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RBG-46124

July 9, 2003

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: River Bend Station, Unit 1
Docket No. 50-458
Supplement to Amendment Request
License Amendment Request (LAR) 2001-43, "High Energy Line Break Analysis Method"

REFERENCES: (1) Letter RBG-45940 to USNRC from P. D. Hinnenkamp dated May 14, 2002

(2) Letter RBG-45985 to USNRC from R. J. King dated June 27, 2002

Dear Sir or Madam:

By letter (Reference 1), Entergy Operations, Inc. (Entergy) proposed a change revising the method of analysis for the High Energy Line Breaks in the subcompartments inside and outside of containment. Reference (2) was in response to discussions with the NRC during June 2002.

In further discussions during January 2003, Entergy and the NRC staff discussed additional information. Entergy is providing this letter as a supplement to the original submittal in order to address the additional questions discussed. The attachment provides the questions discussed and Entergy's response to the 18 questions as discussed.

There are no additional commitments in this information and there are no other technical changes proposed. The original no significant hazards considerations included in Reference 1 is not affected by any information contained in this supplemental letter.

A001
A053

If you have any questions or require additional information, please contact Barry Burmeister at 225-381-4148.

I declare under penalty of perjury that the foregoing is true and correct. Executed on July 9, 2003.

Sincerely,

RJK/BMB

Attachment: Supplemental Information

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Attachment

RBG-46124

Supplemental Information

1. **The May 14, 2002, letter discusses the use of GOTHIC for analyses other than subcompartment analysis. For example, Section 1.0 discusses considering the use of GOTHIC for "other" pressure and temperature analyses. Section 3.0 discusses the use of GOTHIC for EQ analyses.**

   Please confirm that the May 14, 2002 letter is only requesting NRC approval to apply GOTHIC to subcompartment analyses inside and outside containment.

   Response:

   Yes, River Bend only requests NRC approval to apply GOTHIC to subcompartment analyses inside and outside containment. River Bend would request NRC approval prior to use of GOTHIC for licensing / design in accordance with the requirements of 10CFR50.59.

2. **GOTHIC is a mechanistic, best estimate code. However, in using the code for subcompartment pressure and temperature licensing calculations, because of the degree of uncertainty in these analyses, it is important to maintain a degree of conservatism. Discuss the conservatisms included in the HELB subcompartment analyses.**

   Response

   GOTHIC is a general purpose thermal-hydraulics computer program for design, licensing, safety and operating analysis of nuclear power plant containments and other confinement buildings. Applications of GOTHIC include evaluation of containment and containment sub-compartment response to the full spectrum of high energy line breaks within the design basis envelope as described in FSAR Chapter 6, Section 2. Applications may include pressure and temperature determination, equipment qualification profiles and inadvertent system initiation, and degradation or failure of engineered safety features.

   GOTHIC is developed and maintained under the Quality Assurance Plan for Numerical Applications, Inc. (NAI) conforming to 10 CFR 50 Appendix B requirements under the EPRI sponsorship. GOTHIC has been qualified against a wide range of analytical problems and experiments.

   The following are a list of conservatisms included in the HELB subcompartment analyses:

   Conservatisms in Mass & Energy Release calculations:

   - The system pressures were assumed to be the maximum operating pressure not the nominal pressure.
   - The temperatures were also assumed to be higher than the actual operating temperatures.

- Significant conservatism has been added into the mass & energy release calculations by including additional time delays for the isolation valves to close (typically about 7 seconds more than what was assumed in the original calculations).

Conservatisms in the GOTHIC Modeling:

- The input parameters used in the GOTHIC model were calculated conservatively (e.g., volumes, vent path flow areas, flow resistances, heat sinks, etc.).
- A minimal number of vent paths have been modeled for more conservatism. Some potential vent paths, such as the air gaps around the concrete plugs on the top of the RWCU Filter/Demineralizer room were not modeled for the simplicity of the calculations and more conservatism.
- In some cases, the ventilation ducts, if partially blocking the flow paths out of the break room, were assumed to remain in place. This approach conservatively reduced the flow areas of the modeled vent paths and increased the flow resistances.
- Both duct destruction and non-duct destruction cases have been simulated and the actual environmental accident profiles were generated to bound the transient results obtained from both cases.
- Specifically for the subcompartment analyses inside the containment, the GOTHIC run options were set to simulate the THREED options and to be consistent with the SRP guidelines. To obtain realistic but conservative results for the 8-in RWCU line break, the drop-liquid conversion option was enabled. This modeling has been specifically discussed in the May 14, 2002, submittal. For more details, see the responses to Question #3.
- Initial conditions were taken from the most limiting normal conditions from the Environmental Design Criteria (EDC), which is conservative.
- Heat removal by unit coolers is limited to normal operating heat removal rate, and ignores additional heat removal as the room temperatures increase.

3. **It appears that use of the GOTHIC code results in a decrease in conservatism when compared to the current FSAR calculations. For example, FSAR Figure 6.2-54 shows the nodal pressure due to an 8-inch RWCU line break in the RWCU Filter Demineralizer Room. The previously calculated peak pressure was 35.42 psia at 27.6 seconds. The GOTHIC-calculated peak pressure is 24.97 psia at 30.4 seconds. Explain what assumptions or model differences cause this difference in calculated peak pressure. Does the assumption of friction in the blowdown play a role? Is the new result a best estimate value? If not, what conservative assumptions or models are included in the GOTHIC calculation of the pressure in revised Figure 6.2-54? If the calculation is best-estimate, justify why it is not necessary to add margin for a licensing calculation.**

Response

The revised FSAR Figure 6.2-54 results (8-inch RWCU line break in the Filter/Demineralizer room) show that the peak pressure in the RWCU Filter/Demineralizer room is about 10 psi lower than the original peak value. This difference was caused by crediting friction in the mass and energy release calculations and enabling drop-liquid conversion in the GOTHIC model. By enabling the drop-liquid conversion, the fraction of the drop phase in the break room was reduced, which reduced the drop phase fraction flowing through the vent paths exiting the break room and then reduced the flow resistance through the vent paths. In other cases, this GOTHIC option would cause negligible impact on the results. The 8-inch RWCU line break case was very sensitive to this option because the volume of the break room was very small, the blowdown rates were very high, and the total flow areas of the vent paths out of the break room were also relatively small. Crediting of friction reduced the magnitude of the blowdown rates, which reduced the peak pressure in the break room.

Due to the reduced peak pressure for the 8-inch RWCU line break, River Bend's 5/14/2002 letter specifically discussed this case with some discussion on the drop-liquid conversion option in the GOTHIC model. Use of this option in the GOTHIC modeling was considered appropriate based on the following reasoning in addition to the conservatisms discussed in the responses to Question #2:

- According to the fluid conditions inside the RWCU system, the majority of the blowdown fluid at the beginning was at low temperature. The lowest temperatures were conservatively assumed to be at 122.7°F (under normal operating conditions, the lowest temperature is at 115°F). For conservatism, the GOTHIC model would turn the blowdown fluid into the drop phase. If the drop-liquid conversion option was not turned on, the drop phase would remain and raise the drop phase fraction in the break room quickly due to the small size of the room. Provided the initial low temperature of the blowdown fluid, it is reasonable to assume that the low temperature water would remain in the liquid phase and accumulate on the floor. If properly modeled, the cold water actually could also suppress the later high temperature blowdown fluid since the break location was very close to the floor (the 8-inch line break is at the bottom of the RWCU Filter/Demineralizer tank).

- It is conservative not to credit the air spaces along the peripheral of the concrete plugs, which cover the whole ceiling of the Filter/Demineralizer room.

- The original design calculation left no margin to the design limit (21 psid). The peak pressure was already at 35.42 psia or 21.18 psid. The original licensing basis considered the peak pressure still acceptable since it only slightly exceeded the design limit (0.18/21 = 0.86%). Thus, it was desirable to adopt an appropriate alternative method to clearly demonstrate margin to the acceptance limit.

- The design limit of 21 psid was based on the structural design calculations. Design Engineering has reviewed the calculations and a preliminary evaluation for the RWCU Filter/Demineralizer room wall indicated that the walls could withstand a room pressure up to 60 psid. However, this alternative involves revision to a number of design calculations and is resource intensive, thus it was decided to not pursue this option.
- Due to the relatively smaller size of the RWCU Filter/Demineralizer room, the 8-inch line break only generated high peak pressure in the break room. The peak pressures in other nodes were still close to atmospheric pressure. Therefore, the 8-inch RWCU line break has negligible impact on the rest of the containment.

Therefore, it is considered to be appropriate to use the drop-liquid conversion option for the 8-inch RWCU line break case given all other conservatisms in the above discussion.

4. **The benchmarking discussed in the May 14, 2002 letter tried to simulate, using GOTHIC, the results previously obtained with THREED for a 6-inch double-ended rupture of an RWCU line. In order to assist in illustrating the degree of conservatism in the proposed use of GOTHIC, please provide a GOTHIC calculation for the same case, using the assumptions and models proposed in the May 14, 2002 letter for future licensing applications (e.g., pipe friction, vent destruction, entrainment, 100% revaporization, heat transfer coefficient, etc.).**

<u>Response</u>

The benchmark model and the new GOTHIC model for the subject 6-inch double-ended rupture of an RWCU line discussed in the 5/14/2002 letter are quite similar. The differences between the two are:

- The volume, junction, and heat conductor inputs for the benchmark run are taken from the current analysis. The values in the proposed revision are slightly different as they are based upon as-built information. These differences are not expected to contribute significantly to the differences between the two sets of results.
- The mass and energy release rates are different as the new release rates account for extended logic delay and blow down friction losses.
- The benchmark model forces 100% entrainment. The proposed revision has the drop-liquid conversion model enabled, with the drop breakup model enabled.

Thus the data provided in the 5/14/2002 letter provides the information requested. Therefore, the existing calculations have already provided sufficient benchmarking evidence that GOTHIC is appropriate for the proposed applications.

5. (a) **Will friction be assumed in all mass and energy input calculations? If not, what determines whether or not friction will be included?**

(b) **The use of friction is based on an analysis method developed by F J Moody and described in the August 1966 Journal of Heat Transfer. This method, as acknowledged by the author and discussed in the peer review, has several sources of uncertainty. What, if any, conservatisms are connected with the proposed use of this model for licensing calculations?**

(c) **If friction were not included, would the peak and differential pressures still be acceptable?**

<u>Response</u>

(a) River Bend has credited friction for the mass and energy release calculations supporting the subcompartment analyses.

(b) The uncertainties associated with the subject method have been addressed by incorporating more conservatism into the mass and energy release calculations, such as using the maximum system pressures instead of the nominal pressures, assuming higher blowdown fluid temperatures, estimating less friction, including more delay times, etc. Note that the original design and licensing basis credits friction for some HELB's (e.g., RCIC and RHR line breaks), which was based on the frictional Moody flow (Reference: Lahey, R. T. and Moody, F. J., The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, ANS, 1977).

(c) In some cases, credit for friction is required to demonstrate acceptable pressurization, especially for some of the existing HELB Mass and Energy release calculations documented in the RBS SAR that have already credited friction.

6. **Section 4.3.2 of the May 14, 2002, letter states that the vent path parameters were set to zero entrainment which is consistent with Standard Review Plan Section 6.2. However, Standard Review Plan Section 6.2.II.B.4 states that the vent flow should be calculated based on a homogeneous mixture in thermal equilibrium with the assumption of 100% entrainment.**

(a) **Please explain this difference.**

(b) **Why is 0% entrainment conservative?**

(c) **How is water in the subcompartment atmosphere modeled (dispersed liquid water, aerosols, other)? What size is assumed for liquid drops? Why is the modeling of liquid in the atmosphere conservative?**

Response:

(a) The zero entrainment in the 5/14/2002 letter actually means zero de-entrainment fraction for the drop flow (i.e., 100% entrainment) in the GOTHIC model.

(b) See response to Item (a).

(c) In GOTHIC, water in the subcompartment is modeled in three phases (steam/gas mixture, continuous liquid and liquid droplet). The liquid drops were generated by enabling the drop breakup model and is somewhat insensitive to the assumed initial drop sizes. Drop modeling is described in the Section 8.7 of the GOTHIC 7.0 Technical Manual.

7. **Verify that the guidance of Standard Review Plan Section 6.2.1 2.II.B.1 is satisfied for initial conditions which maximize the calculated pressure differential.**

Response:

Yes, the guidance of Standard Review Plan Section 6.2.1 2.II.B.1 is satisfied for initial conditions which maximize the calculated pressure differential. The original calculations assumed initial conditions consistent with maximal, normal operating conditions assumed for equipment qualification. This practice was continued in the revised calculations. Note that model changes, such as specified initial parameter values, are input changes which will be controlled by the River Bend 10CFR50.59 program.

8. **Verify that the noding satisfies Standard Review Plan Section 6.2.1 2.II.B.2.**

Response:

Yes, the noding satisfies Standard Review Plan Section 6.2.1 2.II.B.2. The noding schemes in the revised subcompartment analyses were kept almost the same as in the original licensing bases calculations. With respect to the Auxiliary Building subcompartment analyses, the number of nodes has been chosen such that there is no substantial pressure gradient within a node. Different noding schemes have already been simulated in the original subcompartment analyses for sensitivity studies.

With respect to the subcompartment analyses inside the containment, only the break room and the small rooms adjacent to the break room were impacted by the postulated breaks. Therefore, it is not necessary to divide the rest of the containment into more nodes as the containment is a rather large open volume relative to the small subcompartments.

Note that the noding schemes should also be considered as the input parameters to the subcompartment analyses and controlled under the River Bend 10CFR50.59 program.

9. **Section 4.3.1 of the May 14, 2002 submittal states that two cases are considered for an HELB: duct destruction and non-duct destruction. The duct destruction case generates more limiting pressure/temperature transients for the subcompartments close to the break room while the non-duct destruction case generates more limiting pressure/temperature transients for the subcompartments that are not adjacent to the break room. The most limiting pressure/temperature transient is used for each subcompartment. Small duct flow paths are not considered.**

   (a) **Verify that changes in vent flow paths which are not immediately available at the time of pipe rupture satisfy the guidance of Standard Review Plan Section 6.2.1 2.II.B.3.a and 6.2.1 2.II.B.3.b.**

   (b) **Although the duct destruction case would result in a higher pressure in the adjacent room, won't it then result in a lower pressure in the break room? Please explain.**

   (c) **Explain how the non-duct destruction case is more conservative for rooms not adjacent to the break room.**

   (d) **If not included in response to Question 9(a), explain how the area of the crushed (destructed) duct is determined and the data or analyses that support the values chosen. In addition, explain why the assumption of an instantaneous duct destruction is conservative?**

   (e) **Would acceptable results be obtained if duct destruction were not assumed?**

   (f) **Is duct destruction part of the current licensing basis for River Bend?**

   <u>**Response:**</u>

   (a) Due to the lack of all the detailed experimental data, it is not feasible for River Bend to model all the changes in the vent flow paths which are not immediately available at the time of the postulated pipe rupture. As an alternative method, River Bend adopted the method that simulated both cases with and without duct destruction. As discussed in the following responses, this alternative method satisfies the guideline of SRP Section 6.2.1.2.II.B.3.a and 6.2.1.2.II.B.3.b.

   (b) Duct destruction due to the high energy line breaks was limited to the room in which the break occurred, therefore creating new penetrations to adjacent rooms. The duct destruction case would result in higher pressures in the adjacent rooms, but would generate a lower pressure in the break room.

   (c) The non-duct destruction case credits vent paths directly connecting the break room with the rooms not adjacent to the break room, which would result in more limiting accident conditions in those rooms.

(d) As discussed in (a) and (b), the duct destruction case would generate more limiting results for the rooms adjacent to the break room. The non-duct destruction case would generate more limiting results for the break room and the rooms not adjacent to the break room. Further, the destructed duct flow areas were calculated to be the same as the duct cross-section flow areas, which would generate more limiting results in the adjacent rooms. However, the specified destructed duct flow areas would have no impact on the limiting accident condition for the break room since it was based on the non-duct destructive case.

(e) If the duct destruction were not modeled, the limiting conditions for the break room would still be valid, which are more limiting than the accident conditions in any other room. However, the results obtained for some rooms adjacent to the break room may not be bounding. Therefore, River Bend considered it was more appropriate to consider both cases in determining the limiting pressure / temperature responses for a particular room.

The following table shows that the alternative method would generate more conservative results than the method described in SRP section 6.2.1.2.II.B.3.a and 6.2.1.2.II.B.3.b.

	Most Limiting Conditions		
	Break Room	Rooms Adjacent to Break Room	Rooms Not Adjacent to Break Room
Duct Destruction Only		X	
SRP Method			
Non-Duct Destruction Only	X		X
Alternative Method	X	X	X

In practice, both duct destruction and non-duct destruction are considered for each break in the Auxiliary Building. As there are four breaks evaluated, this results in eight cases to evaluate. Thus for each volume modeled there are eight sets of pressure and temperature responses. In this manner, the limiting temperature and pressure response for each volume is identified.

(f) As part of the sensitivity studies in the original subcompartment analyses for the current licensing basis for River Bend, the duct destruction cases were postulated. However, no discussion on duct destruction exists in the River Bend SAR and SER. Since the revised subcompartment analyses would generate more limiting results, it has been determined that the current licensing basis was not impacted.

10. Specify how the flow inertia, Σ(L/A), is determined for the vent flow paths.

<u>Response:</u>

The flow inertia defined in GOTHIC model is different from the inertia defined in THREED. The THREED computer program was developed based upon the RELAP4 computer program and as such the flow inertia is determined in a similar manner.

The user input for the flow inertia in GOTHIC is an inertia length (L). This is described in Section 8.1.3 of the GOTHIC 7.0 User's Manual and in Section 4.1 of the GOTHIC 7.0 Technical Manual. The flow path inertia inputs for the HELB analyses were determined consistent with the directions in the GOTHIC User's Manual.

11. How is heat transfer to structures modeled? Is credit taken for structures in the room besides the walls? Is credit taken for the velocity of the containment atmosphere in determining the heat transfer coefficients?

<u>Response:</u>

Heat sinks are simulated in the proposed high energy line break analyses using GOTHIC thermal conductors. Heat transfer modes simulated are condensation and convection. The Uchida condensation heat transfer coefficient was modeled, which is consistent with the current licensing basis.

The heat sinks credited in the proposed analyses are consistent with those in the current analyses. The bulk of heat sinks modeled are concrete walls, however, some of the steel is modeled such as floor gratings, beams, posts, stairs, platforms, and in the case of the breaks in containment, the containment shell. No credit is taken for piping, ducting, or conduit as potential heat sinks.

The heat transfer coefficients could be affected by the velocity of the containment atmosphere since the convective heat transfer option was enabled. However, the impact is deemed to be negligible as the condensation heat transfer is dominant for the postulated high energy line breaks.

12. **Section 4.3.2 of the submittal summarizes the results in the RWCU Heat Exchanger room with a peak pressure of 16.286 psia and a peak differential pressure of 1.627 psid. In Table 6.2-16 this differential pressure is shown to be for the 4-inch break, with the 6-inch break having a value of 1.488 psid. Is the peak pressure also for the 4-inch break? Tables 6.2-26 and 6.2-29 only list the differential pressure results, not the peak pressures. Provide a summary of the RWCU Heat Exchanger room calculations for each break analyzed given both the peak pressure and differential pressure results.**

<u>Response:</u>

The summarized results in the 5/14/2002 letter were based on the following detailed result:

Cases	Peak Pressure (psia)	Peak Differential Pressure (psid)
4-inch DER in RWCU Hx Room (RH = 0%)	16.077	1.627*
4-inch DER in RWCU Hx Room (RH = 100%)	15.832	1.234
6-inch DER in RWCU Hx Room (RH = 0%)	15.975	1.488*
6-inch DER in RWCU Hx Room (RH = 100%)	16.286*	1.101

* Values summarized in the 5/14/2002 letter. Note the peak differential pressures may not necessary be equal to (peak pressure – 14.7 psia) since they were calculated based on the actual differential pressures between two adjacent nodes.

13. **Please verify that the input values provided to the NRC are the same as those used for the analyses reported in the May 14, 2002 letter, in particular, the number of points used for the mass and energy input vs. time.**

<u>Response:</u>

All of the analyses were reviewed to ensure that the mass and enthalpy values reported in the May 14, 2002 letter are consistent with the values used in the HELB analysis. The following is the result of that review:

<u>4 Inch RWCU Line Break in the RWCU Heat Exchanger Room (Containment)</u>

The mass and enthalpy values used in the GOTHIC analysis are the same as those provided in the proposed USAR Table 6.2-12 contained in the May 14, 2002 letter.

6 Inch RWCU Line Break in the RWCU Heat Exchanger Room (Containment)

The mass and enthalpy values used in the GOTHIC analysis are the same as those provided in the proposed USAR Table 6.2-28 contained in the May 14, 2002 letter with the exception that there is no point provided for the downstream blowdown flow returning to zero when in fact the flow does go to zero at 2.7903 seconds. A new point will be added to Table 6.2-28 as follows:

Time (sec)	Flow (lbm/sec)	Enthalpy (BTU/lbm)
2.7903	0.0	419.0

8 Inch RWCU Line Break in the RWCU Filter / Demineralizer Room (Containment)

The mass and enthalpy values used in the GOTHIC analysis are the same as those provided in the proposed USAR Table 6.2-31 contained in the May 14, 2002 letter.

3 Inch RWCU Line Break in the Auxiliary Building

The mass and enthalpy values used in the GOTHIC analysis are slightly different from those provided in the proposed USAR Table 3B-7 contained in the May 14, 2002 letter. The reason for the difference appears to be the use of a preliminary mass blowdown function which essentially bounds the mass blowdown function presented in USAR Table 3B-7. A revised Table 3B-7 is provided. Note that the table is also changed to provide the time dependent enthalpy (BTU/lbm) instead of time dependent energy (BTU), as enthalpy is used in the input to the HELB model.

6 Inch RWCU Line Break in the Auxiliary Building

The mass and enthalpy values used in the GOTHIC analysis are slightly different from those provided in the proposed USAR Table 3B-8 contained in the May 14, 2002 letter. The reason for the difference appears to be the use of a preliminary mass blowdown function which essentially bounds the mass blowdown function presented in USAR Table 3B-8. A revised Table 3B-8 is provided. Note that the table is also changed to provide the time dependent enthalpy (BTU/lbm) instead of time dependent energy (BTU), as enthalpy is used in the input to the HELB model.

4 Inch RCIC Line Break in the Auxiliary Building

The mass and energy values used in the GOTHIC analysis are those provided in the proposed USAR Table 3B-9 contained in the May 14, 2002 letter. However, a revised Table 3B-9 is provided to show the time dependent enthalpy (BTU/lbm) instead of the time dependent energy (BTU), as enthalpy is used in the input to the GOTHIC HELB model.

8 Inch RHS Line Break in the Auxiliary Building

The mass and energy values used in the GOTHIC analysis are those provided in the proposed USAR Table 3B-10 contained in the May 14, 2002 letter. However, a revised Table 3B-10 is provided to show the time dependent enthalpy (BTU/lbm) instead of the time dependent energy (BTU), as enthalpy is used in the input to the GOTHIC HELB model.

As a result of the differences in the mass and energy releases identified above, the Auxiliary Building HELB analysis was re-performed, resulting in revised Figures 3B-27, 3B-28, 3B-29, and 3B-30.

14. Please describe how the mass and energy values were calculated (computer code and important assumptions).

Response:

No computer code was used for the mass and energy release calculations in the revised subcompartment analyses. The mass and energy blowdown calculation was similar to the method described in the original licensing bases subcompartment analyses.

A typical mass and energy blowdown calculation would have the following calculation steps:

1. First the most limiting break location was identified.
2. For the postulated double-ended rupture, both the upstream and downstream flow paths were then identified.
3. The inventory depletion flow rate was calculated first. Friction did not play a role during the inventory depletion period. The time for inventory depletion period was calculated as (Inventory mass) / (inventory depletion flow rate).
4. After the inventory depletion period, the steady-state blowdown rates were calculated. Friction is credited for the calculation of steady-state blowdown flow rates.
5. After all the blowdown flow rates and the blowdown time have been calculated, the upstream and downstream blowdown rates were then tabulated versus the blowdown time.

The following are some important assumptions used in the mass and energy blowdown calculations:

1. If the fluid condition was saturated, use the Moody Critical Flow Model to obtain the critical flow rate. If the fluid condition was subcooled, use the Henry subcooled Critical Flow Model to obtain the critical flow rate.

2. The pressure of the fluid is assumed to remain constant before and during the depletion period, which was conservative.
3. The upstream blowdown calculation included the additional steady-state flow through the isolation valve. The blowdown period was determined by the closure time of the isolation valves, which was calculated conservatively (typically 7 seconds more than the closure time assumed in the current licensing basis).
4. Although the isolation valve may have already been fully closed before the depletion of all the fluids up to the isolation valve, the whole blowdown period through the isolation valve was still included, which generated more conservative results.

15. If GOTHIC is to be used for EQ calculations,

(a) Describe what assumptions/models are used to ensure a conservatively high temperature,

Response

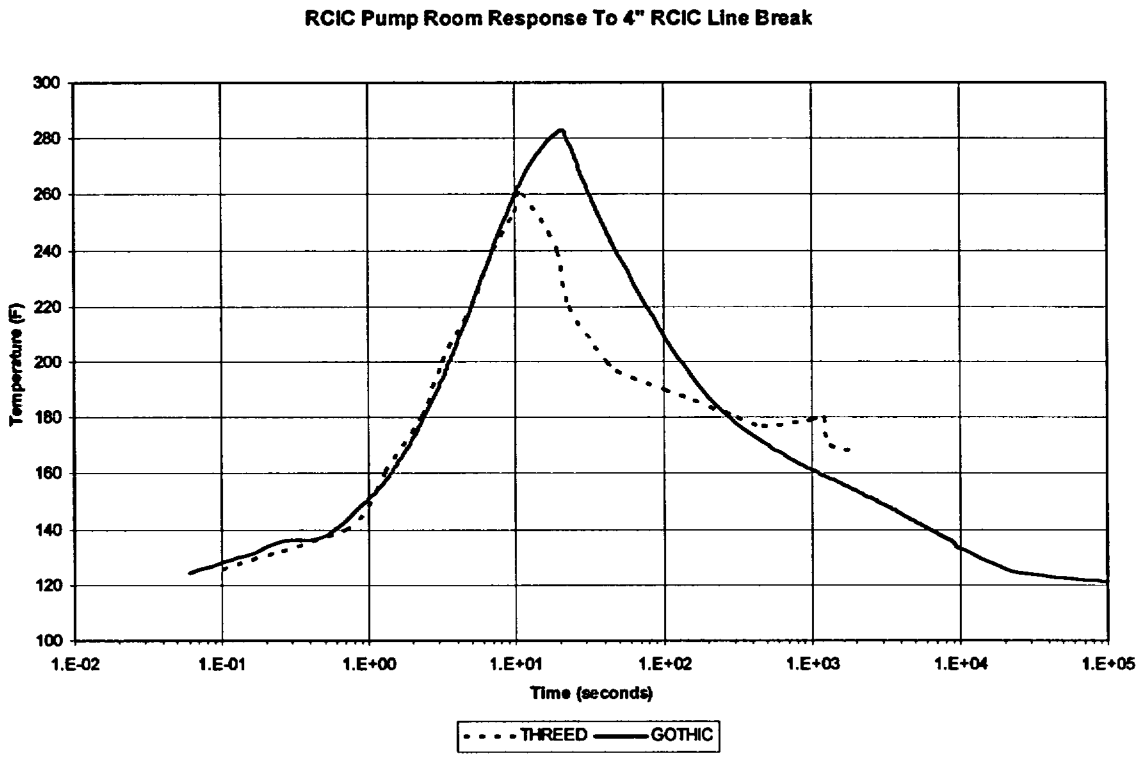
The GOTHIC calculations contain the following conservative assumptions

- All the accident initial conditions were based on the most limiting EDC normal conditions which bound the expected maximum operating conditions.
- The Auxiliary Building safety-related unit coolers are assumed to remove only the normal operating heat loads from piping, equipment, etc. and are not credited for removing additional heat due to the high energy line break.
- The mass and energy releases assume isolation logic delays that bound the current plant configuration.

(b) Provide a comparison of temperature calculation using GOTHIC with a previous calculation for the same case and explain any differences.

Response

The THREED results are not available in an electronic format. Therefore, a number of points were taken from the graphs found in the original HELB analysis to capture the nature of the RCIC pump room transient temperature response to a break in the 4" RCIC steam line. These points are plotted with the results obtained with GOTHIC in the figure below:



As can be seen the responses are quite similar during the early phase of the event. The differences in the peak values are due to the increase in the time delay assumed prior to initiating isolation of the break. The GOTHIC analysis shows that the room cools down a bit further than the THREED analysis (160 °F versus 180°F at 1,000 seconds). This is due largely to more of the actual Auxiliary Building free volume being modeled in the GOTHIC analysis. The heat is dissipated into the additional volume, thus allowing the temperature to reduce further relative to the THREED results.

16. **Section 9.2.2 of the GOTHIC Technical Manual describes a compressibility factor which increases the drag to account for the expansion of the fluid as it flows through an orifice (opening). Was this compressibility factor used in the River Bend calculations? If not, how is the increased drag due to compressibility accounted for?**

Response

The compressible flow option was enabled for all junctions in the Auxiliary Building high energy line break analysis, and in the analysis of a reactor water cleanup (RWCU) system line break inside the RWCU heat exchanger room in containment. The compressible flow option was not enabled for any junction in the analysis of an RWCU line break inside the RWCU filter / demineralizer room in containment. While it would appear that the compressible flow option should have been selected for all junctions in the analysis of an RWCU line break inside the RWCU filter / demineralizer room in containment, it should be noted that the affect of enabling compressible flow in this analysis is negligible. A sensitivity case identical to the

RWCU line break in the RWCU filter / demineralizer room, but with the compressible flow option selected for all flow paths was executed to confirm that there is negligible impact on the room pressures and temperatures.

17. **Please explain how the assumption of 100% entrainment is met if the drop liquid conversion model is used. Please reference pertinent sections of the GOTHIC manuals.**

<u>Response</u>

The 100% water entrainment assumption discussed in NUREG-0800, 6.2.1.2.II.B.4 is not necessarily met with the drop-to-liquid option enabled. However, sensitivity studies indicate that the effect of enabling the drop-to-liquid model is only significant if break fluid is highly subcooled. In the case where the liquid is subcooled below the saturation temperature in the break room it is expected that a portion of the break fluid will deposit in a pool as opposed to remaining as drops suspended in the vapor phase. For this reason the use of the drop-to-liquid model is appropriate.

The drop–liquid phase transformation modeling in GOTHIC 7.0 is described in Section 8.7 of the GOTHIC 7.0 Technical Manual (NAI 8907-6, Rev. 12). Qualification of this modeling is discussed in Section 6 of the GOTHIC 7.0 Qualification Report (NAI 8907-09, Rev. 6).

18. **The staff is trying to assess the differences between the currently accepted THREED code and the GOTHIC code for the 8-inch RWCU break. The use of the GOTHIC models appears to reduce the peak pressure (and differential pressure) by about 10 psi.**

CONTAIN analyses were performed by the staff based on the current guidance in the SRP for subcompartment loads analyses. A comparison of CONTAIN to THREED results for the current USAR case shows very good agreement indicating the two models are comparable.

Studies performed by the staff with the CONTAIN code indicate that the new flow paths would have resulted in an increase in the peak pressure of about 1.7 psi based on the mass and energy releases in the current USAR, above 1 psi over the design limit.

With the revised mass and energies and the USAR flow paths, the peak pressure is reduced by about 3.3 psi when compared to the current USAR case.

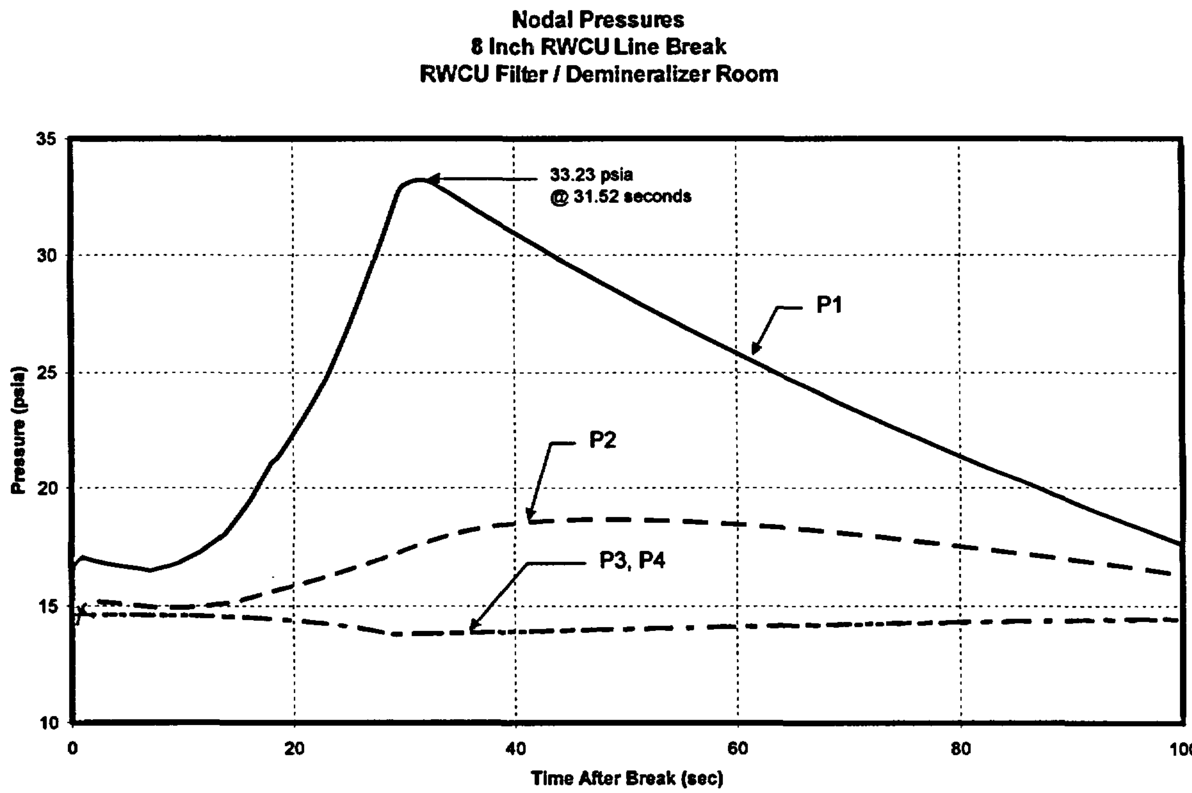
With the new flow paths and the new mass and energies, the peak pressure is reduced by about 2.3 psi when compared to the current USAR case, about 3 psi below the design limit. The differential pressure is about 2.7 psi below the design limit.

The differences between GOTHIC and CONTAIN appear to be attributed to the models in GOTHIC which allow part of the break mass (and energy) to be directed to a liquid pool and not contribute to the increase in the pressure.

To assist the staff, please perform a GOTHIC analysis which sets the liquid-drop conversion flag to "Ignore." This will provide a basis for understanding the magnitude of this GOTHIC feature.

Response

As requested, the case described above has been run, and a plot of nodal pressures, similar to that provided in the May 14, 2002 letter, is provided here. However, it is the EOI position that the results provided here are for information only, and the results provided in the May 14, 2002 letter represent the "Analysis of Record" for this line break for the reasons discussed in the response to Question 17. Therefore, enabling the drop-to-liquid conversion option is appropriate for breaks involving highly subcooled fluid.



In addition, the peak differential pressure across the RWCU Filter / Demineralizer Room walls was calculated to be 19.417 psid.