PWR Model Setup – Exercise 1

Objectives

- Become familiar with the VALVE component.
- Learn to use trips and control blocks to control the behavior of VALVE components.

Acronyms

Acronym	Definition
DC	Downcomer
MFW	Main Feedwater
PWR	Pressurized Water Reactor
SG	Steam Generator
TSV	Turbine Stop Valve

Overview of Steps

1. Run a 100 s steady-state base calculation
2. Add the trip logic to close the TSV on High SG DC water level

   A) Add logic to calculate normalized water level for the upper SG DC

   B) Add the SG DC level trips

   C) Add the TSV trip
3. Add the TSV to the model
4. Verify the TSV operates correctly

STEP 1 RUN A 100 S STEADY-STATE BASE CALCULATION

The **Exercise Key** included in the workbook may be useful to help locate the various regions of the SNAP Model Editor that are referred to in this exercise.

A steady-state base calculation will be performed to verify that the model is working properly.

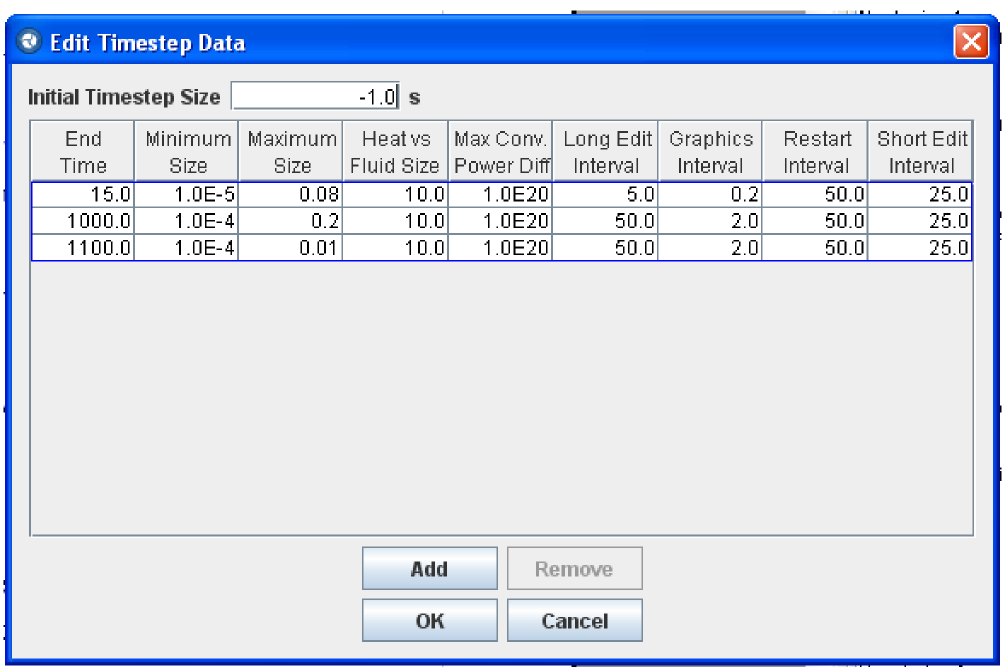
1. Locate and open the PWR model in the SNAP environment:

   a. Go to the Day2/Afternoon/Plant_Exercise_Part_1 folder and double click on the PWR-SS-Ex1.med file. The SNAP model editor will open with the PWR steady-state model.

2. Modify the end time:

   a. Locate and click on Model Options in the Navigator Window.

   b. In the Properties Window locate the Timestep Data field and click . The Edit Timestep Data pop-up window shown below will appear.



End Time	Minimum Size	Maximum Size	Heat vs Fluid Size	Max Conv. Power Diff	Long Edit Interval	Graphics Interval	Restart Interval	Short Edit Interval
15.0	1.0E-5	0.08	10.0	1.0E20	5.0	0.2	50.0	25.0
1000.0	1.0E-4	0.2	10.0	1.0E20	50.0	2.0	50.0	25.0
1100.0	1.0E-4	0.01	10.0	1.0E20	50.0	2.0	50.0	25.0

The TRACE timestep data cards define how long the simulation will run, as well as other things such as the maximum timestep size and how frequently plot points will be saved. Since different sets of options may be desirable at different points in the simulation, the timestep data is divided into time domains where different options can be specified. Any number of time domains may be input. The values in the timestep data table are as follows:

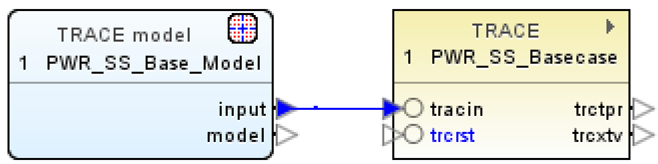
- **End Time** (TEND) - End time in seconds (s) for this time domain.
- **Minimum Size** (DTMIN) - Minimum timestep size (s) for this time domain.
- **Maximum Size** (DTMAX) - Maximum timestep size (s) for this time domain.
- **Heat vs Fluid Size** (RTWFP) - Ratio between heat-transfer and fluid-dynamics timestep sizes.
- **Max Conv. Power Diff** (POWERC) - Maximum convection-power difference (W, Btu/hr) between what goes into the fluid and what comes from the wall in the convection heat-transfer calculation.
- **Long Edit Interval** (EDINT) - Long-printout-edit time interval (s) for this time domain.
- **Graphics Interval** (GFINT) - Graphics-edit time interval (s) for this time domain.
- **Restart Interval** (DMPINT) - Dump/restart-edit time interval (s) for this time domain.
- **Short Edit Interval** (SEDINT) - Short-printout-edit time interval (s) for this time domain.

c. Remove the last timestep entry by clicking on the last row, then clicking the Remove button.

d. Change the End Time value on the last row to 100. With this change, the calculation will end at 100 seconds. Click the OK button to close the pop-up window and apply the changes.

At the bottom of the View Window are several tabs. Each tab shows all or part of the PWR model. Additional tabs can be viewed by clicking on the left or right arrow buttons at the right hand side of the of the tabs.

3. From the tabs at the bottom of the View Window, locate and click on the Job Stream tab. This View Window shows the steps that will execute when the model is run.



The execute button behaves differently when the view is unlocked vs. locked. The lock symbol is shown on the left hand size of the Toolbar. The symbol indicates that the view is unlocked, while indicates a locked view. Clicking this icon toggles the locked/unlocked status. Clicking on Execute executes the simulation when the view is locked, or allows you to set some of the execution properties when the view is unlocked. Two other boxes are shown in this view which can be selected (in locked or unlocked mode) to review or set their properties:

- The box titled **TRACE model** is the TRACE input file to execute. This must be connected to a TRACE block in order to run the simulation.
- The box titled **TRACE** contains configuration information for executing the model, such as which TRACE version to use and whether to open an animation file for viewing the simulation in progress.

4. Currently, the SNAP View Window should be unlocked. Verify that the unlocked symbol is showing in the Toolbar. Click on Execute and do the following.

   a. In the Properties Window, set the Name field to PWR_SS_Step1.

> The **Name** field associated with Execute indicates the name used when executing the simulation. If you would like to compare simulations, you can specify a unique Name each time you modify the model before you run the simulation. If you do this, the old simulation will not be overwritten and will be available for comparison.

   b. Set the View in Job Status value to Yes.

> When you submit a simulation for execution, the Job Status window will open if **View in Job Status** is set to yes. The Job Status window shows you the progress of your simulation and can be very helpful. It is recommended that this be set to "Yes" in general.

5. Click on the TRACE box in the View Window. In the Properties Window do the following:

   a. Verify that V5840 is selected for the Application field. This indicates the version of TRACE that will be used to run the simulation.

   b. The job stream is set up to use an animation file to view the progress of the calculation. Set the Open Animation field to immediately.

   c. Set the Start Paused field to on. With this set, the simulation will not start until the associated SNAP animation model has opened and you have indicated that you are ready for the animation to start.

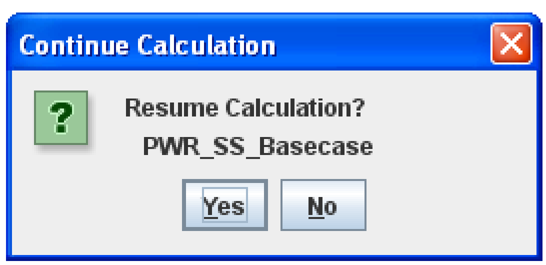
   d. Set the Demultiplex Plot File field to Yes.

Demultiplexing is a process that can be used after a simulation has completed. Demiltiplexing is a reorganization of the plot file that typically leads to a much smaller file. Demultiplexing the plot file is not necessary. However, TRACE plot files can be very large, and extracting data for plotting can be slow. Plotting from a demultiplexed (or demuxed) file is typically much faster. Given that the demuxed plot file is both smaller and more efficient for plotting, demultiplexing is recommended.

6. To execute the job, first lock the View Window by clicking on the icon located in the left-hand side of the Toolbar. The symbol should change to the locked view symbol .

7. With the view locked, click Execute in the View Window to submit the job. A Submit Stream pop-up window should appear. Click the OK button to continue.

8. The SNAP Job Status window will appear and the calculation will start the initialization process. The animation mask will open in the Model Editor and the pop-up window below will open. Click on the Yes button to start the simulation. The calculation will proceed and a set of the calculation plot values will be visible in the animation.



9. View the progression of the calculation using the System View tab and the Steady State Plots tab located at the bottom of the animation's View Window in the Model Editor.

   a. Click on the View Window System View tab and look for Main Feedwater Line 3. To find the scroll to the top left corner of the animation view. Find the Main Feedwater

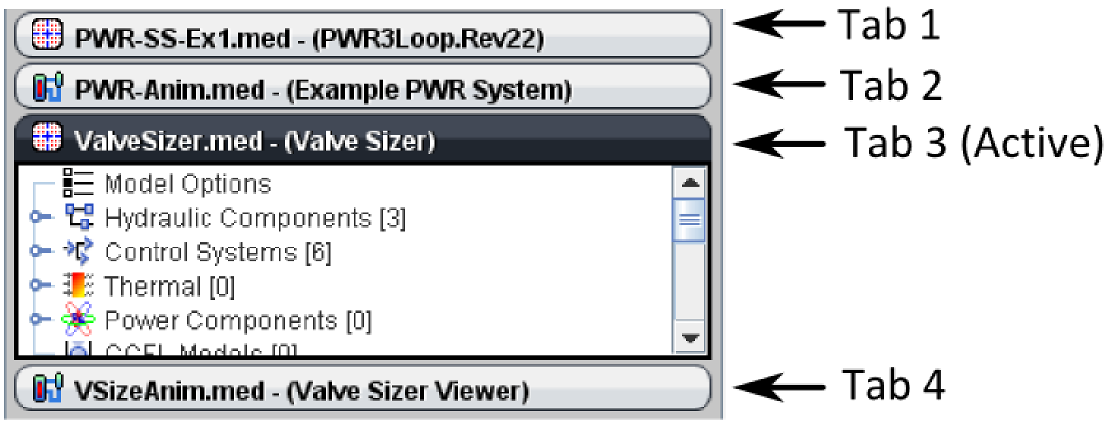
Flow Rate which is shown in the animation in red. Note the magnitude of the flow rate. This will be useful later when we want to test the turbine stop valve logic.

> Before modifying a model, it is typically a good idea to run the model to verify that things are working. It is a highly recommended to save a backup copy of the working model, and make occasional backups as you add and test changes to the model. One excellent way to do this is to use a version control tool, such as the freely available TortoiseSVN, to backup versions of the model. In these exercises, backup copies of the model have already been saved after each step and are available if you need them.

Step 2 Add the trip logic to close the TSV on High SG DC water level

Control systems play an important part in modeling thermal hydraulic accident scenarios and the plant response. To gain some experience in constructing control systems commonly used in TRACE models, a trip signal will be added to the model which turns on if the steam generator downcomer overfills. When the turbine stop valve is added in the next step, this will be used as a signal that causes the valve to close.

SNAP allows you to open multiple files simultaneously. The files that are open are shown in the Navigator Window as expandable vertically stacked tabs. An example with 4 files open is shown below. To view a different SNAP model, click on the tab with the name of the desired model.



1. In the Navigator Window, select the tab for the PWR-SS-Ex1.med model.

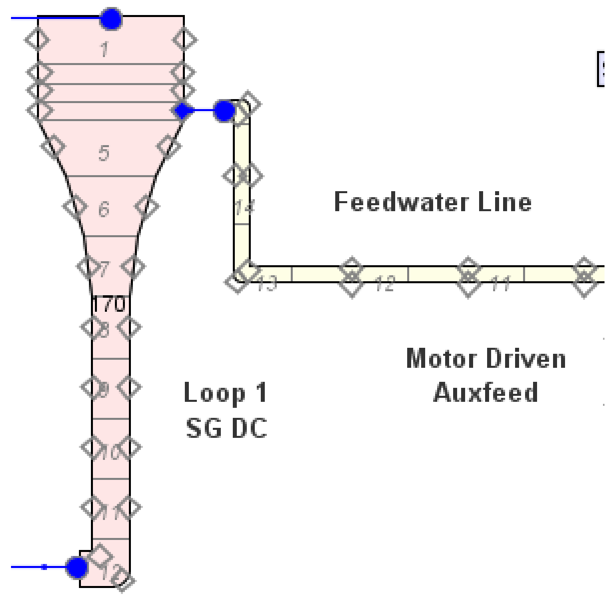
2. We will be adding a control system which checks for overfilling of the steam generator downcomer pipes 170, 270, and 370 (for loops 1, 2, and 3 respectively). Before we add the control system, lets examine the downcomer:

   a. Select the Hydro Comps tab at the bottom of the View Window.

   b. In order to find a component or add control system blocks to the model, the view must be unlocked. Unlock the View Window by clicking on the lock icon in the Toolbar. The unlocked symbol and the icons for adding components to the model should appear on the Toolbar.

   c. Find the steam generator downcomer component 170 using the Find Dialog (see the hint below). Note that the downcomer line has 12 cells, with cell 1 located at the top. The feedwater line enters the downcomer at cell 4.

> The Find dialog is a useful way to locate components in a model. To bring up the find dialog you can use '**ctrl-F**'. If the clipboard menu is enabled on the Toolbar, you can alternatively use the binoculars icon to open the Find dialog. If you click on the label at the top of one of the columns in the Find dialog, the items will be sorted by that column. If you know the component number, the quickest way to locate the component is typically to sort by the (component) **Number** column. Interestingly, find may not work if the view is locked, so you should make sure to unlock the view before using the Find dialog.



d. TRACE has a convenient Collapsed Water Level signal that calculates the collapsed water level for a range of vertical cells in a pipe. To determine whether overfill is occurring, we are primarily interested in the water level at the top of the downcomer, so we will later create a Collapsed Water Level signal that calculates the water level in the top 5 cells of the downcomer. To determine how full the pipe is we need the height of these five cells. To check the height, expand the Component Geometry property for pipe 170. The table that pops up shows both the length and DZ of each of the cells.

Note that you can copy table values from SNAP into a spreadsheet program like excel or openoffice calc to perform calculations such as summing up the length. For convenience, this has been done for you below.

Cell Number	Length (m)
1	1.091
2	0.389
3	0.389
4	0.389
5	1.244
Total	**3.502**

3. Now that we have the necessary input information from the downcomer, we can build the control system. Select the Turbine Stop Trip tab at the bottom of the View Window. This will be used as a workspace to add the new control system.

Step 2.A) Add logic to calculate normalized water level for the upper SG DC

1. First we will add a Constant control block that indicates the height of the 5 upper cells of the downcomer:

   a. Right click on the Toolbar in an empty spot (where no icons are located), and verify that the Main Toolbar toolbar menu is checked. If it isn't checked click on it to add this to the Toolbar.

   b. On the Toolbar, click the ▾ icon and select Control Systems ►Control Blocks. Click on the upper left hand side of the View Window. Select the Constant control block type from the dialog. Note that this may be easier to find if you sort the list by Type. Click on OK.

c. In the Properties Window, set the following:

- Control Block Name = Upper SG DC Height
- Control Block Number = -700
- Constant 1 = 3.502 (Total height of the top 5 cells of SG DC)

> Many models include control system or component setups which are mostly identical with a few differences. For example, in this plant there are three loops, and the components for each of the loops are essentially the same. In such cases, it is useful to construct one of these and then make copies for the other cases that are needed. In this control system we will build the logic to calculate overfill for the first loop and then copy and update this logic for the second and third loops.

2. Add a Collapsed Water Level signal for Loop 1:

a. On the Toolbar, click the icon and select Control Systems ►Signal Variables from the menu. Click in the View Window just below the Constant control block that was just added. From the pop-up dialog that appears, select the Collapsed Water Level signal (sort by Type), and click the OK button to add the signal block to the view.

b. In the Properties Window, set the following:

- Signal Variable Name = Loop 1 SG DC Level
- Signal-variable ID = 710

c. Click E to expand the Signal property and do the following in the pop up dialog:

i. Select S the Signal Source as pipe 170 (note that, to locate component 170, it may be useful to click on the Number label at the top of the center column to sort by component number).

ii. Leave the First Location as 1 and set the Second Location to 5. Click OK.

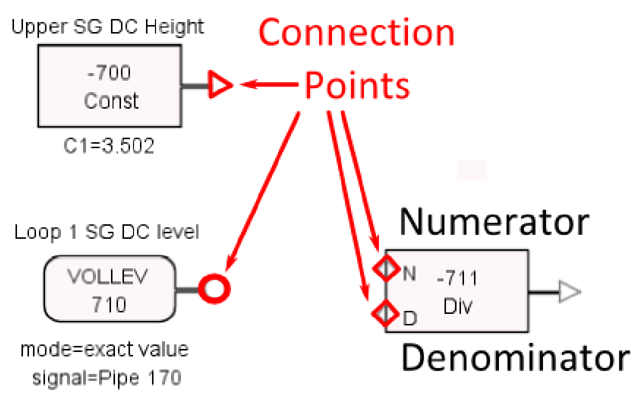
3. A normalized water level will be calculated for the upper steam generator downcomer where the value is 1.0 if the cells are filled with water and 0.0 if the cells are empty. To do this we need to divide the Collapsed Water Level added in step 2 by the Upper SG DC Height constant added in step 1. To add and configure the Divide control block:

a. Click the ▾ icon on the Toolbar and select Control Systems ►Control Blocks. Click in the View Window to the right of the Collapsed Water Level signal block. Select the Divide block from the list.

b. In the Properties Window, set the following:

- Control Block Name = Upper SG 1 DC Normalized Water Level
- Control Block Number = -711.

c. Select the connection tool from the Toolbar, and connect from the Collapsed Water Level (VOLLEV) signal block to the Numerator (labeled with an N) of the Divide (Div) block. Then connect from the Upper SG DC Height block to the Denominator (labeled with a D) of the Divide block. The Divide block is now configured to calculate the normalized water level of the upper downcomer for loop 1.



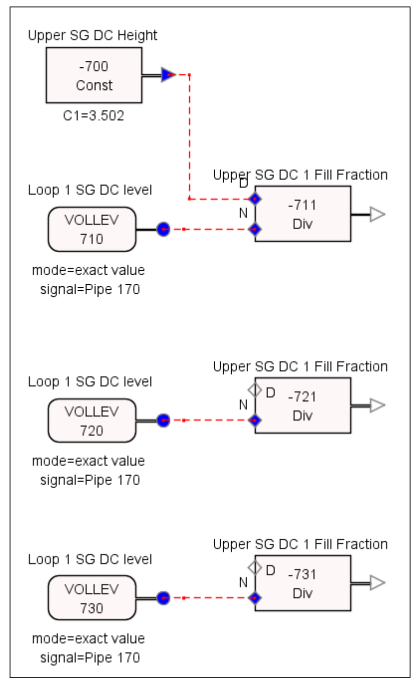
4. The next step is to copy the normalized water level logic created for SG 1, and paste two copies, one for SG2 and one for SG3:

a. To copy the loop 1 normalized water level logic, choose the selection tool from the Toolbar (or for a shortcut, press the Esc key to return to the selection tool). Select the Collapsed Water Level and Divide components by holding down the ctrl key and clicking on each of the control blocks. Release the ctrl key, then right click and select copy.

b. Right click again and select Paste Special. We want to make two copies of these blocks, so select the Paste Multiple Copies option. Set the following and click OK:

- Number of Copies = 2
- Base Offset = 10
- Set Increment = 10

Two copies of the control blocks are added to the view. Arrange them below the original blocks so that they look like the control blocks to the side.



5. Select the connection tool from the Toolbar and connect the Upper SG DC Height block to the denominator connection point of Divide components -721 and -731.

6. Control blocks 720 and 721 should be modified to calculate normalized water level for loop 2, and blocks 730 and 731 should be configured for loop 3. Modify the copied blocks so they perform calculations for loops 2 and 3 by doing the following:

a. For each of the copied blocks, replace the 1 in the component Name field with a 2 or 3 depending on which loop the calculation is associated with (should match the 10s column in the block number).

b. On blocks 720 and 730, click to expand the Signal property and select the Signal Source as pipe 270 (loop 2 downcomer) and 370 (loop 3 downcomer) respectively.

The normalized water level calculation blocks are now ready, and trips can be added for each of the loops that check whether the normalized water level exceeds a specified maximum level. The normalized water level values range from 0 (if the top five cells of the downcomer contain no liquid) to 1 (if the top 5 cells of the downcomer are full of liquid).

STEP 2.B) ADD THE SG DC LEVEL TRIPS

For the turbine stop valve trip logic, the following conditions in the trip logic should be met:

A) Each steam generator should have an independent trip that checks for overfill.

B) The overfill condition is: Normalized Water Level ≥ 0.75

C) The turbine stop valve trip should turn on if any of the loops indicate an overfill condition.

D) Once the turbine stop valve trip is turned on, it should remain on.

1. To add the SG DC level trip for loop 1, click on the Toolbar and select Control Systems ►Trip Data ►Trips from the menu. Then in the View Window, click to the right of Divide component -711.

2. In the Properties View, set the following properties:

   - Component Name = SG 1 DC Overfill Trip
   - Trip ID Number = 712
   - Signal Type = [4] Simple Trip
   - Steady State Evaluated = True

> Note that there is a **Latched Trip** property. If this is set to **on**, the trip will stay on once it is turned on. Otherwise it will turn on and off as the simulation crosses the threshold value. Latch trips are useful when a trip actuates a safety system, and crossing a threshold causes a safety system to turn on and remain on. However if the latch trip property is **off**, the trip will continue to signal crossing of the threshold which may be useful information. In this model, the trips above are not configured to latch, but the turbine stop valve trip added later will latch.

3. To define a trip that turns on above a normalized water level of 0.75, expand the Setpoint Data property and set the trip type to [9] OFF || ON(For) and the Setpoint Value to 0.75 as shown below. Then click Close.

[9] OFF |OFF ON(For)

Setpoint Number	Setpoint Value	Setpoint Units	Delay (s)	Setpoint Factor Table
1	0.75	-	0.0	<none>

4. Right click on trip 712 and select copy. Right click again and select Paste Special. Select the Paste Multiple Times option. Set the following and click OK:
    - Number of Copies = 2
    - Base Offset = 10
    - Set Increment = 10

5. Select trip 722 and 732 and modify the SG 1 in the Component Name to be SG 2 and SG 3 respectively.

6. Place the new trips 722 and 732 to the right of blocks -721 and -731 respectively. Select the connection tool from the Toolbar and connect -711 to 712, -721 to 722, and -731 to 732. This completes the overfill trips for the three loops.

Step 2.C) Add the TSV trip

Sometimes it is useful to set the value of a trip based on the state of a set of different trips. For example, this is common when setting up Reactor Trip logic, where several trip conditions may lead to Reactor Trip. When you want to set the trip value based on the value of other trips, a Trip Controller block combined with a Trip may be used. Trip Controllers allow you to combine input trip values by one of two Operations:

- **Addition** – This is useful for testing if one or more of the trips has been set. If any one of the trips is on, the result will be greater than or equal to 1.
- **Multiplication** – This is useful for detecting if all of the trips are set. If any one of the trips is zero, the trip controller result will be zero. Once all trips are set, the value will be 1.

1. Add a trip controller block to test if any of the overfill trips have been set:

a. Click on the Toolbar and select Control Systems ►Trip Data ►Trip Controller from the menu. Click to the right of the trips that were just added to the model. In the Properties Window, set the following:

- Component Name = Combined DC Overfill Signal
- ID Number = 740
- Operation = Addition

b. In the Properties Window, open the Trips selection dialog. In the Available list on the left hand side of the dialog, find and select one of the overfill trips 712, 722, and 732. Click the add button > to include this trip to the list of selected trips for the trip controller. Repeat this process for the other two overfill trips. Alternatively, you can hold down the ctrl key, selecting all three overfill trips, and click > to add them all at once. Click on the OK button.

2. To add the turbine stop valve trip, click on the Toolbar and select Control Systems ►Trip Data ►Trips from the menu. Then in the View Window, click to the right of the trip controller block.

3. In the Properties Window, set the following:

- Component Name = Turbine Stop Valve Trip
- Trip ID Number = 745
- Signal Type = [3] Trip Controller
- Steady State Evaluated = False

> Note that this trip is not evaluated during steady state. In general, trips which control safety systems in the model are not evaluated during steady state since steady state mode is available primarily to arrive at valid initial conditions for a simulation. Activation of safety systems during steady state would interfere with this process. Since this trip is used to control the turbine stop valve as a safety mechanism it is set to not be evaluated during steady state simulations.

> Only type "[4] Simple Trip(s)" can be specified as latch trips (which remain on once turned on) in TRACE. However the other trip types include banded trips. The banded trip that we will use below turns on when the trip signal exceeds a threshold value, then deactivate when the trip signal falls below a lower threshold value. In banded trips, each trip threshold includes a delay time, after the threshold is crossed, when the trip value will be changed. A trip that remains on can be created by either using an unreachable deactivation threshold, or by setting a deactivation delay time that significantly exceeds the end time of the simulation.

4. Expand the Setpoint Data and set the values shown in the figure below. The first set point value of -1.0 is the off threshold. The normalized water level value cannot go below zero, so the trip will stay on once set. The second set point is the value that turns on the trip if exceeded. The value will exceed 0.5 if any of the trip controller trips gets set. Don't forget to set the trip type to [2] OFF || ON(For).

[2] OFF || ON(For)

Setpoint Number	Setpoint Value	Setpoint Units	Delay (s)	Setpoint Factor Table
1	-1.0	-	0.0	<none>
2	0.5	-	0.0	<none>

5. Select the connection tool from the Toolbar and connect trip controller 740 to trip 745.

The turbine stop valve trip 745 is now complete and ready for inclusion in the turbine stop valve.

Step 3 Add the TSV to the model

The turbine stop valve will be added between the turbine control valve component 550 and the turbine boundary condition break component 555. It will be assumed to have the same cross sectional geometry as the turbine control valve. In this model, the three steam lines merge into a steam line header (component 540). Two turbine pipe lines leave the steam line header. However, these two lines are combined, so turbine control valve component 550 represents two pipes.

When modeling multiple pipes which have a similar geometry using a single pipe (or valve) component, the cross sectional area should be the sum of the cross sectional areas of the combined pipes. However, the hydraulic diameter should be the hydraulic diameter of a single pipe in order for various correlations in TRACE to give valid results. One common place where this occurs is modeling of the steam generator U-Tubes.

1. Click on the HYDRO COMPS tab at the bottom of the View Window.

2. To add the turbine stop valve to the model, do the following:

   a. Locate the turbine boundary condition (component 555) using the Find dialog (ctrl-F).

   b. Since the turbine stop valve will have the same hydraulic diameter as component 550 (turbine control valve), click on the turbine control valve, find the Valve Hydro Diameter in the Properties Window, and either write the hydraulic diameter on paper, or copy the hydraulic diameter to the clipboard by clicking in the cell to highlight the value, then right clicking and selecting copy (or by pressing ctrl-C).

   c. On the Toolbar, select the  icon. Select Hydraulic Components ►Valves. Then in the View Window, click between the turbine boundary condition (component 555) and the turbine control valve (component 550) to add the new turbine stop valve.

   d. An Initialize Valve dialog will pop-up asking for some initial valve properties. If you wrote down the hydraulic diameter, type this in as the hydraulic diameter. If you copied the hydraulic diameter to the clipboard, paste this into the hydraulic diameter cell by right clicking in the cells and selecting paste, or by highlighting the value in the cell and hitting ctrl-V. The Number of Cells should be set as 0 and the Orientation option should be set to Horizontal. Select the OK button.

3. In the Properties Window for the valve, set the following properties (properties that don't need to be modified are skipped):

Property	**Value**	**Comment**
Component Name	Turbine Stop Valve	
Component Number	552	
Valve Type	[3] Flow Area Table After Trip	This valve option allows us to add a trip which causes the valve to close.

Property	Value	Comment
Internal Loss Model	[0] on	When the internal loss model is on, TRACE calculates a default valve pressure loss. If this is turned off, losses can be specified in a table as a function of the valve area fraction.
Maximum Valve Rate	1000	The off rate will be specified via a table, so we just set this to a high value
Off Adjustment Rate	0	Not used in this model. Just set a dummy value.
Minimum Position	0	This is the minimum allowed flow area fraction.
Maximum Position	1	This is the maximum allowed flow area fraction.
Valve Flow Area	0.88491	This valve represents two actual valves, so the area is the sum of the areas.
Valve Hydro Diameter	0.75057	The hydraulic diameter is the diameter of a single pipe. Therefore, it is consistent with half the area specified above.
Initial Flow Area Fraction	1	Initially the valve is full open.
Valve Step Position	1	

After the trip is enabled, the valve area is controlled using a control signal (called the **independent variable**) and a look up table (called the **first adjustment table**). The first adjustment table provides a map between the value of the independent variable and the desired valve area. If the independent variable falls between two values in the first adjustment table, linear interpolation is used to calculate the associated valve area. If the variable goes outside the bounds of the table, the valve area stays fixed at the closest value specified in the table. Often for a valve, the bounding values used are 0 and 1.

4. To configure the control system logic for the valve:

a. In the Properties Window, select [S] for the Valve Trip property. Select the turbine stop trip 745 and click OK.

b. Set the independent variable used to control the valve area after the trip turns on as the Problem Time. In the Properties Window, select [S] the Valve Table Indep. Var. field. From the list of control variable select Signal Variable 1 (Problem Time 1) and click OK.

c. Next, set the table that determines how the valve will behave in response to the control variable (Problem Time) after the trip is enabled. Click the [E] icon for the First Adjustment Table field.

d. Set the Independent Variable Form to negative.

> The **Independent Variable Form** indicates how the Valve Table Independent Variable should be interpreted when applying this to the First Adjustment Table.
>
> - The **positive** option indicates that the actual value of the Independent Variable should be used as the lookup value when calculating the valve area from the First Adjustment Table.
> - The **negative** option indicates that the change in the Independent Variable from the time of the trip should be used as the table lookup value.
>
> When **time** is the signal variable, the correct Independent Variable Form is **almost always negative** since we are typically interested in control behavior of a component relative to the time the component trip occurred rather than controlling behavior relative to the time the simulation started. If the wrong Independent Variable Form is selected, the results can be very different than expected.

e. Click the Add button twice and set the following values. This indicates that at a time of 0 seconds (i.e. the time the trip turns on) the valve area fraction will be

No Unit -	Area Fraction -
0.0	1.0
0.1	0.0

1.0 (fully open), and by 0.1 seconds after the trip turns on, the valve area fraction is 0.0 (fully closed). Click the OK button.

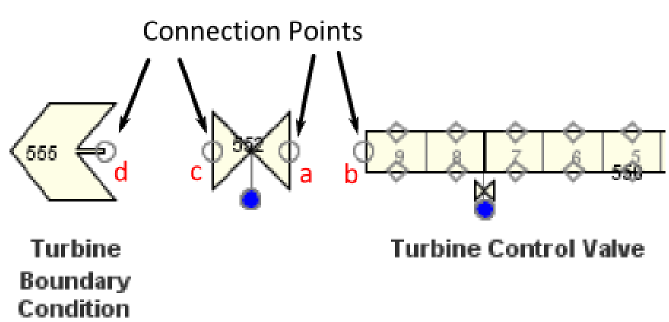
5. To integrate the valve into the model do the following:

a. Click on the blue line connecting the turbine boundary condition (component 555) to the turbine control valve (component 550). Right click on this line and select Disconnect. As a shortcut, you can simply hit the Delete key when the blue line is selected to disconnect the components.

b. Right click on component 555 and bring the mouse pointer over the Drawn Orientation menu item. Note that the orientation is left. Now right click on component 550 (the turbine control valve) and bring the mouse pointer over the Drawn Orientation menu item. Again note that the orientation is left. Now right click on the turbine stop valve that you added, move the mouse pointer over the Drawn Orientation. Note that the value is set to right. Select the left option.

> Various TRACE components have an inlet side and an outlet side. Positive flow is from the inlet to the outlet. In SNAP this is represented via component orientation. SNAP will not complain at you if you connect two adjacent components which have an opposite orientation. (i.e. if you connect and inlet to an inlet or an outlet to an outlet). HOWEVER, this makes it easy to misinterpret simulation results because velocities will APPEAR to flip as you go from one component to the next. How you interpret the results may depend on which component you happened to pick. This problem is avoided by using a consistent orientation for adjacent components (i.e. by connecting outlets to inlets). Note that if you can click on the blue line connecting two components to verify that an outlet is connected to an inlet (See the **face** property for the two connected components in the Property Window).

c. Position the turbine stop valve between components 550 and 555 if it is not already there, and connect the turbine stop valve to these components by



selecting the connection tool icon from the Toolbar. Select connection point a shown in the diagram below then select connection point b to connect the turbine stop value to the turbine control valve. Then select connection point c followed by connection point d to connect the turbine stop valve to the turbine boundary condition. Note that SNAP does not currently let you select b first and then connect to a, or select d first and connect to c. To exit the connection tool, you can choose the selection tool icon from the Toolbar, or simply press the Esc key.

✓ The turbine stop valve has been added to the model and is configured to close on overfill of the steam generator downcomers.

Step 4 Verify the TSV operates correctly

To test that the valve logic operates correctly, the model will be modified in order to induce trip conditions. The following changes will be made:

A) The simulation will be set to transient mode so that the turbine stop trip will be active.

B) The simulation time will be reduced to 50 seconds.

C) In main feewater line 3, the location where water is injected into the downcomer, the water will be injected at the top (cell 1) rather than in cell 4 to make it easier to fill.

D) The motor driven auxfeed will be enabled and set to inject a significant amount of water at a constant rate to speed up the process of filling the downcomer.

1. To set the simulation to transient mode, select Model Options from the Navigator Window. In the Properties Window, set the Transient Calculation property to [1] Transient.

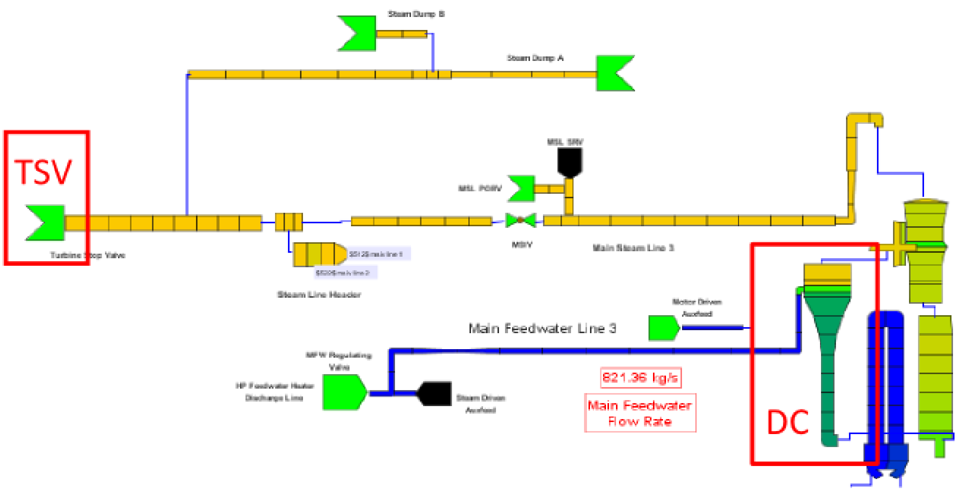
2. Expand the Timestep Data property and change the last End Time value from 100.0 to 50 and click OK.

3. In the View Window, find the steam generator downcomer component 370 (use ctrl-F if needed). Main feedwater (MFW) line 3 is located to the left of the downcomer, and connects to the downcomer at cell 4. Select the blue line connecting the MFW line to the downcomer. In the Properties Window, the Target Component▶Cell number is 4. Change this to 1 so that the MFW is injected at the top of the downcomer.

4. Locate and select the Motor Drive Auxfeed (component 435) for feedwater line 3. In the steady state simulation, the main feedwater flow rate was on the order of 300 kg/s. To get a rapid overfill, we will increase the flow rate. Increasing the flow rate to a little over double the current flow rate should cause overfill relatively quickly, so we will set the aux feedwater flow rate to 400 kg/s. Pressure and liquid and vapor and temperature are chosen to match the main feedwater fill 430. In the Properties Window, set the following properties:

   - Fill Type = [2] Constant Mass Flow
   - Initial Liquid Temperature = 490.0
   - Initial Vapor Temperature = 559.0
   - Initial Pressure = 7.0e6
   - Initial Coolant Mass Flow = 400.0

5. The simulation will be run next. However, before doing this, select the PWRAnim.med tab in the Navigator View to open the animation model. Scroll to the left upper corner of the View Window System View tab. Locate the turbine stop valve and the Main feedwater line 3 downcomer.



In the Animation view, an open valve is represented in green and a closed valve is black. By default, the animation shows fluid properties for hydrodynamic volumes in the model, where subcooled liquid is blue, saturated liquid is green, saturated steam is yellow/orange and superheated steam is red. As the animation starts, the turbine stop valve should be green (indicating it is open) and the SG downcomer will be yellow/orange at the top indicating it contains steam. As the simulation proceeds, you should see the downcomer turn blue and start to fill. When it fills sufficiently, the TSV should trip and turn black if things are working properly.

6. To run the model, select the PWR-SS-ExI.med tab in the Navigator Window. Then select Tools from the SNAP Menu (or press alt-T) and select Submit Job … from the menu. Click the OK button in the Submit Job Stream dialog that pops up. Click OK on the Submit Stream dialog that appears afterward. The animation model should open. Select Yes on the Continue Calculation dialog.

7. Watch the turbine stop valve (TSV) and downcomer (DC) as the animation progresses and note the effects indicated in the information block above.

8. Once the simulation completes, to see when the TSV closed, right click on the (black) turbine stop valve in the animation view and select Plot Data from the pop up menu. The only plot variable available is bxmass-555. Click the OK button. This will open AptPlot so that you can view the time history of the mass flow out the TSV. You should be able to identify the time when the valve closed.

9. It would be useful to plot the normalized water level for downcomer 3 below this for comparison to verify that the valve closure time matches the time when the level exceeds 0.75. From the AptPlot menu, select Edit►Arrange Graphs. In this dialog, check that Add graphs as needed to fill matix is checked, and set the number of Columns to 1 and the number of Rows to 2. Click on OK. A second plot view should appear below the current plot view. Click on the lower (empty) plot view. The corners of this view should show little black squares indicating that it is selected. If we plot another variable from the animation view it will be added to the selected view in AptPlot.

10. Go back to the Model Editor. In the Navigator View, select the PWR-SS-ExI.med tab to open the model. In the View Window, select the Turbine Stop Trip tab. Find Divide block 731, which is the DC normalized water level calculation for SG 3. We are going to copy this over to the animation file. However, we don't need the annotation text with it, so right click on block 731 and click on Display Annotations to turn off the annotation text. Right click and select copy.

11. In the Navigator Window, select the PWR-Anim.med tab to open the animation file. With the View Window System View tab active, right click in the View Window and select paste. The control block should appear. Right click on the control block and select Plot Data. In the Select Data Channels dialog that pops up, the only plot option should be cb731. Click on OK. AptPlot should pop up with the normalized water level for DC 3 plotted in the lower pane. Look for when the value exceeds 0.75. Does this correspond to the time when the TSV closes?

Points to Consider

- Valves are useful for modeling actual valves in the system but also for other things such as modeling breaks. Taking a little time to look over the different types of valves and examining the valve options that are available is worthwhile.
- Valves have a built in loss model which is enabled by default and tries to account for losses caused when passing through the valve. In some cases a valve is used to model something that is not really a valve (such as a pipe break). In other cases, the valve losses are known and do not match the defaults. In these cases, the default loss model should not be used.
- The naming convention of components and control blocks can greatly assist users of a model. For example, in this model, loop 1 components are given component numbers in the range 100-199, loop 2 components are in the range 200-299, and loop 3 in the range 300-399. Matching components in different loops use the same last two digits. For example, the downcomers for the three loops are 170, 270, and 370. In the control system blocks that were added to the model in this exercise. The second digit was purposely made to match the loop number the control was associated with. Naming schemes differ, but understanding the component numbering scheme can be very helpful in a model, particularly when exploring plot result.