The RETRAN & VIPRE Newsletter

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INSIDE

Dominion Describes MSSV Modeling Support Using RETRAN-3D

During the 2008 Spring Meeting in Seattle, Dominion reported a potential modeling benefit when converting the Kewaunee Power Station (KPS) RETRAN Model to Dominion in-house methods. The conversion effort requires moving to RETRAN-02 usage, single-node steam generator (SG) modeling, and developing transient scenario overlays for the KPS base deck. The converted model will then be used in a re-analysis of most non-LOCA transients.

An Opportunity for Improved Modeling

During the conversion project, the Dominion group found a potential for a technical improvement in modeling the MSSV performance, leading to the potential for margin gains when considering the loss of load turbine trip (LOL/TT) event.

The LOL/TT transient is a primary RCS over-pressurization event and is defined as a complete loss-of-steam load and turbine trip from full power without a direct reactor trip. A rise in the primary fluid temperature is followed by a corresponding pressure increase in the steam line.

A preliminary analysis by Dominion indicated that the main steam line pressure response from the RETRAN model had a somewhat tight margin (1202 psia) when compared with the acceptance limit (1210 psia).

The KPS MSSV model uses setpoints that are high with respect to nominal values. The KPS nominal safety valve setpoints are in the range of 1089 psia to 1143 psia. The model MSSV set points were set as high as 1200 psia.

Original KPS Base Model - A Conservative Approach

The original MSSV setpoints were used to address issues described in NRC Information Notice 97-09. The notice described the potential for obtaining nonconservative main steam line peak pressures by neglecting the dynamic pressure response associated with long inlet pipe lengths (from the main steam line to the MSSVs) during overpressurization events. The NRC's concern was that if this stretch of piping is not modeled during an overpressurization transient, then the dynamic pressure drop may be underpredicted, over estimating the MSSV relief capacity with respect to the plant.

The original KPS model accounted for this effect by estimating the piping and fitting losses and determined that when all five valves opened at capacity, an associated 36 psi drop would occur. This entire loss was added to the valve opening setpoint. As a result Valve 5 does not open until the steam pressure exceeds 1200 psia.

Dynamic Response Considered

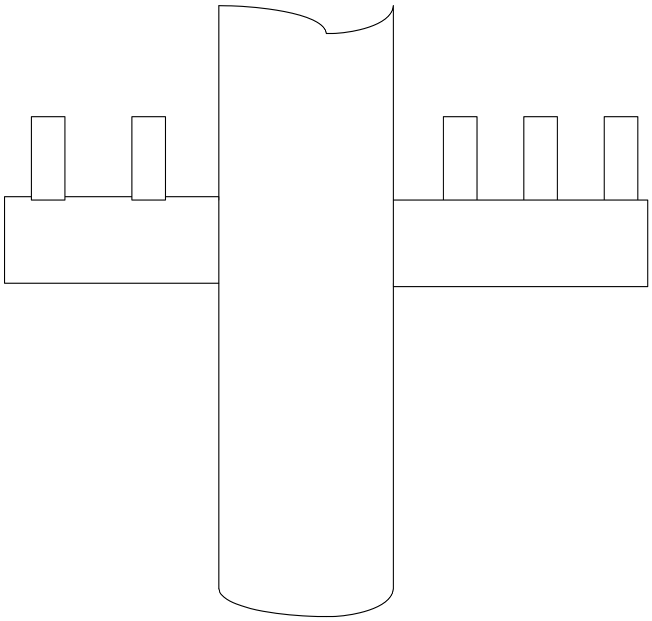
In the NRC information notice, the dynamic pressure drop due to long pipe lengths was a concern. In this work, the pipe length is not the issue as much as considering dynamic losses involved in the fittings and entrances.

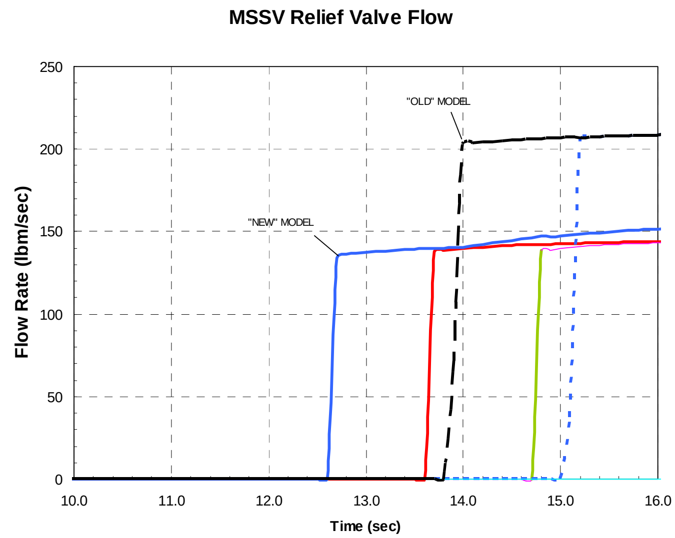
The revised Dominion method uses five separate headers directly attached to the steam line (as shown in the figure). Thus there are five control volumes per steam line with one valve connected to each as an approximation of the actual configuration. This was seen as an acceptable approach since the pipe losses from the steam line into the MSSV header are small. The most significant contribution to the pressure drop occurs at the weld neck flange that forms the entrance into the MSSV header from the valve inlet pipe.

KPS Steam Line Model - MSSV Configuration

This loss was modeled using a formulation for diverging wyes (Handbook of Hydraulic Resistance, "Idel'chik). In this instance the wye is really a Tee consisting of the steam line header as the common channel, and a branch

Dominion Describes MSSV Modeling Support Using RETRAN-3D (Cont'd)



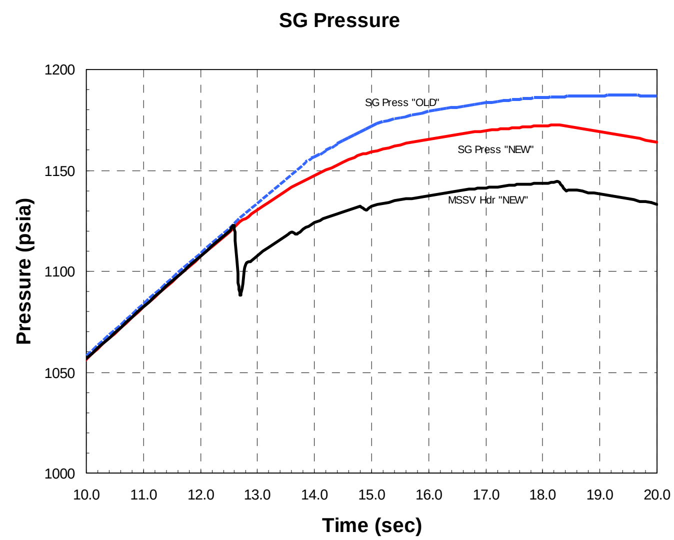


consisting of the valve. This formula allows modeling of the dynamic loss for the different valve opening combinations. The formula requires velocity ratios between the branch and the MSSV header. The header/branch velocity ratio varies (14, 7, 5) depending upon the number of open valves. In this model each valve loss coefficient is very dynamically dependent on the valve configuration and flow rate, (K_f=77, 45, 20), based upon the header velocity.

Dominion reported that even though the K_f varies a great deal, the dynamic pressure drop was fairly uniform (45.2, 45.9 46.1. psid)

For comparison, text book values for sharp edged orifice give K_f = 0.5; translate to a pressure drop of about 26 psid.

The New Result - Less Relief Can be a Good Thing
The LOL/TT was rerun using the newer MSSV model approach. The result is summarized in the two adjoining figures. The 'new' model relief valve flow is contrasted to the 'old' model. The first observation is that the new model shows relief flow earlier into the transient, three valves opening staggered over about a 2 second interval. Even though the relief flow is smaller in the newer model, the relief occurs earlier in the model as the result of the higher pressure drops computed by the dynamic model.
The second figure shows the new model SG pressure response. The MSSV header pressure is also shown for the new model. There is a 15 psi reduction in peak pressure using the new model, by virtue of getting the relief earlier.



A Worthwhile Endeavor
The new KPS MSSV model produces improved and stable results. Although not mentioned above, the addition of several small volumes to an existing system model in RETRAN-02 can have some solution stability implications. Courant limit problems were overcome by increasing the MSSV volumes slightly and reducing the steamline volume accordingly. Reducing the maximum time step slightly then allowed the problem to work very well.

The end result, a 15 psi reduction in peak pressure for a pressure limiting event was well worth the modeling effort. Dominion indicated that this effort was another good reason that using a tool such as RETRAN combined with a trained engineering staff can evaluate and improve plant safety performance.

RETRAN/VIPRE User Group (RVUG) Holds Meeting in Seattle

The Spring 2008 RETRAN/VIPRE User Group (RVUG) Meeting was held at the World Trade Center in Seattle, Washington. The 19 attendees represented eight U.S. utilities, four international organizations, one U.S. commercial vendor, and CSA.

Following introductory remarks by Gregg Swindlehurst, the RVUG Steering Committee Chairman, CSA gave presentations summarizing the status of the VIPRE and RETRAN projects. Each presentation summarized the 2008 fees, budgets, and work scope tasks.

CSA reported on VIPRE-01 code maintenance work including user support, trouble reports, and code installation support. No new trouble reports have been received in 2008. CSA summarized the trouble report activity for 2007.

Two 2007 work scope items were summarized. They include a draft of theVIPRE-01 Model Limitations and Guidelines document, which was finished in March 2008 and placed on the VIPRE web site for review and comment by the VIPER User Group. The URL is:

> *http://www.csai.com/vipre/guidelines/guidelines.pdf*
> Username: vipre
> Password: guest

CSA also presented a demonstration of the VIPRE-01 Excel interface tool that was developed as a visualization tool. The VIPRE-01 data file and the VBA macro were described. A simple result from the VIPRE-01 Sample Problem 1 was used to show the capabilities of the visualization tool.

Maintenance activities for RETRAN-02 and RETRAN-3D were described. A version of RETRAN-3D MOD004.3 was released to RUG members in July 2007. It included 19 error corrections and several new models and features.

The status of both RETRAN-02 and RETRAN-3D trouble reports was given. All RETRAN-02 trouble reports have been resolved and all code modifications that resolve errors have been independently validated.

CSA presented the results of the accumulator model validation effort using test results from LOFT L1-4 isothermal blowdown test and L3-1 small break test.

Technical Presentations
Member organizations made formal and summary presentations of RETRAN and VIPRE activities.

- Rafael de la Fuente, Iberdrola - Qualification of a RETRAN-3D Model for ATWS in Cofrentes NPP
- Hiroshi Kawiai, GISC - PWR Loss of RHR Analysis Using RETRAN-3D
- Gregg Swindlehurst, Duke, Craig Peterson, CSA Oconee Double Main Steam Line Break Without Normal Engineered Safeguards Systems
- John Lautzenheiser, Dominion, Kewaunee RETRAN Model Changes
- Jin-Shou Hseu, WCNOC, Main Steam Line and Main Feedwater Isolation Closure Time Studies
- Yuki Yabushita, CSAJ, Current Status of RETRAN Code In Japan

Steering Committee
Gregg Swindlehurst of Duke Energy is currently serving as the RVUG Steering Committee Chairman. Andres Gomez has served as the international representative, but he recently transferred to a new job within Iberdrola. Rafael de la Fuente, Iberdrola, was selected to be his replacement. Members of the RUG and VUG Steering Committee are

> Gregg Swindlehurst, Duke (Chairman - RETRAN and VIPRE)
> Jorge Arpa, FPL (RETRAN)
> Rafael de la Fuente, Iberdrola (RETRAN)
> John Lautzenheiser, Dominion (RETRAN)
> Steve Love, Westinghouse (RETRAN)
> Daren Chang, STPNOC (VIPRE)
> Kurt Flaig, Dominion (VIPRE)
> Wendell Wagner, WCNOC (VIPRE)

RUG Funds RETRAN-3D Code Modernization Effort

The RETRAN User Group has approved a code modernization project for RETRAN-3D that will extend the shelf life of RETRAN-3D for many years to come. This project is important because as newer compilers and Fortran versions come on line, the RETRAN-3D code structure, developed in the 70's and 80's is increasingly challenged. By eliminating archaic, nonsupported code, this project will extend the life of RETRAN-3D.

A Phased Effort

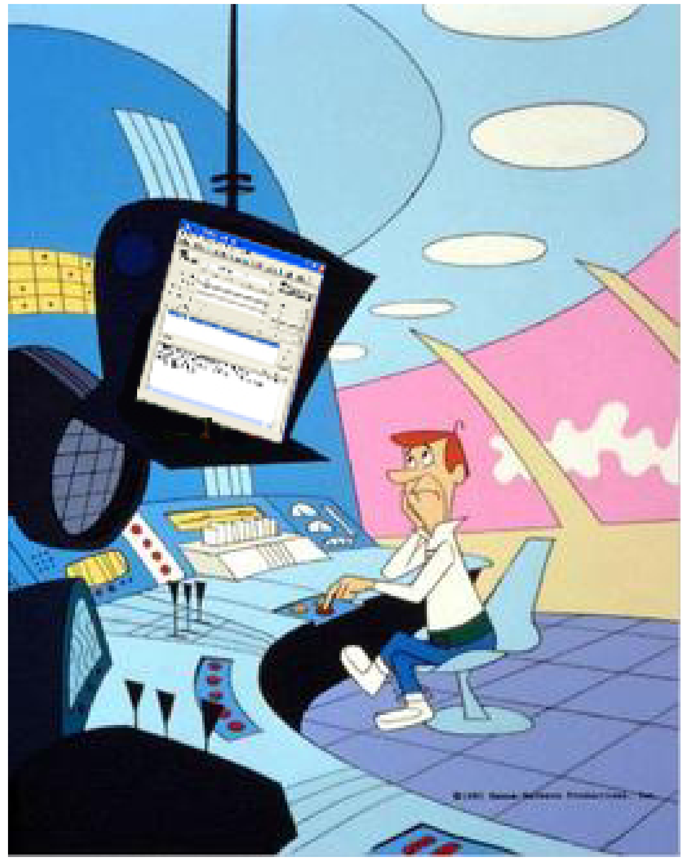
The modernization project consists of four phases. The design and conversion guidelines developed during Phase 1 were completed in 2007. Phase 2 was begun in 2007 and was completed in 2008. Phases 3 and 4 will be completed in 2009.

Phase 2 is a task to convert the RETRAN-3D source code to Fortran 95. As part of the conversion, unused code and variables were removed, assigned go to and computed go to statements were replaced with new control constructs, all variables were explicitly typed, code was converted to use 132 columns with indentation for if, do, and case constructs. Some coding was also restructured to simplify the logic constructs used.

Phase 2 also included a significant effort to replace FTB and the associated equivalence masks with dynamic modules that were prototyped during Phase 1. All FTB variables, subroutine, and function calls were removed and new coding was added that uses the new dynamic memory allocation subroutines.

The restart feature and related functions, e.g., using a restart file to provide time-dependent boundary conditions, have been changed to simplify the restart feature. Since the original major edit subroutines and minor edit variable search were related to the restart file structure, they have been rewritten, resulting in new subroutines that are simpler and will be easier to modify and maintain.

As changes are made, they are compiled and tested by comparison with MOD004.3.

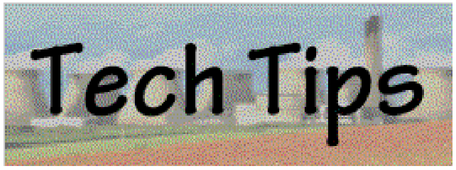


Running RETRAN in 2030

Both Phase 1 and 2 efforts are complete and tested.

Phases 3 and 4 are tasks to convert the one-dimensional and three-dimensional kinetics coding in RETRAN-3D. It was recognized early in the design phase that these models will require an additional effort. For the most part the multidimensional kinetics models in RETRAN-3D have been imported from other codes and the architecture and data storage logic is very different from that developed for the original RETRAN codes. Phases 3 and 4 will be work scope items for 2009.

At the completion of this effort, RETRAN-3D will be a modern code that will take advantage of the features of the new Fortran compilers. As a result the code will be more portable and easier to maintain.



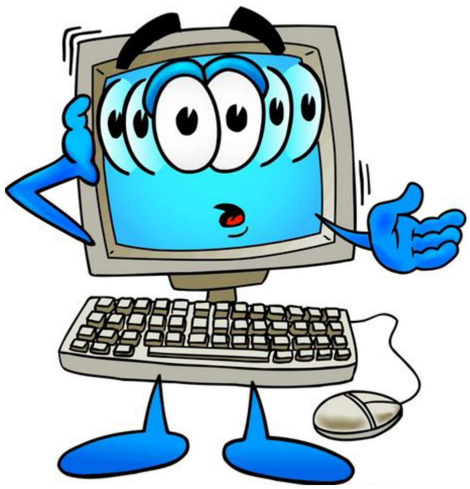
What Does that Darn Warning Message Mean Anyway?

Ever get this message from RETRAN?

**** Warning - Input heat transfer area for Slab (pick a number) is greater than 1.001 Times the maximum implied by the Input Slab Volume and Geometry.*

Then the input area is compared with something called the "Implied MAX."

What does it mean? Should you care? Maybe you've been getting it for 15 years now and nobody ever cares.



Time to explain it.

The RETRAN conductor card (150XXY) requires the user to specify a conductor surface area and a conductor volume. A typical use of a conductor is in the reactor core to specify the fuel rods.

The RETRAN conductor geometry card requires the user to describe the conductor dimensions and material regions. In the core, for example, the geometry card is used to describe the region widths of the fuel, the gap, and the cladding. Here the user describes the conductor geometry at the pin level.

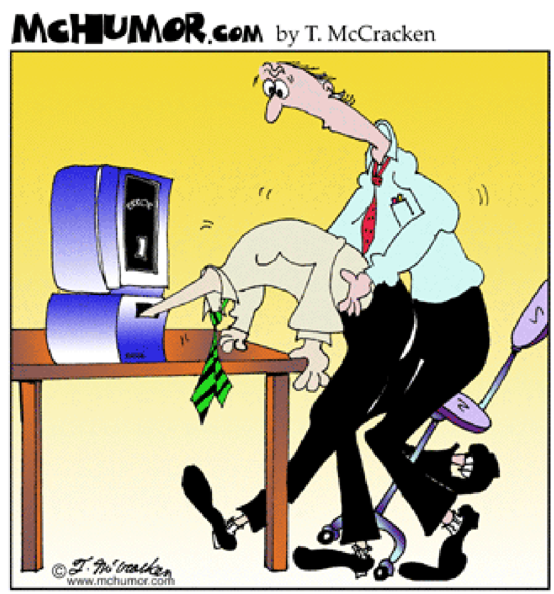
But this may be the beginning of the problem. When the user describes the pin geometry, he is actually over-specifying the conductor. Here's how. RETRAN will interpret the distance to the outer surface of the rod (usually the cladding) and compute what is internally known as a conductor volume per unit height. It looks like a cross sectional area (rod diameter squared times pi over four). But RETRAN will use this value (units of ft3/ft) divided into the total conductor volume (ft^3) supplied on 150XXY to extract an "effective" conductor height (ft) or length. So now RETRAN knows a conductor height as it is implied by the conductor volume.

Next, RETRAN computes a parameter internally known as conductor area per unit height (ft^2/ft). This is simply the conductor perimeter as implied by the rod outer diameter. Finally to perform a consistency check RETRAN computes a conductor surface area as implied by the 'effective' length by dividing the area per unit height the effective height.

This conductor surface area (ft^2) is implied by the conductor volume and the conductor geometric description (the outer rod diameter). Nowhere in this calculation has the code used the actual value of ASUL or ASUR the input value of the conductor surface area.

So to prevent a potential inconsistent specification, the implied area is compared with the input area and if the input area is greater than 1.001 times the implied area.

Now you know the rest of the story....



"Who should I call first?
911 or Technical Support?"

DUKE/CSA Report Solution Improvement with the RETRAN-3D Implicit Nonequilibrium Solution

The Explicit Method
In the RETRAN modeling world users often apply the two-region nonequilibrium volume model (originally developed to model the pressurizer) in the reactor vessel upper head for PWR models. In nearly all applications, the two-region nonequilibrium model uses an explicit solution scheme which works well for most applications. This is the default NUMERICS = 2 option. This refers to the parameter selection on the RETRAN problem dimension record.

The nonequilibrium model has vapor and liquid regions that can coexist at different temperatures and a common pressure. Separate mass and energy equations are explicitly solved for each region. Given the mass (M) and energy (U) for each region, a pressure search is performed that allows both regions to coexist at a common pressure within a single volume.

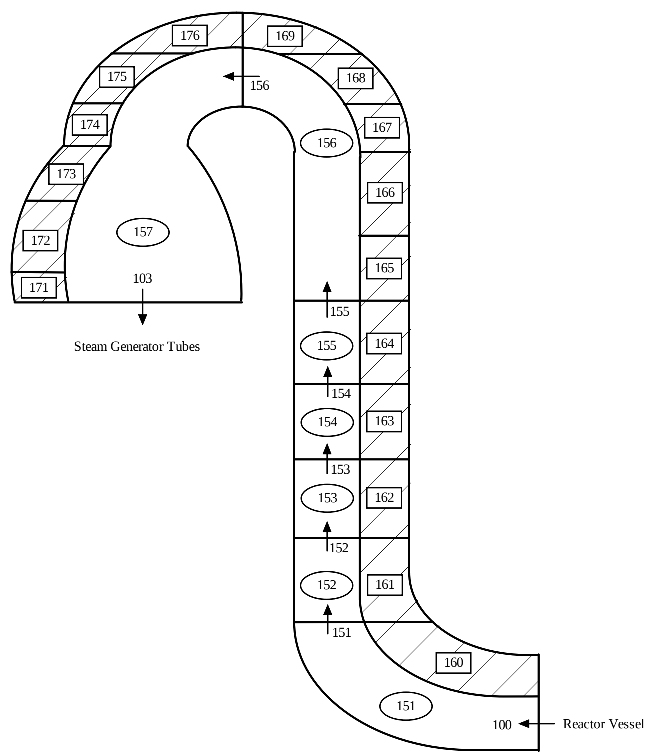
The derivatives of pressure change with respect to M and U are used to linearize the pressure in the flow solution, key in obtaining a stable and converged solution. For a nonequilibrium volume, there are unique values of dP/dM and dP/dU for each region. dP/dM and dP/dU for the vapor differ greatly in magnitude from those for the liquid region and dP/dU for the two regions can have different signs.

The Problem
In prior RETRAN-02 versions, various methods (such as volume or mass weighting methods) have been tried to combine the two-region dP/dM and dP/dU derivatives into a single volume value. These methods did not work very well. What is used to combine derivatives in the RETRAN-02 and RETRAN-3D codes now is to simply sum the region masses and energies to obtain total volume M and U. The total M and U is used as independent state variables to get total volume dP/dM and dU/dM. In other words, as far as these derivatives are concerned, they are computed the same as a normal volume even though the pressure is based on the mass and energy in the two regions. This approach has typically provided a stable solution and allows the nonequilibrium volumes to fill and drain without problems.

Looking for an Implicit Alternative
Duke Energy has applied the RETRAN-3D code to the double ended SLB, which was reported on at the May 2008 User Group Meeting.

The DLSB event is initiated at full power by a guillotine rupture of both steam lines, which begins a severe SG depressurization and RCS cooldown. A loss-of-offsite power is assumed to occur simultaneously with the break causing the control rods to be inserted and the RCPS to coast down. The shutdown margin is sufficient to maintain the reactor subcritical during the cooldown. Nominal decay heat is assumed.

This transient presents a significant challenge for any system transient analysis code such as RETRAN. The challenge occurs after the pumps are tripped, natural circulation flow is established, and the higher regions of the RCS start to void due to RCS inventory contraction. A segment of the DSLB nodalization is shown below where the hot legs are modeled in fine detail. The two top leg volumes, 157 and 156, are nonequilibrium volumes. During the voiding period, the RETRAN slip model allows the liquid to drop to lower regions and the vapor to collect in higher regions. This can make the overall solution difficult. The solution instability is enhanced by frequent periods of loop flow stagnation.



Hot Leg Nodalization

DUKE/CSA Report Solution Improvement with the RETRAN-3D Implicit Nonequilibrium Solution (Cont'd)

During the initial analyses of this DSLB event, code failures prevented the calculation from moving beyond the time of high RCS voiding. The most significant problem was related to the two nonequilibrium volumes in each upper hot leg. These volumes were in the most numerically challenging region of the system model because of phase separation, flow stagnation, and voiding. The culprit was the explicit solution method for the two-region nonequilibrium volumes. The projected pressure changes from the equilibrium derivatives (described above) for these volumes were orders of magnitude different than the pressure changes computed by the two-region nonequilibrium pressure search. This introduced numerical instabilities and time-step control problems that typically lead to code failures

The Implicit Method - A Solution

A solution option in RETRAN-3D (NUMRCS =3 on the problem dimension field), provides an implicit solution for the two-region nonequilibrium volume liquid and vapor balance equations (a six-equation solution). This option uses the region dependent values for dP/dM and dP/dU in the solution scheme, which couples the two-region volume solution with the other volume and junction balance equations. The same solver is used for the five-equation and noncondensable gas flow models but these options are not activated for this analysis. The constitutive models used for energy and mass transfer and the pressure search are the same as for the explicit two-region nonequilibrium solution.

The two-region nonequilibrium volume solution method has been available in RETRAN-3D since it's release, but has had limited testing related only to pressurizer applications and thought problems. Application to the upper hot leg region under these difficult transient conditions identified a few code errors that were related to how the pressurizer constitutive models interface with the solution method. The errors were corrected as they were encountered and have been reported to the RETRAN-3D maintenance project. The analysis presented here uses these corrections which will be included in the next code release.

The use of the implicit two-region nonequilibrium solution method allowed the DSLB calculation to progress through the difficult time period where the standard nonequilibrium volume solution would fail. During the transient, the nonequilibrium volumes would void, leading to a distinct level formation. The volume filled and later re-established levels several times during the transient. Being able to model this behavior was important because voiding and level formation leads to flow stagnation in the steam generators.

The implicit solution uses the region-dependent pressure derivatives and a six-equation formulation for the linearization of the pressure derivatives in the momentum equation solution. This gives an accurate projection of the new time pressure, which also gives an accurate flow solution. On the other hand, the explicit model can give poor estimates for the linearized pressure, which leads to inaccurate flow calculations. This can introduce numerical instabilities and code failures. For these reasons, CSA recommends that the implicit formulation (NUMRCS=3) be used for situations where the flow rates are high enough to significantly affect the mass and energy inventory over a short period, e.g., upper downcomer regions and piping as discussed above. Flows into and out of pressurizers are relatively low and the explicit model generally produces accurate and stable results without restricting the time-step size. The implicit solution method was approved for use by the NRC.

RETRAN Training Sessions Draw Students Worldwide

The June RETRAN session at CSA involved 12 individuals from nine organizations representing a good cross section of the RETRAN user community. These were:

Hongbing Jiang, Ameren
Chad C. King, CSA
Shoichi Suehiro, CSAJ
Timothy J. Drzewiecki, Duke Energy
Andrew Siwy, Duke Energy
Soon- Chung, FNC Tech. Co. Ltd.
Agustin Uruburu Rodriguez, IBERINCO
Robin Jones, Southern Nuclear Operating Co.
Brian Kern, Southern Nuclear Operating Co.
B. Todd Adams, Westinghouse Electric Co.
Christopher S. Trunick, Westinghouse Electric Co.

Congratulations to all of the new RETRAN training graduates.

About This Newsletter

RETRAN Maintenance Program

The RETRAN/VIPRE Maintenance Program is a program that provides for the support of software developed and maintained by CSA. The main features of the Subscription Service include:

- the code maintenance activities for reporting and resolving possible code errors,
- providing information to users through the User Group Meetings and this newsletter, and
- preparing new versions of RETRAN and VIPRE.

The RETRAN Maintenance Program now has 19 organizations participating in the program, including 11 U.S. utilities and six organizations from outside of the U.S. Seven U.S. utilities and three organizations outside the U.S. are currently participating in the VIPRE maintenance program. A Steering Committee, composed of representatives from the participating organizations, advises CSA on various activities including possible enhancements for the code and the scheduling of future code releases. Information regarding the Maintenance Program can be obtained from:

Mark P. Paulsen
Computer Simulation & Analysis, Inc.
P. O. Box 51596
Idaho Falls, ID 83405
paulsen@csai.com or (208) 529-1700

Newsletter Contributions

The RETRAN/VIPRE Newsletter is published for members of the Subscription Service program. We want to use the newsletter as a means of communication, not only from CSA to the code users, but also between code users. If this concept is to be successful, contributions are needed from the code users. The next newsletter is scheduled for 2008 and we would like to include a brief summary of your RETRAN and VIPRE activities. Please provide your contribution to CSA, P. O. Box 51596, Idaho Falls, ID 83405, or to one of the email addresses below by December 4, 2007. We are looking forward to hearing from all RETRAN and VIPRE licensees.

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Garry Gose	gcg@csai.com
Pam Richardson	pam@csai.com

The RETRAN web page is located at

http://www.csai.com/retran/summary.html.

The VIPRE web page is located at

http://www.csai.com/vipre/summary.html

Previous issues of the RETRAN/VIPRE Newsletter are available from the RETRAN or VIPRE web pages.

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Wendell Wagner, WCNOC, wewagne@wcnoc.com

Calendar of Events

User Group Meeting
November 4 & 5, 2008
Juno Beach, Florida
http://www.csai.com/retran/rvug/ugm.html

Basic RETRAN Training Session
June 2009
Idaho Falls, Idaho