FPoliSolutions RELAP5-3D V&V activities: Lesson learned from the assessment of the MULTID component

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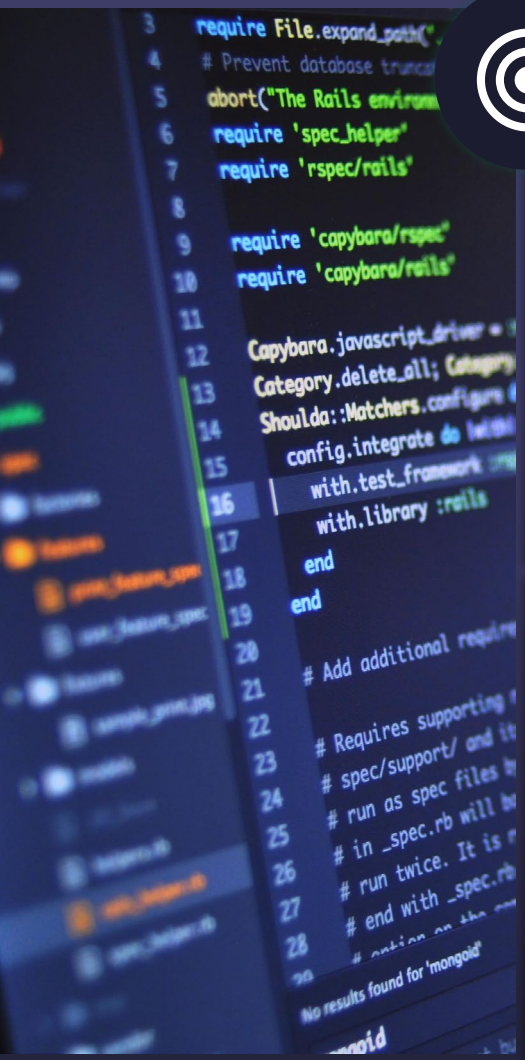


MISSION STATEMENT

Our mission is to serve the global energy transition community with customer-tailored innovative technologies

FPoliSolutions long history and extensive know -how in the nuclear industry helps our customer to accelerate innovation by engineering sustainable energy solutions for the progress of humankind

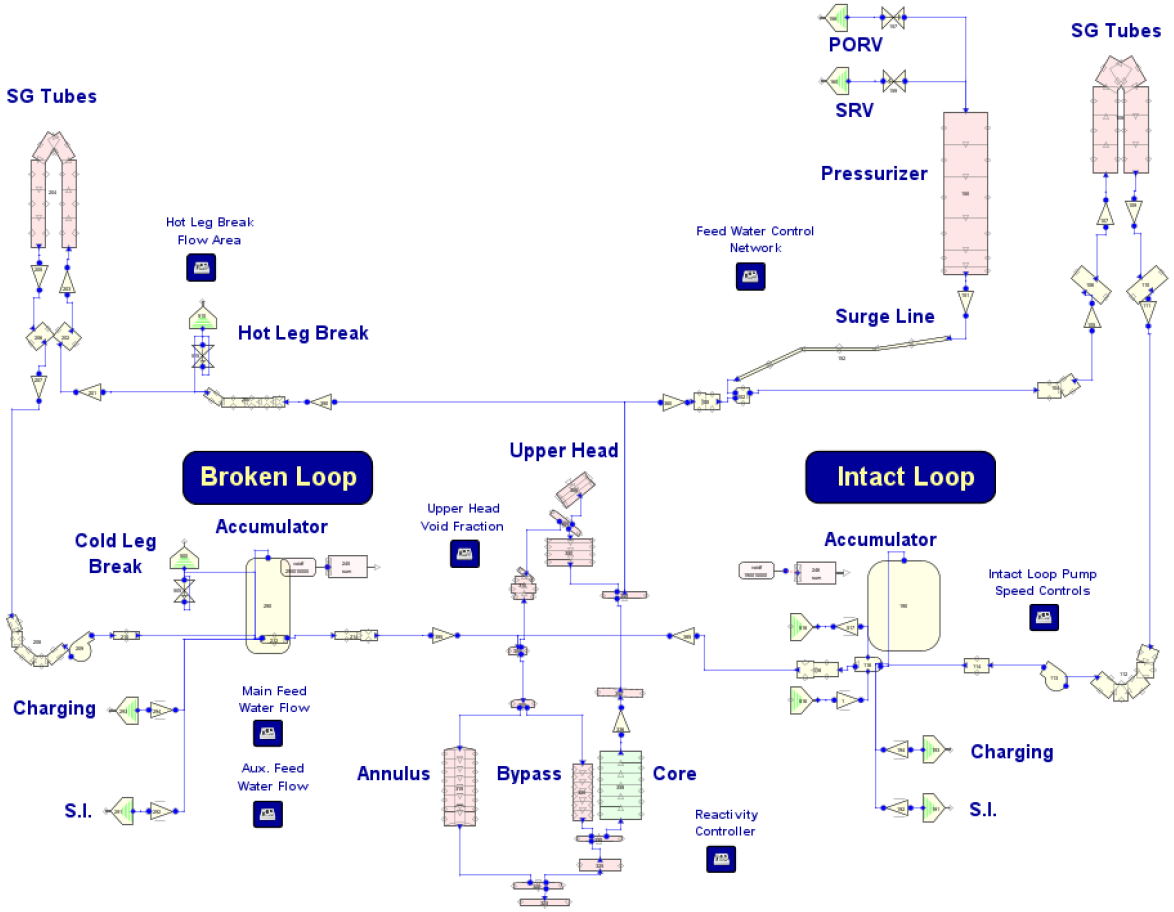
Outline/Objectives

- FPoli lessons learned from modeling a Typical-PWR Large Break LOCA event using RELAP5-3D using the MULTID components
- Limits observed in the RELAP5-3D Developmental Assessment suite when dealing LBLOCA phenomena
- Recommended areas for future development

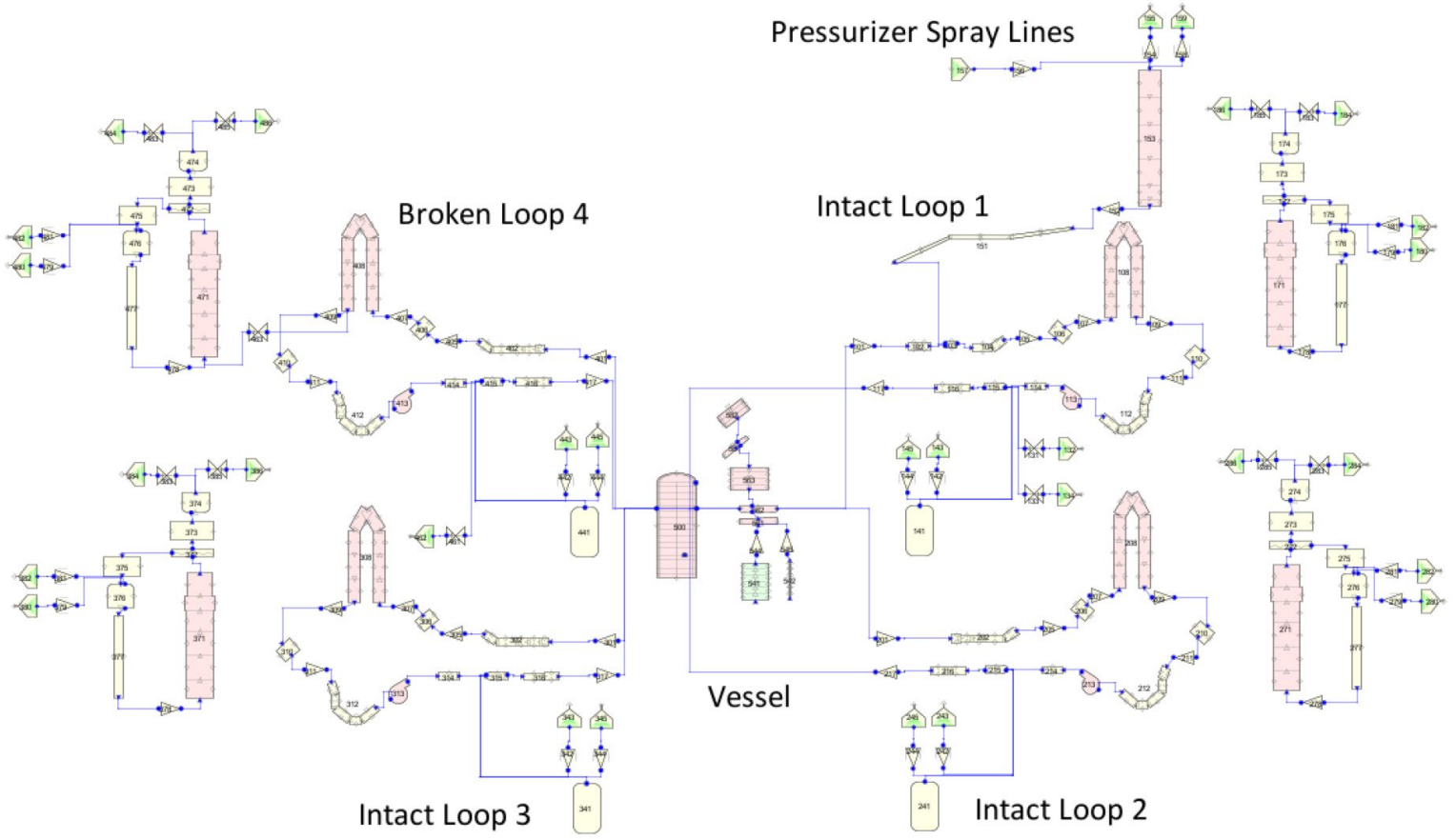
RISA Pathway Project
FPoli Task: Develop a credible Evaluation Model of a 4-Loop PWR

- Objective was to replicated 10 events from a FSAR
- Among those, the LBLOCA was a key event to consider
- Steps taken:
  - Detail review of existing Typical PWR RELAP5-3D model
  - Upgrade of the vessel component from pseudo-1D to MULTID
  - Every loop explicitly model
  - Steady-state calibration to realistic behavior
  - Modeling of the events – focus here on the LBLOCA event

RISA Pathway Project
FPoli Task: Develop a credible Evaluation Model of a 4-Loop PWR



RISA Pathway Project
FPoli Task: Develop a credible Evaluation Model of a 4-Loop PWR



LBLOCA Challenges

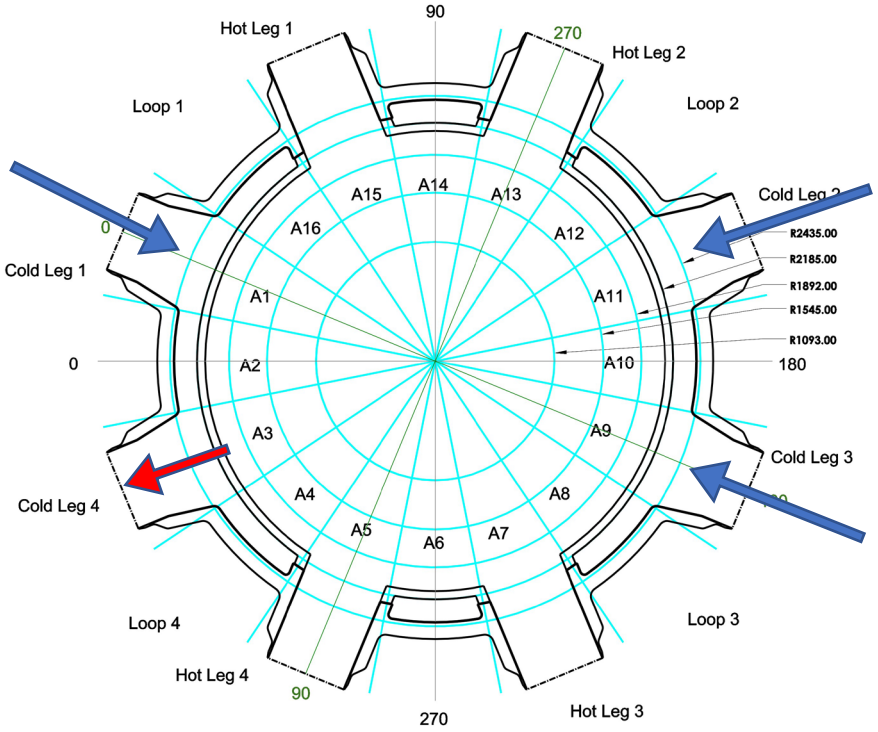
- During the initial blowdown, the 1D model showed a significant distortion of the ECC bypass phenomena
  - ECC water (accumulator injection) completely bypassed the core leading to unrecoverable core heat up and eventual failure of the run
- Similar behavior was observed even when the 1D model was updated to MULTID
- Note that on a separate V&V project, a significant overprediction of the ECC bypass was observed simulating the UPTF Test 6 (Runs 131, 132, 135, and 136)

UPTF Test 6 Program – BCs and ICs

UPTF Test 6 Events

- Cold Leg LB LOCA Simulation
  - 0 seconds: Initial system pure steam
  - 30 seconds: Steam Injection into Core
  - 30 seconds: Steam Injection into Hot Legs
  - 45 seconds: Subcooled ECC injection into Intact Cold Legs

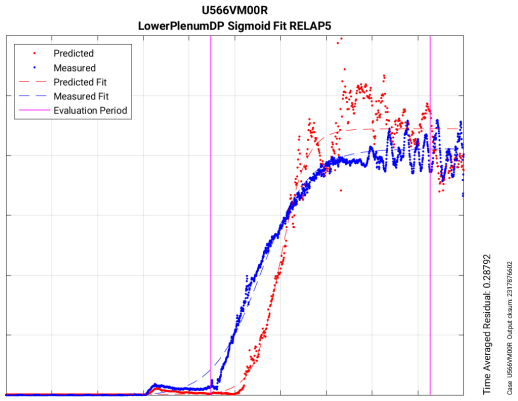
Parameter	131	132	135	136
Total N2 Injection Rate (kg/s)	1	1	1	1
Steam Mass Flow Rate Core Simulator (kg/s)	309	205	349	102
Steam Mass Flow Rate SGS (Total) (kg/s)	87	90	89	0
Total Steam Injection Rate (kg/s)	396	295	438	102
Total ECC Injection (kg/s)	1447	1471	1429	1471
Start of Steam Injection (s)	33	31	30	30
Start of ECC Injection (s)	45	43	42.5	42.5
Evaluation Time Period (s)	60-70	57-65	58-67	49-63
Subcooling of ECC Water (K)	58	51	55	26



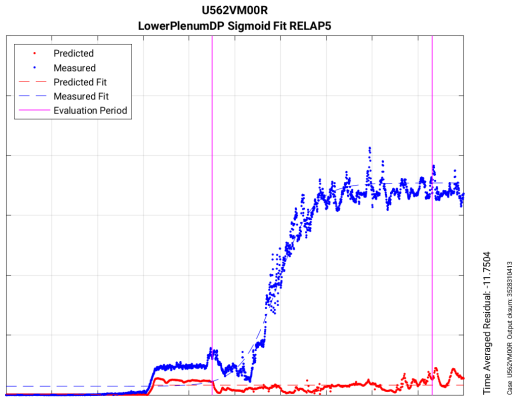
UPTF Test 6 Baseline Results

- Complete sweepout for 3 of the 4 runs
  - No drops flag shows no change
  - Forcing flow down using a large form loss at the break
    - This works but in turn changes the system pressure response
- Interfacial drag may be overpredicted

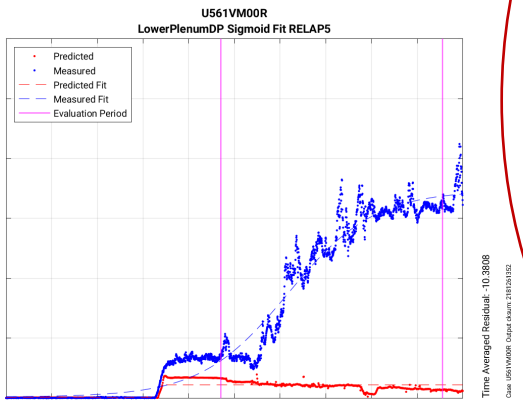
Run: 136
Steam MFR: 102 kg/s
Results: Reasonable



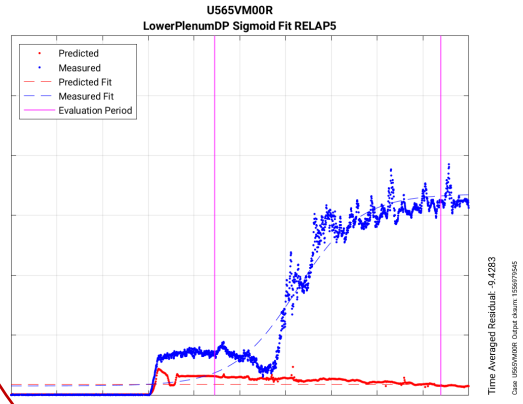
Run: 132
Steam MFR: 295 kg/s
Results: Unacceptable



Run: 131
Steam MFR: 396 kg/s
Results: Unacceptable



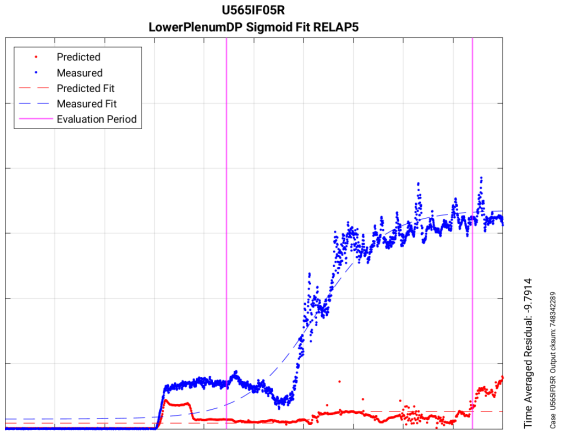
Run: 135
Steam MFR: 438 kg/s
Results: Unacceptable

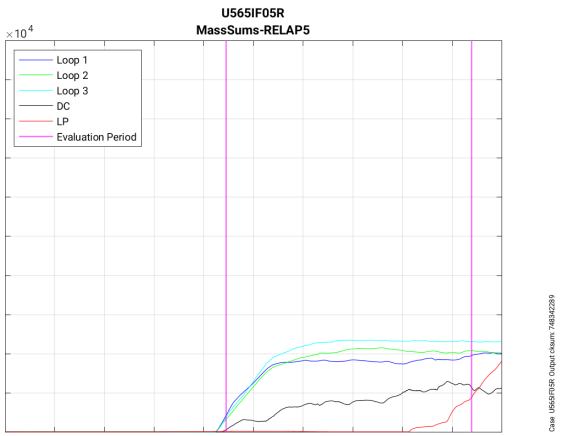


UPTF Test 6 Run 135

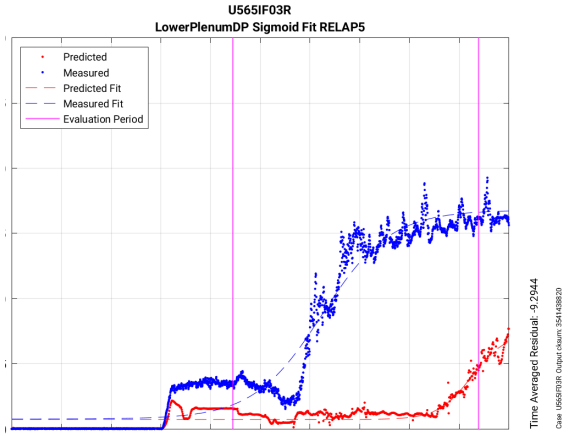
Interfacial Friction Coefficient Multiplier

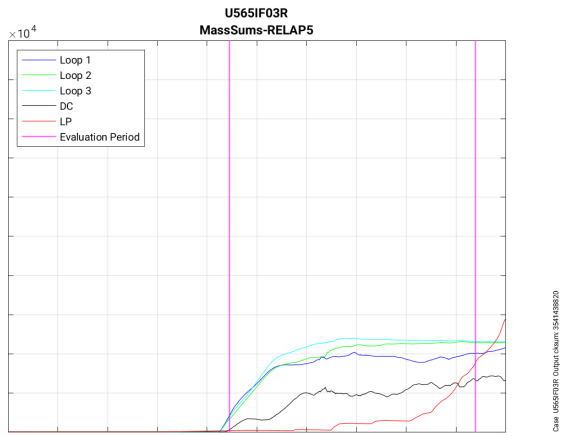
IFC = 0.5



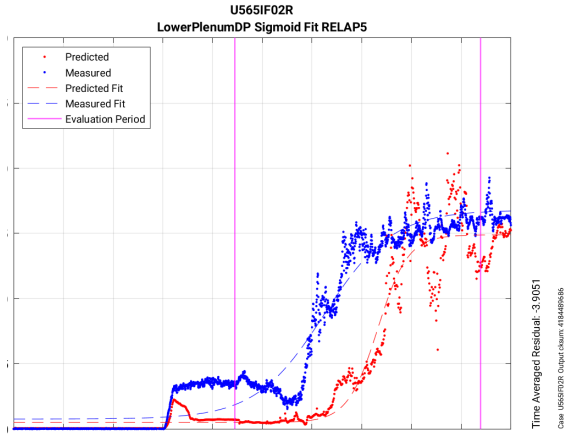


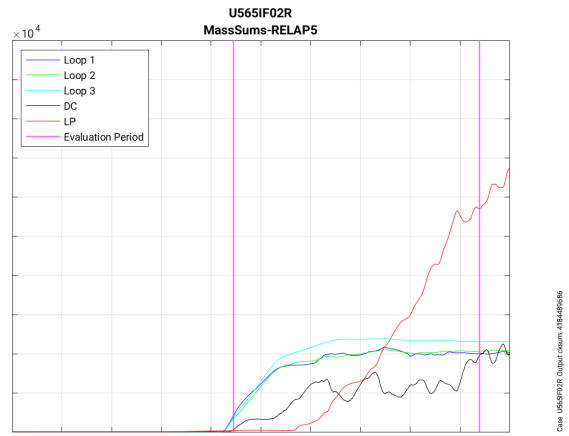
IFC = 0.3



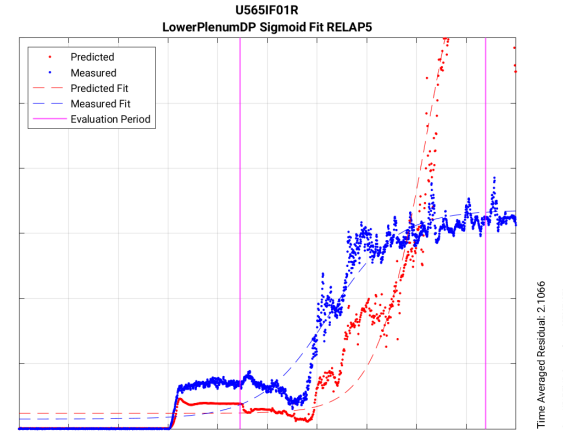


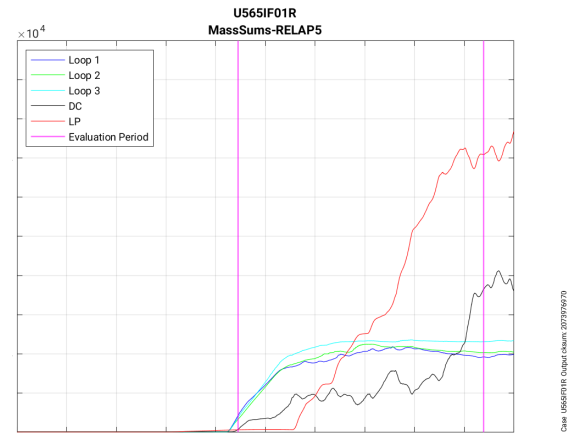
IFC = 0.2





IFC = 0.1





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LBLOCA modeling Conclusions

- UPTF Test 6
  - Interfacial drag – RELAP5-3D overpredicts the interfacial friction causing zero liquid to flow down
  - No drops Flag
    - The RELAP5-3D Volume 3 developmental test of UPTF Test 6 run 131 has a simplified 1D model that notes the usage of the annulus component over a regular pipe is necessarily for tests like UPTF Test 6
    - The equivalent to the annulus component with the MULTID is turning on the no drops flag
      - This should force all liquid into the film and allow down flow
        - However, the flag appeared to have no effect on UPTF Test 6 cases.
  - Applying excessive form loss to force downflow as a temporary workaround
    - This method somewhat resolved the excess ECC bypass issue, but the system pressure was heavily effected

Questions

- Thank you

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Extra Slides

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