BREAK Input Sensitivity Study

Objectives

- Generate a simple BREAK-PIPE-BREAK model that will be used to calculate BREAK flow conditions using TRACE
- Generate a data table to compare flow, velocity, and pressure results from TRACE with hand-calculated values using the Bernoulli equation
- Utilize data comparison to provide guidance for DXIN and VOLIN inputs for an unchoked BREAK component

Background

The BREAK component imposes a pressure boundary condition one cell away from its adjacent component. It can be used anywhere fluid is able to enter or leave the system being simulated and the pressure distribution as a function of time is known.

The pressure condition specified in the BREAK component always represents a static pressure. TRACE will internally calculate a dynamic pressure for the BREAK volume using the BREAK flow area and the length-weighted junction thermodynamic conditions determined during the problem solution.

Overview of Steps

1. Construct a simple BREAK-PIPE-BREAK model in SNAP
2. Run BREAK-PIPE-BREAK model and create an animation to obtain calculated results
3. Compare calculated output to hand-calculated values
4. Repeat calculation for a range of DXIN and VOLIN input values

Step 1. Construct a simple BREAK-PIPE-BREAK model in SNAP

1. Start the Model Editor and select Create a New Model → TRACE Model
2. Modify the Pixels Per Meter (in the Properties Window) to be 2000

> The SNAP numerics capability makes it easier to change input values across multiple components at the same time. Since the DXIN and VOLIN values are the same for both BREAK components in this model, numerics parameters can be created and used in the BREAK input. In this way, input values for both BREAK components can be changed with a single parameter.

3. Set up numerics values for the DXIN and VOLIN BREAK inputs
   - **a.** Open "Numerics" in the Navigator Window
   - **b.** Right-click on "Reals" and select "New"
   - **c.** Select "Length" in the pop-up window
   - **d.** In the Properties Window, change the "Name" to "Length" and set the value to 1.0
   - **e.** Drag the Length variable from the model tree to the View Window to add it to the view
   - **f.** Follow the same steps to add another real to the View Window with the following settings:
     1. Type (in pop-up): Volume
     2. Name: Volume
     3. Value: 1.5394e-4
4. Add a BREAK component to the model and set the following parameters
   - **a.** Length (DXIN) - Click on the double arrow next to the input box and select the Length variable created earlier

- **b.** Volume (VOLIN) – the same as for Length, but select the Volume variable
- **c.** Initial Pressure = 627700 Pa
- **d.** Initial Mixture Temperature = 305.65 K
- **e.** Initial Gas Volume Fraction = 0.0
- **f.** Temperature Table Option = 1 (TIN or table for liquid sets gas to Tsat)

5. Add a PIPE component to the model and set the following parameters

- **a.** Total length = 0.06 m
- **b.** Hydraulic diameter = 0.014 m
- **c.** Number of Cells = 1
- **d.** Number of Pipes = 1
- **e.** Orientation = Horizontal
- **f.** Wall roughness = 1.524e-6 m
- **g.** Pressure = 627700 Pa
- **h.** Liquid Temperature = 305.65 K
- **i.** Vapor Temperature = 305.65 K
- **j.** Gas Volume Fraction = 0.0
- **k.** NC Partial Pressure = 0.0 Pa
- **l.** Friction Losses:
  1. Edge number 1 K-Fact = 0.03
  2. Edge number 2 K-Fact = 1.0

6. Add a BREAK component with the following parameters

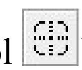
- **a.** Length – set to numerics variable as with the first BREAK
- **b.** Volume – set to numerics variable as with the first BREAK
- **c.** Initial Pressure = 100943 Pa
- **d.** Initial Mixture Temperature = 305.65 K
- **e.** Initial Gas Volume Fraction = 0.0

- **f.** Temperature Table Option = 1

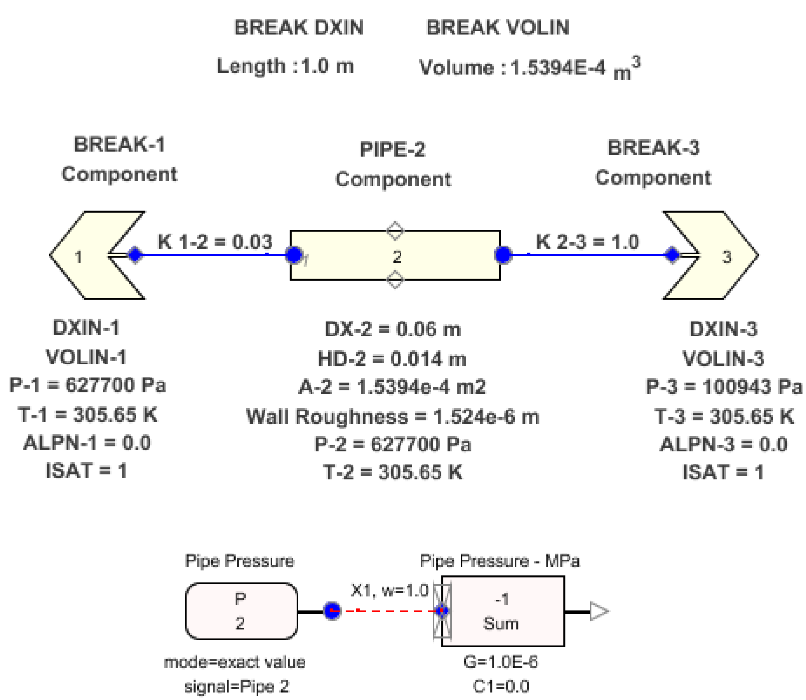
7. Connect the inlet of the PIPE to BREAK 10

8. Connect the outlet of the PIPE to BREAK 30

9. Add a control block to convert PIPE pressure to Mpa

- **a.** Add a Pressure [21] volumetric signal to the View Window and
- **b.** Point the signal variable ("Signal" input box in the Properties Window) to the PIPE
- **c.** Add a Sum [103] control block to the model
- **d.** Set the gain of the Sum control block to 1.0e-6 (converts from Pa to MPa)
- **e.** Connect the signal variable to the control block (use the connection tool )

10. Your model should be similar to the following figure:



STEP 2. RUN BREAK-PIPE-BREAK MODEL AND CREATE AN ANIMATION TO OBTAIN CALCULATED RESULTS

1. Run the TRACE model

- **a.** Click on Tools in the main toolbar and select "Submit Job..."
- **b.** Verify that "Single_Step" and "Local" are selected in the "Submit Job Stream" window and click "OK"
- **c.** Click "OK" in the "Submit Stream" window to start the calculation

2. Create an animation of the model and review the calculated results

- **a.** Right click in the View Window and Select → All
- **b.** Right click and Select → Copy or hit "Cntrl + c"
- **c.** In the main toolbar, select File → New, and in the Pop-Up, select "Animation Model"
- **d.** In the View Window in the animation, right click and Select → Paste or hit "Cntrl + v"
- **e.** In the Navigator Window open "Data Sources" and select "Master"
- **f.** In the Properties Window, expand the "Source Run URL" and select the "Single_Step" and "Base Job" in the pop-up source selection window
- **g.** Connect the animation to the data source using the  icon
- **h.** Add viewable data for the mass flow rate at the inlet face of the PIPE, the liquid velocity at the outlet of the PIPE, and the pressure within the PIPE
    1. Add a "Data Value" item to the animation View Window. Data values are in the "Indicators" Category of the toolbar menu used to add components.
    2. The "Channel Name" entry for the Data Value in the Properties Window should be rmvm-20A01 (mass flow rate at face 1 of PIPE 20)

3. Numerical Format = %10.2f
4. Repeat the steps above for liquid velocity (vln-20A02) and pressure (control block number for the Sum control block created earlier – cb1)

i. Click the play button on the main toolbar – the animation will play back the calculation. Results should be approximately 3.4 kg/s, 22.1 m/s, and 0.5 MPa.

STEP 3. COMPARE CALCULATED OUTPUT TO HAND-CALCULATED VALUES

Table 1 (at the end of this document) lists various DXIN and VOLIN inputs for the break components and the corresponding hand-calculated mass flow rate, liquid velocity, and pressure for each combination. There is also a place to record the TRACE-calculated values.

1. From the animation results, record the mass flow, velocity, and pressure for the first DXIN and VOLIN combination in Table 1.

2. Compare Results to the hand-calculated values

STEP 4. REPEAT CALCULATION FOR A RANGE OF DXIN AND VOLIN INPUT VALUES

1. Return to the SNAP hydraulic model and modify the DXIN and VOLIN for the two BREAK components

a. Click on the “Length” value in the View Window and modify the value to match the next value in Table 1

b. Modify the “Volume” value to match the value corresponding to the Length value in Table 1.

2. Resubmit the calculation, and then check the results in the animation window. You may have to disconnect and reconnect to the data source using the  button

3. Record the TRACE results, and repeat for the remaining values in Table 1.

Points to Consider

- Examine the data shown in the table. What conclusions can you draw from the TRACE results?
- Can we generalize the conditions where we might want a very large VOLIN or DXIN? When might we want a small DXIN or VOLIN?

Condition	Varying BREAK Inputs (in Bold)			Direct Hand Calculation			Table 1 Break Component Input Sensitivity With Unchoked Flow Trace Results		
	DXIN-1 DXIN-3 (m)	**VOLIN-1 VOLIN-3 (M^3)**	A-1 A-3 (m^2)	Flow (kg/s)	Velocity V-2 (m/s)	P-2 (MPa)	Flow (kg/s)	Velocity V-2 (m/s)	P-2 (MPa)
Static (undisturbed flow) Pressure	1	1.54E-04	1.54E-04	4.67	30.47	0.5884			
	0.1	1.54E-05	1.54E-04	4.67	30.47	0.5884			
	0.01	1.54E-06	1.54E-04	4.67	30.47	0.5884			
	0.06	9.24E-06	1.54E-04	4.67	30.47	0.5884			
Dynamic (stagnant) Pressure	0.06	0.0001	1.67E-03	4.67	30.47	0.13034			
	0.06	0.001	0.016667	4.67	30.47	0.12643			
	0.06	0.01	0.16667	4.67	30.47	0.1264			
	0.06	10000	166667	4.67	30.47	0.1264			

Table 1. BREAK Component Input Sensitivity With Unchoked Flow