

#### STARTING A NEW CASE:-

For every new case in HYSYS we need first to specify the basics of the case, then start building it.

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Basics are defined in the Properties (Basis) Environment.

- Required basics to be defined are:
  - 1. Component List.
  - 2. Property Package.



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6 Energy Analysis	Required Info : Fluid Packages Select Required Info : Components Empty o Required Info : Master Component List	omponent list		
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#### 1) Component List:-

Component lists are collections of components you assemble in the Properties Environment for specific simulation purposes.

One component can be added to several lists; however, the instances do not become separate objects. If you edit the properties of a component in any component list, the edits apply to all other components of the same name in any other list. You can create separate instances of a component by cloning and editing pure components or by creating hypothetical components.

#### • Creating Component List:

To add components to the Properties Environment:

- 1. Click the Component Lists folder in the Properties Environment navigation pane.
- 2. In the Component Lists window, use the Add drop down arrow to select the HYSYS or Aspen Properties database as a source for the components.
- 3. Use the respective library browsers (HYSYS or Aspen Properties) to add components from the database to the new list.
  - a. Both browsers let you either add pure components or define groups of hypothetical components within the same list.
  - b. HYSYS and Aspen Properties components cannot be added to the same list.

When you have successfully created the list, its folder icon goes from red to a blue check. You can now associate the component list with a property package to create a complete fluid package.



Component List - 1 × +					
Your List name Source Databank: HYSYS	Use the search to easily find component(s)	Select: Pure Component	ts 👻 Filter:	All Families •	Ŧ
Component Type Methane Pure Component	Group	Search for:	Search by:	Full Name/Synonym	•
Ethane Pure Component		Simulation Name	Full Name / Synonym	Formula	
	2 Add	Propane	3	C3H8	*
		i-Butane	1 i-C4	C4H10	
	Then Click Add	n-Butane	n-C4	C4H10	
Selected		i-Pentane	First Choose i-C5	C5H12	
component for	Replace	n-Pentane	component(s). n-C5	C5H12	
the list are		n-Hexane	C6	C6H14	
shown here.		n-Heptane	C7	C7H16	
	Remove	n-Octane	C8	C8H18	
		n-Nonane	C9	C9H20	
		n-Decane	C10	C10H22	
		n-C11	C11	C11H24	
		n-C12	C12	C12H26	
		n-C13	C13	C13H28	
		n-C14	C14	C14H30	*

#### • Hypothetical Component (Hypo-Component):

The Hypothetical components are non-library. Hypothetical components can be pure components, defined mixtures, undefined mixtures, or solids. You can also clone HYSYS library components into hypotheticals, allowing you to modify the library values.

Hypothetical components are independent of the Fluid Package. When a hypothetical is created, it is placed in a Hypo Group. Since Hypothetical components are not exclusively associated with a particular Fluid Package, it is possible for multiple Fluid Packages to share Hypotheticals. In other words, you need only create a Hypothetical once, and it can be used in any Fluid Package in the case.

Select: Search for:	Pure Component Pure Componer Hypothetical Hypothetical So	ts 🖓		All Families Full Name/Synonym	•
Simulat	ion Name	Full Nam	ne / Synonym	Formula	
	Propane		C3	C3H8	
	i-Butane		i-C4	C4H10	
	n-Butane		n-C4	C4H10	
	i-Pentane		i-C5	C5H12	
	n-Pentane		n-C5	C5H12	

There is TWO methods to add Hypo-Components:

1. Create a batch of Hypos:

Source Databank: HVSYS				Select:	Hypothe	tical 💌	Metho	d:	Create a batch of	hypos • 1
Component	Туре	Group		Hypo Group:	HypoGre	oup1 -				
Methane	Pure Component									
Ethane	Pure Component			Initial Boiling Poi	int: <sup>8</sup>	0.00 F	Interv	val	20.00	F
			< Add All	Final Boiling Poir		0 <b>0.0 F</b> Generate Hypos	Num	ber of H rval	ypos	3
			5	New Нуро 6	roup	Generate Hypos	4			
			< Add	Name		Normal Boiling Point [F]	Molecular V	Veight	Liquid Density [Ib/ft3]	Tc [F]
				N	BP[2]80*	80.0	0	68.51	36.99	350.09
				NB	P[2]132*	132.0	0	80.12	41.40	432.95
			Remove	NB	P[2]184*	184.0	0	92.37	44.47	503.87
					hypo-	the range by IBf components act number o Delete Hypo		the int	erval or requir	

2. Create and Edit single Hypos one by one separately:

Source Databank: HYSYS	don't forget to add the Stect: Hypothetical   Hypothetical   Method: Create and Edit Hypos	-0
Component Type Group Methane Pure Component Ethane Pure Component	component list Hypo Group: HypoGroup1 Type: Base Properties	*
Hypo20000" User Defined Hypothetice HypoGroup1	S New Hypo Group New Hypo 2	
	Add         Name         Normal Boiling Point [F]         Molecular Weight         Liquid Density [Ib/ft3]         T. [F]           Hypo20001* <empty> <empty> <empty> <empty></empty></empty></empty></empty>	
<u>NOTE:</u> Properties must be, at least, Boiling point or Density AND Molecular Weight.	Remove     Enter any known property for the hypo-component,     then click "Estimate Unknown" to calculate all     remaining properties.      Estimate Unknown     Delete Hypo	,

#### 2) Property Package:

Property packages are specialized collections of methods for calculating the properties of components and values of parameters within the simulation. When you have established a component list, you combine the component list with a property package. The combination of the component list and the property package, (along with other simulation settings), comprise the HYSYS fluid package. Hence:

Property Package + Component List = Fluid Package.

#### Available Property Packages:

- Equations of State (EOS): GCEOS, Kabadi Danner, Lee-Kessler Plocker, Peng-Robinson, PRSV, SRK, Sour PR, Sour SRK, Zudkevitch Joffee, BWRS.
- Activity Models: Chien Null, Extended NRTL, General NRTL, Margules, NRTL, UNIQUAC, van Laar, Wilson.
- Chao Seader & Grayson Streed Models: Chao Seader, Grayson Streed.
- Vapor Pressure Models: Antoine, Braun K10, Esso Tabular.
- Acid Gas, Glycol, Electrolyte Acid Gas Package, DBR Amine Package, ASME Stream, Glycol PPkg, NBS Stream, MBWR, OLI\_Electrolyte.
- Choosing the proper property package depend on the process you are going to build. Use the following table to help you in choosing the property package:

Type of System	Recommended Property Package
TEG Dehydration	PR
Sour Water	PR, Sour PR
Cryogenic Gas Processing	PR, PRSV
Air Separation	PR, PRSV
Atm Crude Towers	PR, PR Options, GS
Vacuum Towers	PR, PR Options, GS <10mm Hg, Braun K10, Esso K
Ethylene Towers	Lee Kesler Plocker
High H <sub>2</sub> Systems	PR, ZJ or GS (see T/P limits)
Reservoir Systems	PR, PR Options
Steam Systems	Steam Package, CS or GS
Hydrate Inhibition	PR
Chemical Systems	Activity Models, PRSV
HF Alkylation	PRSV, NRTL (Contact Hyprotech)
TEG Dehydration with Aromatics	PR (Contact Hyprotech)

Properties c	Fluid Packages × +
All Items	
4 💩 Component Lists	Fluid Package Component List Property Package Status
📷 Component List - 1	
Fluid Packages	
Detroleum Ascays Oil Manager	
Reactions	
Component Maps	Click to choose
📷 User Properties	Add   property package
	Aspen Properties
	HYSYS Aspen Properties COMThermo
	Click Here
Properties	Add • Edit Copy Delete
- Cimulatian	
	inport Export
Safety Analysis	S Messages ₹ 9 × 1
-	Resided Markener - Clast encodered Estimating Properties of NBP[1]32* :
69 Energy Analysis	
	Estimating Properties of NeP[2]830 : Estimating Properties of NeP[2]834 : Estimating Properties of NeP[2]184 : Estimating Properties of Hypo20000 : *
	Estimating Properties of Hypo20000° :

ckage Type: HVSYS		Component List Selection	onent List - 1 [HYSYS Databanks]
roperty Package Selection	Options		Parameters
Chao Seader	Enthalpy	Property Package EOS	
Chien Null	Density	Costald	
Clean Fuels Pkg	Modify Tc, Pc for H2, He	Modify Tc, Pc for H2, He	
Esso Tabular	Indexed Viscosity	HYSYS Viscosity	
Extended NRTL GCEOS	Peng-Robinson Options	HYSYS	
General NRTL	EOS Solution Methods	Cubic EOS Analytical Method	
Glycol Package	Phase Identification	Default	
Grayson Streed	Surface Tension Method	HYSYS Method	
Kabadi-Danner Lee-Kesler-Plocker	Thermal Conductivity	API 12A3.2-1 Method	
Margules			
MBWR			
NBS Steam NRTL			
OLI_Electrolyte			
Peng-Robinson *			

Fluid Package	Component List Component List - 1 [HYSYS Datab	Property Package Peng-Robinson	Status Input Complete
DdSIS-	Component List - 1 [H1313 Datab	Peng-Kobinson	input Complete
Fluid Package	Component list 🕂	Property Package	•
ŧ	+	+	
Basis-1 =	Component List - 1 +	Pena-Robinson	

#### > **BUILDING THE PROCESS (SIMULATION ENVIRONMENT):**

In simulation environment, we build our case (process PFD) and do all the simulation work.

Any process represented by equipment and unit operation interconnected together by material streams, every piece of equipment has its own parameter, properties, and specification.



Any equipment for representing the process can be found in the tool palette shown in the next figure.

If the tool palette does not appear, show it by any of the following:

- From the ribbon, "flowsheet/Modify" tab, choose "Models and streams".
- From the ribbon, "View" tab, choose "Models palette".
- Press "F4".

#### To add any equipment or stream:

- a. Double click on it in the palette.
- b. (or) Choose it (by click), then press the green plus sign in the top left corner.
- c. (or) Choose it (by click), then click on any empty area in the flowsheet.



#### **DEFINING THE MOST COMMON UNIT OPERATIONS**

#### 1) Material stream:-

After adding the material stream to your PFD, double click on it to show its property window and define it as shown in the following figures:



# Always keep your eyes on the status bar for every stream/equipment to which appear in three colors:

**<u>Red</u>**: The object is missing a basic requirement or contains errors.

Yellow: All connections are complete but the block is underspecified or contains warnings. Green: Solved without errors.

orksheet Attachme	ents Dynamics		
Worksheet	Stream Name	1	Vapour Phase
Conditions	Vapour / Phase Fraction	1.0000	1.0000
Properties	Temperature [F]	100.0	100.0
Composition	Pressure [psia]	20.00	20.00
Oil & Gas Feed	Molar Flow [lbmole/hr]	100.0	100.0
Petroleum Assay K Value	Mass Flow [lb/hr]	1604	1604
User Variables	Std Ideal Liq Vol Flow [barrel/day]	366.9	366.9
Notes	Molar Enthalpy [Btu/Ibmole]	-3.201e+004	-3.201e+004
Cost Parameters	Molar Entropy [Btu/Ibmole-F]	43.57	43.57
Normalized Yields	Heat Flow [Btu/hr]	-3.201e+006	-3.201e+006
	Liq Vol Flow @Std Cond [barrel/day]	1.615e+005	1.615e+005
	Fluid Package	Basis-1	
	Utility Type		
Delete	OK Define from Stream	/ Assay	(

#### 2) Separator:



The basic requirements for separator are:

- ➢ Inlet stream.
- Liquid outlet stream.
- Vapor outlet stream.

All other parameters are optional, and it helps in rigorous design and rating for the separator.



D					Separator	: V-100	-	• • ×
Design	Reactio	ons Rating	Worksheet	Dynamics				
Ratii Sizing Nozzles Heat Lo: Level Ta Options C.Over S C.Over F	ss ps ietup	Geometry – Flat Cylinc Sphere Ellipsoidal Hemisphe	Head rical Head parator has a		ng and Ra	<pre>   Horizontal   <empty>   <empty>   <empty>   <empty>   ing of the sepational) </empty></empty></empty></empty></pre>	Quick Size Weir	
	elete					ОК		gnored

> Reactions may occur within the separator, and reactions added to the separator as following:

(	Ð				Separ	rator: V-100			- 🗆 🗙
Γ	Design	React	tions Rating Wor	ksheet Dynamics					
	Reaction	ns	Reaction Details —						
	Results		Reaction Set		-	5	Use this if the	ere's a reaction	2
			✓ Ignore Reaction	ns when unable to	Solve	~	takes place ir	n the separator.	
		ſ	-Reaction Results —						
			Reaction Extent	s 🔘 Rea	action Balance		View Global Rxn		
				% Conv	Base Comp	Eqm Const	Rxn Extent		
		)elete				OK			Ignored

/orksheet	Name	Inlet	Liq Out	Vap Out	
Conditions	Vapour	1.0000	0.0000	1.0000	
Properties	Temperature [F]	100.0	100.0	100.0	
Composition	Pressure [psia]	20.00	20.00	20.00	
PF Specs	Molar Flow [lbmole/hr]	100.0	0.0000	100.0	
	Mass Flow [lb/hr]	1604	0.0000	1604	
	Std Ideal Liq Vol Flow [barrel/day]	366.9	0.0000	366.9	
	Molar Enthalpy [Btu/Ibmole]	-3.201e+004	-3.201e+004	-3.201e+004	
	Molar Entropy [Btu/lbmole-F]	43.57	43.57	43.57	
	Molar Entropy [Btu/lbmole-F] Heat Flow [Btu/hr]	43.57 -3.201e+006	43.57 0.0000	43.57 -3.201e+006	
	Heat Flow [Btu/hr]	-3.201e+006	0.0000	-3.201e+006	

#### 3) Cooler/Heater:

The Cooler and Heater operations are one-sided heat exchangers. These operations are useful when you are interested only in how much energy is required to cool or heat a process stream with a utility, but you are not interested in the conditions of the utility itself.

The basics requirements for a cooler/heater are:

- Inlet and outlet stream.
- ➢ Energy stream.
- > Delta P, or defining pressure for each in/out stream.

You can enter a specific duty, then it calculate the other side temperature, or specify inlet and outlet temperature and let it calculate the duty.

The Heater has the same following properties view except the energy is consumed not released.

	>	Cooler: E-100	- 🗆 🗙
	Design Rating Design Connections Parameters User Variables Notes	Worksheet       Performance       Dynamics         Name       E-100         Inlet       Energy         Image       Image         Fluid Package       Image         Bosis-1       Image	
L	Delete	Requires a feed stream	Ignored



#### 4) <u>Heat Exchanger (Shell and Tube):</u>

Basis-1

Delete

Rigorous Model

Ŧ

For a more accurate exchanger rat

lick Rigorous Shell&Tube button here

The heat exchanger performs two-sided energy and material balance calculations. The heat exchanger is very flexible and can solve for temperatures, pressures, heat flows (including heat loss and heat leak), material stream flows, or UA.

	ionowing figures show	w the basic st	eps for adding and	i denning a neat excita	iigei.
		Heat E	xchanger: E-103	1	
Design Rating	g Worksheet Performance Dyr	amics Rigorous She	ll&Tube	•	
Design	Tube Side Inlet	Name E	-103	Shell Side Inlet	
Connections Parameters	Tube inlet	2		Shell inlet	<b>-</b> 3
Specs User Variables	<u>≻</u>				
Notes					
	Tubeside Flowsh	ant	Shellside Flowshee	· · · · · · · · · · · · · · · · · · ·	
		ase (Main)		e (Main)	
		-		<b>&gt;</b>	
	Tube Side Outlet			Shell Side Outlet	
	Tube outlet	4	Switch streams	Shell outlet	-5
	Tube Side Fluid Pkg			Shell Side Fluid Pkg	

Unknown Delta P

¥

Ignored

Basis-1

•

Update

Size Rigorous Shell&Tube

📃 Use Design Template File

> The following figures show the basic steps for adding and defining a heat exchanger:

D	Heat Exchanger: E-103 – 🗖 🗙
Design Rating	
Design	- Heat Exchanger Model Heat Leak/Loss
Connections Parameters	Simple End Point
Specs User Variables	End Point Model
Notes	Overall UA [Btu/F-hr] <empty></empty>
	Specified Pressure Drop [psi]
	Use Ft Tube Passes Shell Passes Shells In Series First Pass Shell Type 2 1 1 Counter E
	Rigorous Model you can use defaults
	For a more accurate exchanger rating Size Rigorous Shell&Tube 💌
	click Rigorous Shell&Tube button here
Delete	Not Solved Update Ignored

#### HYSYS has five different model for the heat exchanger:

- i. <u>Rigorous Shell and Tube</u>: This mode accesses the Aspen Exchanger Design and Rating (EDR) program and lets you set up a rigorous shell and tube exchanger model within it.
- ii. <u>Dynamic Rating:</u> Two models are available for Dynamic Rating: Basic and Detailed. If you specify three temperatures or two temperatures and a UA, you can rate the exchanger with the Basic model. If you provide detailed geometry information, you can rate the exchanger using the Detailed model. Once Dynamic Rating is selected, no further information is required from the Parameters page of the Design tab. Choice of Basic or Detailed model is made on the Parameters page of the Rating tab or the Model Page of the Dynamics tab.
- iii. <u>Simple End Point</u>: This model is based on the standard heat exchanger duty equation defined in terms of overall heat transfer coefficient, area available for heat exchange and the log mean temperature difference. The main assumptions of the model are overall heat transfer coefficient U is constant and specific heats of both shell and tube side streams are constant. This model treats the heat curves for both heat exchanger sides as linear. For simple problems where there is no phase change and Cp is relatively constant, this option may be sufficient to model your heat exchanger. For non-linear heat flow problems, the Weighted model should be used instead.
- iv. <u>Simple Steady State Rating:</u> The Steady State Rating model is an extension of the End Point model to incorporate a rating calculation, and uses the same assumptions as the End Point model. If you provide detailed geometry information, you can rate the exchanger using this model. As the name suggests, this model is only available for steady state rating.
- v. <u>Simple Weighted:</u> This is an excellent model to deal with non-linear heat curve problems such as the phase change of pure components in one or both heat exchanger sides. The heating curves are broken into intervals and an energy balance is performed along each interval. A LMTD and UA are calculated for each interval in the heat curve and summed to calculate the overall exchanger UA.

6	-	Heat Exchanger: E-103	- 🗆 🗙
Design Rating	Worksheet Performance Dynamics	Rigorous Shell&Tube	
Rating Sizing Parameters	Sizing Data Overall OShell OTube	e 🕅 Accept any input data	
Nozzles Heat Loss	- Configuration	Calculated Information	
	Number of Shell Passes	1 Shell HT Coeff [Btu/hr-ft2-F] <empty></empty>	
	Number of Shells in Series	1 Tube HT Coeff [Btu/hr-ft2-F] <empty></empty>	
	Number of Shells in Parallel	1 Overall U [Btu/hr-ft2-F] <empty></empty>	
	Tube Passes per Shell	2 Overall UA [Btu/F-hr] <empty></empty>	
	Exchanger Orientation	Horizontal Shell DP [psi] 5.000	
	First Tube Pass Flow Direction	Counter Tube DP [psi] 5.000	
	Elevation (Base)	0.0000     Heat Trans. Area per Shell [ft2] 649.3     Tube Volume per Shell [ft3] 6.816	
		Tube Volume per Shell [ft3]         6.816           Shell Volume per Shell [ft3]         80.24	
	TEMA Type 🛛 🖌 🗧	L Siter volume per Siter [13] 00.24	
		guration for the heat exchanger sizing. you can use the defaults.	
Delete		Not Solved Update	🔲 Ignored

D			He	eat Exchanger: E-103 – 🗖 🗙
Design	Rating	Worksheet Performance	e Dynamics Rigorou	us Shell&Tube
Desid	jn (	Solver		Unknown Variables
Connecti Paramete Specs User Var Notes	ions ers	Tolerance Current Error Maximum Iterations Iterations Unknown Variables Constraints Degrees of Freedom	m	Flow of Tube inlet <empty></empty>
	e	Specifications E-103 Heat Balance E-103 UA		
		the exchai	cations for ager appear ere.	Active specs are those used for solving the exchanger Click here to add new specs
D	elete		No	ot Solved Dydate 🔲 Ignored

## - To add a new specification for the heat exchanger

From the **Type** drop-down list, select one of the following specification types:

<u>Temperature, Delta Temp, Minimum Approach,</u> <u>UA, LMTD, Duty, Duty Ratio, Flow, Flow</u> <u>Ratio, Subcooling</u>, or <u>Superheating</u>.

The property view changes depending on the type selected. Specify the appropriate parameters for each specification type.

🕞 E-103 ExchSpec - 2 🗕 🗖 🗙							
Parameters Summary							
Name	E-103 ExchSpec - 2						
Туре	Delta Temp						
Stream (+)	<< Stream >>						
Stream (-)	<< Stream >>						
Spec Value	<empty></empty>						
	ne specs type, then te its parameters.						

#### 5) Pumps:





#### 6) <u>Compressor/Expander:</u>

Compressor and Expander are very similar in operation but in reverse direction, so we combined the together in definition and configuration.

The Compressor operation is used to increase the pressure of an inlet gas stream, while the Expander operation is used to decrease the pressure of a high-pressure inlet gas stream to produce an outlet stream with low pressure and high velocity.

In general, the solution for compressor/expander is a function of flow, pressure change, applied energy, and efficiency.

In the following figures are the basic steps for configuring compressor which typically applied for configuring an expander, and any difference will be mentioned.





Linking compressors and expanders in HYSYS means: The speed of each linked unit operation is the same, the sum of duties of each linked pump/compressor/expander and the total power loss equals zero.

- The Previous Link field displays the name of the operation that is attached to current compressor.
- The Gear Ratio field displays the ratio of the speed from the next linked operation divided by the speed of the current pump.
- The Total Power Loss field displays the total power loss or input to the linked operations.

From the Next Link drop-down list, select the pump, expander, or compressor you want to link to.

#### 7) Mixer and Tee:

The mixer operation combines two or more inlet streams to produce a single outlet stream. A complete heat and material balance is performed on the mixer.

The Tee operation splits one feed stream into multiple product streams with the same conditions and composition as the feed stream, and is used for simulating pipe tees and manifolds.

۲	Mixer: MIX-100	
	Mixer: MIX-100 orksheet Dynamics Name MIX-100 Inlets Mixer inlet 1 Mixer inlet 2 << Stream >> 1 1 1 1 1 1 1 1 1 1 1 1 1	
Delete	Not Solved	] Ignored



D	Tee: TEE-100	- 🗆 🗙
Design Rating Design Connections Parameters User Variables Notes		
Delete	Unknown Splits	Ignored

D	Tee: TEE-100 – 🗆 🗙
Design Rating	Worksheet Dynamics
Design	Splits Maximum flow spec
Connections Parameters User Variables	Flow Ratios       Tee out 1
Notes	Tee out 2 <empty> Max flow stream Max flow rate <empty> <empty></empty></empty></empty>
	- Specify the flow ratios for N-1 outlet streams, where N is the number of outlet streams. HYSYS calculates the unknown
	stream flow ratio and the outlet flow rates. - <u>When Maximum Flow on is checked</u> , you can specify the max flow stream and overflow stream from the drop-down list of product streams; once the stream is chosen, its flow ratio status becomes calculated.
	Warn on Negative Flow
Delete	Unknown Splits 🗌 Ignored

### 8) <u>Valve:</u>

HYSYS performs a material and energy balance on the inlet and exit streams of the Valve operation. HYSYS performs a flash calculation based on equal material and enthalpy between the two streams. It is assumed that the valve operation is isenthalpic.

	Valve: VLV-100	- 🗆 🗙
Design Rating W Design Connections Parameters User Variables Notes	Valve: VLV-100 /orksheet Dynamics Name VLV-100 Inlet Valve in VlV-100 Fluid Package Basis-1	
Delete	Unknown Delta P	Ignored

D	Valve: VLV-100	- 🗆 🗙
Design Rating Wo	orksheet Dynamics	
Design		
Connections Parameters	Delta P <empty></empty>	
User Variable		
	$\longrightarrow$	
	Use sizing methods to calculate Delta P	
	Specify a Delta P value	. ]
	or the pressure for bot	th 📔
	inlet and outlet stream	s.
		_
Delete	Unknown Delta P	Ignored
		- ignored

## COLUMNS

HYSYS provide a simple method to define columns which is "The Column Input Expert".

The Input Expert contains a series of input pages. You must supply the required information for the page before advancing to the next one. When you have worked through all the pages, you will have supplied the basic information required to build your column, and the Column property view appears.

It is not necessary to use the Input Experts to install a column. You can disable the use of Input Experts by deactivating the Use Input Experts checkbox on the Options page in the Simulation tab of the Session Preferences property view. If you do not use the Input Expert, the Column property view appears when you install a new column.

- > The Input Expert is available for the following standard column templates:
  - Absorber
  - Liquid-Liquid Extractor
  - Reboiled Absorber
  - Refluxed Absorber
  - Distillation
  - Three Phase Distillation
- The input pages of the Input Expert are the same for all the previous mentioned column types, they only differ in the pages related to some equipment does not exist in the other type, i.e., the pages for configuring a reboiler will not be exist if the column does not have a reboiler, and so on.

Next, will show the basic steps for installing a distillation column, and any difference with other column types we mention.

Distillation Column Input Expert	- 🗆 🗙
Condenser Energy Stream	Vapors Ovhd Outlets Overhead
<< Stream >> 3 (< Stream >> 3)	ws Type Draw Stage
Stage Numbering Top Down 2 So Bottom Up	Bottoms Liquid Outlet Bottom Liquid
< Prev Next > N7 Connections (page	1 of 5) Cancel

- 1. Specify the number of theoretical stages (or trays) in the column.
- 2. Specify the way the column is numbered.
- 3. Specify the inlet stream(s). For each inlet stream, select the stage the stream is entering column from the **Inlet Stage** drop-down list.
- 4. In the Condenser group click one of the following radio buttons: Total, Partial, or Full Rflx.
  - Total: all vapors condensed so, there is liquid product stream but no vapor product stream.
  - Partial: Vapors are partially condensed, and has liquid and vapor product streams.
  - Full Rflx: Full condenser but all its liquid product return the column as a reflux.

0 Partial 0	Vapors  Vhd Outlets Overhead	0 Full Rflx Water Draw	Ovhd Liquid Outlet Overhead
		pors d Vapour Outlet	

- 5. The Water Draw checkbox appears when either the Total or Partial radio button is selected.
- For each optional side draw stream, select the type of draw stream from the Type drop-down list and select the stage the stream is leaving the column from the Draw Stage drop-down list. You are given three options: L (Liquid), V (Vapor), and W (Water).





- If the column does not have a condenser, the condenser pressure replaced by the top stage pressure.
- > If the column does not have a reboiler, the reboiler pressure replaced by the bottom stage pressure.



- If the column does not have a condenser, the condenser temperature will not be exist.
- If the reboiler does not exist, the reboiler temperature replaced by the bottom stage temperature.



If the column has only a reboiler and does not have a condenser, then this page will ask for the reboiler "Boil-up Ratio".

D	Column: T-100 / COL1 Fluid Pkg: Basis-1 / Peng-Robinson – 🗆 🗙
Design Paramete	ters Side Ops Rating Worksheet Performance Flowsheet Reactions Dynamics
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Before running the column, go to the "Monitor" page to see the column specs and which are active.

- 1- The degrees of freedom must equal zero for the column to be converged.
- 2- Active: The active specification is one that the convergence algorithm is trying to meet. An active specification always serves as an initial estimate. An active specification always exhausts one degree of freedom.

Estimate: An estimate is considered an inactive specification because the convergence algorithm is not trying to satisfy it. The value then serves only as an initial estimate for the convergence algorithm. An estimate does not exhaust an available degree of freedom.

**Current**: When the Active check box is selected, the Current check box is automatically selected as well. You cannot alter this check box. When Alternate specs are used and an existing hard to solve spec has been replaced with an Alternate spec, this check box makes clear to you the current specs used to solve the column.

3- To add a new specs to the column. That will show the window to choose your new specs then configure it with the proper value. Column Control Column Column Control Column Control Column Control Column Control Column Control Column Control Co



- 4- When you complete the configuration of the column, press Run to converge the column.
- 5- The Column Environment (Column Subflowsheet):

When you install any prebuilt column, HYSYS creates a column subflowsheet containing all operations and streams associated with the column template you have chosen. The subflowsheet operates as a unit operation in the main flowsheet.

When you are working in the parent flowsheet, the column appears just as any other unit operation, with multiple input and output streams, and various adjustable parameters. If changes are made to any of these basic column parameters, both the Column subflowsheet and parent flowsheet are recalculated.

<u>Having a Column subflowsheet provides a number of advantages</u>: isolation of the Column Solver, optional use of different Property Packages, construction of custom templates, and the ability to solve multiple towers simultaneously.

From the Column window, you can enter the column's own subflowsheet, or the "column environment," and make changes to the specific parts of the column operation if necessary.

To return to the Column's parent environment, click the Parent Environment button in the Column Runner property view or the View Parent icon in the toolbar.



#### - SIDE OPERATION IN COLUMNS:

There are five type of side operations can be attached to the columns:

- 1. Side stripper (with reboiler or steam).
- 2. Side rectifier.
- 3. Pump around.
- 4. Vapor bypass.
- 5. Side draw.



#### They all require defining:

- i. Draw stage.
- ii. Return stage (except side draw).
- iii. If exist, Specify the drawn product and its rate.
- iv. If exist, specify reboiler or side steam stream.

## **OIL CHARACTERIZATION**

Installing crude oil in HYSYS to use it in simulation cases consist of two basic steps:

- Defining the crude oil using "Assays" (oil characterization).
- Creating a "Blend" by using discrete hypothetical components to install in the PFD.

Both of these two steps are completed in the oil manager (also called oil environment). Access the Oil Characterization environment from the **Oil Manager** folder of the Properties Environment navigation pane.

To enter the environment, at least one Fluid Package must exist in the case and any hypothetical (pseudo) components must be compatible with the property method being used by the Fluid Package.

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When you choose to use an Assay data, you have different options for dealing with the following properties:

- 1. Light Ends:
  - Ignore: HYSYS will characterize the light ends portion of your sample as a hypocomponent. This is the least accurate method and as such, is not recommended.
  - Input composition: Select this when you have a separate light ends assay and your petroleum assay was prepared with the light ends in the sample. HYSYS will provide a form listing the pure components you selected in the Fluid Package. Input your data on a non-cumulative basis.
  - Auto-Calculate: Select this when you do not have a separate Light Ends analysis but you want the low boiling portion of your assay represented by pure components. HYSYS will only use the pure components you have selected in the Fluid Package.
- 2. Molecular Wt. Curve, Density Curve, and Viscosity Curves:
  - Not used: No property data will be considered in the assay calculation.
  - **Dependent**: A common set of assay fractions is utilized for both the distillation curve and the physical property curves.
  - Independent: A common set of assay fractions is not used for both the distillation curve and physical property curve.

If you switch the status to Not Used after you have entered assay data, all your data for that property curve will be lost when you return your selection to Dependent or Independent.

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## - Second Step: Creating a "Blend":-

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From the Cut Option Selection drop-down list select one of the following cut options:

<u>Auto Cut</u>: HYSYS will perform the cutting automatically. HYSYS uses the boiling point width guidelines.

Cutpoint Range	Internal Weighting
IBP - 800°F (425°C)	4 per 100°F
800°F - 1200°F (650°C)	2 per 100°F
1200°F to FBP	1 per 100°F

#### User Ranges:

- In the Starting Cut Point cell, specify the initial cut point of your blend. By default HYSYS will
  use the initial boiling point temperature. HYSYS combines the material boiling between the IBP
  and the initial cut point temperature with the material from the first cut to produce the first
  component. This component will have an NBP centered approximately half way between these
  boundaries.
- 2. In the cut point table enter the remaining cut points and the number of cuts in each section. If the final cut point temperature is not equal to or greater than the FBP, HYSYS will combine the material between the FBP and the last cut temperature with the material in the last component.
- 3. The Lower Temp Limit and Upper Temp Limit fields correspond to the initial boiling point (IBP) and the final boiling point (FBP) of HYSYS' internal TBP working curve. At this point all light ends have been removed (if requested) and the IBP presented is on a light ends free basis.
- 4. Click Submit to tell HYSYS to create the hypocomponents.

#### User Points:

Specify the number of cuts you want to use for the oil and HYSYS will perform the cutting process. All splits are based upon TBP temperature, independent of the source or type of assay data. HYSYS will proportion the cuts according to the following:

Cutpoint Range	Internal Weighting
IBP - 800°F (425°C)	4 per 100°F
800°F - 1200°F (650°C)	2 per 100°F
1200°F to FBP	1 per 100°F

After the blend calculated, press install Oil to install a material stream in the PFD represent the oil you specified.

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## **CHEMICAL REACTIONS**

Reactions within HYSYS are defined inside the Reaction Manager. The Reaction Manager lets you define an unlimited number of reactions and attach combinations of these reactions in reaction sets. The reaction sets are then attached to unit operations in the flowsheet.

The following table describes the five types of Reactions that can be modeled in HYSYS:

Reaction Type	Requirements
Conversion	Requires the stoichiometry of all the reactions and the conversion of a base component in the reaction.
Equilibrium	Requires the stoichiometry of all the reactions. The term Ln(K) may be calculated using one of several different methods, as explained later. The reaction order for each component is determined from the stoichiometric coefficients.
Heterogeneous Catalytic	Requires the kinetics terms of the Kinetic reaction as well as the Activation Energy, Frequency Factor, and Component Exponent terms of the Adsorption kinetics.
Kinetic	Requires the stoichiometry of all the reactions, as well as the Activation Energy and Frequency Factor in the Arrhenius equation for forward and reverse (optional) reactions. The forward and reverse orders of reaction for each component can be specified.
Simple Rate	Requires the stoichiometry of all the reactions, as well as the Activation Energy and Frequency Factor in the Arrhenius equation for the forward reaction. The Equilibrium Expression constants are required for the reverse reaction.

Each of the reaction types require that you supply the stoichiometry. To assist with this task, the Balance Error tracks the molecular weight and supplied stoichiometry. If the reaction equation is balanced, this error is equal to zero. If you have provided all of the stoichiometric coefficients except one, you may select the Balance button to have HYSYS determine the missing stoichiometric coefficient.

Reactions can be on a phase specific basis. The Reaction is applied only to the components present in that phase. This allows different rate equations for the vapour and liquid phase in same reactor operation.

#### Possible choices for the Reaction Phase are:

- Overall Reaction -- occurs in all Phases.
- Vapour Phase Reaction -- occurs only in the Vapour Phase.
- Liquid Phase Reaction -- occurs only in the Light Liquid Phase.
- Aqueous Phase Reaction -- occurs only in the Heavy Liquid Phase.
- Combined Liquid Reaction -- occurs in all Liquid Phases.

▶			test	hsc - Aspen HVS	SVS V8.4 - aspenONE				- 6 ×
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## - Conversion Reaction:

Stoichiometry Info Component Mole Weight Stoich Coeff Base Component Rxn Phase Co	<empty> Overall</empty>
**Add Comp** Rxn Phase Co	Overall
Add Your component for the reaction and assign the stoich Coeff.	<cmpty> <cmpty> <cmpty></cmpty></cmpty></cmpty>
Remember: (-) for Reactants, (+) for Products.	reaction phase
Balance         Balance Error         0.00000           Reaction Heat (25 C) <empty></empty>	and conversion
Not Ready	

## - Equilibrium Reaction:

Stoichiometry Keq Approact Stoichiometry Component	h Library Mole Weight	Equilibrium Reaction:	Basis Basis	_ □ ×
**Add Comp**	none vergine		Phase Min Temperature Max Temperature	VapourPhase -459.7 F 5432 F
assi	mponent for the gn the stoich Co r: (-) for Reacta Products.	beff.	Basis Units Specify he reaction p	
Balance	Balance Error Reaction Heat (25 C	0.00000 ) <empty></empty>		
	Not Re	ady		Gibbs







- Kinetic Reaction:

Component	Mole Wt.	Stoich Coeff	Fwd Order	Rev Order	Basis			Molar Conce	
		Stoich Coeff	Fwd Order	Rev Order		Component		<empty></empty>	
**Add Comp**					Rxn Pl			LiquidPhase	
					Min. T	emperature		-459.7 F	
					Max T	emperature		5432 F	
	nember: (-) F assign the	he stoich Co ) for Reacta Products. e forward ord se if availab	ants, (+) fo der, and th			asis Units ate Units Reaction <u>emptys</u> < <u>emptys</u>	Δ.	• • • Reaction <emp <emp< th=""><th>-</th></emp<></emp 	-
					k = A*	(Basis) - k**P(Basis) * exp { -E / RT } * T / * exp { -E' / RT } * T	Sp reac the	ecify here tion phase parameters netic reaction	the and for

## DIFFERENT REACTORS AVAILABLE IN HYSYS:

Reactor	Appearance in PFD	Description
PFR	PFR-100	The Plug Flow Reactor can be used with Kinetics, Kinetics (Rev. Eqm.), or Langmuir-Hinshelwood reactions (any number and combination of the three types can be used in the reaction set).
CSTR	CSTR-100	The CSTR can be used with Kinetics, Kinetics (Rev. Eqm.), or Langmuir- Hinshelwood reactions (any number and combination of the three types can be used in the reaction set).
Gibbs Reactor	CER-100	The Gibbs Reactor (like the one in Aspen) is unique among the reactors in that you are not required to enter a reaction set for it to work. The Gibbs reactor works by finding the equilibrium state with the lowest Gibbs Free Energy. It appears to be akin to finding all the possible equilibrium reactions and allowing them all to equilibrate. It's nice because you do not need to know anything about the individual equilibrium constants.
Equilibrium Reactor	ERV-100	The Equilibrium Reactor uses reaction sets with only, equilibrium reactions in it.
Conversion Reactor		The Conversion Reactor deals with, conversion reactions. You use it when you know how much of the reactants will be converted into products.

# **PIPING OPERATIONS**

Use the Pipe Segment Operation to model pipelines either for single or multiple phases.

The Pipe Segment operation contains four calculation modes:

- Pressure Drop
- Length
- ➤ Flow
- Diameter

The mode is automatically assigned depending on what information is specified.



For Single Phase streams, the Darcy equation is used for pressure drop predictions. This equation is a modified form of the mechanical energy equation, which takes into account losses due to frictional effects as well as changes in potential energy.

for predicting two-phase pressure drops, you can select one of the correlation method used for Two Phase (VL) flow calculations shown in the parameters section as bellow:

Pipe Segment:	t: PIPE-100	– o ×
Design Rating	Worksheet Performance Flow Assurance Dynamics	
Design	Horizontal Pipe Flow Correlation	
Connections Parameters	Beqqs and Brill (1979) View Correlation	Choose the suitable
Calculation Emulsions	Vertical Pipe Flow Correlation	correlation for your Multi- phase case.
User Variables Notes	Beaas and Brill (1979)   View Correlation	
	Inclined Pipe Flow Correlation	
	Beggs and Brill (1979)   View Correlation	]
	C Additional Parameters	
	🕢 Include Accl. Pr. Drop	
	(Beggs/Brill only)	
	Delta P Duty	
	Gravitation Energy Change	
	Those Values can be specified or calculate HYSYS according to the calculation mode	

**Delta P:** The overall pressure drop for the operation. The pressure drop includes the losses due to friction, static head, and fittings.

Duty: The total heat loss from the Pipe Segment.

<u>The Gravitational Energy Change</u>: Displays the change in potential energy experienced by the fluid across the length of the pipe. It is determined for the overall elevation change, based on the sum of the elevation change specified for each segment on the Sizing page of the Rating tab.

When the pressure drop is specified, the Pipe Segment can be used to calculate either the length of the Pipe Segment or the flow of the material through the length of pipe.

The methods (Correlations) have all been developed for predicting twophase pressure drops. Some methods were developed exclusively for flow in horizontal pipes, others exclusively for flow in vertical pipes while some can be used for either. Some of the methods define a flow regime map and can apply specific pressure drop correlations according to the type of flow predicted. Some of the methods calculate the expected liquid holdup in two-phase flow while others assume a homogeneous mixture.

The table below summarizes the characteristics of each model:

Model	Horizontal Flow	Vertical Flow	Liquid Holdup	Flow Map
Aziz, Govier & Fogarasi	No	Yes	Yes	Yes
Baxendell & Thomas	Use with Care	Yes	No	No
Beggs & Brill (1973 or 1979)	Yes	Yes	Yes	Yes
Duns & Ros	No	Yes	Yes	Yes
Gregory, Aziz, Mandhane	Yes	Use with Care	Yes	Yes
Hagedorn & Brown	No	Yes	Yes	No
HTFS Homogeneous	Yes	Yes	No	No
HTFS Liquid Slip	Yes	Yes	Yes	No
Olgas2000	Yes	Yes	Yes	Yes
Orkisewski	No	Yes	Yes	Yes
Poettman & Carpenter	No	Yes	No	No
Tulsa	No	Yes	Yes	Yes

### ≻ <u>Sizing:</u>

🜔 Pipe Segment: PIPE-	100			- 🗆	×
Design Rating Wor	ksheet Performance Flow As	surance Dynamics			
Rating	Length - Elevation Profile	0			
Sizing 1 Heat Iransier	Segment	3 1			
Heat Loss Overal HTC	Fitting/Pipe	Pipe			
Segment HTC Estimate HTC	Length/Equivalent Length	<empty></empty>			
Estimate HIC	Elevation Change	0.0000			
	Outer Diameter	<empty></empty>			
	Inner Diameter	<empty></empty>			
	Material	Mild Steel			
	Roughness	4.572e-005			
	Pipe Wall Conductivity	45.00			
	Increments	5			
	FittingNo	<empty></empty>			
	Append Segment	Insert Segment	View Segment 4		
	Delete Segment	Clone Segment	Clear Profile		
Delete		Unknown Pipe	Diameter	🔲 Ignor	ed

Use "Append Segment" to add New segment before the selected one, or use "Insert Segment" to add New segment after the selected one.

Pipe/Fitting: Select a pipe section, swage or one of the available fittings from the drop-down list.

Length: The actual length of the Pipe Segment. Not required for fittings.

**Elevation Change:** The change in vertical distance between the outlet and inlet of the pipe section. Positive values indicate that the outlet is higher than the inlet. Not required for fittings.

Outer Diameter: Outside diameter of the pipe or fitting.

Inner Diameter: Inside diameter of the pipe or fitting.

Material: Select one of the available default materials or choose User Specified for the pipe section. Not required for fittings.

Roughness: A default value is provided based on the Pipe Material. You can specify this value.

<u>**Pipe Wall Conductivity:**</u> Thermal conductivity of pipe material in W/m.K to allow calculation of heat transfer resistance of pipe wall.

Increments: The number of increments the pipe section is divided for calculation purposes.

The horizontal pipe sections have an Elevation of zero. A positive elevation indicates that the outlet is higher than the inlet.



With the cursor located on a segment, click the View Segment button to show the segment Info property view.

**<u>Pipe Schedule:</u>** Choose from Schedule 40, 80, or 160. If you choose "Actual", the nominal diameter cannot be specified.

Available Nominal Diameters: Choose the proper diameter then click specify to automatically specify nominal and inner diameter for the pipe.

Pipe Schedule		(1)	Schedule 40	1
Nominal Dian			<empty></empty>	1
Inner Diamete	er.		<empty></empty>	
Pipe Material			Mild Steel	
Roughness			4.572e-05	
Pipe Wall Con	ductivity		45.000	
vailable Nom	inal Diamet	ers —	1	י ר
Available Nom 25.40	152.4	ers	]	
	2		]	
25.40	152.4	406.4	Specify	3
25.40 38.10	152.4 203.2	406.4 457.2	Specify	3

#### Heat transfer:

There are four ways of defining heat transfer:

- <u>Heat loss</u>: If the Overall heat duty of the pipe is known, each increment is assumed to have the same heat loss.
- <u>Overal HTC</u>: If the overall HTC and a representative ambient temperature are known, rigorous heat transfer calculations are performed on each increment.
- <u>Segment HTC</u>: If the heat transfer coefficient and a representative ambient temperature are known for each segment.
- <u>Estimate HTC</u>: If the pipe's HTC is unknown, you can enter information in this property view and HYSYS calculates the HTC for the pipe.



Include Pipe Wall: To include the pipe's thermal resistance in your HTC calculations.

Include Inner HTC: to estimate the inside film HTC using one of the five correlations provided.

**Include Insulation:** To estimate conduction through the insulation or any other pipe coating. You must specify a thickness.

Include Outer HTC: To include outside convection to either Air, Water, or Ground.