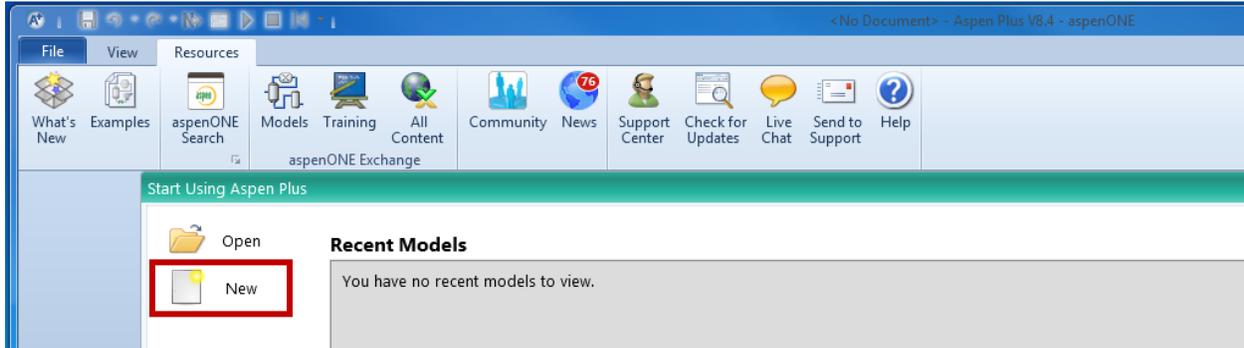


Aspen Plus Tutorial

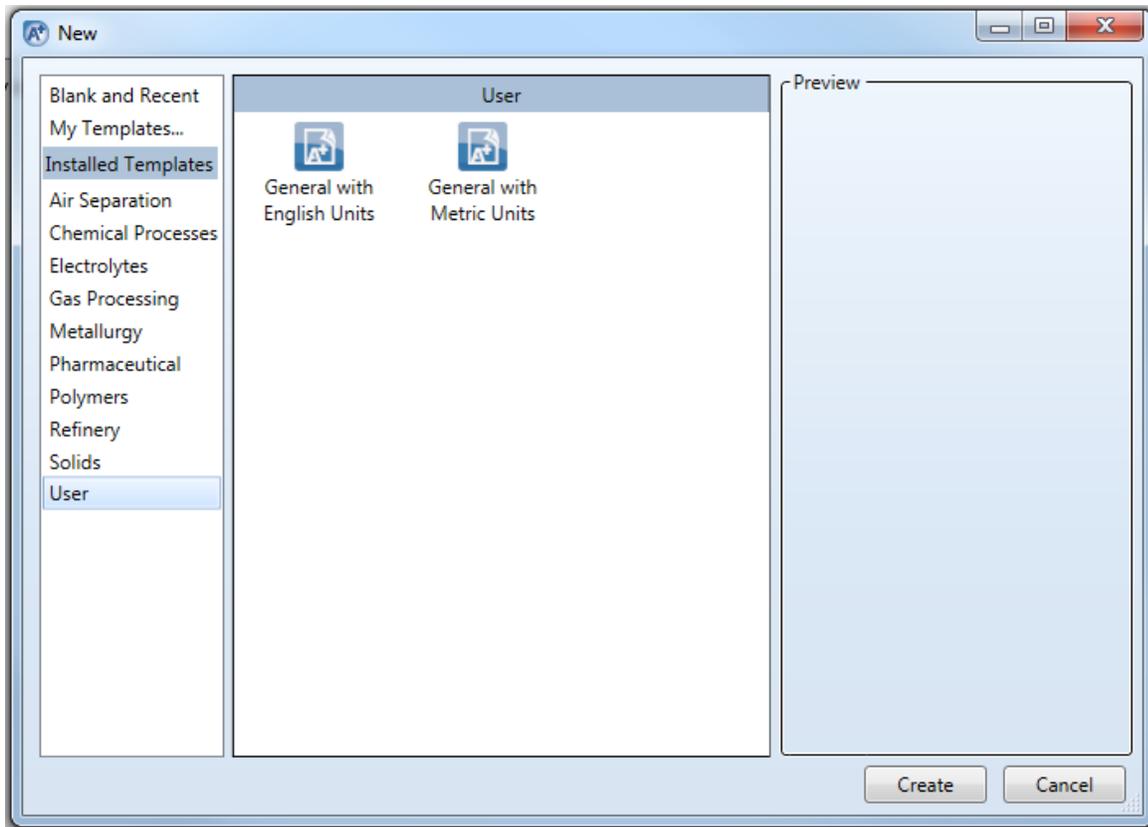
Start Menu -> All Programs -> Aspen Plus -> Aspen Plus V9

You will be prompted to start video or register now, exit out of this pop up to continue to the program

If you want to start a new project, simply click the “New” button that appears when Aspen Plus starts. If you don’t see this option, go to file -> new.

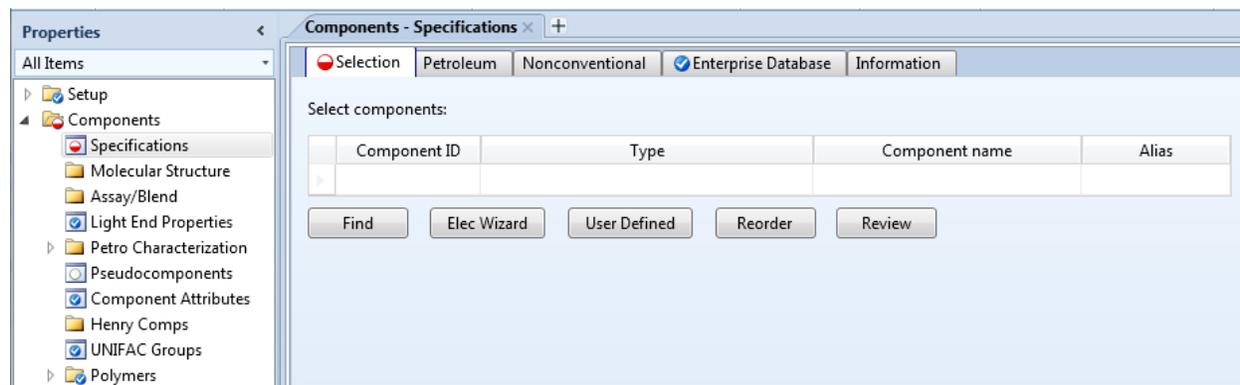


A new window should pop up with template options. Click on “User” in the left sidebar, and then choose either “General with English Units” or “General with Metric Units” depending on which units you would like to use. For this tutorial, the units template isn’t quite so important since we will be using a mixture of English and Metric units. We will select the “General with English Units” button and then click “create”.

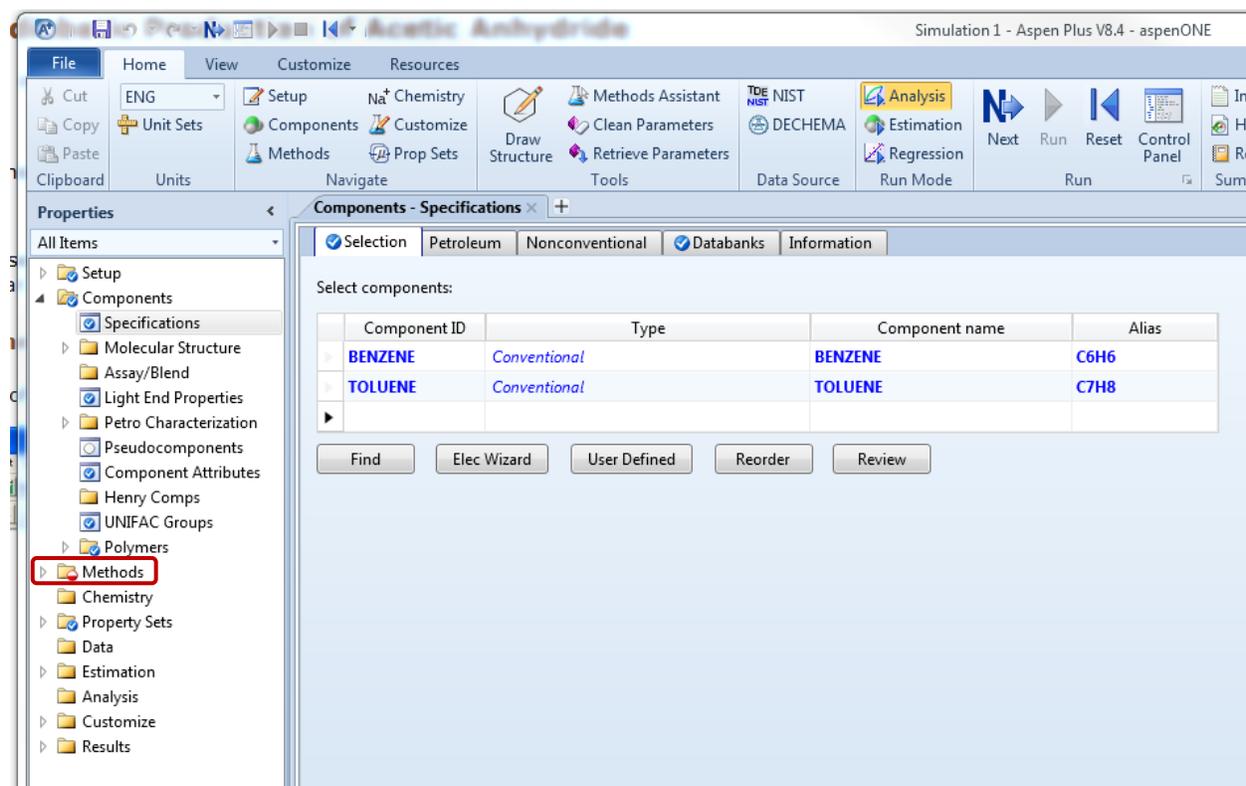


This tutorial will show a simplified version of how to use the RADFRAC block with some design constraints. We want to separate benzene and toluene, with a 99% mass purity of benzene in our 4500 kg/day product stream.

The first step of creating a simulation is defining the properties of the simulation. We will start by telling Aspen which compounds will be present in our system, which should be the first screen to come up anyways.

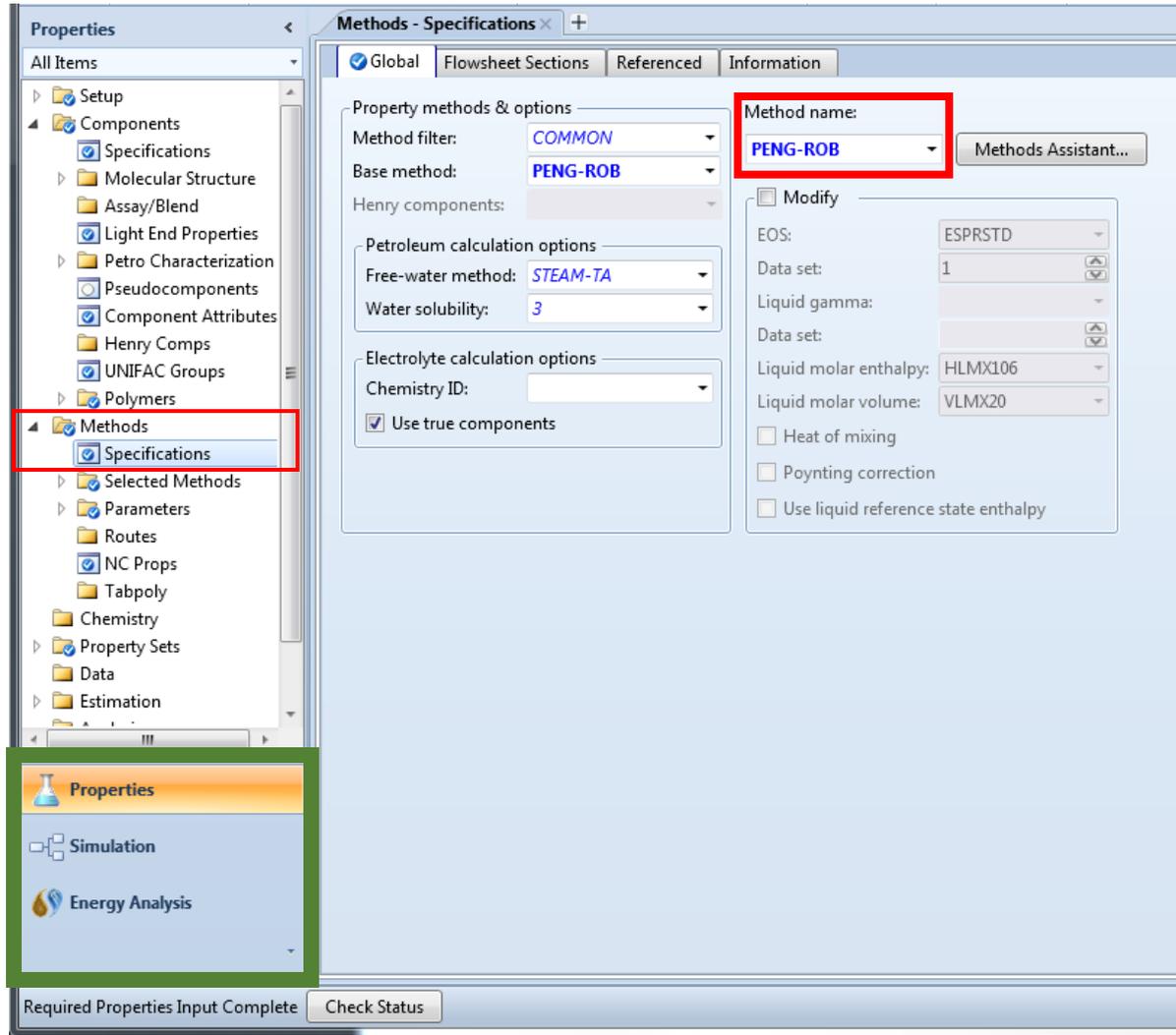


We will simply have benzene and toluene in our system. Because these are common chemicals, we can type them directly into the Component ID box. Type benzene and then press enter. Type toluene and then press enter. The screen should now look something like this.

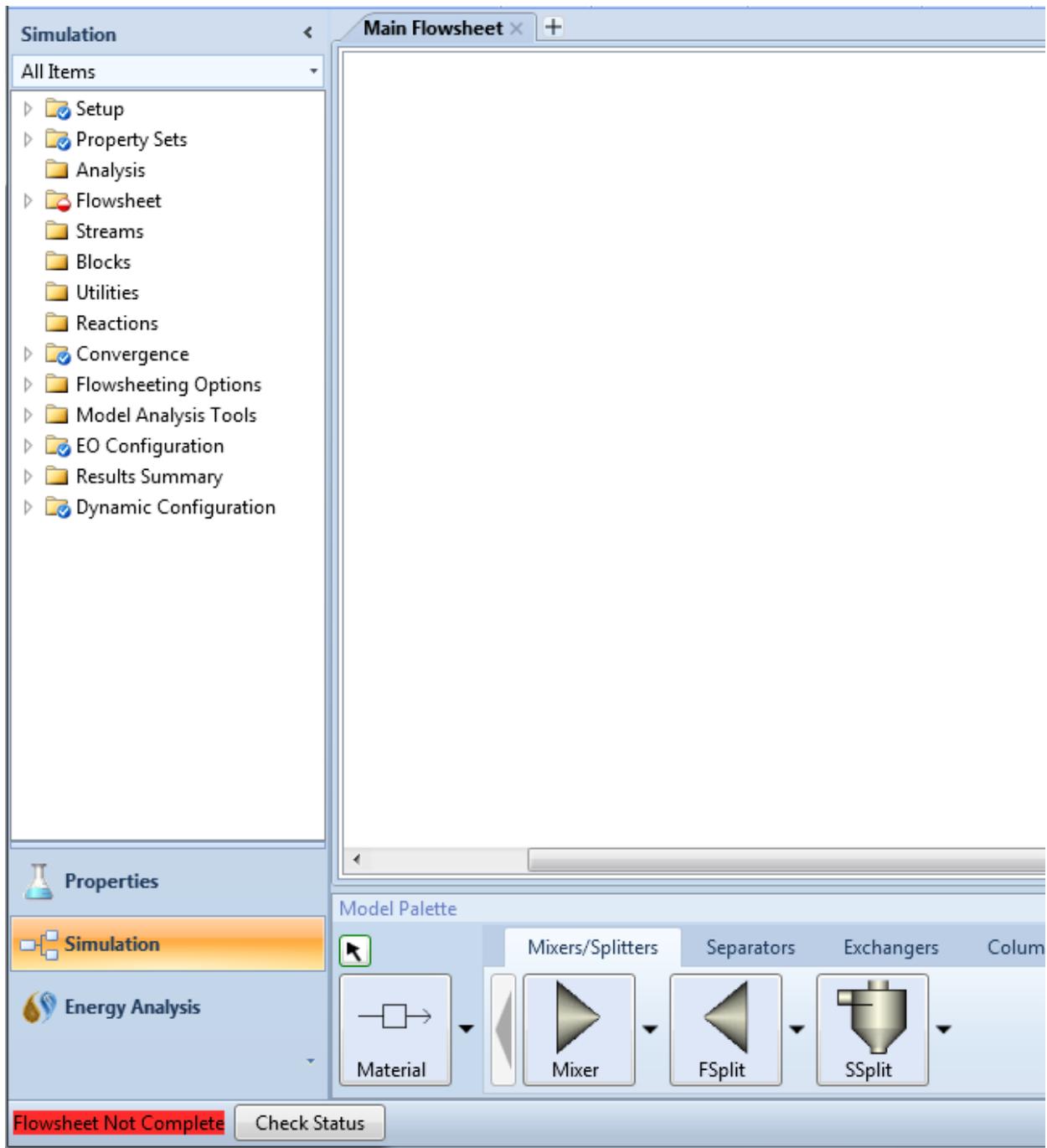


You'll notice in the previous picture that the folder named Methods on the left side of the screen (in the red box) has a small red half-filled circle icon on the folder icon. This indicates that more input is needed

in this section. Click on the little white arrow to the left of this folder and then click on Specifications. Here is where we will have to tell Aspen which equations to use to estimate properties of each of our components. These components are nonpolar, so we will use the Peng-Robinson Equation of State. In Aspen, click on the drop down menu for Method Name and find PENG-ROB. The rest of the sheet will be filled in by Aspen, and now the Methods folder on the left side of the screen has a blue check mark on it, which means we have provided enough information.



In the thick green box, you'll notice that we are in the Properties environment. This is all the background information that we just put in that Aspen Plus needs to calculate all the things we will want it to calculate later. Now we are ready to start our simulation. Click on Simulation right below Properties to go to the Simulation environment.



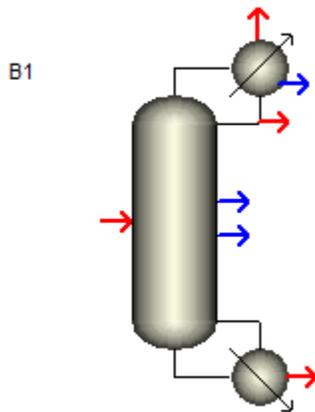
We now have a blank sheet to make a flowsheet of our process. To draw our process, we will need to use blocks and streams to tell Aspen Plus what components are going where and what is happening to them between the entrance and the exit of our process.

The picture below is the Model Palette, and it has everything we will need to draw the flowsheet. Click on the Columns tab, and Aspen Plus gives us a variety of different ways to model a distillation column

and other separation unit operations. We will be using RadFrac, which is a rigorous method of solving a distillation column.

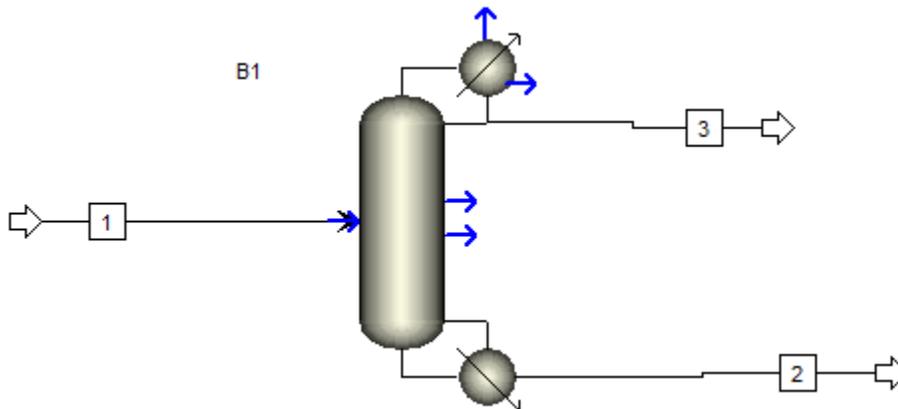


Click on the RadFrac icon and then anywhere in the white space above to put a distillation column in the flowsheet. Then click on the material icon to put in our streams. You'll notice that the distillation column now has red and blue arrows going in and out of it. The red arrow on the left is where the feed stream connects. The arrows coming out to the right are product and water streams. If you hover over them with your mouse, it will give a description of what each arrow is for. When connecting the streams, each stream must be connected exactly where Aspen wants it to be, otherwise it will be very confused. The red arrows indicate required streams, and the blue arrows indicate optional streams.



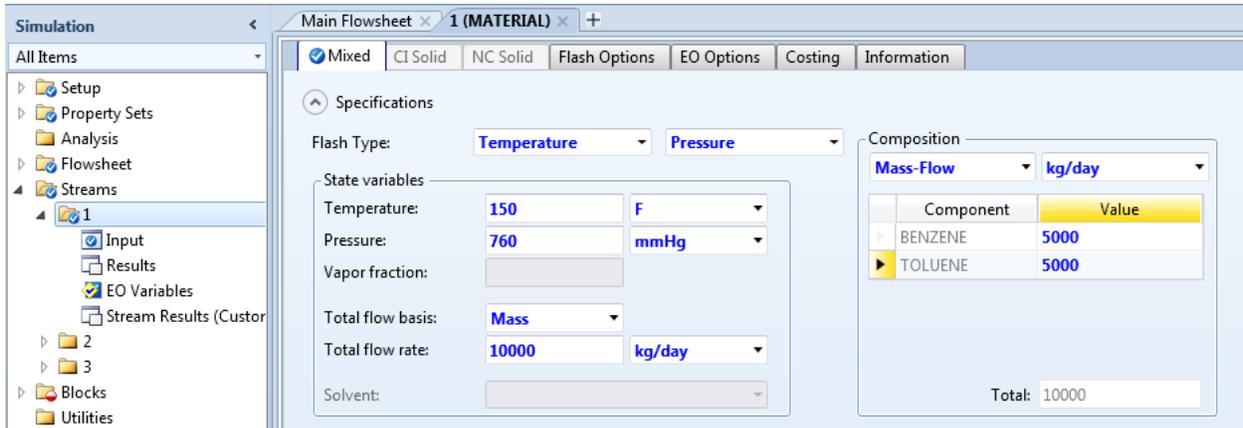
Click on the red arrow going into the distillation column, and then click again somewhere to the left of the picture. This is your feed stream. The circle below and to the right of the column is the reboiler, where we will get our bottoms product, toluene, out. Click on this red arrow and again somewhere to the right of the picture to get a product stream. The circle above and to the right of the column is a condenser. We can get either a vapor or a liquid distillate product, but we will just use a liquid distillate. Click on the lower red arrow on the condenser and click again somewhere to the right of the column. This will be our benzene product stream.

Now your flowsheet should look like this.

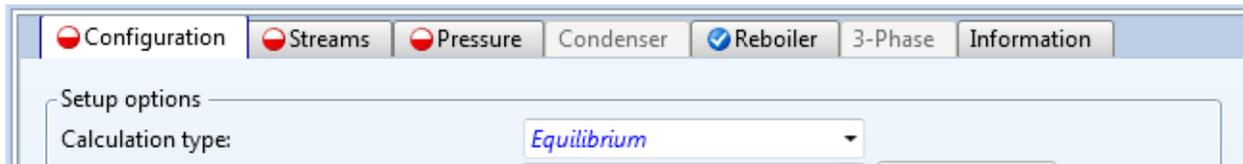


Our flowsheet is complete, but we still have to tell Aspen Plus the background information of each of the blocks and streams. To do this, we will go back to the folders on the left side of the screen. Streams

is at the top, so we'll start there. Click the little white arrow next to Streams and then click on 1, which is our feed stream. We need two of either temperature, pressure, and vapor fraction. We will use temperature and pressure and set them to 150°F and 760 mm Hg, respectively. To change the units on the pressure, use the drop down menu and find mmHg. Our total flow rate will be 10000 kg/day. First change the flow basis to mass instead of mole, and then find kg/day in the units box. To the right, there is a box for Composition. To specify this, we want Mass-Flow in kg/day, with half of the mass being benzene and the other half being toluene. This means 5000 kg/day for each component. Another way to do this is to use mass fractions, with values of 0.5 for each component. You should end up with the picture below.



Now you'll see that the Streams folder is good, and we only have the Blocks folder left to fill in information. Click on the white arrow next to Blocks and then click on B1, which is the default name for our distillation column. You'll notice there are several tabs on this page that need more information.



We'll start with Configuration and work our way through the rest of them.

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

Setup options

Calculation type: *Equilibrium*

Number of stages: Stage Wizard

Condenser:

Reboiler: *Kettle*

Valid phases: *Vapor-Liquid*

Convergence: *Standard*

Operating specifications

Distillate rate *Mole* *lbmol/hr*

Reflux ratio *Mole*

Free water reflux ratio:

We want 35 stages with a total condenser. We want a Distillate rate of 4500 kg/day, and we'll start with a Reflux ratio on a mole basis of 5. The reflux ratio will be changed later to get the purity that we want. Below is what your screen should look like with this information entered.

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

Setup options

Calculation type: *Equilibrium*

Number of stages: **35** Stage Wizard

Condenser: **Total**

Reboiler: *Kettle*

Valid phases: *Vapor-Liquid*

Convergence: *Standard*

Operating specifications

Distillate rate **Mass** **4500** **kg/day**

Reflux ratio **Mole** **5**

Free water reflux ratio:

Now we will specify the streams, which is all of telling Aspen Plus where our feed stream connects to our tower. Let's put that at Stage 20 and leave the Above-Stage Convention. The product streams can be left where they are, and we don't have any pseudo streams.

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

Feed streams

Name	Stage	Convention
1	20	<i>Above-Stage</i>

The last thing to specify for this tower is the pressure. To do this, we will set the stage 1/condenser pressure to 5 psig and leave the optional boxes blank to make this simulation simpler.

Configuration Streams Pressure Condenser Reboiler 3-Phase Information

View: *Top / Bottom*

Top stage / Condenser pressure

Stage 1 / Condenser pressure: 5 psig

Stage 2 pressure (optional)

Stage 2 pressure: psia

Condenser pressure drop: psi

Pressure drop for rest of column (optional)

Stage pressure drop: psi

Column pressure drop: psi

You'll notice that we are done now. When we specified a total condenser, it became fully specified, and the reboiler was specified from the Kettle type we put in. Feel free to look at these to see what other options are for these pieces of the distillation column, but leave them how they are. Now our simulation



is ready to run, or calculate. The run button looks like this and can be found under the home tab. If you can't find it, there is always a run button that is just the triangle on the very top ribbon, to the right of the save icon. Click this button and wait a few seconds for Aspen Plus to calculate the simulation. With how we specified our tower, this message should show up saying we have some warnings.

Simulation Warnings

Your simulation has completed with warnings.
Results are present.

Display Run-Status results form

Enter Equation Oriented input

Synchronize Equation Oriented models

OK Cancel

Click OK so we can see what the problems are.

The screenshot shows the Aspen Plus Status window. At the top, there are two tabs: 'Summary' and 'Status' (which is active and has a warning icon). Below the tabs, there are three sections: 'Convergence status:', 'Property status:', and 'Aspen Plus messages:'. The 'Aspen Plus messages:' section contains the following text:

```
The following Unit Operation blocks were
completed with warnings:
B1

The following messages were issued during Input Translation:

INFORMATION
BINARY PARAMETERS PRKIJ (DATA SET 1) FOR MODEL ESPRSTD
ARE RETRIEVED FROM SDF TABLE. TABLE NAME = ESPRSTD
```

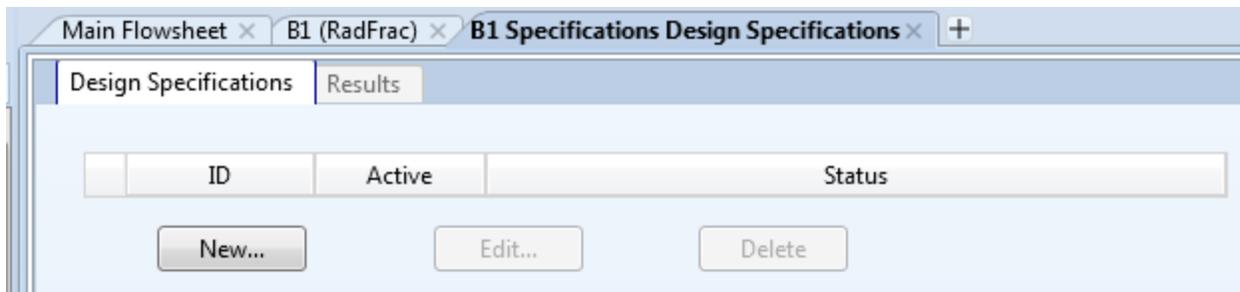
Click on the blue B1 and Aspen Plus tells us that the feed pressure is lower than the stage pressure. Usually, this means that the fluid won't enter the tower because it is going the wrong way across a pressure gradient. Go back to specifying block B1 and change the pressure of the condenser to 0 psig. Now run it again.

If everything worked just fine, there will be no warning or error message to pop up and the bottom left corner will read "Results Available". Now we will look at our results. There are several ways to do this, but the easiest way sometimes is to go back to the Main Flowsheet, click on a stream to select it, and then right click it to choose Results → Custom Stream Results, which is shown below for stream 3, our benzene product stream.

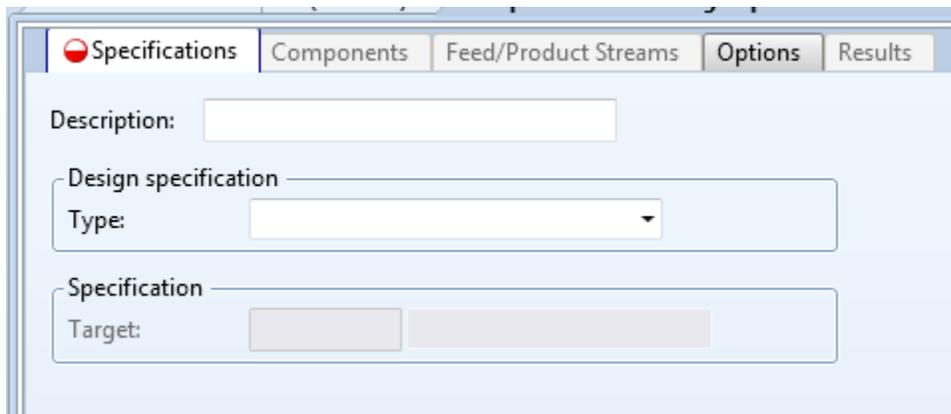
Default				
		Units	3	
▶	From		B1	
▶	To			
▶	Substream: MIXED			
▶	Phase:		Liquid	
▶	Component Mole Flow			
▶	BENZENE	KMOL/DAY	57.6084	
▶	TOLUENE	KMOL/DAY	5.89663e-06	
▶	Mole Flow	LBMOL/HR	5.29186	
▶	Mass Flow	LB/HR	413.367	
▶	Volume Flow	CUFT/HR	8.13035	
▶	Temperature	F	176.263	
▶	Pressure	PSIA	14.696	
▶	Vapor Fraction		0	
▶	Liquid Fraction		1	
▶	Solid Fraction		0	
▶	Molar Enthalpy	BTU/LBMOL	24604	
▶	Mass Enthalpy	BTU/LB	314.978	
▶	Enthalpy Flow	BTU/HR	130201	
▶	Molar Entropy	BTU/LBMOL-R	-54.4248	
▶	Mass Entropy	BTU/LB-R	-0.696739	
▶	Molar Density	LBMOL/CUFT	0.650877	
▶	Mass Density	LB/CUFT	50.8424	
▶	Average Molecular Weight		78.1136	

You can change the units on all of the rows that have units if the default units are not very helpful. Mass Flow is shown for the whole stream, and the component flows are shown in molar flow. This stream is extremely pure benzene, but we did have a high reflux ratio specified before. To make this purity closer to what we want, let's add a design specification to this problem to tell Aspen Plus that we want a mass purity of 99%.

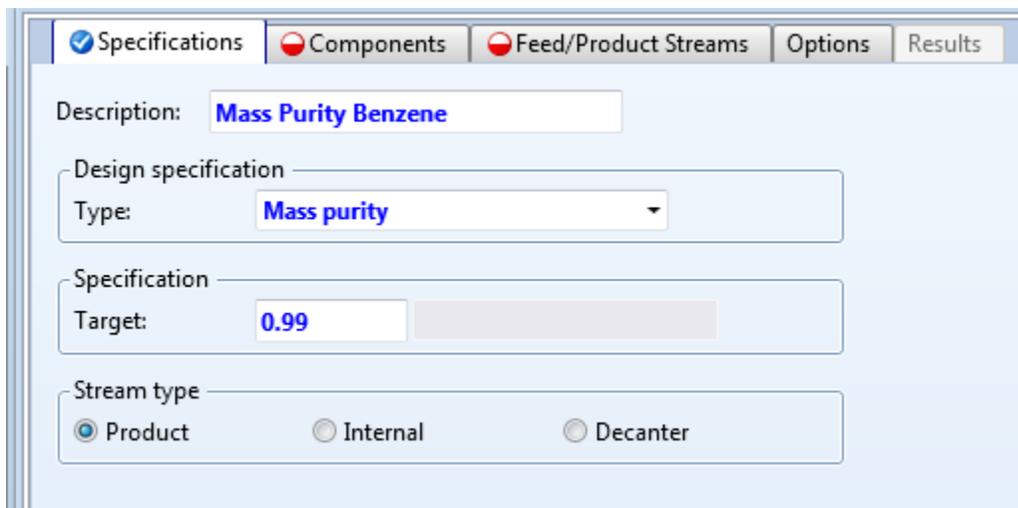
To do this, click on the white arrow next to B1 to expand the folder. Then do the same for Specifications folder under B1. Click on the Design Specifications folder and you should have something like this pop up.



Click on New... and it should bring you this.

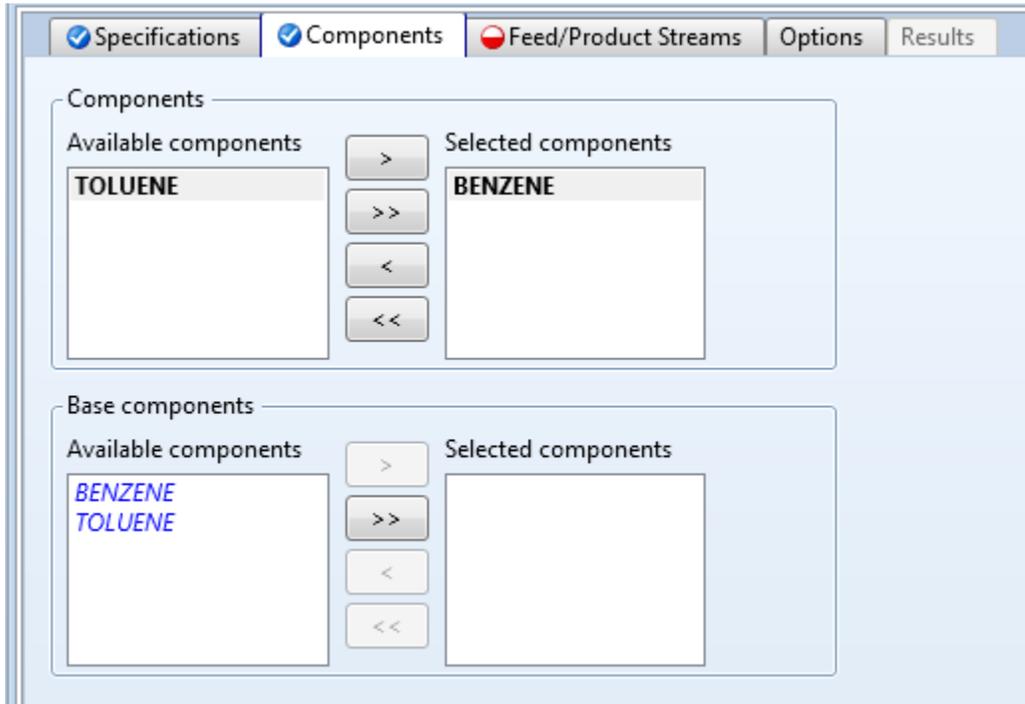


The description can be whatever you like, but is usually something that describes the design specification, such as “mass purity” or “mole recovery”. Ours can be simply mass purity. The type of design specification that we want is Mass purity and the target is 0.99. Leave the stream type set to product, since we want our product stream to have this mass purity. When you are finished, it should look like this.

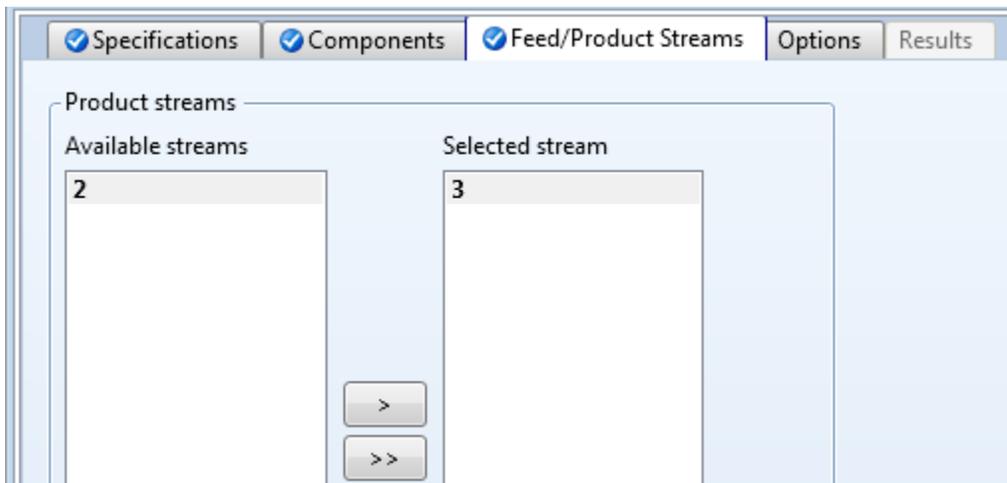


You'll notice that the Components tab and the Feed/Product Streams tabs now have red circles on them. This is where we will tell Aspen which component we want the mass purity of, and in which stream. Open the Components tab and click on Benzene in the Available components box and click the

single arrow pointing to the right to move it over to the selected components box. Leave the Base components boxes alone, and you should end up with this.



Now if we move on to the Feed/Product Streams tab, stream 3 is our benzene product stream, so select it and click the single arrow to the right to move it over to the Selected stream box.



Our Simulation is now overspecified, so we will have to tell Aspen to un-specify, or vary, something else so that a unique solution can be found for our distillation tower. Click on the Vary folder below the Design Specifications folder, which now contains a design specification simply named 1. Click on New... and the following screen should show up.

Specifications Components Results

Adjusted variable
Type:

Upper and lower bounds
Lower bound:

Upper bound:

Optional
Maximum step size:

The type that we will be varying is Reflux ratio, which we specified earlier in the simulation. Let's set the Lower bound to 0.1 and the Upper bound to 6. This will look like the following picture when it is filled in.

Specifications Components Results

Adjusted variable
Type: **Reflux ratio**

Upper and lower bounds
Lower bound: **0.1** lbmol/hr

Upper bound: **6** lbmol/hr

Optional
Maximum step size:

Our simulation is ready to run again, it should run with no warnings or errors. If we go back to the custom stream results for stream 3 and change the Component Mole Flow units to KMOL/HR, we can see that the Toluene flow is about 1% of the Benzene flow, which is what we wanted.

Default			
	Units	3	
▶ From		B1	
▶ To			
▶ Substream: MIXED			
▶ Phase:		Liquid	
▶ Component Mole Flow			
▶ BENZENE	KMOL/HR	2.37635	
▶ TOLUENE	KMOL/HR	0.0203484	
▶ Mole Flow	LBMOL/HR	5.28381	
▶ Mass Flow	LB/HR	413.367	
▶ Volume Flow	CUFT/HR	8.13311	
▶ Temperature	F	176.583	
▶ Pressure	PSIA	14.696	
▶ Vapor Fraction		0	
▶ Liquid Fraction		1	
▶ Solid Fraction		0	
▶ Molar Enthalpy	BTU/LBMOL	24485.1	
▶ Mass Enthalpy	BTU/LB	312.978	
▶ Enthalpy Flow	BTU/HR	129375	
▶ Molar Entropy	BTU/LBMOL-R	-54.4822	
▶ Mass Entropy	BTU/LB-R	-0.696412	
▶ Molar Density	LBMOL/CUFT	0.649666	
▶ Mass Density	LB/CUFT	50.8252	
▶ Average Molecular Weight		78.2327	