Step	Action
114	Press the <**Insert**> key;
	Naming the seventh unit operation (a compressor) as "K-100".
115	Highlight the word **Operation** and then press the <**Enter**> key.
116	Type the word **K-100** and then press the <**Enter**> key.
117	Highlight the words **Comp/Expander** and then press the <**Enter**> key.
	The following screen will then appear:

```
═══════════ Compressor/Expander ═══════════
        Operation Name: K-100_______


                                  \
 Inlet: _______ ═══►              \╔═══════════► Outlet: _____________
                                    \
                                     ├─► Energy Stream: _____________
                                    /          Function: Compressor__
                                   /         Efficiency:  75.0 % Adiabatic_
                                  /         Use curves?: No_
                                 /       Calculated Adia. Eff: _____
                                         Calculated Poly. Eff: _____
```

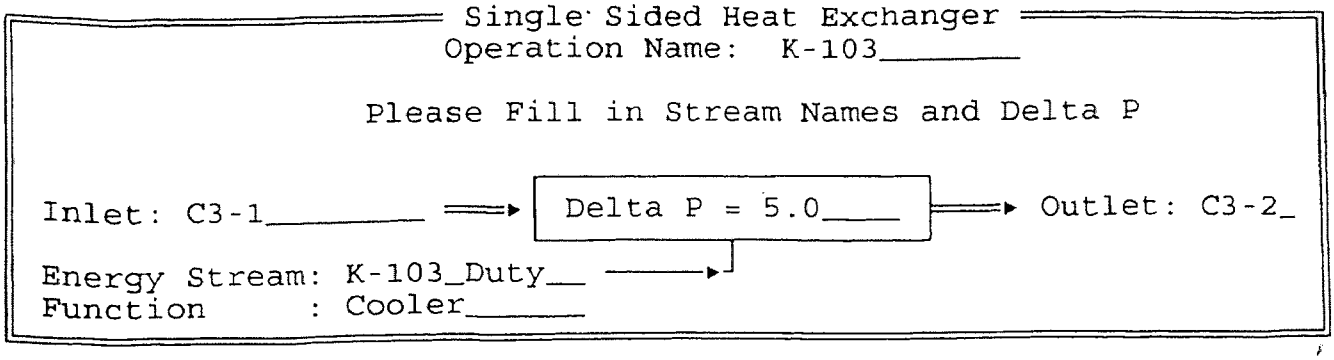
Step	Action
	Specifying the inlet and outlet stream names from the K-100 Compressor.
118	Type the stream name **C3-4** and then press the **<Enter>** key.
119	Type the stream name **C3-1** and then press the **<Enter>** key.
120	Type the stream name **K-101** and then press the **<Enter>** key.
	The following screen will then appear:



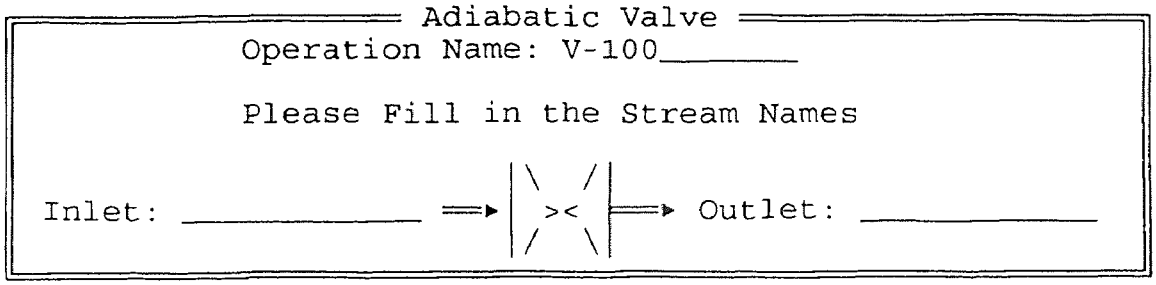
Step	Action
121	Press the **<Insert>** key;
	Naming the eighth unit operation (a single-sided heat exchanger) as "K-103".
122	Highlight the word **Operation** and then press the **<Enter>** key.
123	Type the word **K-103** and then press the **<Enter>** key.
124	Highlight the words **Cooler/Heater** and then press the **<Enter>** key.
	The following screen will then appear:



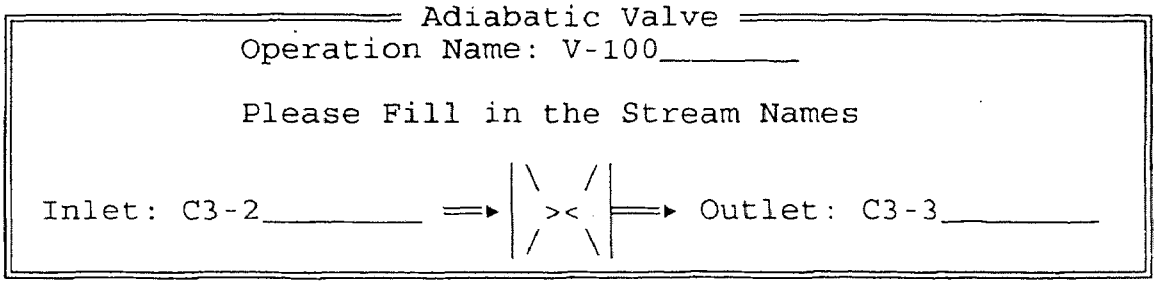
Step	Action
	Specifying the inlet and outlet stream names from the K-103 Cooler.
125	Type the stream name **C3-1** and then press the **<Enter>** key.
126	Type the stream name **C3-2** and then press the **<Enter>** key.
127	Type the stream name **K-103_Duty** and then press the **<Enter>** key two times.
	Specifying the ΔP across the Cooler.
128	Type the number **5.0**.
	The screen will then appear as shown on the following page.



Step	Action
129	Press the <**Insert**> key;
	Naming the ninth unit operation (a valve) as "V-100".
130	Highlight the word **Operation** and then press the <**Enter**> key.
131	Type the word **V-100** and then press the <**Enter**> key.
132	Highlight the word **Valve** and then press the <**Enter**> key.
	The following screen will then appear:



Step	Action
	Specifying the inlet and outlet stream name for the V-100 Valve.
133	Type the stream name **C3-2** and then press the <**Enter**> key.
134	Type the stream name **C3-3**.
	The following screen will then appear:



Step	Action
135	Press the **<Insert>** key.
136	Highlight the word **Worksheet** and then press the **<Enter>** key;
	Specifying the vapor fraction of the stream C3-4.
137	*Place the cursor using the arrow keys in the column for the C3-4 stream and the row for the vapor fraction. (Use the <Page Up> and <Page Down> keys if necessary to find stream C3-4 on the Worksheet).* Type the number **1.0** and then press the **<Enter>** key;
	Specifying the vapor fraction of the stream C3-2.
138	*Place the cursor using the arrow keys in the column for the C3-2 stream and the row for the vapor fraction. (Use the <Page Up> and <Page Down> keys if necessary to find stream C3-2 on the Worksheet).* Type the number **0.0** and then press the **<Enter>** key;
	Specifying the Temperature of stream C3-2 in °F.
139	*Place the cursor using the arrow keys in the column for the C3-2 stream and the row for the Temperature.* Type the number **120** and then press the **<Enter>** key;
140	Press the **<Esc>** key;
	Using the Set operation to specify the Temperature of the Coldgas stream as related to stream C3-3.
141	Highlight the word **Operation** and then press the **<Enter>** key.
142	Type the letters **Set-TC3** and then press the **<Enter>** key.
143	Highlight the word **Set** and then press the **<Enter>** key.
	The following screen will then appear:

Set/Controller Block

Operation Name: Set-TC3___

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
_____ of	_____	= 1.0000___ *	_____	+ 0.0000_

Step	Action
	Completing the Set/Controller Block for the Set Operation.
144	Type the word **Temperature** and then press the **<Enter>** key.
145	Type the stream name **Coldgas** and then press the **<Enter>** key two times.
146	Type the stream name **C3-3** and then press the **<Enter>** key.
147	Type the number **5.00**.
	The screen on the following page will then appear.

Set/Controller Block

Operation Name: Set-TC3___

Controlled Variable	Controlled Stream	Multiplier	Independent Stream	Offset
Temperatur of	Coldgas___	= 1.0000___	* C3-3_____	+ 5.00_

Step	Action
148	Press the **<Insert>** key;
149	Highlight the word **Print** and then press the **<Enter>** key;

Print Options:

The various print options available are as follows:

a) *Streams* - The conditions, physical properties, and compositions of the streams will be printed out.

b) *Operations* - The different unit operations will be printed out.

c) *Spec_Sheets* - The specifications sheets will be printed out.

d) *Hypotheticals* - Hypothetical component information will be printed out.

e) *Format* - Specifies the format of the printout.

f) *Cost* - Lists costs of the run, if a royalty is being charged.

g) *File* - Saves results in a file.

h) *Printer* - Toggles on a printer.

i) *Cases* - Lists the stored files.

j) *Description* - Prints case descriptions.

k) *Oil_Input* - Lists inputted information on an oil.

NOTE: It is useful to print out all of the inputted process data to check for accuracy.

Step	Action
150	Highlight the word **Streams** and then press the **<Enter>** key;
151	Highlight the word **All** and then press the **<Enter>** key;
152	Highlight the dash symbol - and then press the **<Enter>** key;
	Wait for the printing to the screen to stop. Then, press the <F10> key to get the Main Menu off of the screen in order to see the data on the screen underneath it
153	Press the **<F10>** key;
	The screen will then appear as seen on the following three pages. Use the <Page Up> and <Page Down> or arrow keys to scroll the screen text up and down.

Stream		Feed	Sepliq	Sepvap	Coolgas
Description					
Vapour frac.		0.4836	0.0000	1.0000	0.9807
Temperature	F	60.0000*	60.0000	60.0000	32.1274
Pressure	psia	600.0000*	600.0000	600.0000	590.0000
Molar Flow	lbmole/hr	144.0000*	74.3626	69.6374	69.6374
Mass Flow	lb/hr	5438.2035	4013.7623	1424.4413	1424.4413
LiqVol Flow	barrel/day	788.6378	499.4297	289.2080	289.2080
Enthalpy	Btu/hr	231865.6189	-41348.8026	273214.4039	243440.9930
Density	lb/ft3	8.2828	34.8685	2.6308	2.8515
Mole Wt.		37.7653	53.9755	20.4551	20.4551
Spec. Heat	Btu/lb-F	0.5779	0.5736	0.5901	0.6020
Therm Cond	Btu/hr-ft-F	---	0.0572	0.0192	---
Viscosity	cP	---	0.1585	0.0119	---
Z Factor		---	0.1665	0.8365	---
Sur Tension	dyne/cm	---	9.8719	---	---
Std Density	lb/ft3	---	34.8684	---	---
Methane	mole frac.	0.4861*	0.1933	0.7988	0.7988
Ethane	mole frac.	0.1389*	0.1435	0.1339	0.1339
Propane	mole frac.	0.0694*	0.1040	0.0325	0.0325
i-Butane	mole frac.	0.0625*	0.1067	0.0153	0.0153
n-Butane	mole frac.	0.0556*	0.0979	0.0104	0.0104
i-Pentane	mole frac.	0.0486*	0.0900	0.0044	0.0044
n-Pentane	mole frac.	0.0417*	0.0779	0.0030	0.0030
n-Hexane	mole frac.	0.0486*	0.0929	0.0013	0.0013
n-Heptane	mole frac.	0.0278*	0.0535	0.0003	0.0003
n-Octane	mole frac.	0.0208*	0.0403	0.0001	0.0001

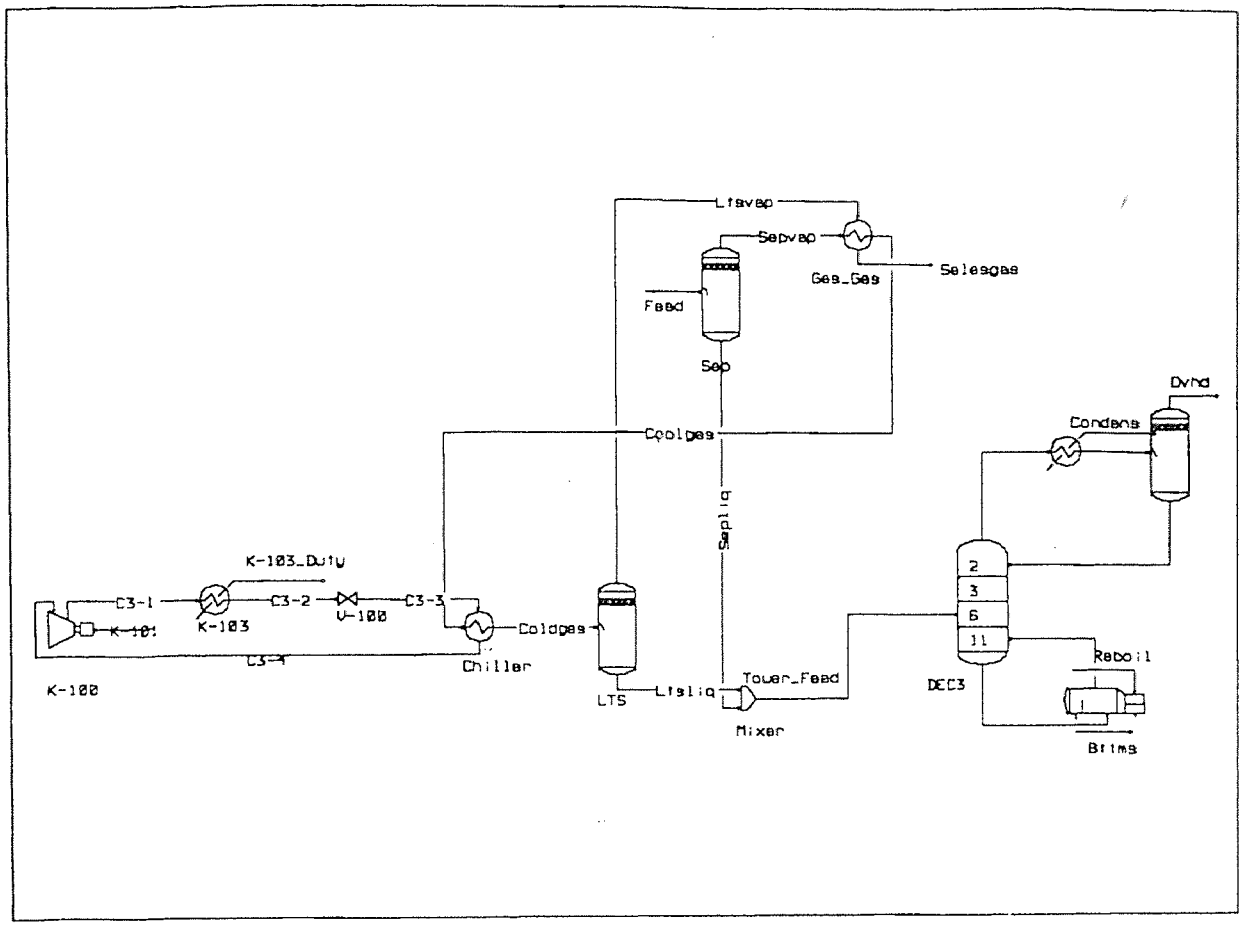
Stream		Ltsvap	Salesgas	Coldgas	C3-3
Description					
Vapour frac.		1.0000	1.0000	0.9563	0.4381
Temperature	F	12.4700	50.0000	12.4700*	7.4700
Pressure	psia	580.0000	570.0000	580.0000	44.2496
Molar Flow	lbmole/hr	66.5975	66.5975	69.6374	5.6636
Mass Flow	lb/hr	1295.5755	1295.5755	1424.4413	249.7471
LiqVol Flow	barrel/day	271.1740	271.1740	289.2080	33.7510
Enthalpy	Btu/hr	223504.8933	253278.2987	219653.3027	6114.8641
Density	lb/ft3	2.7814	2.3840	3.0323	0.9473
Mole Wt.		19.4538	19.4538	20.4551	44.0970
Spec. Heat	Btu/lb-F	0.6147	0.5862	0.6127	0.4889
Therm Cond	Btu/hr-ft-F	0.0178	0.0190	---	---
Viscosity	cP	0.0111	0.0116	---	---
Z Factor		0.8006	0.8504	---	---
Sur Tension	dyne/cm	---	---	---	---
Std Density	lb/ft3	---	---	---	---
Methane	mole frac.	0.8239	0.8239	0.7988	0.0000
Ethane	mole frac.	0.1304	0.1304	0.1339	0.0000
Propane	mole frac.	0.0272	0.0272	0.0325	1.0000
i-Butane	mole frac.	0.0101	0.0101	0.0153	0.0000
n-Butane	mole frac.	0.0059	0.0059	0.0104	0.0000
i-Pentane	mole frac.	0.0016	0.0016	0.0044	0.0000
n-Pentane	mole frac.	0.0009	0.0009	0.0030	0.0000
n-Hexane	mole frac.	0.0002	0.0002	0.0013	0.0000
n-Heptane	mole frac.	0.0000	0.0000	0.0003	0.0000
n-Octane	mole frac.	0.0000	0.0000	0.0001	0.0000

Stream Description		C3-4	Ltsliq	Tower_Feed	Ovhd
Vapour frac.		1.0000*	0.0000	0.0118	1.0000
Temperature	F	7.3519	12.4700	57.7823	18.1458
Pressure	psia	44.1496	580.0000	580.0000	200.0000
Molar Flow	lbmole/hr	5.6636	3.0399	77.4025	34.0733
Mass Flow	lb/hr	249.7471	128.8657	4142.6277	923.6441
LiqVol Flow	barrel/day	33.7510	18.0341	517.4638	166.8027
Enthalpy	Btu/hr	29902.5546	-3851.6074	-45200.4082	138932.3007
Density	lb/ft3	0.4207	32.6126	33.0600	1.2189
Mole Wt.		44.0970	42.3920	53.5206	27.1076
Spec. Heat	Btu/lb-F	0.3798	0.5928	0.5719	0.4684
Therm Cond	Btu/hr-ft-F	0.0083	0.0609	---	0.0131
Viscosity	cP	0.0072	0.1311	---	0.0095
Z Factor		0.9233	0.1488	---	0.8674
Sur Tension	dyne/cm	---	9.1741	---	---
Std Density	lb/ft3	---	29.9285	---	---
Methane	mole frac.	0.0000*	0.2494	0.1955	0.4441
Ethane	mole frac.	0.0000*	0.2106	0.1462	0.3319
Propane	mole frac.	1.0000*	0.1494	0.1058	0.2149
i-Butane	mole frac.	0.0000*	0.1308	0.1076	0.0080
n-Butane	mole frac.	0.0000*	0.1083	0.0983	0.0010
i-Pentane	mole frac.	0.0000*	0.0670	0.0891	0.0000
n-Pentane	mole frac.	0.0000*	0.0492	0.0768	0.0000
n-Hexane	mole frac.	0.0000*	0.0269	0.0903	0.0000
n-Heptane	mole frac.	0.0000*	0.0065	0.0517	0.0000
n-Octane	mole frac.	0.0000*	0.0020	0.0388	0.0000

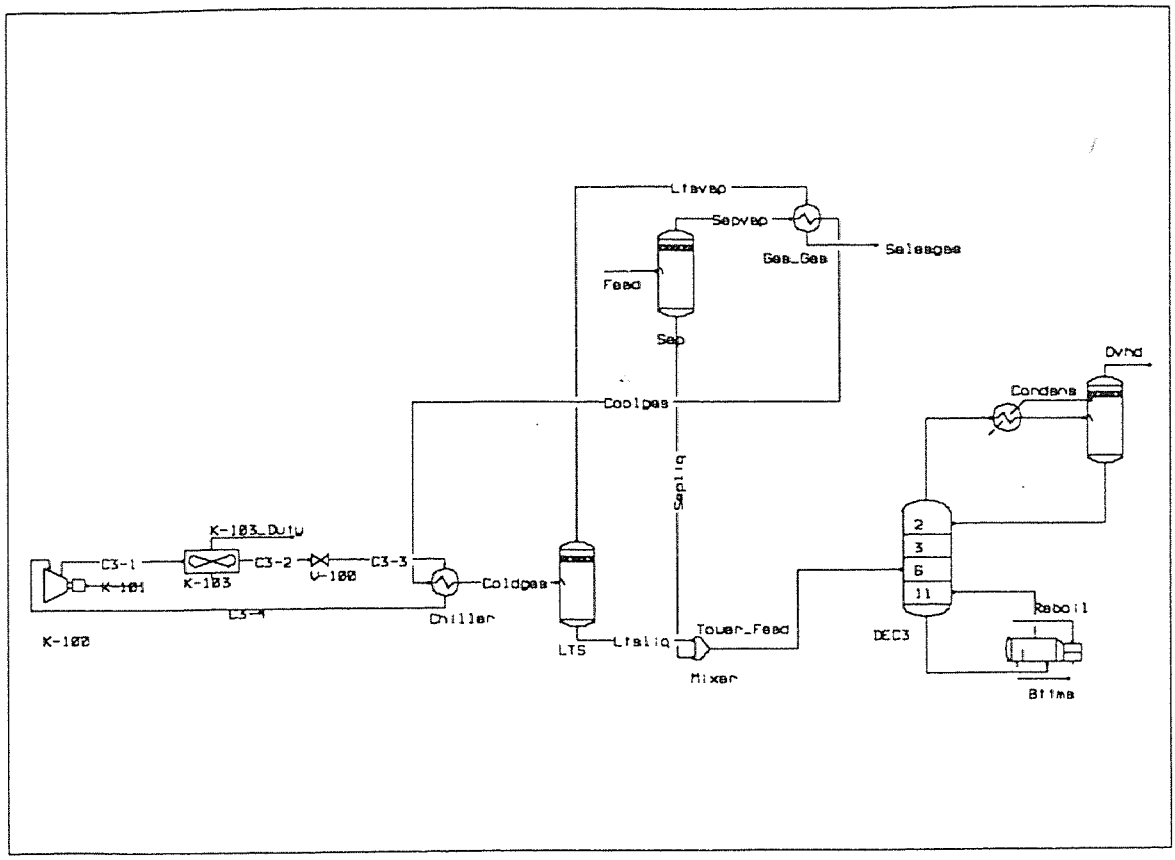
Stream Description		Bttms	Condens	Reboil	C3-1
Vapour frac.		0.0000	2.0000*	2.0000*	1.0000
Temperature	F	260.0444	0.0000*	0.0000*	155.2748
Pressure	psia	205.0000	0.0000*	0.0000*	248.5033
Molar Flow	lbmole/hr	43.3292	0.0000*	0.0000*	5.6636
Mass Flow	lb/hr	3218.9838	0.0000*	0.0000*	249.7471
LiqVol Flow	barrel/day	350.6610	0.0000*	0.0000*	33.7510
Enthalpy	Btu/hr	315275.6272	250334.2007	749752.0763	41472.1380
Density	lb/ft3	31.1878	0.0000	0.0000	2.1348
Mole Wt.		74.2913	0.0000	0.0000	44.0970
Spec. Heat	Btu/lb-F	0.7292	---	---	0.5220
Therm Cond	Btu/hr-ft-F	0.0355	---	---	0.0141
Viscosity	cP	0.1007	---	---	0.0103
Z Factor		0.0632	---	---	0.7778
Sur Tension	dyne/cm	4.7833	---	---	---
Std Density	lb/ft3	39.5465	---	---	---
Methane	mole frac.	0.0000	0.0000*	0.0000*	0.0000
Ethane	mole frac.	0.0001	0.0000*	0.0000*	0.0000
Propane	mole frac.	0.0200	0.0000*	0.0000*	1.0000
i-Butane	mole frac.	0.1859	0.0000*	0.0000*	0.0000
n-Butane	mole frac.	0.1748	0.0000*	0.0000*	0.0000
i-Pentane	mole frac.	0.1591	0.0000*	0.0000*	0.0000
n-Pentane	mole frac.	0.1372	0.0000*	0.0000*	0.0000
n-Hexane	mole frac.	0.1613	0.0000*	0.0000*	0.0000
n-Heptane	mole frac.	0.0923	0.0000*	0.0000*	0.0000
n-Octane	mole frac.	0.0692	0.0000*	0.0000*	0.0000

Stream Description		K-101	C3-2	K-103_Duty
Vapour frac.		2.0000*	0.0000*	2.0000*
Temperature	F	0.0000*	120.0000*	0.0000*
Pressure	psia	0.0000*	243.5033	0.0000*
Molar Flow	lbmole/hr	0.0000*	5.6636	0.0000*
Mass Flow	lb/hr	0.0000*	249.7471	0.0000*
LiqVol Flow	barrel/day	0.0000*	33.7510	0.0000*
Enthalpy	Btu/hr	11569.5835	6114.8641	35357.2728
Density	lb/ft3	0.0000	28.1719	0.0000
Mole Wt.		0.0000	44.0970	0.0000
Spec. Heat	Btu/lb-F	---	0.7996	---
Therm Cond	Btu/hr-ft-F	---	0.0467	---
Viscosity	cP	---	0.0790	---
Z Factor		---	0.0613	---
Sur Tension	dyne/cm	---	4.2069	---
Std Density	lb/ft3	---	31.6435	---
Methane	mole frac.	0.0000*	0.0000	0.0000*
Ethane	mole frac.	0.0000*	0.0000	0.0000*
Propane	mole frac.	0.0000*	1.0000	0.0000*
i-Butane	mole frac.	0.0000*	0.0000	0.0000*
n-Butane	mole frac.	0.0000*	0.0000	0.0000*
i-Pentane	mole frac.	0.0000*	0.0000	0.0000*
n-Pentane	mole frac.	0.0000*	0.0000	0.0000*
n-Hexane	mole frac.	0.0000*	0.0000	0.0000*
n-Heptane	mole frac.	0.0000*	0.0000	0.0000*
n-Octane	mole frac.	0.0000*	0.0000	0.0000*

Step	Action
154	Press the **<F10>** key;
	Looking at the PFD (Process Flow Diagram) containing all of the unit operations in the process which was specified.
155	Highlight the letters **PFD** and then press the **<Enter>** key;
	Pressing the <Home> key reduces the PFD to screen size.
156	Press the **<Home>** key;
	The screen will then appear as shown on the following page.



Step	Action
157	*Place the cross-hatched lines over the K-103 heat exchanger using the mouse.* Press the **<Left Mouse Button>;**
	Typing the letter I (for icons) brings up a menu of icons for various types of heat exchangers.
158	Press the letter **<I>** ;
	Changing the icon for K-103 to reflect that it is an aerial cooler.
159	*Place the cross-hatched lines over the first icon (located in the first row and first column).* Press the **<Left Mouse Button>.**
	The PFD will then appear as shown on the next page.



Step	Action
	Getting back to the Main Menu.
160	Press the <**Esc**> key until you reach the Main Menu.
161	Turn to the "Exiting HYSIM" Section of this manual.

REFERENCES

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