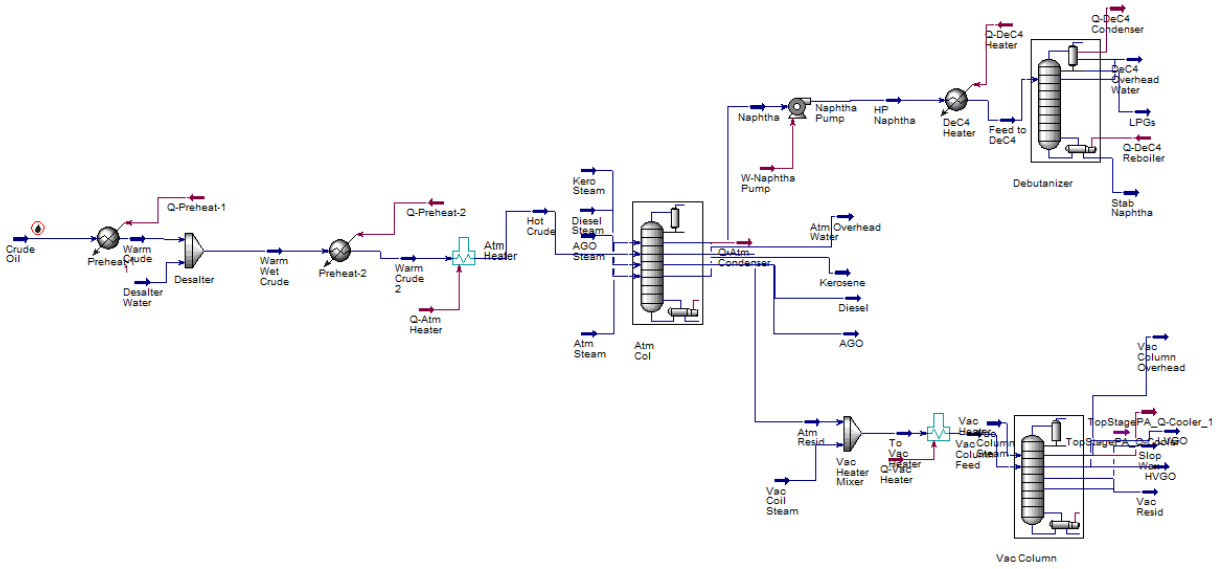
Crude Tower Simulation – HYSYS v8.6

Steps to set up a simulation in HYSYS v8.6 to model a crude tower system consisting of:

- Crude Oil Preheat Train
- Atmospheric Crude Tower
- Vacuum Crude Tower
- Debutanizer to stabilize the overhead naphtha stream from the Atmospheric Crude Tower

The feedstock to the crude system will be an equal mix of Light, Medium, & Heavy Crude oils.

When the simulation is set up the overall PFD should look like the following figure.

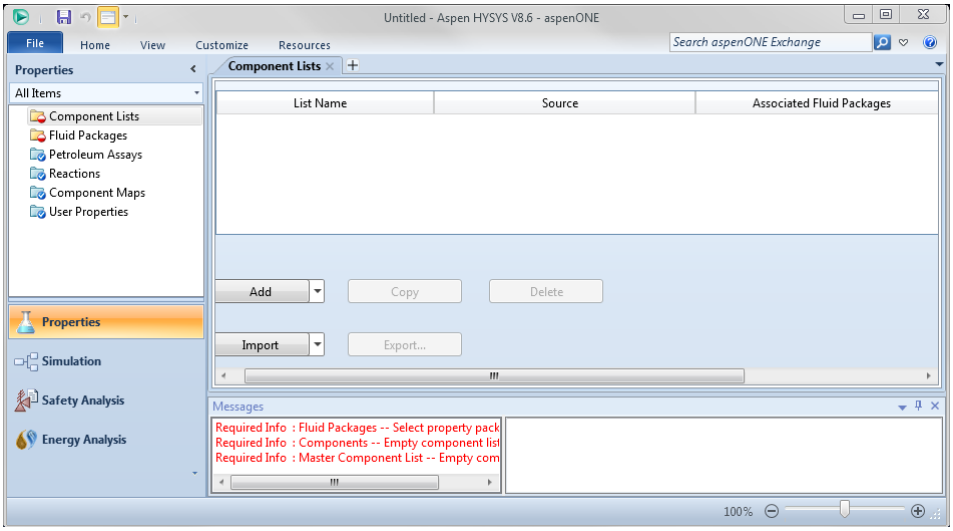


Create new simulation file

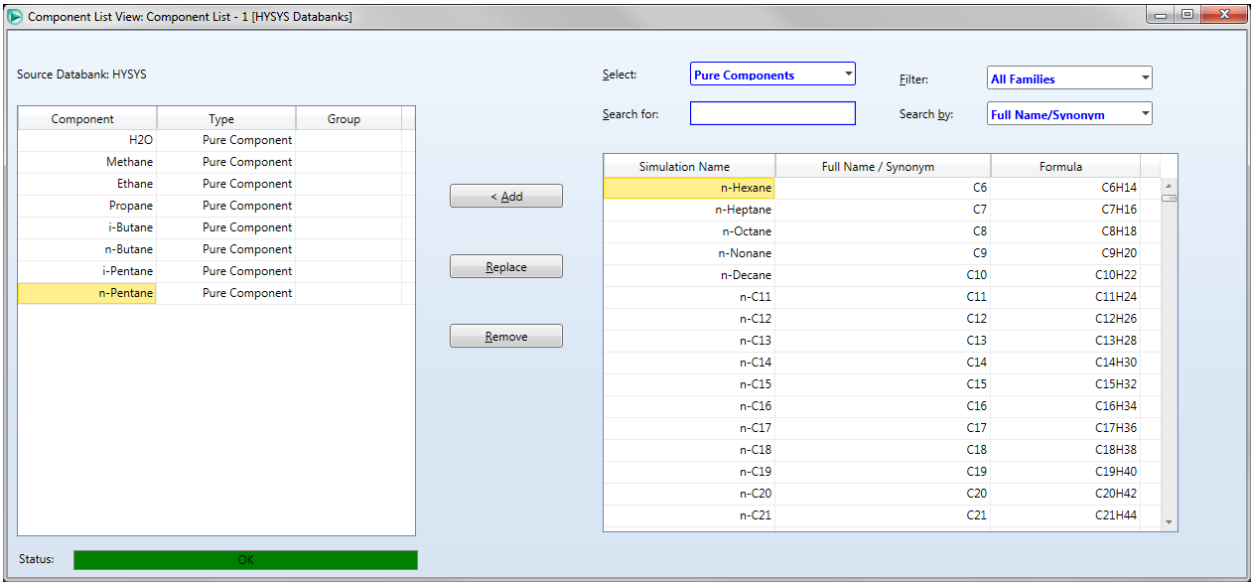
Start the program from *Start*, *All Programs*, *Aspen Tech*, *Process Modeling V8.6*, *Aspen HYSYS*, *Aspen HYSYS V8.6*. When the program opens choose the *New* button.

Define the Components & the Property Models

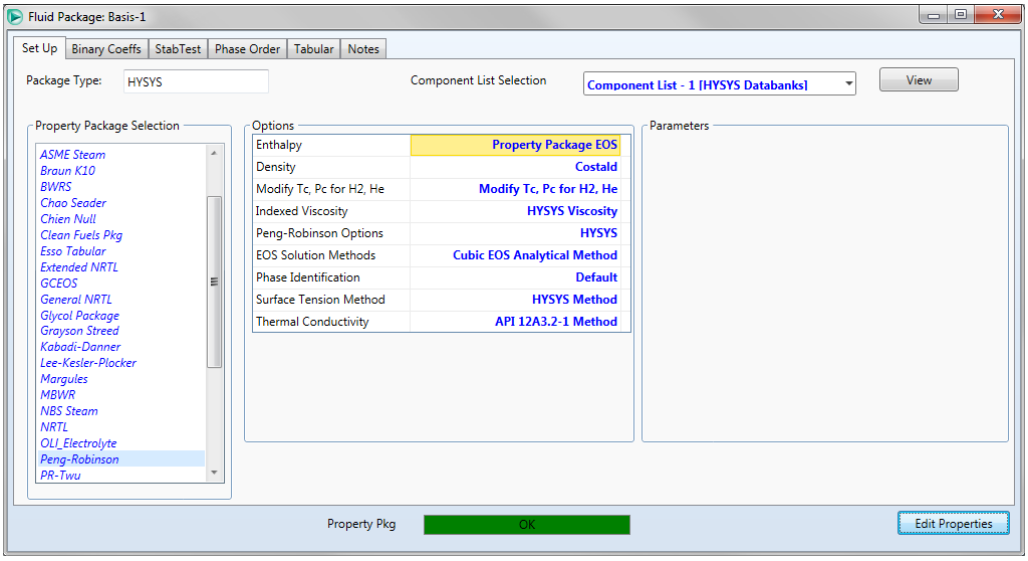
Specify components, fluid property packages, & crude oil assays



The first step is to add a set of pure chemical species to represent the light components of the crude oils. With *Component Lists* highlighted click on the *Add* button. From the list of pure components pick water, methane, ethane, propane, i-butane, n-butane, i-pentane, & n-pentane.



The next step is to pick a fluid property package. From the Fluid Packages screen click the Add button. Choose the *Peng-Robinson* option and make sure it is associated with *Component List – 1*.



We now want to add assay data for the three crude oils: Light Crude, Medium Crude, & Heavy Crude. The data to be added is shown in the following tables.

Table 1. Assay Data for Light Crude

Light Crude							
		Cumulative Yield [wt%]		Density	Sulfur	Light Ends Analysis	
IBP	EP	@ IBP	@ Mid	lb/ft3[1]	wt%		[wt%]
Whole Crude				53.27	1.77	Ethane	0.000
31	160	0	2.5	42.75	0.019	Propane	0.146
160	236	5	7.5	45.40	0.031	i-Butane	0.127
236	347	10	15	48.33	0.060	n-Butane	0.702
347	446	20	25	50.46	0.379	i-Pentane	0.654
446	545	30	35	52.38	1.064	n-Pentane	1.297
545	649	40	45	54.18	1.698		
649	758	50	55	56.04	2.159		
758	876	60	65	57.92	2.554		
876	1015	70	75	60.05	3.041		
1015	1205	80	85	62.84	3.838		
1205	1350	90	92.5	64.92	4.503		
1350	FBP	95	97.5	70.64	6.382		

[1] Note that HYSYS uses a water density to convert to specific gravity of 62.3024 lb/ft^3 =8.32862 lb/gal = 997.989 kg/m^3.

Table 2. Assay Data for Medium Crude

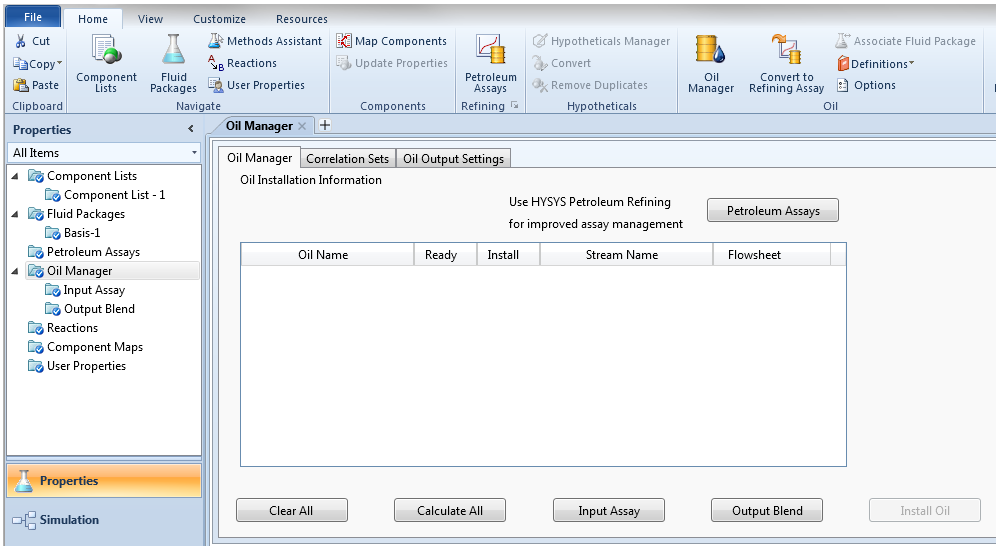
Medium Crude							
		Cumulative Yield [wt%]		Density	Sulfur	Light Ends Analysis	
IBP	EP	@ IBP	@ Mid	lb/ft3	wt%		[wt%]
Whole Crude				55.00	2.83	Ethane	0.000
88	180	0	2.5	43.47	0.022	Propane	0.030
180	267	5	7.5	47.14	0.062	i-Butane	0.089
267	395	10	15	49.42	0.297	n-Butane	0.216
395	504	20	25	51.83	1.010	i-Pentane	0.403
504	611	30	35	54.08	2.084	n-Pentane	0.876
611	721	40	45	55.90	2.777		
721	840	50	55	57.73	3.284		
840	974	60	65	59.77	3.857		
974	1131	70	75	62.30	4.706		
1131	1328	80	85	65.74	5.967		
1328	1461	90	92.5	68.08	6.865		
1461	FBP	95	97.5	73.28	8.859		

Table 3. Assay Data for Heavy Crude

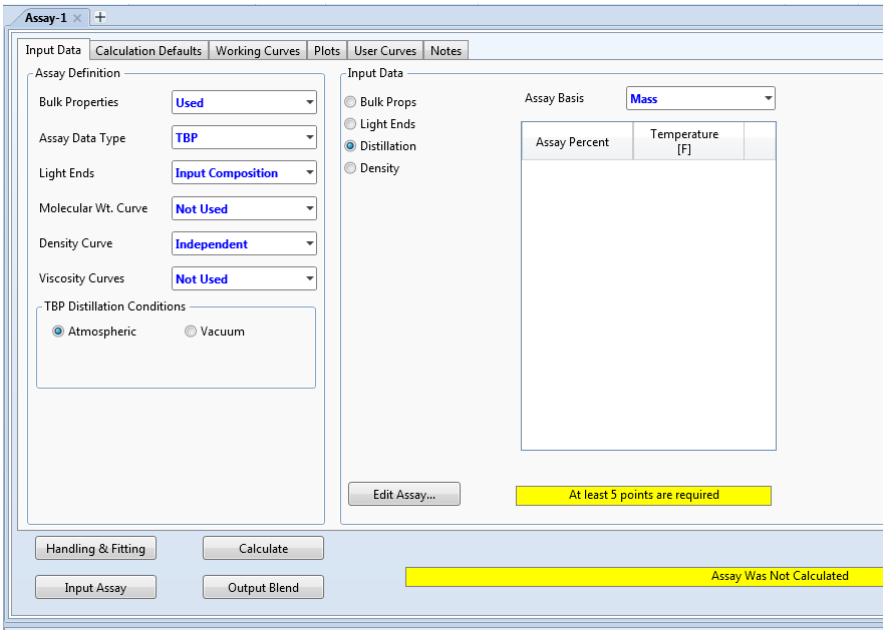
Heavy Crude							
		Cumulative Yield [wt%]		Density	Sulfur	Light Ends Analysis	
IBP	EP	@ IBP	@ Mid	lb/ft3	wt%		[wt%]
Whole Crude				55.20	2.8	Ethane	0.039
27	154	0	2.5	42.92	0.005	Propane	0.284
154	255	5	7.5	45.75	0.041	i-Butane	0.216
255	400	10	15	49.44	0.341	n-Butane	0.637
400	523	20	25	52.23	1.076	i-Pentane	0.696
523	645	30	35	54.49	1.898	n-Pentane	1.245
645	770	40	45	56.62	2.557		
770	902	50	55	58.77	3.185		
902	1044	60	65	61.09	3.916		
1044	1198	70	75	63.61	4.826		
1198	1381	80	85	66.63	5.990		
1381	1500	90	92.5	68.71	6.775		
1500	FBP	95	97.5	73.10	8.432		

The following steps show how to enter the data for Light Crude. Similar steps should be used for the other crude oils. The steps will be shown using the *Oil Manager*[2].

- Click on the *Oil Manager* button in the *Home* tab. You will have the options to install individual crude oil assays & then create a blend of the assays.

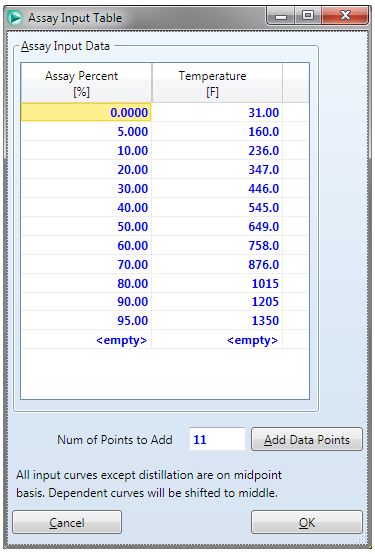


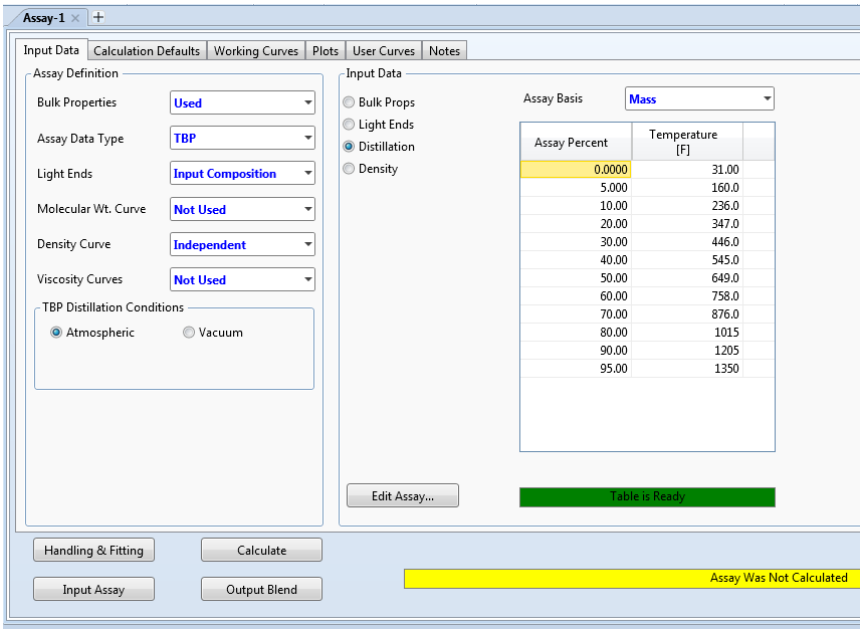
- Click on the *Input Assay* button & then the *Add* button. In the Assay Definition section we want to use *Bulk Properties*, specify a TBP *Assay Data Type*, input compositions for the *Light Ends*, and input an independent *Density Curve*. Ensure the *Assay Basis* is Mass. When all of these are specified the Input Data should look like below.



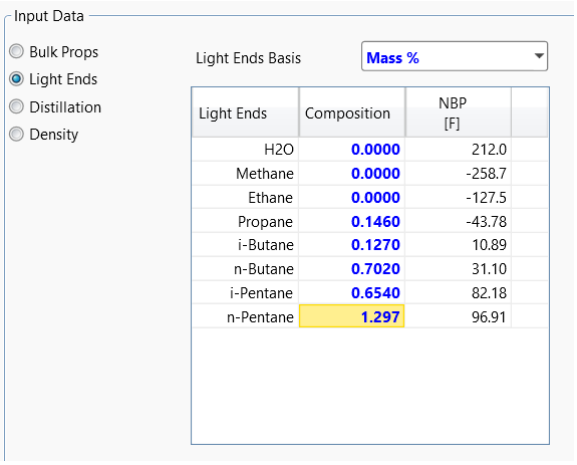
[2] Though the Assay Manager is more powerful it requires a special license which may not be available to you at your location.

- Let's input the TBP curve on a wt% basis for Light Crude. Click on the *Edit Assay…* button. Since we will be entering 12 data points enter 11 for the *Num of Points to Add* & click the *Add Data Points* button (since 1 is already showing). Now the table of Cumulative wt% Yield values (scaled 0 to 100) vs. temperatures (in °F) can be entered. Click *OK*.

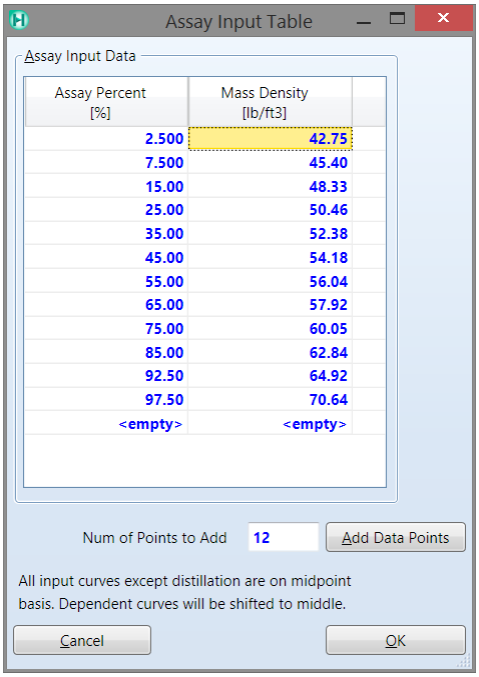


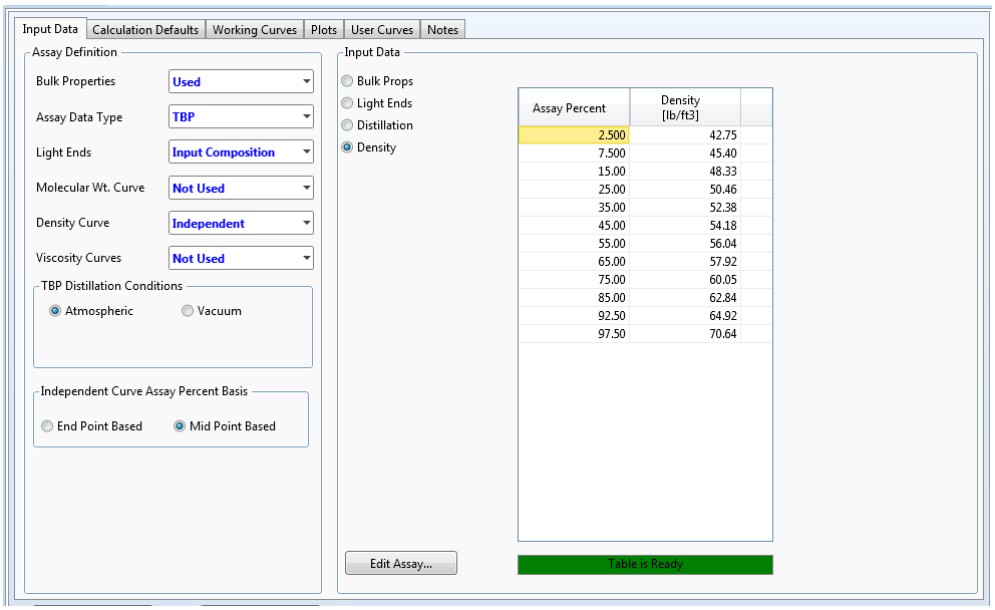


- Now we'll add in the composition of the light ends. Make the *Light Ends* option active & the form will change to allow you to enter the compositions (based on the component list previously specified). Make sure you change the *Light Ends Basis* to Mass%.

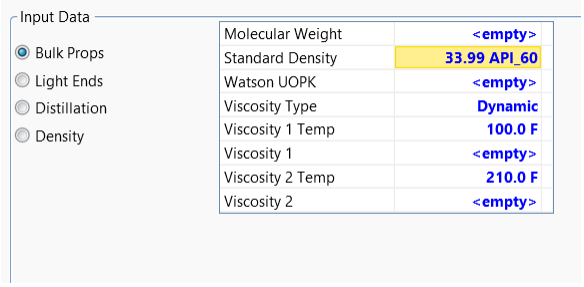


- Now we'll add in the density data. Make the *Density* option active & the form will change to show you the density vs. yield data entered. Click on the Edit Assay… button. Since we will be entering 12 data points enter 11 for the *Num of Points to Add* & click the *Add Data Points* button (since 1 is already showing). Now the table of Cumulative wt% Yield values at the middle of the cut (scaled 0 to 100) vs. standard liquid density values (in lb/ft^3) can be entered. Click *OK*. Note that even though the standard liquid density might be in the crude oil assay in other forms (such as specific gravity of API gravity) HYSYS will request the information in a specific form & it cannot be changed on this form.

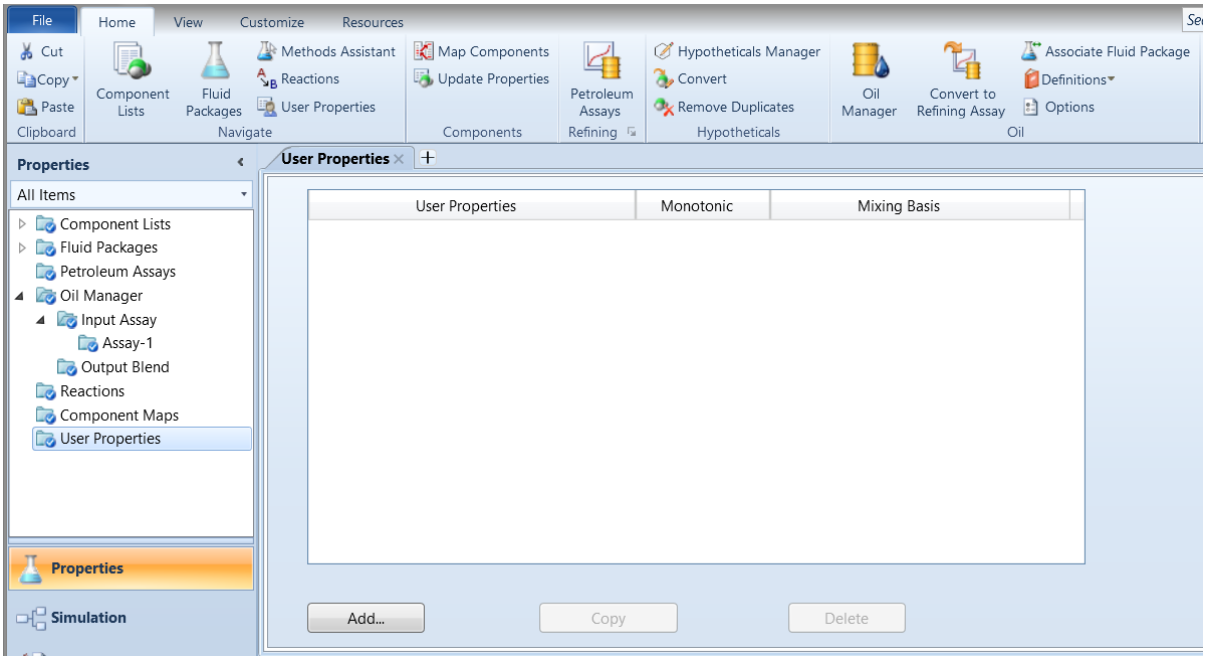




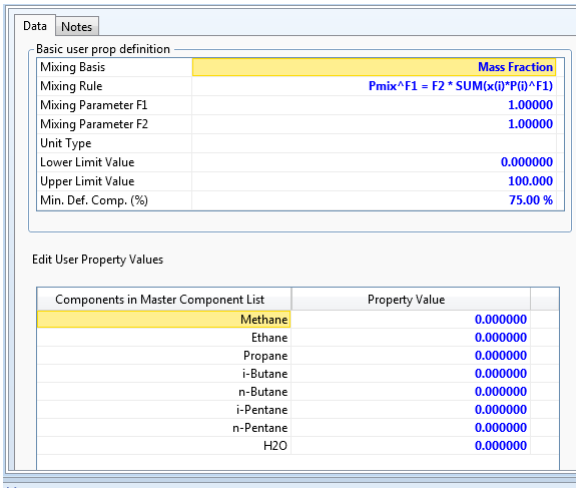
- Let's finish adding in the data needed to characterize the assay and allow HYSYS to create pseudo components. Make the *Bulk Props* option active & the form will change to allow you to enter the data. The only information we have to add is the standard liquid density for the whole crude. Enter this value in the Standard Density field. Note that other units can be used on this form. Further note that whatever units are used for the data entry HYSYS will convert the value to the units and form it is expecting (in this case API gravity).



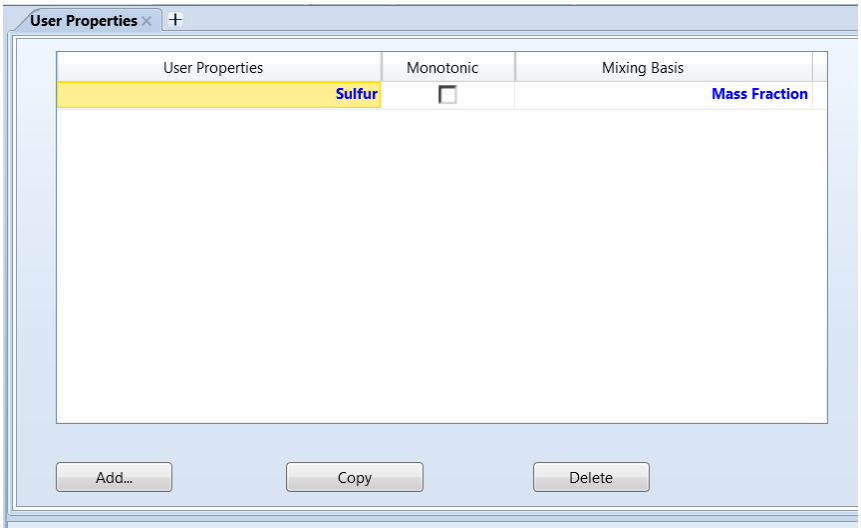
- Even though we can now characterize the pseudo components for the flash calculations we still need to add the sulfur distribution so that this can be tracked. First we'll have to define a User Property that represents the sulfur content. Click on *User Properties* either from the tree structure in the left-hand column or the appropriate button under the *Home* tab. When the User Properties form comes up press the *Add…* button.



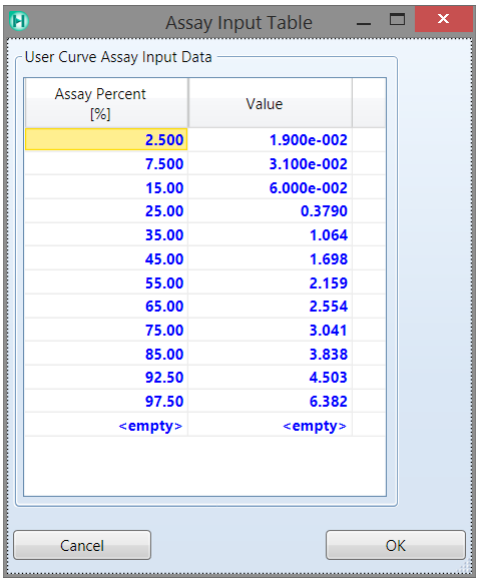
On the *UserProp-1* form choose the *Mass Fraction* option & leave the *F1* and *F2* mixing parameters as 1. Set the values for the pure components as zeroes.

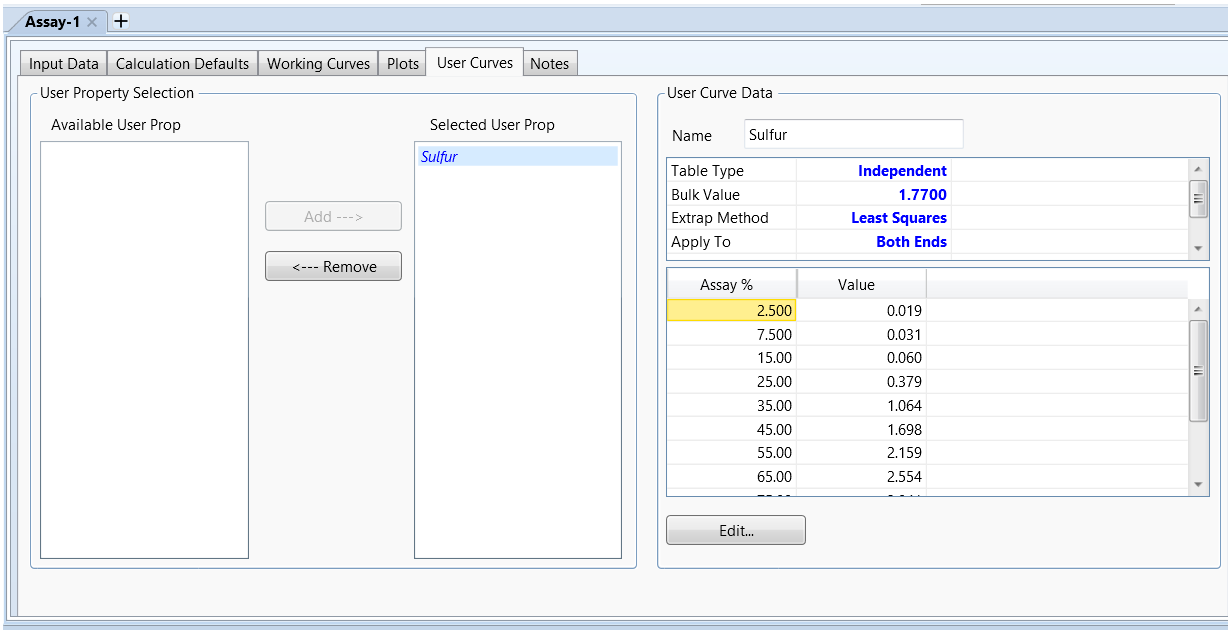


Let's make the label for this property more meaningful. Return to the *User Properties* tab and single click the *UserProp-1* label. Now type in *Sulfur*.

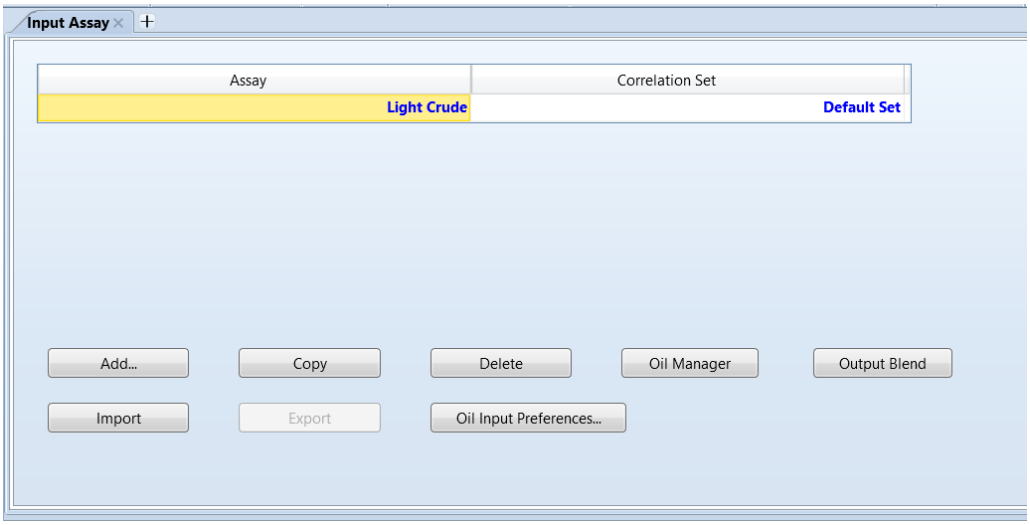


Now we can add the sulfur distribution for the assay. Click on *Assay-1* in the tree structure in the left-hand column & choose the *User Curves* tab. Highlight *Sulfur* in the *Available Properties* column & press *Add--->*. Under the *User Curve Data* area retain the *Independent* setting for the *Table Type*, enter the whole crude value for the *Bulk Value*, and set the lower and upper limits to 0 and 100. Press the *Edit...* button at the bottom of the form to enter the assay values. Press *OK*.





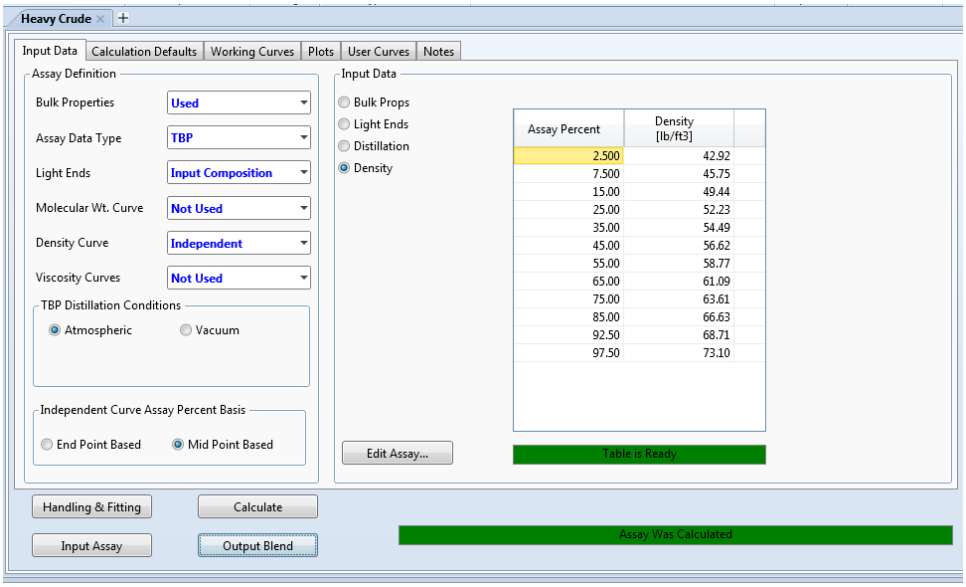
- One more thing to clean up for the assay, changing its name. Click on *Input Assay* in the tree structure of the left-hand column. In the *Input Assay* form single click *Assay-1* & type *Light Crude*.



Repeat the steps for the Medium & Heavy Crudes.

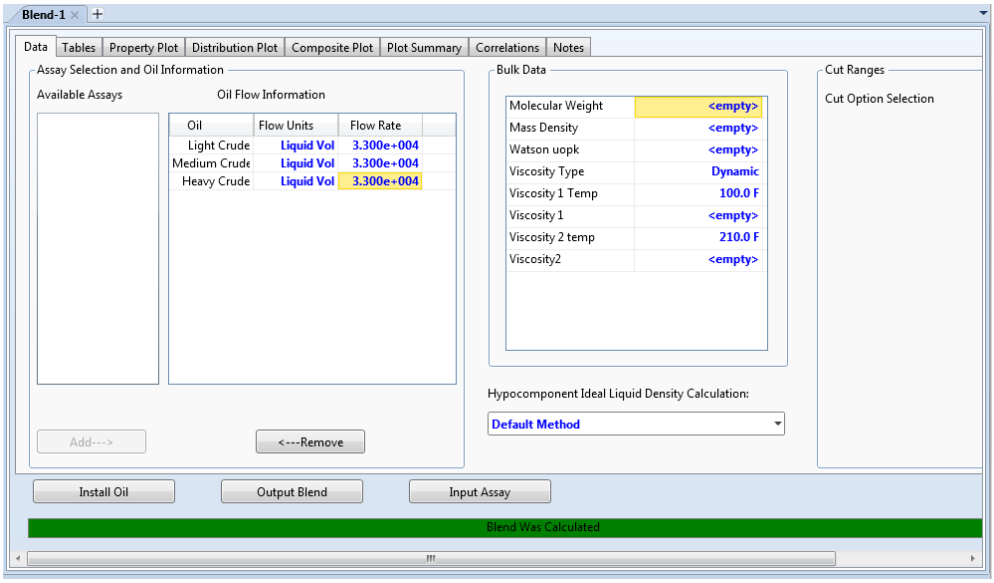
Do characterization calculations, specify crude oil blend, & install into flowsheet

After entering the assay we have to tell HYSYS to perform the characterization calculations. Select each crude oil in the tree structure of the left-hand column & click on the *Calculate* button if there is a warning that the assay has not been calculated. When properly calculated there should be a message in green.

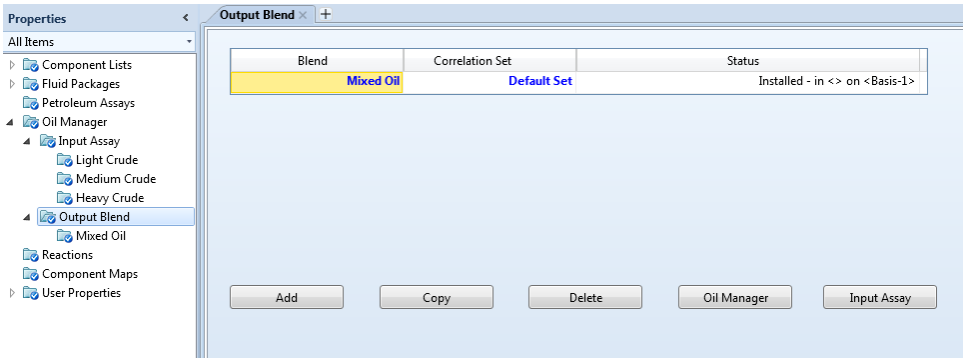


Now we'll create a blend of the three crudes and use that as our feedstock in the simulation. Select *Output Blend* in the tree structure of the left-hand column. On the *Output Blend* tab select the *Add* button. On the *Blend-1* tab select the crudes & press *Add--->*. Accept the *Liquid Vol* option for the *Flow Units*. Enter three equal flow units under *Flow Rate*, such as 33 kbpd (thousands of barrels per day).

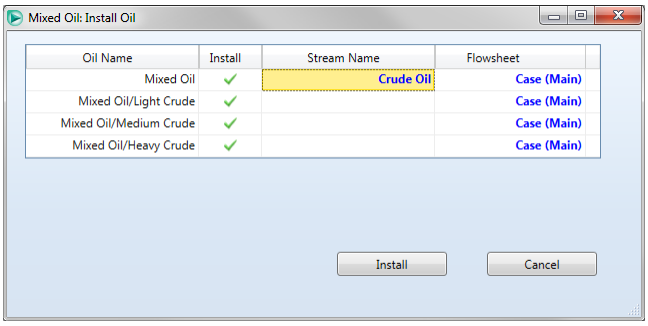
If all of the crude oils have been characterized previous to this then you should receive a *Blend Was Calculated* message in green.



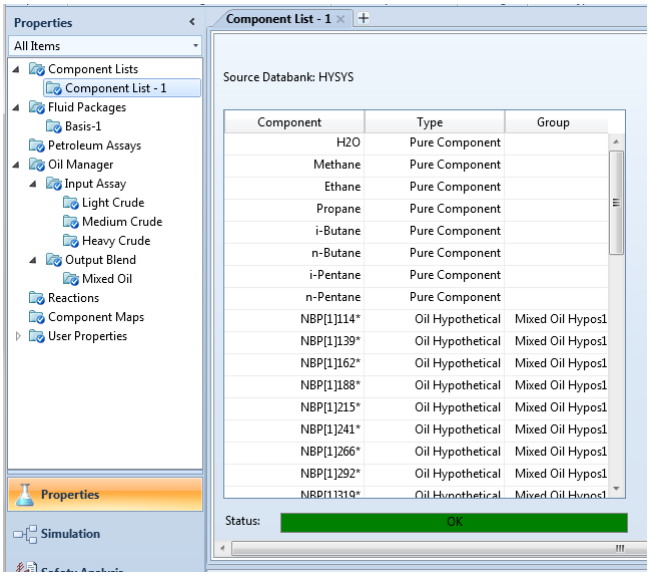
One more cleanup step, changing the name of the blend. Select *Output Blend* in the tree structure of the left-hand column. In the tabbed form select *Blend-1* and change to *Mixed Oil*.



The next step is to install the blend into the flowsheet. From this tabbed form select *Oil Manager* and then select *Install Oil* from the next form. Now we get a form that we can install one or more of the oils. We're only interested in installing the blend, *Mixed Oil*. In the *Stream Name* column enter *Crude Blend* for *Mixed Oil*. Click *Install*.



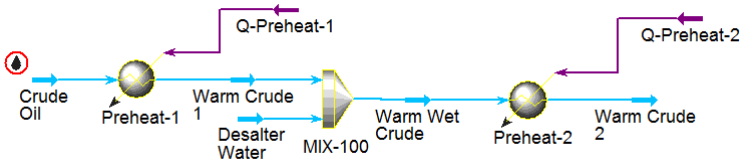
As a final step let's make sure everything is calculated & the pseudo components are installed into the component list. Select *Oil Manager* in the tree structure in the left-hand column. At the bottom of the form click *Calculate All*. Now when you look at the *Component List* you should see a series of pseudo components after the pure components chosen earlier.



Set up & Solve the Flowsheet

Crude Oil Feed & Preheat

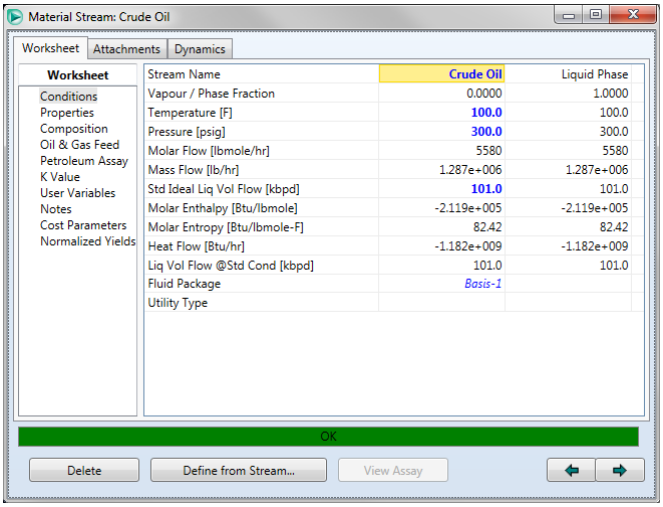
When you activate the Simulation you'll see a single steam called *Crude Oil*. We want to attach this stream to two heat exchangers (to model the preheat before & after the Desalter) and a Mixer to set an expected amount of water in the Crude Oil coming from the Desalter.



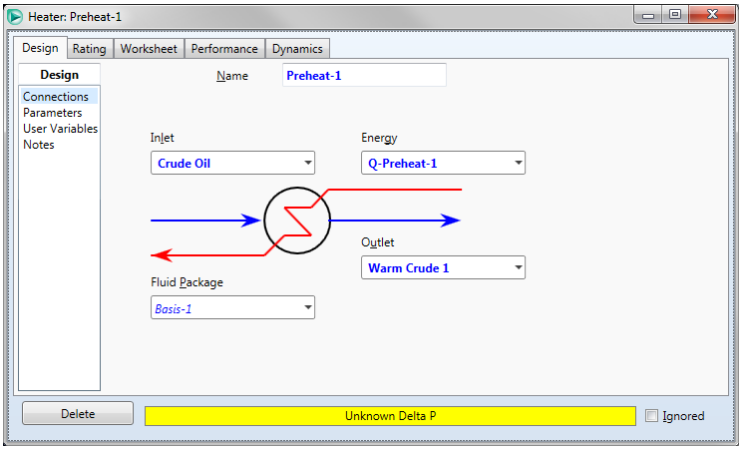
The following are the conditions to be set on the operations.

- Crude Oil Feed: 100°F, 300 psig, 101,000 bpd
- Preheat-1 outlet: 260°F, 294 psig
- Desalter outlet: 260°F, 294 psig, 500 bpd of water
- Preheat-2 outlet: 450°F, 260 psig

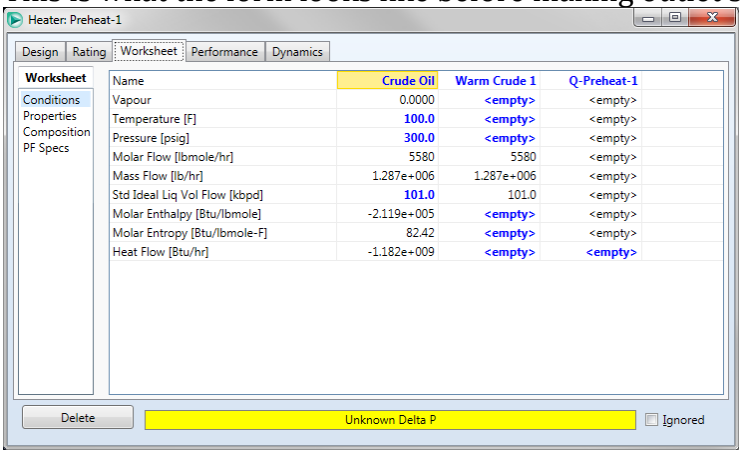
Double-click on the *Crude Oil* stream to open up the entry forms for this stream. Note that the flow rate comes from Oil Manager, but we're going to overwrite this. Note that once you enter the pressure & temperature the calculations for *Crude Oil* are complete & it takes on a new color in the flowsheet.



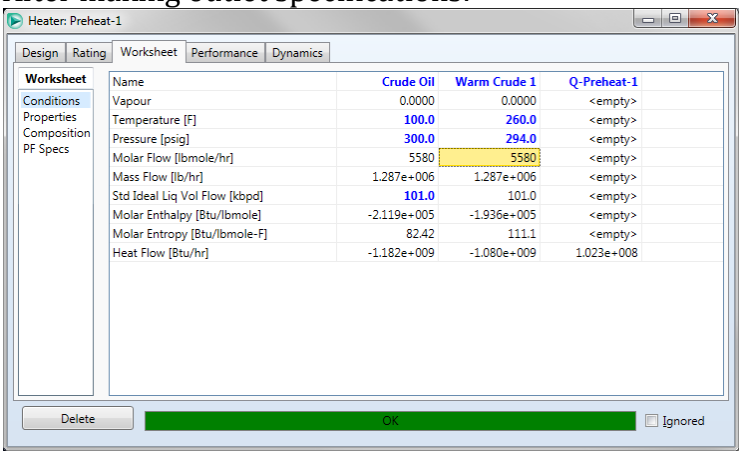
For the heat exchangers the stream connections are done on the *Design* tab, *Connections* selection. There are two ways to specify the outlet conditions. The most direct is to set both temperature & pressure via the *Worksheet* tab.



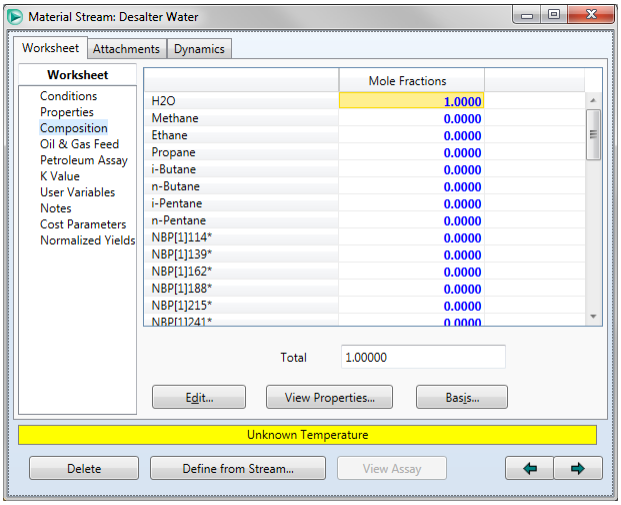
This is what the form looks like before making outlet specifications:

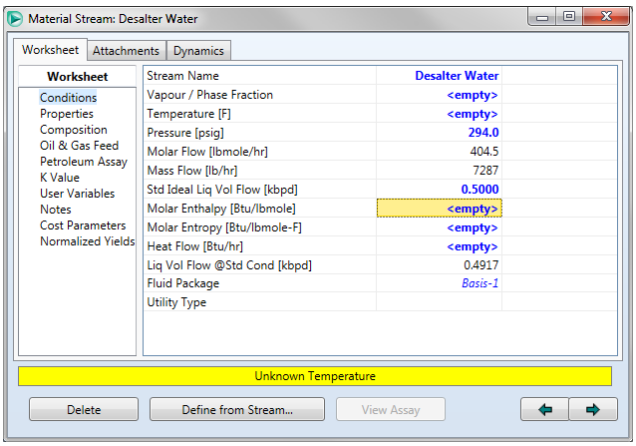


After making outlet specifications:



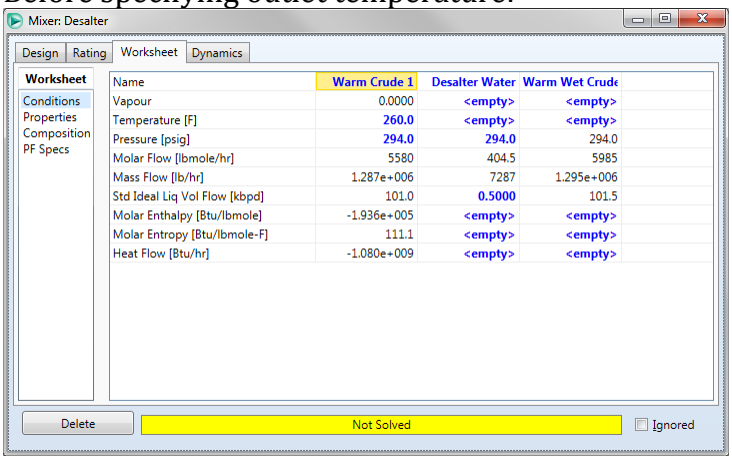
The entrained water is set by opening up the input form for *Desalter Water*. On the *Worksheet* tab select *Composition*. Click on the *Edit…* button, enter 1 for the fraction of H2O, click the *Normalize* button, and then *OK*. Next we will set the pressure of the entrained water (same as the outlet from the Desalter) & the flowrate. Note that we will not set the temperature at this time.



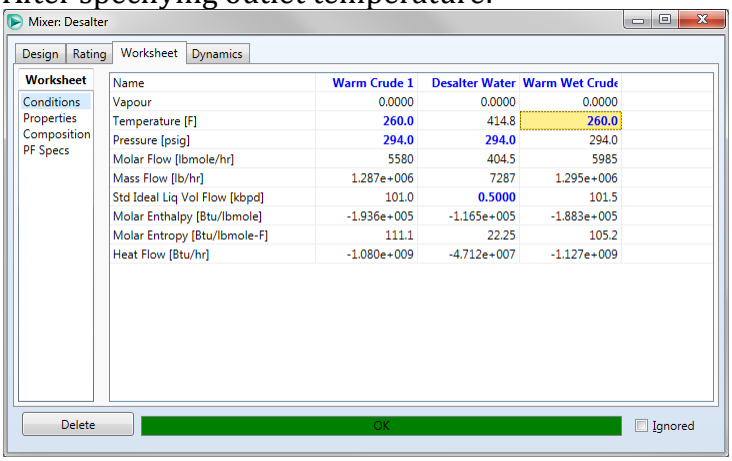


Now let's set the conditions for the outlet of the Desalter. Double click on the Mixer and click on the *Worksheet* tab. Note that the pressure of the outlet stream has been determined (set as the lowest pressure of all streams being mixed) & the standard liquid flowrate has been determined (since this is just additive of the two streams into the Mixer). Now, let's specify the temperature of the outlet of the Desalter; note that the temperature of the water stream has been back-calculated to make sure the outlet temperature is correct.

Before specifying outlet temperature:



After specifying outlet temperature:

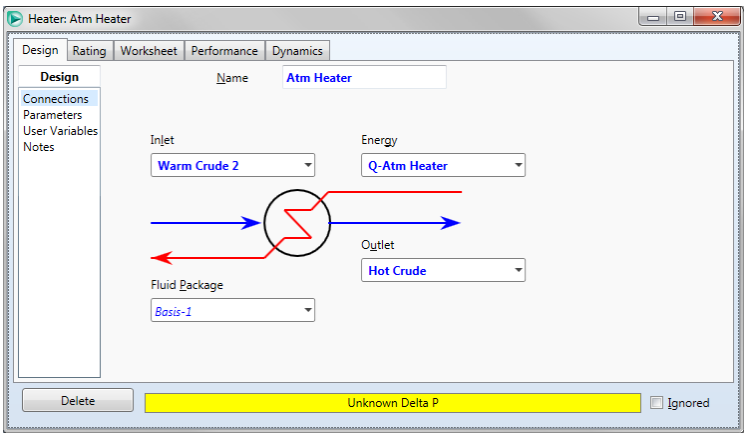


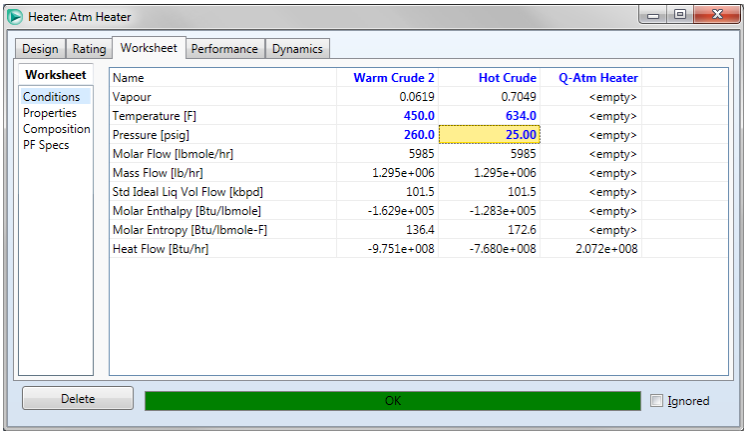
Specifying outlet conditions on the second preheater completes the flowsheet calculations for this part of the simulation.

Atmospheric Distillation Column

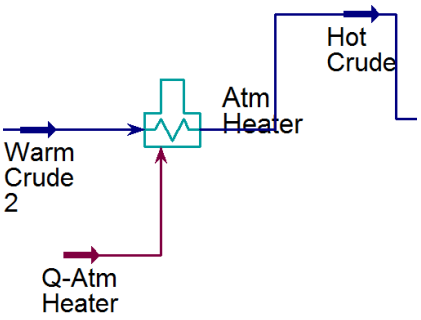
The next step is to set up the Atmospheric Distillation Column. Table 4 contains the conditions & configuration for this column.

The fired heater on the feed is separate from the column environment & will be created first. Create a new Heater on the flowsheet & call it *Atm Heater*. Change the icon to look like a heater instead of a shell & tube heat exchanger. Enter the following connections & set the following outlet conditions to match the approximate atmospheric column conditions in Table 4.





This portion of the PFD should look like the following.



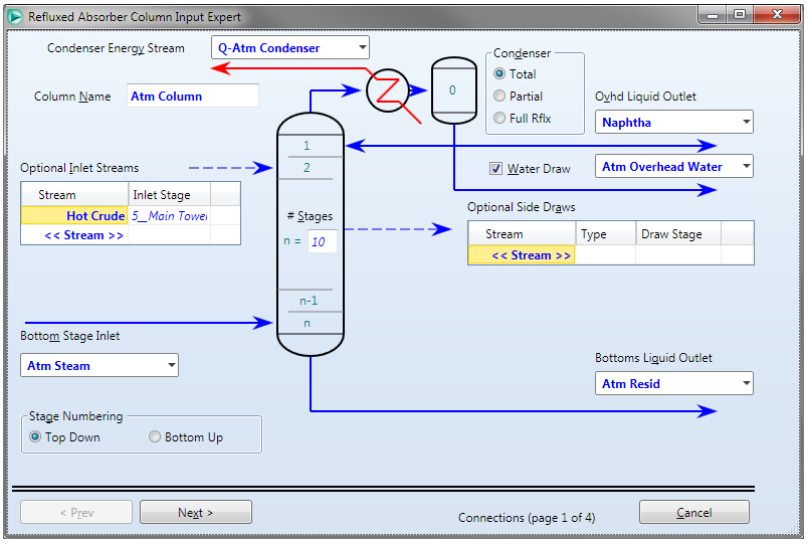
Setting up a distillation column is a multi-step process in HYSYS. First, create a *Refluxed Absorber Column* on the flowsheet then start to fill in the information.

Table 4. Definitions for Atmospheric Distillation Column

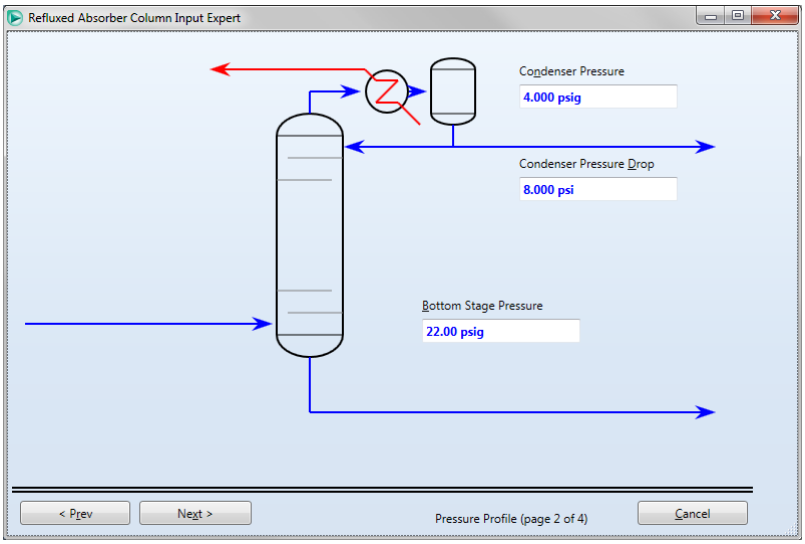
Type	Operating Parameter
Trays & Efficiencies	50 trays. Numbering from top: Trays 1 to 6: 80% Trays 7 to 10: 50% Trays 11 to 16: 70% Trays 17 to 30: 50% Trays 31 to 39: 30% Tray 40: 100% Trays 41 to 50: 30%
Condenser Type	Total Condenser; 130°F (approximate) Distillate product 410°F D86 T95; 30,200 bpd (approximate)
Reboiler Type	None, Direct Fired Heater
Pressures	Condenser: 4 psig Top Tray: 12 psig Bottom Tray: 22 psig
Temperatures	Top Tray #1 250°F (estimate) Bottom Tray #50 650°F (estimate)
Feed Locations	Crude oil to Tray #40 Stripping Steam at bottom (Tray #50) – 20,000 lb/hr @ 500°F, 150 psig
Feed Heater	Outlet @ 25 psig & 635°F Desire is 2,500 bpd overflash (liquid rate from tray above feed, Tray #39)
Side Strippers	Kerosene Stripper 10 trays @ 30% efficiency Kerosene draw from Tray #10, vapor returned to Tray #6 Stripping steam @ bottom (Tray #10) – 2500 lb/hr @ 500°F & 150 psig Kerosene product 525°F D86 T95; 8800 bpd product (approximate)
	Diesel Stripper 10 trays @ 30% efficiency Diesel draw from Tray #20, vapor returned to Tray #16 Stripping steam @ bottom (Tray #10) – 2500 lb/hr @ 500°F & 150 psig Diesel product 645°F D86 T95; 10,240 bpd product (approximate)
	AGO Stripper 10 trays @ 30% efficiency AGO draw from Tray #30, vapor returned to Tray #26 Stripping steam @ bottom (Tray #10) – 2500 lb/hr @ 500°F & 150 psig AGO product 750°F D86 T95; 3835 bpd product (approximate)
Pumparounds	Kerosene Pumparound Draw from Tray #10, returned to Tray #7 25,000 bpd flow, 200°F return temperature
	Diesel Pumparound Draw from Tray #20, returned to Tray #17 15,000 bpd flow, 250°F return temperature
	AGO Pumparound Draw from Tray #30, returned to Tray #27 10,000 bpd flow, 350°F return temperature

When you double click on the column for the first time a wizard starts and will guide you through entering information. If you don't fill it all in, don't worry – you can always specify the information from the forms & column sub-flowsheet.

The first step in the wizard is to set up the basic information for the main feeds & products (but not the side products which will be processed through side strippers). Fill in the information as shown below. Make sure you check the box for *Water Draw*. When done press *Next>*.

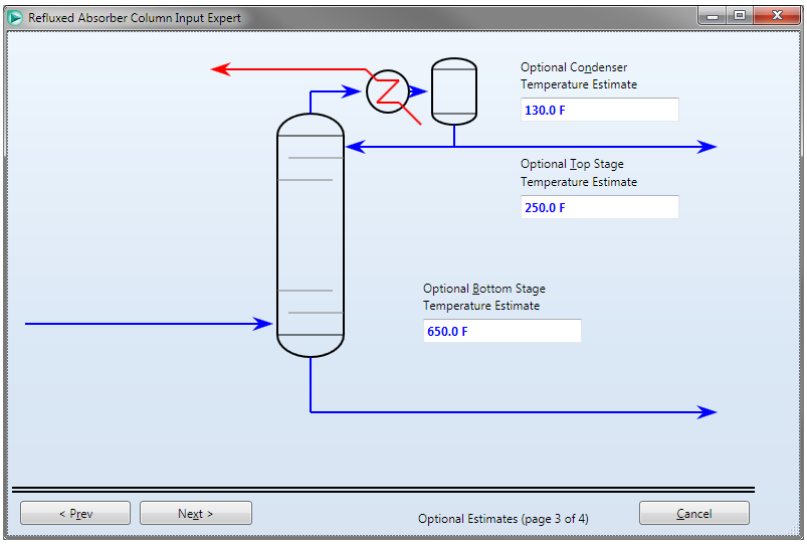


The next step is to set up the basic pressure profile in the column. Fill in values & press *Next>*.

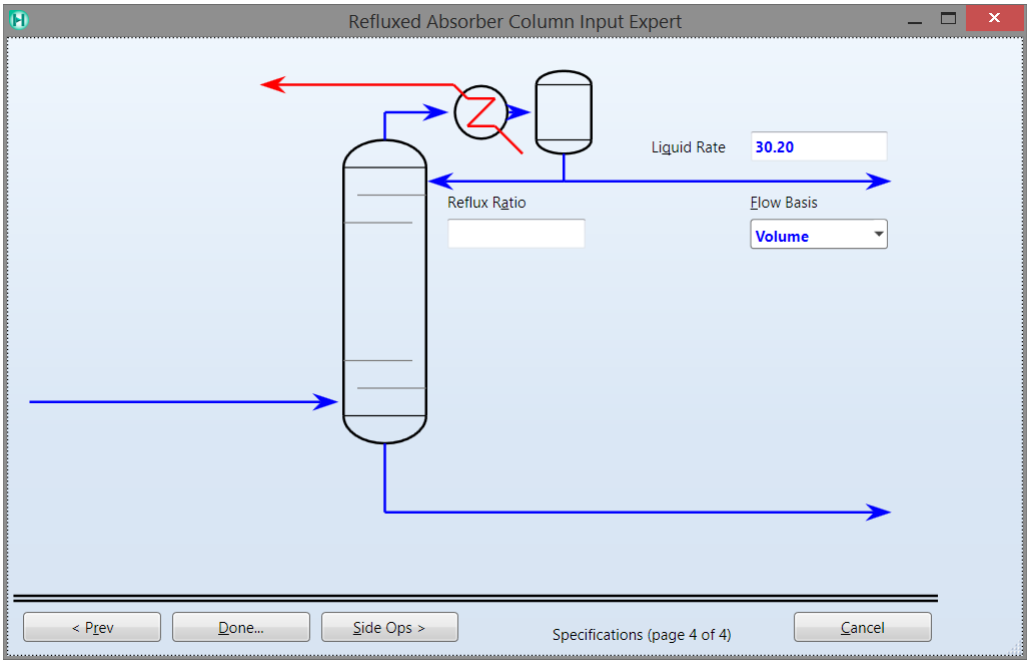


On the third screen we will set an estimate for the condenser temperature. Press *Next>*. Though the other temperatures are not required it usually good practice to enter values.

For a atmospheric crude tower reasonable starting points are 250°F & 650°F for the top & bottom stages, respectively.



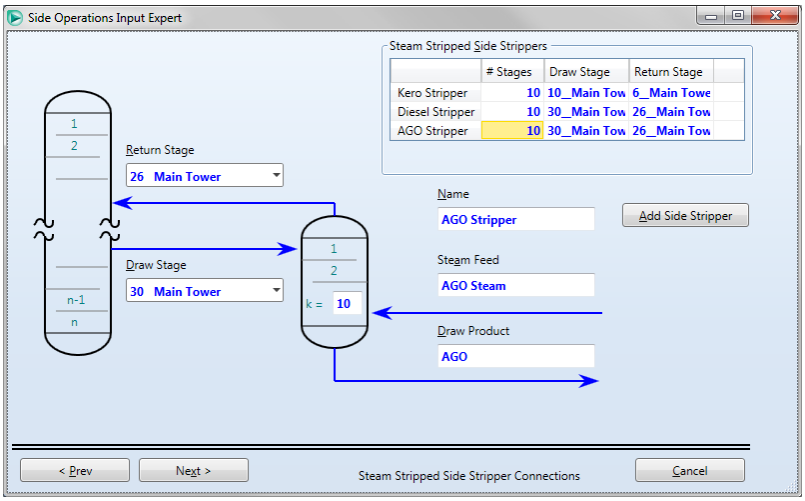
On the fourth screen we'll set an estimate for the distillate rate. Press the *Side Ops>* button to start setting up the side strippers & pumparounds.



We'll skip this first side operation screen since none of the side strippers are reboiled. Press *Next>*.

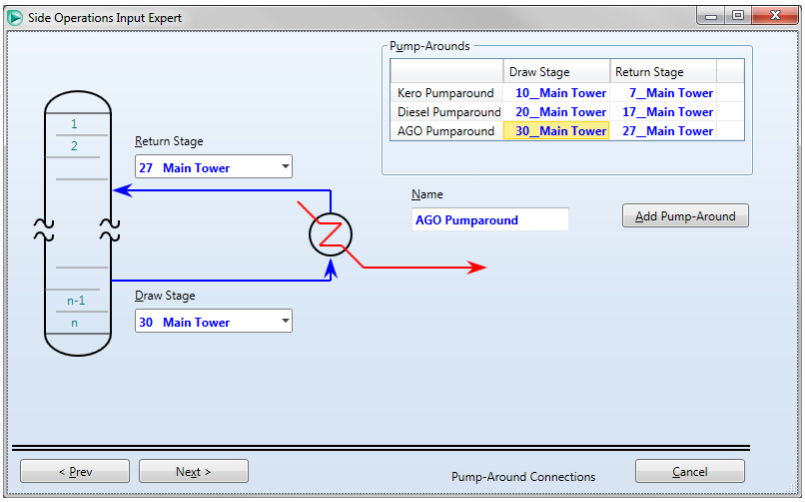
Now we can start adding the basic information for the three side strippers. To start entering the configuration information for each side stripper press the *Add Side Stripper*

button; when done press the *Install* button. When done with the three side strippers press the *Next>* button.



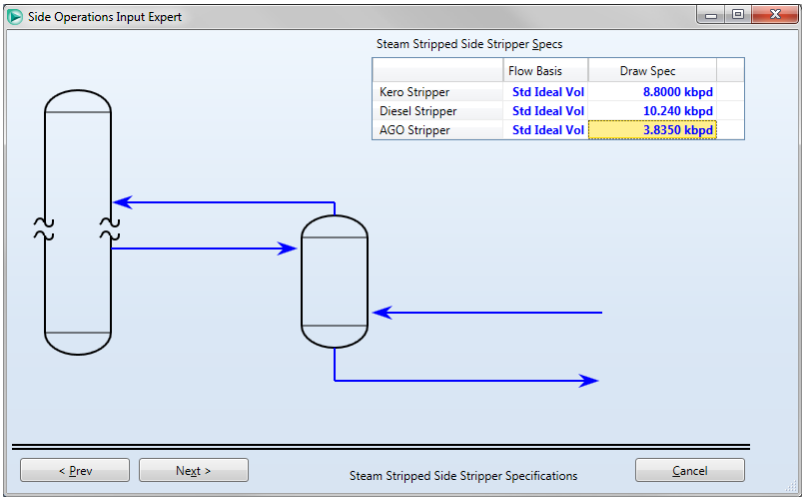
We do not have any side rectifiers. Press the *Next>* button.

Now we can start adding the basic information for the three pumparounds. To start entering the configuration information for each pumparound press the *Add Pump-Around* button; when done press the *Install* button. When done with the three pumparounds press the *Next>* button.

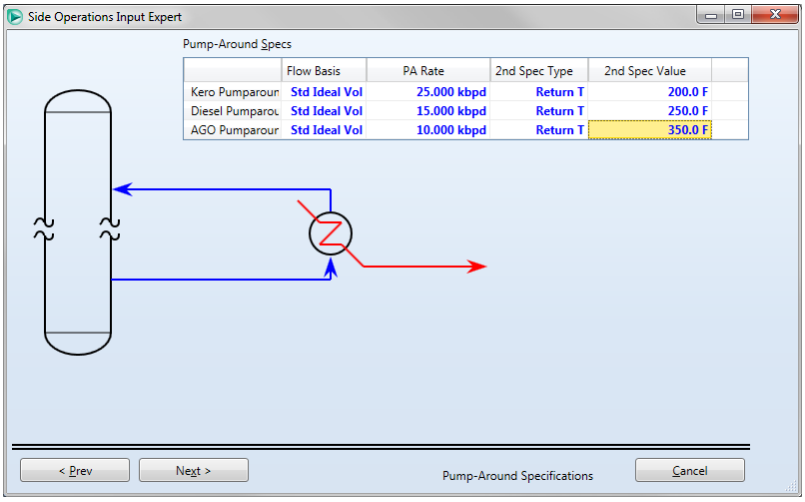


We do not have any vapor bypasses. Press the *Next>* button.

Now we can enter the side product flows through the side strippers. Enter the estimates for the flowrates out the bottom of the strippers & then press *Next>*.



Now we can set the specs on the pumparounds. Enter the flowrate values & the values associated with the heat exchanger duties. Note that all of the duty/temperature specs are *Return T* type. When done press *Next>*.



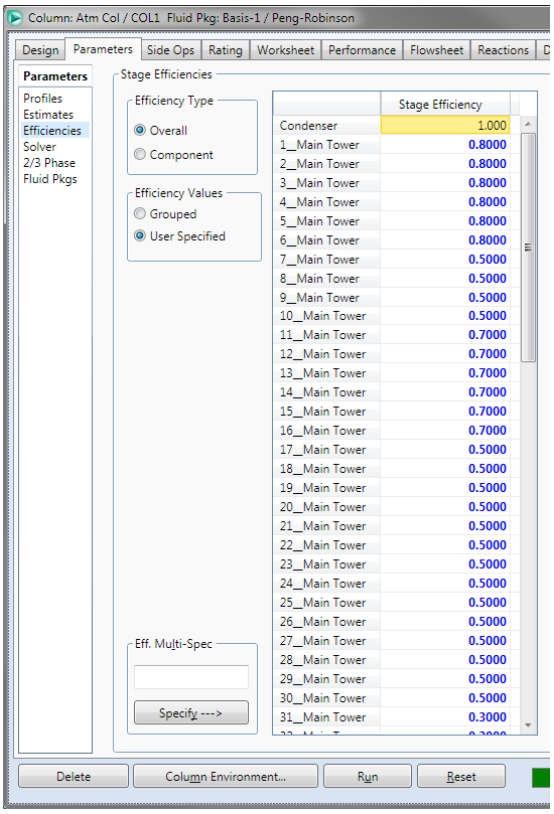
Now we can set the pressures in the side strippers. Use the default values with no changes. Press *Next>*.

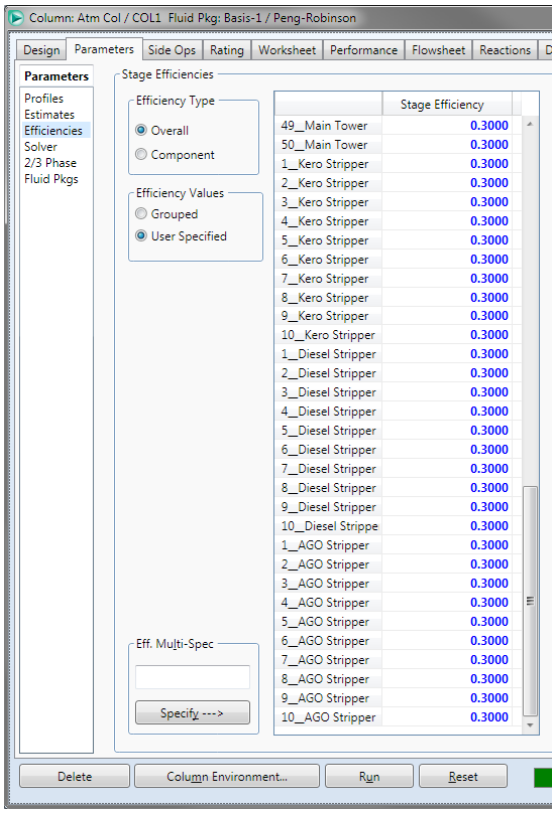
Now we can set the pressure drops across the pumparounds. Use the default values of zero. Press *Done*.

Distillation columns are different from the rest of the HYSYS operations in that they do not automatically run the first time they are created; rather, you must press the Run button when everything has been set up properly. However, we still have a couple more changes to make so let's not do this yet.

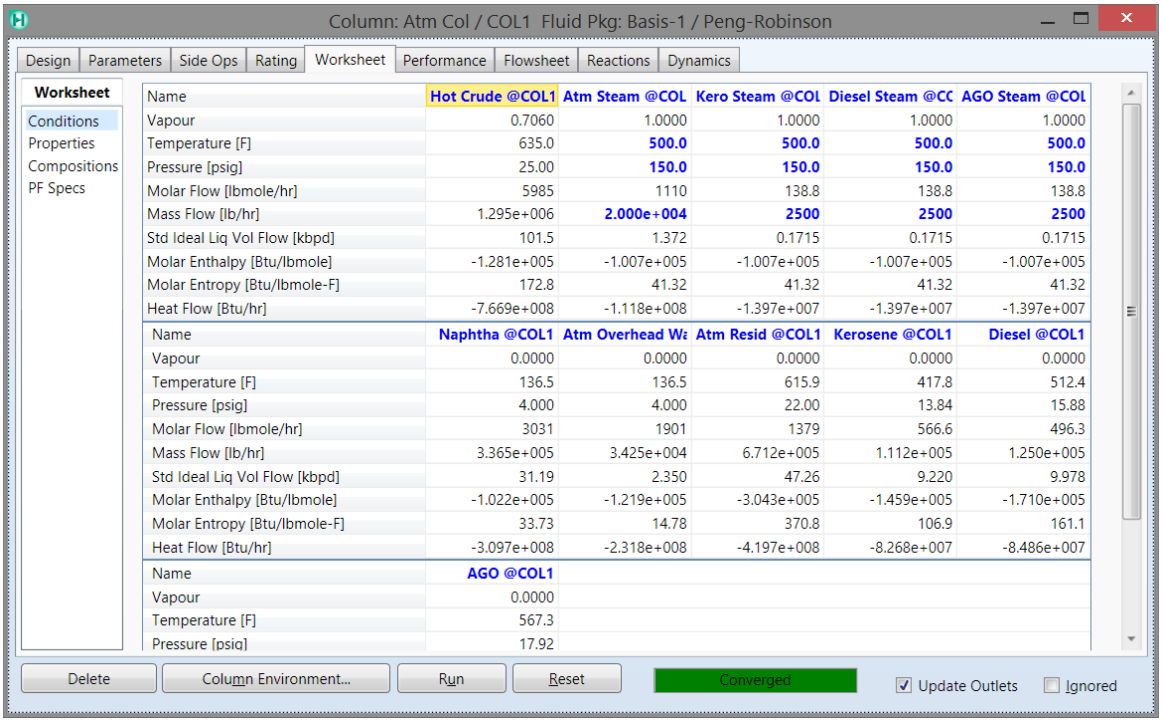
First, let's specify the stage efficiencies to model the stages as real trays. Under the *Parameters* tab select *Efficiencies*. Make sure that *Overall* & *User Specified* items are

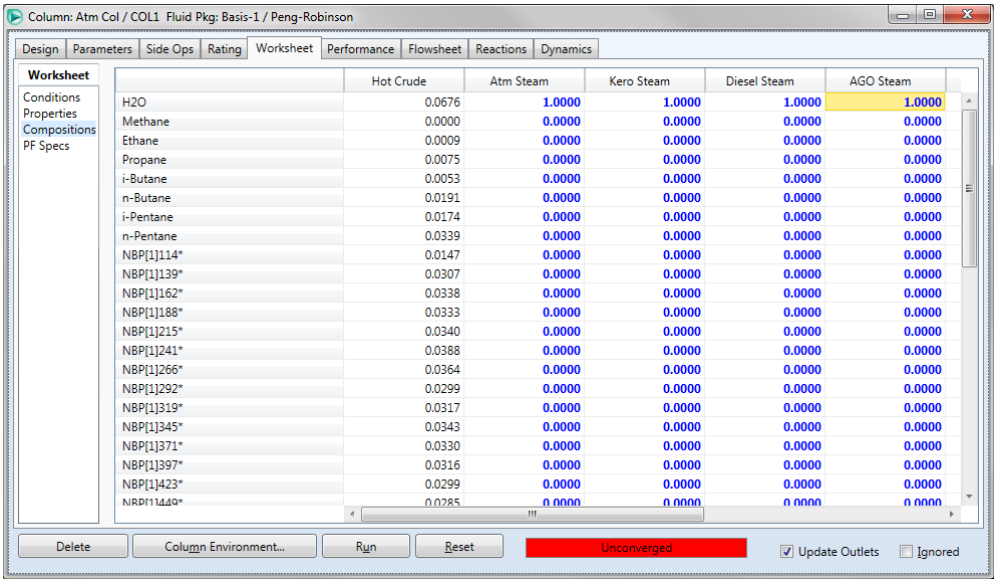
highlighted. Now let's start applying the efficiencies in Table 4. Note that stages associated with the side strippers are listed in this table as if part of the main column (in a way they are, but that's a subject for a different discussion).





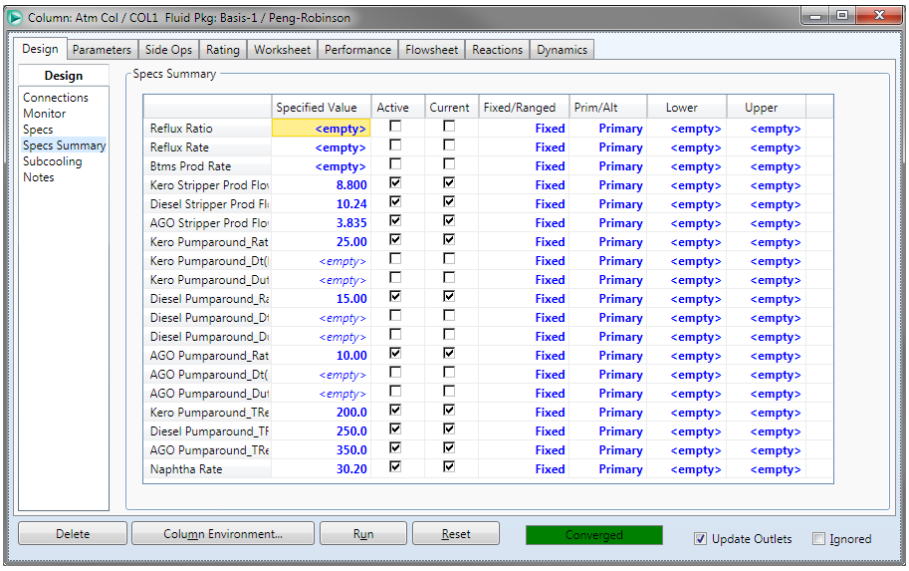
The next requirement is to specify the steam streams. This can be done using the *Worksheet* tab. Select *Conditions* and specify the temperature, pressure, & mass flowrate values. Select *Compositions*; now the compositions can be set as 100% H2O (entering a value of 1 will bring up the *Input Composition* form; press the *Normalize* button & then *OK*).



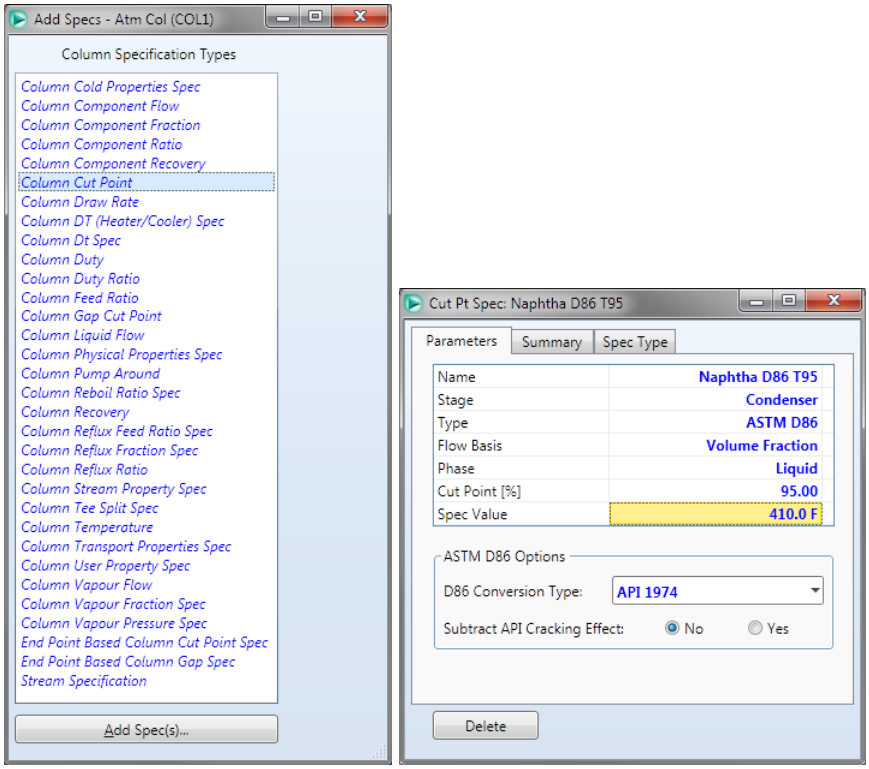


Even though we don't have all of the operating specs added we can do an initial run of the simulation by pressing *Run*. You should get a converged solution in about 4 iterations.

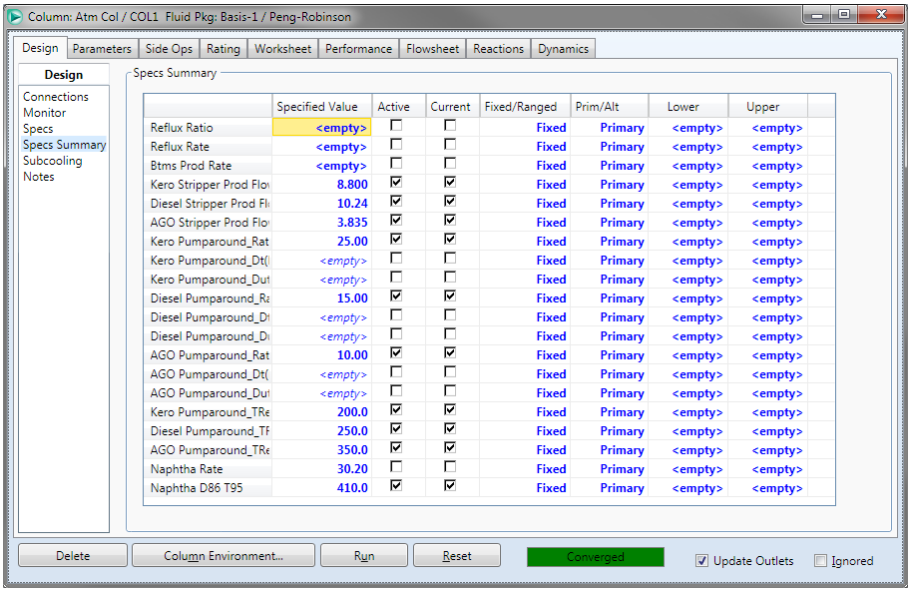
How can the distillation column equations be solved without putting the composition specs? This is because the "estimated" flowrates entered during the setup are used as the actual specifications. We can see this by checking the *Spec Summary* setting under the *Design* tab. Notice that all of these flowrate specs have checks in the *Active* column; this means that these values are the specifications to which the solution is driven.

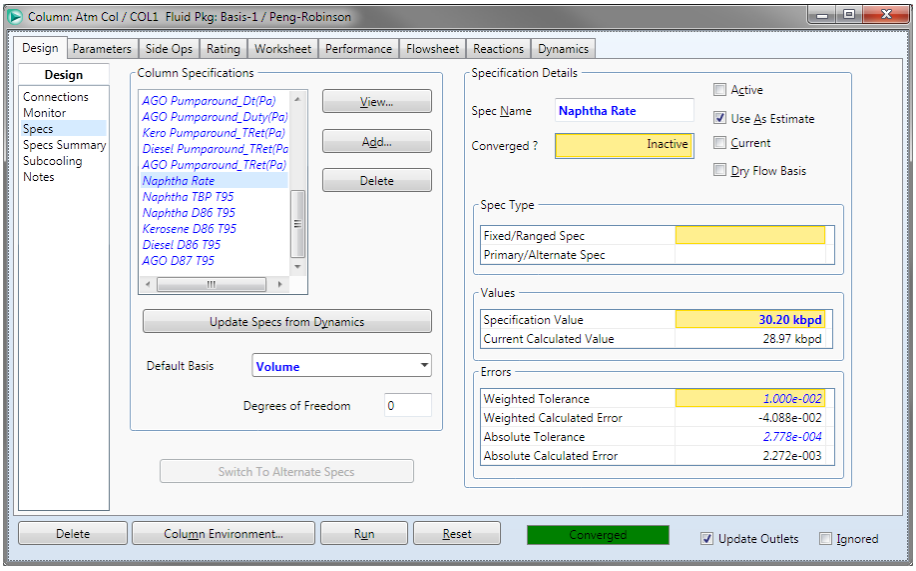


Let's now add the composition specs but not make them active. Select *Specs* under the *Design* tab. In the *Column Specifications* area we can add, remove, or change any of the specs that will show up in the Summary. Let's first add the ASTM D86 95 vol% temperature spec for the Naphtha stream. Click *Add*… In the list that comes up choose Column Cut Point (do not choose *End Point Based Column Cut Pint Spec* near the bottom of the list) & click *Add Spec(s)*… Call the spec Naphtha D86 T95, associate the spec with the liquid phase off of the Condenser, set the % as 95, and set the Spec Value as 410°F. (Keep the default *API 1974* conversion method.) You can now close the form.

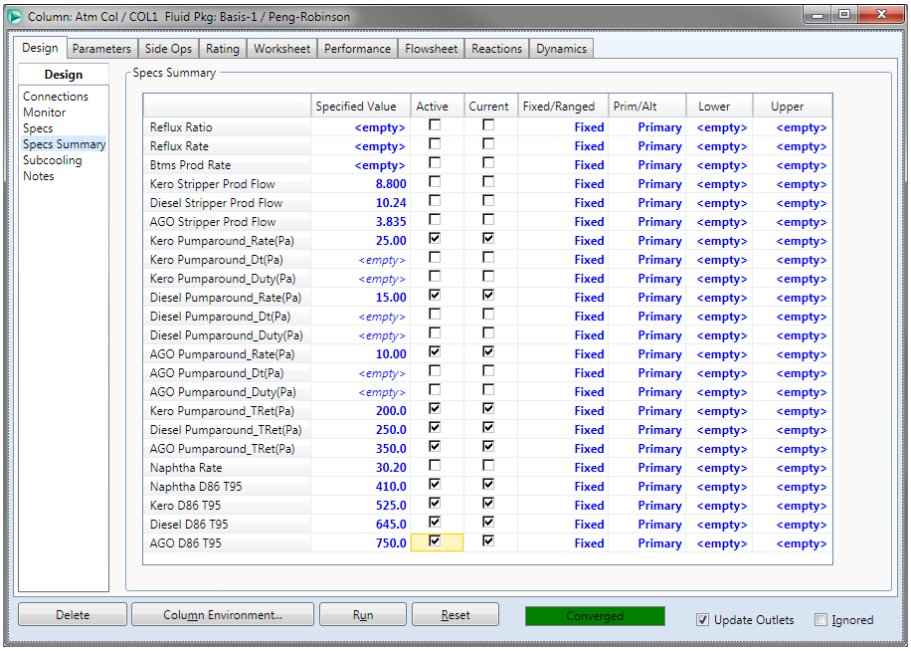


Once we close the input form we can see information about the specification details. The value is supposed to be 410°F but because the spec is not active the value is only 398.1°F. Close, but not close enough. In the actual operation of the tower we would adjust the distillate draw rate to make this spec. In HYSYS we make the *Naphtha Rate* spec inactive & make the *Naphtha D86 T95* spec active. The easiest way to do this is from the *Specs Summary* form. Changing the check boxes will cause the tower to rerun & quickly converge. Now when we check the individual specs by selecting *Specs* under the *Design* tab we see that the *Naphtha Rate* value is 28,970 bpd, not the 30,200 bpd estimate.





We can create similar design specs for the Kerosene, Diesel, & AGO D86 T95 values. Each time we make the T95 spec active we will make the corresponding produce rate inactive.



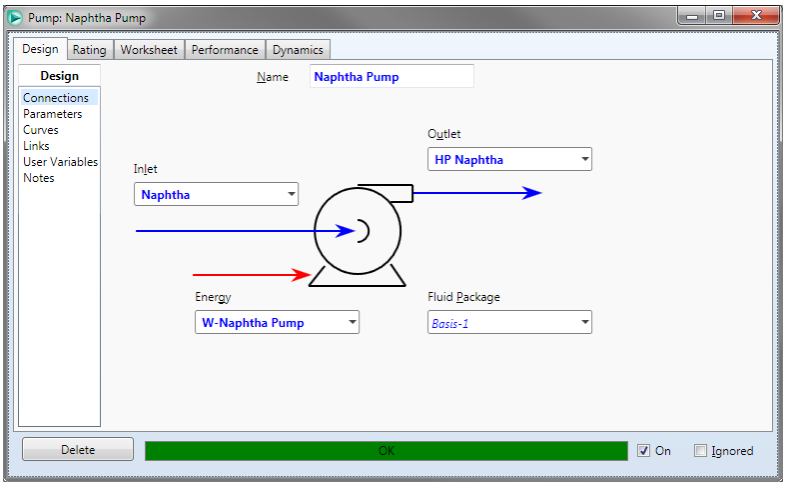
Debutanizer Column

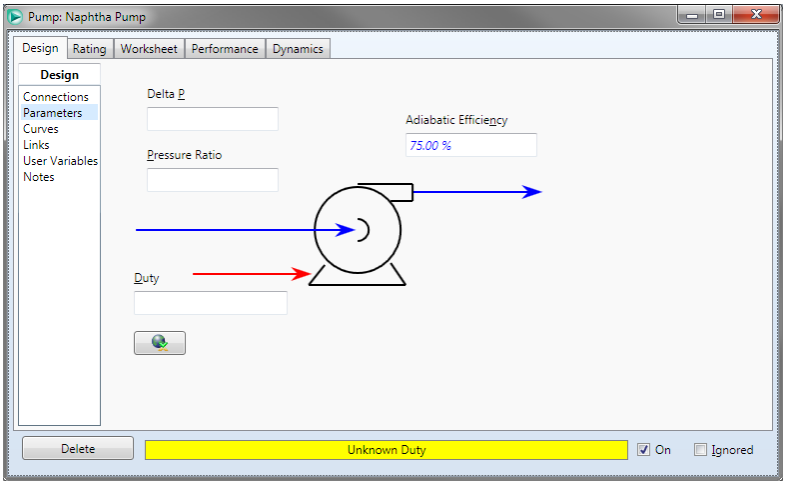
Next, let's do the simpler of the two remaining columns, the Debutanizer Column (i.e., the Naphtha Stabilizer). We will want to operate the Debutanizer at a higher pressure than the Atmospheric Distillation Column, so we will need a pump for the Unstabilized Naptha. We will also preheat the feed entering the column. Table 5 shows the operating conditions for the column & the feed's pump & preheater.

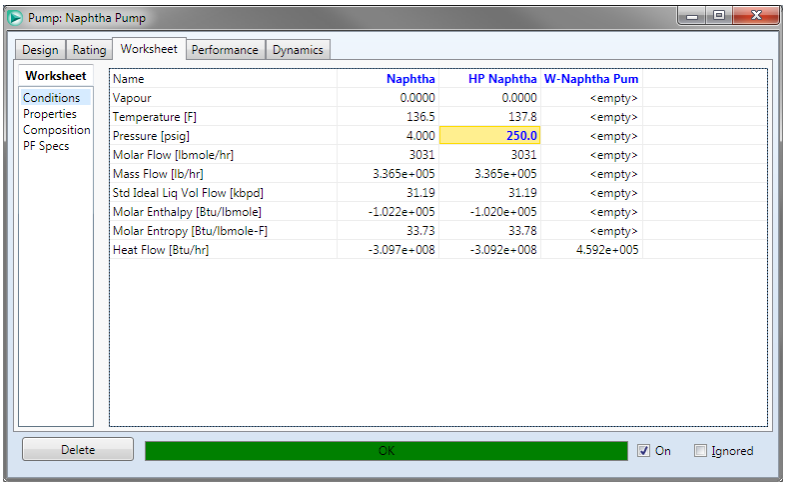
Table 5. Definitions for Debutanizer Column

Type	Operating Parameter
Feed Prep	Increase pressure to 250 psig; use default adiabatic efficiency for pump (75%) Preheat to 250°F; assume negligible pressure drop through exchanger
Trays & Efficiencies	45 trays. Number from top. All trays 80% efficiency
Condenser Type	Total condenser 1.5 reflux ratio
Reboiler Type	Kettle reboiler
Pressures	Condenser: 150 psig Top Tray: 150 psig Bottom Tray: 160 psig Reboiler: 160 psig
Temperature	No other estimates needed
Feed Locations	Unstabilized Naphtha to Tray #22
Products	Overhead LPGs, 5,500 bpd Stabilized naphtha from bottom

Place a *Pump* on the flowsheet & define the following connections. Retain the default adiabatic efficiency. Set the outlet pressure as 250 psig in the *Worksheet* tab.

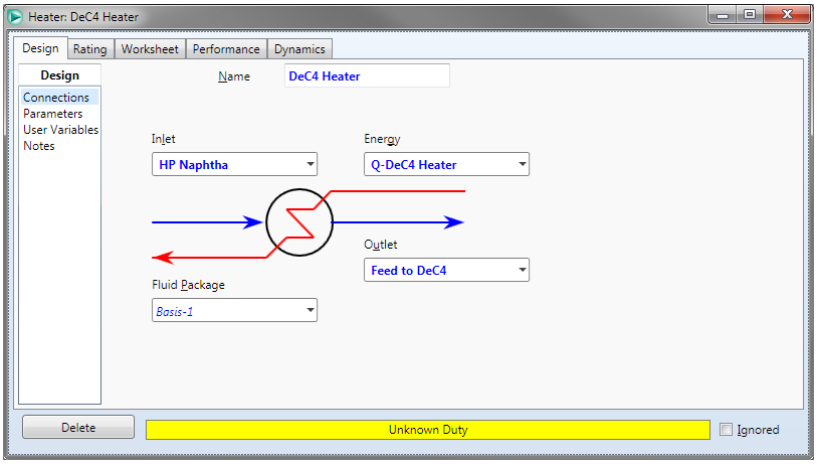


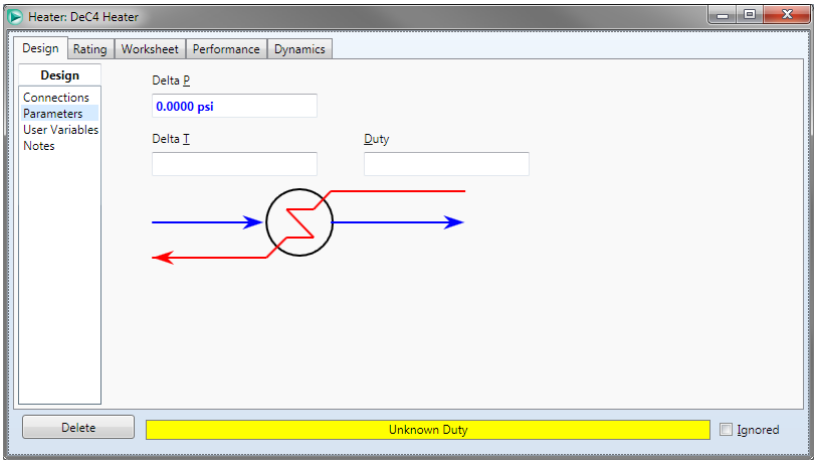


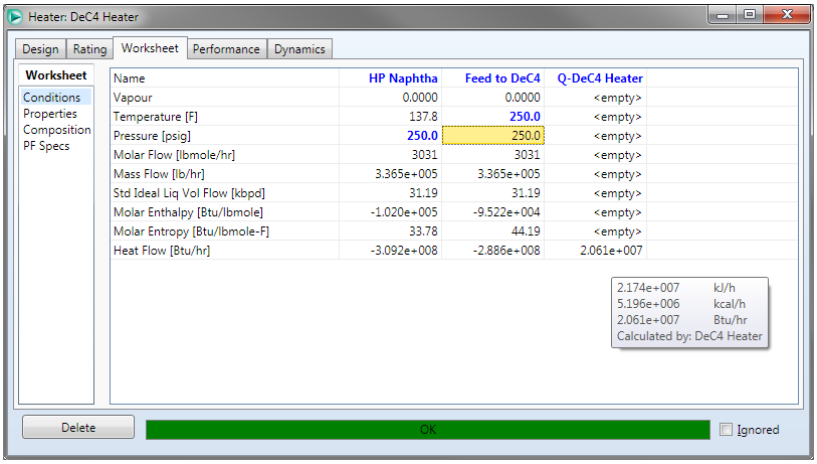


Name	Naphtha	HP Naphtha	W-Naphtha Pum
Vapour	0.0000	0.0000	<empty>
Temperature [F]	136.5	137.8	<empty>
Pressure [psig]	4.000	250.0	<empty>
Molar Flow [lbmole/hr]	3031	3031	<empty>
Mass Flow [lb/hr]	3.365e+005	3.365e+005	<empty>
Std Ideal Liq Vol Flow [kbpd]	31.19	31.19	<empty>
Molar Enthalpy [Btu/lbmole]	-1.022e+005	-1.020e+005	<empty>
Molar Entropy [Btu/lbmole-F]	33.73	33.78	<empty>
Heat Flow [Btu/hr]	-3.097e+008	-3.092e+008	4.592e+005

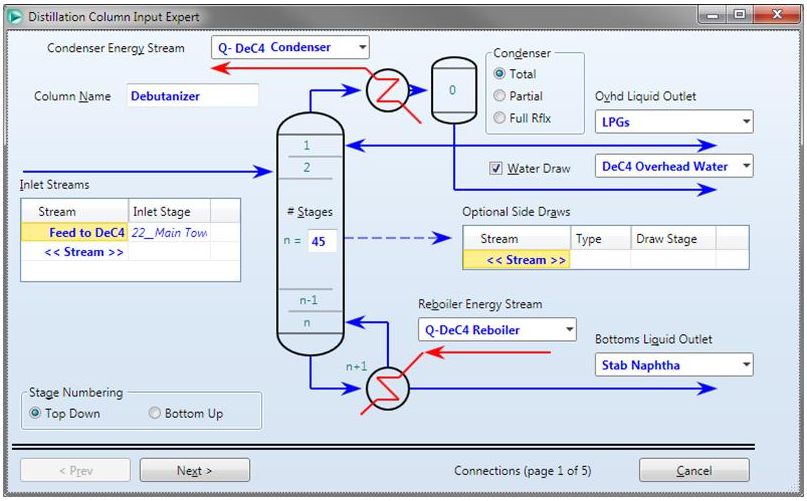
Place a *Heater* on the flowsheet & define the following connections. Set the pressure drop in the *Parameters* section. Since the outlet pressure is calculated from the pressure drop it does not have to be set on the *Worksheet* tab. However, we still need to set the outlet temperature & this can be done on the *Worksheet* tab.



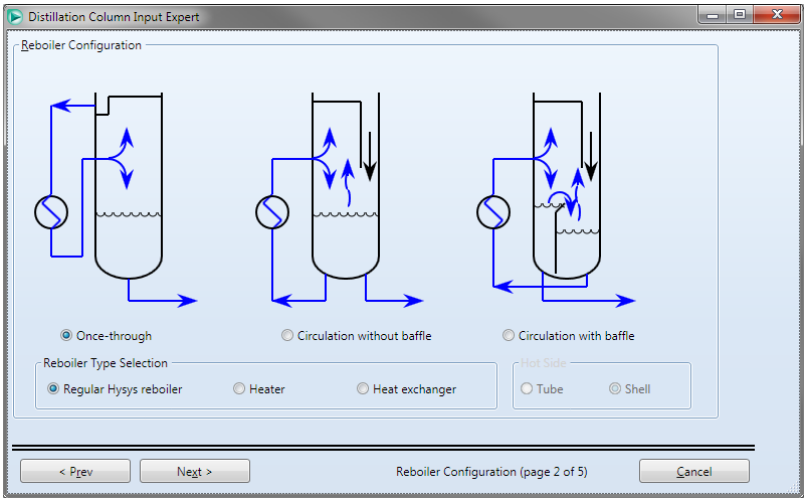




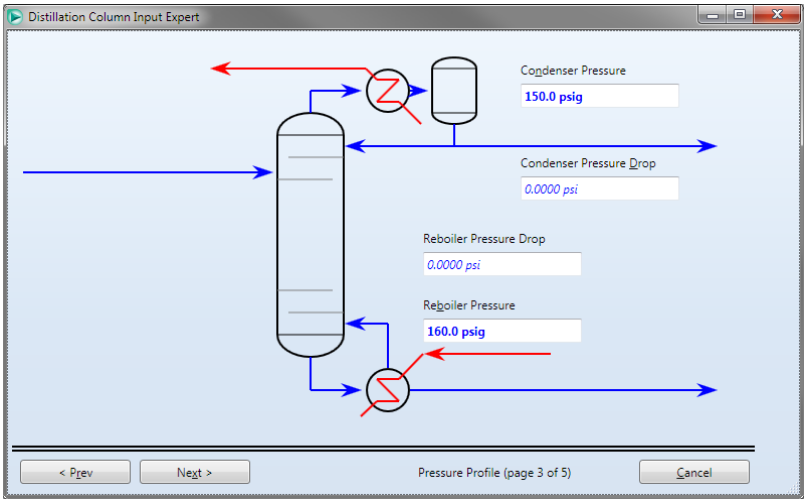
Now we can define the Debutanizer. Just like with the Atmospheric Distillation Column HYSYS will start the process with a 5 step wizard to walk you through the basic configuration. From the *Columns* tab in the model *Palette* chose the *Distillation Column* sub-flowsheet (the one with both a condenser & a reboiler).



The next step is to pick a type of reboiler. The first entitled Once-through depicts a kettle reboiler & is the one we want (liquid from the bottom tray is the feed to the reboiler, produced vapors are returned to the bottom tray and the liquid exits as the bottoms product). The other two configurations are for thermosiphon reboilers; though used commercially they will not be chosen for this example. Click *Next>* when done.

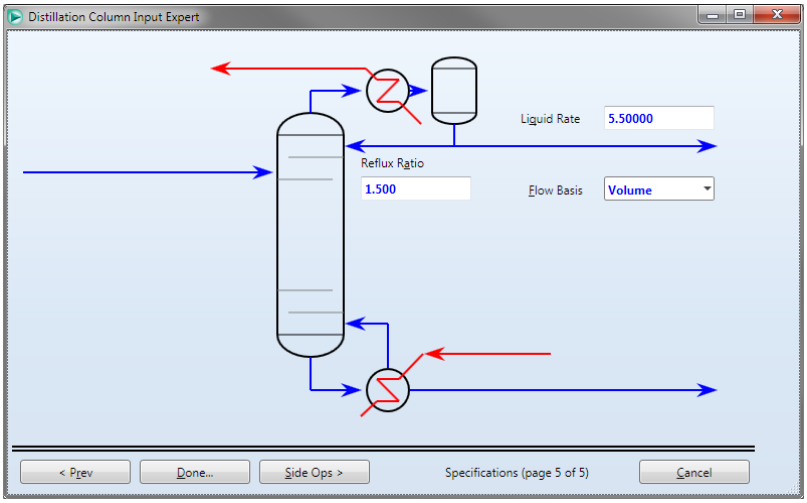


The next form is for entering the basic pressure profile. Enter the values from Table 5. Click *Next>* when done.

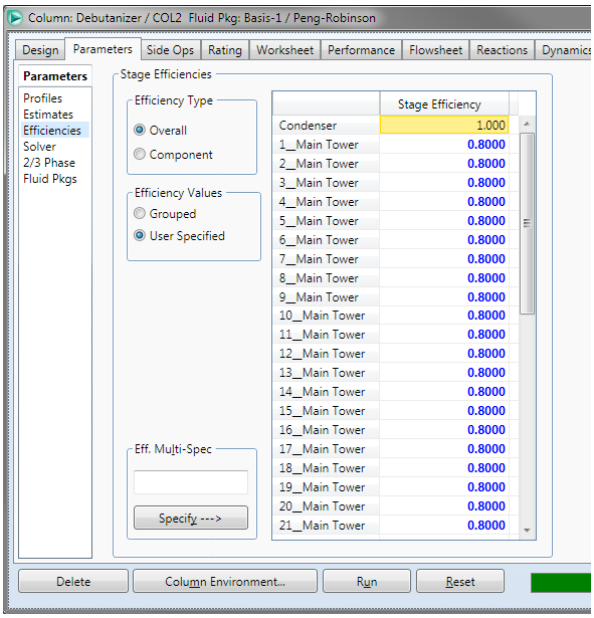


For this tower we will skip entering temperature estimates. Click *Next>*.

On the next form enter the reflux ratio & distillate rate. Click *Done* when finished.



The final step before trying to run is to specify the stage efficiencies to model the stages as real trays. Under the *Parameters* tab select *Efficiencies*. Make sure that *Overall* & *User Specified* items are highlighted. Apply the same efficiency to all stages representing trays, leaving the efficiencies for the Condenser & Reboiler at 1.0.



Now we can click on the *Run* button. The convergence should be very rapid.

Vacuum Distillation Column

The final step is to define the feed heater & Vacuum Distillation Column. Additional steam is injected into the Vacuum Feed Heater to increase velocity & minimize coke formation within the heater. Even though the Vacuum Column is packed it will be modeled as "trays," i.e., sections of non-equilibrium stages.

The first step is to mix the Atm Resid from the Atmospheric Distillation Column with the steam upstream of the Vacuum Heater. Place a Mixer on the flowsheet & define the following configuration. You will have to define the steam stream; this can be done via the *Worksheet* tab.

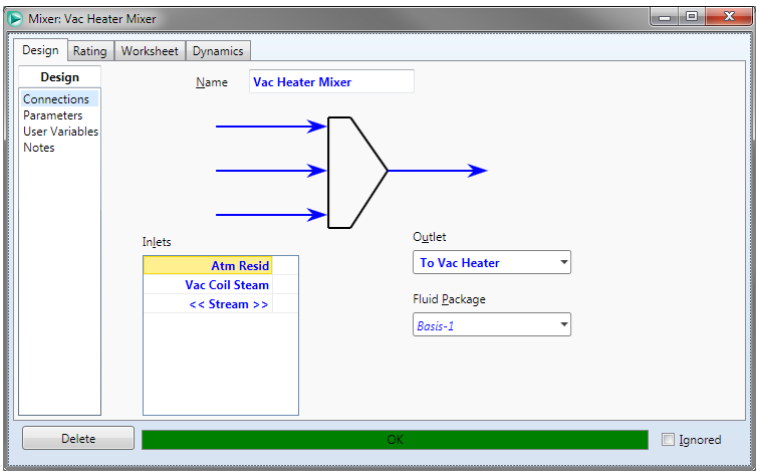
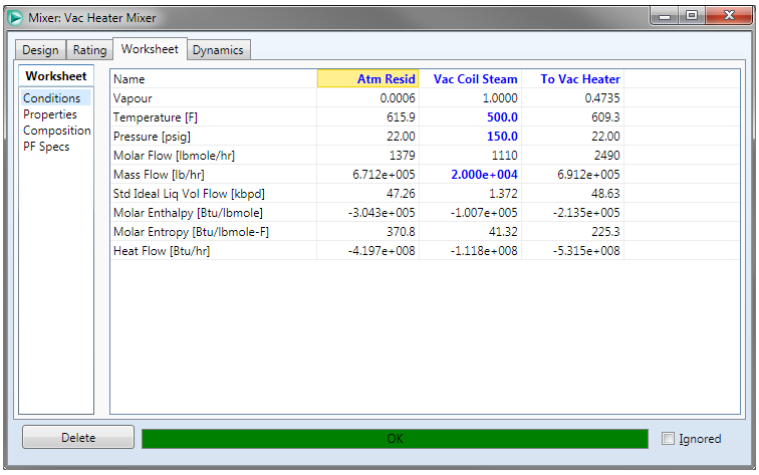


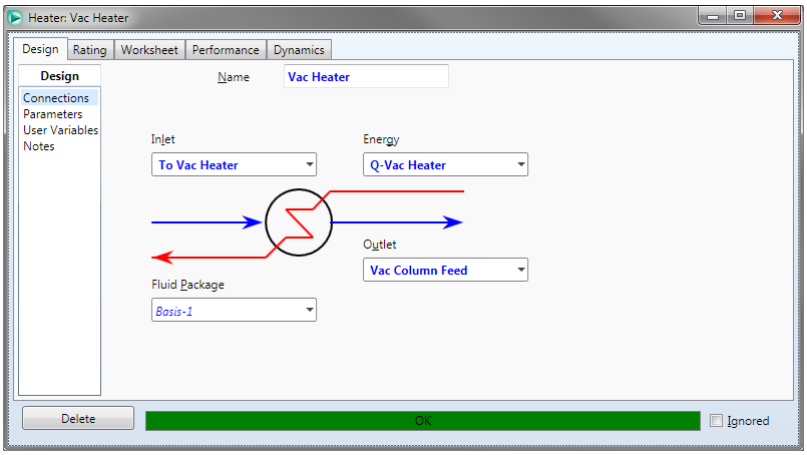
Table 6. Definitions for Vacuum Distillation Column

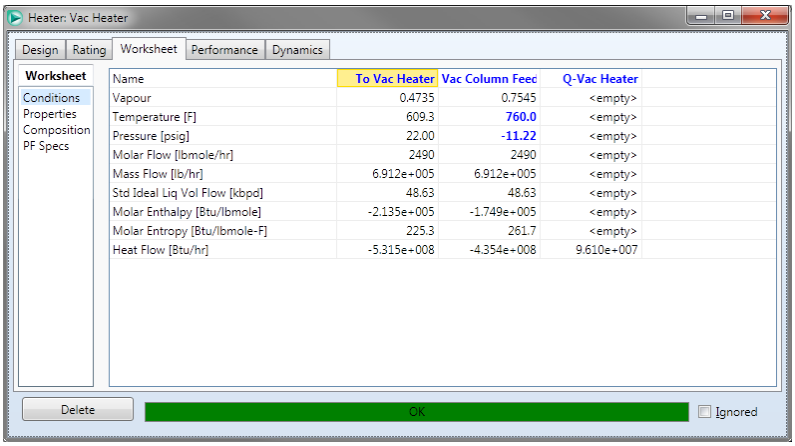
Type	Operating Parameter
"Trays" & Efficiencies	14 trays. Numbering from top: Tray 1: 100% Trays 2 to 11: 50% Tray 12: 100% Trays 13 to 14: 30%
Condenser Type	No condenser, LVGO pumparound liquid return to top stage
Reboiler Type	None, Direct Fired Heater
Pressures	Top Tray: 50 mmHg Bottom Tray: 62 mmHg
Temperatures	Top 180°F (controlled by top LVGO pumparound)
Feed Locations	Crude oil to Tray #12 Stripping Steam at bottom (Tray #14) – 20,000 lb/hr @ 500°F, 150 psig
Feed Heater	20,000 lb/hr steam injected into heater coils with the Atmospheric Resid feedstock (500°F & 150 psig) Outlet @ 180 mmHg & 760°F (max); would like 3,000 bpd excess wash liquid (liquid rate from tray above feed, #11)
Pumparounds	LVGO Pumparound Draw from Tray #4, returned to Tray #1 22,300 bpd flow, outlet temperature adjusted to control top temperature of tower; approximately 85°F, 42 MMBtu/hr cooling
	HVGO Pumparound Draw from Tray #8, returned to Tray #5 50,000 bpd flow, 150°F cooling
Products	LVGO from Tray #4; 915°F D1160 T95; 5,000 bpd (approximate) HVGO from Tray #8, 1050°F D1160 T95; 21,000 bpd (approximate) Slop Wax from Tray #11, 1,000 bp Vacuum resid from bottom



The fired Vacuum Heater is separate from the column environment & will be created next. Create a new Heater on the flowsheet & call it *Vac Heater*. Change the icon to look like a heater instead of a shell & tube heat exchanger. Enter the following connections & set the

following outlet conditions to match the vacuum column conditions in Table 6. Note that even though the pressure is specified as *180 mmHg(0C)* the value is immediately converted to the units used in the flowsheet, here *psig*[3].

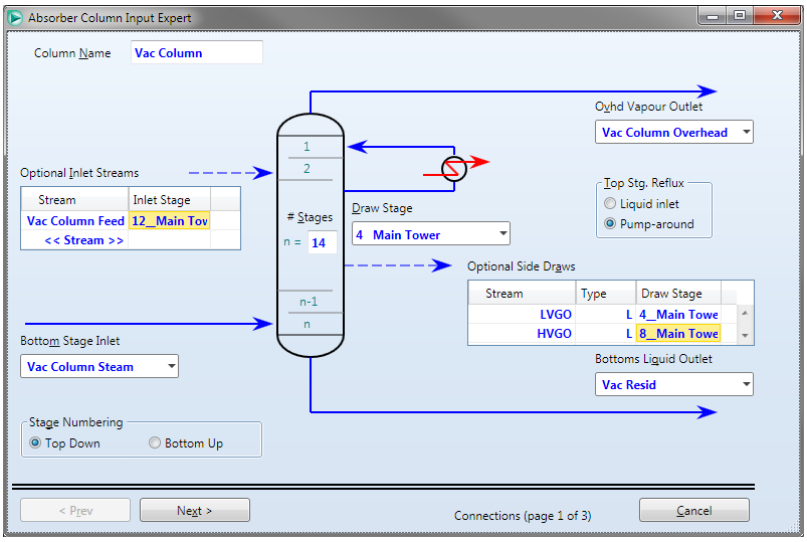




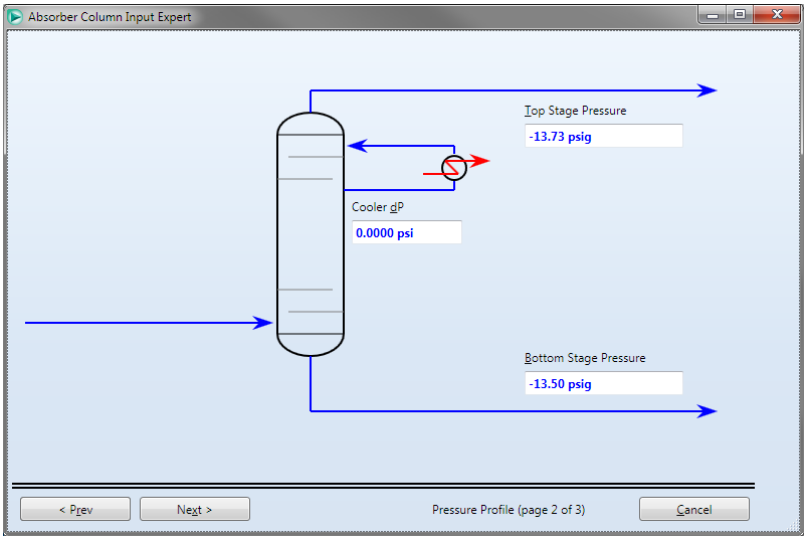
Configuring the Vacuum Column for the first time is a multi-step process. First, create an *Absorber Column* on the flowsheet then double-click start to fill in the information. Fill in the basic information for the configuration on the first form. Couple things that are different from the previous two columns:

- Specify that the top stage reflux comes from a *Pump-around* (note that HYSYS will define this first pumparound & give it a default name; this can be changed later).
- Specify the *LVGO*, *HVGO*, & *Slop Wax* streams on this form as *Optional Side Draws* (since they are not processed further in side strippers). Note in the image below that only 2 *Optional Side Draws* are shown; you will have to scroll down to see the connection for the *Slop Wax*.

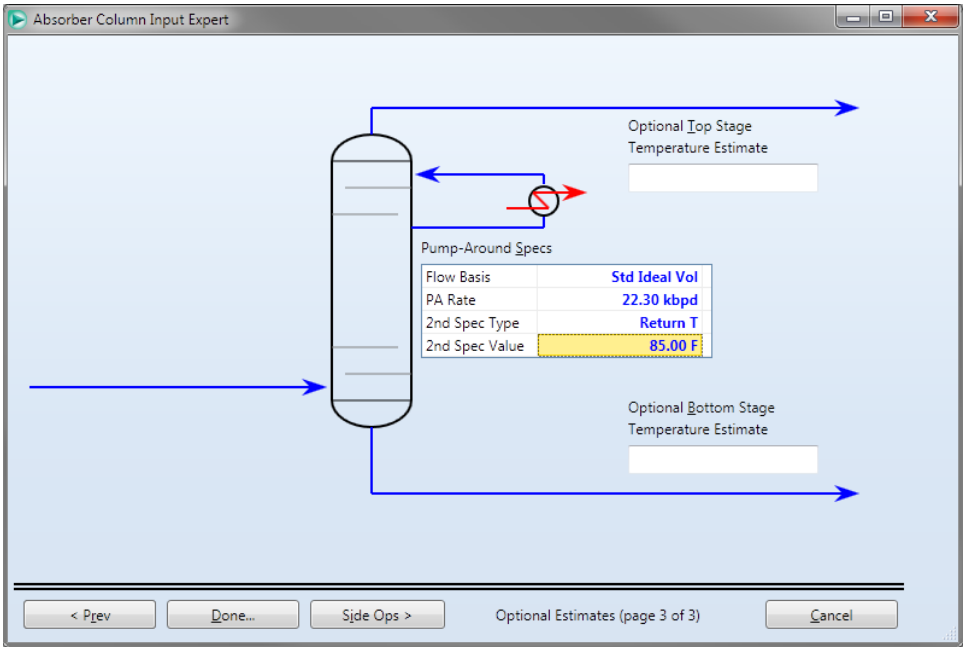
[3] Be very careful which units you choose for the pressure. If you choose *mmHg(0C)_g* by mistake you've specified a gauge pressure & will be much too high since it would be above 1 atm instead of at vacuum conditions.



On the next form we'll initialize the pressure profile. Again, even though the pressures are input in units of *mmHg(0C)* they get converted to *psig*. Click *Next>*.

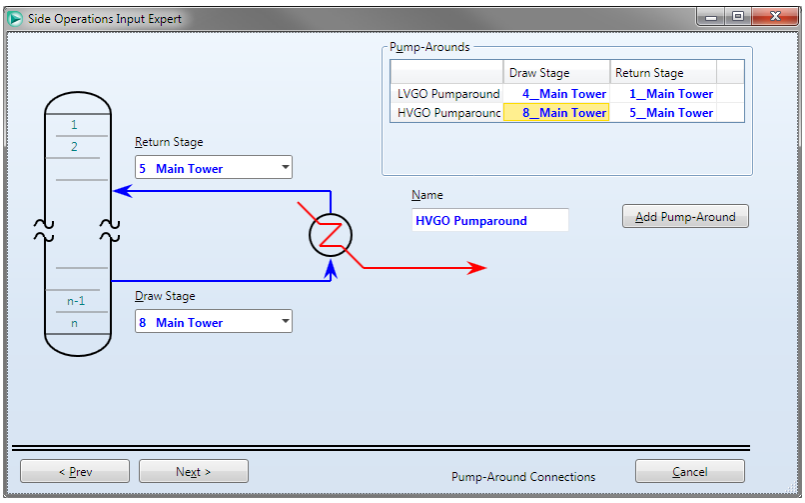


The next form will allow us to add temperature estimates & flow information for the top pumparound. Enter the data for the LVGO Pumparound. We will skip adding temperature estimates on this form & show how they can be added later. Click *Side Ops>*.



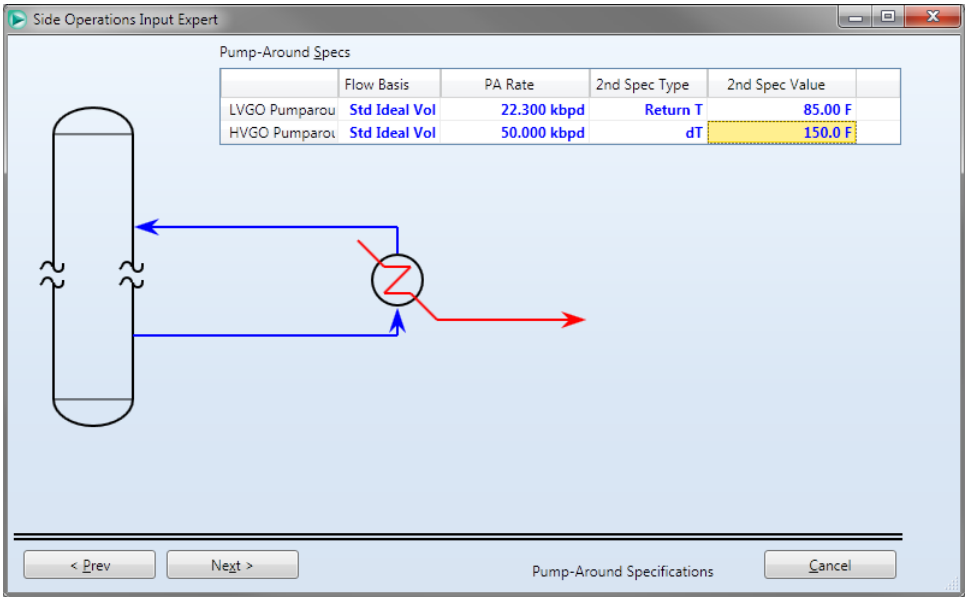
There are no side strippers or rectifiers so skip the next 3 forms for *Reboiled Side Stripper Connections*, *Steam Stripped Side Stripper Connections*, & *Side Rectifier Connections*.

There is already one pumparound defined (since we specified a pumparound return to provide the top stage reflux). Let's changed the Name from the default to *LVGO Pumparound*. Then click Add Pump-Around and define the *HVGO Pumparound*. Click *Next>* when done.

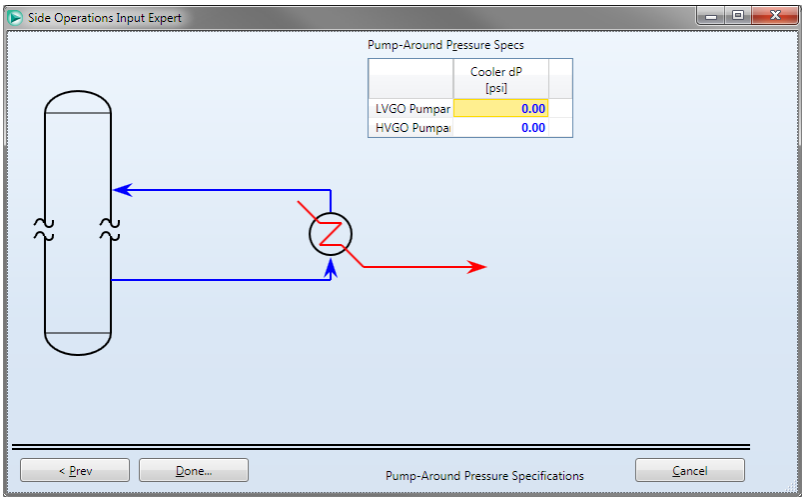


We will skip the next form for *Vapor Bypass Connections*.

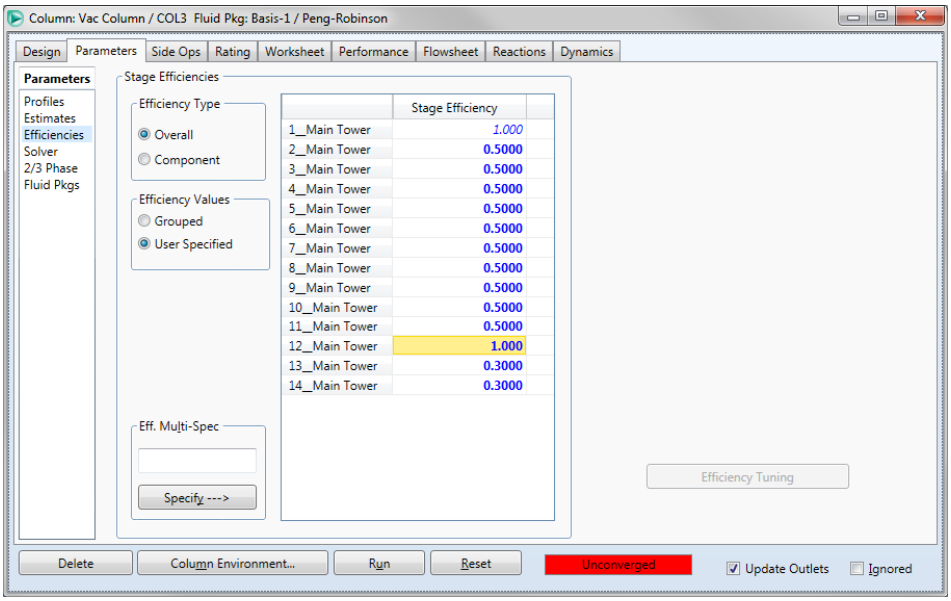
The next form allows us to add the HVGO Pumparound specs. Note that the specs for the LVGO Pumparound were previously entered & are shown here. Click *Next>* when done.



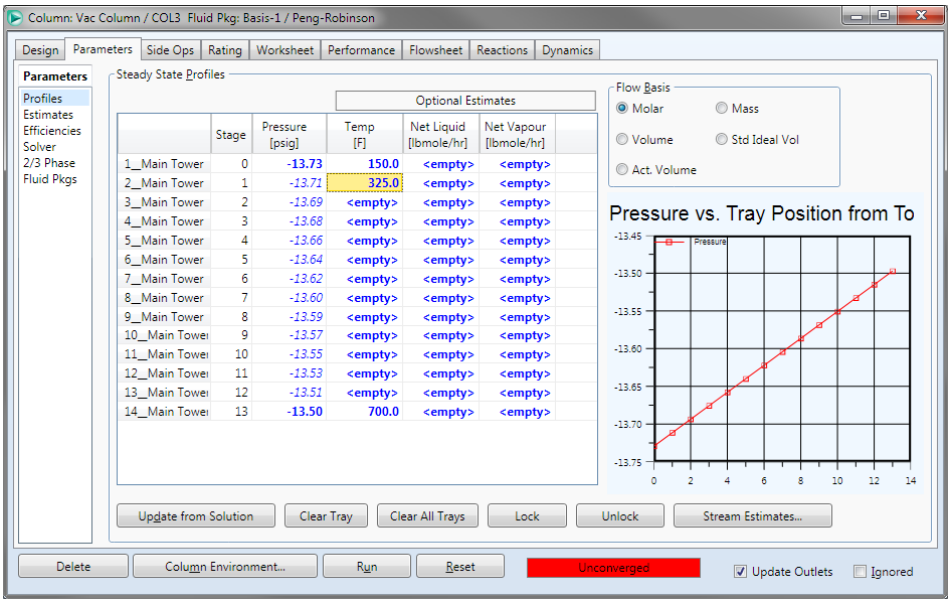
On the last form we will accept zero pressure drops through the pumparounds. Click *Done…*



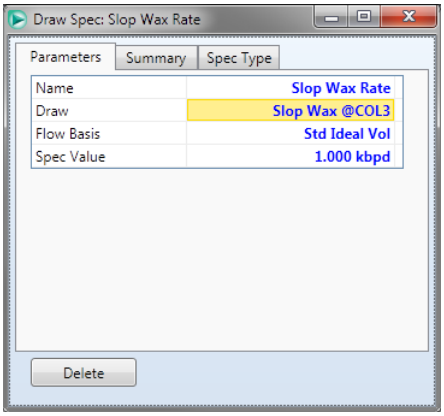
Before we try running the column we need to enter the efficiencies for the stages. Select *Efficiencies* under the *Parameters* tab & enter the values from Table 6.



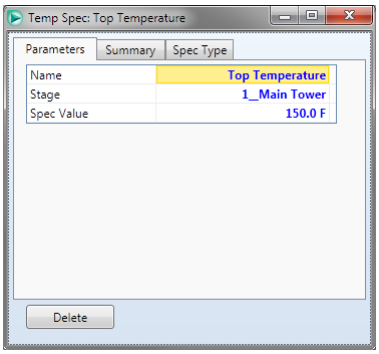
We skipped adding temperature estimates before but we can add them now. Go to the *Profiles* item under the *Parameters* tab. It's pretty typical to have a top temperature of about 150°F (this will actually be changed to be our specification) & a bottom temperature of 700°F. You may also want to specify the 2nd stage temperature of 325°F (since there is a significant cooling between the top & next stage).

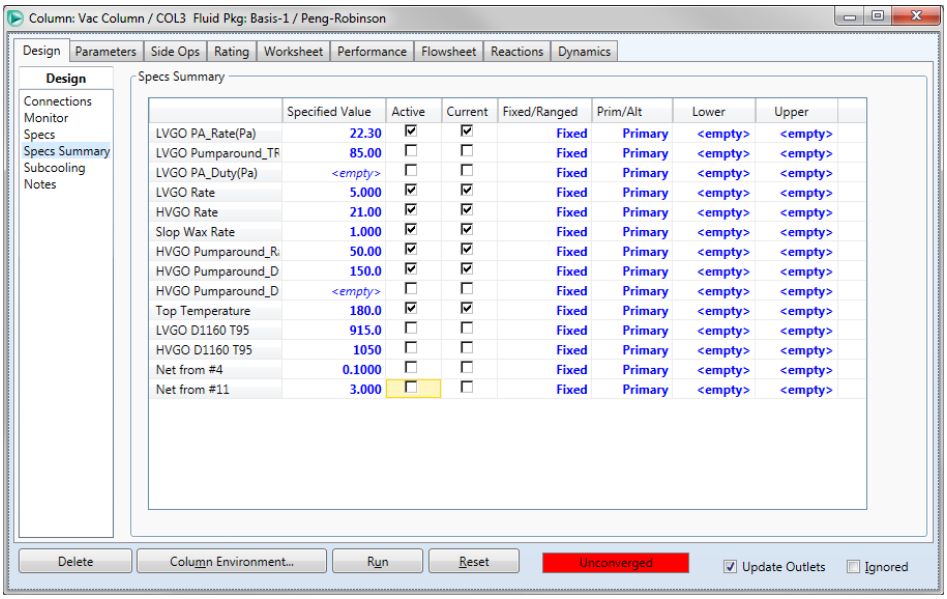


Before we can run the column we have to specify something about the side draws (*LVGO*, *HVGO*, & *Slop Wax*). Let's specify the estimated flowrates and use these as specifications. For example, for the *Slop Wax* rate, select the *Specs* item in the left-hand column under the *Design* tab & press *Add…* Call the spec *Slop Wax Rate*, associate with the *Draw* named *Slop Wax @COL3*, set the flow basis as *Std Ideal Vol*, and set the rate as *1 kbpd*.



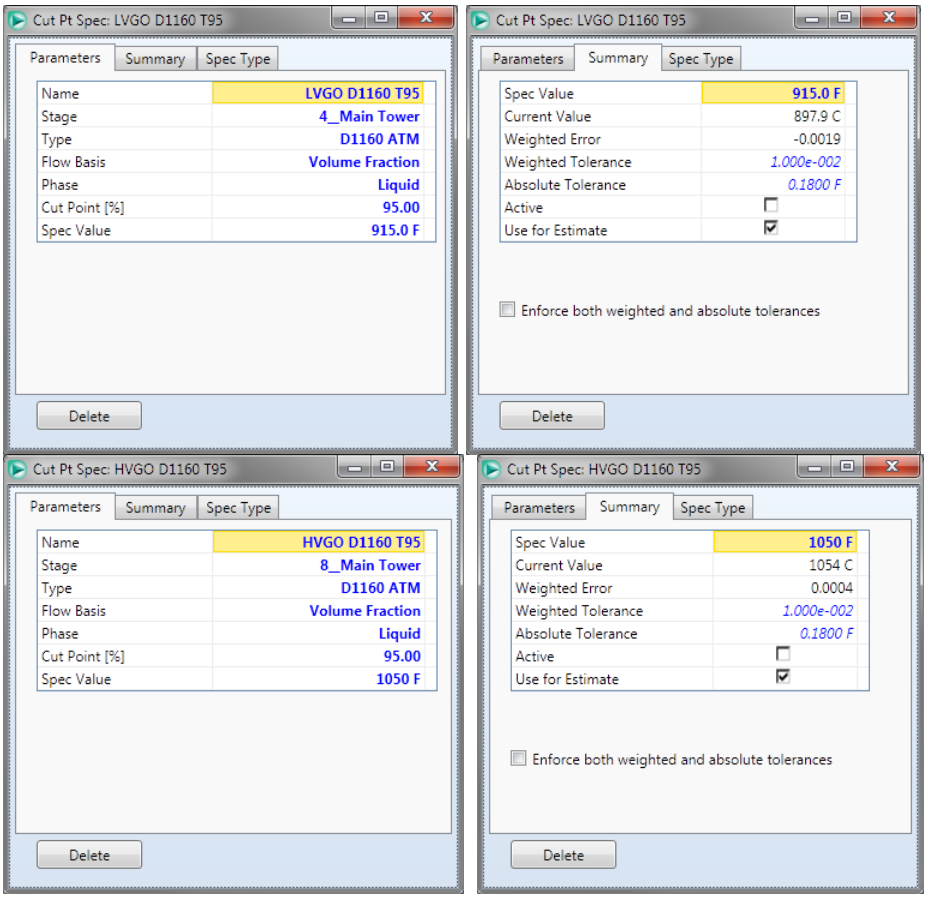
Now let's change the performance of the LVGO Pumparound to adjust the return temperature in that pumparound to meet the temperature spec at the top of the column. Select the *Specs* item under the *Design* tab & add a spec for the top temperature. To make it active go to the *Spec Summary* item, uncheck the *LVGO Pumparound_TRet(Pa)* & check the *Top Temperature* spec.



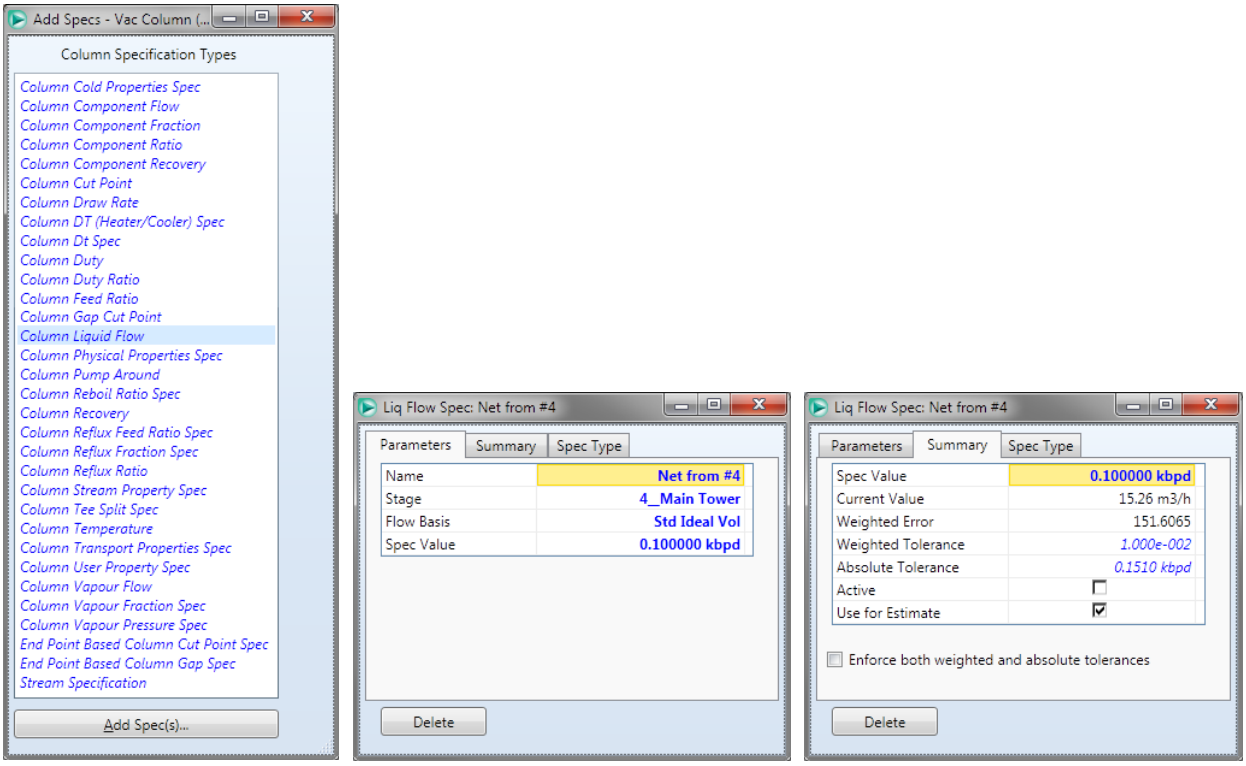


Now we can press *Run*. The Vacuum Column should converge fairly quickly.

We can add the D1160 specs for the LVGO & HVGO in a similar manner to the Atmospheric Column specs except that these streams are direct liquid draws from the main column & do not go through side strippers. To set the LVGO spec first *Add* a *Column Cut Point* from the *Specs* item on the *Design* tab. However, for right now we do not want to make them active; click on the Summary tab & uncheck the *Active* box. You can also go to the *Specs Summary* item & make sure that these new D1160 specs are not checked in the *Active* column.



It is also useful to add specs for the liquids flowing from the LVGO to the HVGO section (from tray #4) and the HVGO to feed tray (from tray #11). These can be added as a *Column Liquid Flow* spec. Make sure you specify the values as *Std Ideal Vol* for the *Flow Basis* & ensure that the *Active* box is unchecked on the *Summary* tab's form.



Before we apply the D1160 specs for the HVGO & LVGO let's examine some of the internal flowrates. The most important is the liquid runback to the feed tray; this will be the liquid rate from Tray #11. Select the *Specs* item under the *Design* tab & then select the *Net from #11* item in the *Column Specifications*. In the *Specifications Details* area we can see that we'd like to apply a Specification Value of 3,000 bpd & currently have 4,888 bpd. We have some flexibility to pull additional HVGO and/or LVGO without drying up the column.

Let's look at the HVGO D1160 T95 value. We want 1050°F & we actually have 1044°F. This is very close; we'll increase the HVGO draw rate to increase this value to the spec. Go to the *Spec Summary*, uncheck the *Active* box for *HVGO Rate*, & check the *Active* box for *HVGO D1160 T95*. The simulation should quickly converge. Go back to the *Specs* form to check the actual HVGO D1160 T95 value; it should be 1050°F. (If not, press, *Reset* & *Run*.) Note that the HVGO rate is large as expected, 21.47 kbpd vs. 21.00 kbpd. Also note that the *Net from #11* flowrate has decreased slightly to 3,961 bpd.

Now let's look at the LVGO results. For 5,000 bpd LVGO rate the D1160 T95 value is too low. Since the T95 value is too low, we will have to increase the LVGO draw rate to try to meet this spec. Let's apply this D1160 spec instead of the flowrate spec. The column will converge. The LVGO flow rate has increased to 7,534 bpd, the HVGO flow rate has actually decreased to 18,700 bpd, and the Tray #11 liquid runback has increased to 4,462 bpd.

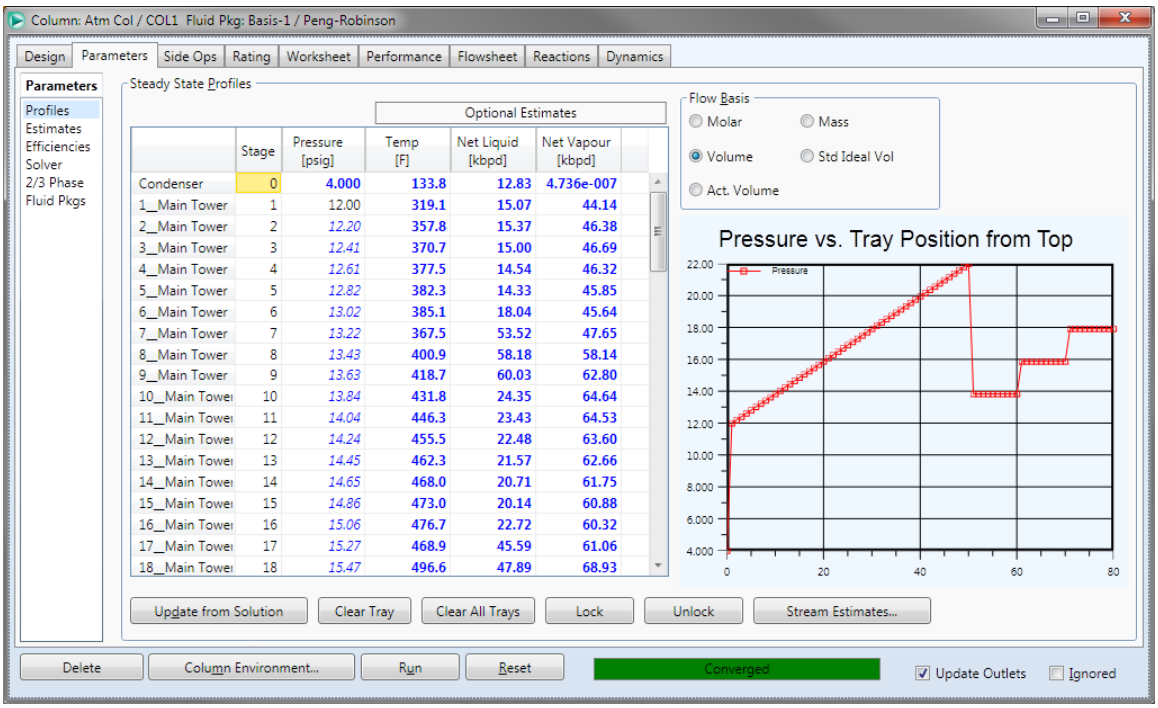
Let's go back to the runback rate. This rate is too large & how could we decrease? We actually have to back up to the Feed Heater & decrease the temperature so that we don't boil up as much gas oils. We can manually adjust to 749.6°F to get 3,011 bpd runback from Tray #11.

Stream & Unit Analyses

Now that the simulation has been run & converged we want to be able to analyze the results. First we'll look at ways of further examining unit & stream results.

First, let's look at the temperature & liquid/vapor traffic in the Atmospheric Column. Let's double click on *Atm Col* & click on the *Parameters* tab. Select the *Profiles* option & you can see the temperatures, pressures, & liquid & vapor flows for all of the trays (including the side stripper trays at the bottom of the list). Notice there are several options for showing the liquid & vapor flows: molar, mass, & 3 types of volume. The molar & mass quantities should be self-evident, but the volume factors are somewhat confusing:

- *Act. Volume* – this is the volumetric flow based on the density at the temperature & pressure conditions (as calculated by the corresponding density method, usually COSTALD). This is the most appropriate value to use when determining the hydrodynamics on the tray & within the column.
- *Volume* – this is the standard liquid volume as calculated from each component's specific gravity value & blended by the mass amount of each component in the mixture assuming ideal mixing (i.e., no shrinkage effects). This is the most normal definition for "standard liquid volume."
- *Std Ideal Vol* – this is the volumetric flow calculated, not at the actual pressure & temperature for the fluid, but rather at the standard temperature & bubble point pressure (again by the COSTALD method). This will be very similar to the *Volume* value but will include shrinkage effects. This is a value calculated by HYSYS but very few other simulation programs.



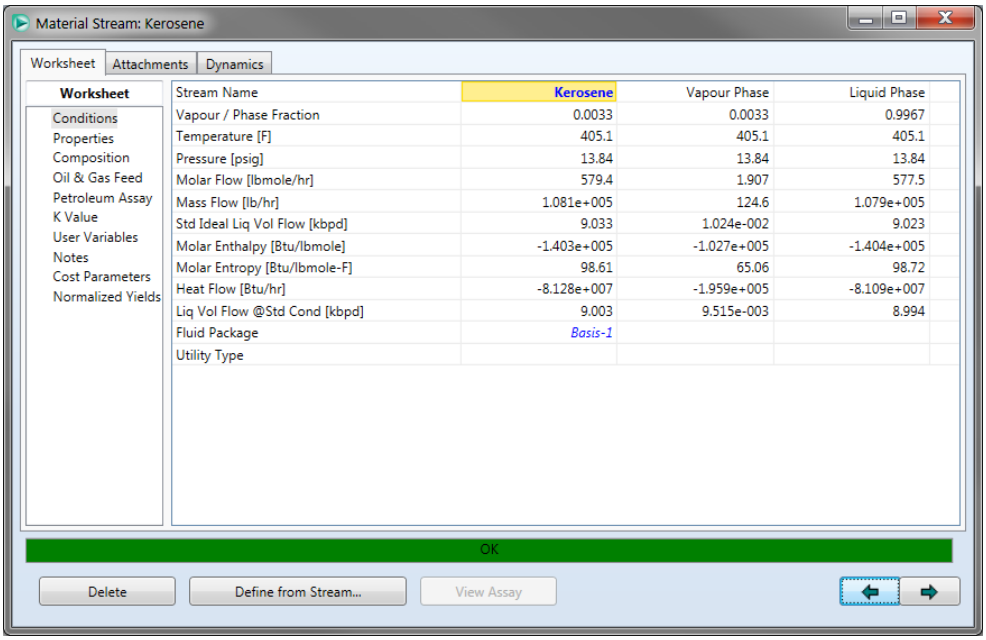
Which of these values should you use? This depends on your purpose:

- If you're trying to track how much of each fraction goes out with each side stream, then use the *Volume* values. As long as there is no chemical reaction these values are conserved (since they are essentially a transformed mass amount).
- If you are doing hydraulic calculations then use the *Act Volume* values.
- If you want to determine the ideal gas flows (such as scf of a produced light gas) then start with *Molar* flow values & convert the units as appropriate.

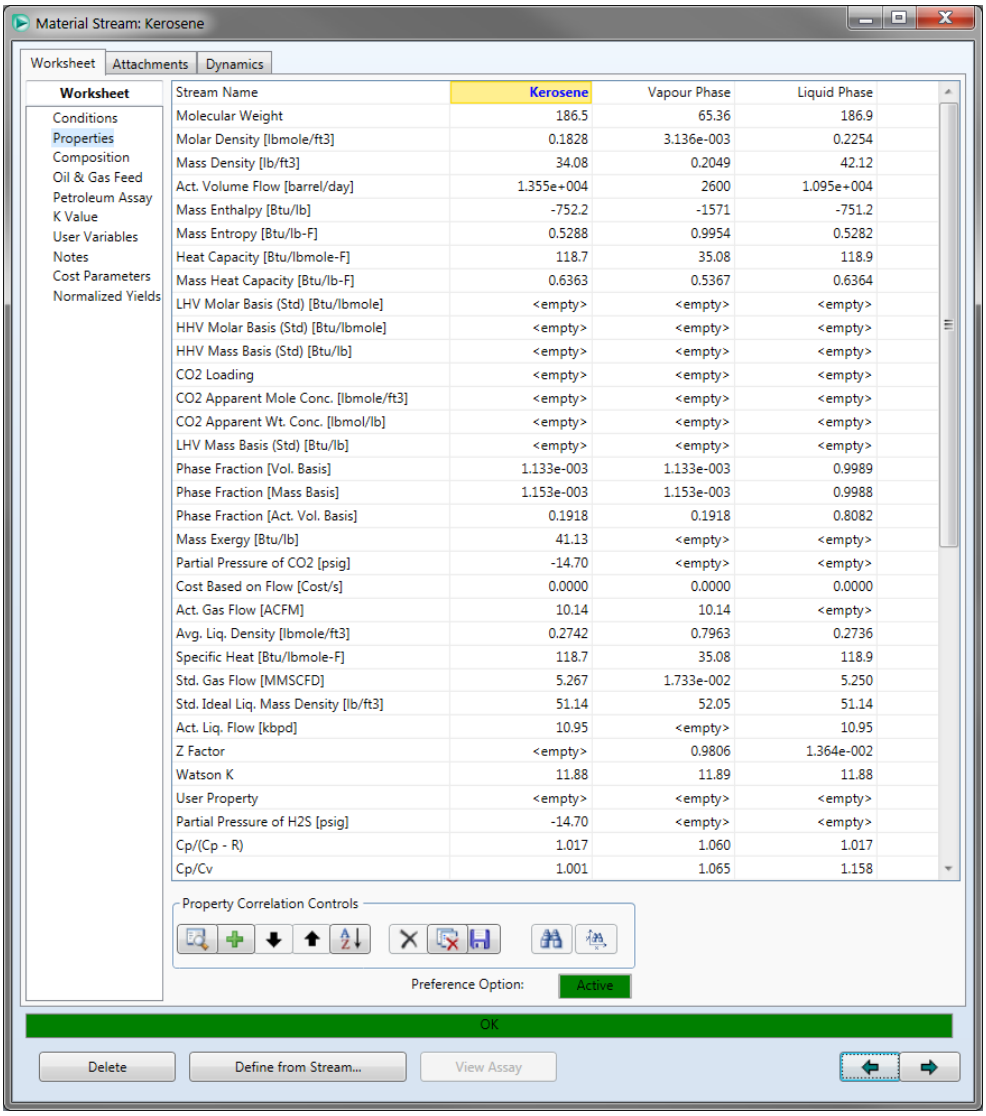
What are some of the properties of interest for streams? In general we will want to know:

- How much?
- What quality?
- At what conditions?

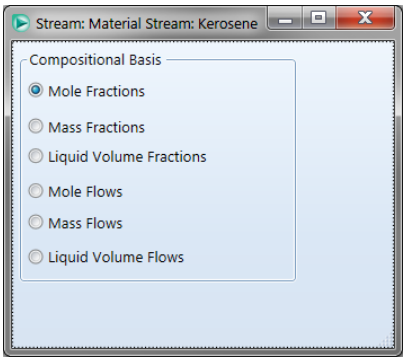
Let's first look at the Kerosene stream. We can double click on the *Kerosene* stream in the Flowsheet & look at the *Conditions* item under the *Worksheet* tab. This shows us answers to "how much" & "at what conditions." We can see the pressure & temperature, flowrate in various sets of units (mass, molar, standard liquid volume, & actual volumetric flow at operating conditions).

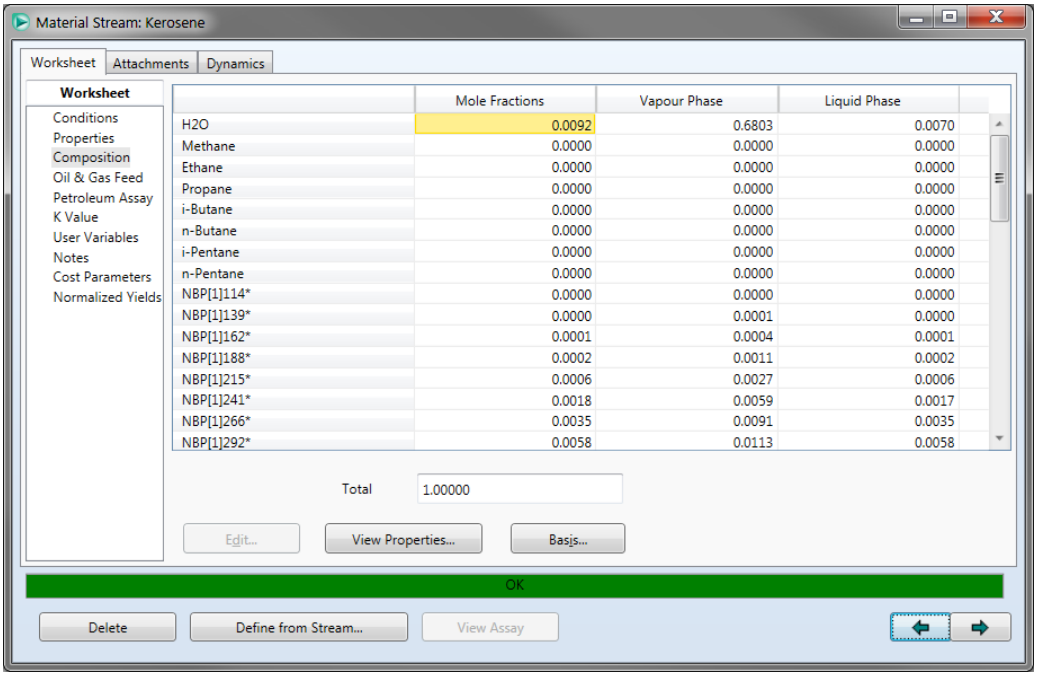


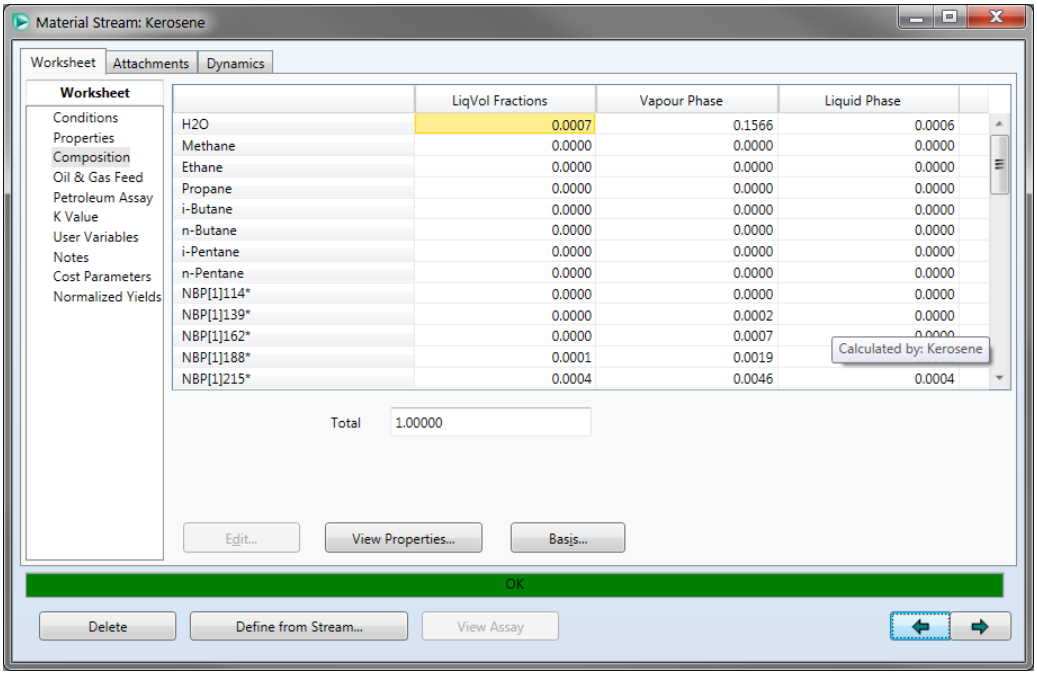
If we want to see other physical properties for this stream we would select the *Properties* item. Now we can see an extensive set of physical & transport properties for this stream. This answers a great deal of the "what quality" questions.

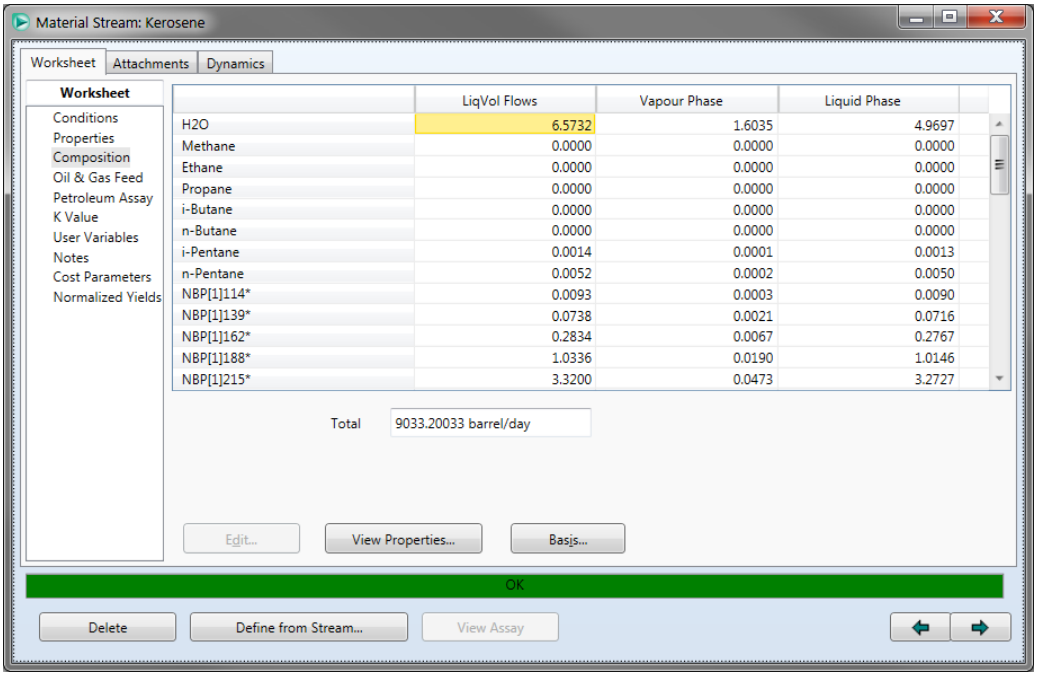


The *Composition* item will show tables of the stream's composition using multiple possible bases: molar, mass, & standard liquid volume. The default will generally be for mole fractions. But pressing the Basis… button will allow you to change to other types on both fractional & flowing values. When working with petroleum fluids the liquid volume fractions or flows are very convenient.



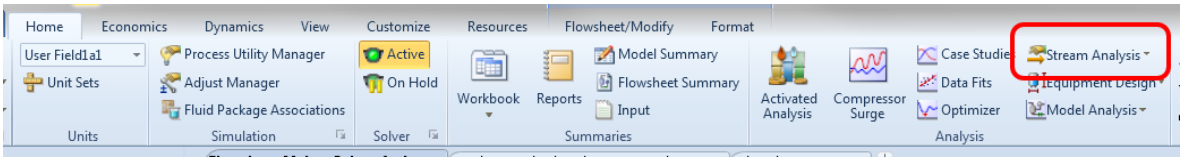

Material Stream: Kerosene
Worksheet
Attachments
Dynamics
Worksheet
Conditions
Properties
Composition
Oil & Gas Feed
Petroleum Assay
K Value
User Variables
Notes
Cost Parameters
Normalized Yields
Mole Fractions
Vapour Phase
Liquid Phase
H2O 0.0092 0.6803 0.0070
Methane 0.0000 0.0000 0.0000
Ethane 0.0000 0.0000 0.0000
Propane 0.0000 0.0000 0.0000
i-Butane 0.0000 0.0000 0.0000
n-Butane 0.0000 0.0000 0.0000
i-Pentane 0.0000 0.0000 0.0000
n-Pentane 0.0000 0.0000 0.0000
NBP[1]114* 0.0000 0.0000 0.0000
NBP[1]139* 0.0000 0.0001 0.0000
NBP[1]162* 0.0001 0.0004 0.0001
NBP[1]188* 0.0002 0.0011 0.0002
NBP[1]215* 0.0006 0.0027 0.0006
NBP[1]241* 0.0018 0.0059 0.0017
NBP[1]266* 0.0035 0.0091 0.0035
NBP[1]292* 0.0058 0.0113 0.0058
Total 1.00000
Edit...
View Properties...
Basis...
OK
Delete
Define from Stream...
View Assay

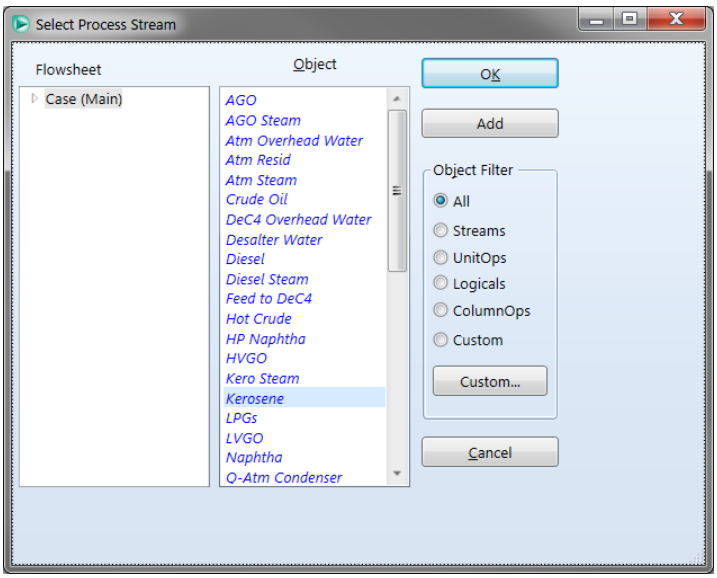

Material Stream: Kerosene
Worksheet
Attachments
Dynamics
Worksheet
Conditions
Properties
Composition
Oil & Gas Feed
Petroleum Assay
K Value
User Variables
Notes
Cost Parameters
Normalized Yields
LiqVol Fractions
Vapour Phase
Liquid Phase
H2O 0.0007 0.1566 0.0006
Methane 0.0000 0.0000 0.0000
Ethane 0.0000 0.0000 0.0000
Propane 0.0000 0.0000 0.0000
i-Butane 0.0000 0.0000 0.0000
n-Butane 0.0000 0.0000 0.0000
i-Pentane 0.0000 0.0000 0.0000
n-Pentane 0.0000 0.0000 0.0000
NBP[1]114* 0.0000 0.0000 0.0000
NBP[1]139* 0.0000 0.0002 0.0000
NBP[1]162* 0.0000 0.0007
NBP[1]188* 0.0001 0.0019
NBP[1]215* 0.0004 0.0046 0.0004
Calculated by: Kerosene
Total 1.00000
Edit...
View Properties...
Basis...
OK
Delete
Define from Stream...
View Assay



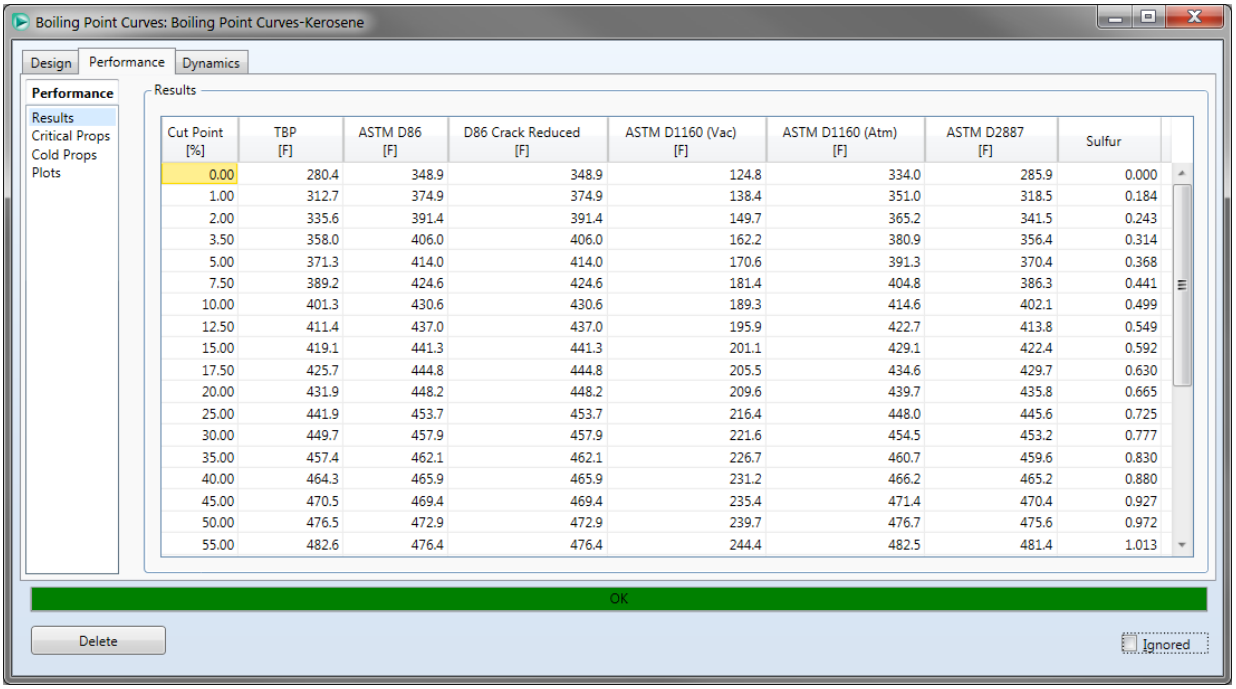
Since we are working with petroleum streams we may also want to determine the distillation curve associated with a stream composition. For this we'll use one of the *Stream Analysis* options. You can create a stream analysis for the first time by right-clicking on a stream & choosing *Create Stream Analysis*> & then *Boiling Point Curves*. A more general way to create a new analysis or review an existing analysis is to choose the *Steam Analysis* drop down list & choosing the *Boiling Point Curves* option in the *Home* tab of the ribbon. Choose the *Kerosene* stream & click *OK*.

> Please note that there is a second similar option, *Petroleum Assay*, but do not choose this. The two options give slightly different results. The *Boiling Point Curves* option is consistent with the correlations used for the tower specs. The *Boiling Point Curves* option is also consistent with what can be calculated using the amounts & boiling points for the pseudo components.

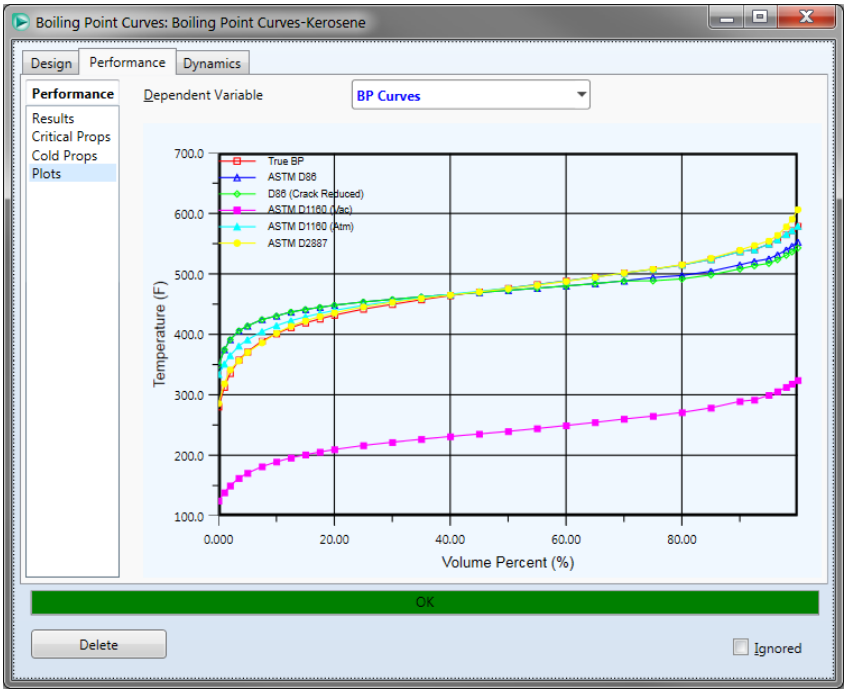




Note that we have various distribution curves based on the cumulative yield for the stream. Two of the curves that will be of most interest are the TBP & ASTM D86 curves. Note that not only can we get the results in tabular form but we can also directly make a plot.



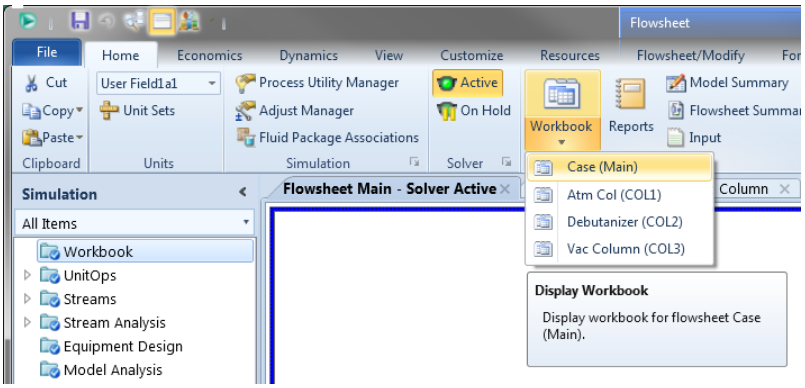
Cut Point [%]	TBP [F]	ASTM D86 [F]	D86 Crack Reduced [F]	ASTM D1160 (Vac) [F]	ASTM D1160 (Atm) [F]	ASTM D2887 [F]	Sulfur
0.00	280.4	348.9	348.9	124.8	334.0	285.9	0.000
1.00	312.7	374.9	374.9	138.4	351.0	318.5	0.184
2.00	335.6	391.4	391.4	149.7	365.2	341.5	0.243
3.50	358.0	406.0	406.0	162.2	380.9	356.4	0.314
5.00	371.3	414.0	414.0	170.6	391.3	370.4	0.368
7.50	389.2	424.6	424.6	181.4	404.8	386.3	0.441
10.00	401.3	430.6	430.6	189.3	414.6	402.1	0.499
12.50	411.4	437.0	437.0	195.9	422.7	413.8	0.549
15.00	419.1	441.3	441.3	201.1	429.1	422.4	0.592
17.50	425.7	444.8	444.8	205.5	434.6	429.7	0.630
20.00	431.9	448.2	448.2	209.6	439.7	435.8	0.665
25.00	441.9	453.7	453.7	216.4	448.0	445.6	0.725
30.00	449.7	457.9	457.9	221.6	454.5	453.2	0.777
35.00	457.4	462.1	462.1	226.7	460.7	459.6	0.830
40.00	464.3	465.9	465.9	231.2	466.2	465.2	0.880
45.00	470.5	469.4	469.4	235.4	471.4	470.4	0.927
50.00	476.5	472.9	472.9	239.7	476.7	475.6	0.972
55.00	482.6	476.4	476.4	244.4	482.5	481.4	1.013



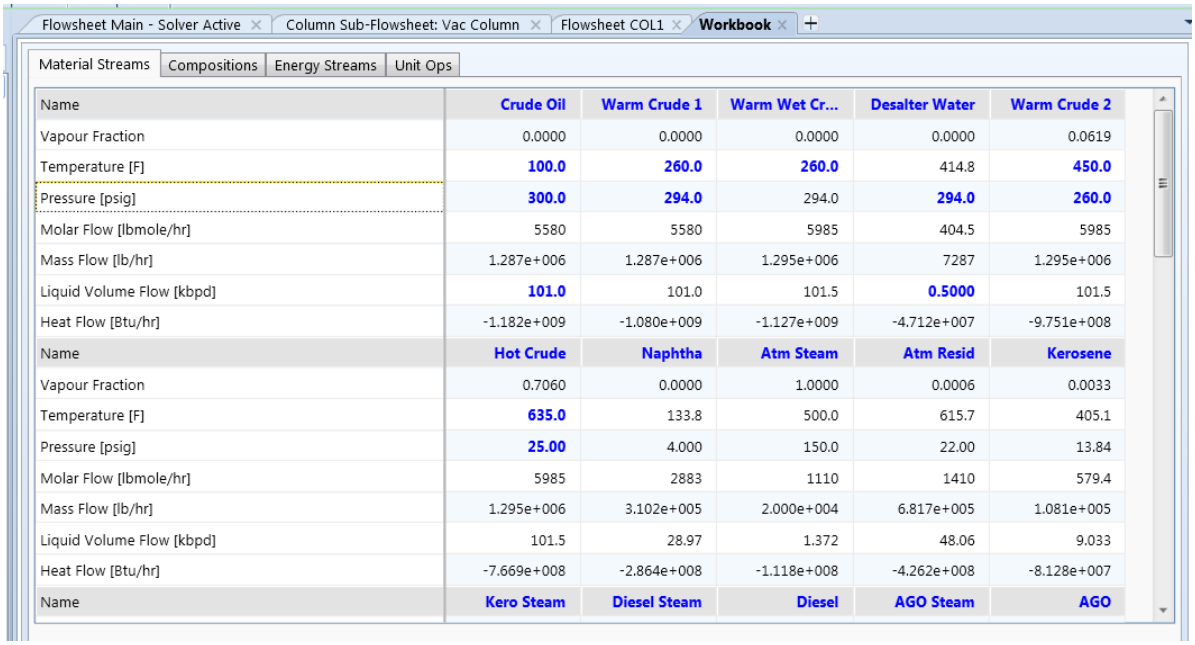
Export results to spreadsheet

There are many times that you'd like to create a general table of stream and/or unit results to a spreadsheet so that you pick & choose various values for *ad hoc* reports. There are a couple options for doing this.

HYSYS has a default workbook that summarizes a great deal of the stream & unit information in a single location. Click on the *Workbook* button under the *Home* tab of the ribbon & choose the default workbook for *Case (Main)*.



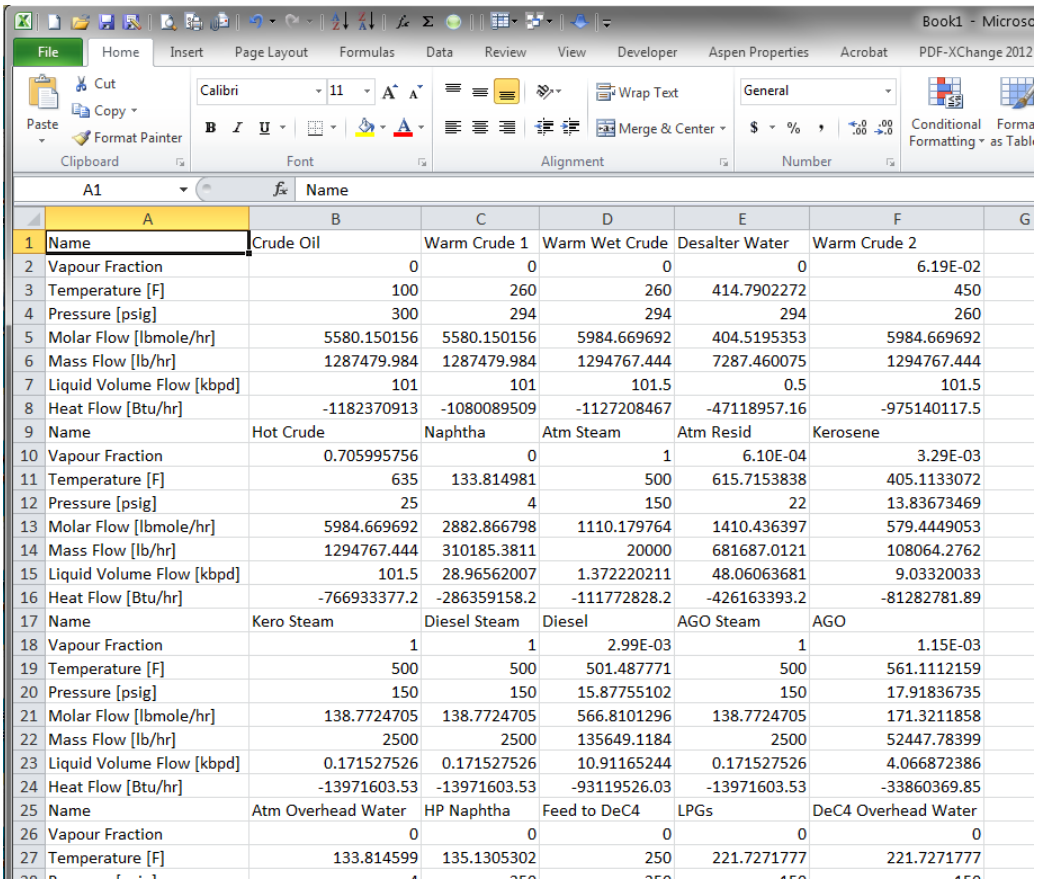
You should see a series of tabs that summarize the input & calculated results for the main flowsheet: conditions for the material streams, mole fractions for the pure & pseudo components for the material streams, values for the energy streams, & a summary listing for the unit operations.



Name	Crude Oil	Warm Crude 1	Warm Wet Cr...	Desalter Water	Warm Crude 2
Vapour Fraction	0.0000	0.0000	0.0000	0.0000	0.0619
Temperature [F]	100.0	260.0	260.0	414.8	450.0
Pressure [psig]	300.0	294.0	294.0	294.0	260.0
Molar Flow [lbmole/hr]	5580	5580	5985	404.5	5985
Mass Flow [lb/hr]	1.287e+006	1.287e+006	1.295e+006	7287	1.295e+006
Liquid Volume Flow [kbpd]	101.0	101.0	101.5	0.5000	101.5
Heat Flow [Btu/hr]	-1.182e+009	-1.080e+009	-1.127e+009	-4.712e+007	-9.751e+008
Name	Hot Crude	Naphtha	Atm Steam	Atm Resid	Kerosene
Vapour Fraction	0.7060	0.0000	1.0000	0.0006	0.0033
Temperature [F]	635.0	133.8	500.0	615.7	405.1
Pressure [psig]	25.00	4.000	150.0	22.00	13.84
Molar Flow [lbmole/hr]	5985	2883	1110	1410	579.4
Mass Flow [lb/hr]	1.295e+006	3.102e+005	2.000e+004	6.817e+005	1.081e+005
Liquid Volume Flow [kbpd]	101.5	28.97	1.372	48.06	9.033
Heat Flow [Btu/hr]	-7.669e+008	-2.864e+008	-1.118e+008	-4.262e+008	-8.128e+007
Name	Kero Steam	Diesel Steam	Diesel	AGO Steam	AGO

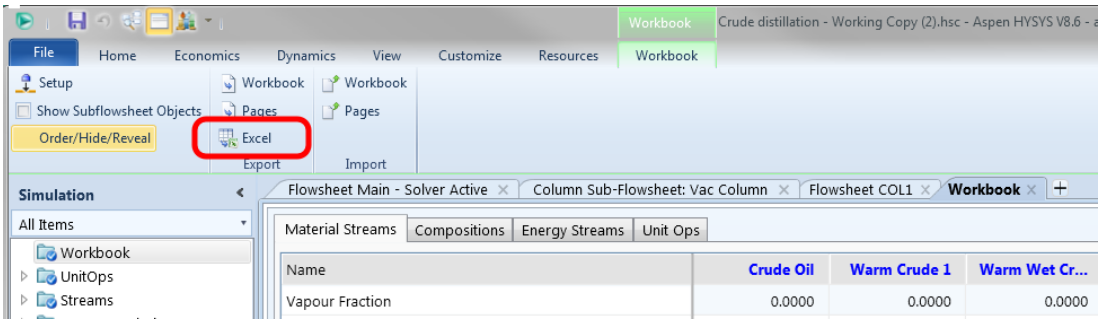
Let's look at the table of *Material Streams*. Note that the default format is to have information for each stream in a column & items of information in each row. One might expect that the columns would continue out of view off to the right. Instead, however, only a small set of columns are shown & then the information for the next set of columns is shown below. This is unfortunate in that if you were to copy & paste into a spreadsheet this same format is retained. This can be demonstrated by:

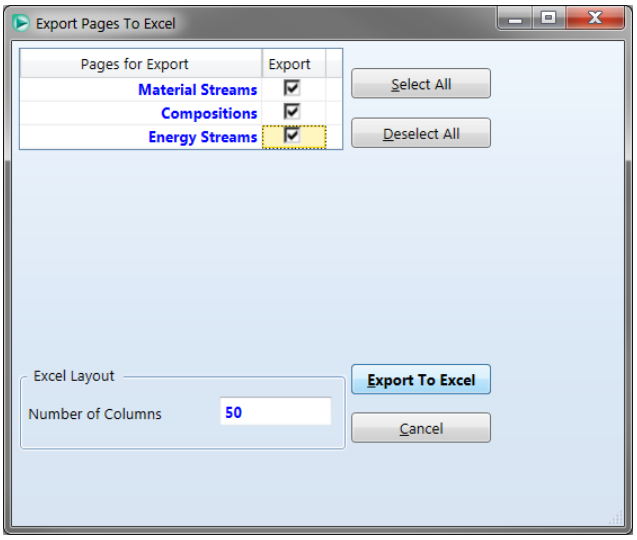
- open up Excel
- go back to HYSYS & select any cell
- right-click & choose *Select All*
- right-click & choose *Copy*
- highlight any cell in Excel (preferably A1)
- paste (either by pressing Ctrl-c or right-click & select the paste text icon). After resizing the columns in Excel you should see table like below.



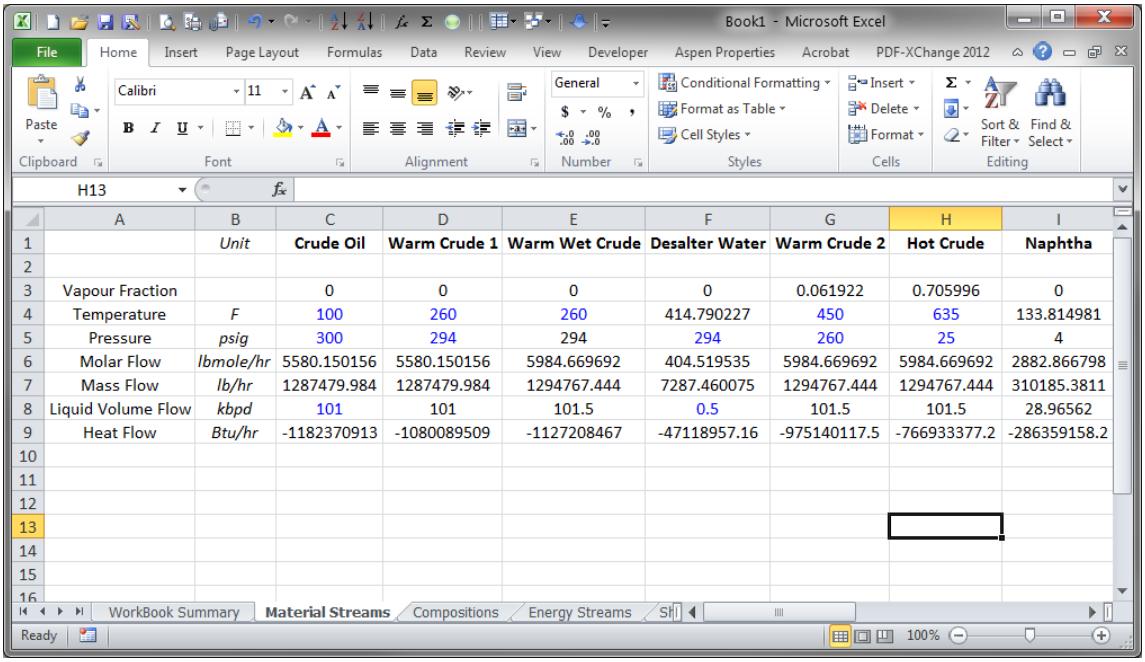
	A	B	C	D	E	F
1	Name	Crude Oil	Warm Crude 1	Warm Wet Crude	Desalter Water	Warm Crude 2
2	Vapour Fraction	0	0	0	0	6.19E-02
3	Temperature [F]	100	260	260	414.7902272	450
4	Pressure [psig]	300	294	294	294	260
5	Molar Flow [lbmole/hr]	5580.150156	5580.150156	5984.669692	404.5195353	5984.669692
6	Mass Flow [lb/hr]	1287479.984	1287479.984	1294767.444	7287.460075	1294767.444
7	Liquid Volume Flow [kbpd]	101	101	101.5	0.5	101.5
8	Heat Flow [Btu/hr]	-1182370913	-1080089509	-1127208467	-47118957.16	-975140117.5
9	Name	Hot Crude	Naphtha	Atm Steam	Atm Resid	Kerosene
10	Vapour Fraction	0.705995756	0	1	6.10E-04	3.29E-03
11	Temperature [F]	635	133.814981	500	615.7153838	405.1133072
12	Pressure [psig]	25	4	150	22	13.83673469
13	Molar Flow [lbmole/hr]	5984.669692	2882.866798	1110.179764	1410.436397	579.4449053
14	Mass Flow [lb/hr]	1294767.444	310185.3811	20000	681687.0121	108064.2762
15	Liquid Volume Flow [kbpd]	101.5	28.96562007	1.372220211	48.06063681	9.03320033
16	Heat Flow [Btu/hr]	-766933377.2	-286359158.2	-111772828.2	-426163393.2	-81282781.89
17	Name	Kero Steam	Diesel Steam	Diesel	AGO Steam	AGO
18	Vapour Fraction	1	1	2.99E-03	1	1.15E-03
19	Temperature [F]	500	500	501.487771	500	561.1112159
20	Pressure [psig]	150	150	15.87755102	150	17.91836735
21	Molar Flow [lbmole/hr]	138.7724705	138.7724705	566.8101296	138.7724705	171.3211858
22	Mass Flow [lb/hr]	2500	2500	135649.1184	2500	52447.78399
23	Liquid Volume Flow [kbpd]	0.171527526	0.171527526	10.91165244	0.171527526	4.066872386
24	Heat Flow [Btu/hr]	-13971603.53	-13971603.53	-93119526.03	-13971603.53	-33860369.85
25	Name	Atm Overhead Water	HP Naphtha	Feed to DeC4	LPGs	DeC4 Overhead Water
26	Vapour Fraction	0	0	0	0	0
27	Temperature [F]	133.814599	135.1305302	250	221.7271777	221.7271777

There is an option to directly export the workbook information directly to Excel. Press the *Excel* button on the Workbook tab in the ribbon. Choose which of the pages you'd like to export (here we'll choose them all) & how many columns to produce before repeating below (50 should be sufficient for this example). Press *Export to Excel*. A set of macros will run that will open a new Excel spreadsheet & values will be copied from the HYSYS simulation to the spreadsheet. Be patient, this may take a while. (It might be a good time to get up & get that cup of coffee you've been wanting.)





After adjusting column widths the product spreadsheet will look like the following. Note that there will be at least 50 columns before the information is repeated below row 9. Also, the color formatting showing the user input values (in blue) is retained.

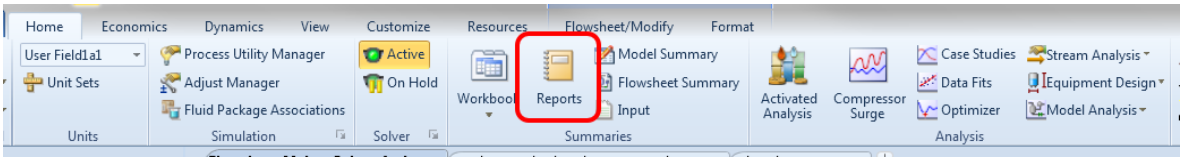


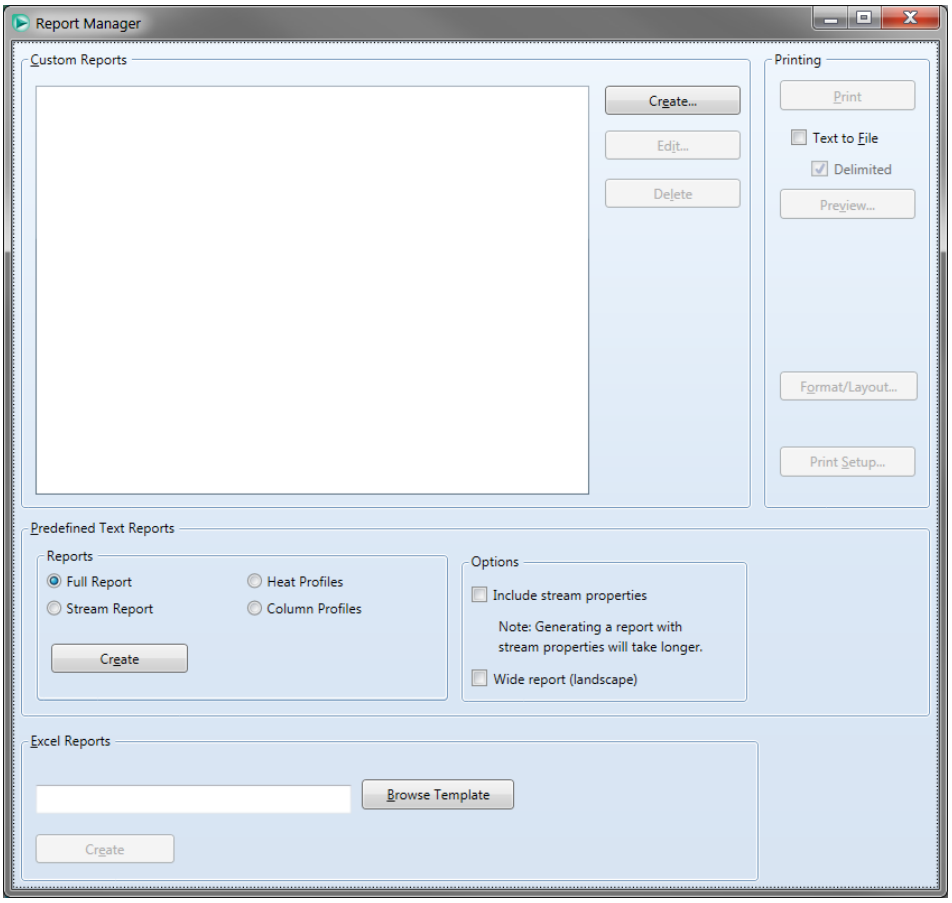
	A	B	C	D	E	F	G	H	I
1		*Unit*	**Crude Oil**	**Warm Crude 1**	**Warm Wet Crude**	**Desalter Water**	**Warm Crude 2**	**Hot Crude**	**Naphtha**
2									
3	Vapour Fraction		0	0	0	0	0.061922	0.705996	0
4	Temperature	*F*	100	260	260	414.790227	450	635	133.814981
5	Pressure	*psig*	300	294	294	294	260	25	4
6	Molar Flow	*lbmole/hr*	5580.150156	5580.150156	5984.669692	404.519535	5984.669692	5984.669692	2882.866798
7	Mass Flow	*lb/hr*	1287479.984	1287479.984	1294767.444	7287.460075	1294767.444	1294767.444	310185.3811
8	Liquid Volume Flow	*kbpd*	101	101	101.5	0.5	101.5	101.5	28.96562
9	Heat Flow	*Btu/hr*	-1182370913	-1080089509	-1127208467	-47118957.16	-975140117.5	-766933377.2	-286359158.2

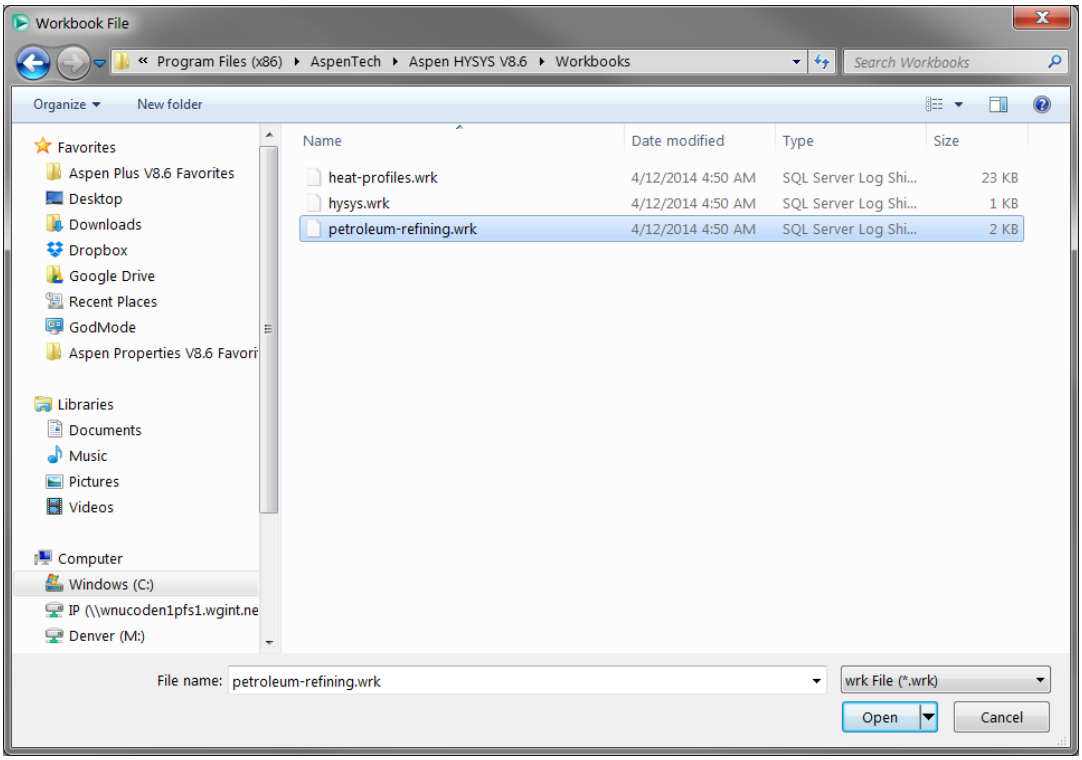
There are a couple limitation to this default workbook report. One is the information reported in the *Composition* tab – it is only for the mole fractions. For petroleum streams liquid volume fraction would be more convenient. To get this then you'll have to create a custom workbook sheet and/or report.

	A	B	C	D	E	F	
1		*Unit*	**Crude Oil**	**arm Cruderm Wet Cr**		**salter Wat**	**ar**
2							
3	Comp Mole Frac (Methane)		0	0	0	0	
4	Comp Mole Frac (Ethane)		0.00101	0.00101	0.000942	0	0
5	Comp Mole Frac (Propane)		0.008035	0.008035	0.007492	0	0
6	Comp Mole Frac (i-Butane)		0.005727	0.005727	0.00534	0	0
7	Comp Mole Frac (n-Butane)		0.020504	0.020504	0.019118	0	0
8	Comp Mole Frac (i-Pentane)		0.018667	0.018667	0.017405	0	0
9	Comp Mole Frac (n-Pentane)		0.036384	0.036384	0.033925	0	0
10	Comp Mole Frac (H2O)		0	0	0.067593	1	0
11	Comp Mole Frac (NBP[1]114*)		0.015784	0.015784	0.014718	0	0
12	Comp Mole Frac (NBP[1]139*)		0.032911	0.032911	0.030686	0	0
13	Comp Mole Frac (NBP[1]162*)		0.036225	0.036225	0.033777	0	0
14	Comp Mole Frac (NBP[1]188*)		0.035664	0.035664	0.033253	0	0
15	Comp Mole Frac (NBP[1]215*)		0.036484	0.036484	0.034018	0	0
16	Comp Mole Frac (NBP[1]241*)		0.041581	0.041581	0.038771	0	0

Let's look at some report options that come with HYSYS. Click on the *Reports* button in the *Home* tab of the ribbon. At the bottom of the form we'll want to choose one of the existing templates for the *Excel Reports*. Click on the *Browse Template* button. On the next window choose *petroleum-refining.wrk* (make sure you're in the appropriate folder to choose this). Now when you click on the *Create* button a set of macros will run that will open a new Excel spreadsheet & values will be copied from the HYSYS simulation to the spreadsheet. This will also take a while. (It might be a good time to refill that cup of coffee.)




Report Manager
Custom Reports
Create...
Edit...
Delete
Printing
Print
Text to File
Delimited
Preview...
Format/Layout...
Print Setup...
Predefined Text Reports
Reports
Full Report
Heat Profiles
Stream Report
Column Profiles
Create
Options
Include stream properties
Note: Generating a report with stream properties will take longer.
Wide report (landscape)
Excel Reports
Browse Template
Create


Workbook File
Program Files (x86) ▸ AspenTech ▸ Aspen HYSYS V8.6 ▸ Workbooks
Search Workbooks
Organize
New folder
Favorites
Aspen Plus V8.6 Favorites
Desktop
Downloads
Dropbox
Google Drive
Recent Places
GodMode
Aspen Properties V8.6 Favori
Libraries
Documents
Music
Pictures
Videos
Computer
Windows (C:)
IP (\\wnucoden1pfs1.wgint.ne
Denver (M:)
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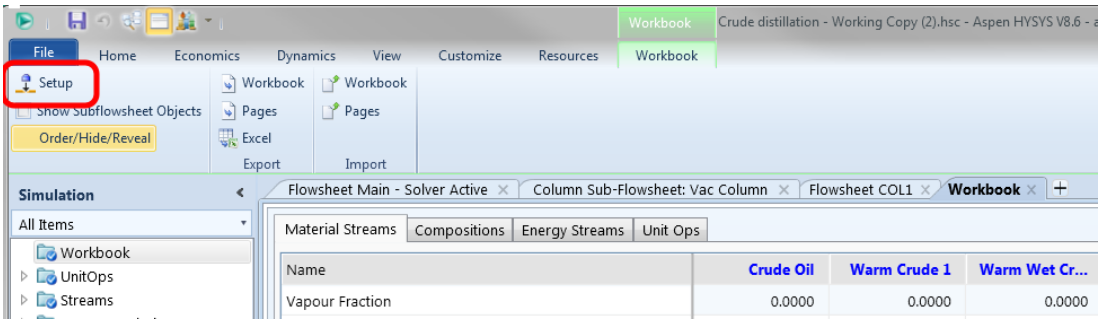
1 KB
petroleum-refining.wrk
4/12/2014 4:50 AM
SQL Server Log Shi...
2 KB
File name: petroleum-refining.wrk
wrk File (*.wrk)
Open
Cancel

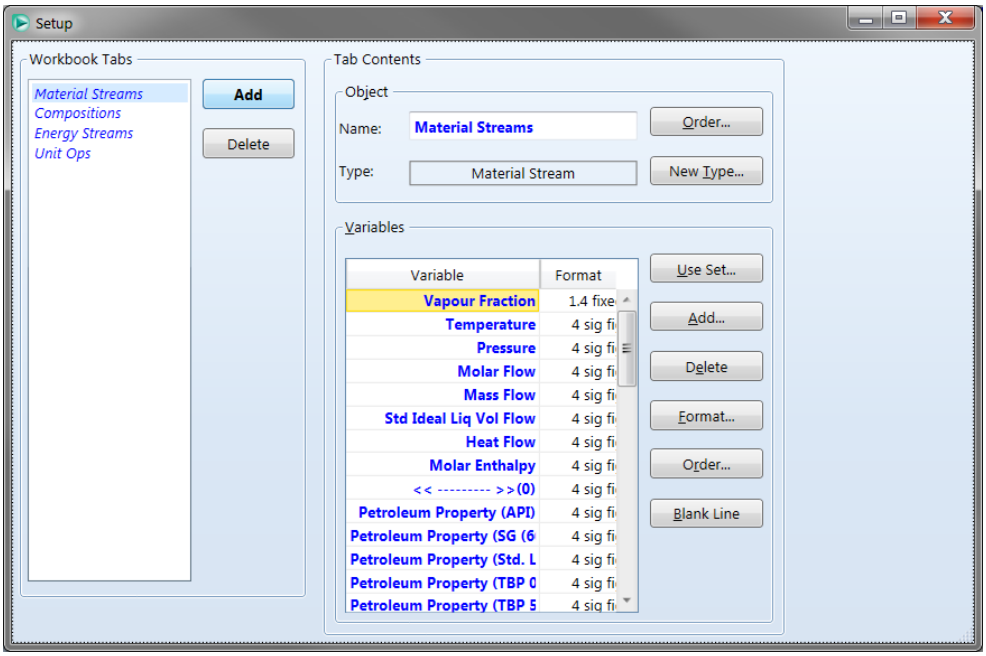
The Excel spreadsheet produced this time has additional information useful for analyzing petroleum streams. If you look at the *Compositions* tab you'll see that this still reports mole fractions (so no difference here). But if you look at the *Material Streams* tab you can see that a lot of the data from the *Conditions* & *Properties* items are in the *Material Streams* tab. This will also contain the TBP & D86 assay information from the *Steam Analysis*. (Unfortunately these are boiling point curves consistent with the *Petroleum Assay* option; we will not want to use these.)

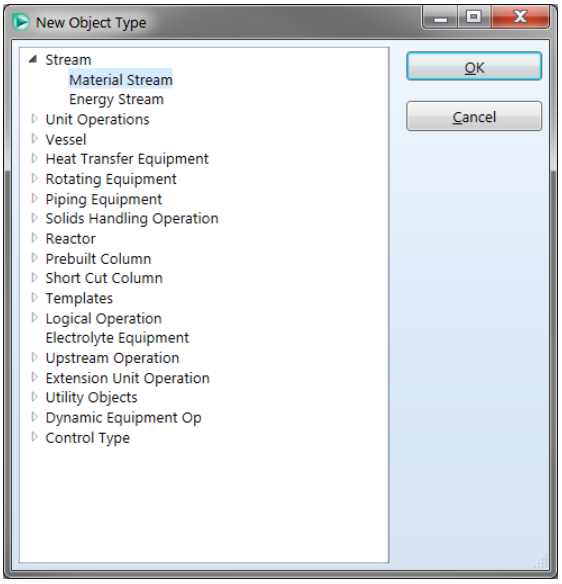
	A	B	C	D	E
1		*Unit*	**Crude Oil**	**arm Crud**	**erm W**
2					
3	Vapour Fraction		0	0	0
4	Temperature	*F*	100	260	26
5	Pressure	*psig*	300	294	29
6	Molar Flow	*lbmole/hr*	5580.15	5580.15	5984
7	Mass Flow	*lb/hr*	1287480	1287480	1294
8	Std Ideal Liq Vol Flow	*kbpd*	101	101	101
9	Heat Flow	*Btu/hr*	-1.2E+09	-1.1E+09	-1.1E
10	Molar Enthalpy	*Btu/lbmole*	-211887	-193557	-188
11					
12	Petroleum Property (API)		30.45123	30.45123	30.3
13	Petroleum Property (SG (60/60))		0.87372	0.87372	0.874
14	Petroleum Property (Std. Liquid Density)		872.8455	872.8455	873.
15	Petroleum Property (TBP 0%)		-142.361	-142.361	-142.
16	Petroleum Property (TBP 5%)		58.55681	58.55681	58.5
17	Petroleum Property (TBP 10%)		101.0484	101.0484	101.0
18	Petroleum Property (TBP 30%)		225.6626	225.6626	225.6
19	Petroleum Property (TBP 50%)		342.988	342.988	342.
20	Petroleum Property (TBP 70%)		480.9266	480.9266	480.9
21	Petroleum Property (TBP 90%)		684.5566	684.5566	684.5
22	Petroleum Property (TBP 95%)		779.2339	779.2339	779.2
23	Petroleum Property (TBP 100%)		1113.346	1113.346	1113
24	Petroleum Property (D86 IBP)		-158.818	-158.818	-158.
25	Petroleum Property (D86 5%)		62.23428	62.23428	62.23
26	Petroleum Property (D86 10%)		105.8315	105.8315	105.8
27	Petroleum Property (D86 30%)		221.3333	221.3333	221.3
28	Petroleum Property (D86 50%)		332.629	332.629	332.
29	Petroleum Property (D86 70%)		481.9482	481.9482	481.9
30	Petroleum Property (D86 90%)		798.9689	798.9689	798.9
31	Petroleum Property (D86 95%)		823.32	823.32	823
32	Petroleum Property (D86 FBP)		909.2539	909.2539	909.2
33	Petroleum Property (Sulfur Wt Pct)		<empty>	<empty>	<emp
34	Petroleum Property (Nitrogen Content)		<empty>	<empty>	<emp
35	Petroleum Property (Basic Nitrogen Content)		<empty>	<empty>	<emp
36	Petroleum Property (Conradson Carbon Content)		<empty>	<empty>	<emp
37	Petroleum Property (RON (Clear))		<empty>	<empty>	<emp
38	Petroleum Property (MON (Clear))		<empty>	<empty>	<emp
39	Petroleum Property (Cetane Idx D4737)		-37.761	-37.761	-37.6
40	Petroleum Property (Kinematic Viscosity @ X C)		10.54231	10.54205	10.37

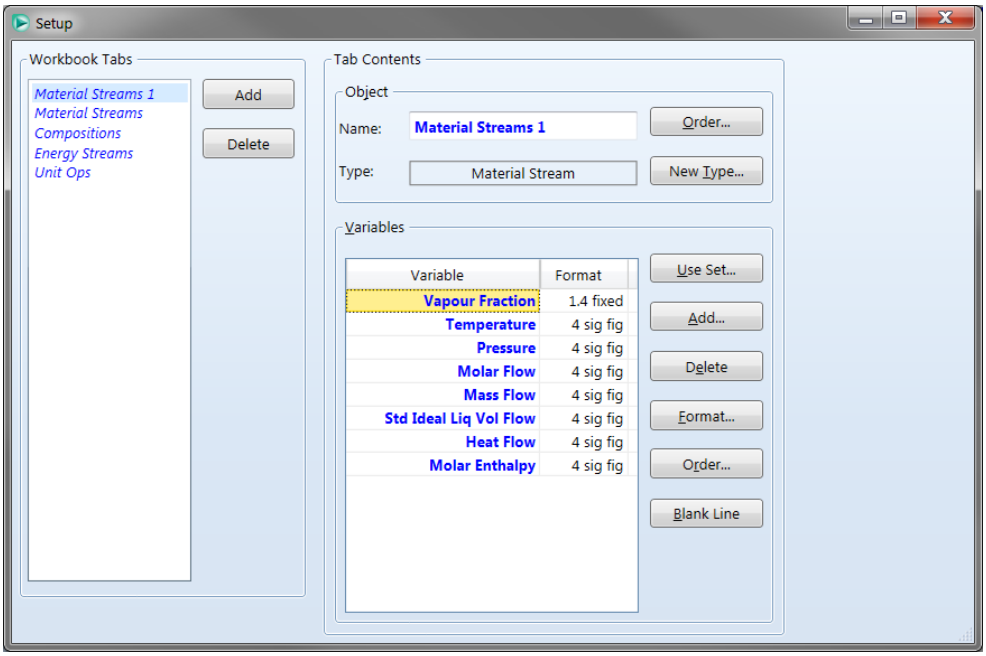
Let's go back to HYSYS & look at the workbook for *Case (Main)*. Notice that the *Materials Streams* tab has now been modified with the extra petroleum-related information that we see in the Excel spreadsheet. This shows that customizing the workbook & subsequently exporting to Excel is possible.

Let's create a new tab in the workbook for the liquid volume flows for each component. Select *Setup* under the *Workbook* tab in the ribbon. Let's *Add* a new *Workbook Tab*. Select the *Material Stream* type. Now there is a new tab called *Material Streams 1* with the basic stream conditions.

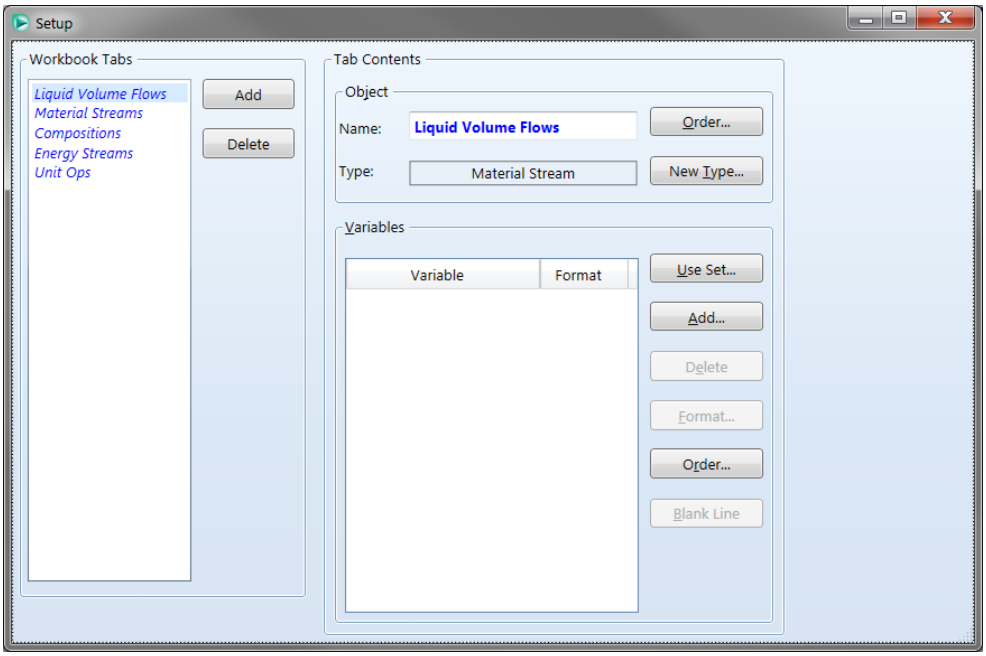



Setup
Workbook Tabs
Material Streams
Compositions
Energy Streams
Unit Ops
Add
Delete
Tab Contents
Object
Name:
Material Streams
Order...
Type:
Material Stream
New Type...
Variables
Variable
Format
Vapour Fraction
Temperature
Pressure
Molar Flow
Mass Flow
Std Ideal Liq Vol Flow
Heat Flow
Molar Enthalpy
Petroleum Property (API)
Use Set...
Add...
Delete
Format...
Order...
Blank Line

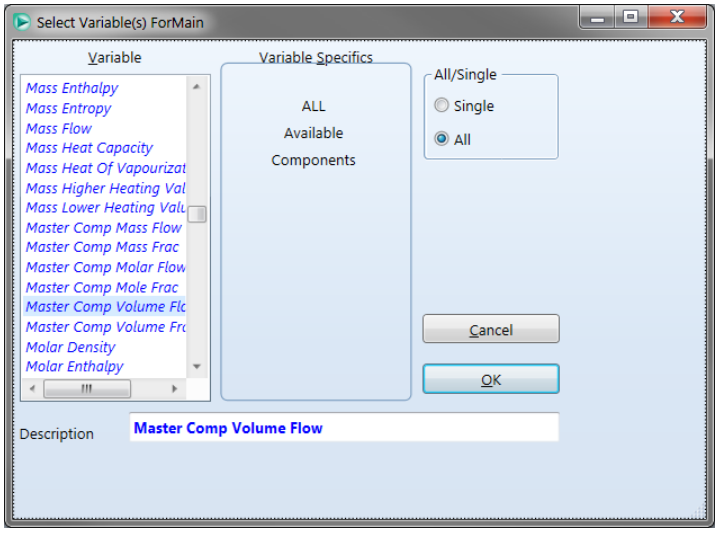

New Object Type
Stream
Material Stream
Energy Stream
Unit Operations
Vessel
Heat Transfer Equipment
Rotating Equipment
Piping Equipment
Solids Handling Operation
Reactor
Prebuilt Column
Short Cut Column
Templates
Logical Operation
Electrolyte Equipment
Upstream Operation
Extension Unit Operation
Utility Objects
Dynamic Equipment Op
Control Type
OK
Cancel

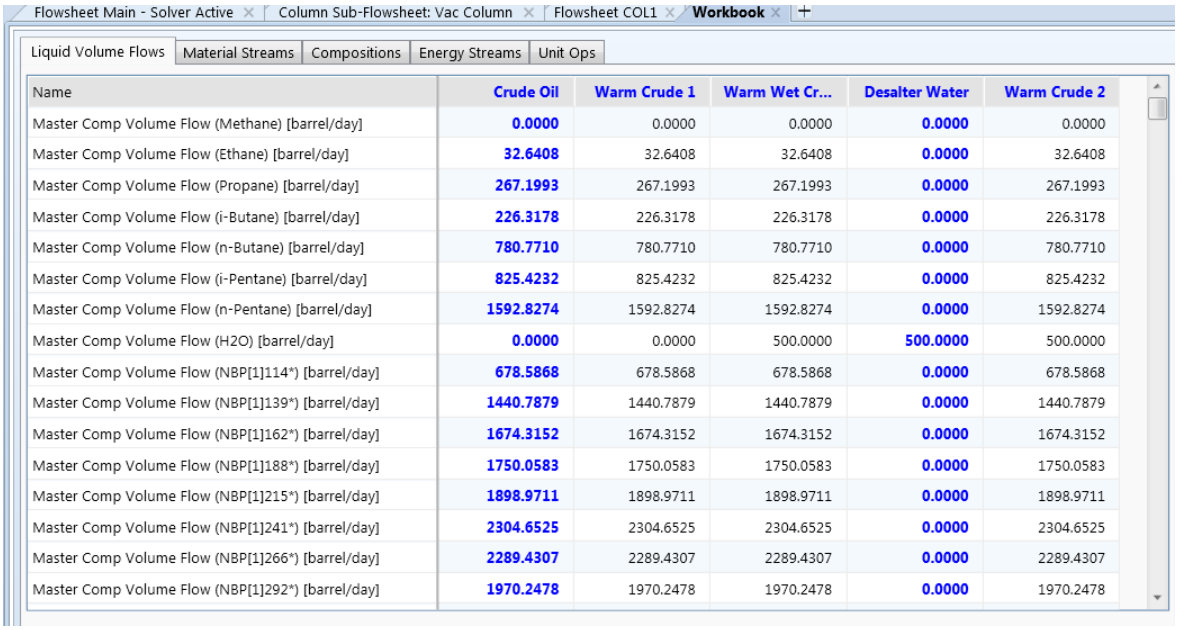


Let's change the *Name* to *Liquid Volume Flows*. Highlight all of the variables in the *Variable* list & press *Delete*. Now we can create a brand new list of variables.



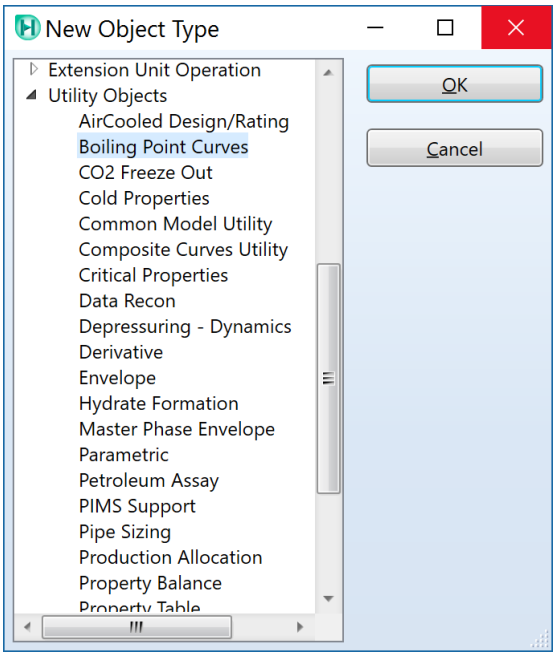
Press the *Add…* button. From the Variable list select *Master Comp Volume Flow* & press the *All* button. Now we'll get a table with all of the liquid volume flow values for each pure & pseudo component. However, before we commit to this, let's remove the " (Methane)" from the *Description* so it only says "Master Comp Volume Flow". Now we can press *OK*. We can close the Setup form & see that there is now tab for these component volume flows.

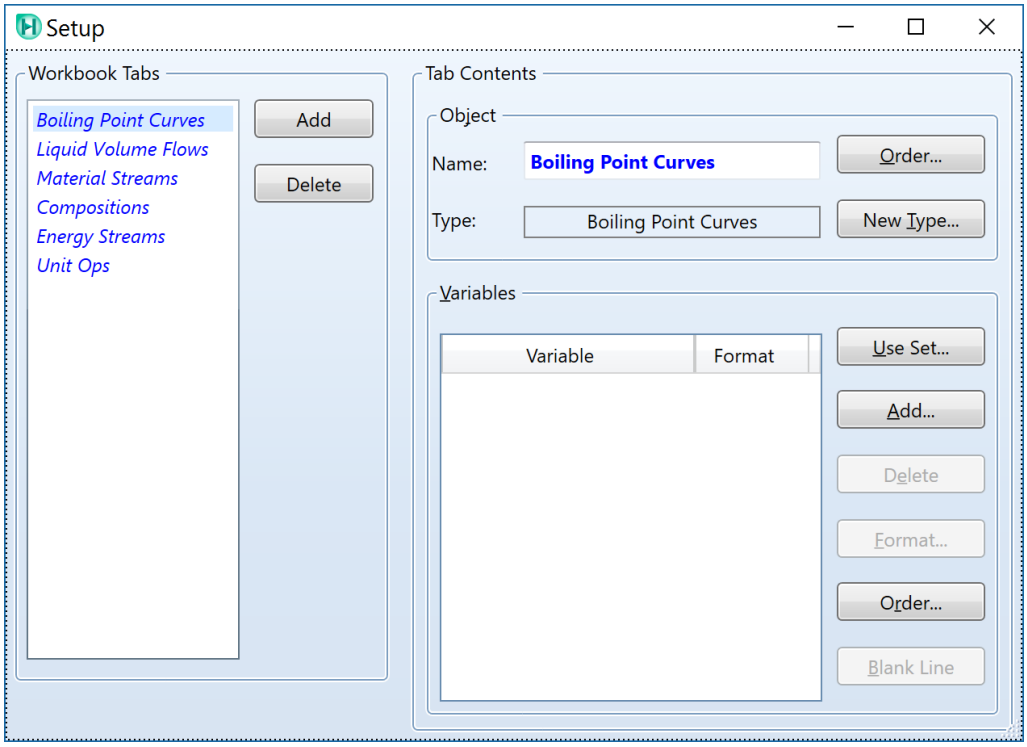




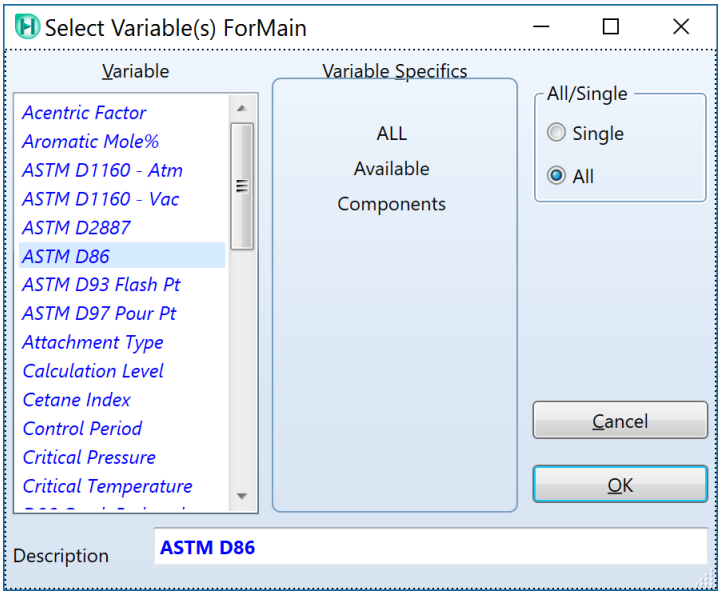
Name	Crude Oil	Warm Crude 1	Warm Wet Cr...	Desalter Water	Warm Crude 2
Master Comp Volume Flow (Methane) [barrel/day]	0.0000	0.0000	0.0000	0.0000	0.0000
Master Comp Volume Flow (Ethane) [barrel/day]	32.6408	32.6408	32.6408	0.0000	32.6408
Master Comp Volume Flow (Propane) [barrel/day]	267.1993	267.1993	267.1993	0.0000	267.1993
Master Comp Volume Flow (i-Butane) [barrel/day]	226.3178	226.3178	226.3178	0.0000	226.3178
Master Comp Volume Flow (n-Butane) [barrel/day]	780.7710	780.7710	780.7710	0.0000	780.7710
Master Comp Volume Flow (i-Pentane) [barrel/day]	825.4232	825.4232	825.4232	0.0000	825.4232
Master Comp Volume Flow (n-Pentane) [barrel/day]	1592.8274	1592.8274	1592.8274	0.0000	1592.8274
Master Comp Volume Flow (H2O) [barrel/day]	0.0000	0.0000	500.0000	500.0000	500.0000
Master Comp Volume Flow (NBP[1]114*) [barrel/day]	678.5868	678.5868	678.5868	0.0000	678.5868
Master Comp Volume Flow (NBP[1]139*) [barrel/day]	1440.7879	1440.7879	1440.7879	0.0000	1440.7879
Master Comp Volume Flow (NBP[1]162*) [barrel/day]	1674.3152	1674.3152	1674.3152	0.0000	1674.3152
Master Comp Volume Flow (NBP[1]188*) [barrel/day]	1750.0583	1750.0583	1750.0583	0.0000	1750.0583
Master Comp Volume Flow (NBP[1]215*) [barrel/day]	1898.9711	1898.9711	1898.9711	0.0000	1898.9711
Master Comp Volume Flow (NBP[1]241*) [barrel/day]	2304.6525	2304.6525	2304.6525	0.0000	2304.6525
Master Comp Volume Flow (NBP[1]266*) [barrel/day]	2289.4307	2289.4307	2289.4307	0.0000	2289.4307
Master Comp Volume Flow (NBP[1]292*) [barrel/day]	1970.2478	1970.2478	1970.2478	0.0000	1970.2478

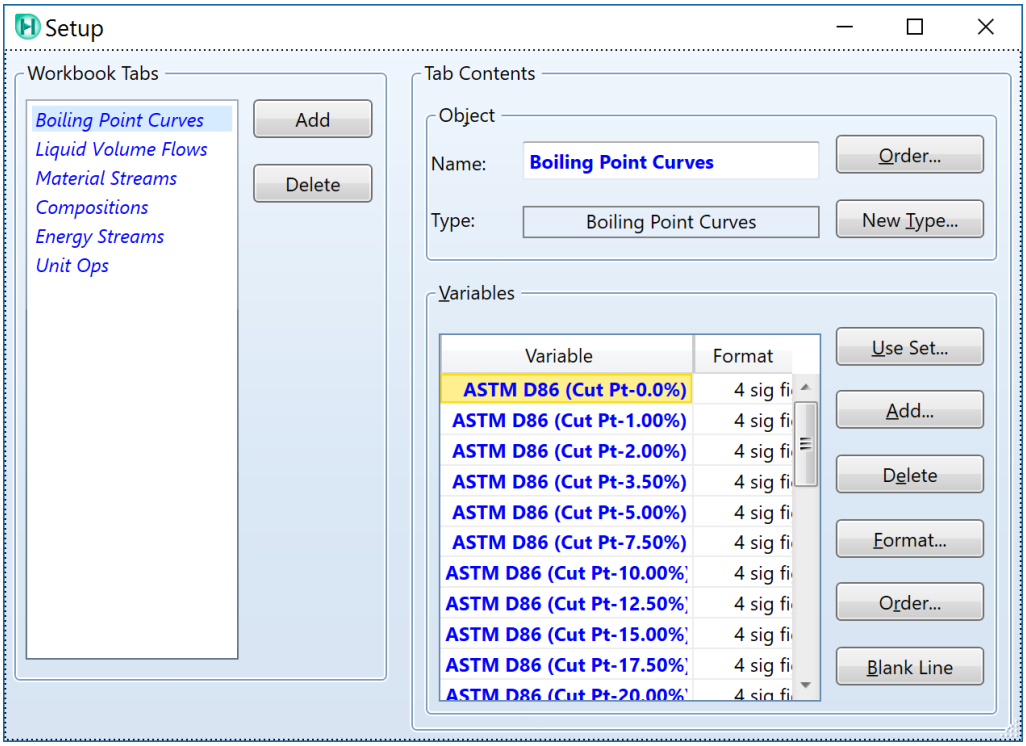
Let's address the issue with the distillation curves that are part of the create a new tab in the workbook for the liquid volume flows for each component. Select *Setup* under *petroleum-refining.wrk* additions. Let's create a workbook table that reports the *Boiling Point Curves* for the stream analyses set up in the simulation. Go to the *Workbook* tab & press *Setup*. Similar to what was done before, choose *Add*. But this time expand the *Utility Objects* item & select Boil*ing Point Curves* & press *OK*. Rename the tab *Boiling Point Curves*; there should be no the default items in the list.


New Object Type
Extension Unit Operation
Utility Objects
AirCooled Design/Rating
Boiling Point Curves
CO2 Freeze Out
Cold Properties
Common Model Utility
Composite Curves Utility
Critical Properties
Data Recon
Depressuring - Dynamics
Derivative
Envelope
Hydrate Formation
Master Phase Envelope
Parametric
Petroleum Assay
PIMS Support
Pipe Sizing
Production Allocation
Property Balance
OK
Cancel

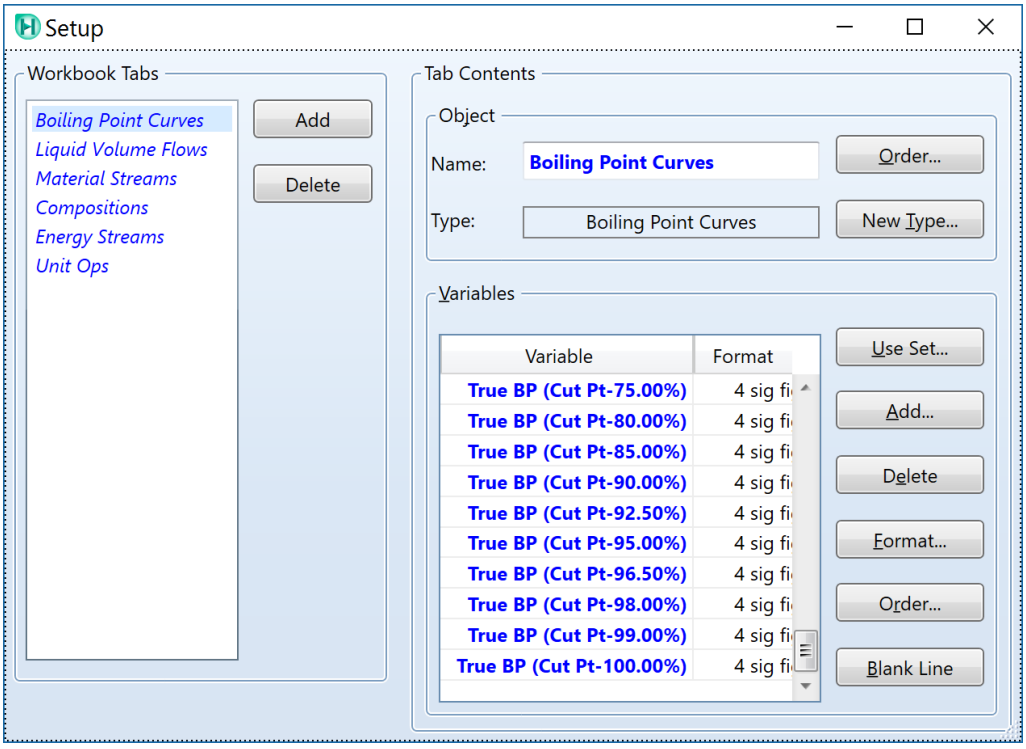

Setup
Workbook Tabs
Boiling Point Curves
Liquid Volume Flows
Material Streams
Compositions
Energy Streams
Unit Ops
Add
Delete
Tab Contents
Object
Name:
Boiling Point Curves
Order...
Type:
Boiling Point Curves
New Type...
Variables
Variable
Format
Use Set...
Add...
Delete
Format...
Order...
Blank Line

Press the *Add…* button. From the Variable list select *ASTM D86* & highlight *All*, & press the *OK* button. Now we'll get a table with all of the ASTM D86 values as calculated by the routines for the *Boiling Point Curves*.

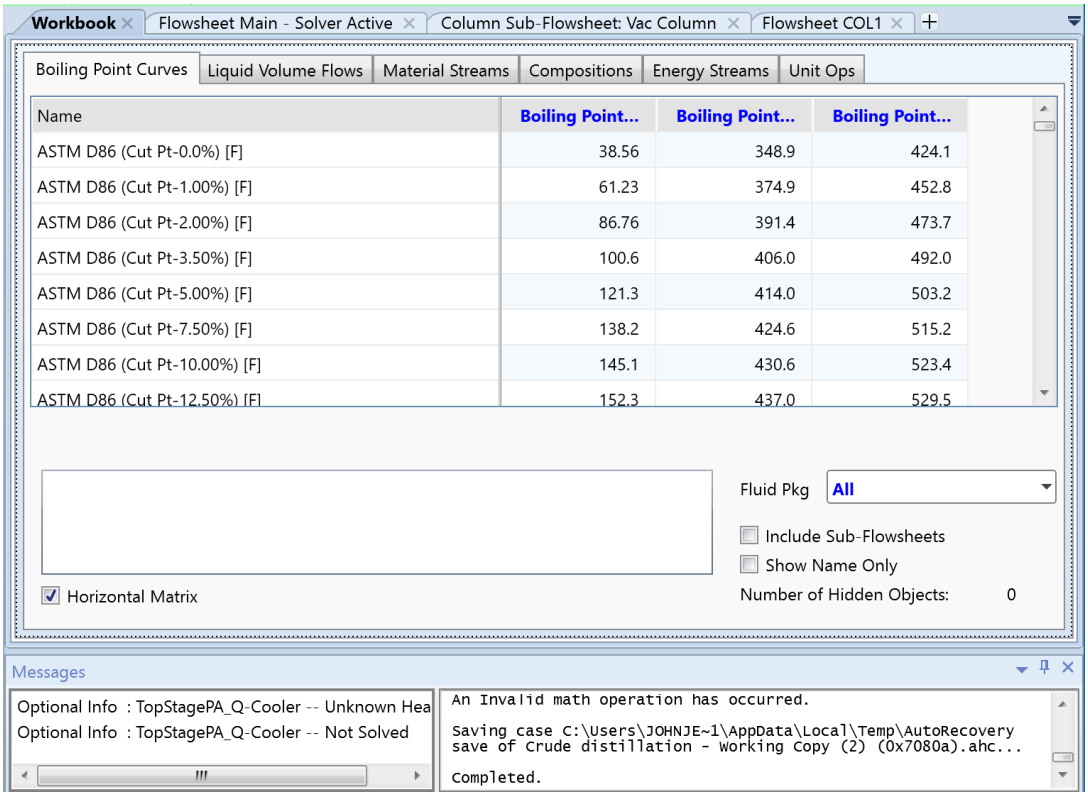


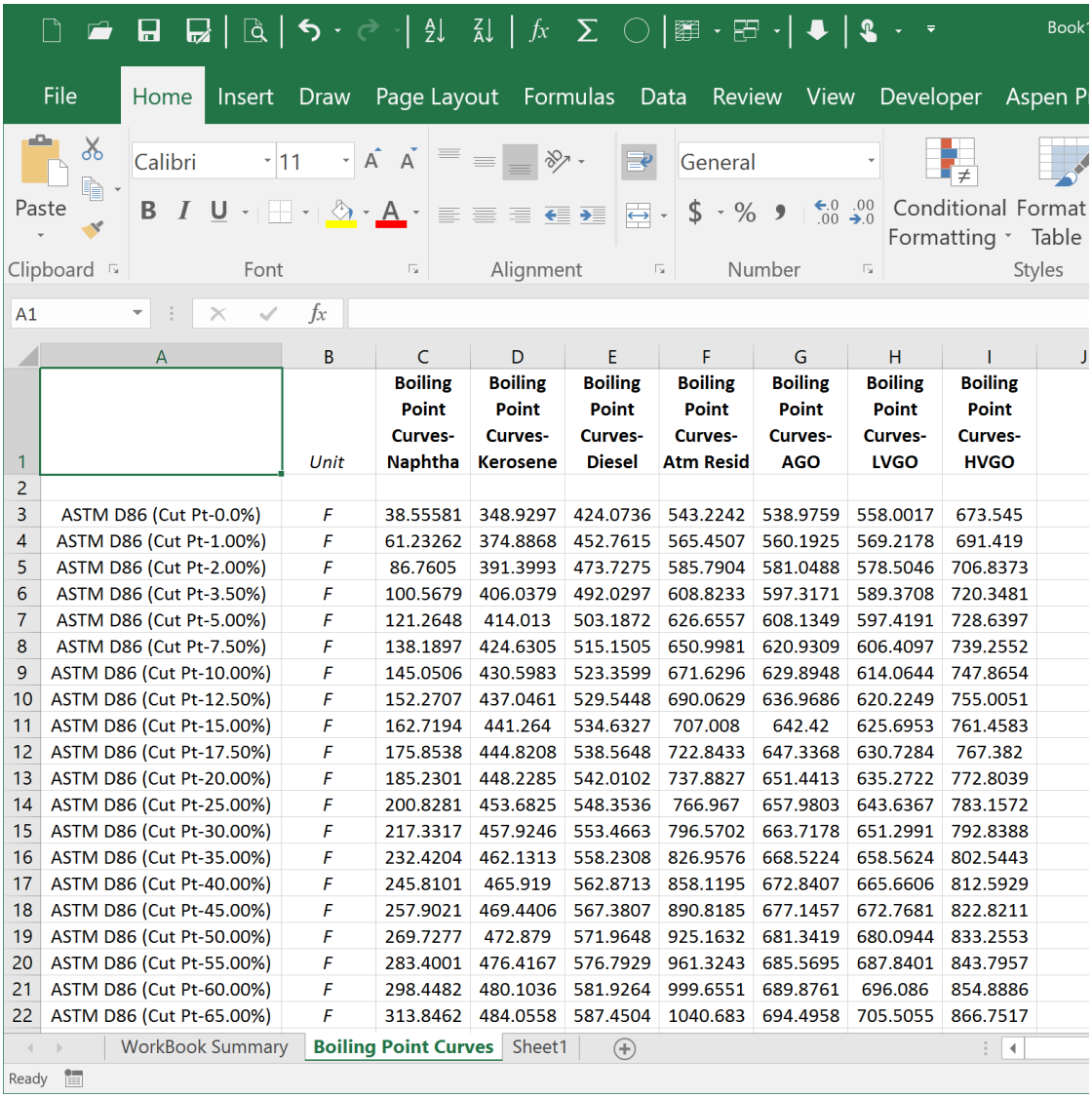


Repeat the steps & choose True BP. This will the TBP values at the bottom the table.



Now the boiling point curves from the Stream Analyses will be part of the workbook. (Note that if you did not set up a *Stream Analysis* for a stream it will not be h ere either.) This spreadsheet can also exported to Excel.





	A	B	C	D	E	F	G	H	I
1		*Unit*	**Boiling Point Curves-Naphtha**	**Boiling Point Curves-Kerosene**	**Boiling Point Curves-Diesel**	**Boiling Point Curves-Atm Resid**	**Boiling Point Curves-AGO**	**Boiling Point Curves-LVGO**	**Boiling Point Curves-HVGO**
2									
3	ASTM D86 (Cut Pt-0.0%)	*F*	38.55581	348.9297	424.0736	543.2242	538.9759	558.0017	673.545
4	ASTM D86 (Cut Pt-1.00%)	*F*	61.23262	374.8868	452.7615	565.4507	560.1925	569.2178	691.419
5	ASTM D86 (Cut Pt-2.00%)	*F*	86.7605	391.3993	473.7275	585.7904	581.0488	578.5046	706.8373
6	ASTM D86 (Cut Pt-3.50%)	*F*	100.5679	406.0379	492.0297	608.8233	597.3171	589.3708	720.3481
7	ASTM D86 (Cut Pt-5.00%)	*F*	121.2648	414.013	503.1872	626.6557	608.1349	597.4191	728.6397
8	ASTM D86 (Cut Pt-7.50%)	*F*	138.1897	424.6305	515.1505	650.9981	620.9309	606.4097	739.2552
9	ASTM D86 (Cut Pt-10.00%)	*F*	145.0506	430.5983	523.3599	671.6296	629.8948	614.0644	747.8654
10	ASTM D86 (Cut Pt-12.50%)	*F*	152.2707	437.0461	529.5448	690.0629	636.9686	620.2249	755.0051
11	ASTM D86 (Cut Pt-15.00%)	*F*	162.7194	441.264	534.6327	707.008	642.42	625.6953	761.4583
12	ASTM D86 (Cut Pt-17.50%)	*F*	175.8538	444.8208	538.5648	722.8433	647.3368	630.7284	767.382
13	ASTM D86 (Cut Pt-20.00%)	*F*	185.2301	448.2285	542.0102	737.8827	651.4413	635.2722	772.8039
14	ASTM D86 (Cut Pt-25.00%)	*F*	200.8281	453.6825	548.3536	766.967	657.9803	643.6367	783.1572
15	ASTM D86 (Cut Pt-30.00%)	*F*	217.3317	457.9246	553.4663	796.5702	663.7178	651.2991	792.8388
16	ASTM D86 (Cut Pt-35.00%)	*F*	232.4204	462.1313	558.2308	826.9576	668.5224	658.5624	802.5443
17	ASTM D86 (Cut Pt-40.00%)	*F*	245.8101	465.919	562.8713	858.1195	672.8407	665.6606	812.5929
18	ASTM D86 (Cut Pt-45.00%)	*F*	257.9021	469.4406	567.3807	890.8185	677.1457	672.7681	822.8211
19	ASTM D86 (Cut Pt-50.00%)	*F*	269.7277	472.879	571.9648	925.1632	681.3419	680.0944	833.2553
20	ASTM D86 (Cut Pt-55.00%)	*F*	283.4001	476.4167	576.7929	961.3243	685.5695	687.8401	843.7957
21	ASTM D86 (Cut Pt-60.00%)	*F*	298.4482	480.1036	581.9264	999.6551	689.8761	696.086	854.8886
22	ASTM D86 (Cut Pt-65.00%)	*F*	313.8462	484.0558	587.4504	1040.683	694.4958	705.5055	866.7517