

Aspen Plus®

STEADY STATE SIMULATION

Version

10



*Modeling Petroleum
Processes*



GETTING STARTED

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A Connecting to the Aspen Plus Simulation Engine

About This Manual

Aspen Plus is a powerful tool that allows you to easily model petroleum processes. Using this book, you will learn the basics of how to build and run a process model of a simplified crude fractionation train. After completing the five sessions in this guide, you will be able to perform basic simulations of petroleum processes.

This manual assumes you have:

- Installed the Aspen Plus Simulation Engine and User Interface
- Completed the tutorial sessions in *Getting Started Building and Running a Process Model*, so that you are familiar with the basics of how to use Aspen Plus

Modeling Petroleum Processes with Aspen Plus

Petroleum refining processes are highly complex and integrated. They have unique characteristics that set them apart from other chemical processes, including:

- Process feedstocks, which consist of complex and wide-boiling mixtures of hydrocarbons, whose exact compositions are unknown
- Highly-coupled and heat-integrated fractionation units, used to separate feedstocks into a variety of products with different specifications
- Open steam and cooling water for stripping and heat recovery, giving rise to the presence of two liquid phases throughout the refining process
- Degree of separation specified in terms of distillation temperatures, gaps, overlaps, and other properties
- Product specifications given in terms of stream properties such as flash point, pour point, sulfur content, metal contents, and octane number

Aspen Plus provides special features to handle the unique characteristics of petroleum refining applications. With Aspen Plus, you can develop a simulation model of your petroleum process, then use this model to study alternative modes of operation or optimize the existing operation.

This manual guides you through some of the key petroleum features in Aspen Plus. You can use these features with the wide range of other Aspen Plus capabilities, such as estimating and regressing physical properties, fitting plant data to simulation models, and optimizing your process.

Sessions in this Book

This book guides you in building a flowsheet that describes a crude fractionation train in a petroleum refinery. Each chapter contains a tutorial session that builds one block of the flowsheet. You can complete the entire flowsheet by following each chapter in succession.

This book includes the following hands-on sessions:

Complete this chapter	To learn how to
1 Blending Crude and Petroleum Fractions	Define components, enter assay data for two crude oils, and blend the crude oils into a single process feed.
2 Adding a Preflash Tower	Model a preflash tower.
3 Adding an Atmospheric Crude Distillation Unit	Model a crude atmospheric unit.
4 Adding a Vacuum Unit	Model a vacuum unit.
5 Displaying Petroleum Properties	Use petroleum properties with your simulation model to obtain more information about the process.

Using Backup Files

We recommend that you perform all sessions sequentially in order to build the entire model. However, you can skip chapters and work on the session of your choice, using backup files containing simulation data.

Aspen Plus provides backup files containing all problem specifications and results for each tutorial session. If you skip a session, you might need to load a backup file to supply missing data. The chapter describes how to do this. If you perform each tutorial session in order, you can use backup files to compare your results.

For More Information

Online Help Aspen Plus has a complete system of online help and context-sensitive prompts. The help system contains both context-sensitive help and reference information. For more information about using Aspen Plus help, see the *Aspen Plus User Guide*, Chapter 3.

Aspen Plus Getting Started Building and Running a Process Model This tutorial includes several hands-on sessions to familiarize you with Aspen Plus. The guide takes you step-by-step to learn the full power and scope of Aspen Plus.

Aspen Plus Getting Started Modeling Processes with Electrolytes This tutorial includes several hands-on sessions to familiarize you with simulating electrolyte systems with Aspen Plus.

Aspen Plus Getting Started Modeling Petroleum Processes This tutorial includes several hands-on sessions to familiarize you with simulating petroleum processes with Aspen Plus.

Aspen Plus Getting Started Customizing Unit Operation Models This tutorial includes several hands-on sessions to familiarize you with the customization of unit operation models with Aspen Plus.

Aspen Plus User Guide The three-volume *Aspen Plus User Guide* provides step-by-step procedures for developing and using an Aspen Plus process simulation model. The guide is task-oriented to help you accomplish the engineering work you need to do, using the powerful capabilities of Aspen Plus.

Aspen Plus reference manual series Aspen Plus reference manuals provide detailed technical reference information. These manuals include background information about the unit operation models and the physical properties methods and models available in Aspen Plus, tables of Aspen Plus databank parameters, group contribution method functional groups, and a wide range of other reference information. The set comprises:

- *Unit Operation Models*
- *Physical Property Methods and Models*
- *Physical Property Data*
- *User Models*
- *System Management*
- *System Administration*
- *Summary File Toolkit*

Aspen Plus application examples A suite of sample online Aspen Plus simulations illustrating specific processes is delivered with Aspen Plus.

Aspen Plus Installation Guides These guides provide instructions on platform and network installation of Aspen Plus. The set comprises:

- *Aspen Plus Installation Guide* for Windows
- *Aspen Plus Installation Guide* for OpenVMS
- *Aspen Plus Installation Guide* for UNIX

The Aspen Plus manuals are delivered in Adobe portable document format (PDF) on the Aspen Plus Documentation CD.

Technical Support

World Wide Web For additional information about AspenTech products and services, check the AspenTech World Wide Web home page on the Internet at:

<http://www.aspentech.com/>

Technical resources To obtain in-depth technical support information on the Internet, visit the Technical Support homepage. Register at:

<http://www.aspentech.com/ts/>

Approximately three days after registering, you will receive a confirmation e-mail and you will then be able to access this information.

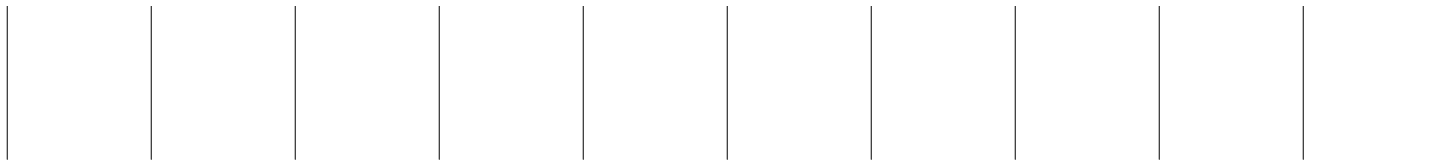
The most current Hotline contact information is listed. Other information includes:

- Frequently asked questions
- Product training courses
- Technical tips

AspenTech Hotline If you need help from an AspenTech Customer Support engineer, contact our Hotline for any of the following locations:

If you are located in:	Phone Number	Fax Number	E-Mail Address
North America & the Caribbean	+1-617/949-1021 +1-888/996-7001 (toll free)	+1-617/949-1724	support@aspentech.com
South America (Argentina office)	+54-11/4393-5308	+54-11/4394-8621	tecnoba@aspentech.com
(Brazil office)	+55-11/5506-0756	+55-11/5506-0567	tecnosp@aspentech.com
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(UK office)	+44-1223/312220	+44-1223/366980	
Japan	+81-3/3262-1743	+81-3/3262-1744	atjsupport@aspentech.com
Asia & Australia (Hong Kong office)	+85-2/2838-6077	+85-2/2833-5642	atasupport@aspentech.com
(Korea office)	+82-2/761-5800	+82-2/761-5803	





1 Blending Crude and Petroleum Fractions

This tutorial contains five sessions to guide you through the process of building a model of a crude fractionation train typically found in a petroleum refinery.

In this first session, you will begin to build the model by defining the crude feed to the process, using the Aspen Plus Assay Data Analysis Run Type. You will use this run type to analyze petroleum crudes before running a flowsheet simulation.

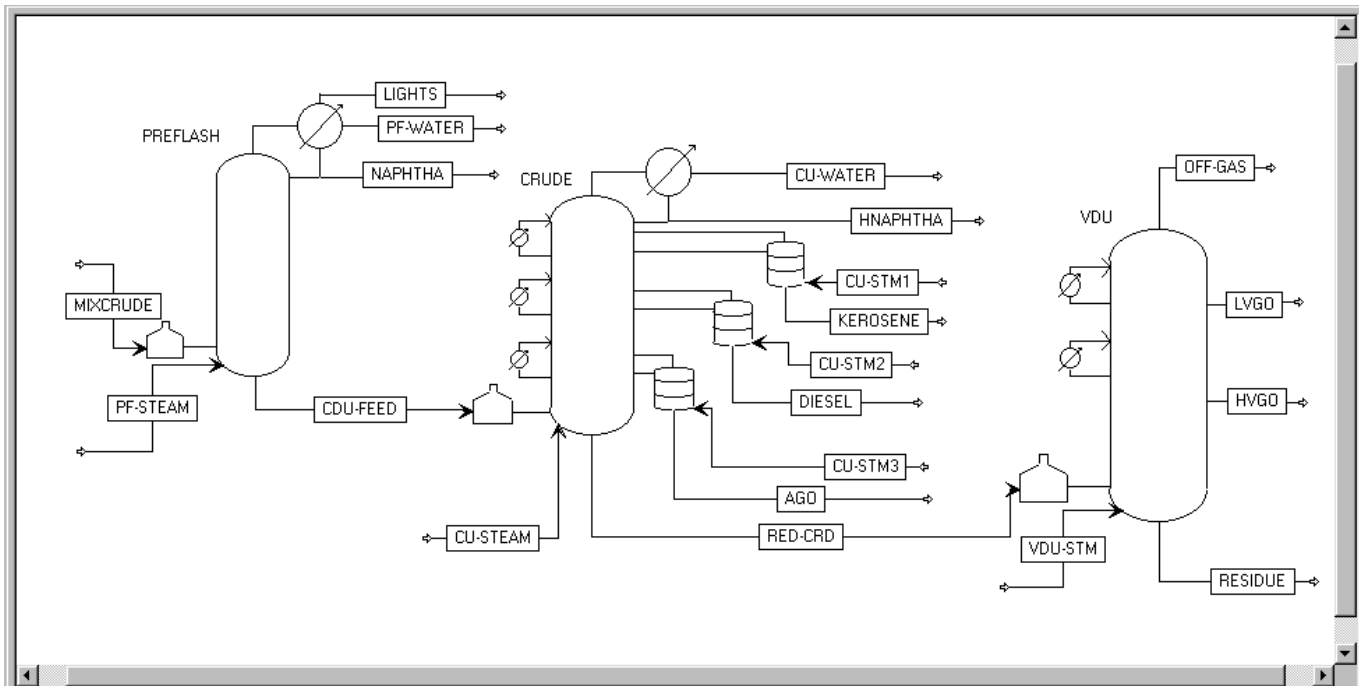
In this session you will:

- Define components
- Enter assay data for two crude oils
- Blend the crude oils to produce the crude feed
- Generate pseudocomponents for the blend
- Run the Assay Data Analysis calculations
- Examine results

Allow about 45 minutes to complete this session.

Petroleum Process Flowsheet

The following illustration shows the petroleum process flowsheet you will work with throughout this book:



Problem Definition: Crude Fractionation Train

The process consists of the following steps:

1. The process feed (MIXCRUDE), consisting of a blend of two crude oils (OIL-1, see Table 1.1; OIL-2, see Table 1.2), goes to the preflash furnace.
2. The preflash tower (PREFLASH) removes light gases and some naphtha from the partially vaporized feed.
3. Preflash bottoms (CDU-FEED) are further processed in the crude distillation unit (CDU). The CDU consists of a crude unit furnace and an atmospheric tower. First, the crude unit furnace partially vaporizes the bottoms from the preflash. Then the atmospheric tower separates the preflash bottoms into five cuts:
 - Heavy naphtha (HNAPHTHA)
 - Kerosene (KEROSENE)
 - Diesel (DIESEL)
 - Atmospheric gas oil (AGO)
 - Reduced crude (RED-CRD)
4. Reduced crude goes to the vacuum distillation unit (VDU) for further fractionation under vacuum conditions. The VDU consists of a vacuum unit furnace and vacuum tower. The vacuum tower produces the following additional cuts:

- Overhead (OFF-GAS)
- Light vacuum gas oil (LVGO)
- Heavy vacuum gas oil (HVGO)
- Asphaltic residue (RESIDUE)

Table 1.1 OIL-1: (API = 31.4)

TBP Distillation		Light Ends Analysis		API Gravity Curve	
Liq. Vol. %	Temperature (F)	Component	Liq. Vol. Frac.	Mid. Vol. %	Gravity
6.8	130.0	Methane	0.001	5.0	90.0
10.0	180.0	Ethane	0.0015	10.0	68.0
30.0	418.0	Propane	0.009	15.0	59.7
50.0	650.0	Isobutane	0.004	20.0	52.0
62.0	800.0	N-Butane	0.016	30.0	42.0
70.0	903.0	2-Methyl-Butane	0.012	40.0	35.0
76.0	1000.0	N-Pentane	0.017	45.0	32.0
90.0	1255.0			50.0	28.5
				60.0	23.0
				70.0	18.0
				80.0	13.5

Table 1.2 OIL-2: (API = 34.8)

TBP Distillation		Light Ends Analysis		API Gravity Curve	
Liq. Vol. %	Temperature (F)	Component	Liq. Vol. Frac.	Mid. Vol. %	Gravity
6.5	120.0	Water	0.001	2.0	150.0
10.0	200.0	Methane	0.002	5.0	95.0
20.0	300.0	Ethane	0.005	10.0	65.0
30.0	400.0	Propane	0.005	20.0	45.0
40.0	470.0	Isobutane	0.01	30.0	40.0
50.0	550.0	N-Butane	0.01	40.0	38.0
60.0	650.0	2-Methyl-Butane	0.005	50.0	33.0
70.0	750.0	N-Pentane	0.025	60.0	30.0
80.0	850.0			70.0	25.0
90.0	1100.0			80.0	20.0
95.0	1300.0			90.0	15.0
98.0	1475.0			95.0	10.0
100.0	1670.0			98.0	5.0

Starting Aspen Plus

To start Aspen Plus:

- From your Windows desktop, click Start, then select Programs.
- Select AspenTech, then Aspen Plus 10.1-0, then Aspen Plus User Interface.

The Aspen Plus Startup dialog box appears.

Aspen Plus displays a dialog box whenever you must enter information or make a selection before proceeding. In this simulation, you will use an Aspen Plus template.

- Point the mouse to the Template radio button and click the left mouse button.
- Click OK.

The New dialog box appears.

Use the New dialog box to specify the Application Type and Run Type for the new run. Aspen Plus uses the Application Type you choose to set appropriate defaults for your application. For this simulation, you will use the Petroleum with English Units template and the Assay Data Analysis Run Type.

- Use the left mouse button to select the Petroleum with English Units template.
- Click the arrow to the right of the Run Type box to display the available run types.
- From the list, select Assay Data Analysis to specify an Assay Data Analysis/PCS run.
- Click OK.

Note If the Connect Host dialog box appears, see Appendix A.

Wait a few seconds while the changes are applied.

The Aspen Plus graphics workspace is shaded because you do not use a graphical simulation flowsheet in specifying an Assay Data Analysis run.

Use the Aspen Plus expert guidance Next function to take you to the next required input specification.

- In the toolbar, click Next.

The Setup Specifications Global sheet appears.

Specifying Title and Global Options

The Setup Specifications Global sheet displays the defaults Aspen Plus uses for other forms. You will use this form to:

- Specify a title for your simulation
- Review the global settings that were set when you selected the Petroleum with English Units Application Type

The Run Type Assay Data Analysis is already selected. You do not need to change this field.

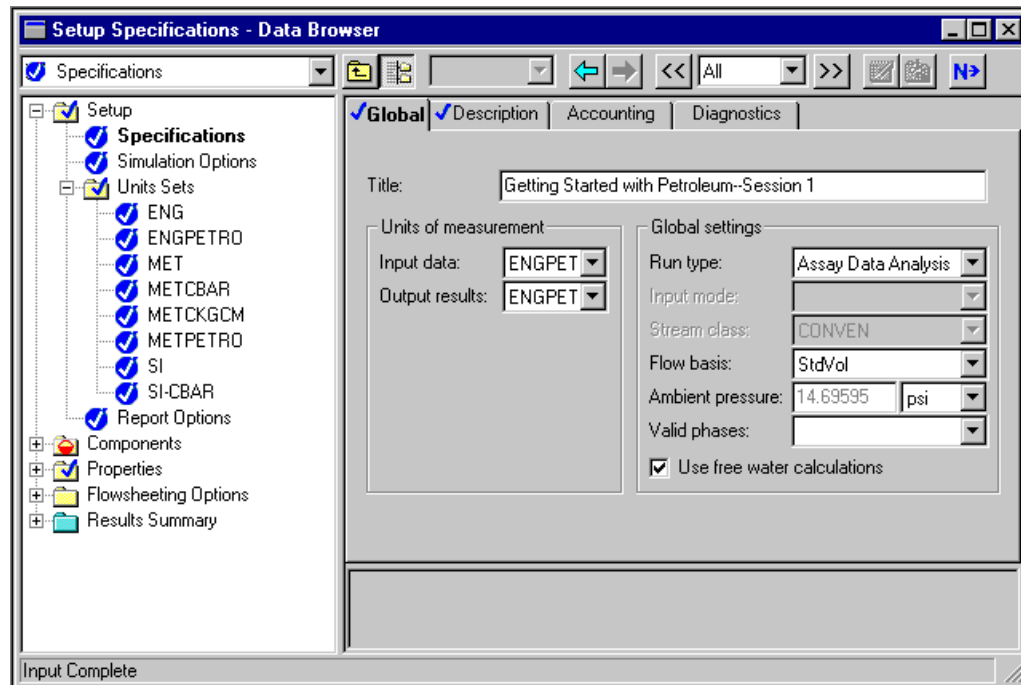
It is always good practice to describe your problem by entering a title for the simulation.

- In the Title box, type **Getting Started With Petroleum -- Session 1**. Press Enter.

Since you chose the Petroleum with English Units Application Type when you started this session, Aspen Plus has set the following global defaults for input specifications:

- ENGPETRO units (English Engineering units appropriate for Petroleum applications, such as volume flow in barrels per day)
- StdVol flow basis for all flow inputs
- Free-water calculations

The form is complete, and all the defaults set by the Petroleum with English Units Application Type are appropriate for this problem:



- On the Setup Specifications form, click the Next button at the right of the toolbar.

The Components Specifications Selection sheet appears.

Specifying Components

Use the Components Specifications Selection sheet to specify components for the simulation.

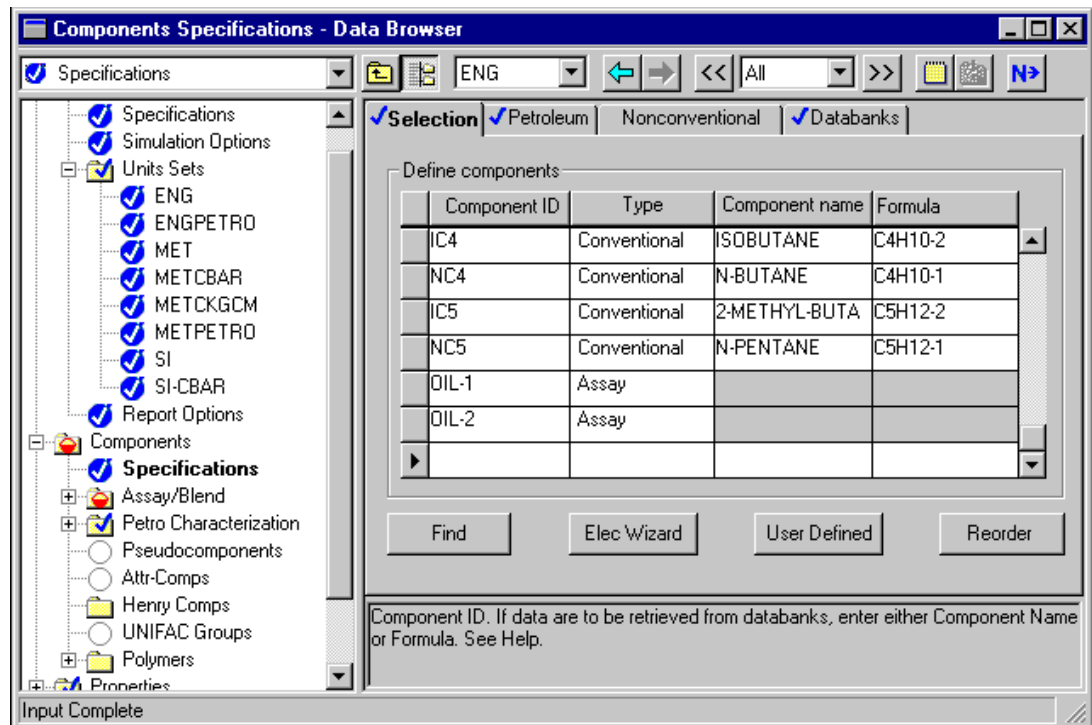
- Enter the component IDs and component names shown below:

Component ID	Component Name
H2O	WATER
C1	METHANE
C2	ETHANE
C3	PROPANE
IC4	ISOBUTANE
NC4	N-BUTANE
IC5	2-METHYL-BUTANE
NC5	N-PENTANE

You will define two crude assays, OIL-1 and OIL-2.

- In the next Component ID field, type **OIL-1**.
- In the Type field for OIL-1, click the left mouse button and select Assay.
- Enter **OIL-2** and identify it as an Assay, in the same way as you did for OIL-1.

The Components Specifications form is complete:



► Click the Next button.

The Components Assay/Blend Basic Data form for OIL-1 appears.

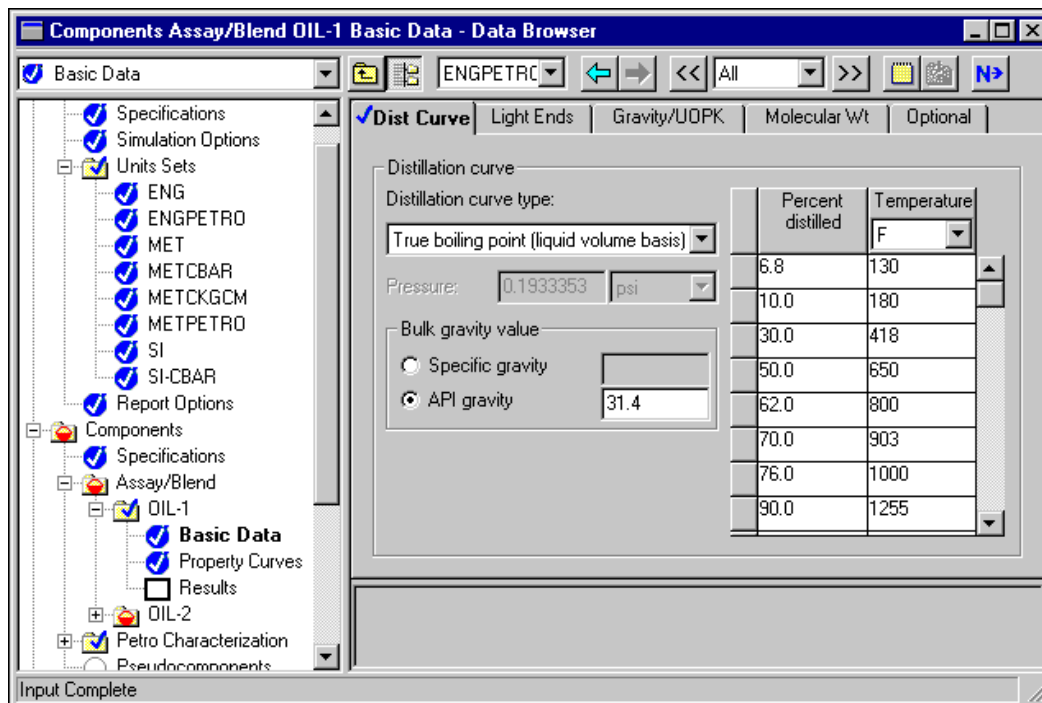
Entering Assay Data

On the Components Assay/Blend Basic Data form for OIL-1, you will enter the laboratory assay data for OIL-1 (Table 1.1).

- In the Distillation curve type field, click the list box. Select True boiling point (liquid volume basis) to indicate you are entering data for a TBP curve on a standard liquid volume basis.
- In the Bulk gravity value box, select the API gravity option by clicking the radio button.
- In the API gravity field, enter **31.4**.
- In the Percent Distilled and Temperature fields, enter the following TBP distillation values for OIL-1:

Percent Distilled	Temperature F
6.8	130
10.0	180
30.0	418
50.0	650
62.0	800
70.0	903
76.0	1000
90.0	1255

The Components Assay/Blend Basic Data Dist Curve sheet for OIL-1 is complete:



- Click the Light Ends tab.

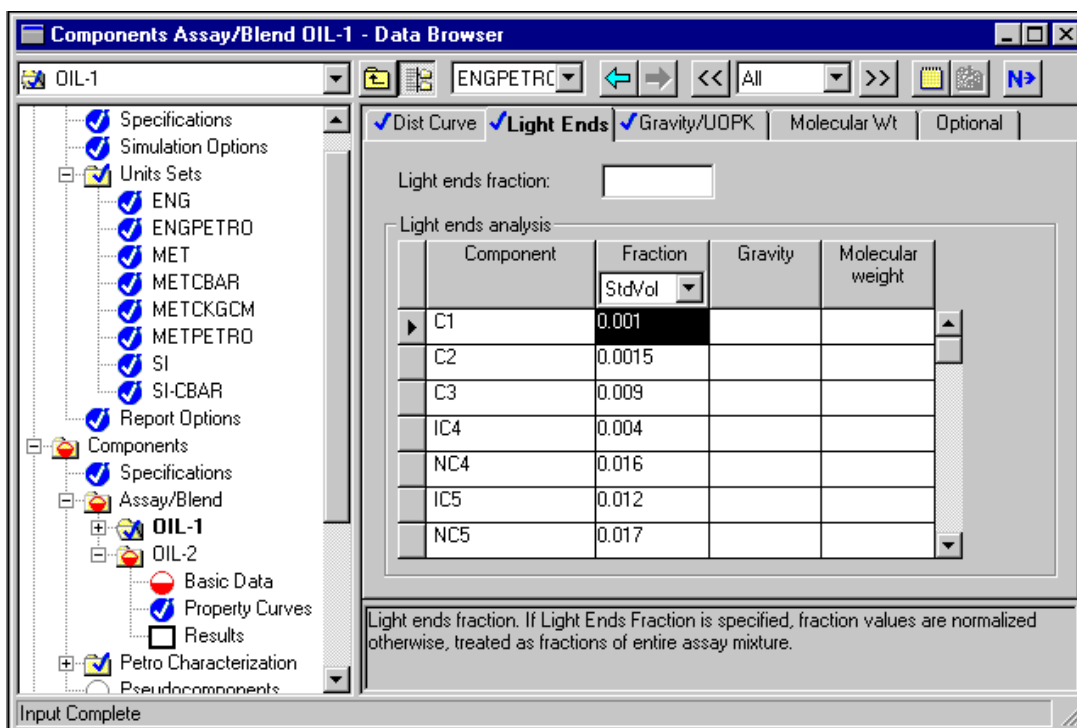
The Light Ends sheet for OIL-1 appears.

Use this sheet to enter light ends analysis data, given as a fraction of the assay mixture.

- In the Component and StdVol Fraction fields, enter the following light ends analysis data:

Component	Fraction StdVol
C1	0.001
C2	0.0015
C3	0.009
IC4	0.004
NC4	0.016
IC5	0.012
NC5	0.017

The Light Ends sheet for OIL-1 is complete:



- Click the Gravity/UOPK tab.

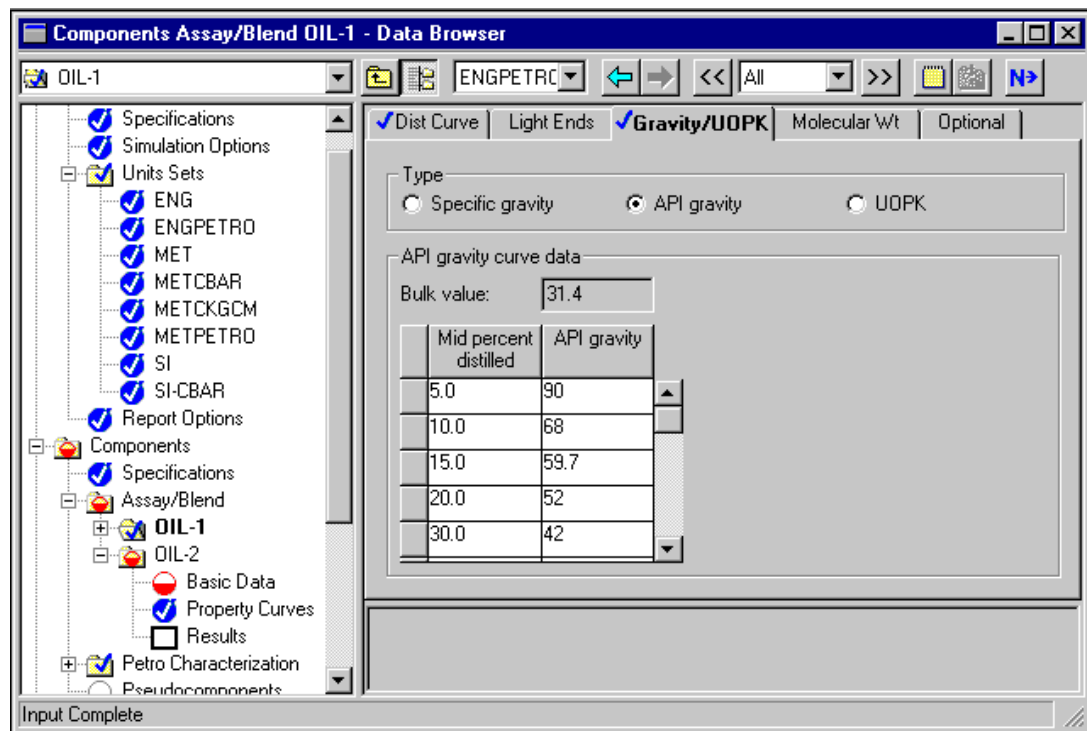
The Gravity/UOPK sheet for OIL-1 appears.

- In the Type box, select API gravity by clicking the radio button.

- In the Mid percent distilled and API gravity fields, enter the following API gravity curve data:

Mid Percent Distilled	API Gravity
5.0	90.0
10.0	68.0
15.0	59.7
20.0	52.0
30.0	42.0
40.0	35.0
45.0	32.0
50.0	28.5
60.0	23.0
70.0	18.0
80.0	13.5

The Gravity/UOPK sheet for OIL-1 is complete:



- Click the Next button.

The Assay/Blend Basic Data form for OIL-2 appears.

- Enter laboratory assay data for OIL-2 (Table 1.2) in the same way as you entered assay data for OIL-1.
- In the Distillation Curve Type field, click the list box. Select True boiling point (liquid volume basis) to indicate you are entering data for a TBP curve on a standard liquid volume basis.
- In the Bulk gravity value box, select the API gravity option by clicking the radio button.
- In the API field, enter **34.8**.
- In the Percent Distilled and Temperature fields, enter the following TBP distillation values:

Percent Distilled	Temperature F
6.5	120.0
10.0	200.0
20.0	300.0
30.0	400.0
40.0	470.0
50.0	550.0
60.0	650.0
70.0	750.0
80.0	850.0
90.0	1100.0
95.0	1300.0
98.0	1475.0
100.0	1670.0

The Assay/Blend Basic Data form for OIL-2 is complete.

- Click the Light Ends tab.

The Light Ends sheet for OIL-2 appears.

- In the Component and StdVol Fraction fields, enter the following light ends analysis data:

Component	Fraction StdVol
H2O	0.001
C1	0.002
C2	0.005
C3	0.005
IC4	0.01
NC4	0.01
IC5	0.005
NC5	0.025

The Light Ends sheet for OIL-2 is complete.

- Click the Gravity/UOPK tab.

The Gravity/UOPK sheet for OIL-2 appears.

- In the Type box, select API gravity by clicking the radio button.
- In the Mid percent distilled and API gravity fields, enter the following API gravity curve data:

Mid percent Distilled	API gravity
2.0	150.0
5.0	95.0
10.0	65.0
20.0	45.0
30.0	40.0
40.0	38.0
50.0	33.0
60.0	30.0
70.0	25.0
80.0	20.0
90.0	15.0
95.0	10.0
98.0	5.0

The Gravity/UOPK sheet for OIL-2 is complete.

- ▶ Click the Next button.

The Required ADA/PCS Input Complete dialog box appears.

Blending the Oils

You should be viewing the Required ADA/PCS Input Complete dialog box.

- To specify a blend, select Modify assay/blend specifications.

- Click OK.

The Assay/Blend Object Manager appears.

- Select New.

The Create New ID dialog box appears.

- Enter **MIXOIL** as the ID.

- Select **BLEND** as the Type.

- Click OK.

The Mixture Specifications sheet for MIXOIL appears.

Use this sheet to define the fractions for each crude oil in the blend.

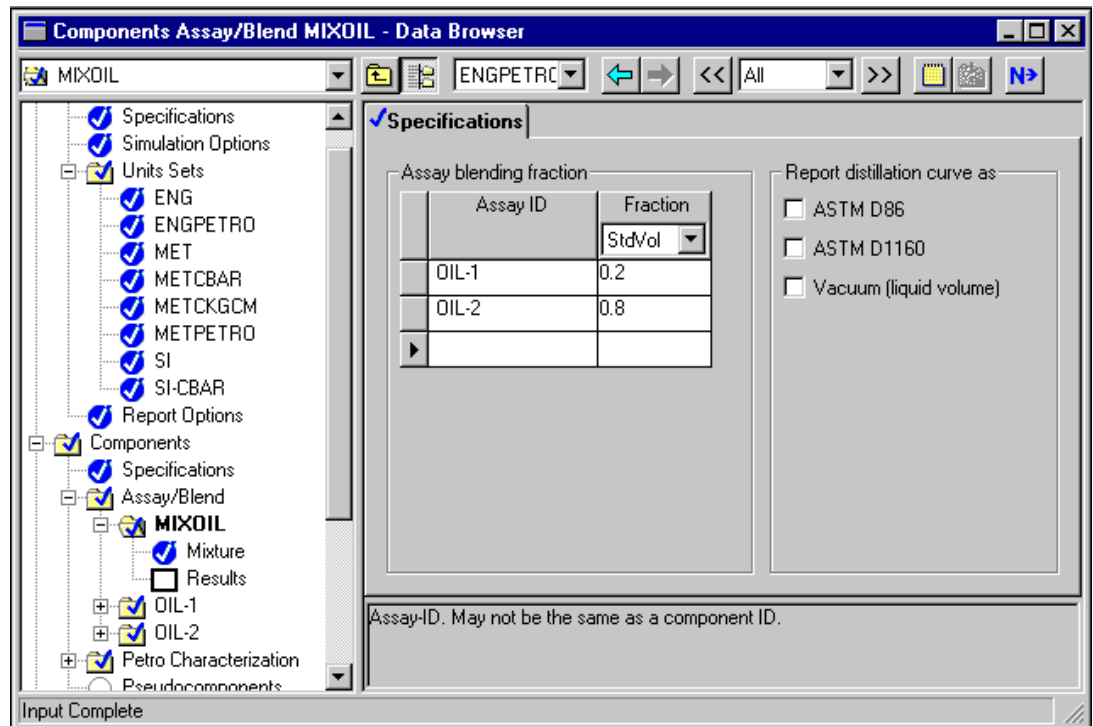
- Click the first Assay ID field and select OIL-1.

- In the StdVol Fraction field, enter **0.20**.

- Click the next Assay ID field and select OIL-2.

- In the StdVol Fraction field, enter **0.80**.

The MIXOIL Mixture Specifications sheet is complete:



- Click the Next button.

The Required ADA/PCS Input Complete dialog box appears.

Generating Pseudocomponents

By default, Aspen Plus generates a set of pseudocomponents for your simulation based on all the assays and blends in your problem. However, in this problem, the pseudocomponents should be based on the blend only.

You should be viewing the Required ADA/PCS Input Complete dialog box.

- Select the Specify options for generating pseudocomponents.

- Click OK.

The Petro Characterization Generation Object Manager appears.

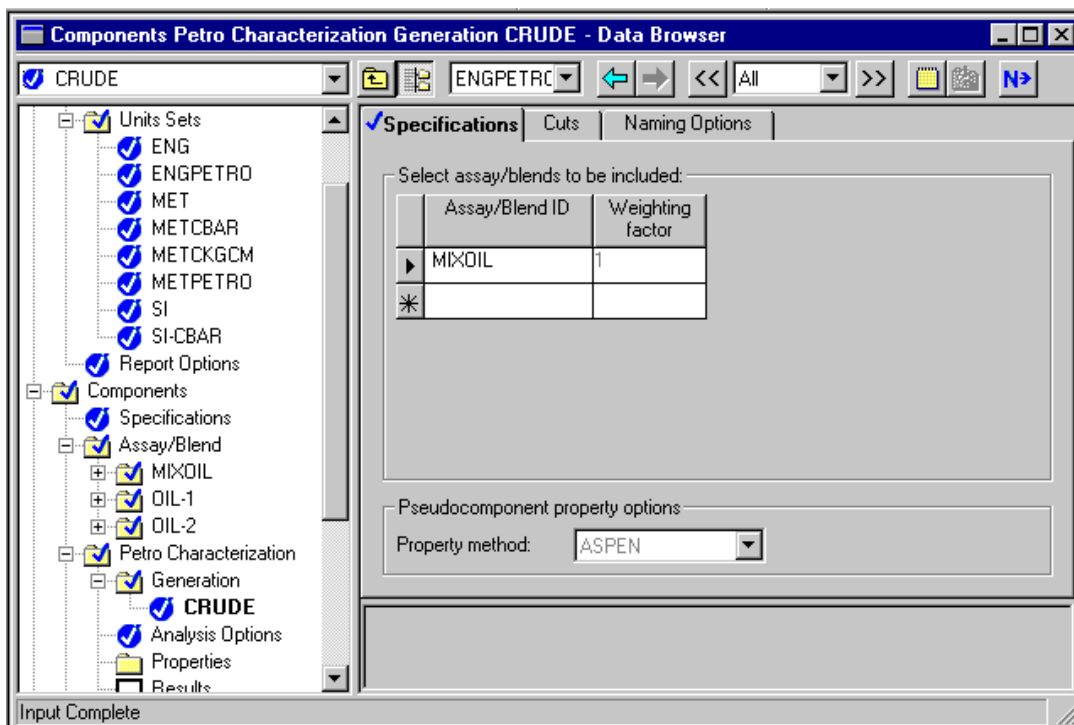
- Select New.

- Enter **CRUDE** as the new ID, and click OK.

The Specifications sheet for CRUDE appears.

- Click the Assay/Blend ID field and select MIXOIL.

The Specifications sheet is complete. You do not need to enter data in any other fields.



- Click the Next button.

The Required ADA/PCS Input Complete dialog box appears.

- Select Go to Next required input step, and click OK.

The Required Properties Input Complete dialog box appears.

- Click OK.

The Required Assay Data Analysis/Pseudocomponent Generation Input Complete dialog box appears.

Running the Simulation

You have entered the data and specifications for this session. You can now run the Assay Data Analysis.

- In the Required Assay Data Analysis/Pseudocomponent Generation Input Complete dialog box, click OK.

Aspen Plus displays the Control Panel. The Control Panel allows you to monitor and interact with the Aspen Plus simulation calculations.

As Aspen Plus performs the analysis, status messages will display in the Control Panel. Soon you will see the message *Results Available* in the status bar at the bottom of the main window.


- Use the vertical scroll bar to the right of the Control panel window to see the messages.

You can now examine the results of your analysis.

Examining Results

An ADA run calculates a wide variety of properties for the assays, blends, and generated pseudocomponents.

For this session, you will review pseudocomponent properties and TBP curves for the oils and the blend.

- Click the Check Results button  on the Control Panel.

The Results Summary Run-Status form appears. It indicates that calculations were completed normally. The main properties for each pseudocomponent appear on the Components Petro Characterization Results Summary sheet.

- Expand the Components folder.

The Assay/Blend and the Petro Characterization folders are revealed.

- Expand the Petro Characterization folder.

The Results form is revealed.

- Click Results.

The main properties for each pseudocomponent appear on the Components Petro Characterization Results Summary sheet.

- Click the scroll arrow at the bottom left of the form to scroll through the component properties.

Components Petro Characterization Results - Data Browser

Results

- Components
 - Assay/Blend
 - Petro Characterization
 - Results**
 - Results Summary
 - Run Status

Summary

Pseudocomponents	Normal BP	API Gravity	Specific gravity	Molecul weight
	F			
PC120F	120.089471	81.8332787	0.66328142	77.09157
PC138F	137.70481	77.4601986	0.67716245	81.19633
PC163F	162.680744	72.0614456	0.69512181	87.23542
PC188F	187.729121	67.2545235	0.71193348	93.52802
PC213F	212.976267	62.4253273	0.7296623	103.3290
PC238F	238.262494	57.3528678	0.74926053	109.0283
PC263F	263.191275	51.9331906	0.77139802	114.4645

Results Available

Plotting Distillation Curves

You will plot the TBP curves for the blend and each crude oil in a single plot. The results for each assay or blend appear on the Components Assay/Blend Results form. To plot the TBP curve for OIL-1:

- From the Data Browser, click the Assay/Blend folder to expand it.

The MIXOIL, OIL-1, and OIL-2 folders are revealed.

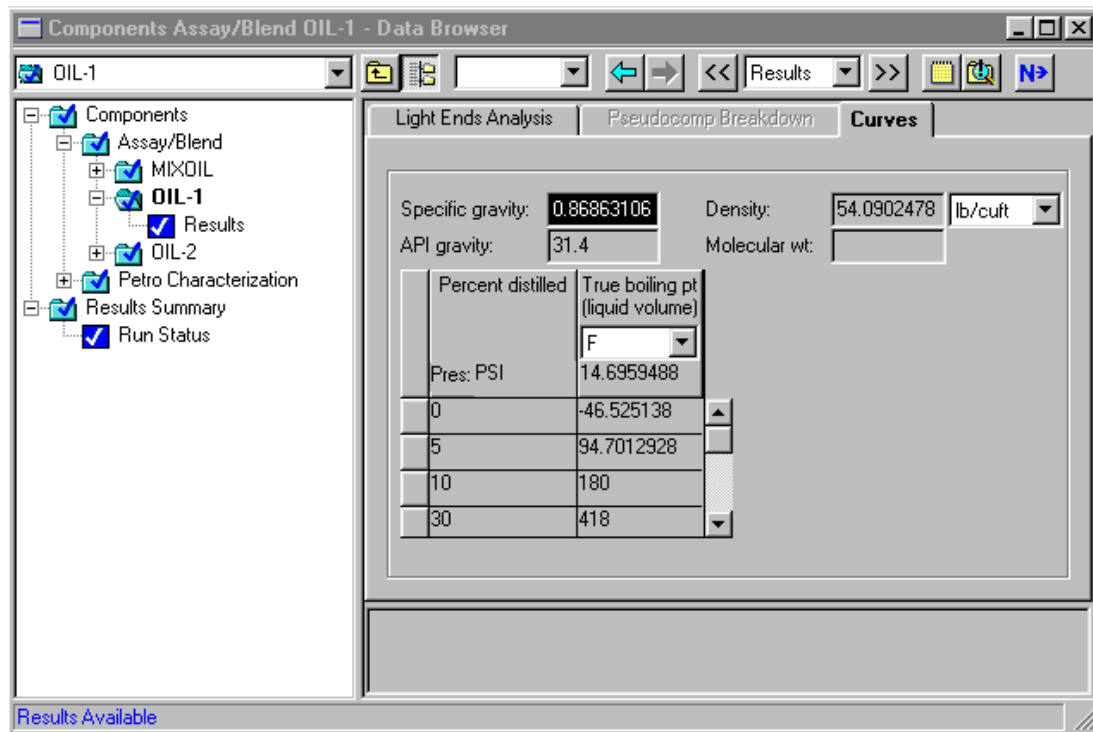
- Click the OIL-1 folder to expand it.

The Results form is revealed.

Component	Volume percent of assay	Weight percent of assay	Mole fraction
C1	0.1	0.03457145	0.03161354
C2	0.15	0.06145202	0.02998087
C3	0.9	0.5256157	0.17486383
IC4	0.4	0.2591946	0.06542002
NC4	1.6	1.07641199	0.27168351
Total	6.05	4.05453574	1

- Click the Curves tab.

The Curves sheet for OIL-1 appears.



To plot the TBP curve:

- Select the Percent distilled column by clicking on the column heading.
- From the Plot menu on the Aspen Plus toolbar, select X-Axis Variable.
- Select the True boiling pt. (liquid volume) column by clicking on the column heading.
- From the Plot menu, select Y-Axis Variable.
- From the Plot menu, select Display Plot.

The TBP curve for OIL-1 appears in a new window.

To label this curve for OIL-1:

- Double-click the legend box.

The Plot Legend Box dialog box appears.

- Select True boiling pt (vol).
- Edit the Text field to read **TBP for OIL-1**.
- Click Replace.
- Click OK.

To plot the TBP curve for OIL-2, select the data and assign it to the X and Y-axes the same way you did for OIL-1.

- Expand the OIL-2 folder in the Data Browser.
The Results form is revealed.
- Click the Curves tab.
The Curves sheet for OIL-2 appears.
- Select the Percent distilled column.
- From the Plot menu on the Aspen Plus toolbar, select X-Axis Variable.
- Select the True boiling pt. (liquid volume) column.
- From the Plot menu, select Y-Axis Variable.

To add this curve to the plot containing the curve for OIL-1: .

- From the Plot pulldown menu, select Add New Curve.
The Plot Window List dialog box appears.
- Select the available item, and click OK.

The curve for OIL-2 appears on the plot. To label this curve for OIL-2:

- Double-click the legend box.
The Plot Legend Box dialog box appears.
- Select True boiling pt (vol).

- Edit the Text field to read **TBP for OIL-2**.
- Click Replace.
- Click OK.

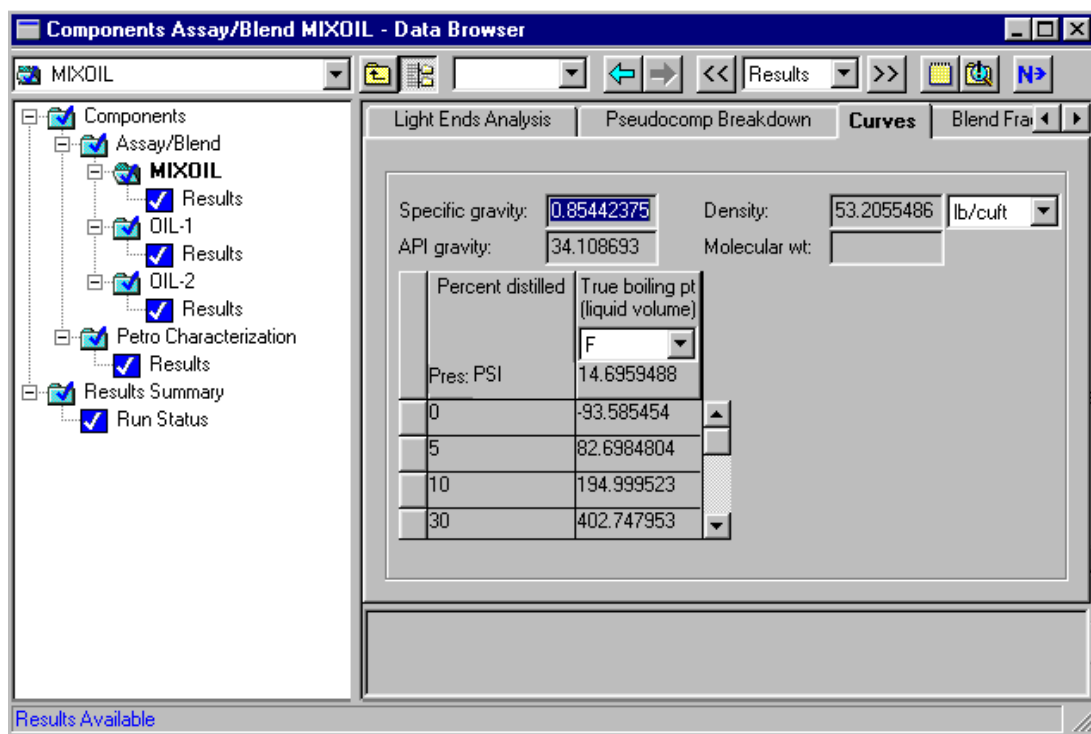
To plot the BLEND curve:

- In the Data Browser, click the MIXOIL folder to expand it.

The Results form is revealed.

- Click the Curves tab.

The Curves sheet for MIXOIL appears.



Add this curve to the plot containing curves for OIL-1 and OIL-2, using the same procedure as for OIL-2.

- Select the Percent distilled column.
- From the Plot menu on the Aspen Plus toolbar, select X-Axis Variable.

- Select the True boiling pt. (liquid volume) column.
- From the Plot menu, select Y-Axis Variable.

To add this curve to the plot containing the curve for OIL-1 and OIL-2: .

- From the Plot pulldown menu, select Add New Curve.
The Plot Window List dialog box appears.
- Select the available item, and click OK.

The curve for MIXOIL appears on the plot. To label this curve for MIXOIL:

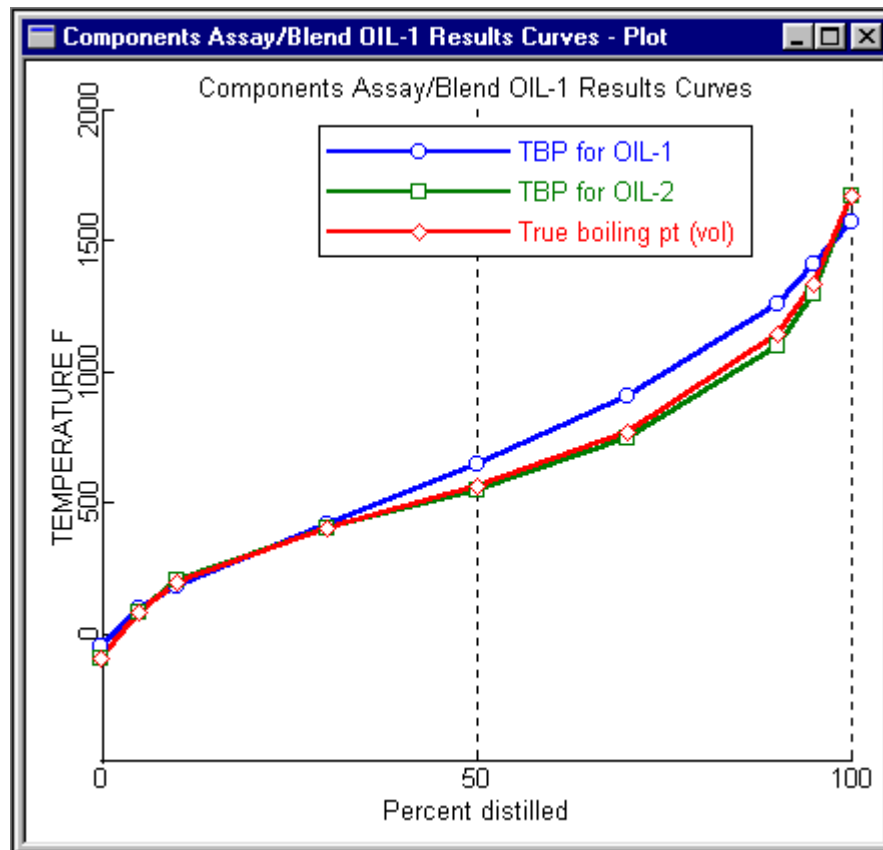
- Double-click the legend box.
The Plot Legend Box dialog box appears.
- Select True boiling pt (vol).
- Edit the Text field to read **TBP for Blend**.
- Click Replace.
- Click OK.

To combine the y-axes:

- Double-click on the plot.
- Select the AxisMap tab.
- Select All in One, and click OK.
- Edit the plot title to read **TBP Curves for Crude Oils and Blend**.
- Double-click the plot title to select it.
- Type **TBP Curves for Crude Oils and Blend**.

➤ Click OK.

As the completed plot shows, the TBP curve for the blend is between the curves for each oil. Curve locations depend on the proportions of the two oils you define for the blend:



Creating a Backup File

Once you are satisfied with your Assay Data Analysis results, you can save this simulation as a backup file. This allows you to use the assay data analysis you have developed in another Aspen Plus simulation.

To save this simulation as a backup file:

- From the File menu, select Save As.
- In the Save As dialog box, select Aspen Plus Backup Files for the Save as type.
- In the File name field, enter **BLEND**.

Your working directory appears in the Save In box.

Your simulation is saved as *blend.bkp*.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

Exiting Aspen Plus

To exit Aspen Plus:

- From the Aspen Plus File menu, select Exit.

This run will be used as the starting point for the session in Chapter 2.



2 Adding a Preflash Tower

In this session you will add a preflash tower to the simulation. You will also specify options for pseudocomponent generation.

You will:

- Define the flowsheet graphically
- Specify properties, feed streams, and preflash tower
- Modify cuts specifications for pseudocomponents generation
- Run the simulation
- Examine simulation results

Allow about 45 minutes to complete this session.

Preflash Tower Flowsheet

Figure 2.1 shows the process flowsheet for this session. The process feed, consisting of the oil blend, goes first to the preflash furnace where it is partially vaporized. The partially vaporized feed then enters the preflash tower. You will model the tower and the furnace simultaneously with a single PetroFrac block.

Steam is fed to the bottom of the tower. The tower produces a wide naphtha cut as a distillate product.

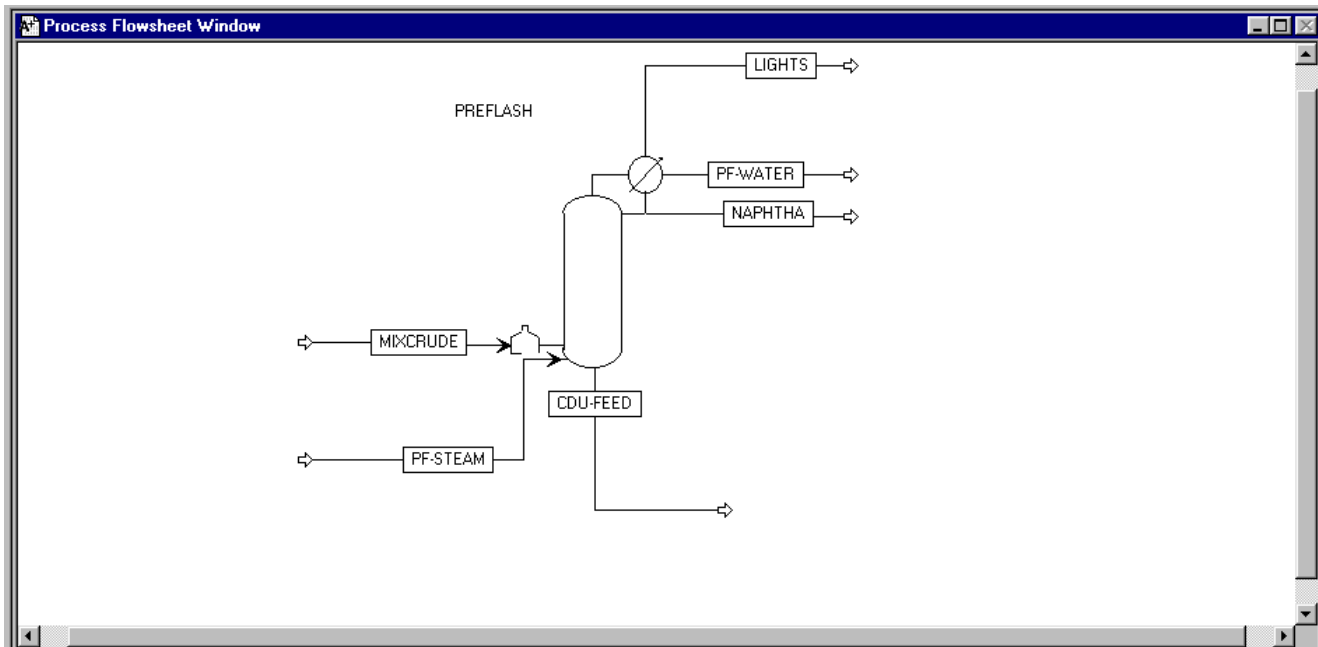


Figure 2.1 *Flowsheet for Preflash Tower*

You will simulate the tower with 10 theoretical stages, no reboiler, and a partial condenser. The condenser operates at 170 F and 39.7 psia, with a pressure drop of 2 psi. The tower pressure drop is 3 psi.

The tower is stripped with open steam in the bottom. The steam stream is at 400 F and 60 psia, and has a flow rate of 5,000 lb/hr. The furnace operates at a pressure of 50 psia and a temperature of 450 F. The distillate rate is estimated at 15,000 bbl/day. Its value is manipulated to produce a wide naphtha cut with an ASTM 95% temperature of 375 F.

Starting Aspen Plus

To start Aspen Plus:

- Use the Windows Start menu, or double-click the Aspen Plus icon on your desktop.

Note If the Connect Host dialog box appears, see Appendix A.

The Aspen Plus Startup dialog box appears.

Opening an Existing Run

If you saved the assay data analysis simulation created in Chapter 1:

- In the Aspen Plus Startup dialog box, select Open an Existing Simulation .

If your saved file `blend.bkp` appears in the list box:

- Select `blend.bkp` in the list and click OK.

If your saved file `blend.bkp` does not appear in the list box:

- Double-click on More Files... in the list box.

The Open dialog box appears.

- Navigate to the directory containing your saved file `blend.bkp`.
- Select `blend.bkp` from the list of files, and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

If you did not create the assay data analysis simulation in Chapter 1, you can open the backup file `blend.bkp` in the Examples folder.

- From the Aspen Plus Startup dialog box, select Open an Existing Simulation, then click OK.

The Open dialog box appears.

- Click the Look in Favorites button .

By default, the Favorites list contains five folders that are provided with Aspen Plus.

- Double-click the Examples folder.
- Select `blend.bkp`, and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

Saving a Run Under a New Name

Before you create a new run adding a preflash tower, you will create and save a copy of BLEND with a new Run ID, PREFLASH. Then you can make modifications under this new Run ID.

- From the File menu, click Save As.

The Save As dialog box appears.

- Choose the directory where you want to save the simulation.

- In the File name box, enter the new filename **PREFLASH**.

- From the Save as Type list, select Aspen Plus Backup Files (*.bkp).

- Click Save to save the simulation and continue.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

The current Run ID, PREFLASH, appears in the titlebar.

Changing the Run Type

In Chapter 1, the BLEND run you performed was an Assay Data Analysis run. In this session, you will perform a flowsheet simulation. You need to switch to the Flowsheet Run Type.

- From the Data menu, select Setup.
The Setup Specifications form appears.
- Click the Run type field. Select Flowsheet from the list.
- Change the simulation title to **Getting Started with Petroleum-Session 2**.
- Close the window.

The graphics workspace is now active and ready for you to build the flowsheet. No more changes to this form are necessary.

Selecting a Distillation Model

Aspen Plus offers several distillation models. To determine which is appropriate for the preflash tower, you will use prompts and online help.

- From the Aspen Plus main window, click the Columns tab on the Model Library.

The list of available distillation columns is displayed.

- Move the mouse over any model in the Model Library and read the description in the lower left of the window.

From the prompts, it appears that PetroFrac is appropriate for this petroleum problem. You can obtain more extensive information on PetroFrac by reading the online help:

- Click PetroFrac.
- Press the Help Key–F1 on most systems.

A Help window appears, with detailed information about PetroFrac.

- Review this information to confirm that PetroFrac is the best choice, then close the Help window.

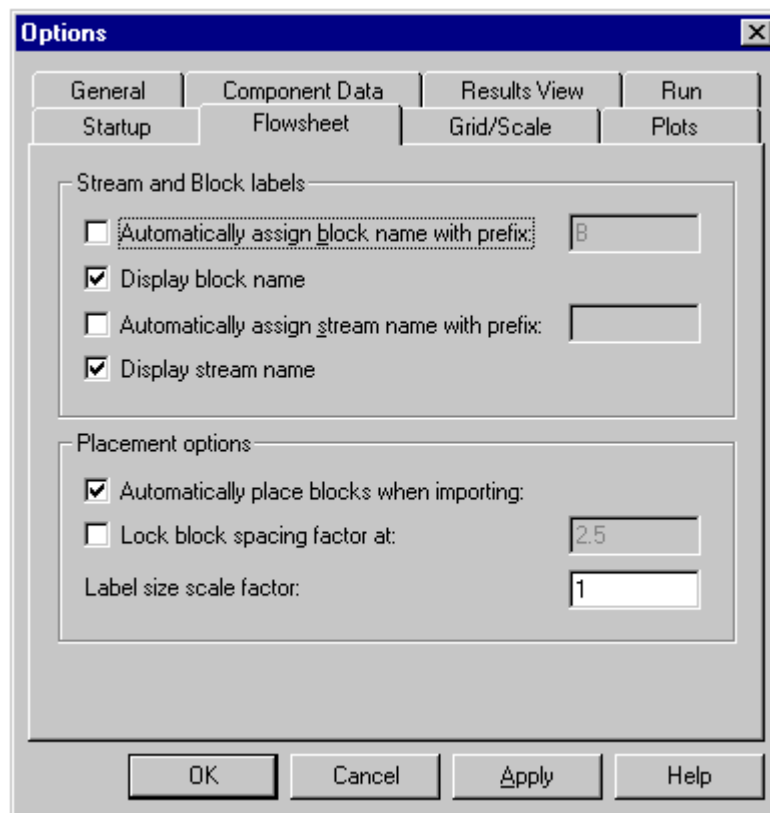
Defining the Graphical Simulation Flowsheet

Now you will begin to build the process flowsheet. Since you will enter your own block and stream IDs, you must turn off the default Create auto block ID and Create auto stream ID options, which provide these IDs automatically.

- From the Tools menu, select Options.

The Options dialog box appears.

- Click the Flowsheet tab.
- Click the Automatically assign block name check box, to deselect this option.
- Click the Automatically assign stream name check box, to deselect this option.



- Click OK to apply these changes.

You are ready to build your flowsheet. Figure 2-1 shows the process flow diagram for this session. To review how to define a flowsheet graphically, see *Getting Started Building and Running a Process Model*, Chapter 2.

To place and connect the distillation unit on the flowsheet:

- Click the Column tab in the Model Library.
- In the Model Library, select PetroFrac, the unit operation model that you want to place in your process flowsheet.

You can choose a different icon for the model:

- Click the down arrow next to the PetroFrac block icon to display all the icons available for the PetroFrac model.
- Move the mouse over the icons to see a name (or label) for each.

In this exercise, you will select the PetroFrac icon PREFL1F.

- Hold down the mouse button on the PetroFrac icon PREFL1F, and drag the icon to the Process Flowsheet window. Release the mouse button when the icon is in the desired location.

The Input dialog box appears.

- Enter the Block ID **PREFLASH**, and click OK.

Connect and name the streams, as shown in Figure 2.1. You can use the port names shown below to connect to the appropriate port.

Stream	Port
MIXCRUDE	Main Column Feed
PF-STEAM	Main Column Feed
LIGHTS	Vapor Distillate from Main Column
PF-WATER	Condensed Water Decant for Main Column
NAPHTHA	Liquid Distillate from Main Column
CDU-FEED	Bottoms Product from Main Column

- Click the Material Stream icon on the left side of the Model Library.

- Move the cursor to the Process Flowsheet window. Point to the Main Column Feed port on the PetroFrac and click to create a new stream.
- Point to a blank part of the process flowsheet window where you want the feed to originate and click once.
- Enter the Stream ID **PF-STEAM**, and click OK.
- Create the remaining streams in similar fashion.

For the MIXCRUDE stream, first connect it to the bottom feed port and then drag it to the desired location in front of the feed furnace.

- In the Aspen Plus main window toolbar, click the Next button to guide you to the next required input.

The Flowsheet Complete dialog box appears.

- Click OK.

The Properties Specifications Global sheet appears.

Specifying Properties

Use the Properties Specifications Global sheet to select the thermodynamic methods used to calculate properties such as K-values, enthalpy, and density. Property methods in Aspen Plus are arranged according to Process Types, and in logical groupings called Base Methods. The BK10 physical property option set (Braun K-10 method) is appropriate for most refining applications involving heavy petroleum fractions and low pressures.

- To select the BK10 option set for the physical properties, click the arrow to the right of the Process Type box, and select REFINERY.
- Click the arrow to the right of the Base Method box, and select BK10.

Since you selected the Petroleum with English Units Application Type in Chapter 1, Aspen Plus has selected appropriate defaults for petroleum applications. Steam Tables (STEAM-TA) is the default for the free-water phase properties, as shown in the Free-water method field. Aspen Plus has also selected Method 2 for the water solubility default, as shown in the Water solubility field. The Water solubility option controls the method for calculating the solubility and K-value of water in the hydrocarbon phase.

You do not need to change anything on this form.

The screenshot displays the 'Properties Specifications - Data Browser' window. The left sidebar shows a tree view with 'Specifications' selected. The main area is divided into 'Global', 'Flowsheet Sections', and 'Referenced' tabs, with 'Global' active. Under 'Property methods & models', the following settings are visible:

- Process type: REFINERY
- Base method: BK10
- Henry components: (empty)
- Petroleum calculation options:
 - Free-water method: STEAM-TA
 - Water solubility: 2
- Electrolyte calculation options:
 - Chemistry ID: (empty)
 - Use true-components

On the right, under 'Modify property models', the following settings are visible:

- Modify property models
- Vapor EOS: ESIG
- Data set: 1
- Liquid gamma: GMIDL
- Data set: 1
- Liquid enthalpy: HLMX13
- Liquid volume: VLMX20
- Poynting correction
- Heat of mixing

The status bar at the bottom indicates 'Input Complete'.

- Click the Next button.

The Required Properties Input Complete dialog box appears.

Correct representation of physical properties is essential to process modeling. For many simulations, the only physical property specification you must provide is to select an option set. The Required Properties Input Complete dialog box is a reminder that the Aspen Plus physical property system has many optional capabilities that you can use to increase the accuracy of physical property calculations.

- Click OK.

The Stream MIXCRUDE Input form appears.

Entering Stream Data

You should be viewing the Stream MIXCRUDE Input form, as indicated in the Data Browser window title bar. MIXCRUDE is the crude oil blend feed stream to the tower. You will enter condition and flow rates for the MIXCRUDE stream.

- In the Temperature field, enter the feed temperature **200**. The default units F (Fahrenheit) are correct for this session.
- In the Pressure field, enter **60**. The default units PSI are correct for this session.
- Enter **100000** for the MIXOIL component flow value. This is the oil flow rate in bbl/day.

The Streams Input form for MIXCRUDE is complete:

The screenshot shows the 'Stream MIXCRUDE (MATERIAL) Input - Data Browser' window. The 'Specifications' tab is active, showing the following fields:

- Substream name: **MIXED**
- State variables:
 - Temperature: **200** F
 - Pressure: **60** psi
 - Total flow: Stdvol, **bbl/day**
 - Solvent: (empty)
- Composition:

Component	Value
C2	
C3	
IC4	
NC4	
IC5	
NC5	
MIXOIL	100000
Total:	100000

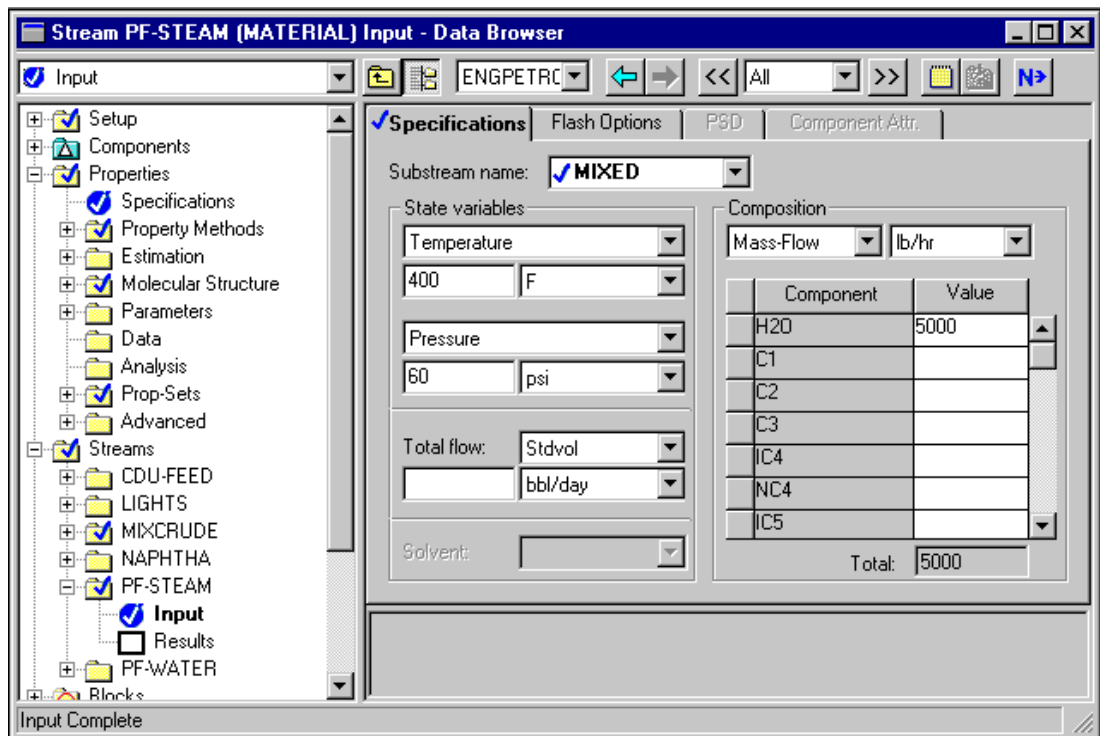
The status bar at the bottom of the window indicates 'Input Complete'.

- Click the Next button.

The Input form for PF-STEAM appears. PF-STEAM is the steam feed to the tower.

- In the Temperature field, enter **400 F**.
- In the Pressure field, enter **60 PSI**.
- In the Composition area, click the arrow and select Mass-Flow to specify the steam flow in lb/hr.
- Enter **5000** for the H2O component value, to enter a Steam flow rate of 5000 lb/hr.

The Input form for PF-STEAM is complete:



- Click the Next button.

The PREFLASH Setup Configuration sheet appears.

Specifying the Preflash Unit

Use the PREFLASH Setup Configuration sheet to enter configuration and operating specifications for the column, including:

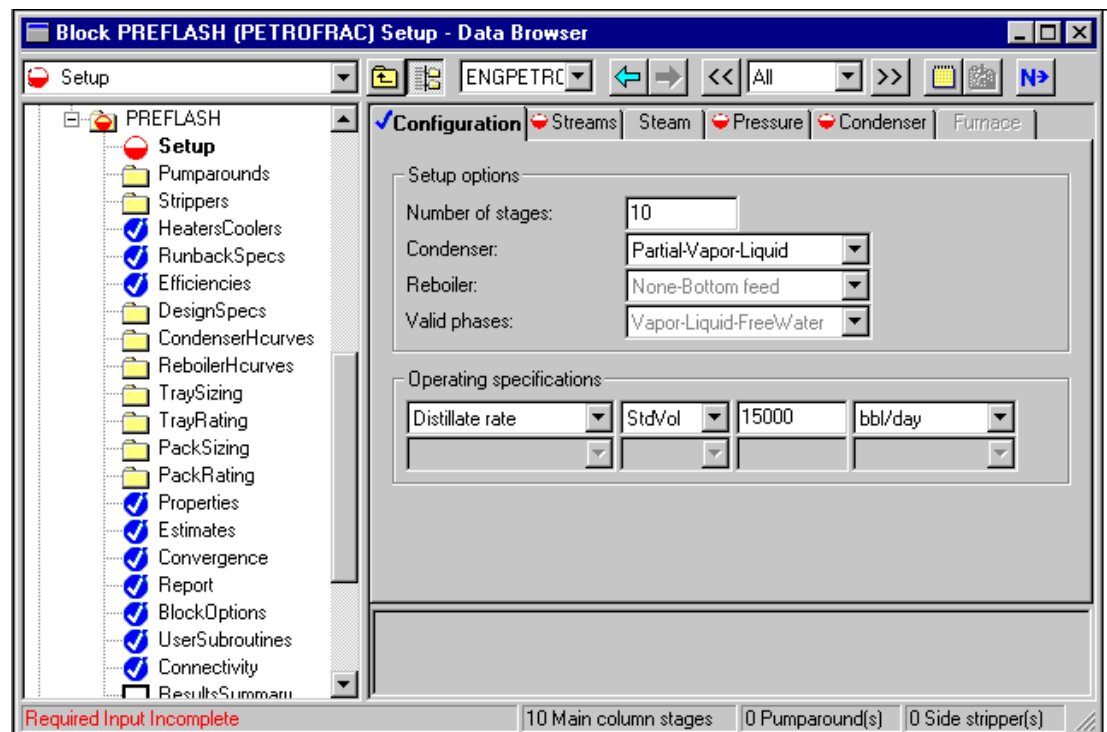
- Number of theoretical stages
 - Valid phases in the column
 - Distillate vapor fraction
- In the Number of stages field, enter **10** for ten theoretical stages.
 - Click the Condenser list box and select Partial-Vapor-Liquid. This indicates that there is a partial condenser with both vapor and liquid distillate.

In the Reboiler field, the default None-Bottom-Feed is appropriate, since the column has no reboiler and there is a bottom steam feed.

- In the Distillate rate field, enter **15000** to specify an estimate for the distillate rate of 15,000 bbl/day.

The distillate rate will be manipulated to achieve a specification on the ASTM 95% temperature for the naphtha product.

The Blocks PREFLASH Setup Configuration sheet is complete.



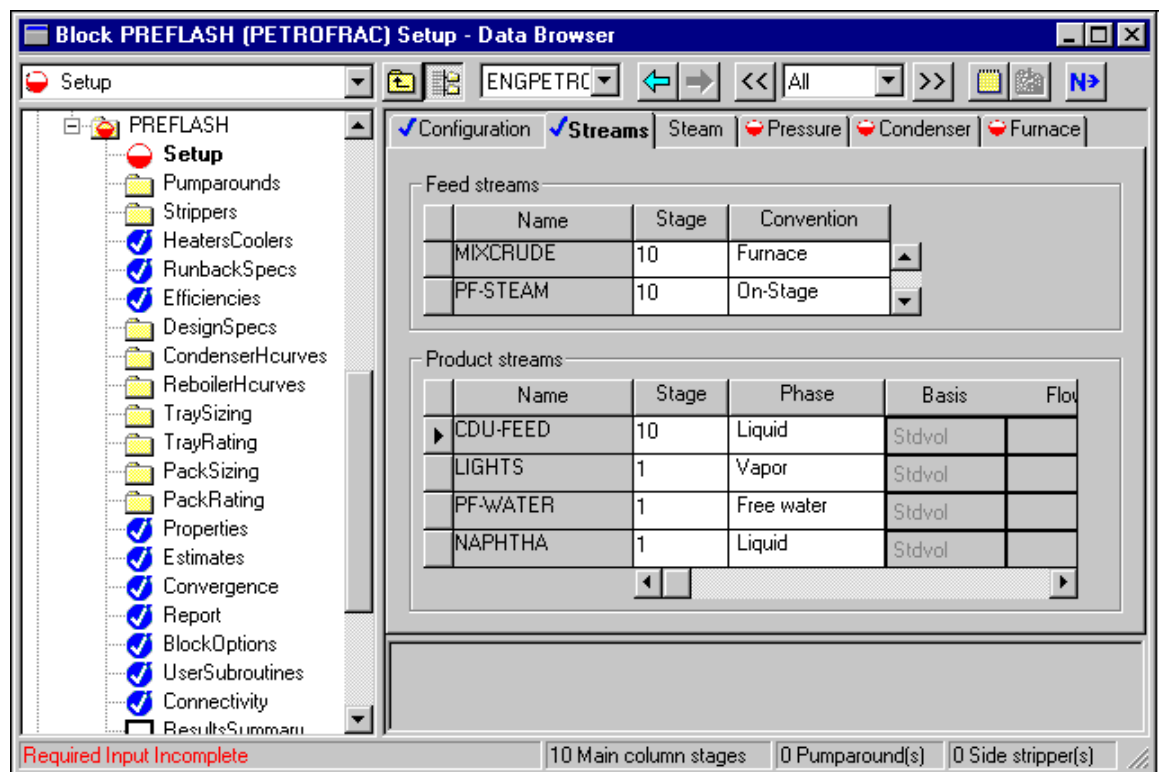
- Click the Next button.

The Blocks PREFLASH Setup Streams sheet appears.

You will enter feed locations and conventions for the MIXCRUDE stream.

- For MIXCRUDE, enter **10** in the Stage field. Click the convention list box, and select **Furnace** to indicate that a furnace is attached to the tower on stage 10. The feed goes to the furnace first.
- For PF-STEAM, enter **10** in the Stage field. Click the convention list box and select **On-Stage**.

The Blocks PREFLASH Setup Streams sheet is complete:



- Click the Next button.

The Setup Pressure sheet for the PREFLASH block appears. On this sheet, you will enter the column pressure profile, or specify a top stage pressure and a pressure drop or the rest of the column.

- Click the arrow to the right of the View box to display a list of available views. Select **Top/Bottom**.

- Enter the following pressure profile data:

Top Stage Pressure	39.7 PSI
Second Stage Pressure	41.7 PSI
Bottom Stage Pressure	44.7 PSI

The Setup Pressure sheet is complete.

- Click the Next button.

The Setup Condenser sheet appears.

- Click the Temperature radio button. Enter a value of **170 F**.

The Setup Condenser sheet is complete.

- Click the Next button.

The Setup Furnace sheet appears.

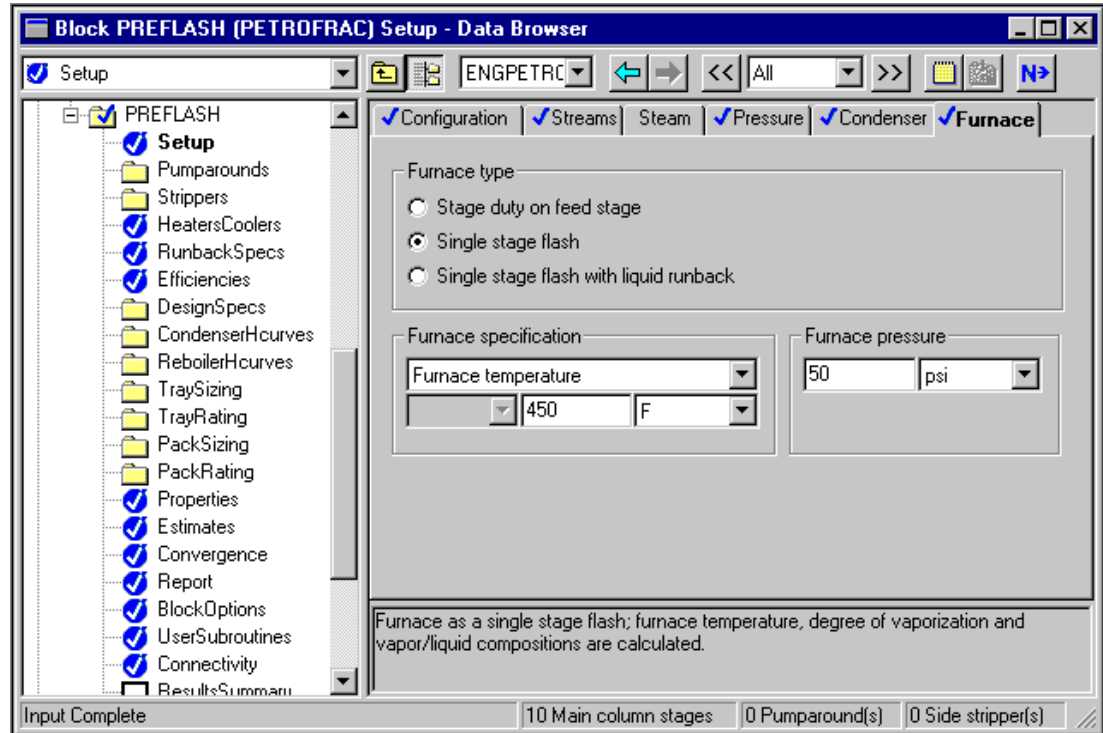
- Select **Single stage flash** as the furnace type.

- Enter the following information to specify furnace operating conditions:

Furnace temperature	450 F
Furnace pressure	50 PSI

These specifications model the furnace as a single-stage flash at the specified conditions.

The Setup Furnace form for the PREFLASH block is complete:



- Click the Next button.

The Required Input Complete dialog box appears.

- Click Cancel.

Next, you need to set up a design specification for the product quality of the naphtha stream, using the ASTM 95% temperature. You will manipulate the distillate rate to achieve this target.

- From the Data Browser, select the PREFLASH block's Design Specs folder.

The Design Specs Object Manager appears.

- Select New.

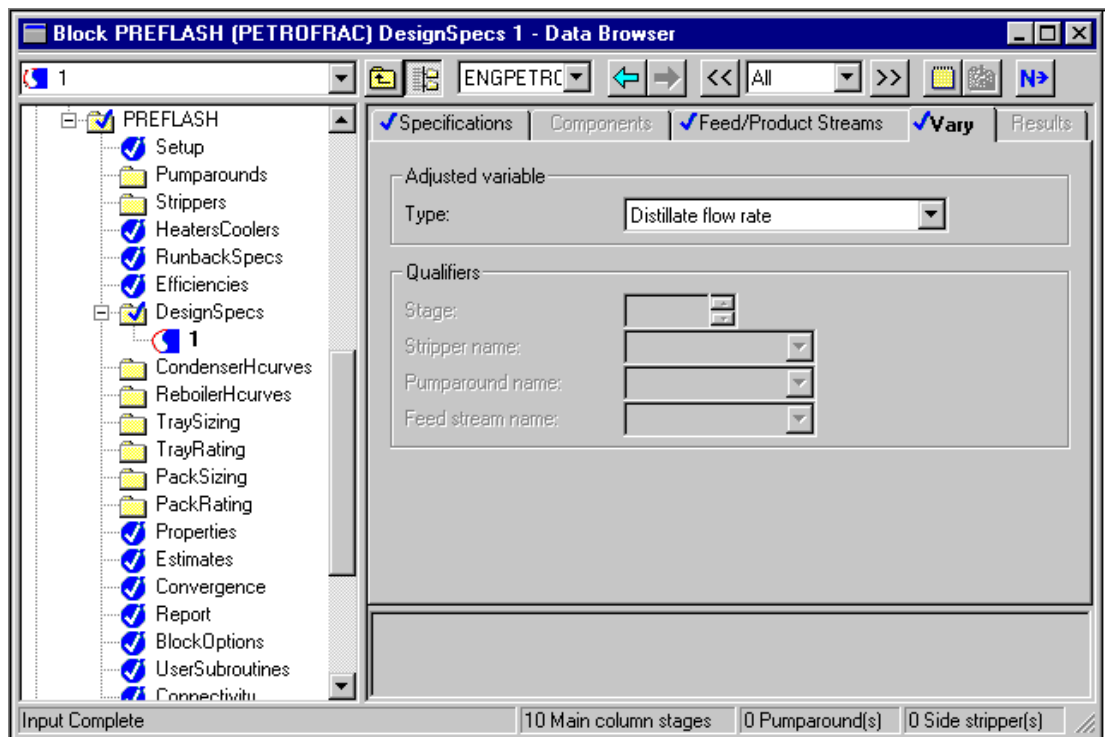
- In the dialog box, click OK to accept the default ID, 1.

The Design Spec 1 form appears.

- On the Specifications sheet, enter the following information for the naphtha product design specification:

Type **ASTM D86 temperature (dry, liquid volume basis)**
 Target **375 F**
 Liquid % **95**

- Click Next.
- On the Feed/Product Streams sheet, move the NAPHTHA stream from the Available streams area to the Selected streams area using the single arrow key.
- Click Next.
- On the Vary sheet, select Distillate flow rate from the available list.



- Click the Next button.

The Required Input Complete dialog box appears.

- Click Cancel.

Modifying Pseudocomponents

In Chapter 1, Aspen Plus generated all pseudocomponents using default options. In this session, you will modify the number of pseudocomponents generated for different temperature ranges.

- From the Data Browser, click the Components folder to expand it.
- Expand the Petroleum Characterization folder. Click Generation.

The Object Manager appears.

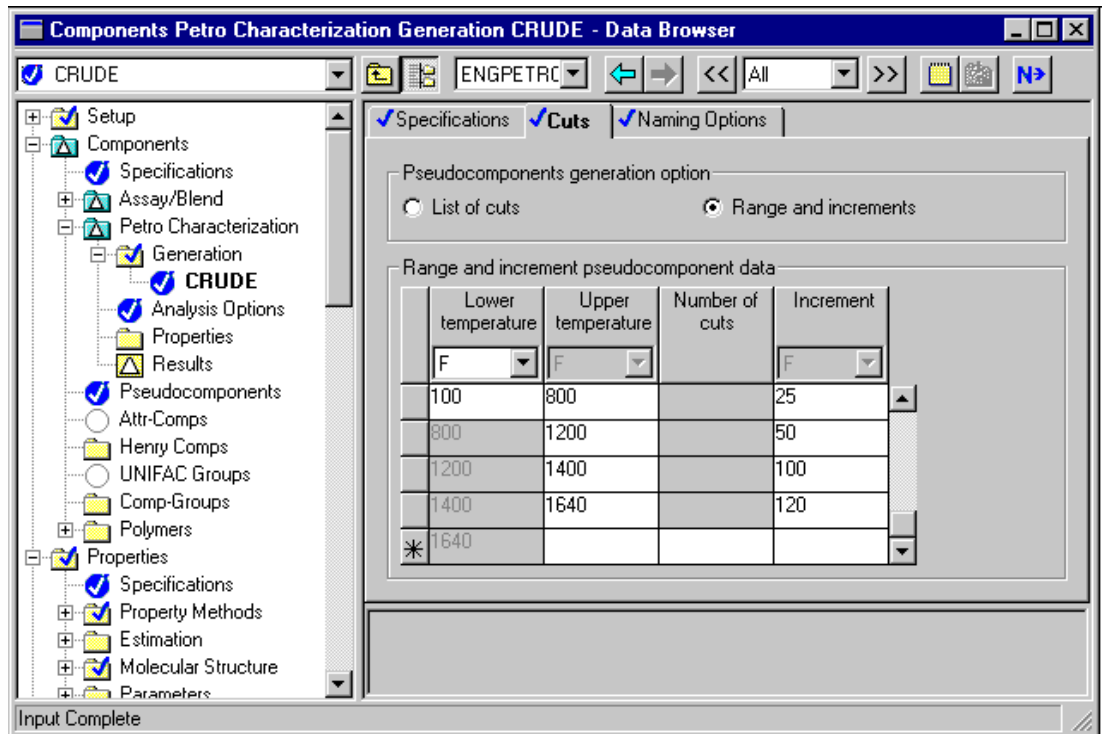
- Click CRUDE, then click the Edit button.

The Specifications sheet appears.

- Click the Cuts tab.
- Click the Range and Increments radio button.
- Enter the following temperature ranges and increments to generate pseudocomponents for this problem:

Lower temperature 100	Upper temperature 800	Increment 25
	Upper temperature 1200	Increment 50
	Upper temperature 1400	Increment 100
	Upper temperature 1640	Increment 120

The Cuts sheet is complete:



- Click the Next button.

The Required ADA-PCS Input Complete dialog box appears.

- Click OK.

The Required Input Complete dialog box appears.

Running the Simulation

To run the simulation:

- Click OK in the Required Input Complete dialog box.

The Control Panel appears.

As the run proceeds, status messages appear in the Control Panel. It takes about a minute for Aspen Plus to process input specifications and perform the simulation. When the calculations finish, the message *Results Available* appears in the status bar at the bottom of the main window.

- Use the vertical scroll bar to the right of the Control panel window to see the messages.
- When the *Results Available* message appears in the toolbar, click the Close button to close the Control Panel window.
- Click the Close button to close the Data Browser.

You can now examine the results of your run.

Examining Simulation Results

Aspen Plus produces a wide variety of simulation results. In this session you will examine:

- Condenser duty
- Distillate rate
- Temperature profile
- Crude TBP curves

Condenser duty results appear on the PREFLASH Results Summary sheet. To examine these results:

- Select the PREFLASH block by clicking the PREFLASH icon.
- Press or click the right mouse button to display the Block menu.
- Select Results.

The Results Summary form for PREFLASH appears, showing a summary of all condenser and bottom stage results.

The screenshot shows the Aspen Plus software interface. The window title is "Block PREFLASH (PETROFRAC) Results Summary - Data Browser". The left pane shows a tree view with "Results Summary" selected under "PREFLASH". The main area displays the "Summary" tab for the "Condenser / Top stage" performance. The table below shows the following data:

Parameter	Value	Unit
Temperature:	169.999779	F
Pressure:	39.7	psi
Heat duty:	-63.316286	MMBtu/hr
Subcooled duty:		
Distillate rate:	2355.01498	lbmol/hr
Reflux rate:	806.842888	lbmol/hr
Reflux ratio:	0.34260627	
Free water distillate rate:	221.662548	lbmol/hr
Free water reflux ratio:	0	

At the bottom of the window, it indicates "Results Available" and "10 Main column stages | 0 Pumparound(s) | 0 Side stripper(s)".

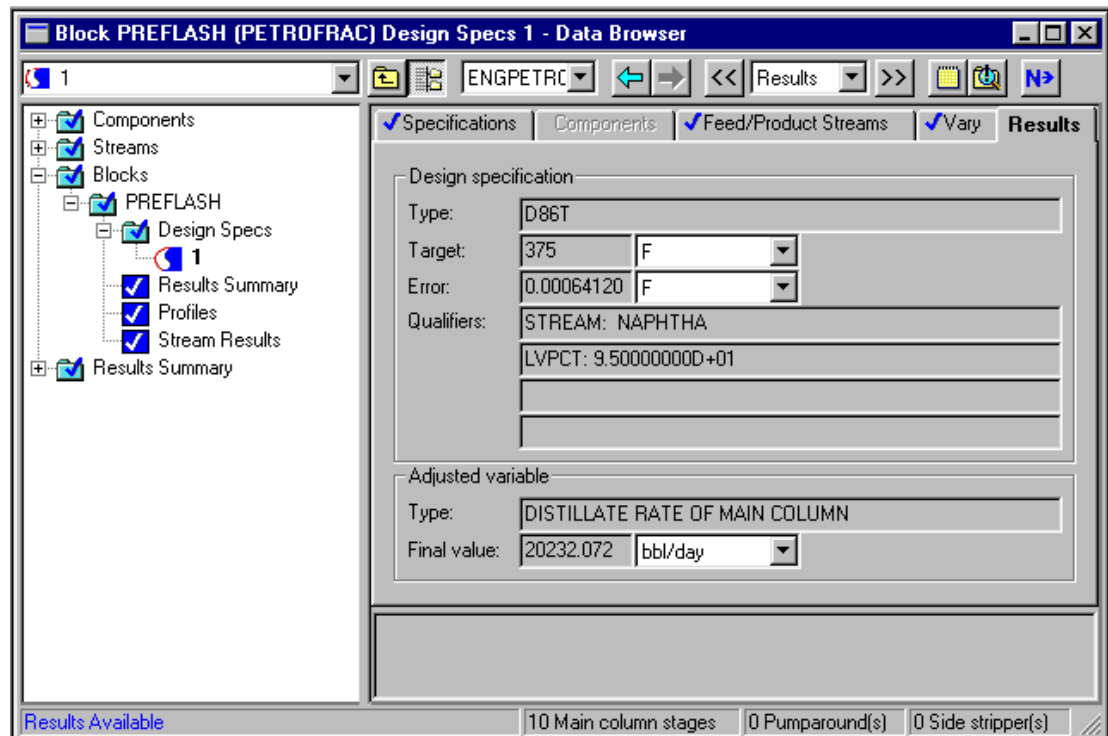
Distillate rate results appear on the PREFLASH Design Specs 1 Results sheet.
To examine distillate rate results:

- Expand the Design Specs folder in the Data Browser, and click design-spec 1.

The Design Specs 1 form is revealed.

- Click the Results tab.

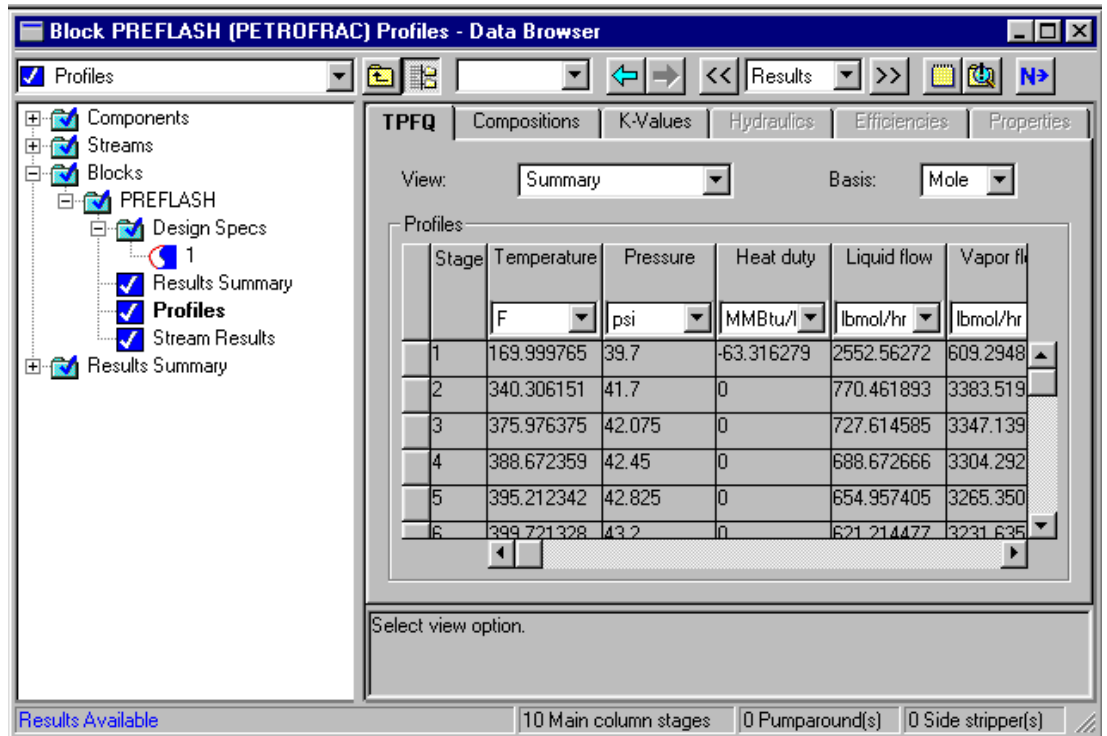
The Results sheet appears, showing the distillate rate value that Aspen Plus calculated to satisfy the design specification.



The temperature profile for the column appears on the PREFLASH Profile form.
To examine results by plotting a temperature profile:

- In the Data Browser, click the Profiles form.

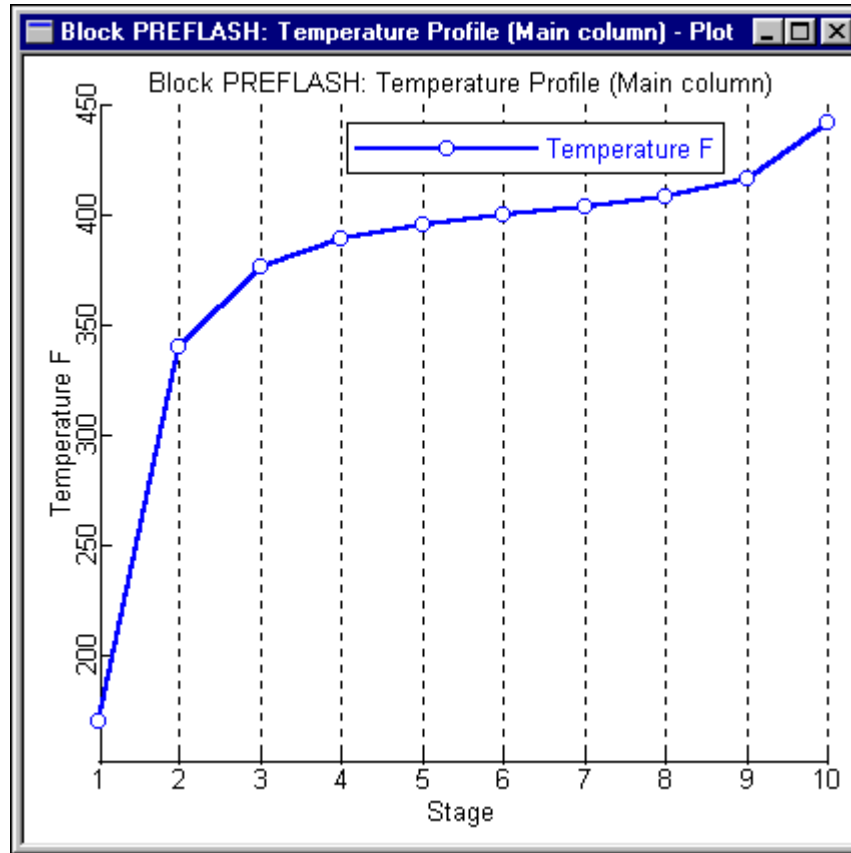
The PREFLASH Profiles form appears.



To plot the temperature profile:

- From the Plot menu, select Plot Wizard.
 - The Plot Wizard Step 1 dialog box appears.
- Click the Next> button.
 - The Plot Wizard Step 2 dialog box appears.
- Click the Temperature Plot Type.
 - The Plot Wizard Step 3 dialog box appears.
- Click the Next> button.
 - The Plot Wizard Step 4 dialog box appears.
- Click the Finish button.

The temperature profile plot appears.

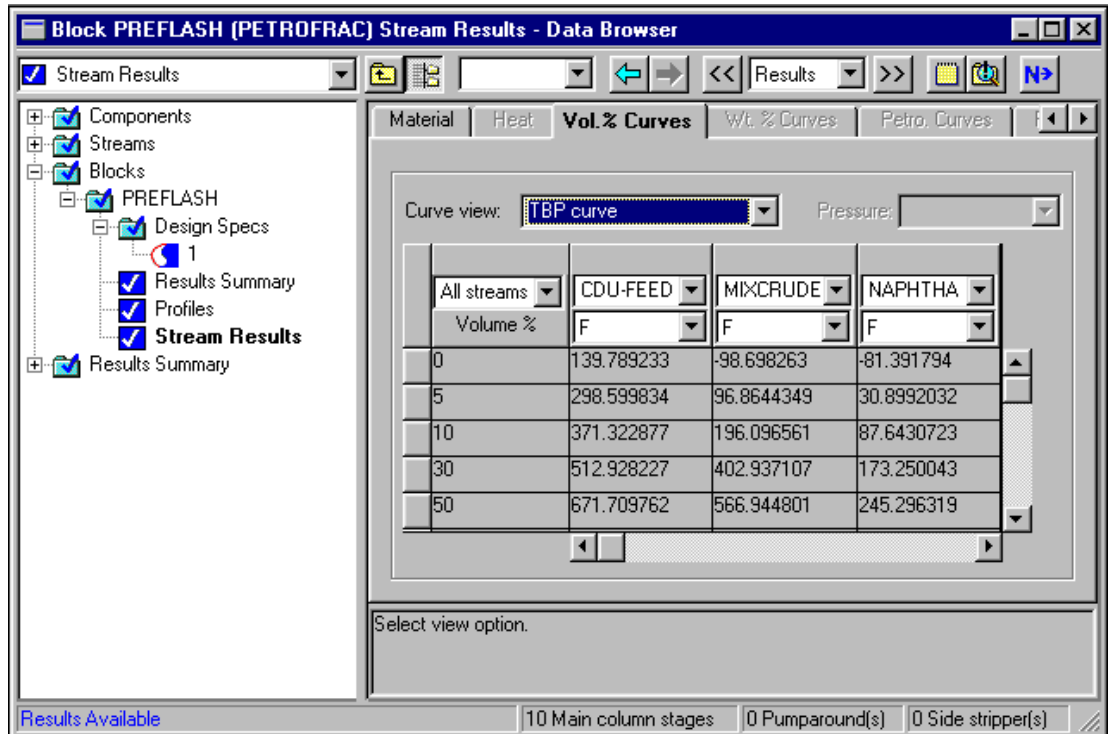


You can follow the same steps to display any other column profile. You may want to close some forms to make space for the new plots.

The True Boiling Point curves appear on the Stream Results Vol.% Curves sheet. To plot TBP curves for PREFLASH feed and product streams:

- In the Data Browser, click the PREFLASH Stream Results form.
The Stream Results form is revealed.
- Click the Vol.% Curves tab.

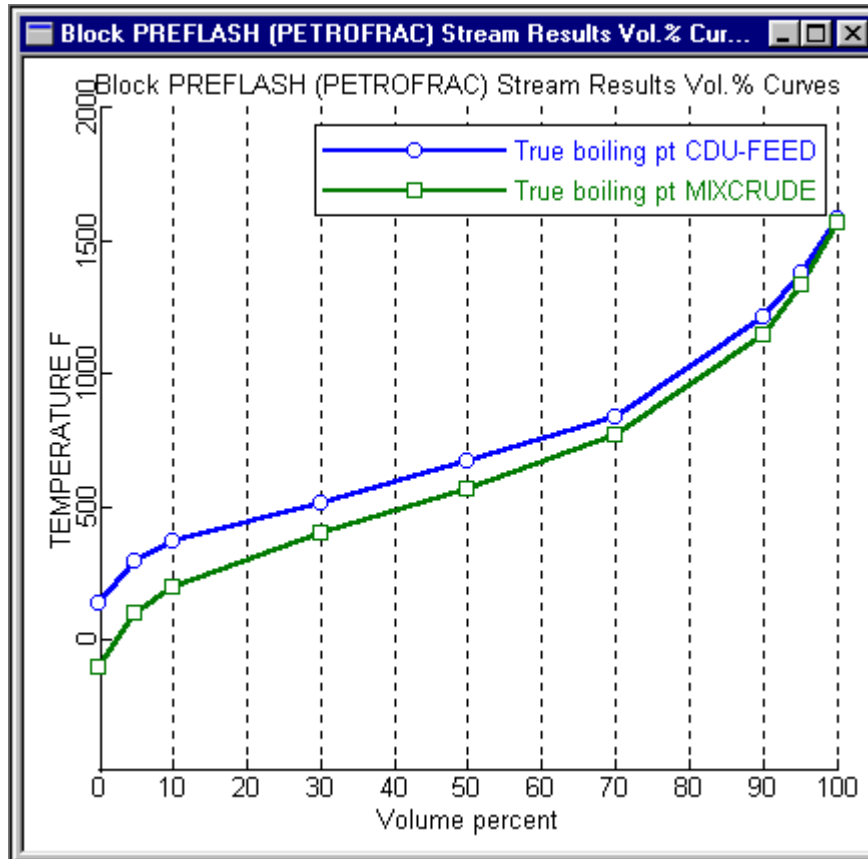
The Stream Results Vol.% Curves sheet is displayed.



To select CDU-FEED and MIXCRUDE as dependent variables:

- Click the CDU-FEED column label to select the column.
- Move the mouse to the MIXCRUDE column. Ctrl-Click the MIXCRUDE column label to select the MIXCRUDE column in addition to the CDU-FEED column.
- From the Aspen Plus Plot menu, select Y-Axis Variable.
- Click the Volume % column label.
- From the Aspen Plus Plot menu, select X-Axis Variable.
- From the Aspen Plus Plot menu, select Display Plot.

Aspen Plus displays the following plot:



As expected, the preflash tower removes a significant portion of the light material from the process feed. This reduces the load for the subsequent atmospheric crude unit and increases overall process capacity.

- When you finish viewing this plot, close the Plot window.

Exiting Aspen Plus

To exit Aspen Plus:

- From the File menu, select Exit.

A dialog box asks if you want to save your simulation.

- Select Yes to save the simulation.

A dialog box asks if you also want save the simulation as an Aspen Plus Document file.

- Click No.

This run will be used as the starting point for the session in Chapter 3.



3 Adding an Atmospheric Crude Distillation Unit

In this session, you will add an atmospheric crude distillation unit to the simulation you ran in Chapter 2.

You will:

- Add the atmospheric crude distillation unit to the flowsheet.
- Specify additional feed streams.
- Specify the atmospheric crude distillation unit.
- Run the simulation.
- Examine the results.

Allow about 45 minutes to complete this session.

Atmospheric Crude Distillation Unit Flowsheet

Figure 3.1 shows the process flowsheet you will develop in this session. The topped crude from the preflash tower goes first to the crude furnace, then to the atmospheric tower. You will model the crude furnace and the atmospheric tower units together, using a single PetroFrac block. This approach enables you to adjust furnace variables to achieve certain tower specifications, such as the overflash. The tower has:

- A total condenser
- Three coupled side strippers
- Two pumparound circuits

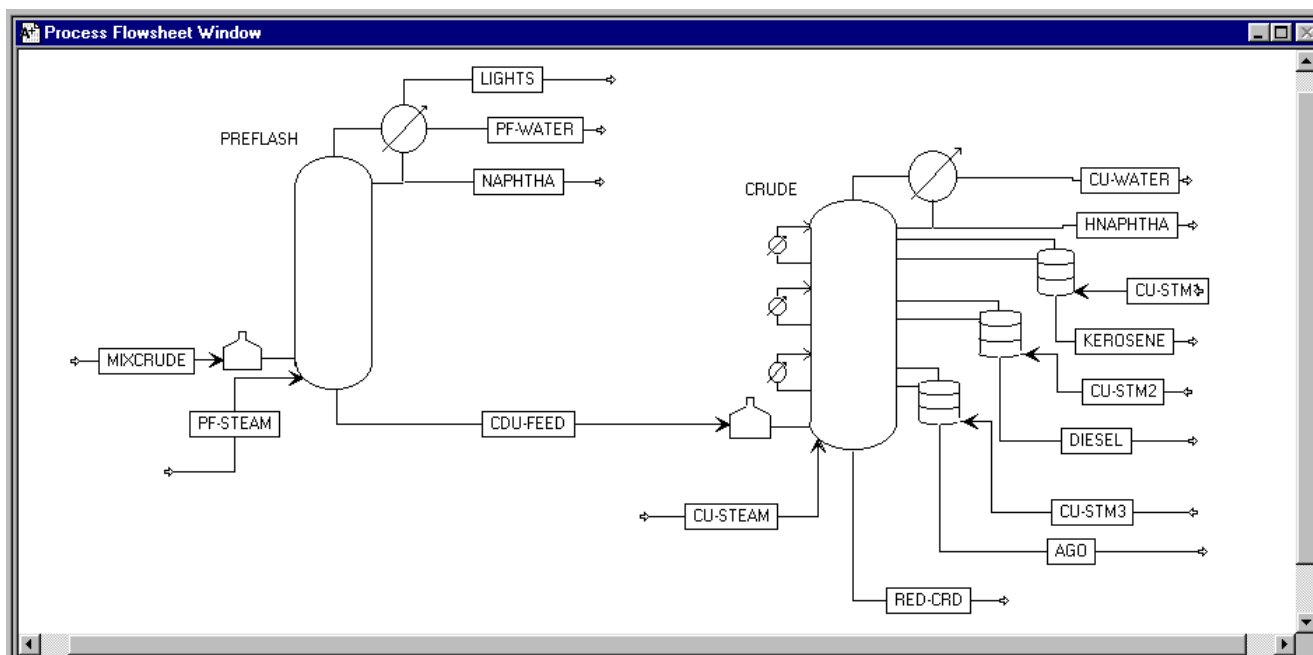


Figure 3.1 *Process Flowsheet: The Atmospheric Crude Distillation Unit*

PetroFrac simulates the furnace and the atmospheric tower simultaneously, as a single unit. The furnace operates at a pressure of 24.18 psia and provides an overflash of 3% in the tower. The furnace outlet enters the atmospheric tower on stage 22 of the main fractionator.

The main fractionator is modeled with 25 equilibrium stages. The heavy naphtha product flow is estimated at 13,000 bbl/day, and is manipulated to achieve an ASTM 95% temperature of 375 F. The condenser operates at 15.7 psia with a pressure drop of 5 psi. The tower pressure drop is 4 psi.

The main fractionator has 2 pumparound circuits. The following table summarizes the pumparound locations and specifications:

Pumparound	Location	Specifications
1	From stage 8 to 6	Flow: 49,000 bbl/day Duty: -40 MMBTU/hr
2	From stage 14 to 13	Flow: 11,000 bbl/day Duty: -15 MMBTU/hr

The crude distillation unit has three sidestrippers. Their locations and operating specifications are:

Stripper	Location	Specifications
KEROSENE	Liquid draw from stage 6 Vapor return to 5	Product rate: 11,700 bbl/day Steam stripping (CU-STM1) 4 equilibrium stages
DIESEL	Liquid draw from stage 13 Vapor return to 12	Product rate: 16,500 bbl/day (estimate) Steam stripping (CU-STM2) 3 equilibrium stages
AGO	Liquid draw from stage 18 Vapor return to 17	Product rate: 8,500 bbl/day Steam stripping (CU-STM3) 2 equilibrium stages

The diesel flow rate is an estimate only. You will manipulate it to achieve an ASTM 95% temperature of 640 F for the diesel product.

All sidestrippers and the main fractionator use steam for stripping. The following table summarizes the steam flows and conditions:

Stream	Location	Conditions and Flow
CU-STEAM	Main tower	400 F, 60 psia, 12,000 lb/hr
CU-STM1	Kerosene stripper	400 F, 60 psia, 3,300 lb/hr
CU-STM2	Diesel stripper	400 F, 60 psia, 1,000 lb/hr
CU-STM3	AGO stripper	400 F, 60 psia, 800 lb/hr

Starting Aspen Plus

To start Aspen Plus:

- Use the Windows Start menu or double-click the Aspen Plus icon on your desktop.

Note If the Connect Host dialog box appears, see Appendix A.

The Aspen Plus Startup dialog box appears.

Opening an Existing Run

If you saved the preflash flowsheet simulation created in Chapter 2:

- In the Aspen Plus Startup dialog box, select Open an Existing Simulation.

If your saved file preflash.bkp appears in the list box:

- Select preflash.bkp from the list and click OK.

If your saved file preflash.bkp does not appear in the list box:

- Double-click More Files... in the list box.

The Open dialog box appears.

- Navigate to the directory containing your saved file preflash.bkp.
- Select preflash.bkp from the list of files and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

If you did not create the assay data analysis simulation in Chapter 2, you can open the backup file preflash.bkp in the Examples folder.

- From the Aspen Plus Startup dialog box, select Open an Existing Simulation. Click OK.

The Open dialog box appears.

- Click the Look in Favorites button .

By default, the Favorites list contains five folders that are provided with Aspen Plus.

- Double-click the Examples folder.
- Select preflash.bkp and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

Aspen Plus displays the graphical flowsheet for the PREFLASH run.

Saving a Run Under a New Name

Before you create a new run adding the atmospheric crude unit, you will create and save a copy of PREFLASH with a new Run ID, CRUDE. Then you can make modifications under this new Run ID.

- From the File menu, click Save As.

The Save As dialog box appears.

- Choose the directory where you want to save the simulation.

- In the Filename box, enter the new filename **CRUDE**.

- From the Save as Type list, select Aspen Plus Backup Files (*.bkp).

- Click Save to save the simulation and continue.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

The current run ID, CRUDE, now appears in the titlebar. To update the title for this run:

- From the Data menu, select Setup.

The Setup Specifications form appears.

- Change the simulation title to **Getting Started with Petroleum-Session 3**.

- Close the window.

The graphics workspace is now active and ready for you to add to the existing flowsheet.

Adding the Crude Distillation Unit to the Flowsheet

You are ready to add the crude distillation unit to the flowsheet. To make space for the new tower:

- Drag a region around the entire flowsheet.
- Press and hold the left mouse button within the region and drag the flowsheet to the left, to make room for the crude distillation unit, as shown in Figure 3.1.

To place and connect the distillation unit on the flowsheet:

- In the Model Library, click the Column tab.
- Select the unit operation model, PetroFrac, to place in your process flowsheet.
- Click the down arrow next to the PetroFrac block icon to display all the icons available for the PetroFrac model.
- Move the mouse over the icons to see a name (or label) for each.

In this exercise, you will select the PetroFrac icon CDU10F.

- Hold down the mouse button on the PetroFrac icon CDU10F, and drag the icon to the Process Flowsheet window. Release the mouse button in the desired location.
- Place the CDU10F icon in the flowsheet, as shown in Figure 3.1. Name the block **CRUDE**.
- To increase the size of the icon, click the PetroFrac icon, hold down the Shift key, then press the + key.

To reconnect the distillation unit to the preflash block already on the flowsheet:

- Select the CDU-FEED stream.
- Click the right mouse button on the stream, and select Reconnect Destination from the menu that appears.

- Point to the Main Column Feed port at the bottom of the column.
- Click to connect the CDU-FEED stream to the bottom feed port and then drag it to the desired location in front of the feed furnace
- To display the flowsheet as large as possible, from the View menu, select Zoom full.
- Connect, move, and name the streams as shown in Figure 3.1. Use the port names in Table 3.1 to help you connect to the appropriate port.

Table 3.1 Streams and Corresponding Ports

Stream ID	Port Name
CDU-FEED	Main Column Feed
CU-STEAM	Main Column Feed
CU-STM1	Stripper Steam Feeds
CU-STM2	Stripper Steam Feeds
CU-STM3	Stripper Steam Feeds
CU-WATER	Condenser Water Decant for Main Column
HNAPHTHA	Liquid Distillate from Main Column
KEROSENE	Bottoms Product from Stripper
DIESEL	Bottoms Product from Stripper
AGO	Bottoms Product from Stripper
RED-CRD	Bottoms Product from Main Column

You have finished adding the distillation unit to the flowsheet.

- Click the Next button.
The Flowsheet Complete dialog box appears.
- Click OK.
The Input form for stream CU-STEAM appears.

Specifying Steam Feeds to the Tower

Use the Input form for stream CU-STEAM to enter the specifications for the steam feed to the main column.

- Enter the following state variable and component flow specifications:

Temperature	400 F
Pressure	60 PSI
Composition Basis	Mass-Flow LB/HR
H2O Flow value	12000 LB/HR

The Input form for CU-STEAM is complete:

Stream CU-STEAM (MATERIAL) Input - Data Browser

Input

ENGPETRC

Specifications

Substream name: MIXED

State variables

Temperature: 400 F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Solvent:

Composition

Component	Value
H2O	12000
C1	
C2	
C3	
IC4	
NC4	
IC5	
Total: 12000	

H2O WATER

Input Complete

- Click the Next button.

The Input form for CU-STM1 appears.

- Enter the following state variable and component flow specifications:

Temperature	400 F
Pressure	60 PSI
Composition Basis	Mass-Flow LB/HR
H2O Flow value	3300 LB/HR

- Click the Next button.

The Input form for CU-STM2 appears.

- Enter the following state variable and component flow specifications:

Temperature	400 F
Pressure	60 PSI
Composition Basis	Mass-Flow LB/HR
H2O Flow value	1000 LB/HR

- Click the Next button.

The Input form for CU-STM3 appears.

- Enter the following state variable and component flow specifications:

Temperature	400 F
Pressure	60 PSI
Composition Basis	Mass-Flow LB/HR
H2O Flow value	800 LB/HR

You have finished entering steam feed specifications.

- Click the Next button.

The Blocks CRUDE Setup form appears.

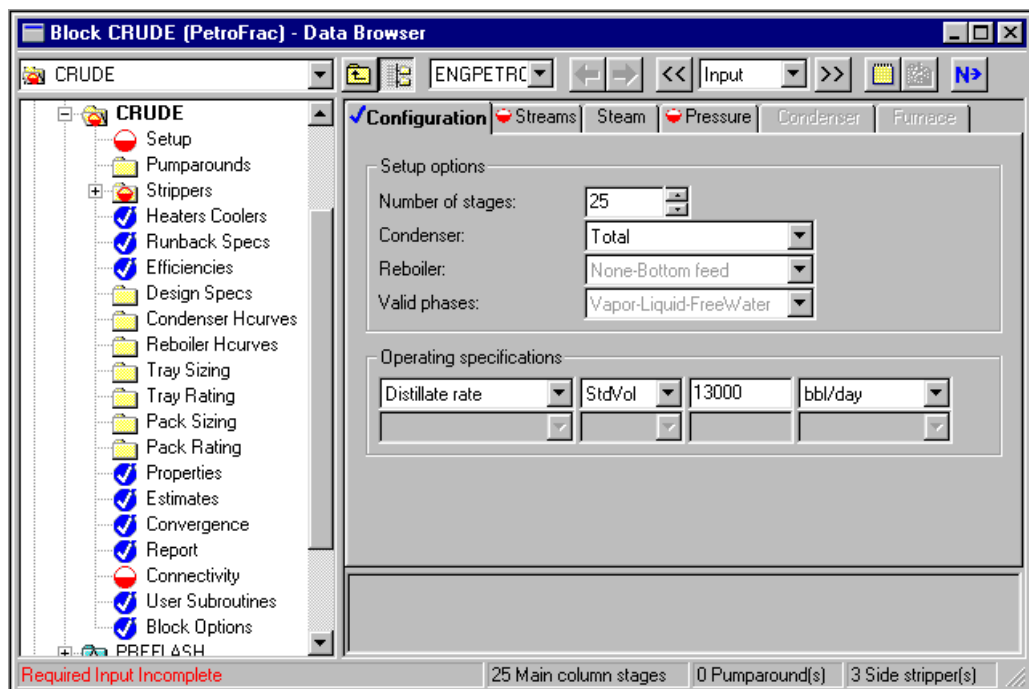
Specifying the Atmospheric Tower

Use the Blocks CRUDE Setup form to specify the main column configuration.

- On the Configuration sheet, specify:

Number of stages	25
Condenser	Total
Reboiler	None-Bottom Feed
Distillate rate	13000 BBL/DAY

The distillate flow rate is an estimate. This value will be manipulated to achieve the desired ASTM 95% temperature for the heavy naphtha stream.



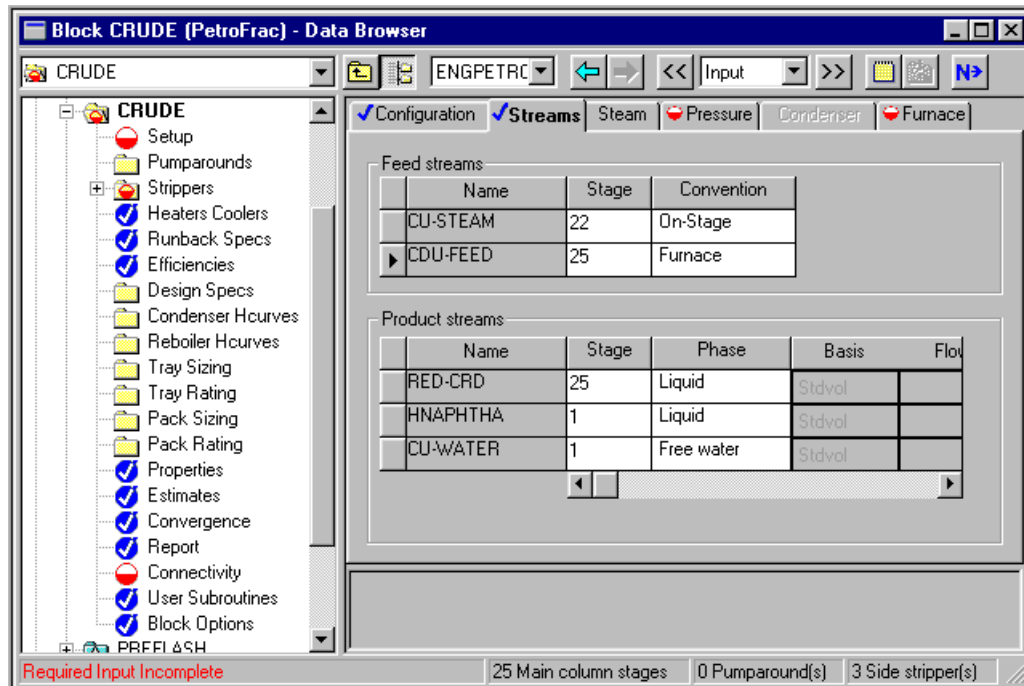
- Click the Next button.

The Blocks CRUDE Setup Streams sheet appears.

- Enter the following feed locations and conventions:

	Stage	Convention
CDU-FEED	22	Furnace
CU-STEAM	25	On-Stage

The Furnace feed convention attaches a furnace to stage 22. This furnace is solved simultaneously with the main fractionation column and strippers.



- Click the Next button.

The Pressure sheet appears.

- Enter the following pressures using the Top/Bottom View:

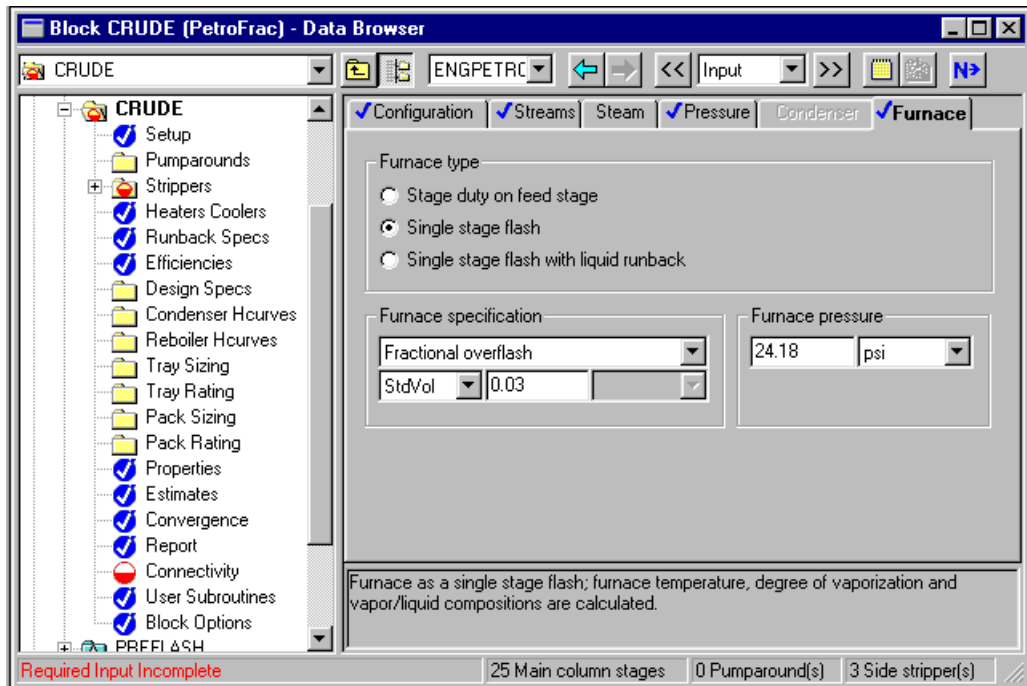
Stage 1 / Condenser Pressure	15.7 PSI
Stage 2 Pressure	20.7 PSI
Bottom Stage Pressure	24.7 PSI

- Click the Next button.

The Furnace sheet appears.

- Select the Single stage flash Furnace type
- Specify a StdVol Fractional overflash of 0.03 and a Furnace pressure of 24.18 psi.

The Furnace sheet is now complete:



You have completed specifications for the main column.

- Click the Next button.

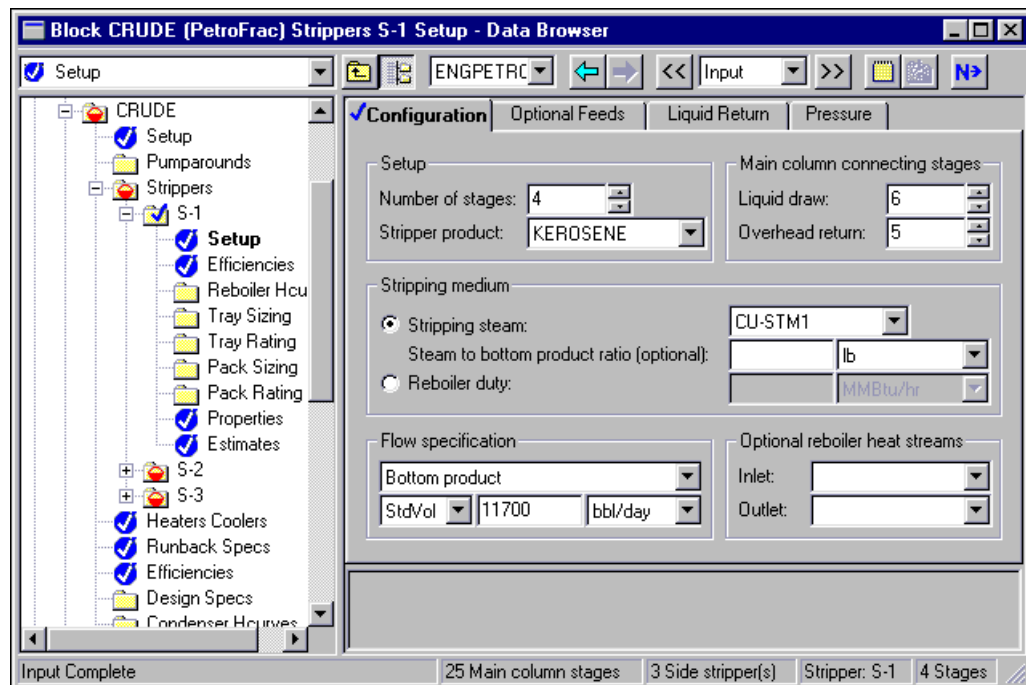
Because you attached feed and product streams for three sidestrippers in the graphical flowsheet, Aspen Plus automatically configured this block with three sidestrippers: S-1, S-2, and S-3.

The Setup form for Stripper S-1 appears.

- Enter the following specifications:

Number of stages	4
Liquid draw stage	6
Overhead return stage	5
Stripper product	KEROSENE
Stripping steam	CU-STM1
Bottom product flow	11700 BBL/DAY

The S-1 Setup form is complete:



- Click the Next button.

The S-2 Setup form appears.

- Enter the following specifications:

Number of stages	3
Liquid draw stage	13
Overhead return stage	12
Stripper product	DIESEL

Stripping steam **CU-STM2**
 Bottom product flow **16500 BBL/DAY**

The S-2 Setup form is complete:

The screenshot shows the 'Block CRUDE (PetroFrac) Strippers S-2 Setup - Data Browser' window. The left pane shows a tree view with 'S-2 Setup' selected. The main pane shows the 'Configuration' tab with the following settings:

- Setup:
 - Number of stages: 3
 - Stripping product: DIESEL
- Main column connecting stages:
 - Liquid draw: 13
 - Overhead return: 12
- Stripping medium:
 - Stripping steam: CU-STM2
 - Steam to bottom product ratio (optional): [] lb
 - Reboiler duty: [] MMBtu/hr
- Flow specification:
 - Bottom product: []
 - StdVol: 16500 bbl/day
- Optional reboiler heat streams:
 - Inlet: []
 - Outlet: []

At the bottom of the window, a status bar shows: 'Input Complete', '25 Main column stages', '3 Side stripper(s)', 'Stripper: S-2', and '3 Stages'.

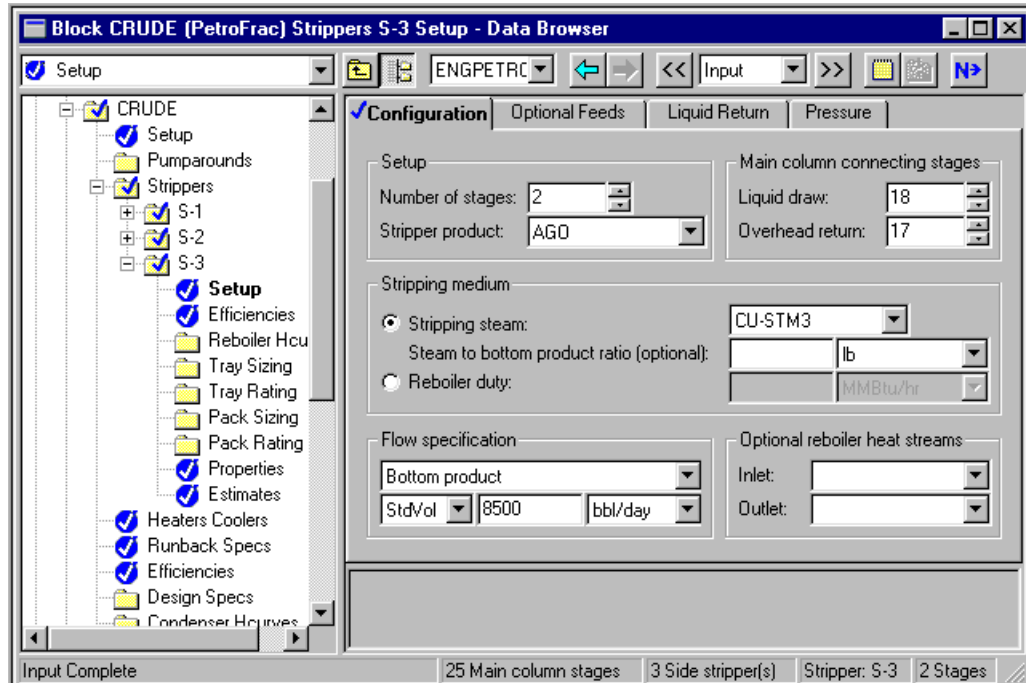
- Click the Next button.

The S-3 Setup form appears.

- Enter the following specifications:

Number of stages	2
Liquid draw stage	18
Overhead return stage	17
Stripping product	AGO
Stripping steam	CU-STM3
Bottom product flow	8500 BBL/DAY

The S-3 Setup form is complete:



- Click the Next button.

The Required Input Complete dialog box appears.

- Click Cancel.

Next, you will supply specifications for Pumparound 1 and Pumparound 2.

- In the Data Browser, click the Block CRUDE Pumparounds folder.

The Pumparounds Object Manager sheet appears.

- Select New.

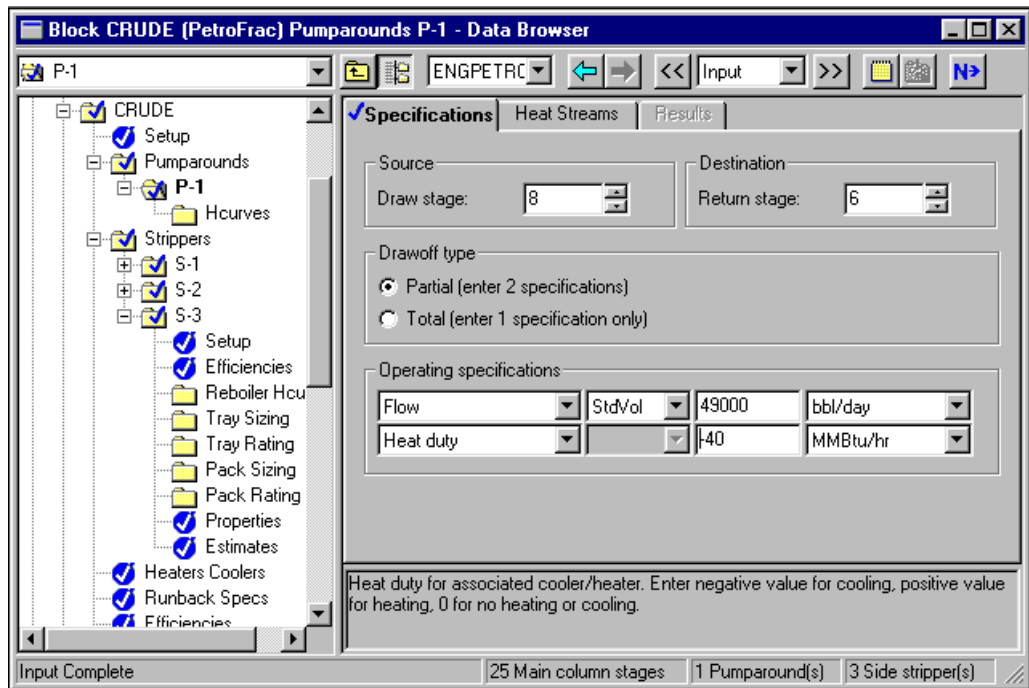
- In the dialog box, click OK to accept the default ID P-1.

The Pumparounds P-1 Specifications sheet appears.

- To specify P-1, enter:

Draw stage	8
Return stage	6
Drawoff type	Partial
StdVol Flow	49000 BBL/DAY
Heat duty	-40.0 MMBTU/HR

The Pumparounds P-1 Specifications sheet is complete:



- Click the Pumparounds folder to reopen the Object Manager.

The Pumparound Object Manager appears.

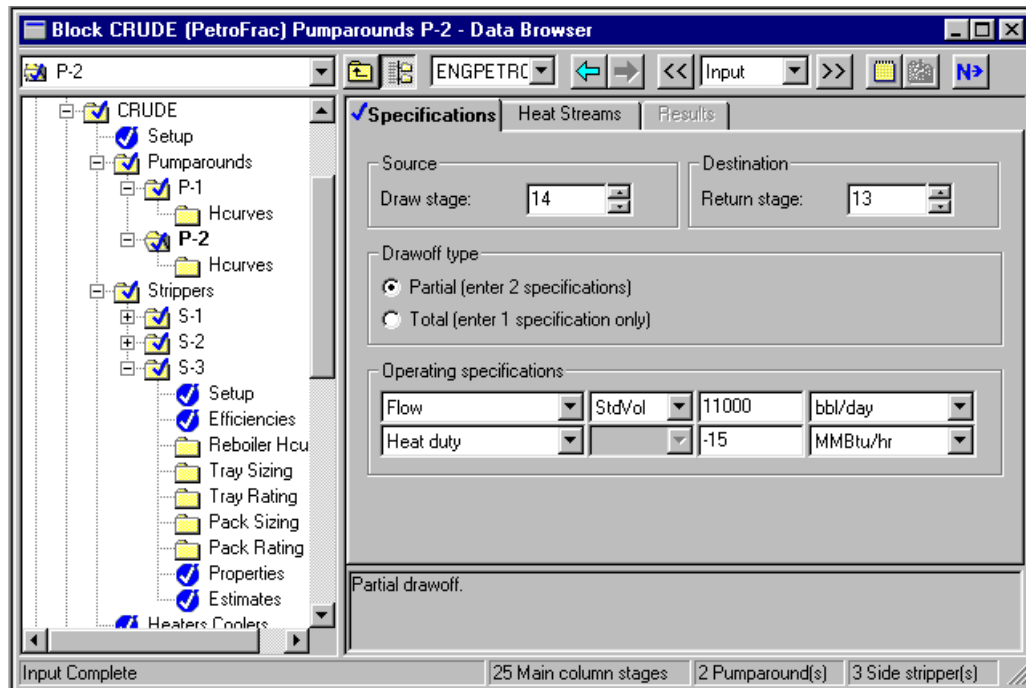
- Select New.
- In the dialog box, click OK to accept the default ID P-2.

The Pumparounds P-2 Specifications sheet appears.

- Enter the following specifications for P-2:

Draw stage	14
Return stage	13
Drawoff type	PARTIAL
StdVol Flow	11000 BBL/DAY
Heat duty	-15.0 MMBTU/HR

The Pumps P-2 Specifications sheet is complete:



- Click the Next button.

The Required Input Complete dialog box appears.

- Click Cancel.

You have completed all required PetroFrac specifications. However, in this session you will specify two design specifications, the ASTM 95% temperature for HNAPHTHA and for DIESEL.

- From the Data Browser, click the Blocks CRUDE Design Specs folder.

The Design Spec Object Manager appears.

- Click New.

- In the dialog box, click OK to accept the default ID 1.

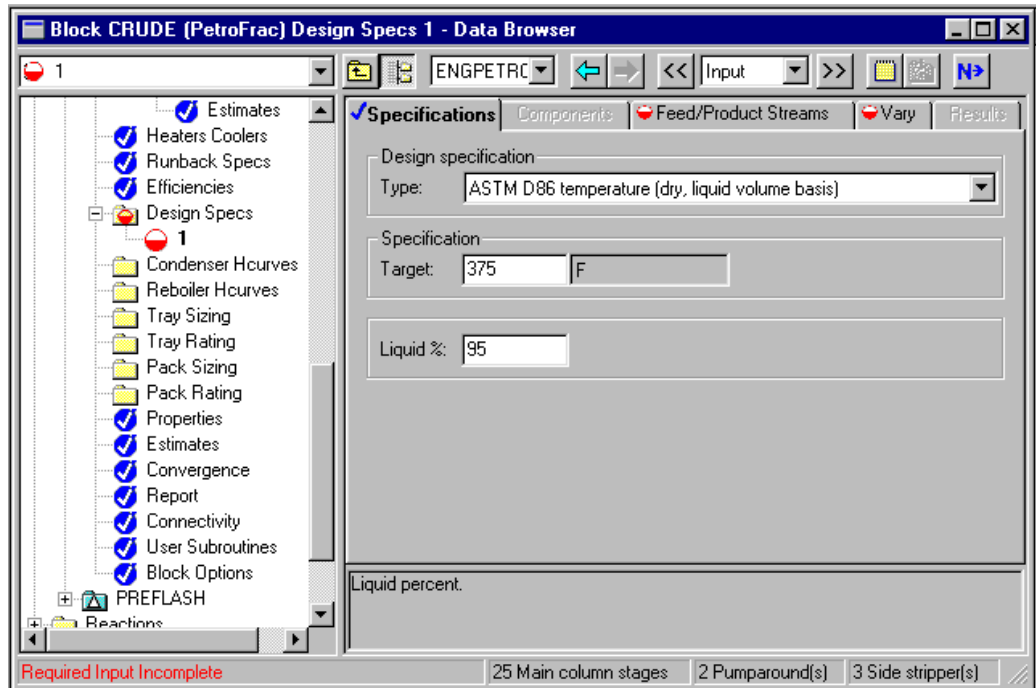
The Blocks CRUDE Design Specs 1 Specifications sheet appears.

First, you will enter specifications to have PetroFrac manipulate the distillate rate to achieve an ASTM 95% temperature of 375 F for HNAPHTHA:

- In the Type field, select **ASTM D86 temperature (dry, liquid volume basis)**.

- Enter the following specifications:

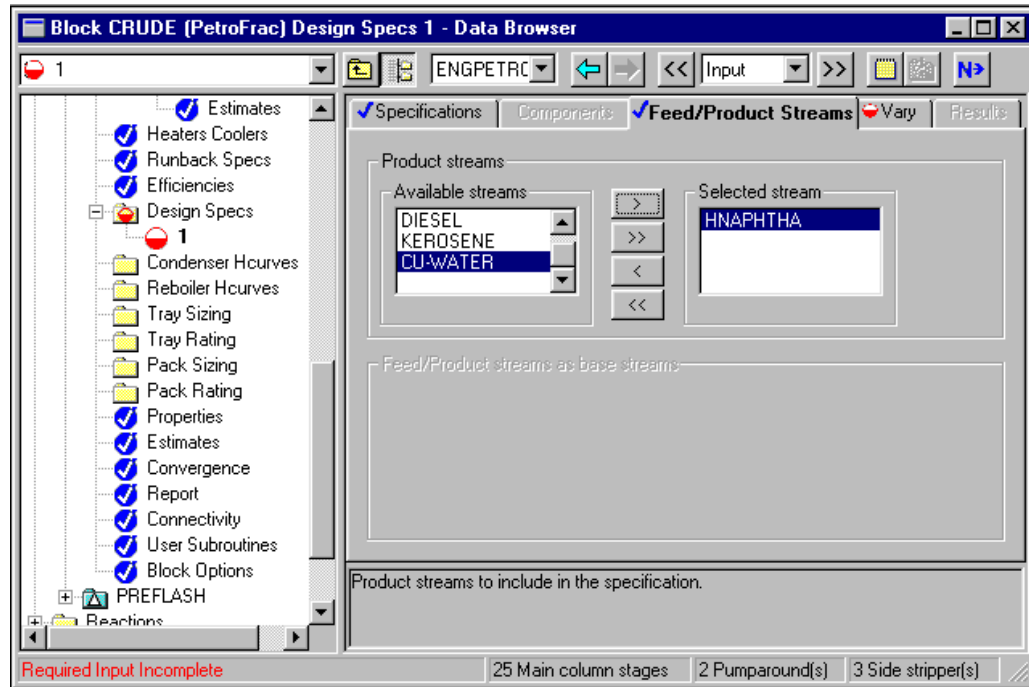
Target **375**
Liquid % **95**



- Click the Next button.

The Feed/Product Streams sheet appears.

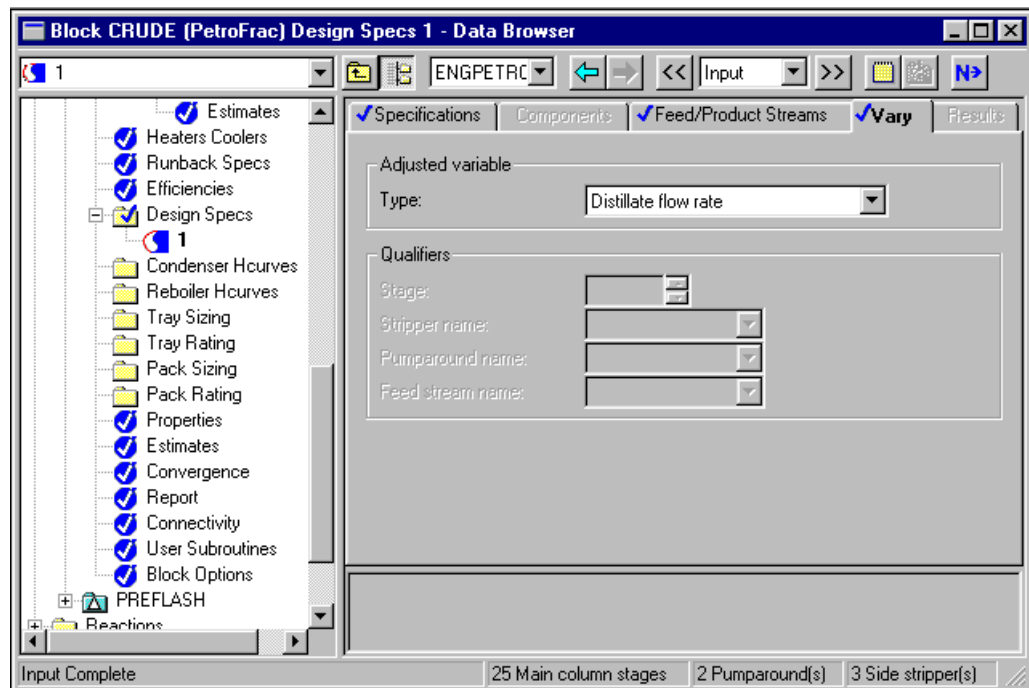
- Move HNAPTHA from the Available streams area to the Selected stream area by clicking the > button.



- Click the Next button.

The Vary sheet appears.

- Click the arrow to the right of the Type box, and select Distillate flow rate from the list.



The HNAPHTHA design specification is complete.

- Click the Design Specs folder to reopen the Object manager.

For the second design specification, you will enter specifications to have PetroFrac manipulate the DIESEL flow rate to reach an ASTM 95% temperature of 640 F.

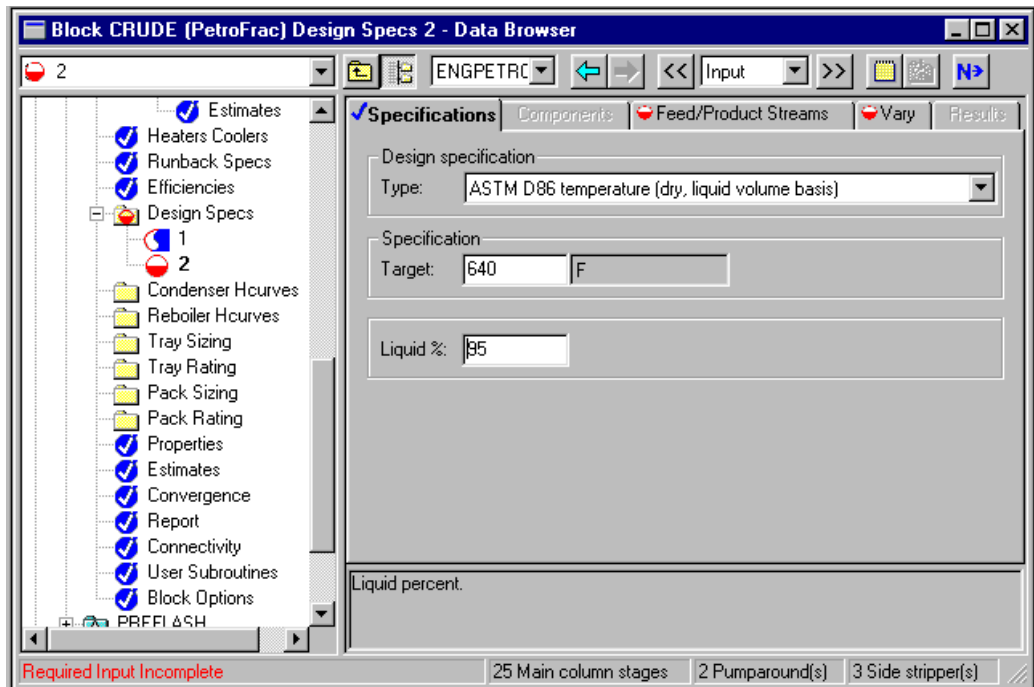
The Design Specs Object Manager appears.

- Click New.
- In the dialog box, click OK to accept the default ID 2.

The Block CRUDE Design Specs 2 Specifications sheet appears.

- Enter, or use List to select, the following specifications:

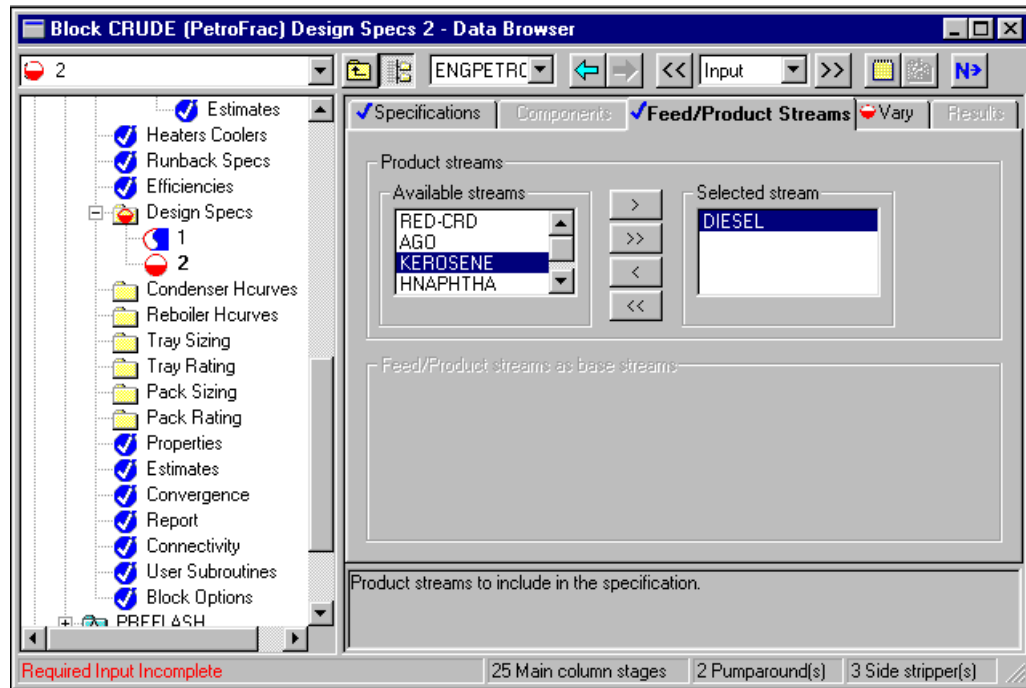
SpecType	ASTM D86 temperature (dry, liquid volume basis)
Target	640
Liquid %	95



- Click the Next button.

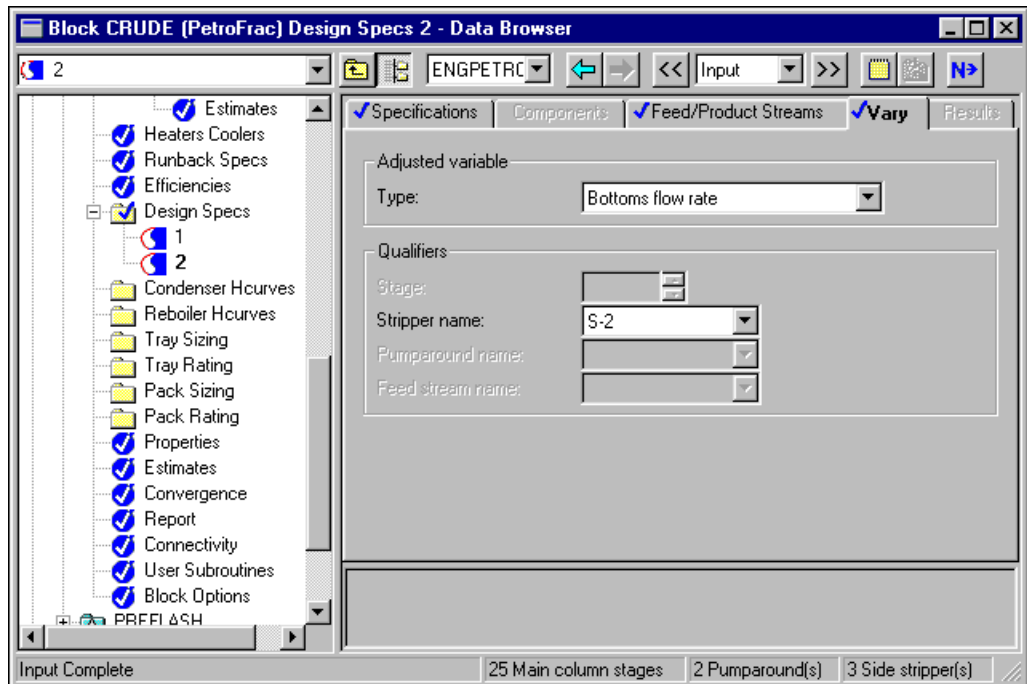
The Feed/Product Streams sheet appears.

- Move the DIESEL stream from the Available streams area to the Selected stream area using the > button.



- Click the Next button.
- The Vary sheet appears.
- Select **Bottoms flow rate** as the Adjusted variable Type.
- Select **S-2** as the Stripper name.

The Block CRUDE Design Specs 2 form is complete:



You have entered all the specifications for the atmospheric crude tower, without any initial profile estimates for tower temperatures, flow rates, or compositions. Aspen Plus can converge the column without estimates for these variables.

- Close the Data Browser window.
- In the Aspen Plus main window, click the Next button.

Running the Simulation

To run the simulation:

- In the Required Input Complete dialog box, click OK.

The Control Panel appears.

As the run proceeds, status messages appear in the Control Panel. It takes about a minute for Aspen Plus to process input specifications and perform the simulation. When the calculations finish, the message *Results Available* appears in the status bar at the bottom of the main window.

- Use the vertical scroll bar to the right of the Control panel window to see the messages.
- When the *Results Available* message appears in the toolbar, click the Close button to close the Control Panel window.
- Click the Close button to close the Data Browser.

You can now examine the results of your run.

Examining Simulation Results

This run produces a wide variety of simulation results. In this session, you will examine:

- Furnace duty
- Pumparound return temperatures
- Stream results for the atmospheric tower products
- ASTM curves for the tower products

Furnace duty results appear on the CRUDE Results Summary Furnace sheet. To examine these results:

- Select the CRUDE block by clicking on the CRUDE icon.
- Press or click the right mouse button to display the Block menu.
- Select Results.

The Blocks CRUDE Results Summary form appears.

- Click the Furnace tab.

A summary of important Furnace results appears:

Parameter	Value	Unit
Basis:	Mole	
Furnace summary		
Temperature:	673.710051	F
Pressure:	24.18	psi
Heat duty:	199.752418	MMBtu/hr
Feed flow:	3869.27865	lbmol/hr
Vapor flow:	2565.43792	lbmol/hr
Liquid flow:	1303.84073	lbmol/hr

Select view option.

Results Available | 25 Main column stages | 2 Pumparound(s) | 3 Side stripper(s)

To examine pumparound return temperatures:

- In the Data Browser, click the Pumparounds folder for CRUDE.
- Click the Results tab.

The Pumparounds Results sheet appears:

The screenshot shows the 'Block CRUDE (PETROFRAC) Pumparounds - Data Browser' window. The left pane shows a tree view with 'Pumparounds' expanded under 'CRUDE'. The right pane shows the 'Results' tab with a table of pumparound data.

Pumparound ID:		P-1	P-2
Draw stage:		8	14
Return stage:		6	13
Temperature:	F	337.091373	389.236672
Pressure:	psi	21.7434783	22.7869565
Vapor fraction:		0	0
Heat duty:	MMBtu/hr	-40	-15
Mole flow:	lbmol/hr	3364.69914	577.390196
Mass flow:	lb/hr	593005.981	138508.935
StrMol flow:	lbMol/hr	49000.0469	11000.0204

At the bottom of the window, a status bar indicates: 25 Main column stages | 2 Pumparound(s) | 3 Side stripper(s)

Examining the Product Streams

To review the stream results for the crude tower products:

- In the Data Browser, click the Stream Results form for CRUDE.

The Blocks CRUDE Stream Results Material sheet appears.

To examine the results for the five product streams:

- Click the first Streams field, then select HNAPHTHA.
- In the next four Streams fields, select KEROSENE, DIESEL, AGO, and RED-CRD.

To examine the 5% and 95% cutpoints and product yields:

- Using the scrollbar, scroll down until ***** Dry Total***** is the top line displayed.

From these results, you can see that the tower produces a large quantity of the diesel cut. By specifying a high ASTM 95% temperature (375 F), you also maximize the amount of heavy naphtha produced.

Stream results for the crude tower products appear on the Blocks CRUDE Stream Results Material sheet:

Block CRUDE (PETROFRAC) Stream Results - Data Browser

Stream Results

Material Heat Vol.% Curves Wt.% Curves Petro. Curves Poly. Curves

Display: Streams Format: PETRO_E Stream Table

	HNAPHTHA	KEROSENE	DIESEL	AGO	RED-CRD
*** DRY TOTAL ***					
Liq Vol 60F bbl/day	7831.7	11693.0	17244.1	8499.9	34548.0
API Gravity	50.3	39.2	33.4	27.0	16.5
Gravity 60F	0.778	0.829	0.858	0.893	0.956
Watson UOP-K	11.7	11.6	11.7	11.7	11.6
TBP Curve F					
0 %	27.3	309.9	366.6	433.1	587.3
5 %	138.3	363.0	449.1	557.6	686.3
10 %	192.2	380.8	473.6	605.2	730.9
30 %	264.2	414.1	519.7	672.1	827.4
50 %	298.1	436.8	554.7	707.3	955.4
70 %	332.9	458.6	594.2	743.3	1132.5
90 %	370.4	490.0	646.0	788.1	1405.5
95 %	387.3	501.0	666.9	804.2	1512.0
100 %	417.5	523.7	697.7	861.4	1612.4

Results Available 25 Main column stages 2 Pumparound(s) 3 Side stripper(s)

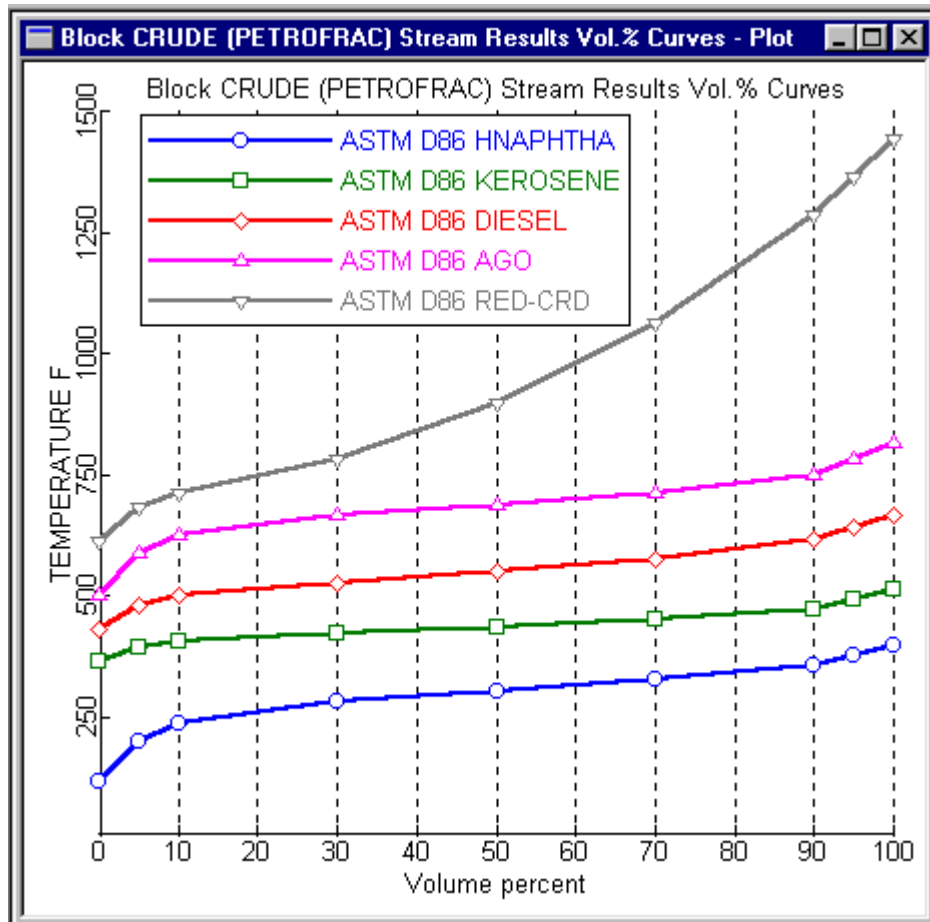
➤ Scroll through this form to examine stream information for different products.

Plotting Distillation Curves

Next, you will examine and plot the ASTM curves for the products. The ASTM curves are on the Stream Results Vol.% Curves sheet. To plot the curves for the product streams:

- In the Data Browser, click the CRUDE Stream Results form.
The Stream Results form is revealed.
- Click the Vol.% Curves tab.
The Stream Results Vol.% Curves sheet is displayed.
- Click the arrow to the right of the Curve view box, and select ASTM D86.
- Select the Volume % column label to select the column.
- From the Plot menu, select X-Axis Variable.
- Click the HNAPTHA column label to select the column.
- Move the mouse to the RED-CRD column. Shift-Click on the column label to select the HNAPTHA column, the RED-CRD column, and all of the columns in between, KEROSENE, DIESEL, and AGO.
- From the Aspen Plus Plot menu, select Y-Axis Variable.
- From the Plot menu, select Display Plot.

The ASTM curves should appear as shown:



- When you finish viewing this plot, close the Plot window.

At this point, you can simulate other modes of operation, such as maximizing kerosene production to satisfy a higher demand for jet fuel. You can do this by:

- Decreasing the ASTM 95% temperature for heavy naphtha to 325 F
- Increasing the ASTM 95% temperature for kerosene to about 520 F
- Introduce another design specification by manipulating the kerosene flow rate

The product flow rates resulting from these specifications are:

	ASTM-D86 5% Temperature F	ASTM-D86 95% Temperature F	Product Flow-Rate (m bbl/day)
HNAPHTHA	166	325	4.7
KEROSENE	374	520	20.0
DIESEL	502	640	10.9
AGO	578	772	8.5
RED-CRD	674	1358	35.6

The results show that the kerosene production goes up at the expense of heavy naphtha and diesel.

Exiting Aspen Plus

To exit Aspen Plus:

- From the File menu, select Exit.

A dialog box asks if you want to save your simulation.

- Select Yes to save the simulation.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

This run will be used as the starting point for the session in Chapter 4.



4 Adding A Vacuum Unit

In this session, you will build on the simulation from the previous session and install a vacuum unit to complete the process model.

You will:

- Add a vacuum tower, steam feed, and product streams to the flowsheet
- Specify the steam feed
- Specify the vacuum unit
- Run the simulation
- Examine the results

Allow about 30 minutes to complete this session.

Vacuum Unit Flowsheet

Figure 4.1 shows the process flowsheet for this session. It contains a vacuum unit that separates the reduced crude from the atmospheric tower into:

- Off-gas
- Light vacuum gas oil
- Heavy vacuum gas oil
- Residual vacuum oil

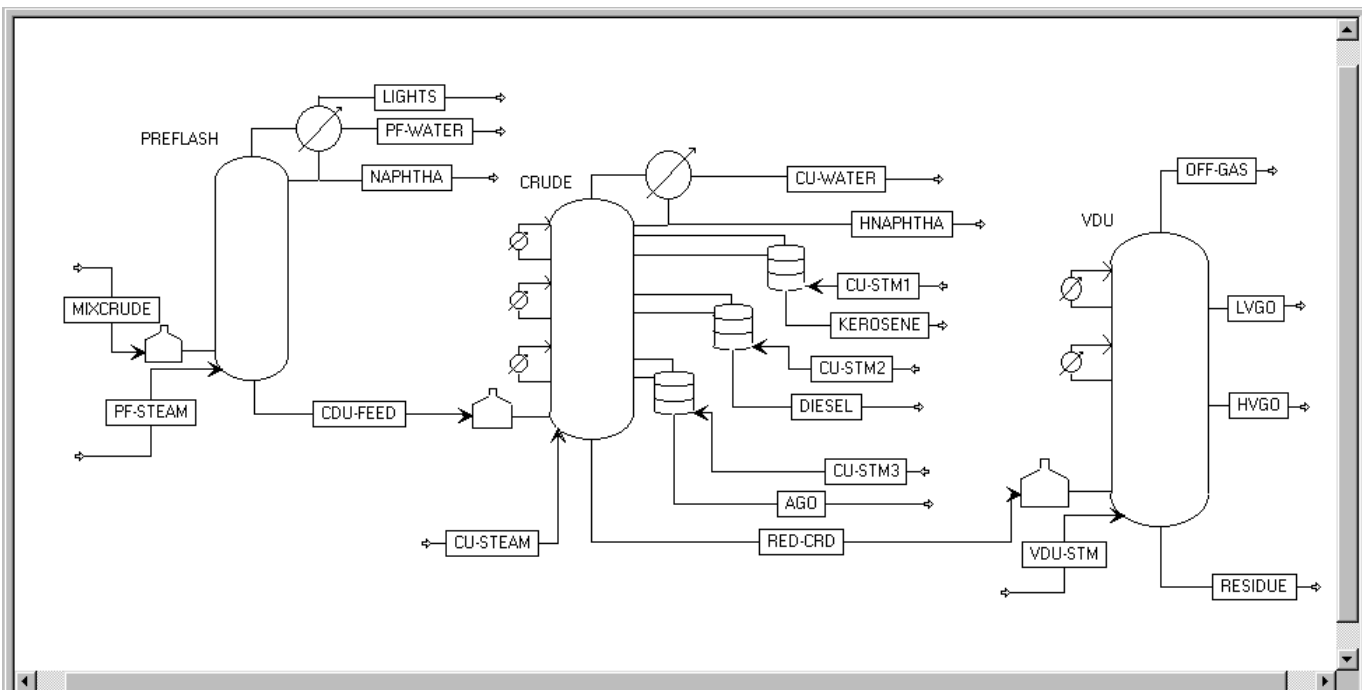


Figure 4.1 *Process Flowsheet Adding a Vacuum Unit*

The vacuum tower has no condenser or reboiler. Stripping steam is fed to the bottom of the tower. The following table shows the steam flow rate and conditions:

Stream	Location	Conditions and Flow
VDU-STM	Bottom of main fractionator	400 F, 60 psia, 20,000 lb/hr

The furnace operates at a pressure of 2.03 psia, and provides an overflash of 0.6%. The overflash is bypassed to the tower furnace.

The tower has two pumparound circuits. The following table shows their locations and specifications:

Pumparound	Location	Specifications
1	From stage 2 to 1	Flow: 20,000 bbl/day Duty: -28 MMBtu/hr (estimated)
2	From stage 4 to 3	Flow: 49,000 bbl/day Duty: -80 MMBtu/hr

The duty for the first pumparound is adjusted so that the top of the tower is at 150 F.

You will model the tower with six equilibrium stages. The light vacuum gas oil is taken out from stage 2 as a total draw. The flow is estimated at 8,000 bbl/day.

The second pumparound provides all the necessary reflux for the lower section of the tower. The heavy vacuum gas oil is withdrawn from stage 4 at 17,000 bbl/day.

Starting Aspen Plus

To start Aspen Plus:

- Use the Windows Start menu, or double-click the Aspen Plus icon on your desktop.

Note If the Connect Host dialog box appears, see Appendix A.

The Aspen Plus Startup dialog box appears.

Opening an Existing Run

If you saved the crude flowsheet simulation created in Chapter 3:

- In the Aspen Plus Startup dialog box, select Open an Existing Simulation.

If your saved file `crude.bkp` appears in the list box:

- Select `crude.bkp` from the list and click OK.

If your saved file `crude.bkp` does not appear in the list box:

- Double-click on More Files... in the list box.

The Open dialog box appears.

- Navigate to the directory that contains your saved file `crude.bkp`.
- Select `crude.bkp` from the list of files and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

If you did not create the crude distillation simulation in Chapter 3, you can open the backup file `crude.bkp` in the Examples folder.

- From the Aspen Plus Startup dialog box, select Open an Existing Simulation. Click OK.

The Open dialog box appears.

- Click the Look in Favorites button .

By default, the Favorites list contains five folders that are provided with Aspen Plus.

- Double-click the Examples folder.
- Select `crude.bkp` and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

Aspen Plus displays the graphical flowsheet for the CRUDE run.

Saving a Run Under a New Name

Before you create a new run adding the vacuum unit, you will create and save a copy of CRUDE with a new Run ID, VACUUM. Then you can make modifications under this new Run ID.

- From the File menu, click Save As.

The Save As dialog box appears.

- Choose the directory where you want to save the simulation.

- In the Filename box, enter the new filename **VACUUM**.

- From the Save as Type list, select Aspen Plus Backup Files (*.bkp).

- Click Save to save the simulation and continue.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

The current run ID, VACUUM, now appears in the titlebar.

To update the title for this run:

- From the Data menu, select Setup.

The Setup Specifications form appears.

- Change the simulation title to **Getting Started with Petroleum-Session 4**.

- Close the window.

The graphics workspace is now active and ready for you to add to the existing flowsheet.

Adding a Vacuum Tower to the Flowsheet

You are ready to add the vacuum tower and steam feed to the flowsheet. To make space for the new tower:

- From the View menu, select Zoom Out.
- Drag a region around the entire flowsheet.
- Press and hold the left mouse button within the region and drag the flowsheet to the left, as shown in Figure 4.2.

Next, you will place and connect the vacuum unit on the flowsheet to create the process flowsheet in Figure 4.2. If you need to review how to create a graphical simulation flowsheet, see *Getting Started Building and Running a Process Model*, Chapter 2.

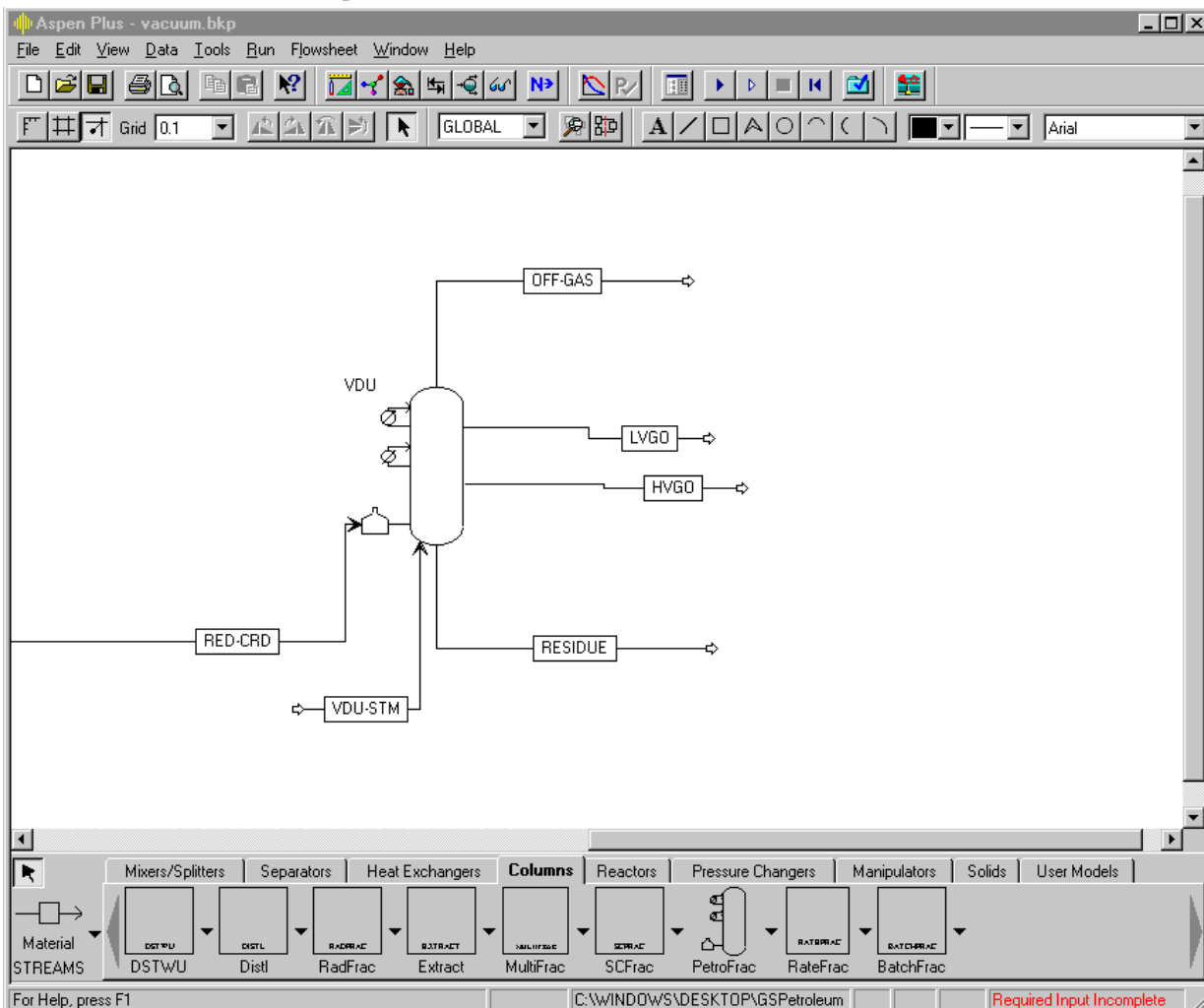


Figure 4.2 The Vacuum Unit

To place and connect the distillation unit on the flowsheet:

- Click the Column tab in the Model Library.
- Select the unit operation model, PetroFrac, to place in your process flowsheet.
- Click the down arrow next to the PetroFrac block icon to display all the icons available for the PetroFrac model.
- Move the mouse over the icons to see a name (or label) for each.

In this exercise, you will select the PetroFrac icon VACUUM1F.

- Click and hold down the mouse button on the PetroFrac icon CDU10F, and drag it to the Process Flowsheet window. Release the mouse button when it is in the desired location.
- Place the VACUUM1F icon in the flowsheet, as shown in Figure 4.2. Name the block **VDU**.
- To increase the size of the icon, hold down the Shift key, then press the + key.
- Connect, move, and name the streams, as shown in Figure 4.2, using the port information below for guidance.

Stream ID	Port Name
RED-CRD	Main Column Feed
VDU-STM	Main Column Feed
OFF-GAS	Vapor Distillate from Main Column
LVGO	Side Product from Main Column
HVGO	Side Product from Main Column
RESIDUE	Bottoms Product from Main Column

- Click the Next button.

The Flowsheet complete dialog box appears.

- Click OK.

The Input form for stream VDU-STM appears.

Specifying the Steam Feed

Use the Input form for stream VDU-STEAM to specify the steam feed to the main column.

- Enter, or use List to select, the following stream conditions. (Be sure to check the prompts to see which fields are List fields.):

Temp	400 F
Pres	60 PSI
Composition Basis	Mass-Flow LB/HR
H2O Flow value	20000 LB/HR

The Input form for VDU-STM is complete:

Stream VDU-STM (MATERIAL) Input - Data Browser

Input

ENGPETRC

Specifications Flash Options PSD Component Attr.

Substream name: MIXED

State variables:

Temperature: 400 F

Pressure: 60 psi

Total flow: Stdvol bbl/day

Solvent:

Composition: Mass-Flow lb/hr

Component	Value
H2O	20000
C1	
C2	
C3	
IC4	
NC4	
IC5	
Total:	20000

Input Complete

- Click the Next button.

The Blocks VDU Setup Configuration sheet appears.

Specifying the Vacuum Unit

Use the Blocks VDU Setup form to specify the main column configuration.

- On the Configuration sheet, specify:

Number of stages **6**
 Condenser **None-Top pumparound**
 Reboiler **None-Bottom feed**

- Click the Next button.

The Setup Streams sheet appears.

- Enter the following feed locations and connections:

	State	Convention
RED-CRD	6	Furnace
VDU-STM	6	On-Stage

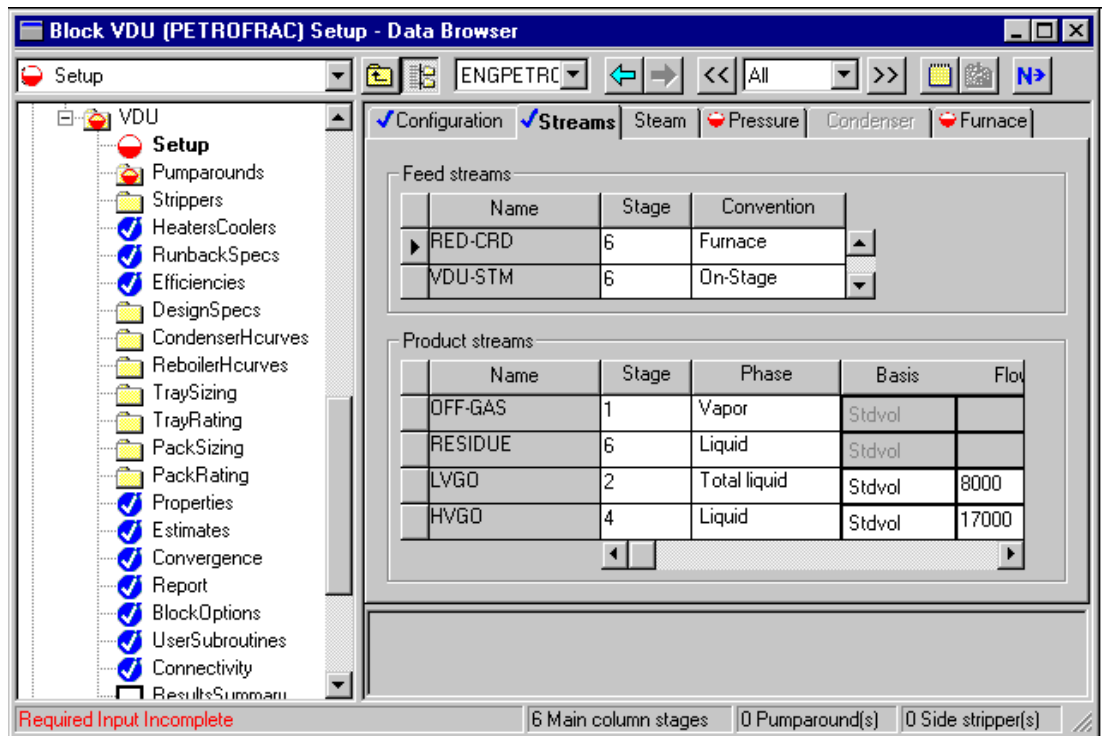
The Furnace feed convention attaches a furnace to stage 6. This furnace is solved simultaneously with the vacuum tower.

- Enter the following product location, phase, and rate specifications:

	Stage	Phase	Flow
LVGO	2	Total liquid	8000 bbl/day (estimate)
HVGO	4	Liquid	17000 bbl/day

LVGO is a total liquid draw from stage 2. The flow rate you enter is an estimate only.

The Setup Streams sheet is complete:



- Click the Next button.

The Setup Pressure sheet appears.

- Click the View field and select **Pressure profile**.

You will specify the pressure profile by entering stage numbers and corresponding pressures on this form.

- In the Pressure profile section of this form, change the pressure units to mmHg.
- Enter the following values:

Stage 1	Pressure 60 mmHg
Stage 6	Pressure 70 mmHg

The Setup Pressure sheet is complete.

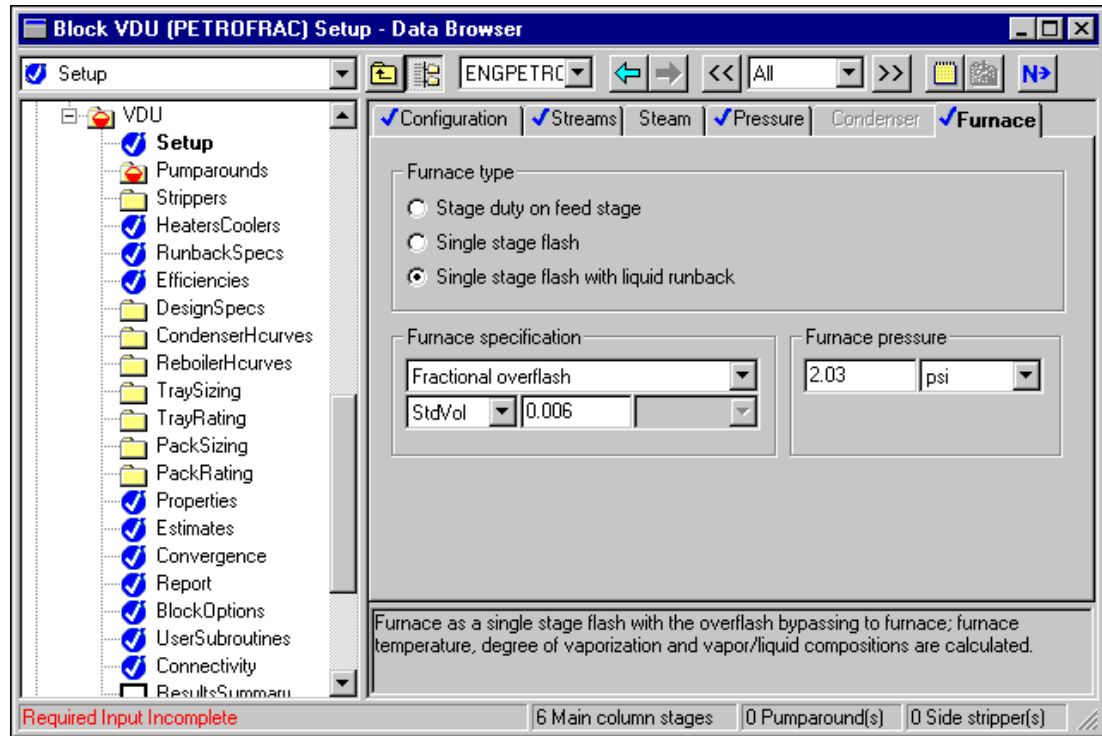
- Click the Next button.

The Setup Furnace sheet appears.

- Select the Single Stage Flash with liquid runback as the Furnace type.
- Specify a StdVol Fractional overflow of 0.006 and a Furnace pressure of 2.03 psi.

The single stage flash with liquid runback option models the furnace as a single-stage flash with the overflow from the flash zone now bypassed to the furnace.

The Setup Furnace sheet is complete:



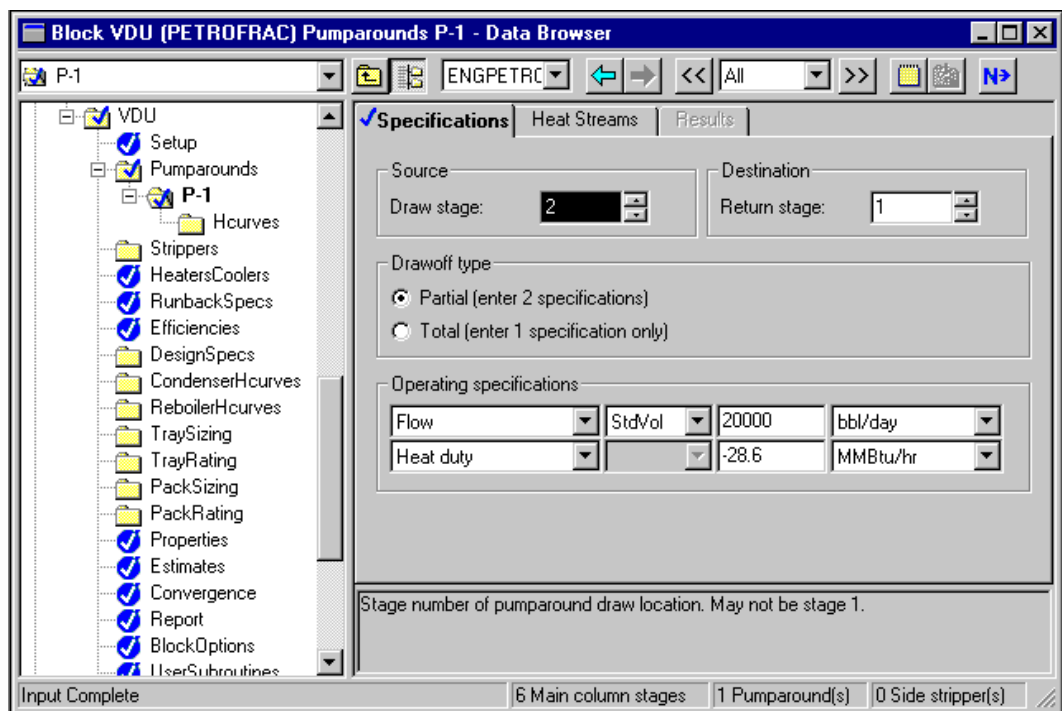
- Click the Next button.
- The Pumparounds Object Manager appears.
- Select New.
- In the dialog box, click OK to accept the default ID P-1.

The Blocks VDU Pumparounds P-1 form appears.

- To specify P-1, enter, or use List to select, the following specifications:

Draw stage	2
Return stage	1
Drawoff type	Partial
StdVol Flow	20000 bbl/day
Heat duty	-28.6 MMBtu/hr

The Pumparounds P-1 form is complete:



- In the Data Browser window, click the Pumparounds folder.

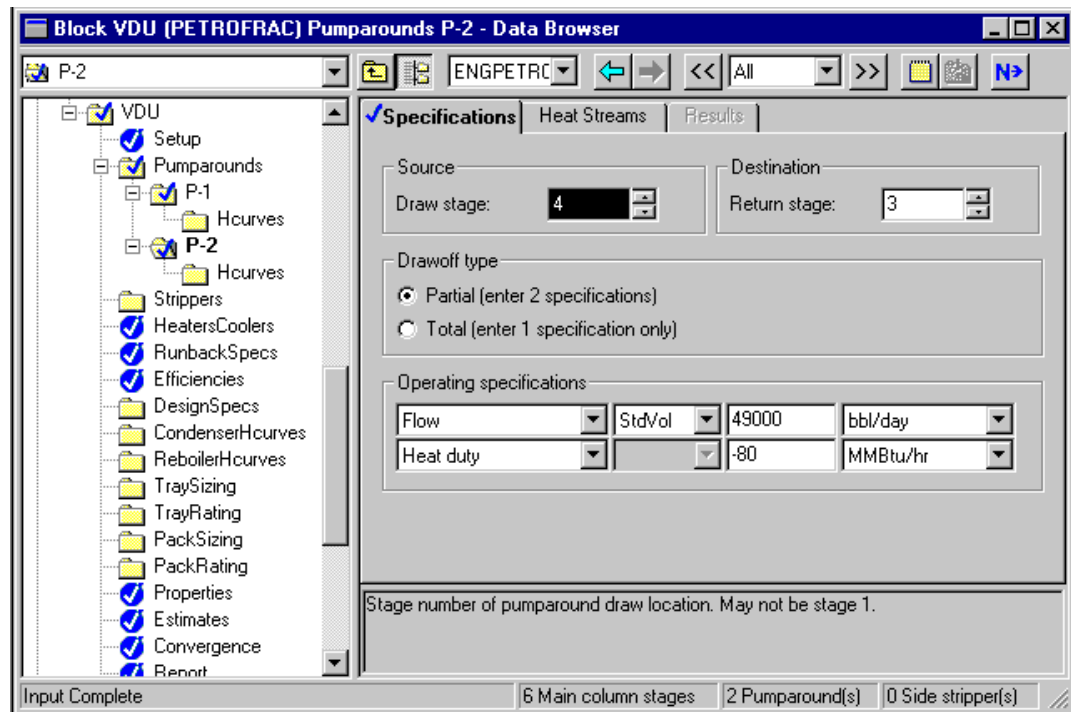
The Pumparound Object Manager appears.

- Select New.
- In the dialog box, click OK to accept the default ID P-2.

- Enter, or use List to select, the following specifications for P-2:

Draw stage	4
Return stage	3
Drawoff type	Partial
StdVol Flow	49000 bbl/day
Heat duty	-80.0 MMBtu/hr

The Pumparounds P-2 form is complete:



- Click the Next button.

The Required Input Complete dialog box appears.

You have completed all required PetroFrac specifications. However, in this session you have a design specification—the temperature specification for the top of the tower.

- Click Cancel.
- Click the Blocks VDU Design Specs folder.

The Design Specs Object manager appears.

- Click New.

- In the dialog box, click OK to accept the default ID 1.

The Blocks VDU Design Specs 1 Specifications sheet appears.

- Enter, or use List to select, the following specifications:

Type	Stage temperature
Target	150
Stage	1

- Click Next.

The Blocks VDU Design Specs 1 Vary sheet appears.

- Click on the arrow to the right of the Type box, and select Pumparound duty from the list.
- Select P-1 as the Pumparound name.

The design specification is complete.

- Close the window.

You have entered all the specifications for the vacuum unit.

- Close the Data Browser window.
- In the Aspen Plus main window, click the Next button.

Running the Simulation

To run the simulation:

- In the Required Input Complete dialog box, click OK.

The Control Panel appears.

As the run proceeds, status messages appear in the Control Panel. It takes about a minute for Aspen Plus to process input specifications and perform the simulation. When the calculations finish, the message *Results Available* in the status bar at the bottom of the main window.

- Use the vertical scroll bar to the right of the Control panel window to see the messages.
- When the *Results Available* message appears in the toolbar, click the Close button to close the Control Panel window.

You can now examine the results of your run.

Examining Simulation Results

This run produces a wide variety of simulation results. You will examine simulation results for the vacuum tower that include:

- Column profiles
- Pumparound results
- TBP curves
- Stream results

Column profiles are on the VDU Profiles sheet. To examine column profiles:

- Click the VDU block icon to select it.
- Press or click the right mouse button to display the Block menu.
- Select Results.

The Blocks VDU Results Summary form appears on the screen.

- Click the Profiles form in the Data Browser.

The screenshot shows the 'Block VDU (PETROFRAC) Profiles - Data Browser' window. The left pane shows a tree view with 'Profiles' selected. The main pane displays a table of profiles for 6 stages. The table columns are Stage, Temperature, Pressure, Heat duty, Liquid flow, and Vapor flow. The temperature unit is set to Fahrenheit (F), pressure to psi, and heat duty to MMBtu/l. The status bar at the bottom indicates 'Results Available' and '6 Main column stages | 2 Pumparound(s) | 0 Side stripper(s)'.

Stage	Temperature	Pressure	Heat duty	Liquid flow	Vapor flow
	F	psi	MMBtu/l	lbmol/hr	lbmol/hr
1	150.000527	1.16020648	-25.975401	812.289642	1110.323
2	320.639097	1.19888003	0	1095.21978	1131.690
3	524.630042	1.23755358	-80	2181.36794	1414.620
4	603.647375	1.27622713	0	2084.19237	2146.724
5	781.826607	1.31490068	0	4.28268393	2049.548
6	791.028483	1.35357423	0	178.220848	1203.670

This form shows that the simulation calculated a bottom temperature above 790 F. If this is higher than you want, you can reduce the tower pressure in a later simulation case. Lowering the tower pressure also affects the gas oil yield.

The pumparound results are on the VDU Pumparound Results sheet. To examine these results:

- In the Data Browser, click the Pumparounds folder.
- Click the Results tab.

The Pumparounds Results sheet appears, displaying pumparound results:

Pumparound ID:		P-1	P-2
Draw stage:		2	4
Return stage:		1	3
Temperature:	F	128.277734	419.352865
Pressure:	psi	1.19888003	1.27622713
Vapor fraction:		0	0
Heat duty:	MMBtu/hr	-25.975401	-80
Mole flow:	lbmol/hr	790.922786	1449.2646
Mass flow:	lb/hr	263663.383	675832.178
Std/Mol flow:	bb/dsu	19999.9637	49000.0881

- Close the window.

Plotting Distillation Curves

Next you will plot the TBP curve for streams LVGO, HVGO, and RESIDUE. The True Boiling Point curves appear on the Stream Results Vol.% Curves sheet. To plot TBP curves:

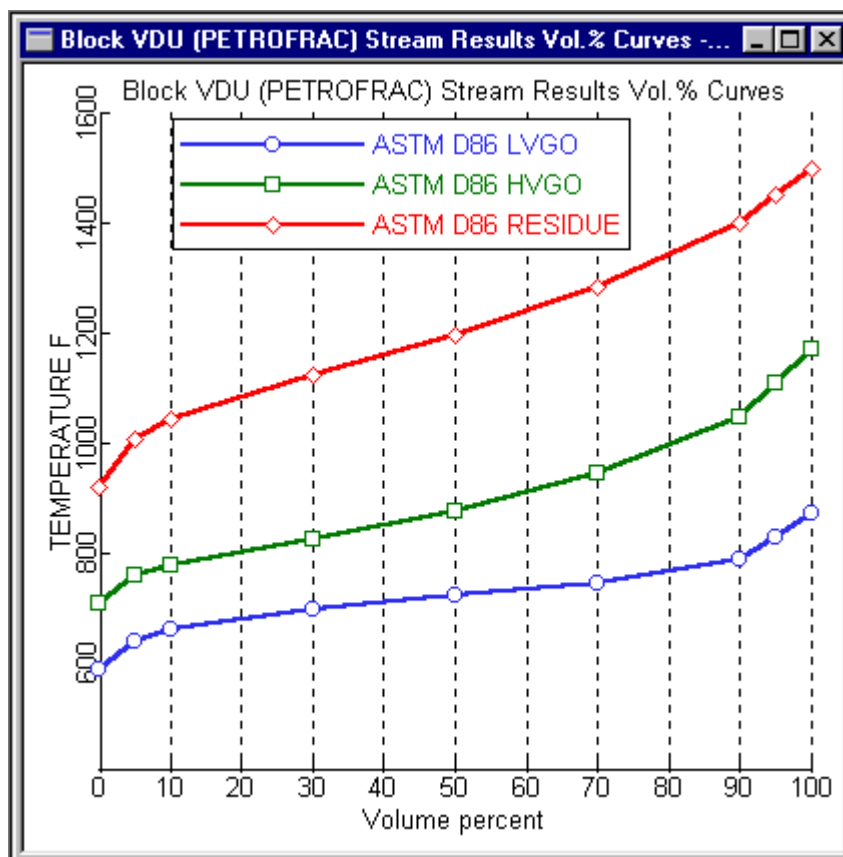
- In the Data Browser, click the VDU Stream Results form.

The Stream Results form is revealed.

- Click the Vol.% Curves tab.

The Stream Results Vol.% Curves sheet is displayed.

- Plot the ASTM curves for streams LVGO, HVGO, and RESIDUE following the same steps as in Chapter 3, Plotting Distillation Curves.



The simulation shows a good separation between the gas oils and residue. However, the separation between the light and heavy gas oils is rather sloppy.

- Close the Plot window.

Examining Stream Results

Next, you will review the stream results.

- Click the Material tab.
- Click the horizontal scrolling arrow at the bottom left of the form until the RESIDUE stream appears.
- Click the scrolling arrow at the bottom right of the form to scroll through the form and examine the results for the RESIDUE stream.

You can review the calculated flows and properties of the stream.

- To examine the calculated API gravity for this stream, click the scrolling arrow at the bottom left of this form until the API Gravity row appears.
- Click the horizontal scrolling arrow at the bottom left of the form until the LVGO stream appears.

The calculated value for LVGO product rate is different from the specified value of 8000 bbl/day. Since you specified a total draw, Aspen Plus treated the specified value as an initial guess. The final value is the one corresponding to the total draw from the stage.

Exiting Aspen Plus

To exit Aspen Plus:

- From the File menu, select Exit.

Aspen Plus displays a dialog box asking if you want to save your simulation.

- In the dialog box, select Yes to save the simulation.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

This run will be used as the starting point for the session in Chapter 5.



Adding a
Vacuum
Unit

5 Displaying Petroleum Stream Properties

It is important to monitor certain petroleum properties such as sulfur content, PNA composition, octane number, flash point, metals content, and pour point when modeling refinery operations. Frequently, operating parameters are adjusted in order to achieve a desired product quality, expressed in terms of these petroleum properties.

These properties are often available as part of the assay data for a crude feed. Aspen Plus enables you to enter these data as property curves. Once you enter these curves, Aspen Plus can calculate these properties for any flowsheet stream.

You can use the calculated stream properties as column specifications, access them in Fortran blocks, use them in optimization constraints, and so on.

In this session, as an example, you will include sulfur content in your model.

You will:

- Add a sulfur curve for each of the two crude oils
- Select options for the property sulfur
- Define a property set for the sulfur content
- Run the simulation
- Examine simulation results

Allow about 30 minutes to complete this session.

Starting Aspen Plus

To start Aspen Plus:

- Use the Windows Start menu, or double-click the Aspen Plus icon on your desktop.

Note If the Connect Host dialog box appears, see Appendix A.

The Aspen Plus Startup dialog box appears.

Opening an Existing Run

If you saved the crude flowsheet simulation created in Chapter 4:

- In the Aspen Plus Startup dialog box, select Open an Existing Simulation.

If your saved file vacuum.bkp appears in the list box:

- Select vacuum.bkp from the list and click OK.

If your saved file vacuum.bkp does not appear in the list box:

- Double-click on More Files... in the list box.

The Open dialog box appears.

- Navigate to the directory containing your saved file vacuum.bkp.
- Select vacuum.bkp from the list of files and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

If you did not create the vacuum unit simulation in Chapter 4, you can open the backup file vacuum.bkp in the Examples folder.

- From the Aspen Plus Startup dialog box, select Open an Existing Simulation, then click OK.

The Open dialog box appears.

- Click the Look in Favorites button .

By default, the Favorites list contains five folders that are provided with Aspen Plus.

- Double-click the Examples folder.
- Select vacuum.bkp and click Open.

Note If the Connect to Engine dialog box appears, see Appendix A.

The Aspen Plus main window appears.

Aspen Plus displays the graphical flowsheet for the VACUUM run.

Saving a Run Under a New Name

Before you create a new run adding sulfur content specifications, you will create and save a copy of VACUUM with a new Run ID, PPROP. Then you can make modifications under this new Run ID.

- From the File menu, click Save As.

The Save As dialog box appears.

- Choose the directory where you want to save the simulation.

- In the Filename box, enter the new filename **PPROP**.

- From the Save as Type list, select Aspen Plus Backup Files (*.bkp).

- Click Save to save the simulation and continue.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No.

The current run ID, PPROP, now appears in the titlebar.

To update the title for this run:

- From the Data menu, select Setup.

The Setup Specifications form appears.

- Change the simulation title to **Getting Started with Petroleum-Session 5**.

- Close the window.

Adding Sulfur Content Data

In Chapter 1 you defined and blended two crude oils, OIL-1 and OIL-2. Now you will enter the sulfur content (in weight percent) of these oils into your simulation.

- From the Data menu, select Components.

The Assay/Blend and the Petro Characterization folders are revealed.

- Expand the Assay/Blend folder.

The folders for the blend, MIXOIL, and the two assays, OIL-1 and OIL-2, that were created are revealed.

- Expand the OIL-1 folder.

The Basic Data, Property Curves, and Results form are revealed.

- Click on the Property Curves form.

The Assay/Blend Property Curves form for OIL-1 appears.

- Click the Property type field, and select SULFUR from the list.

- In the Bulk value field, enter **2.3**.

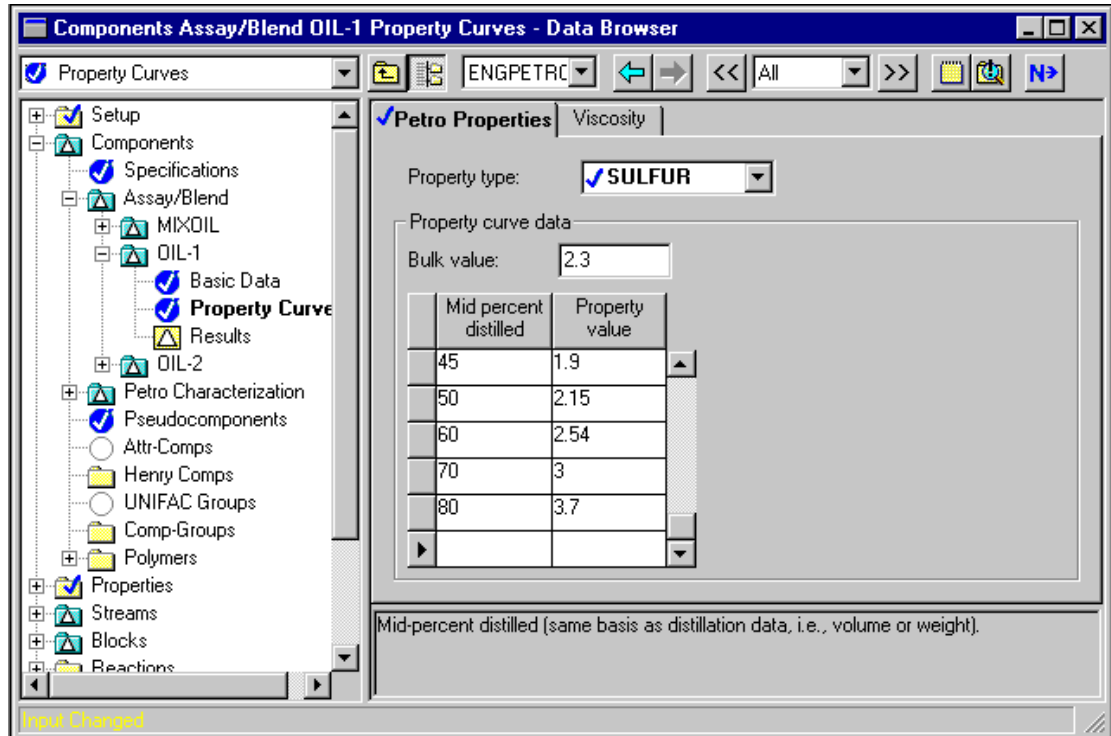
- In the Mid percent distilled and Property value fields, enter the following sulfur content percentage values for OIL-1:

Mid percent distilled	Property value (wt% sulfur)
2.0	0.0
5.0	0.01
10.0	0.013
20.0	0.05
30.0	1.15
40.0	1.62
45.0	1.90
50.0	2.15

Continued

Mid percent distilled	Property value (wt% sulfur)
60.0	2.54
70.0	3.0
80.0	3.7

The Assay/Blend Property Curves form for OIL-1 is complete:



To add sulfur content percentages for OIL-2:

- In the Data Browser, expand the OIL-2 folder.
The Basic Data, Property Curves, and Results form are revealed.
- Click the Property Curves form.
The Assay/Blend Property Curves form for OIL-2 appears.
- Click the Property type field, and select SULFUR from the list.
- In the Bulk value field, enter 2.5.
- Enter the following sulfur content percentage values for OIL-2:

Mid-Pct	Prop. Value
2.0	0.0
5.0	0.01
10.0	0.015
20.0	0.056
30.0	1.3
40.0	1.7
45.0	2.0
50.0	2.3
60.0	2.7
70.0	3.2
80.0	3.8

The Assay/Blend Property Curves form for OIL-2 is complete.

Selecting Options for the Sulfur Property

For a petroleum property, you can select calculation options such as the blending and extrapolation methods.

Now you will select options for the sulfur property.

- In the Data Browser, expand the Petro Characterization folder.

The Generation and Property Methods folders, and Analysis Options and Results forms are revealed.

- Click the Analysis Options form.

- Click the Blend Options tab.

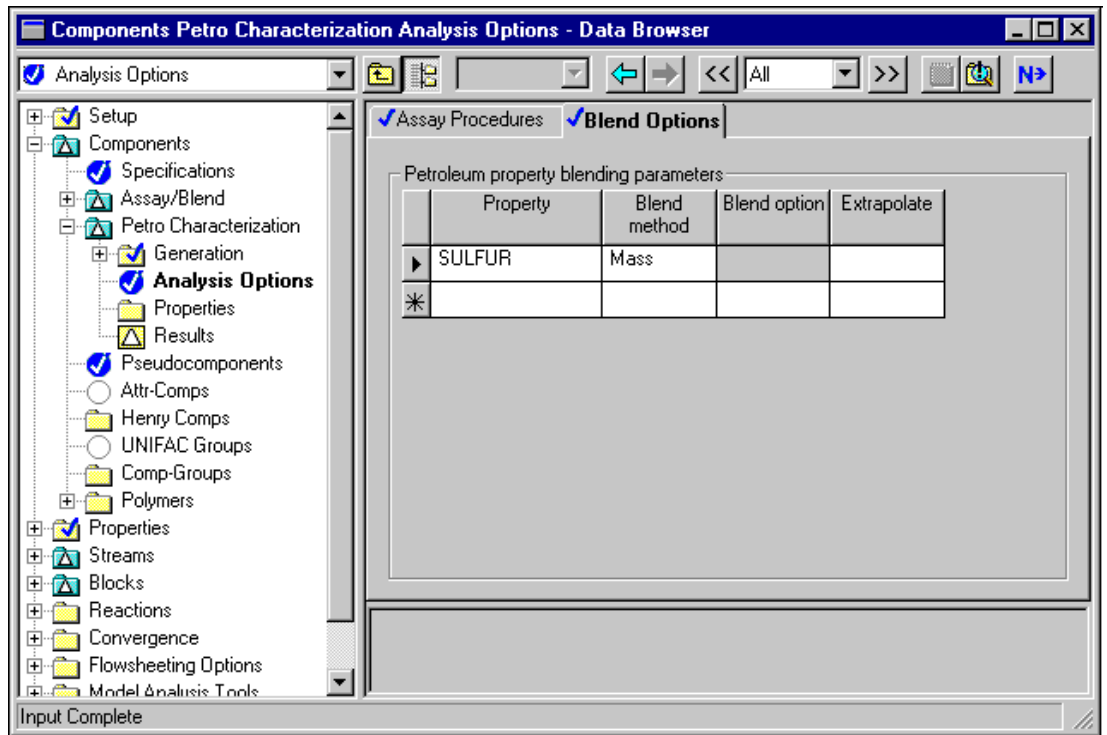
The Components Petro Characterization Analysis Options Blend Options sheet appears.

- Enter the following data for the Property and Blend method fields:

Property	SULFUR
Blend Method	Mass

By default, Aspen Plus will extrapolate to the 0 and 100% points, if these values are missing from the curve.

The Petro Characterization Analysis Options form is complete:

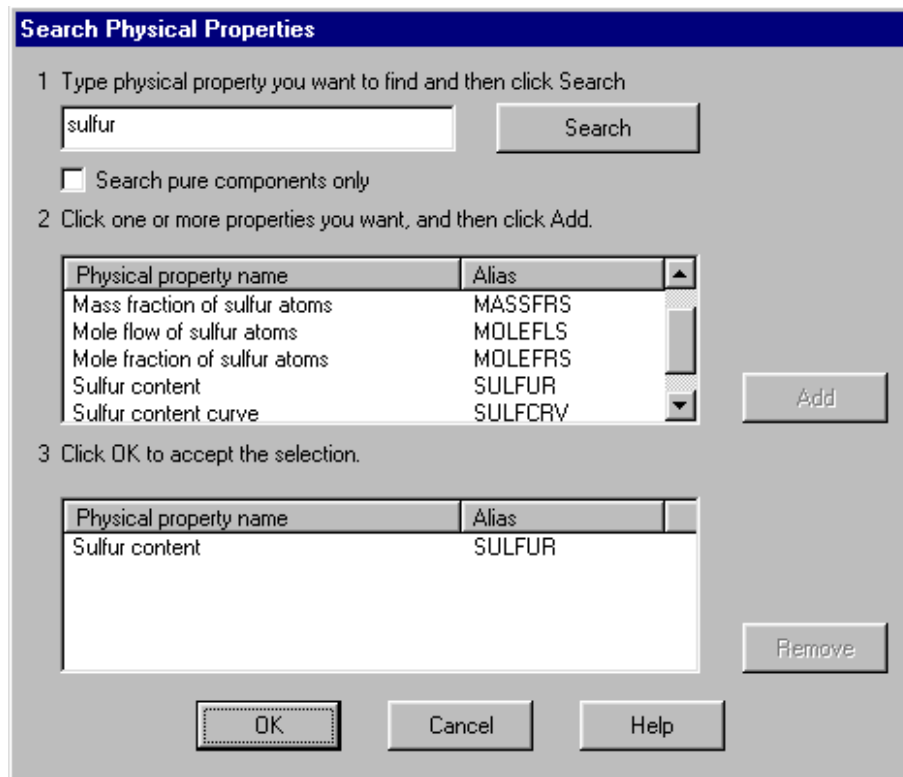


- Close the Data Browser window.

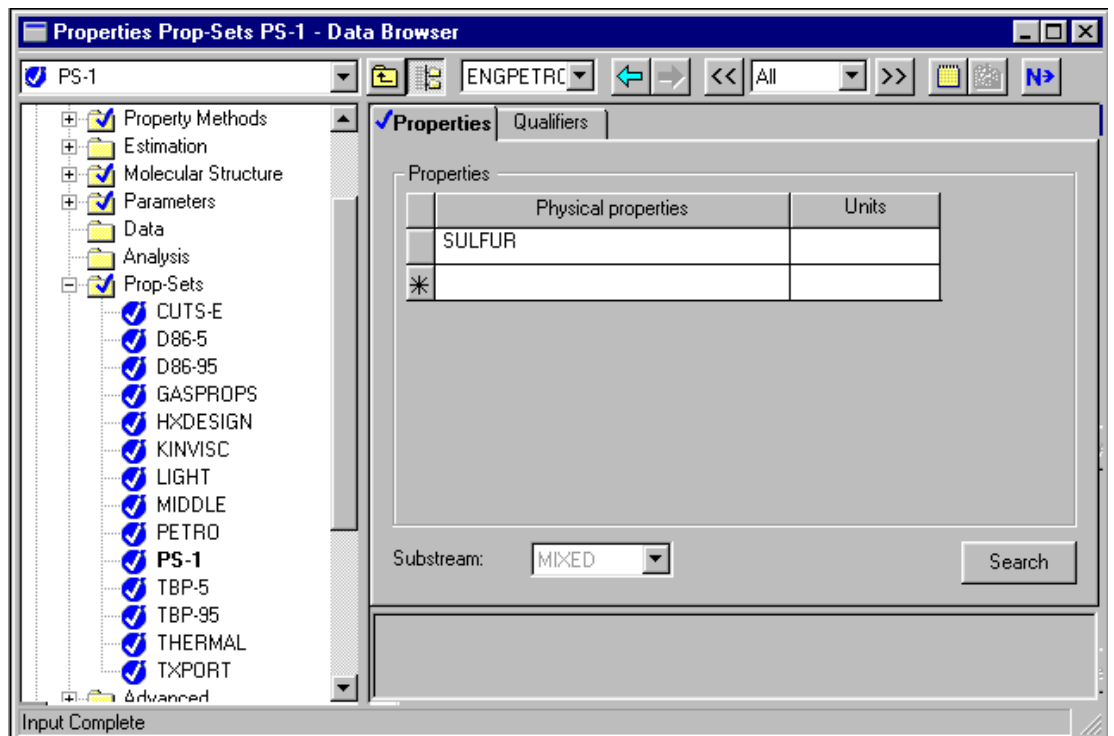
Adding the Sulfur Property

In order to include in the report the sulfur property you just defined, you must create a Property Set.

- From the Data menu, select Properties.
- Click the Prop-Sets folder.
The Prop-Sets Object Manager appears.
- Select New.
- In the dialog box, click OK to accept the default name, PS-1.
- Click OK.
- Click the Search button.
- In the Search Physical Properties dialog box, type **Sulfur** in the field and click the Search button.
- Select **Sulfur content** from the list of Physical property names.
- Click the Add button.
- Click OK.



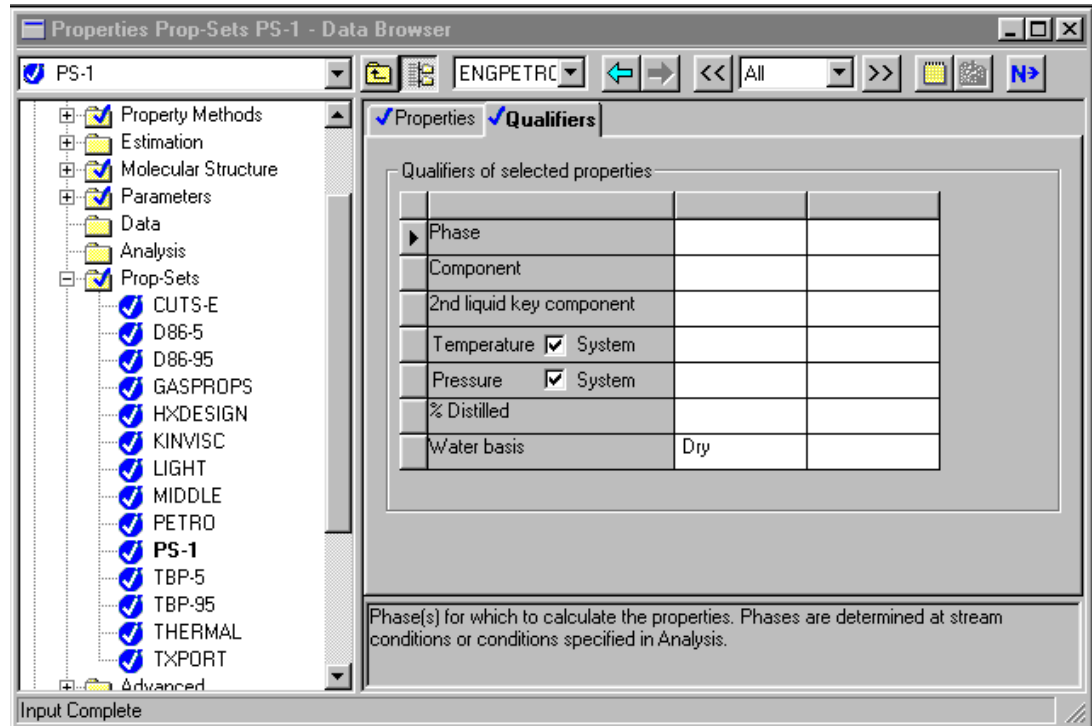
SULFUR now appears as a selected Physical Property on the Prop-Set form.



➤ Click the Qualifiers tab.

- In the Water basis field, select Dry from the list.

The Properties Prop-Sets PS-1 form is complete:



- Close the Data Browser window.

Now you will add the SULFUR Property Set to the stream property list.

- From the Data menu, expand the Setup folder.

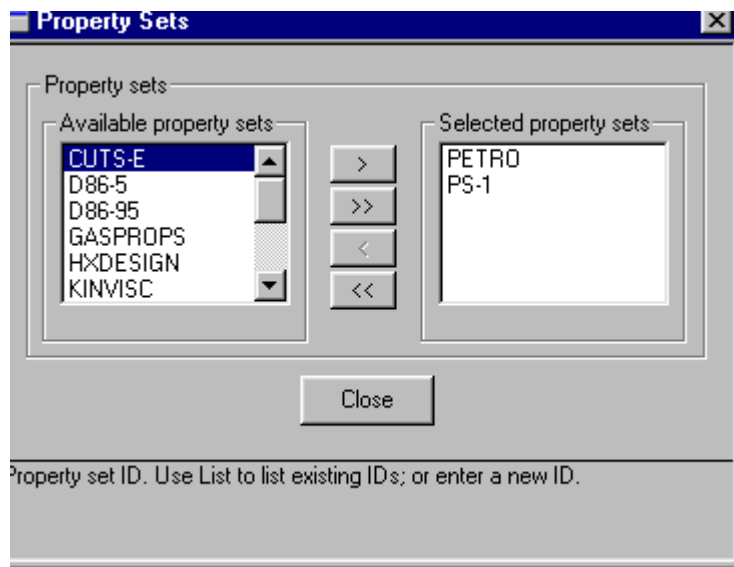
- Click the Report Options form.

- Click the Stream tab.

The Setup Report Options Stream sheet appears.

- Click the Property Sets button.

- Move PS-1 from the Available property sets area to the Selected property sets area using the > button.



- Click the Close button.

The Report Options form is now complete.

- Close the Data Browser window.
- In the Aspen Plus main window, click the Next button.

Running the Simulation

To run the simulation:

- In the Required Input Complete dialog box, click OK.

The Control Panel appears.


As the run proceeds, status messages appear in the Control Panel. It takes about a minute for Aspen Plus to process input specifications and perform the simulation. When the calculations finish, the message *Results Available* appears in the status bar at the bottom of the main window.

- Use the vertical scroll bar to the right of the Control panel window to see the messages.

You can now examine the results of your run.

Examining Results

To review the stream results for the crude tower products:

- ▶ Click the Check Results button  on the Control Panel.

The Results Summary Run-Status form appears and indicates that the calculations were completed normally.

To examine the stream results:

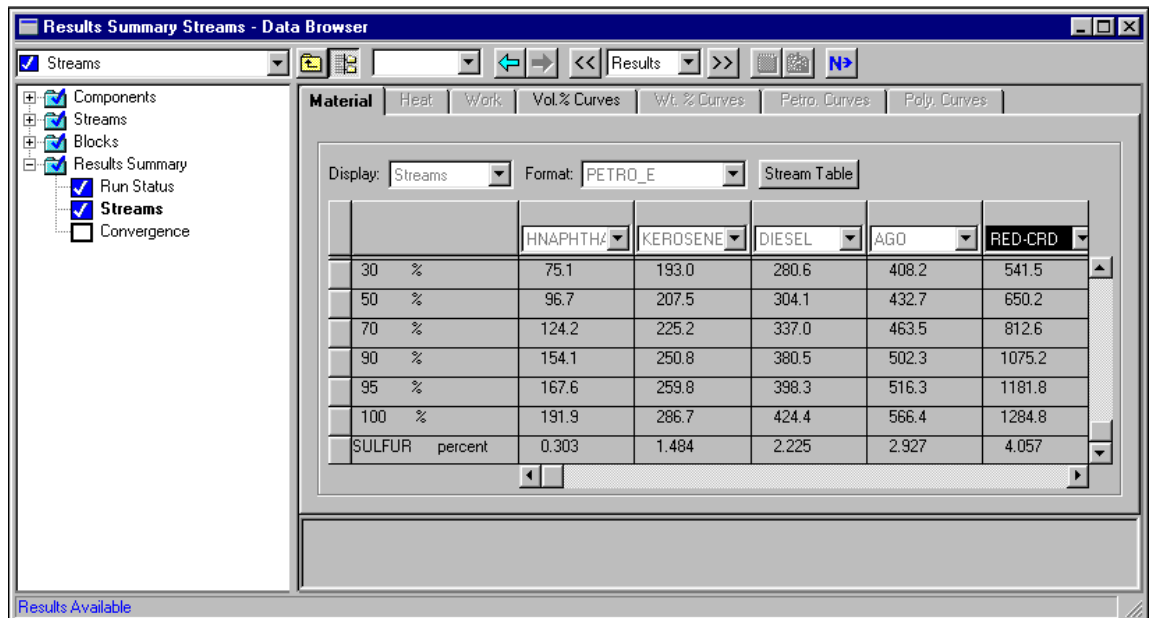
- ▶ Click the first Results Summary Streams form.

The Blocks Results Summary Streams Material sheet appears.

To examine the results for the five product streams:

- ▶ Click the first Streams field, select HNAPHTHA.
- ▶ In the next four Streams fields, select KEROSENE, DIESEL, AGO, and RED-CRD.
- ▶ Click the vertical scroll bar until you reach the SULFUR results.

The Results Summary Streams form displays sulfur content:



The screenshot shows the 'Results Summary Streams - Data Browser' window. The left sidebar has a tree view with 'Streams' selected. The main area displays a table with columns for 'Material', 'HNAPHTHA', 'KEROSENE', 'DIESEL', 'AGO', and 'RED-CRD'. The table shows sulfur content in percent for various streams, with a 'SULFUR percent' row at the bottom.

Material	HNAPHTHA	KEROSENE	DIESEL	AGO	RED-CRD
30 %	75.1	193.0	280.6	408.2	541.5
50 %	96.7	207.5	304.1	432.7	650.2
70 %	124.2	225.2	337.0	463.5	812.6
90 %	154.1	250.8	380.5	502.3	1075.2
95 %	167.6	259.8	398.3	516.3	1181.8
100 %	191.9	286.7	424.4	566.4	1284.8
SULFUR percent	0.303	1.484	2.225	2.927	4.057

As expected, the sulfur content of the heavier products, such as RED-CRD, is higher than the sulfur content for the lighter products, such as HNAPHTHA. By following the same procedure described in this section, you can incorporate other petroleum stream properties into your model and track their distribution throughout the flowsheet.

Leaving Aspen Plus

To exit Aspen Plus:

- From the File menu, select Exit.

A dialog box asks if you want to save your simulation.

- Select Yes to save the simulation.

A dialog box asks if you also want to save the simulation as an Aspen Plus Document file.

- Click No



A Connecting to the Aspen Plus Simulation Engine

If either of the following conditions exist, you will be prompted to specify the host computer for the Aspen Plus simulation engine after you start the Aspen Plus User Interface:

- The simulation engine is not installed on your PC.
- The simulation engine is installed on your PC, but the Activator security device is not connected to your PC.

In these cases, the Connect to Engine dialog box appears.

- Click the Server Type list box and select the type of host computer for the simulation engine.

If you choose Local PC as the server for the simulation engine, you do not need to enter any more information into the dialog box.

- Click OK to continue.

If you choose UNIX host, OpenVMS host, or Windows NT server as the server for the simulation engine:

- Enter the node name of the computer on which the Aspen Plus simulation engine will execute.
- Enter your User Name, Password, and Working Directory, and click OK.

When the network connection is established, a message box appears saying Connection Established.

If the Connection Established message does not appear, see your Aspen Plus system administrator for more information on network protocols and host computers for the Aspen Plus simulation engine.

