

Release Notes for RELAP5-3D[®] Version 2.0

Note: Please open Volumes I, IV, Appendix A of Volume II, and the Pygmalion Users Guide before clicking on the links below.

Improvements in Version 2.0

The following is a brief description of improvements and new features in version 2.0. Links to associated material in the User Manuals show as yellow boxes around text. Open the appropriate volume before clicking on the link.

DETECTOR MODEL

A detector model has been added to the code. This model simulates the response of an in-core detection device that senses the radiation field and generates a signal based on the strength of the field. The output signal can be used as an input to a control system. It is implemented for both the point kinetics model and the nodal kinetics model. For each detector modeled, the user specifies the kinetics node(s) "seen" by the detector. The model is described in subsection 7.3 of Volume I, and its input requirements in subsection 12.16 of Appendix A of Volume II.

PRIZER MODEL

The PRIZER model now permits the user to specify a multiplier to be applied to the interfacial heat transfer coefficients (gas and liquid sides). The multiplier is used when the vertically stratified flow regime exists or the level model is invoked and applies. The multiplier can be input through a general table or control variable via word 6 of card CCC0001 (Pipe, Annulus, or Pressurizer Information).

RBMK CROSS-SECTION LIBRARIES

The International Atomic Energy Agency (IAEA) program "Accident Analysis and its Associated Training Programme for the Kursk 1 RBMK Nuclear Power Plant (NPP)" requires that plant personnel acquire a RELAP5-3D license to perform accident analyses. To support licensing the code for this program, the RBMK-specific cross section libraries must be available. Two sets of RBMK-specific cross section libraries were developed, one for Kursk and one for Ignalina. The two versions were combined into one, adding options in the input file for specifying problem-dependent information, adding the capability for accessing pointwise kinetics output data, and other miscellaneous changes. Descriptions are found in subsection 7.2.5.4 of Volume 1 and subsection 12.14.18 of Appendix A, Volume 2.

CRITICAL FLOW MODEL

Discontinuities in the default critical flow model would occasionally be reported, particularly during the transition from single to two-phase conditions. The root cause of

the problem was determined to be part of the logic for making this transition. Eliminating this logic produced much smoother results, yet did not alter the fidelity of the model in simulating legacy critical flow validation cases. Figure 1 compares the critical flow in the Edwards-O'Brien pipe blowdown experiment before and after the modified transition was implemented. The new transition logic is illustrated in Figure 7.2-7 of Volume IV.

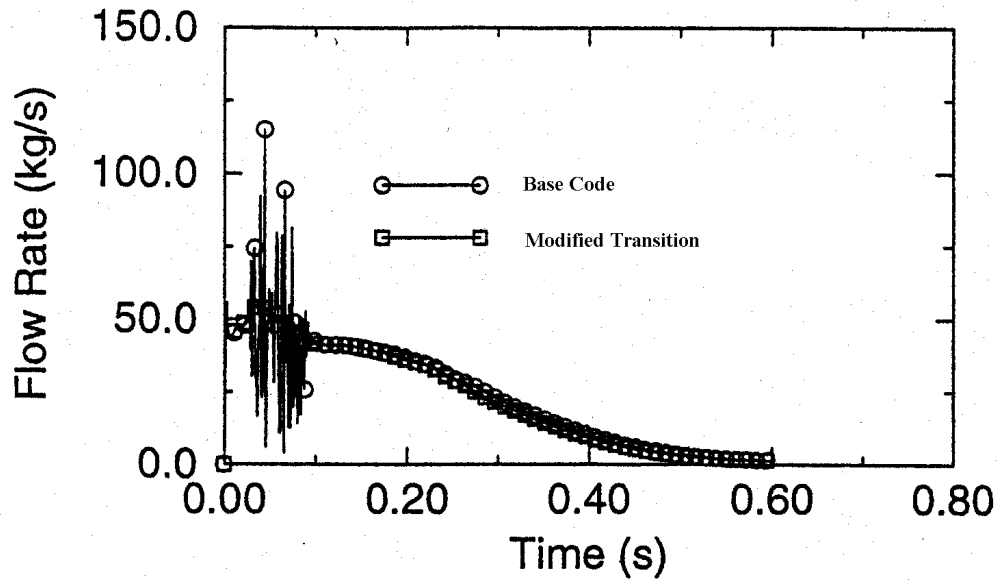


Figure 1. Calculated critical flow in Edwards-O'Brien experiment

INTERFACIAL DRAG MODEL

The interfacial drag model was modified to overcome non-physical void oscillations that were exhibited in a model of the GE 1-ft. Level Swell Experiment 1004-3. It was determined that these oscillations could be eliminated by "widening" the transition region within which the interfacial drag is interpolated between the churn-turbulent bubbly correlation and that of Kataoka-Ishii. Figure 2 compares the base code prediction to data for the void fraction at the 6-ft. level, and Figure 3 shows the same comparison after the code was modified. Because this was a pervasive change to the code, a significant number of legacy assessment cases were run with and without the change to gauge its effect. No detrimental effects were noted.

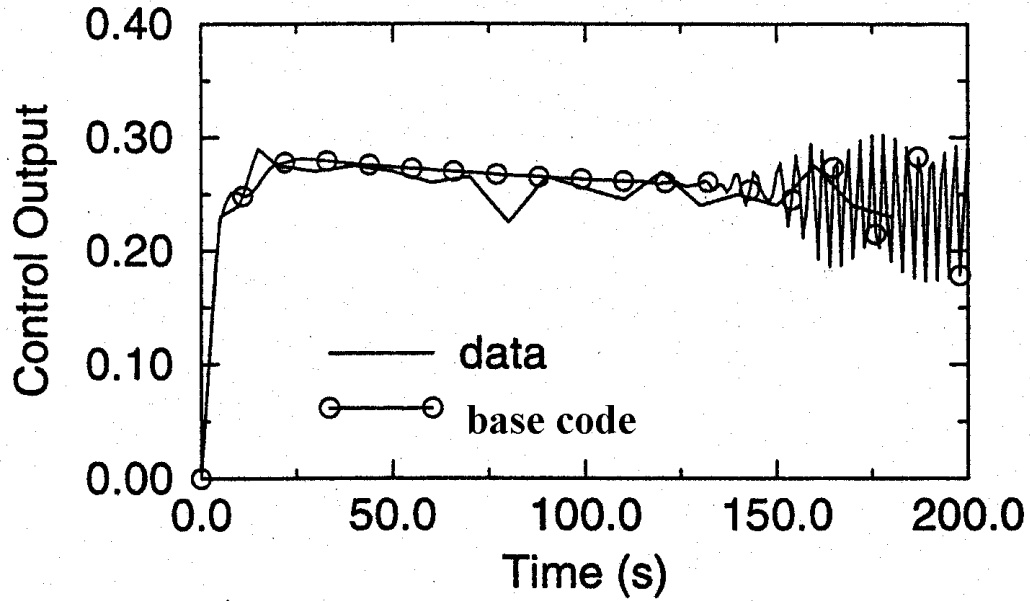


Figure 2. Calculated and measured void fraction at the 6-ft. level in G.E. Level Swell Experiment 1004-3 (base code)

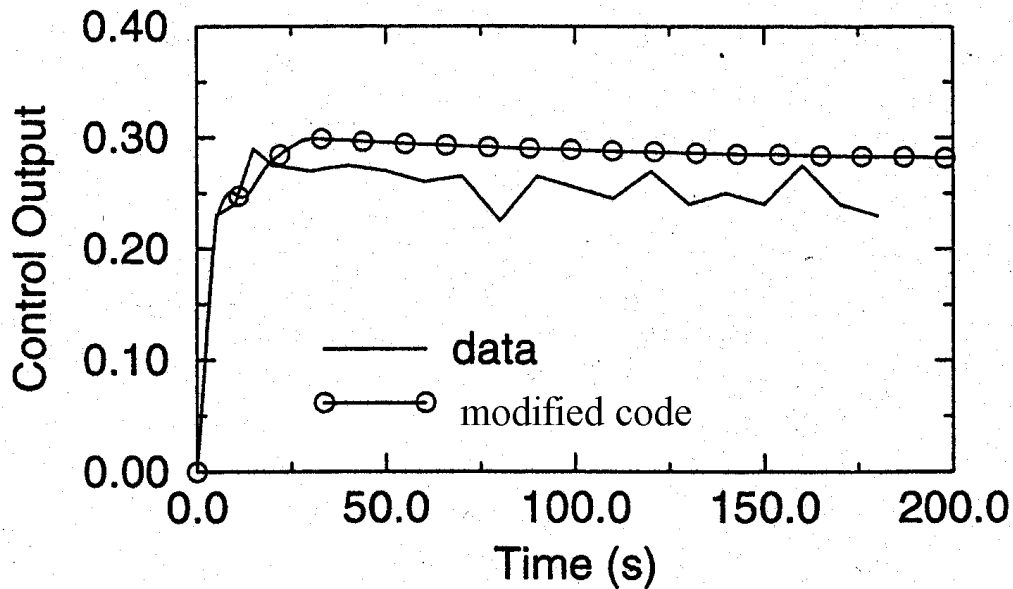


Figure 2. Calculated and measured void fraction at the 6-ft. level in G.E. Level Swell Experiment 1004-3 (modified code)

BPLU

Border-Profile-Lower-Upper (BPLU) is the fastest solver for virtually all RELAP5-3D problems and often results in a 10% reduction of RELAP5-3D run time. (BPLU is currently invoked by card 1 option 33.) It has not been the default solver however,

because there have been two outstanding user problem reports that involve BPLU. These were solved.

The first problem reported was the so-called "zero bandwidth error." For some large problems, the input processing subprograms would produce a message saying that the bandwidth of the matrix was non-positive. This resulted from initializing an operation count variable to the cube of the size of the matrix. Since this variable was a 32-bit integer, when the size exceeded the cube root of 2^{31} , (about 1300) its cube may have a 1 in the 32nd bit, the sign bit. Rather than stopping the program with an overflow error, many computers store the last 32 bits into the integer thereby producing a negative value. Eventually, this produces a non-positive bandwidth. This problem is fixed by declaring the variable as real rather than integer.

The second problem occurs in some problems that have three-dimensional regions. It was evidenced by a BPLU input processing subroutine that gave a message that a disconnected component exists in the input model. This is impossible with RELAP5-3D. The error was traced to a typographical error in a non-BPLU subprogram that constructs three-dimensional regions. This was fixed.

Users are encouraged to try the BPLU solver and report back to the INEEL what improvements in run time they are able to attain.

LARGER MODELS ACCOMMODATED

In order to accommodate the larger RELAP5-3D models being developed it became necessary to increase the size of the main storage array in the code. Whereas Version 1.3 required at least 28 MB of RAM to load, Version 2.0 requires at least 72 MB.

NEW USER OPTIONS

- ***Add volume initial condition option 8*** (t in the packed word ebt). This option allows the user to specify the initial composition and thermodynamic state of the fluid in a hydrodynamic component by inputting pressure, liquid temperature, vapor/gas temperature, vapor/gas void fraction, and noncondensable quality.
- ***Allow heat structures to be "decoupled" from the hydrodynamic model.*** It is sometimes useful to examine the effects of wall heat transfer on the hydrodynamic response of a system. This new capability retains the normal response of a heat slab to the model's hydraulic conditions, but does not include the energy convected to the heat structure from the fluid or from the heat structure to the fluid. This feature is invoked using word 3 of the heat structure input card 1CCCG000 (input as a negative number) to indicate a particular heat structure is to be decoupled. A warning message is printed in the output file indicating this heat structure is decoupled from the hydrodynamics.
- ***Allow restart without inputting the restart number.*** Word 1 of card 103 now permits the user to indicate that the last restart record on the plot/restart file should be used to

restart a problem or that the record associated with a specific time be used for the restart.

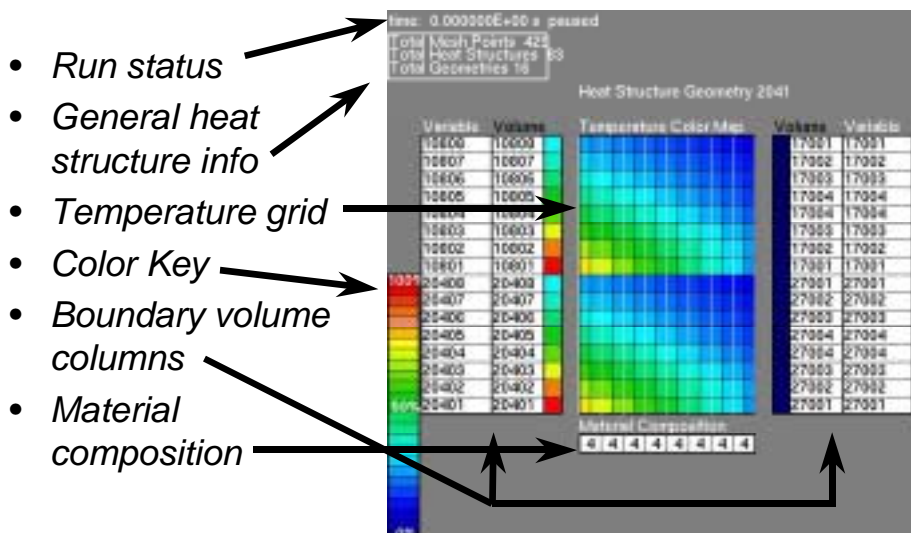
- **Allow specification of a sink temperature as a control variable in the wall heat transfer.** An option has been added to specify a sink temperature for a heat slab through a control variable. Word 1 of cards 1CCCG501-1CCCG599 (left boundary) and 1CCCG601-1CCCG699 (right boundary) are used to specify the control variable number.
- **Add variables representing parts of the pressure drop term to the list of junction quantities available for plots/minor edits.** The various pressure difference terms in the momentum equations have been added to the list of junction quantities. These are included in subsection 4.5 of Appendix A of Volume II.
- **Extend the simple separator model to allow some liquid to exit the vapor/gas outlet junction and some vapor/gas to exit liquid fall back junction.** Cards CCCN901-CCCN909 were added to allow for input/use of the separator maximum volume fractions for the vapor/gas outlet junction and the liquid fall back junction.
- **Permit turning off interfacial drag.** This change incorporated the capability to reduce the interphase drag and virtual mass terms in the momentum equations to near zero. This is useful when comparing RELAP5-3D calculations to problems that have exact solutions when these effects are absent. Card 1 option 7 is used for this purpose. A warning message is included in the print file when the code is run in this manner.

RGUI IMPROVEMENTS

Heat Structures Visualization Added to RGUI

A Heat Structure Geometry (HSG) visualization screen has been added. It is broken into three parts, the menu bar, tool bar, and Display area. The HSG Display Area (see

Heat Structure Screen Image Area



graphic) shows the time in the upper left corner, a table of key HSG values below that, and a color map key in the lower left corner. The rest of the screen shows an annotated HSG which is comprised of left and right numerical columns of numbers and a central display of the HSG nodes and mesh lines. The central display depicts temperature in the domain of each discrete temperature via the color map in the lower left corner. Both boundary columns on the left and both on the right show the hydrodynamic control volume.

The color bar and HSG grid use a new color map. The color bar displays the maximum and minimum temperatures within the HSG on the top and bottom bars respectively to help the viewer recognize the color spectrum. The color map can automatically adjust as the maximum and minimum temperatures change, or a user defined maximum and minimum can be used. Also, the color for the boundary volume shows the liquid temperature variable "tempf" with the same color map as a background under the white control volume number.

Above the Display Area is the tool bar. It has buttons for start/pause the transient/replay, turn the legends on and off, present a list of HSG to select from, recenter, and various other functions. The menu bar is the same as the Hydro menu bar. The view menu item allows switching between Hydro and HSG. There are hot keys for the switch also. The HSG Screen is not currently a separate screen from Hydro. Rather, switching replaces the tool bars and display area from whatever was previously displayed to those associated with the user request.

PYGMALION Added

The program that uses both a RELAP5 input file and restart plot file to create a new input file with steady-state initial conditions, PYGMALION, has been added to the Tools Menu of the RELAP5-3D Station. It has its own graphical front end that resembles the "RELAP5-3D Run Options Settings" Screen.

User Requested RGUI Modifications

Plotting Package SI Units Restored

Fixed the button in tkXMGR that allows display choice of SI or British. This previously only showed British.

Decimation Modified

Decimation is used to reduce the number of labels showing on the hydro screen. In response to the requests of many users, the restriction that the upper and lower limits of the decimation range must be actual volume or junction numbers has been removed. These limits are now allowed to be any integer value and the decimation will occur within the range and with the frequency requested.

RGUI.TMP message eliminated

Just about everyone who uses RGUI on a Windows PC complained about the spurious message concerning the inability to delete this file, especially since RELAP5-3D would run normally in spite of it. This problem has been fixed.

Color Key Added to Hydro Screen

As with the Heat Structure Geometry and Vessel Screens, users wanted a color key on the Hydro Screen. One is now available on the Hydro Screen, but only with 3D pipes.

Better Button Icons

Users requested more easily recognized button symbols. The somewhat cryptic icons for Exit (stylized X) and “Help Menu” (question mark & down arrow) have been replaced with words on every screen. The buttons for Replay, Detail Screen, and Variable Labels have also been upgraded. Balloon descriptions for toolbar buttons have been shortened.

Reworked Dialog Screens

As per user requests, the Replay and Find dialog windows have been modified to be more compact. Find looks more like the standard MS Windows finder.

FORTRAN 90

Work began on the goal of adopting FORTRAN 90 programming constructs throughout the code. This will be transparent to those who receive executable code. On the other hand, those receiving source code will have to have a FORTRAN 90 compiler in order to compile the source of version 2.0.

The starting point for this effort is the conversion of so-called bit-packing from FORTRAN 77 and Milspec to FORTRAN 90. This is making the code more readable and less prone to programming errors.