RELAP5-3D User Problems[a]

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1.0 Introduction

The Reactor Excursion and Leak Analysis Program with 3D capability[1] (RELAP5-3D) is a reactor system analysis code that has been developed at the Idaho National Engineering and Environmental Laboratory (INEEL) for the U. S. Department of Energy (DOE). The 3D capability in RELAP5-3D includes 3D hydrodynamics[2] and 3D neutron kinetics[3,4]. Assessment, verification, and validation of the 3D capability in RELAP5-3D is discussed in the literature[5,6,7,8,9,10]. Additional assessment, verification, and validation of the 3D capability of RELAP5-3D will be presented in other papers in this users seminar. As with any software, user problems occur. User problems usually fall into the categories of input processing failure, code execution failure, restart/renodalization failure, unphysical result, and installation. This presentation will discuss some of the more generic user problems that have been reported on RELAP5-3D as well as their resolution.

2.0 Unphysical Result 1

In running a modified General Electric (GE) 1 ft level swell test 1004-3 problem[11,12,13] (includes blowdown line downstream of the valve, where high velocities result in smaller time steps using the semi-implicit scheme because of the Courant limit), void oscillations were observed. These oscillations were not observed in the GE 1 ft level swell test 1004-3 problem from the RELAP5-3D assessment library[14].

Studies showed that the oscillations go away by changing the upper transition

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value to 2.5 for the interpolation between the churn-turbulent bubbly drift flux correlation and the Kataoka-Ishii drift flux correlation. Figure 1 shows the results of the GE 1 ft level swell test 1004-3 run on RELAP5-3D version 140. Figure 2 shows the results of the GE 1 ft level swell test 1004-3 run on RELAP5-3D version 140 with the modified interpolation. Verification and validation consisted of also running the other GE level swell tests, the Marviken tests, the Wyle test, the Workshop problem 2 test, the Workshop problem 3 test, the MIT pressurizer test, the Bennett heated tube tests, the Christensen subcooled boiling test, the FRIGG tests, the FLECHT-SEASET test, and the Zion-1 PWR small break calculation (typpwr) from the RELAP5-3D assessment library[14].

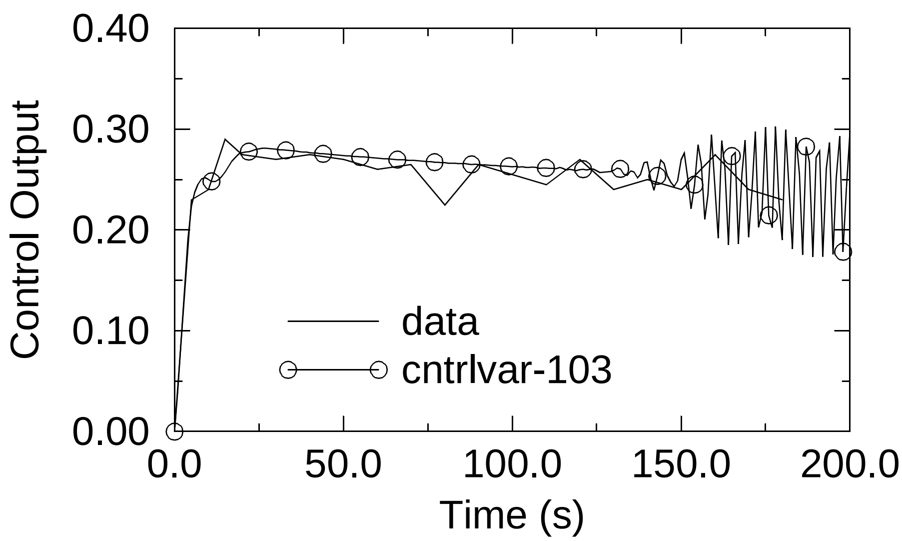

FIGURE 1. GE 1 ft level swell test 1004-3 void fraction at 6 ft (version 140).

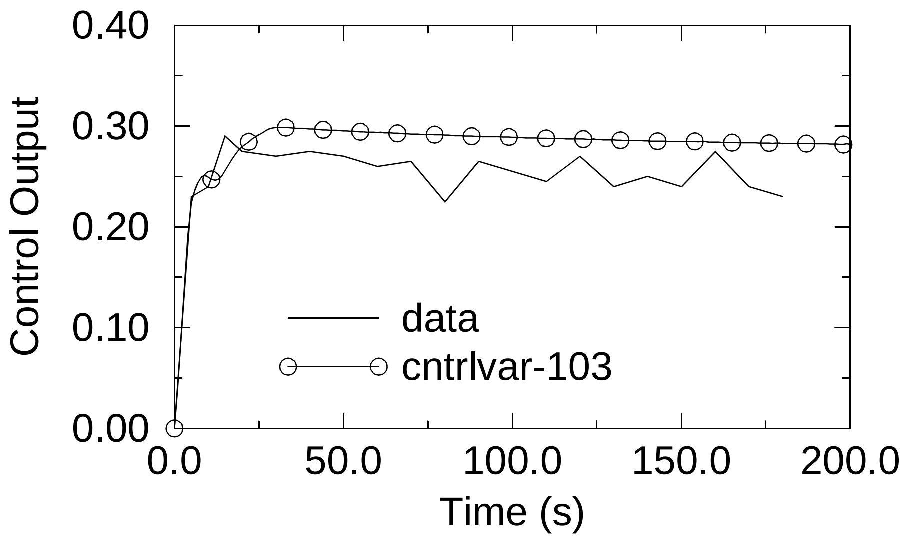

FIGURE 2. GE 1 ft level swell test 1004-3 void fraction at 6 ft (version 140+).

3.0 Unphysical Result 2

Unphysical flows and pressure drops occur at times because the user is not aware of what the code is using for the individual pressure drops that make up the overall pressure drop. Because of this, some users would like to plot and/or minor edit parts of the pressure drop due to elevation change, friction, form loss, momentum flux, etc.

The following junction quantities are now available for plotting and/or minor editing (these are always written to the restart-plot file, no 2080XXXX card is required):

DLLPZK - - - Junction elevation change pressure drop (‘from’ side).

DLLPZL - - - Junction elevation change pressure drop (‘to’ side).

DPELJ - - - Junction elevation change pressure drop (total).

DPFKJ - - - Junction wall friction and form loss pressure drop (total).

FRICXK - - - Junction wall friction pressure drop (‘from’ side).

FRICXL - - - Junction wall friction pressure drop (‘to’ side).

HLOSSX - - - Junction form loss pressure drop.

TASAPK - - - Junction temporal and spatial variation of momentum pressure drop ('from' side).

TASAPL - - - Junction temporal and spatial variation of momentum pressure drop ('to' side).

4.0 Unphysical Result 3

Some users indicated the simple separator option only allows for pure vapor/gas out the vapor/gas outlet junction and for pure liquid out the liquid fall back junction. They indicated there is no provision for some liquid out the vapor/gas outlet junction and for some vapor/gas out the liquid fall back junction, which is seen in a real separator.

New cards (CCCN901-CCCN909) now allow for this feature. The user can input (used in the simple separator model) the separator maximum vapor/gas volume (void) fraction for the vapor/gas outlet junction and the separator maximum liquid volume fraction for the liquid fall back junction. For a real separator both are less than 1.0. If 1.0 is input for both, the original model is used.

5.0 Input Processing Failure 1

Some users indicated they found the input non-equilibrium option (option t = 6: pressure, liquid specific internal energy, vapor/gas specific internal energy, vapor/gas void fraction, noncondensable quality) difficult to use, even though there are guidelines in the code manual. They would prefer to input phasic temperatures instead of phasic specific internal energies.

A new input non-equilibrium option (t = 8) now allows for this feature. The input for this option is pressure, liquid temperature, vapor/gas temperature, vapor/gas void fraction, and noncondensable quality. As with option 6, if the noncondensable quality is set to 0.0, noncondensables are not present and the input processing branches to that type of processing. Using t = 8 with the noncondensable quality set to 0.0 can thus be used as a replacement for non-equilibrium option t =0; this option uses phasic temperatures instead of phasic specific internal energies. As with option t = 6, this new option t = 8 is allowed for all volume input components (i. e., single volume, time dependent volume, pipe, annulus, pressurizer, branch, separator, jetmixer, turbine, ecc mixer, pump, multid) except the accumulator.

6.0 Code Execution Failure 1

A code failure occurred while trying to run a design calculation for a supercritical pressurized light water reactor (a Generation IV reactor). The pressure was set to 25 MPa (which is above the critical pressure 22.12 MPa) with a time-dependent volume at the exit. The flow was set with a time-dependent junction at the inlet. The inlet temperature was initially set below the critical temperature (647.3 K) and ramped to a value over the critical temperature. The code failed on a water property error when the fluid temperature became approximately 655 K. The problem runs (along with 27 'fillpcr' problems) when modifications were made to the steam tables, the interpolation subroutines, subroutine STATEP, and subroutine FWDRAG. This was discussed in a paper[15] at the 2001 RELAP5 International Users Seminar.

A series of 85 modified Edwards pipe blowdown calculations were then run with the code modifications. The decks had a pipe pressure of 25 MPa and various temperatures ranging from 500 K to 800 K. Of the these 85 problems, 8 of them failed.

Additional code modifications [includes some suggested modifications by Cliff Davis (INEEL) and Jim Steiner (formerly of INEEL, work done while at INEEL)] were made to the viscosity and thermal conductivity; subroutines ISTATE, TSTATE, STATEP, and JCHOKE; and subroutines PHANTV and VEXPLT. These code modifications now allow all the 85 modified Edwards pipe blowdown calculations to run. Figures 3 and 4 show the pressure and break mass flow rate for the case of 25 MPa and 647 K.

A modified Zion-1 PWR small break calculation (typpwr) from the RELAP5-3D assessment library[14] was also run successfully with the code modifications. The input deck had a primary system pressure of 25 MPa and primary system temperatures ranging from 583 K to 704 K. Figures 5 and 6 show the primary system pressure and break mass flow rate for this calculation.

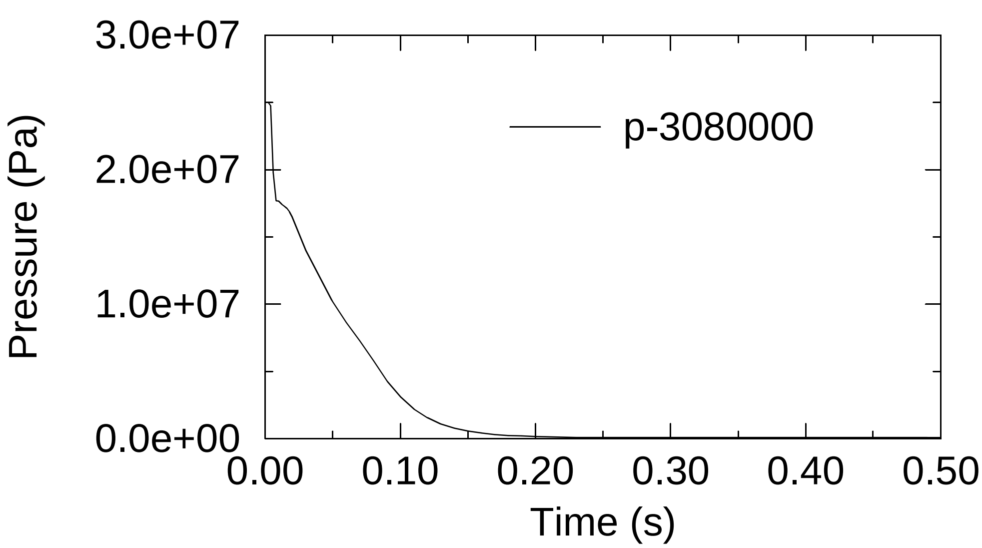

FIGURE 3. Supercritical Edwards pipe pressure.

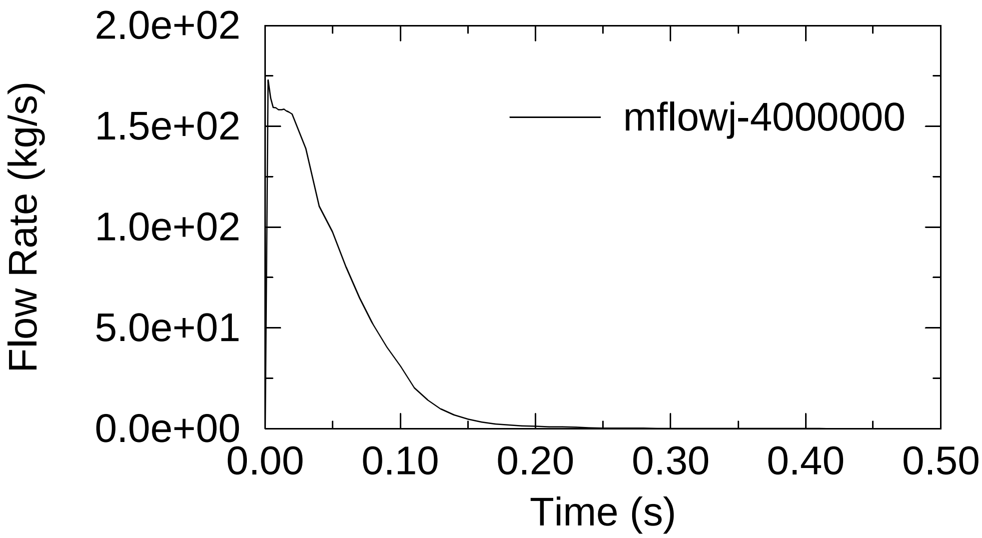

FIGURE 4. Supercritical Edwards pipe break mass flow rate.

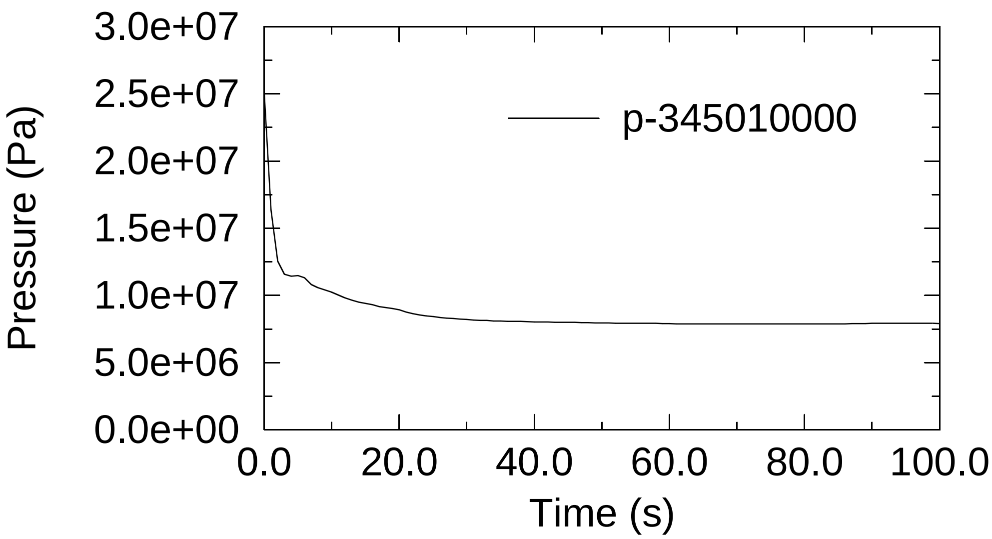

FIGURE 5. Supercritical Zion-1 primary pressure.

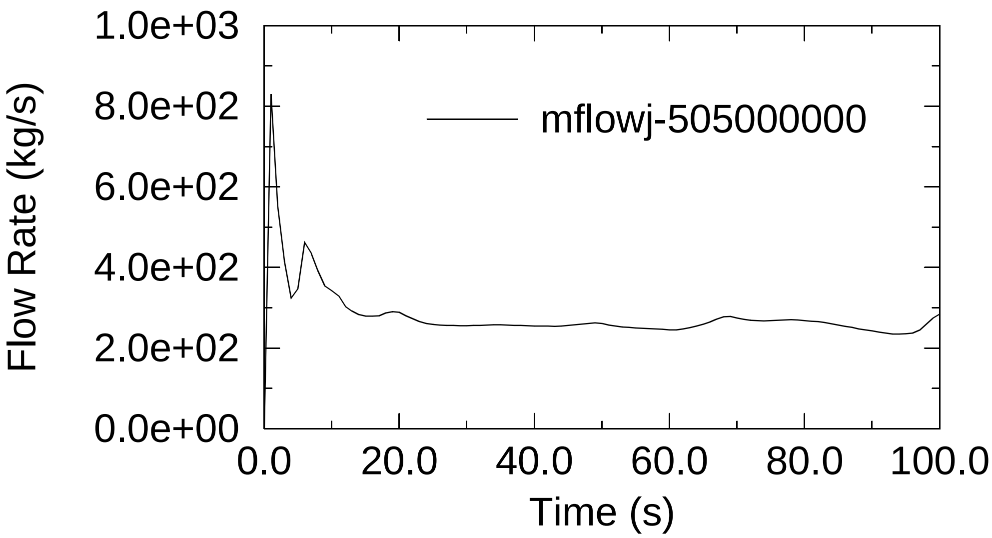

FIGURE 6. Supercritical Zion-1 break mass flow rate.

7.0 Summary

This presentation has discussed some of the more generic user problems that have been reported on RELAP5-3D as well as their resolution. The unphysical result problem 1 resulted in code fixes to the interphase drag model. The unphysical result problem 2 resulted in new plot and/or minor edit variables. The unphysical result problem 3 resulted in new input for the simple separator model. The input processing failure problem 1 resulted in new input for non-equilibrium thermodynamic conditions. The code execution failure problem 1 resulted in code fixes to the state-related subroutines.

8.0 References

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