BREAK Component Guidance For Unchoked Flow

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BREAK Component Description

- Boundary condition one cell away from the adjacent component.
- Used anywhere fluid can enter or leave system and the pressure distribution is known.
- Given these characteristics, when/where would you use a BREAK component? (4 places)

Typical BREAK component uses

- Four scenarios that call for the use of a break:
  1. Modeling outflow from a piping system into a large volume (SBLOCA, LBLOCA)
  2. Modeling inflow from a large volume into a piping system (containment flow into loops when pressure is low enough)
  3. Modeling a test section with a pressure tap downstream of the area of interest; pressure tap location is modeled with the BREAK (known time-dependent pressure distribution). BREAK models flow out of the system (as in a critical flow separate effects test).
  4. Pressure tap is upstream of modeled flow conditions, so BREAK models inflow. BREAK is used to force flow into the system based on differential pressure (as opposed to using a FILL component).

BREAK Geometry

- BREAK geometry input is simple:
  - DXIN – specifies BREAK component length
  - VOLIN – specifies volume
  - BELEV – sets BREAK elevation at cell center or elevation change across entire BREAK component
    - Used only when NAMELIST variable IELEV = 1 or 2
    - Used to compute gravity vector at the junction between the BREAK and the adjacent volume
- Volume-centered flow area is computed using VOLIN and DXIN
  - A = VOLIN / DXIN

BREAK Flow Conditions

- Junction Flow Conditions (BREAK inflow or outflow)
  - Flow in BREAK-connected junctions is determined by pressure difference between the BREAK and the adjacent volume
  - If the junction is choked, thermodynamic properties in the junction are set equal to the conditions in the upstream connected volume
  - If the connecting junction is unchoked, properties are determined by a length-weighted average between the connecting volume and the BREAK component.
- How does the method of computing junction flow properties impact how we model BREAKs?

Effects of BREAK Modeling Choices

- Using a small BREAK length (DXIN) will minimize the impact of the BREAK conditions on the junction properties.
- A large DXIN (relative to the length of the connected volume) gives more weight to the BREAK volume properties.
- The averaged junction properties (and by extension, the BREAK length) can have a pronounced effect on the interfacial and wall drag closure models.

BREAK Component Pressure

- Pressure specified in input for a BREAK component is a **static** pressure.
- TRACE calculates BREAK volume **dynamic** pressure internally using:
  - Length-weighted junction thermodynamic conditions (see previous slides)
  - BREAK flow area

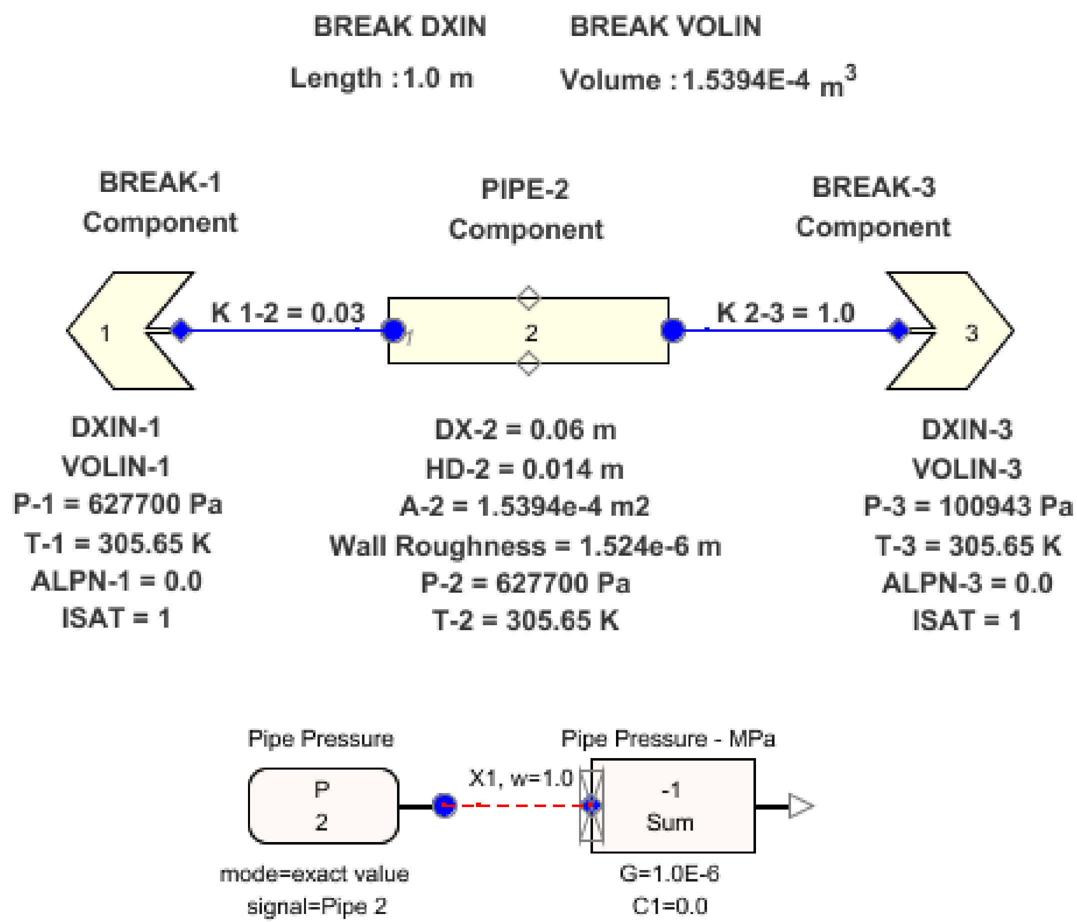
$$P_d = P_s + \frac{\dot{m}_j^2}{2\rho_j A_B^2}$$

  - Where:
    - P_d – BREAK volume dynamic pressure
    - P_s – BREAK volume static pressure
    - $\dot{m}_j$ - Mass flow in connecting junction
    - A_B - BREAK volume area

Guidance for BREAK Geometry

- Assessment of TRACE-calculated results
  - Steady-state
  - Simple BREAK-PIPE-BREAK
  - BREAK DXIN and VOLIN inputs are varied
  - Compare the range of flow and thermodynamic condition TRACE results with results of hand-calculations using the Bernoulli equation

BREAK Input Sensitivity Model



Bernoulli Hand Calculations

DXIN-1 and DXIN-3 (m)	VOLIN-1 and VOLIN-3 (m3)	A-1 and A-3 (m2)	Flow (kg/s)	Velocity V-2 (m/s)	P-2 (MPa)	Condition
1.0	1.5394e-4	1.5394e-4	4.67	30.47	0.5884	Static
0.1	1.5394e-5	1.5394e-4	4.67	30.47	0.5884	Static
0.01	1.5394e-6	1.5394e-4	4.67	30.47	0.5884	Static
0.06	9.2364e-6	1.5394e-4	4.67	30.47	0.5884	Static
0.06	0.0001	0.0016667	4.67	30.47	0.13034	Dynamic
0.06	0.001	0.016667	4.67	30.47	0.12643	Dynamic
0.06	0.01	0.16667	4.67	30.47	0.1264	Dynamic
0.06	10000.0	166667.0	4.67	30.47	0.1264	Dynamic

Exercise

- Purpose of the exercise
  - Examine the sensitivity of TRACE predictions of pipe mass flow rate, liquid velocity, and pressure to the BREAK geometry inputs DXIN and VOLIN
- Exercise steps
  - Construct simple BREAK-PIPE-BREAK model
  - Create animation to examine TRACE output
  - Run model using TRACE
    - Vary BREAK DXIN and VOLIN
  - Compare TRACE results to hand-calculations
- Refer to BREAK Input Sensitivity Study exercise instructions for details

Evaluate Results

- Based on the results of your evaluation, what recommendations would you make for unchoked flow?

Unchoked Flow Recommendations

- If a TRACE volume (PIPE or similar), is connected to a pressure source or sink which has the same flow area, the BREAK component DXIN and VOLIN values should be set equal to the similar values in the connecting volume.
  - Pressure input for the BREAK component represents the static pressure.
  - Dynamic pressure will be calculated by TRACE using the equation shown previously

Unchoked Flow Recommendations (concluded)

- If a TRACE volume is connected to a large pressure source or sink volume, the BREAK component should have a small value for DXIN and a large value for VOLIN.
  - The BREAK will have a very large flow area and a very small velocity
  - Pressure input for the BREAK represents a dynamic pressure
  - Large flow area implies that the BREAK input pressure (static) is essentially equal to the TRACE-calculated dynamic pressure
  - Rule of thumb
    - DXIN should be equal to the adjacent cell DX
    - VOLIN should be at least 100 times larger than VOL of adjacent cell

Guidance for Choked Flow Conditions

- Similar study as described previously can be performed for choked flow
  - Flow rate is not dependent on the value of the BREAK VOLIN and DXIN inputs
  - Choked flow rate is determined by the flow area of the break junction connected to the BREAK component
- BREAK component input guidelines for unchoked flow are also applicable to choked flow conditions