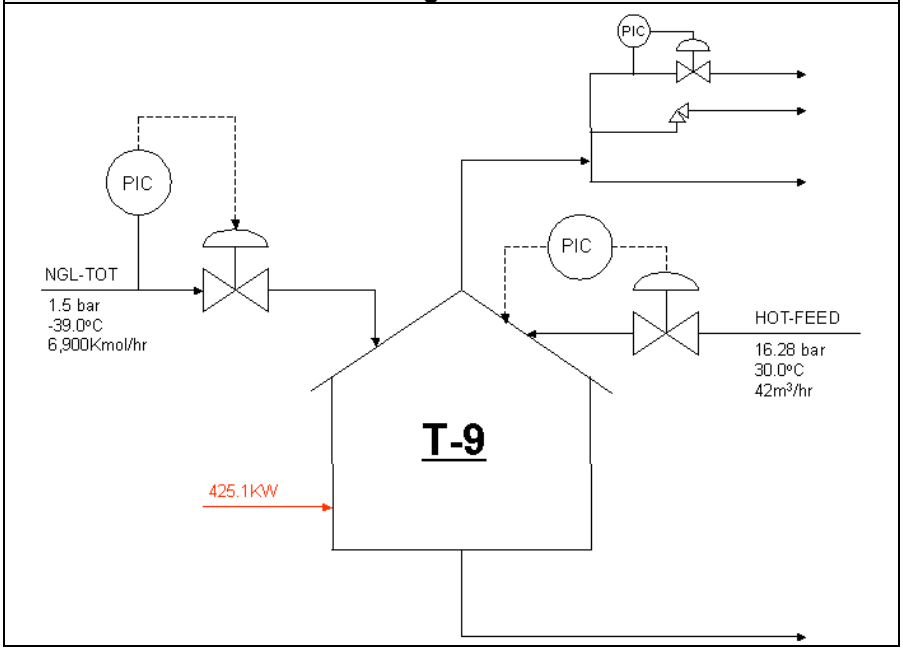
Dynamic Simulation for T-9 Storage Tank (Holding Case)

CASE 1: 19,642 Kg/Hr (Holding: 52°C), No Liquid Draw

Workshop Description

- Estimation of vapor flow rate coming out from the T-9 tank for holding case (52°C) using dynamic simulation.
- Schematic diagram for T-9 tank holding case is shown below in Figure 1.

Figure 1



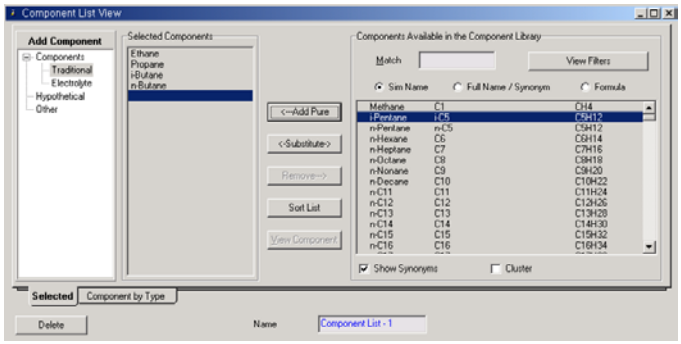
- Feed conditions and compositions for stream NGL-TOT & HOT-FEED are shown in Table 1.

Table 1

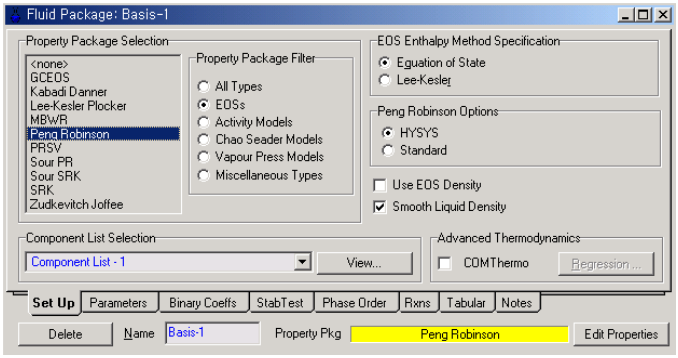
Stream	NGL-TOT	HOT-FEED
Temperature (°C)	-39.0	42.0
Pressure (bar)	1.50	2.5
Component		
Ethane Propane Iso-butane N-butane	0.020 0.976 0.003 0.001	0.020 0.976 0.003 0.001
Flowrate	6,900 Kmole/hr	42m^3/hr

Building a Steady State Simulation for T-9 tank.

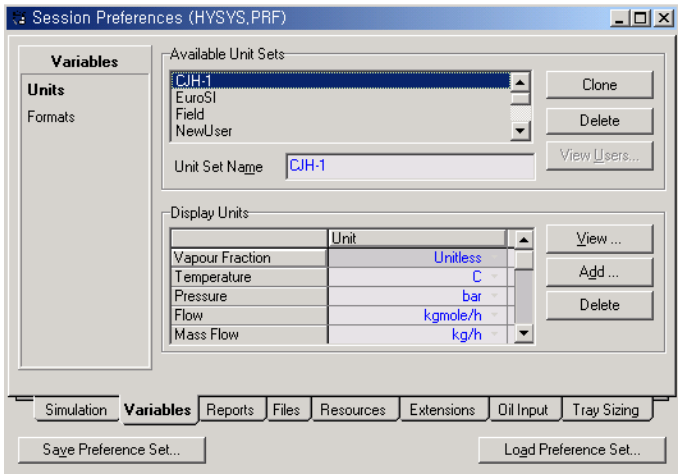
- Open the Component List View.



- Open the Fluid Package View.



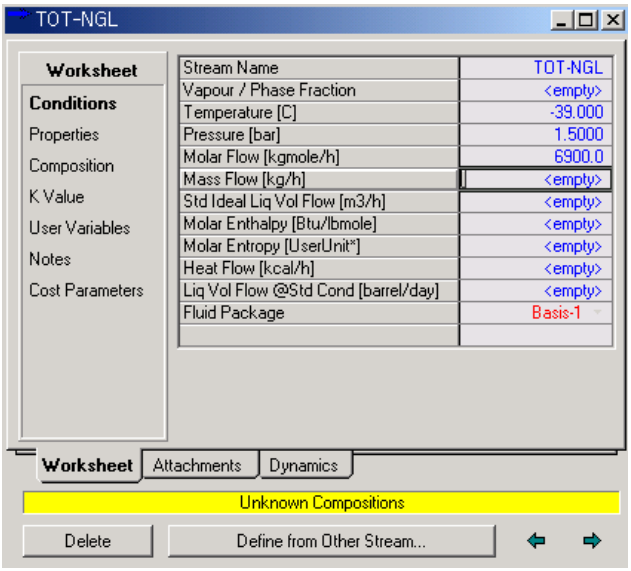
- Selecting a Unit Set.

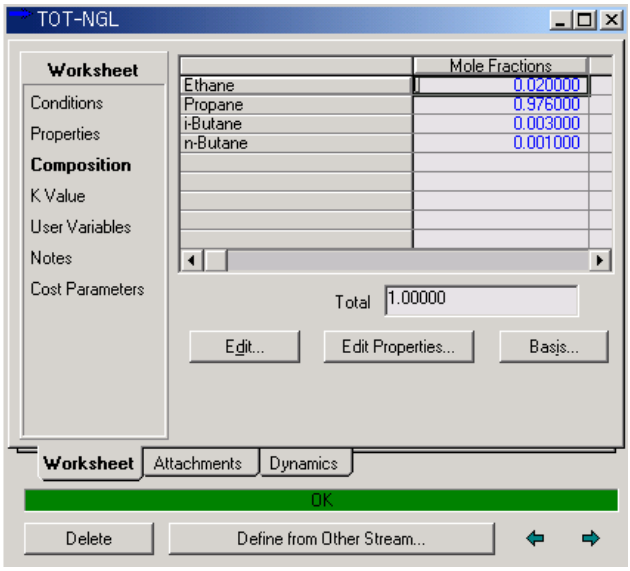


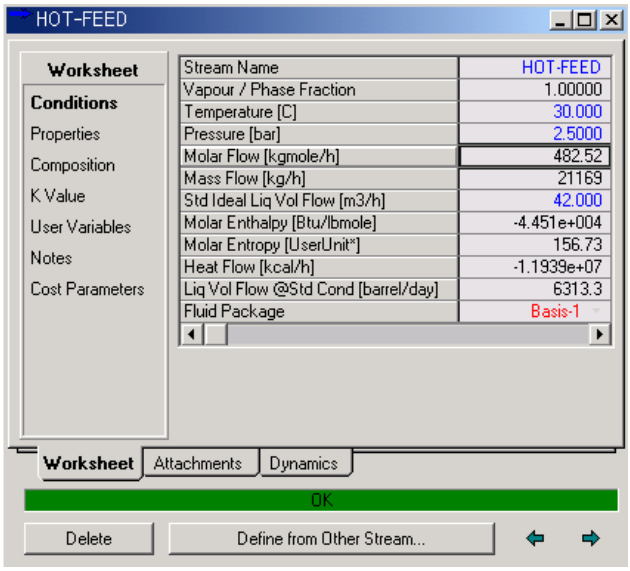
- Adding Streams

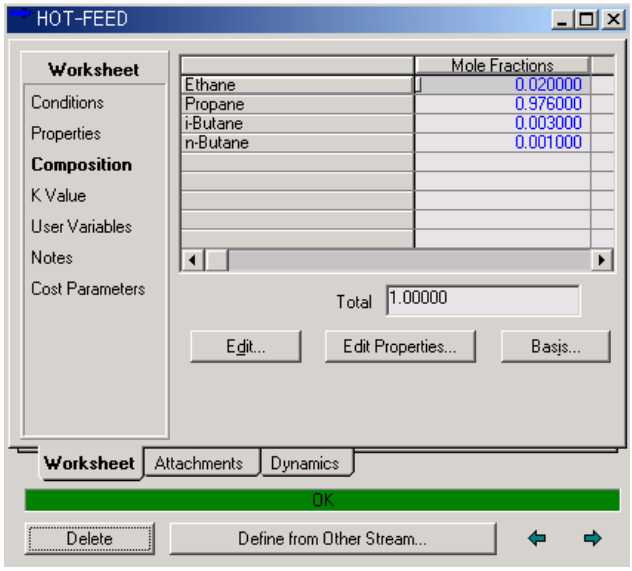
In HYSYS, there are two types of streams, Material and Energy . Material streams have a composition and parameters such as temperature, pressure and flow rate. They are used to represent Process Streams. Energy streams have only one parameter, Heat Flow. They represent heating and cooling duties in a plant we well as power to drive pumps and compressors.

Entering Stream conditions and compositions for streams TOT-NGL & HOT-FEED.

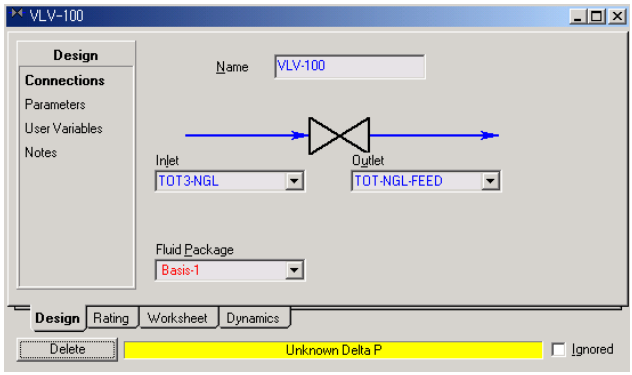

TOT-NGL
Worksheet
Conditions
Properties
Composition
K Value
User Variables
Notes
Cost Parameters
Stream Name TOT-NGL
Vapour / Phase Fraction <empty>
Temperature [C] -39.000
Pressure [bar] 1.5000
Molar Flow [kgmole/h] 6900.0
Mass Flow [kg/h] <empty>
Std Ideal Liq Vol Flow [m3/h] <empty>
Molar Enthalpy [Btu/lbmole] <empty>
Molar Entropy [UserUnit*] <empty>
Heat Flow [kcal/h] <empty>
Liq Vol Flow @Std Cond [barrel/day] <empty>
Fluid Package Basis-1
Worksheet
Attachments
Dynamics
Unknown Compositions
Delete
Define from Other Stream...


TOT-NGL
Worksheet
Conditions
Properties
Composition
K Value
User Variables
Notes
Cost Parameters
Mole Fractions
Ethane 0.020000
Propane 0.976000
i-Butane 0.003000
n-Butane 0.001000
Total 1.00000
Edit...
Edit Properties...
Basis...
Worksheet
Attachments
Dynamics
OK
Delete
Define from Other Stream...

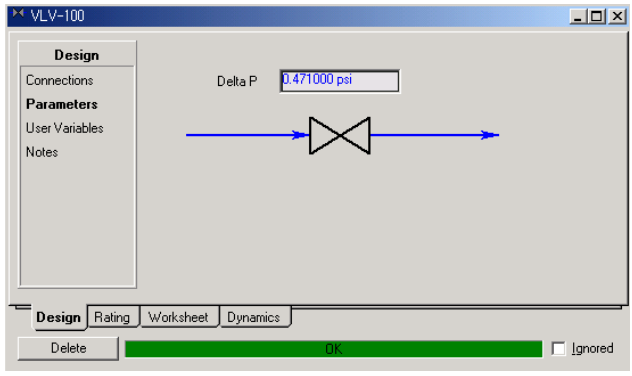

HOT-FEED
Worksheet
Conditions
Properties
Composition
K Value
User Variables
Notes
Cost Parameters
Stream Name HOT-FEED
Vapour / Phase Fraction 1.00000
Temperature [C] 30.000
Pressure [bar] 2.5000
Molar Flow [kgmole/h] 482.52
Mass Flow [kg/h] 21169
Std Ideal Liq Vol Flow [m3/h] 42.000
Molar Enthalpy [Btu/lbmole] -4.451e+004
Molar Entropy [UserUnit*] 156.73
Heat Flow [kcal/h] -1.1939e+07
Liq Vol Flow @Std Cond [barrel/day] 6313.3
Fluid Package Basis-1
Worksheet
Attachments
Dynamics
OK
Delete
Define from Other Stream...



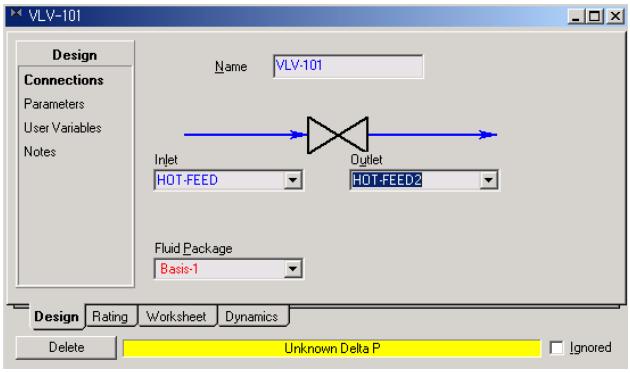
- For VLV-100 (Connection Tab)



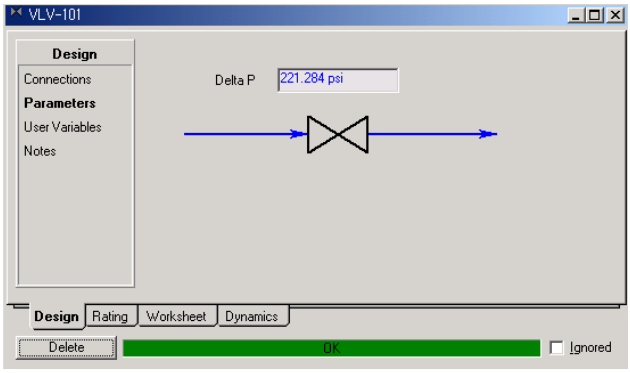
- For VLV-100 (Parameters Tab)



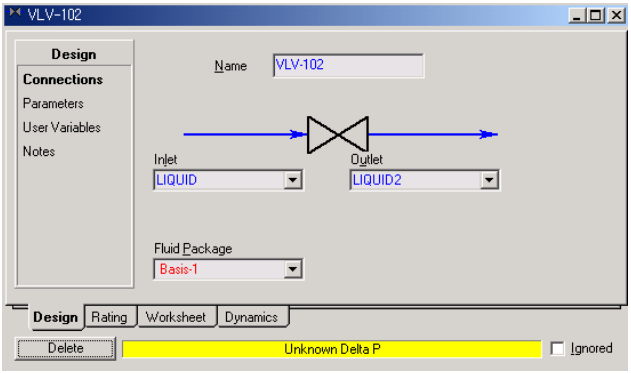
- For VLV-101 (Connection Tab)



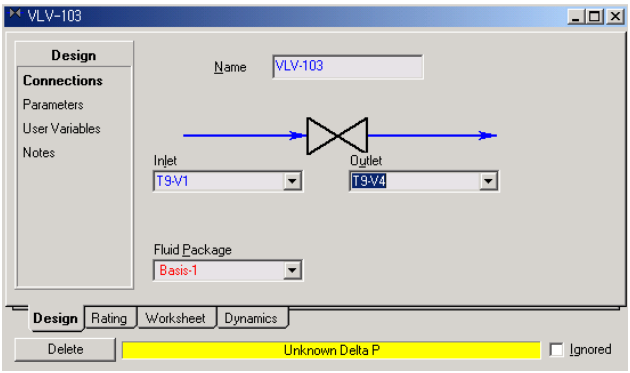
- For VLV-101 (Parameters Tab)



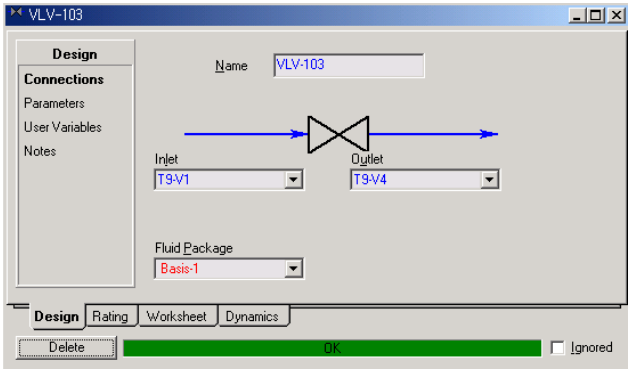
- For VLV-102 (Connection Tab)



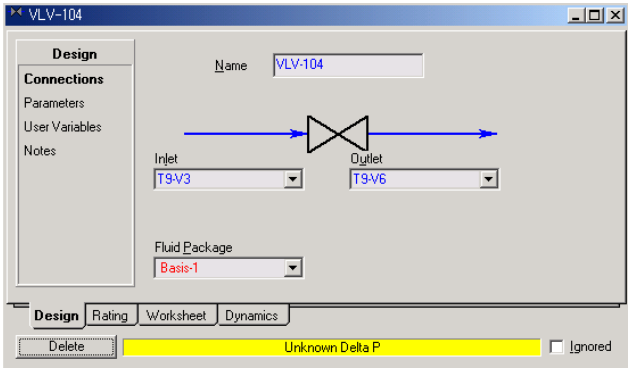
- For VLV-103 (Connection Tab)



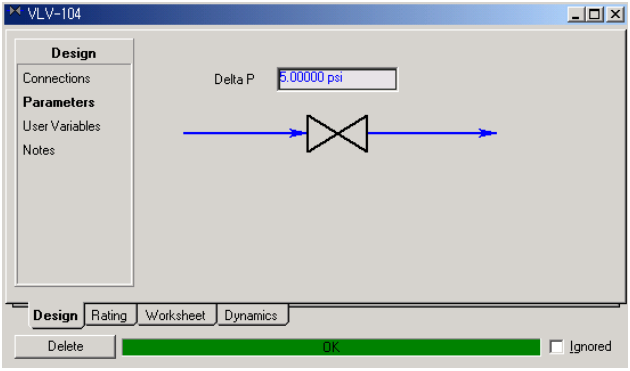
- For VLV-103 (Parameters Tab)



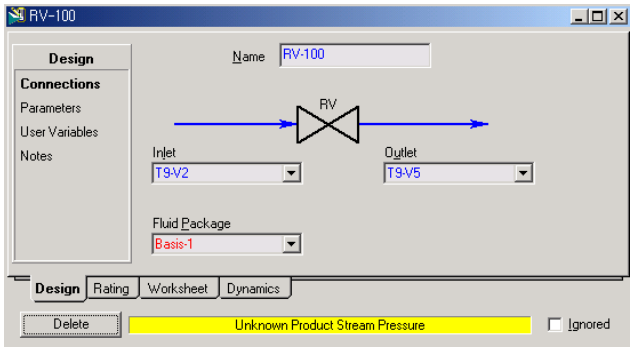
- For VLV-104 (Connection Tab)



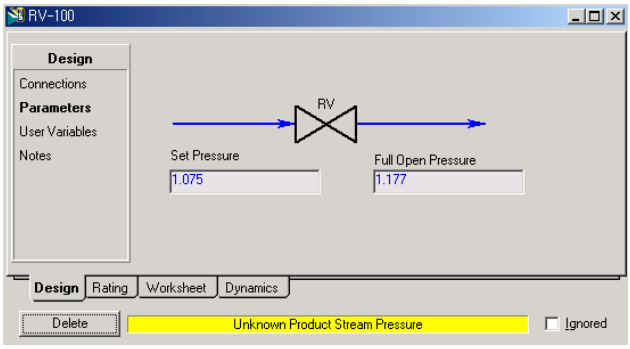
- For VLV-103 (Parameters Tab)



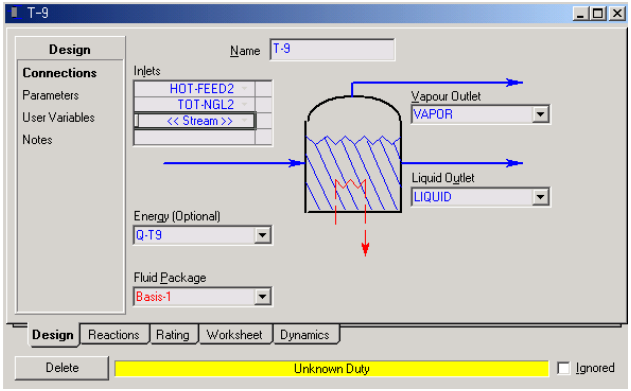
- For RV-100 (Connection Tab)



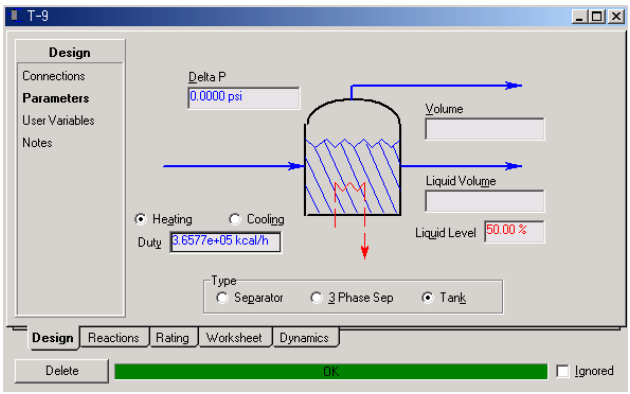
- For RV-100 (Parameters Tab)



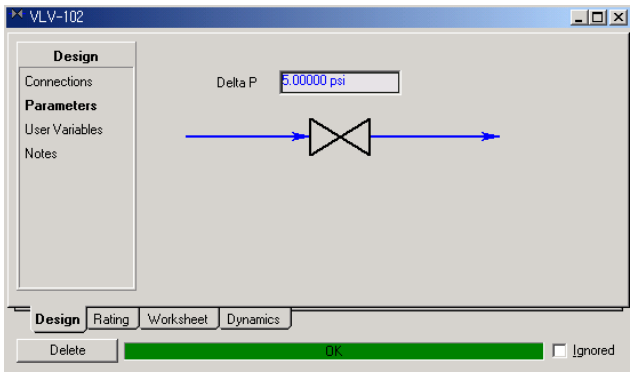
- For T-9 (Connection Tab)



- For T-9 (Parameters Tab)

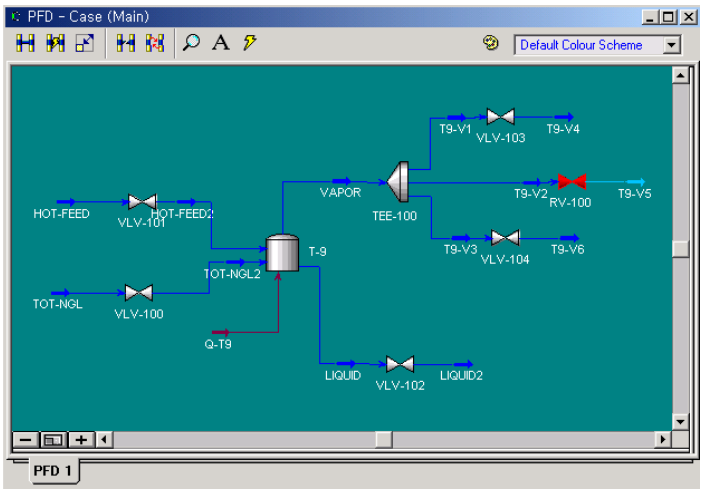


- For T-9 (Parameters Tab)



- Save your case as T9-Holding-52C-Steady.hsc.

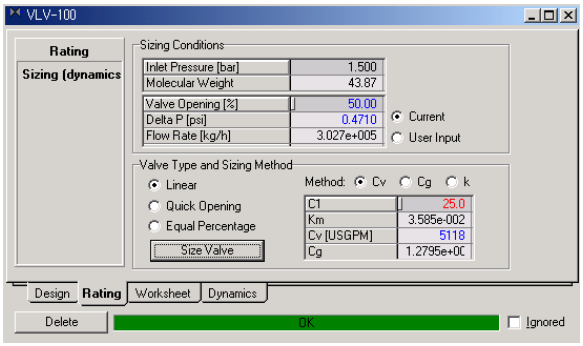
- Flowsheet Configuration (1)

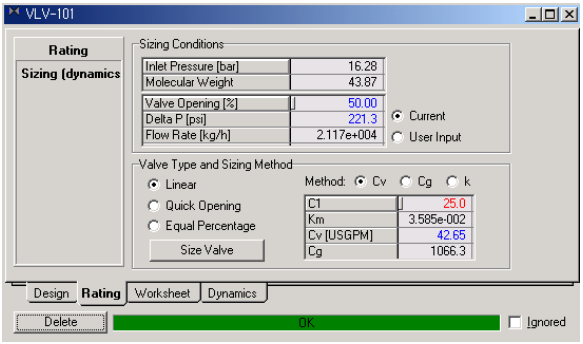


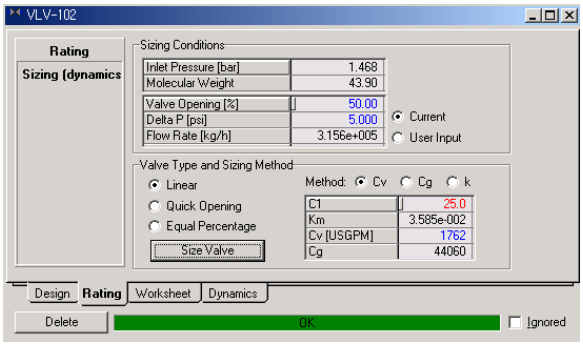
Transitioning from Steady State to Dynamics

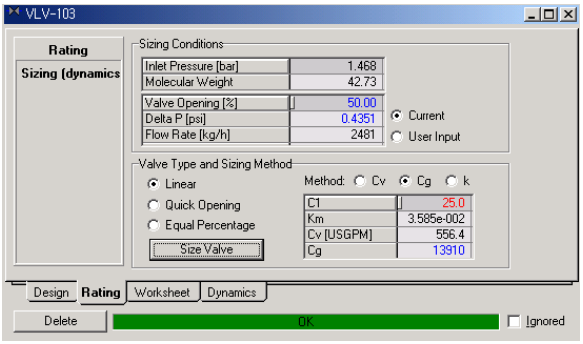
All unit operations in the simulation need to be sized using actual plant equipment or predetermined sizing techniques. Vessels should be sized to accommodate actual plant flow rates and pressures while maintaining acceptable residence times.

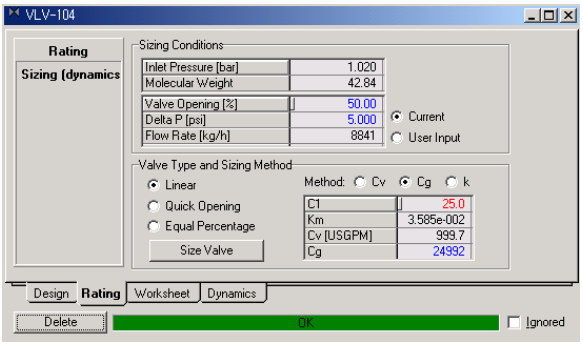
- Sizing the Valves
  - Valve type (linear, quick opening or equal percentage)
  - The normal valve opening position
  - The pressure drop across the valve
  - The current flow rate

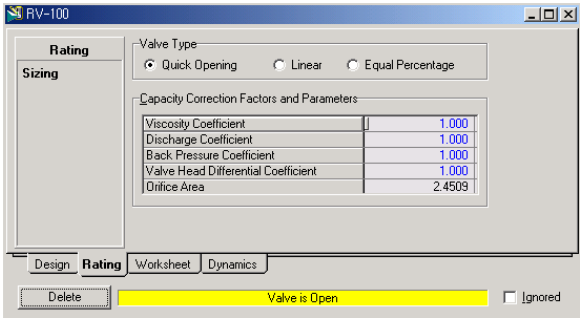

VLV-100
Rating
Sizing (dynamics
Sizing Conditions
Inlet Pressure [bar] 1.500
Molecular Weight 43.87
Valve Opening [%] 50.00
Delta P [psi] 0.4710
Flow Rate [kg/h] 3.027e+005
Current
User Input
Valve Type and Sizing Method
Linear
Quick Opening
Equal Percentage
Size Valve
Method: Cv Cg k
C1 25.0
Km 3.585e-002
Cv [USGPM] 5118
Cg 1.2795e+0C
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored


VLV-101
Rating
Sizing (dynamics
Sizing Conditions
Inlet Pressure [bar] 16.28
Molecular Weight 43.87
Valve Opening [%] 50.00
Delta P [psi] 221.3
Flow Rate [kg/h] 2.117e+004
Current
User Input
Valve Type and Sizing Method
Linear
Quick Opening
Equal Percentage
Size Valve
Method: Cv Cg k
C1 25.0
Km 3.585e-002
Cv [USGPM] 42.65
Cg 1066.3
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored


VLV-102
Rating
Sizing (dynamics
Sizing Conditions
Inlet Pressure [bar] 1.468
Molecular Weight 43.90
Valve Opening [%] 50.00
Delta P [psi] 5.000
Flow Rate [kg/h] 3.156e+005
Current
User Input
Valve Type and Sizing Method
Linear
Quick Opening
Equal Percentage
Size Valve
Method: Cv Cg k
C1 25.0
Km 3.585e-002
Cv [USGPM] 1762
Cg 44060
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored


VLV-103
Rating
Sizing (dynamics
Sizing Conditions
Inlet Pressure [bar] 1.468
Molecular Weight 42.73
Valve Opening [%] 50.00
Delta P [psi] 0.4351
Flow Rate [kg/h] 2481
Current
User Input
Valve Type and Sizing Method
Linear
Quick Opening
Equal Percentage
Size Valve
Method: Cv Cg k
C1 25.0
Km 3.585e-002
Cv [USGPM] 556.4
Cg 13910
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored

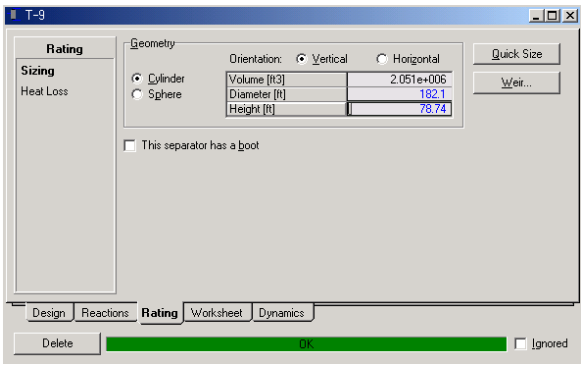




Note that the normal valve opening percent of VLV-102 should be 0.0 percent instead of 50.0 percent for a holding case.

- Sizing the Separator

  - Open the dynamic tab of the separator.
  - Enter 182.1 ft for a vessel diameter and 78.74 ft for vessel height.

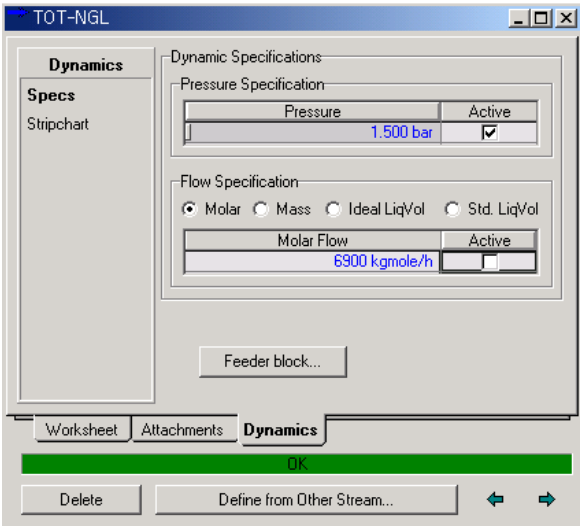


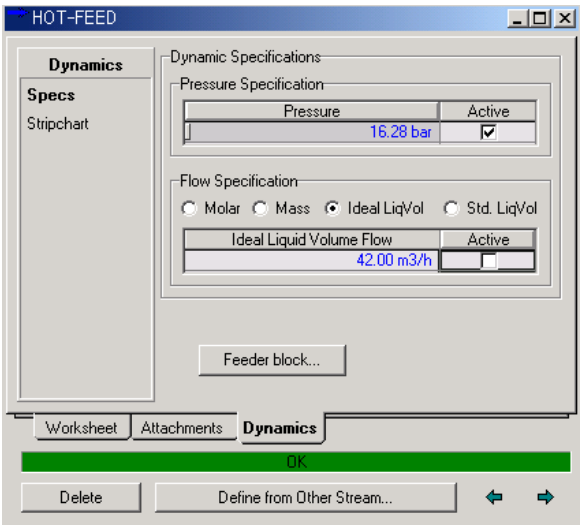
- Save your case as T9-Holding-52C-Sizing.hsc.

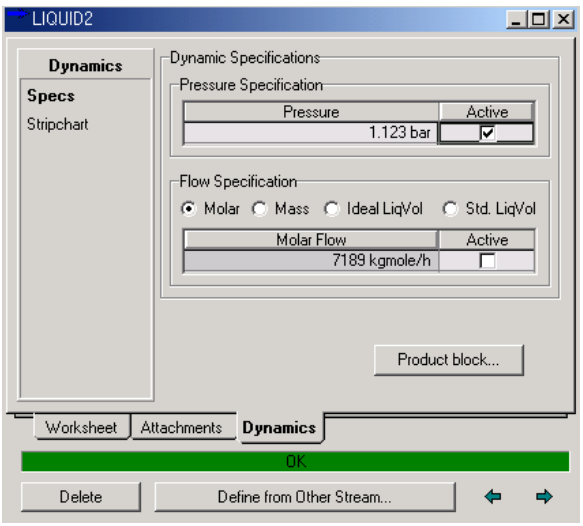
Making Pressure-Flow and Dynamics Specifications

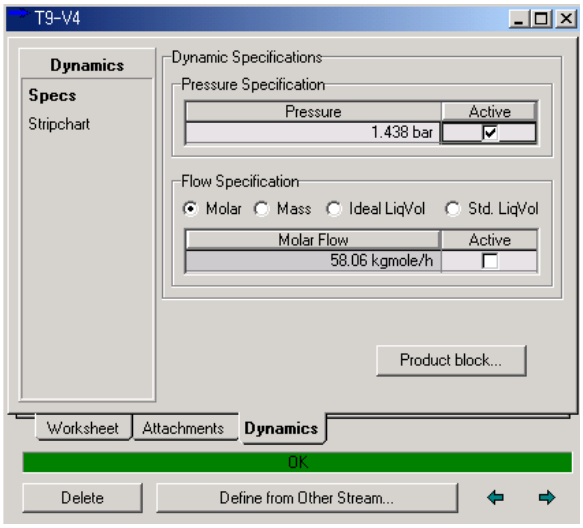
- Analysis of the Process Flowsheet

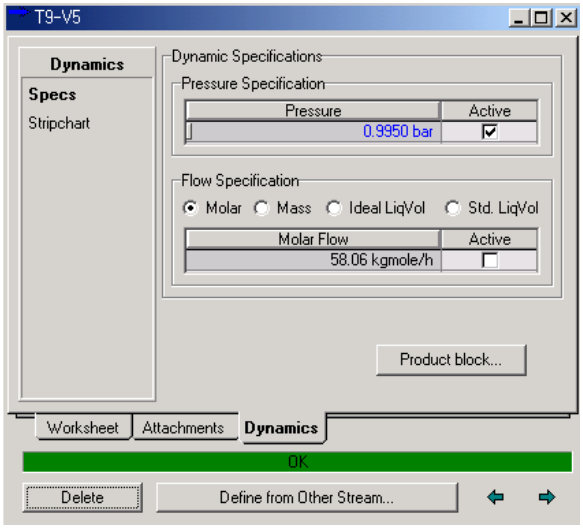
  - For the current simulation, the boundary streams are TOT-NGL, HOT-FEED, LIQUID2, T9-V3, and T9-V4. All boundary streams in the Flowsheet must have a pressure specification.
  - On the Dynamics tab of the TOT-NGL, HOT-FEED, LIQUID2, T9-V4, T9-V5 and T9-V6, select the Pressure Specification by checking the box Active.

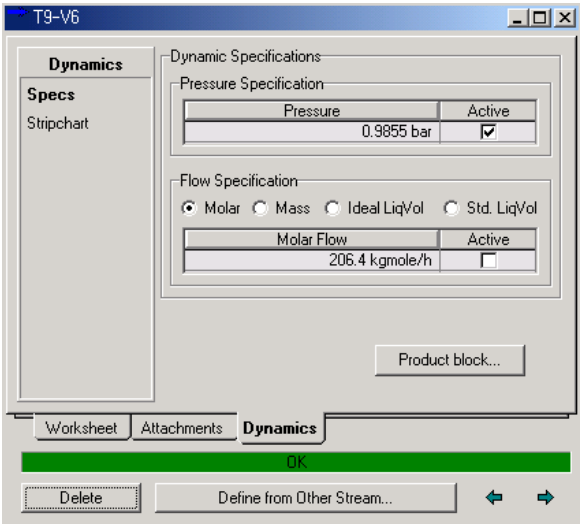

TOT-NGL
Dynamics
Specs
Stripchart
Dynamic Specifications
Pressure Specification
Pressure
Active
1.500 bar
Flow Specification
Molar
Mass
Ideal LiqVol
Std. LiqVol
Molar Flow
Active
6900 kgmole/h
Feeder block...
Worksheet
Attachments
Dynamics
OK
Delete
Define from Other Stream...


HOT-FEED
Dynamics
Specs
Stripchart
Dynamic Specifications
Pressure Specification
Pressure
Active
16.28 bar
Flow Specification
Molar
Mass
Ideal LiqVol
Std. LiqVol
Ideal Liquid Volume Flow
Active
42.00 m3/h
Feeder block...
Worksheet
Attachments
Dynamics
OK
Delete
Define from Other Stream...


LIQUID2
Dynamics
Specs
Stripchart
Dynamic Specifications
Pressure Specification
Pressure
Active
1.123 bar
Flow Specification
Molar
Mass
Ideal LiqVol
Std. LiqVol
Molar Flow
Active
7189 kgmole/h
Product block...
Worksheet
Attachments
Dynamics
OK
Delete
Define from Other Stream...







- Save your case as T9-Holding-52C-Specs.hsc.

Controllers

- Controllers can added to the Flowsheet using the same methods as for other unit operations. The PID Controller button on the palette represents this unit operation. Once the Controller has been added to the Flowsheet.

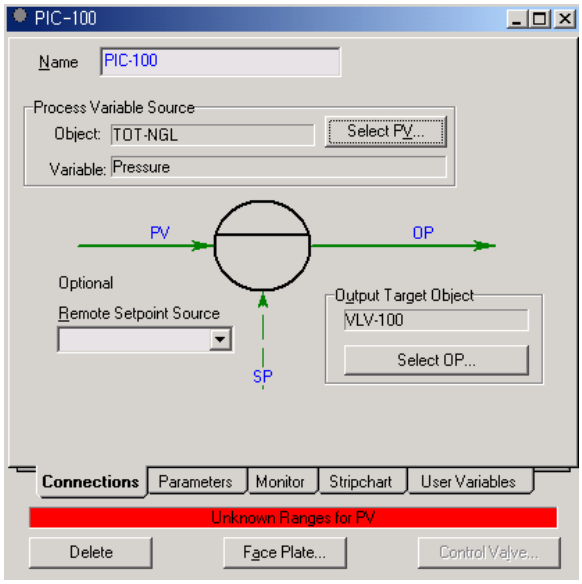
  - Make the necessary connections for the Process Variable Source and Output Target Object.
  - Select the Minimum and Maximum values for the Process Variable. These values should bracket all possible PV values.
  - Size the valve – controller range. This is not necessary if a valve was chosen as the Output Target Object.
  - Select Controller Action, Reverse or Direct.
  - Input Controller Tuning Parameters.
  - If desired, choose the mode of the controller, Off, Manual, or Automatic.

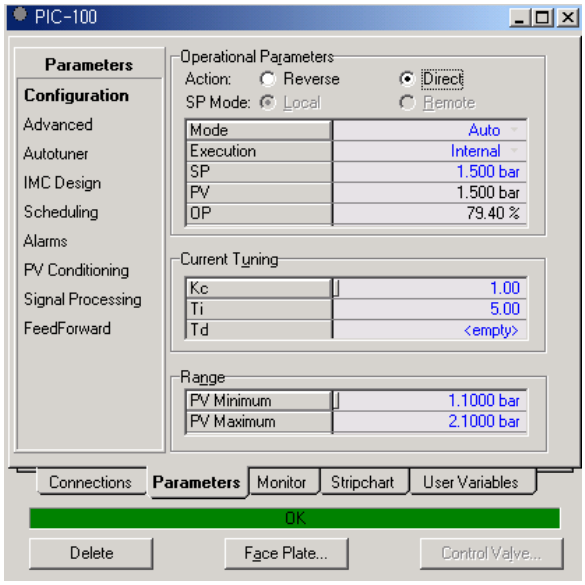
- Add the Proposed Control Strategy for the Flash Drum System

  - Add a Flow Controller that will control the Stream TOT-NGL Flowrate to Tank T-9.

Table 2	
Controller Settings	
Connections	
Controller Name	**PIC-100**
Process Variable Source	Stream TOT-NGL Pressure
Output Target Variable	VLV-100
Parameters	
Action	Direct
PV Minimum	1.1 bar
PV Maximum	2.1 bar
Mode	Auto
Set Point	1.50 bar
Kc	1
Ti	5

  - Insert a Controller Face Plate for monitoring by pressing the Face Plate button on the property view.

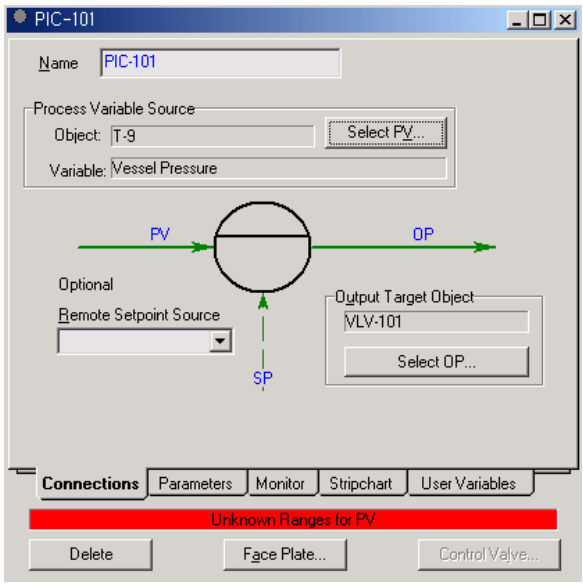


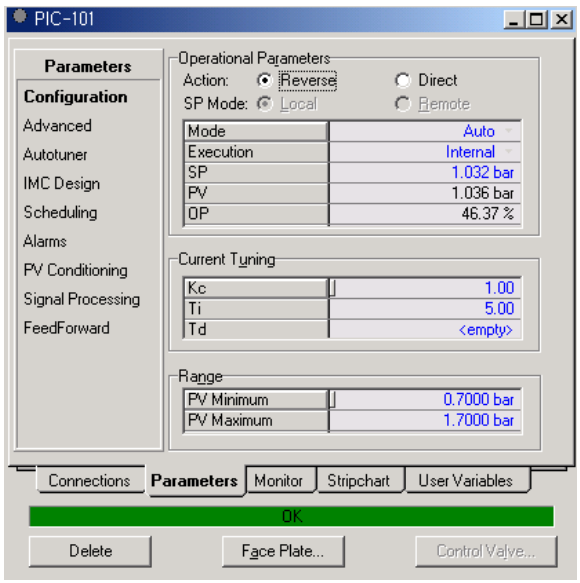


- Add another controller to control the pressure inside the Separator.

Table 3	
Controller Setting	
Connections	
Controller Name	**PIC-101**
Process Variable Source	Separator, T-9 Vessel Pressure
Output Target Variable	VLV-101
Parameters	
Action	Reverse
PV Minimum	0.7 bar
PV Maximum	1.7 bar
Mode	Auto
Set Point	1.032 bar
Kc	1
Ti	5

- Insert a Face Plate for Tank-PC.

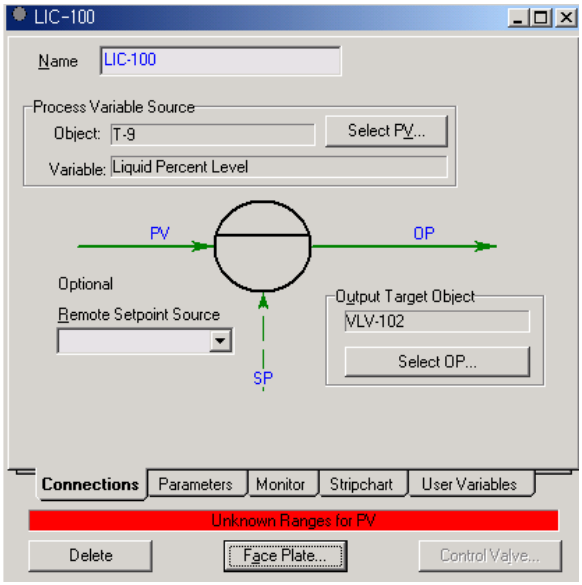


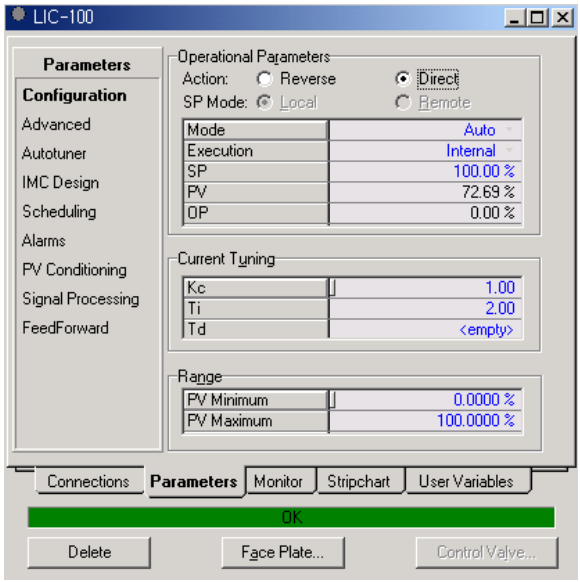


- Add a Level Controller to control the level of liquid in the tank.

Table 4	
Controller Settings	
Connections	
Controller Name	**LIC-100**
Process Variable Source	Separator, T-9 Liquid Percent Level
Output Target Variable	VLV-102

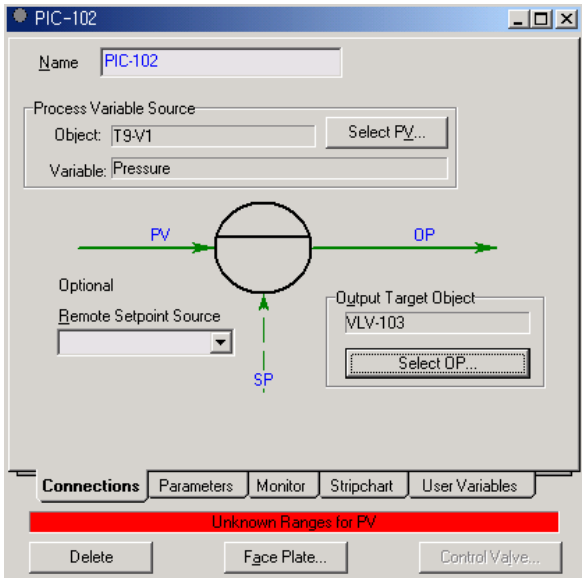
Parameters	
Action	Direct
PV Minimum	0 percent
PV Maximum	100 percent
Mode	Auto
Set Point	0 %
Kc	1
Ti	2

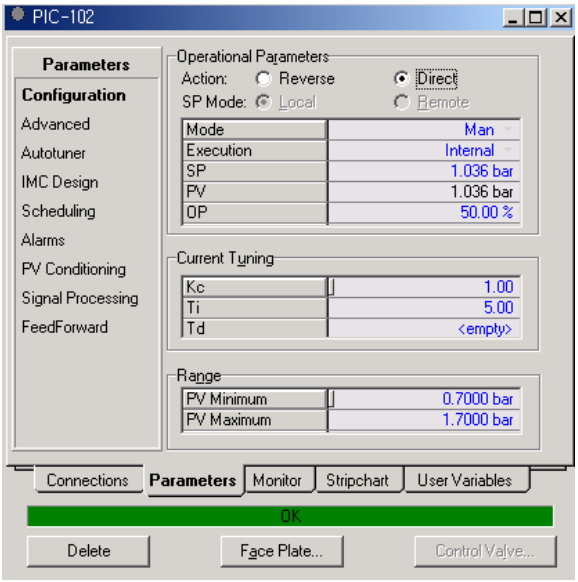




- Add a Level Controller to control the level of liquid in the tank.

Table 5	
Controller Settings	
Connections	
Controller Name	**PIC-102**
Process Variable Source	Stream, T9-V1 Liquid Percent Level
Output Target Variable	VLV-103
Parameters	
Action	Direct
PV Minimum	0.0981 bar
PV Maximum	2.1575 bar
Mode	Auto
Set Point	1.068 bar
Kc	1
Ti	5





- Save your case as T9-Holding-52C-Controllers.hsc.

Strip Charts

While the Flowsheet is now running dynamically, it is difficult to observe the simulation variables. Using a strip chart allows the user to observe several variables in real time as the dynamic simulation runs.

- Press the hot key (Ctrl><D> to create a strip chart.
- Select the Variables page and press the Insert button.
- Add the following two variables.
  - TOT-NGL Mass Flow
  - HOT-Feed Mass Flow
- Select the Strip Charts page tab.
- Change the name to Feed System.

- Add the following three variables.
  - T9-V4 Mass Flow
  - T9-V5 Mass Flow
  - T9-V6 Mass Flow
- Select the Strip Charts page tab.
- Change the name to Product Vapor Stream.

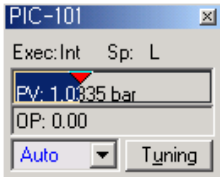
- Add the following variable.
  - LIQUID2 Mass Flow
- Select the Strip Charts page tab.
- Change the name to Product Liquid Stream.

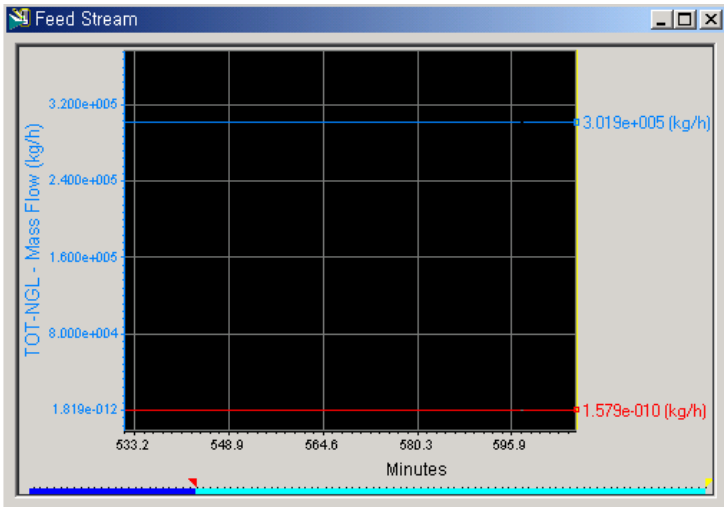
- Add the following variable.
  - T-9 Vessel Pressure
- Select the Strip Charts page tab.
- Change the name to T9 Vessel Pressure

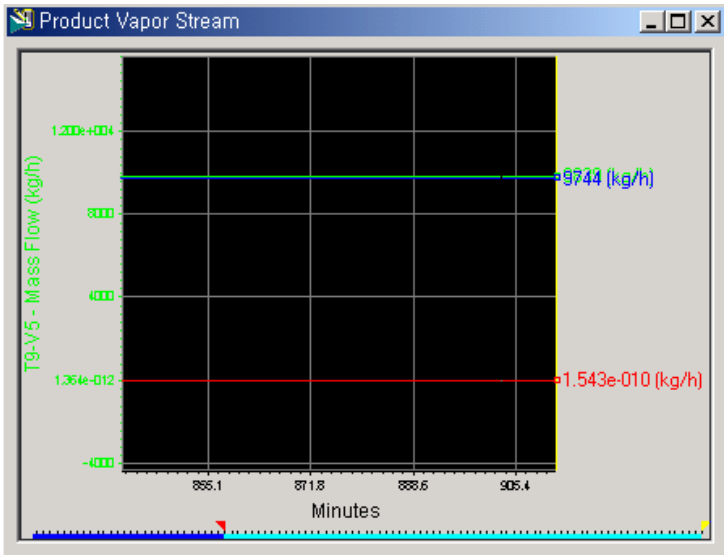
- Save your case as T9-Holding-52C-Dynamics-0.hsc.

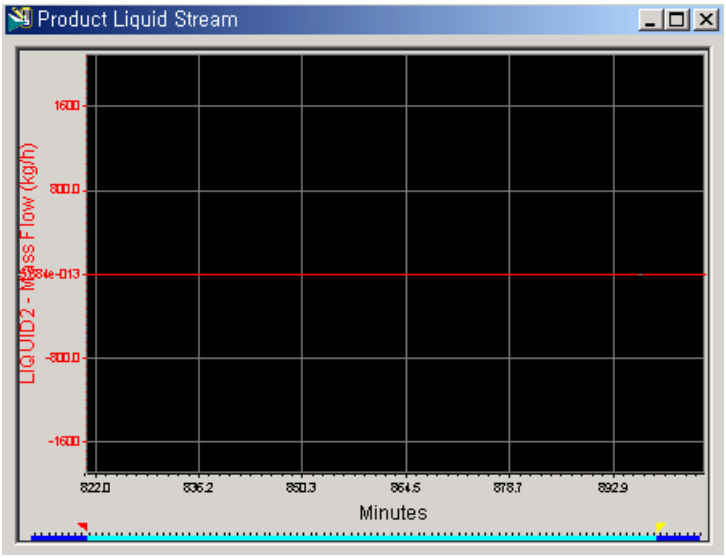
View Results

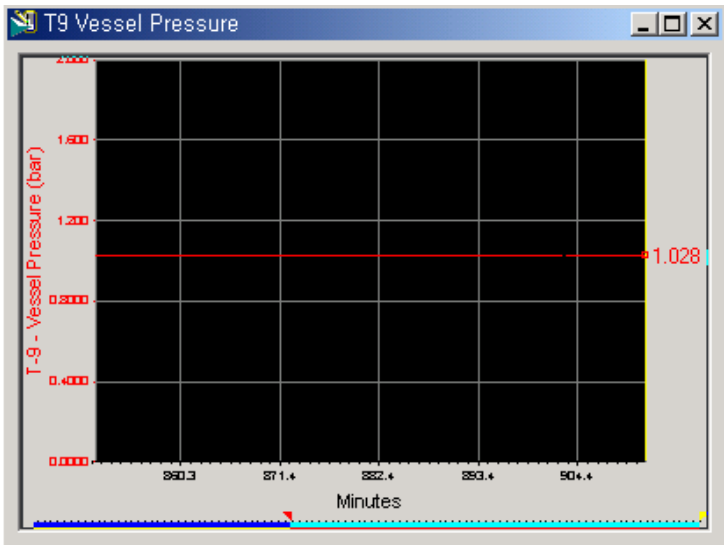
- T9-V4 Stream Mass Flowrate = Nearly zero flow.
- T9-V5 Stream Mass Flowrate = 9,837.8 Kg/hr
- T9-V6 Stream Mass Flowrate = 9,743.7 Kg/hr








Product Liquid Stream
1600
800.0
-800.0
-1600
LIQUID2 - Mass Flow (kg/h)
822.0
836.2
850.3
864.5
878.7
892.9
Minutes


T9 Vessel Pressure
1.600
1.200
0.8000
0.4000
0.0000
T-9 - Vessel Pressure (bar)
1.028
860.3
871.4
882.4
893.4
904.4
Minutes