Break Modeling Exercise

Objectives

- Review of break modeling best practices
- Break model validation

Day3/Afternoon/PWR/4_Break_ModelOverview of Steps

1. Preliminary Setup (Open the Model)
2. Add 3 inch Cold Leg Break to the PWR Model
3. Configure Break Valve to open on SBLOCA Trip
4. Run SNAP 'Model Check' and Fix Any Errors
5. Run a Short SBLOCA Simulation to Test the Break
6. Check Results. Make Corrections if Necessary.
7. Rerun the short SBLOCA Simulation and Recheck the Results.

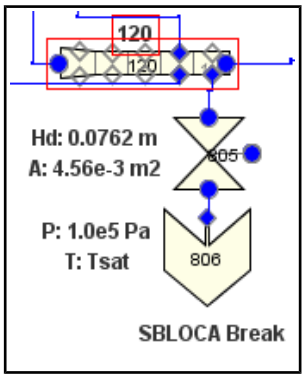
Step 1 Preliminary Setup (Open the Model)

If your model is not current, open the 'Day3/Afternoon/PWR/4_Break_Model' folder and double click on 'PWR4-Break.med' to open the PWR model.

Step 2 Add 3 inch Cold Leg Break to the PWR Model

Step Summary

1. Add a 3 inch (0.0762 m) break to the bottom of Loop 1 Cold Leg.



   - Use a VALVE  with zero cells and zero length (an SJC valve) to model the break.
   - Connect the valve to PIPE 120 cell 1.
   - Set the component number to 805 and configure the valve parameters.
   - Set Internal Loss Model [1] Off and set the 'Form Loss Table' values for 0 (closed) and 1 (fully open) valve positions to 1E-6 (a negligible K loss factor).
   - Orient the valve downward and enable the 'Offtake Model' on the valve to pipe connection.

2. Add break discharge boundary conditions (BCs).

   - Connect a BREAK  component to the valve outlet.
   - Set the component number to 806.
   - Set the BCs to 1.0E5 Pa (~atmospheric pressure) and 380 K.
   - Set Temperature Table Option [3] Set liquid and gas to Tsat.
   - Set Initial Gas Volume Fraction 1.0.

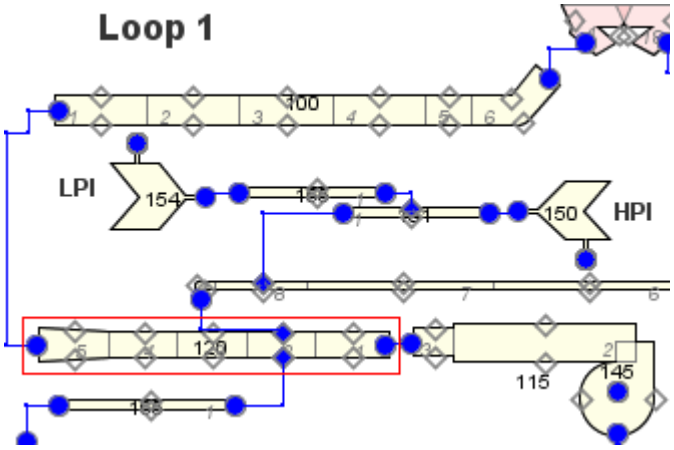
Noncondensibles can significantly slow down a simulation. In some simulations backflow from the break will enter the system. Pure steam conditions can be set at the break to avoid backflow of noncondensibles.

Detailed Steps

1. Add a 3 inch (0.0762 m) break to the bottom of Loop 1 Cold Leg.

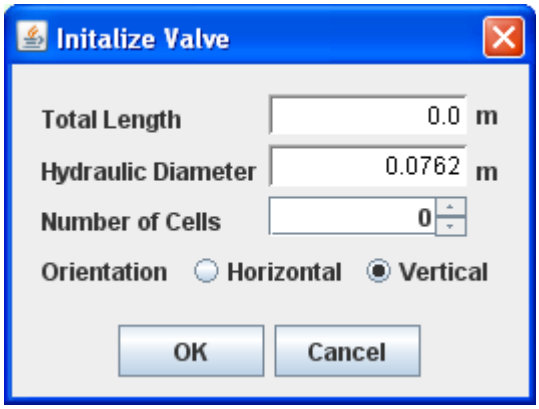
a) If it is not currently visible, click on the Hydro Comps tab below the View Window to show the PWR model.

b) The cold leg break model will be connected to cold leg pipe 120. Find pipe 120 typing 'Ctrl-F' to bring up the 'Find Component' dialog. Click on the Number column header in the dialog to sort the list by component number and look for 120. Click on the 120 to select this component and click Find. Cold Leg pipe 120 should now be highlighted as shown below:



c) Click on the VALVE component icon from the Toolbar and then click below pipe 120 in the View Window to insert a valve.

d) An 'Initialize Valve' dialog should pop-up. Set the following values and click OK. 'Number of Cell' and 'Total Length' of zero indicate that an SJC VALVE is added.



e) In the Properties Window set Component Name | Loop 1 Cold Leg Break, and hit enter.

> Naming components is a good practice since it makes the components easier to identify in the TRACE input file, and in various SNAP dialogs as well.

f) In the Properties Window, set Component Number | 805.

> A good component numbering scheme makes the model easier to interpret. In this case the loop one component numbers are in the 100-199 range, loop 2 components are in the range 200-299, and loop 3 in 300-399. Corresponding components use the same last two digits. For example, the pumps in the three loops are 115, 215, and 315. Although the break is located on Loop 1, it was elected to use a unique numbering scheme for the break components.

g) In the Properties Window set the Unknown values for the valve as shown below:

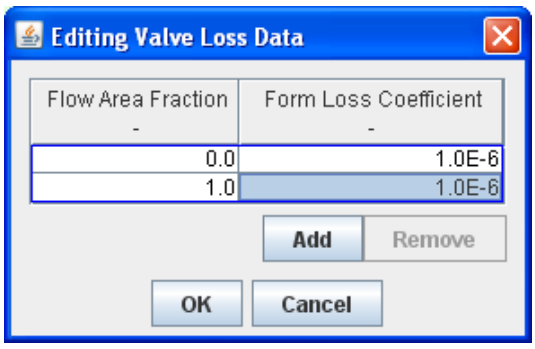
Maximum Valve Rate	1.0E5	(1/s)
Off Adjustment Rate	1.0E5	(1/s)
Minimum Position	0.0	(-)
Maximum Position	1.0	(-)
Valve Flow Area	4.56E-3	(m^2)
Valve Hydro Diameter	0.0762	(m)
Initial Flow Area Fraction	0.0	(-)
Valve Stem Position	0.0	(-)

The Maximum Valve Rate needs to be large enough for the valve to be responsive. The valve behavior will be configured later. The Minimum Position and the Maximum Position, as well as the Initial Flow Area Fraction and Valve Stem Position values are all fractions (values between 0 and 1). The valve is closed at the start.

h) In the Properties Window, set Internal Loss Model [1] Off.

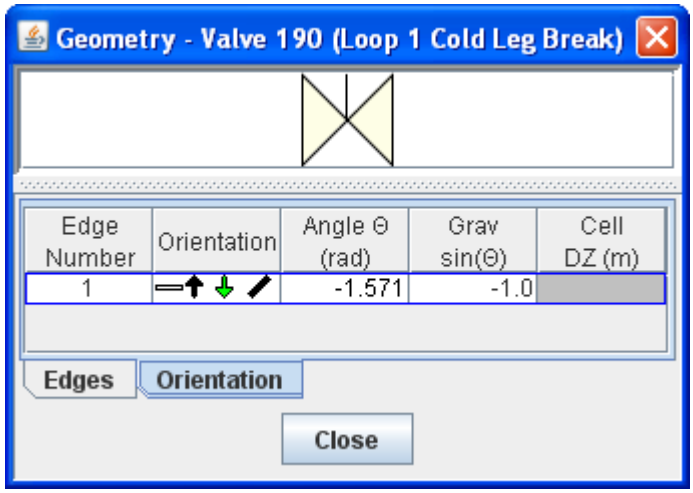
This is an easy step to forget, and one which can affect the break flow. TRACE VALVE components have a built-in loss factor. Since we are modeling a hole in the cold leg pipe and not a physical valve, this loss factor should be disabled. No SNAP or TRACE warning or error messages will indicate that this step has been neglected.

i) In the Properties Window, expand the Form Loss Table Undefined Values dialog by clicking on , and set the following values in the dialog:



Losses of zero can be used. However, TRACE will print out warning messages. To avoid this a very small value was used for the loss coefficients.

j) In the Properties Window, expand the Component Geometry | Cells: 0 properties dialog by clicking on . Click on the Orientation tab on the dialog and set the orientation to down (Grav of -1) by double clicking the down arrow, then click Close.

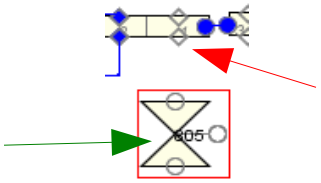


k) Right click on the valve . From the pop-up menu, set Drawn Orientation to Down.

Setting the 'Drawn Orientation' is cosmetic. It doesn't actually modify the valve component orientation as in the step above. However keeping the visual orientation consistent with the component orientation makes the model easier to interpret.

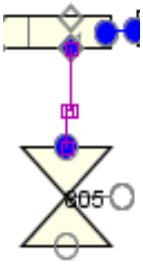
l) Right click on the valve component and select Scale Drawing... . On the 'Scale Drawing' dialog select Preserve Ratio and set the Length Scale Factor to about 0.55, and click OK. (Again this is cosmetic).

m) Drag the valve such that it is located below PIPE 120 cell 1.



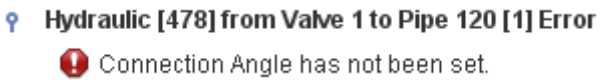
The previous image includes arrows which point to the connection points for the SJC VALVE (green arrow) and PIPE 120 cell 3 (red arrow) which will be used in the next step.

n) Click on the 'connection tool' icon  from the Toolbar, then click on the connection point for the SJC VALVE (see green arrow above) followed by the connection point for PIPE 120 cell 1 (see red arrow above). A line should appear connecting the valve to the pipe.



o) The Properties Window should show the properties for the valve to pipe connection. If it doesn't click on the 'selection tool' icon  in the Toolbar and select the line connecting the valve to the pipe. In the Properties Window, change **Angle:** Unknown (deg) to **Angle:** 90 (deg) and hit enter.

Setting the angle is an easy step to forget. If **Check Model** is selected from the **Tools** menu (Step 4 in this tutorial), SNAP issues the following error to help you find the problem:



p) Below **Angle:** 90 **(deg)**, set **Offtake Model:** **[1] On**.

The vertical orientation of a pipe break is important, since it affects whether steam or liquid goes through the break when there is stratified flow. The offtake model is a flag that indicates whether offtake orientation should be tracked. The position of the break depends on the orientation of the valve that models the break. If it is oriented down, the break is at the bottom of the pipe, and liquid is expelled before steam in stratified flow.

Turning on the offtake model is an easy step to forget and can affect the vessel depressurization timing since it influences when steam is able to reach the break. For a LOCA, a break that is oriented downward is typically more conservative. No TRACE or SNAP warning or errors messages will be shown indicating that you have not turned on the offtake model.

2. Add the break discharge boundary conditions (BCs).

a) On the Toolbar click on the BREAK component icon  , then click in the View Window below the break valve.

b) In the Properties Window, set Component Name Loop 1 Cold Leg Break BC and Component Number 806, and set the Unknown break properties as shown below:

Length	0.6985	(m)
Volume	1.0E5	(m^3)
Initial Gas Volume Fraction	1.0	(-)
Initial Mixture Temperature	380.0	(K)
Initial Pressure	1.0E5	(Pa)

The length and volume values for the BREAK component are somewhat arbitrary, but the change in flow area between the VALVE and BREAK components affects choking. The BREAK component volume-to-length ratio (i.e. the BREAK component flow area) should be large to ensure that choking at the VALVE component is enabled appropriately. Since the frictional pressure drop calculation is based on the lengths of the upstream and downstream cells, the BREAK component length should be on the same order of magnitude as the length of the cell upstream of the choking location (which for this exercise is the cold leg cell).

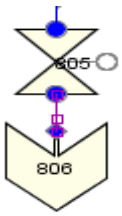
c) Set Temperature Table Option [3] Set liquid and gas to Tsat.

As noted in the summary, the break conditions are set to saturated steam to avoid having noncondensables enter the system due to backflow, since noncondensables can significantly impact the simulation run-time.

d) Right click on the break component and set Drawn Orientation to Down.

e) Right click on the break component and select Scale Drawing... . In the 'Scale Drawing' dialog enable Preserve Ratio and set Length Scale Factor 0.55 .

f) Drag break 806 below valve 805. Click on the connection tool  from the Toolbar, then click on the bottom connection point of VALVE 805 followed by the BREAK 806 connect point. A line should appear connecting the two components.



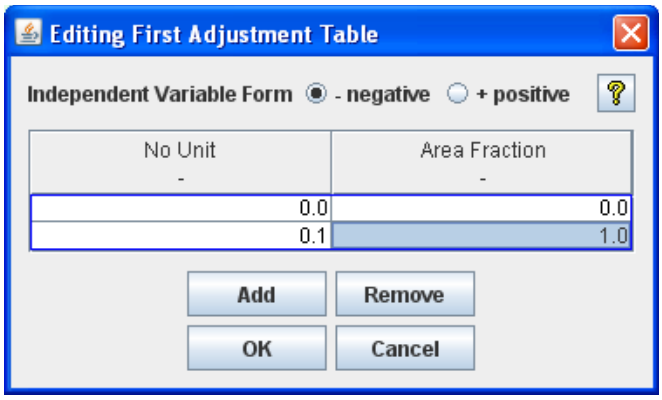
STEP 3 CONFIGURE BREAK VALVE TO OPEN ON SBLOCA TRIP

Next we will configure valve 805 to open over 1/10th of a second when trip 2 is activated.

1. Click on valve 805 (the cold leg break valve) and in the Properties Window, click ▼ on 'Valve Type' and select Valve Type | [3] Flow Area Table After Trip ▼.
2. Click ↗ on Valve Trip | <none> ↗, select 'Trip 2 (SBLOCA/LBLOCA Trip)', and click OK.
3. Click ↗ on Valve Table Indep. Var. | <none> ↗, select Signal Variable 1 (Problem Time) as the table signal, and click OK.

> Time is the signal that will be used as the valve control signal. **Signal categories** are organized alphabetically in this dialog, so scroll down to the 'General Signals' section. The relationship between this signal variable and the valve area fraction is set in the next step.

4. In the Properties Window, expand First Adjustment Table | Rows: 0 [] E↗. Click Add twice and set the values shown below. Above the table, set Independent Variable Form ◉ - negative and click OK.



This 'Flow Area Table' option is actually a flow area fraction that ranges from 0 to 1. Make sure to use flow area fractions in this table rather than actual flow areas.

Independent Variable Form - negative indicates that the table input is based on the change in the table signal from the time of the trip rather than the actual value of the table signal. For a time signal, this means that the time of the trip is the zero reference time for the table. This table causes the break to open over 1/10th of a second after the SBLOCA trip is activated:

Step 4 Run SNAP 'Model Check' and Fix Any Errors

From the `Tools` menu select `Check Model` and verify that there are no errors or warnings to address.

Step 5 Run a Short SBLOCA Simulation to Test the Break

Step Summary:

If you have not finished adding the 3 inch break, close your model and open the SNAP file 'PWR4-BreakA.med'. This is a model that follows the detailed instructions to this point.

Run a short simulation (15 s) in order to see whether TRACE detects any errors and whether the break is behaving properly.

The model initial conditions should be relatively close to steady state conditions when running a quick test case. Otherwise errors may arise due to ill-conditioned initial conditions. Initial conditions can either be imported into the model after a steady state is run and the test run directly, or the simulation can be run as a restart from a current steady state simulation. For this model, the initial conditions have been imported, so the model can be run directly.

1. Configure the SBLOCA trip (Trip 2) to activate at time zero.
2. In model options, configure the model to run as a transient simulation.
3. In model options, adjust the timestep.
   - End Time: 15 (s)
   - Maximum Size: 0.1 (s)
   - Graphics Interval: 0.2 (s)
4. Start the simulation using the name 'BreakTest'.

Detailed Steps

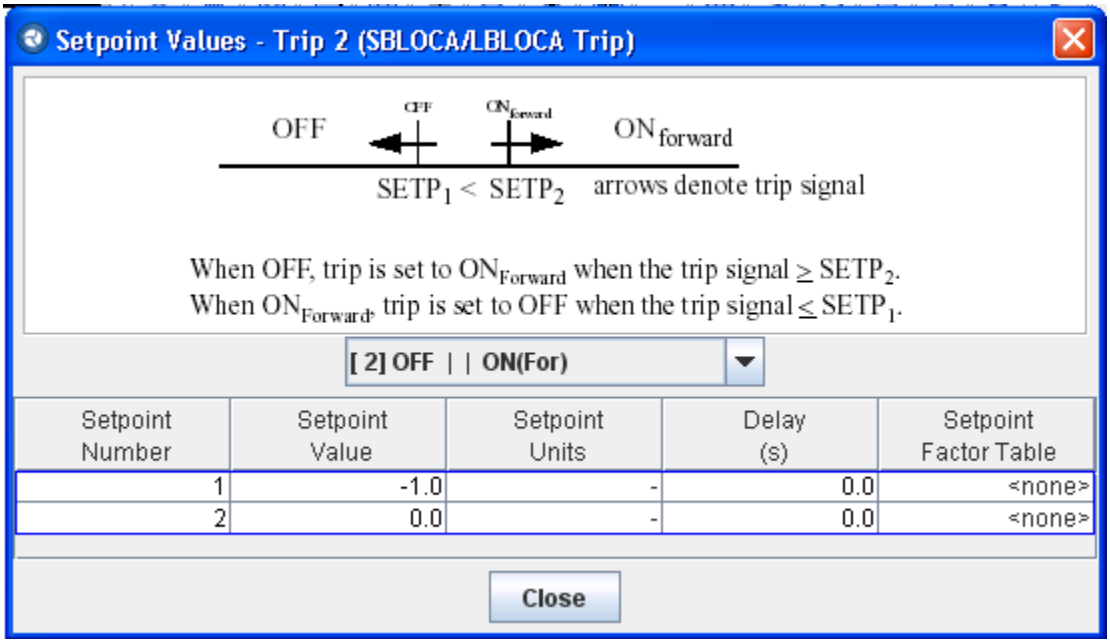
1. Configure the SBLOCA trip (Trip 2) to activate at time zero.

   a) Select the 'Control System' view by clicking on the Control System tab below the View Window.

   b) Type 'Ctrl-F' to bring up the 'Find Component' dialog. Click on the Number column to sort by component number and scroll to find Trip 2. Select this row and click Find. The properties for Trip 2 should now be visible in the Properties Window.

   c) The signal for Trip 2 is time. The SBLOCA begins when time crosses setpoint 2. In the Properties Window, locate and expand the "Setpoint Data" section.

Set the "Setpoint Value" to 0.0 for "Setpoint Number" 2 as shown below then click on the close button.



2. In model options, configure the model to run as a transient simulation.

a) In the Navigator Window, click on Model Options. In the Properties Window, set Transient Calculation [1] Transient.

Trips are not evaluated in the Steady-State mode unless the trip number is proceeded by the negative sign. Trip 2 is a positive trip. Therefore in order for the trip to function, the transient mode must be selected.

3. In model options, adjust the timestep.

a) In the Properties Window, find Timestep Data [1] Timesteps and click on to expand the 'Edit Timestep Data' dialog. Set:

- End Time: 15 (s)
- Maximum Size: 0.1 (s)
- Graphics Interval: 0.2 (s)

Click OK.

A maximum timestep size of 0.1 s is a common maximum size to use for a LOCA transient. Sometimes the timestep size has to be reduced by one or two orders of magnitude in order for the model to avoid timestep failures. Failures used to be more common, but TRACE now automatically backs up and adjusts the time step size when a solution runs into problems.

4. Open the `Job Stream` tab and `Execute` the simulation.

Step 6 Check Results. Make Corrections if Necessary.

1. Using 'Windows Explorer', go to the folder 'Day3/Afternoon/PWR/4_Break_Model' and double click on the animation file 'PWR4-Anim.med' to open it in SNAP.
2. If the simulation was successful, connect the animation to the simulation:
   a) In the Navigator Window, click the on Data Sources [1]. Expand Source Run URL | calcserv://localhost/... , navigate to the current simulation, and select it.
   b) Connect to to the PWR4-Break simulation and play the simulation.
3. Check whether break flow is reasonable
   a) Break flow is an important factor in LOCA events. To determine if it is reasonable, compare the TRACE calculated break flow velocity against the reference critical flow velocities given below.

Pressure	Temperature	Critical Liquid Velocity
15.5 MPa	559 K	155 m/s
10 MPa	551 K	107 m/s

Checking important model responses against reference values is a useful way to determine if there are modeling errors that need to be addressed. When possible, it is helpful to do a simple test that verifies that the system is behaving as expected.

b) If you followed the detailed instructions above, the calculated break flow velocity should be significantly higher than the velocities shown in the table above. This difference is because setting the choked flow flag in the break VALVE component was intentionally omitted from the instructions to emphasize the importance of checking the model results to make sure that reasonable values are being obtained.

4. To set the choking flag, go to the PWR model and click on the break valve (VALVE 805).

5. In the Properties Window, locate and expand 

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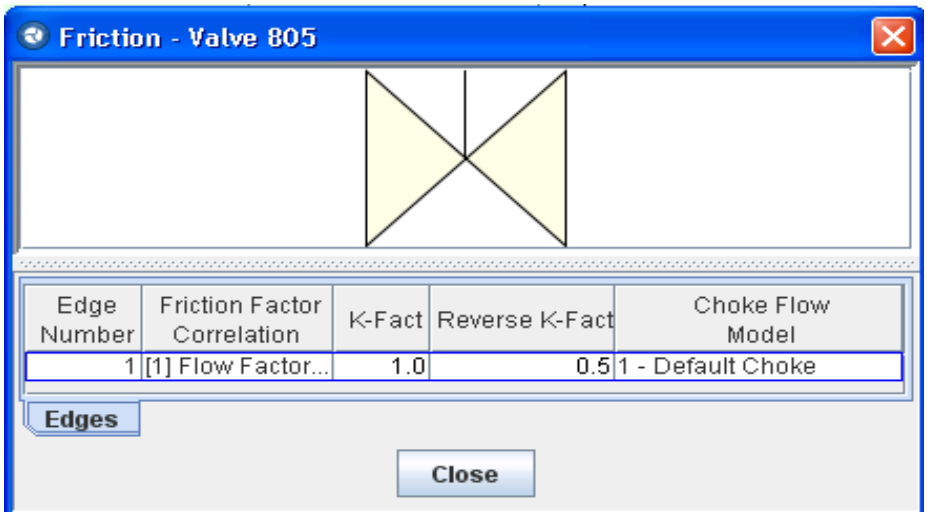
6. The geometry at the break can be considered an infinite expansion, for which the forward flow loss coefficient is about 1.0 and the reverse flow loss coefficient is about 0.5. In the 'Friction' dialog box, set the following values for the K-facts and choking model selection, then click on the Close button at the bottom of the window.



7. If you have not completed the steps to this point, close your model and open the SNAP file 'PWR4-Break-Final.med' located in the 'Day3/Afternoon/PWR/4_Break_Model' folder.

Step 7 Rerun the short SBLOCA Simulation and Recheck the Results.

Rerun the simulation, then check the results again by replaying the simulation in the animation med file. Verify that the break flow is reasonable according to the break flow rates in Step 6 item 3.