January 23, 2001

Mr. Mark Reddemann
Site Vice President
Kewaunee and Point Beach Nuclear Power Plants
Nuclear Management Company, LLC
6610 Nuclear Road
Two Rivers, WI 54241

SUBJECT: KEWAUNEE NUCLEAR POWER PLANT - REQUEST FOR ADDITIONAL INFORMATION RELATED TO RELOAD SAFETY EVALUATION METHODS TOPICAL REPORT, WPSRSEM-NP, REVISION 3 (TAC NO. MB0306)

Dear Mr. Reddemann :

By letter dated October 12, 2000, Nuclear Management Company, LLC (NMC or the licensee) forwarded a topical report WPSRSEM-NP, Revision 3, entitled, "Reload Safety Evaluation Methods for Application to Kewaunee" and requested Nuclear Regulatory Commission (NRC) staff review and approval. Also, the topical report is intended to be applicable to Kewaunee reload cycles after and including Cycle 25, presently scheduled to commence in the fall of 2001.

The topical report reflects the following:

- Editorial changes, including corrections to the limiting directions of core physics parameters and clarification of the definition of core physics parameters.
- Changes made to incorporate the CONTEMPT code for containment analysis. CONTEMPT is currently described for this purpose in the Kewaunee updated safety analysis report (USAR).
- The adoption of the GOTHIC code for containment analysis.
- Changes in Reload Safety Evaluation Methods due to Large Break Loss-of-Coolant Accident Upper Plenum Injection Analysis.
- The adoption of RETRAN- 3D for use in the 2D mode for system analysis.
- The extension of the VIPRE-01 code to reflect changes in fuel design.

The NRC staff finds that the additional information identified in Enclosure 1 is needed.

A draft of the request for additional information (RAI) (Enclosure 2) was e-mailed to Mr. G. Riste (NMC) and discussed by telephone call on January 4, 2001. Enclosure 2 contains a portion of the NRC safety evaluation report regarding the forthcoming Electric Power Research Institute (EPRI) report NP-7450(P), Revision 4, "RETRAN-3D - A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems." Another phone call was held on January 9, 2001, between the NRC staff and the NMC staff to discuss the questions to ensure that there was no misunderstanding.

Also, the phone call on January 9, 2001, established that February 1, 2001, would be a mutually agreeable response date.

Please contact me at (301) 415-1446, if future circumstances should require a change in this response date.

Sincerely,

/RA/

John G. Lamb, Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-305

Enclosures: 1. Request for Additional Information
2. E-mail with Draft Request for Additional Information

cc w/encls: See next page

Please contact me at (301) 415-1446, if future circumstances should require a change in this response date.

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REQUEST FOR ADDITIONAL INFORMATION REGARDING

KEWAUNEE RELOAD SAFETY EVALUATION METHODS TOPICAL REPORT,

WPSRSEM-NP, REVISION 3 (TAC NO. MB0306)

By letter dated October 12, 2000, Nuclear Management Company, LLC (NMC or the licensee) forwarded a topical report WPSRSEM-NP, Revision 3, entitled, "Reload Safety Evaluation Methods for Application to Kewaunee" and requested Nuclear Regulatory Commission (NRC) staff review and approval. Also, the topical report is intended to be applicable to Kewaunee reload cycles after and including Cycle 25, presently scheduled to commence in the fall of 2001.

The topical report reflects the following:

- Editorial changes, including corrections to the limiting directions of core physics parameters and clarification of the definition of core physics parameters.
- Changes made to incorporate the CONTEMPT code for containment analysis. CONTEMPT is currently described for this purpose in the Kewaunee updated safety analysis report (USAR).
- The adoption of the GOTHIC code for containment analysis.
- Changes in Reload Safety Evaluation Methods due to Large Break Loss-of-Coolant Accident Upper Plenum Injection Analysis.
- The adoption of RETRAN- 3D for use in the 2D mode for system analysis.
- The extension of the VIPRE-01 code to reflect changes in fuel design.

The NRC staff finds that the following additional information is needed:

A. As a result of generic review of the RETRAN-3D code, the NRC staff limits the use of the code to certain conditions. Address your compliance with each item of the following conditions identified for use of RETRAN-3D computer code:

1. Multidimensional neutronic space-time effects cannot be simulated as the maximum number of dimensions is one. Conservative usage has to be demonstrated.

2. There is no source term in the neutronics and the maximum number of energy groups is two. The space-time options assume an initially critical system. Initial conditions with zero fission power cannot be simulated by the kinetics. The neutronic models should not be started from subcritical or with zero fission power without further justification.

3. A boron transport model is unavailable. User input models will have to be reviewed on an individual basis.

4. Moving control rod banks are assumed to travel together. The boiling-water *reactor (BWR)* plant qualification work shows that this is an acceptable approximation.

5. The metal-water heat generation model is for slab geometry. The reaction rate is therefore underpredicted for cylindrical cladding. Justification will have to be provided for specific analyses.

6. Equilibrium thermodynamics is assumed for the thermal-hydraulics field equations although there are nonequilibrium models for the pressurizer and the subcooled boiling region.

7. While the vector momentum model allows the simulation of some vector momentum flux effects in complex geometry, the thermal-hydraulics are basically one-dimensional.

8. Further justification is required for the use of the homogeneous slip options with BWRs.

9. The drift flux correlation used was originally calibrated to BWR situations, and the qualification work for both this option and for the dynamic slip option only cover BWRs. The drift flux option can be approved for BWR bundle geometry if the conditions of (16) are met.

10. The profile effect on the interphase drag (among all the profile effects) is neglected in the dynamic slip option. Form loss is also neglected for the slip velocity. For the acceptability of these approximations refer to (17).

11. Only one-dimensional heat conduction is modeled. The use of the optional gap linear thermal expansion model requires further justification.

12. Air is assumed to be an ideal gas with a constant specific heat representative of that at containment conditions. It is restricted to separated and single-phase vapor volumes. There are no other noncondensables.

13. The use of the water properties polynomials should be restricted to the subcritical region. Further justification is required for other regions.

14. A number of regime-dependent minimum and maximum heat fluxes are hardwired. The use of the heat transfer correlations should be restricted to situations where the pre-CHF heat transfer or single-phase heat transfer dominates.

15. The Bennet flow map should only be used for vertical flow within the conditions of the data base and the Beattie two-phase multiplier option requires qualification work.

16. No separate effects comparison have been presented for the algebraic slip option and it would be prudent to request comparisons with the FRIGG tests before the approval of the algebraic slip option.

17. While FRIGG tests comparisons have been presented for the dynamic slip option, the issues concerning the Schrock-Grossman round tube data comparisons should be resolved before the dynamic slip option is approved. Plant comparisons using the option should also be required.

18. The nonequilibrium pressurizer model has no fluid boundary heat losses, cannot treat thermal stratification in the liquid region and assumes instantaneous spray effectiveness and a constant rainout velocity. A constant L/A is used and flow detail within the component cannot be simulated. There will be a numerical drift in energy due to the inconsistency between the two-region and the mixture energy equations but it should be small. No comparisons were presented involving a full or empty pressurizer. Specific application of this model should justify the lack of fluid boundary heat transfer on a conservative basis.

19. The nonmechanistic separator model assumes quasistatics (time constant approximately few tenths of seconds) and uses General Electric (GE) BWR6 carryover/carryunder curves for default values. Use of default curves has to be justified for specific applications. As with the pressurizer, a constant L/A is used. The treatment in the off normal flow quadrant is limited and those quadrants should be avoided. Attenuation of pressure waves at low flow/low quality conditions are not simulated well. Specific applications to BWR pressurization transients under those conditions should be justified.

20. The centrifugal pump head is divided equally between the two junctions of the pump volume. Bingham pump and Westinghouse pump data are used for the default single-phase homologous curves. The SEMISCALE MOD-1 pump and Westinghouse Canada data are for the degradation multiplier approach in the two-phase regime. Use of the default curves has to be justified for specific applications. Pump simulation should be restricted to single-phase conditions.

21. The jet pump model should be restricted to the forward flow quadrant as the treatment in the other quadrants is conceptually not well founded. Specific modeling of the pump in terms of volumes and junctions is at the user's discretion and should therefore be reviewed with the specific application.

22. The nonmechanistic turbine model assumes symmetrical reaction staging, maximum stage efficiency at design conditions, a constant L/A and a pressure behavior dictated by a constant loss coefficient. It should only be used for quasistatic conditions and in the normal operating quadrant.

23. The subcooled void model is a nonmechanistic profile fit using a modification of Electric Power Research Institute (EPRI) recommendations for the bubble departure point. It is used only for the void reactivity computation and has no direct effect on the thermal-hydraulics. Comparisons have only been presented for BWR situations. The model should be restricted to the conditions of the qualification data base. Sensitivity studies should be requested bor specific applications. The profile blending algorithm used will be reviewed when submitted as part of the new manual (MOD003) modifications.

24. The bubble rise model assumes a linear void profile, a constant rise velocity (but adjustable through the control system), a constant L/A, thermodynamic equilibrium, and makes no attempt to mitigate layering effects. The bubble mass equation assumes zero junction slip which is contrary to the dynamic and algebraic slip model. The model has limited application and each application must be separately justified.

25. The transport delay model should be restricted to situations with a dominant flow direction.

26. The stand-alone auxiliary departure from nucleate boiling ratio (DNBR) model is very approximate, and is limited to solving a one-dimensional steady-state simplified homogeneous equilibrium model (HEM) energy equation. It should be restricted to indicating trends.

27. Phase separation and heat addition cannot be treated simultaneously in the enthalpy transport model. For heat addition with multidirectional, multifunction volumes, the enthalpy transport

model should not be used without further justification. Approval of this model will require submittal of the new manual (MOD003) modifications.

28. The local conditions heat transfer model assumes saturated fluid conditions, one-dimensional heat conduction and a linear void profile. If the heat transfer is from a local condition volume to another fluid volume, that fluid volume should be restricted to a nonseparated volume. There is no qualification work for this model and its use will therefore require further justification.

29. The initializer does not absolutely eliminate all ill-posed data and could have differences with the algorithm used for transient calculations. A null transient computation is recommended. A heat transfer surface area adjustment is made and biases are added to feedwater inlet enthalpies in order to justify steady-state heat balances. These adjustments should be reviewed on a specific application basis.

30. Justification of the extrapolation of FRIGG data or other data to secondary-side conditions for pressurized-water reactors (PWRs) should be provided. Transient analysis of the secondary side must be substantiated. For any transients in which two-phase flow is encountered in the primary, all the two-phase flow models must be justified.

31. The pressurizer model requires model qualification work for the situations where the pressurizer either goes solid or completely empties.

32. Transients which involve three-dimensional space-time effects such as rod ejection, transients would have to be justified on a conservative basis.

33. Transients from subcritical, such as those associated with reactivity anomalies should not be run.

34. Transients where boron injection is important, such as steamline break will require separate justification for the user-specified boron transport model.

35. For transients where mixing and cross flow are important, the use of various cross flow loss coefficients has to be justified on a conservative basis.

36. Anticipated transient without scram (ATWS) events will require additional submittals.

37. For PWR transients where the pressurizer goes solid or completely drains, the pressurizer behavior will require comparison against real plant or appropriate experimental data.

38. PWR transients, such as steam generator tube rupture, should not be analyzed for two-phase conditions beyond the point where significant voiding occurs on the primary side.

39. BWR transients were asymmetry leads to reverse jet pump flow, such as the one recirculation pump trip, should be avoided.

B. RETRAN-3D USE IN A RETRAN-02 MODE

In the letter dated October 12, 2000, the NMC staff stated that you intend to adopt use of RETRAN-3D in the 2D mode for system analysis. The NRC staff has determined that it is not possible to use RETRAN-3D in a pure RETRAN-02 mode. The code's numerical solution scheme and various models have been changed so that there is no exact RETRAN-02 substitution that can be performed. However, the code can be used in a near RETRAN-02 mode provided that the user carefully selects models and options that reduce the divergence from those not available to the RETRAN-02 user.

While functionally equivalent to RETRAN-02, RETRAN-3D is more robust. The following models are always active when using RETRAN-3D:

- Improved transient numerical solution (fully implicit solution of the balance equations, component models and source terms are linearized)
- Improvements to the time-step selection logic
- Improved water property curve fits

Other model options have been improved with the improvements being active when the particular option is selected in an input model. For these options, the RETRAN-02 model was replaced by the improved model and there is no backward compatibility option. Consequently, the following improvements, if selected by the user, may be used for RETRAN-02 mode analyses:

- Fully implicit steady-state solution
- Implicit pressurizer solution
- Wall friction model revised to use the Colebrook equation, allowing consideration of wall roughness rather than assuming smooth pipe
- Control system solution revised to solve a coupled system of equations using a Gauss-Seidel method rather than the single pass marching scheme
- Enthalpy transport model revised by eliminating several simplifying assumptions
- Improved dynamic slip formulation adding form losses
- Improved countercurrent flow junction properties
- Implicit solution of the heat conduction equation
- Combined heat transfer map updated with an improved set of heat transfer correlations and smoothed transitions
- Wall friction and hydrostatic head losses included in critical flow pressure

The new steady-state option available for initializing models with steam generators makes some problems easier to initialize. The low power steam generator steady-state option can be used with RETRAN-02 mode analyses.

A RETRAN-02 mode model must not use any of the new RETRAN-3D features such as:

- Generalized laminar friction model
- Dynamic gap conductance model
- Accumulator model
- Dynamic flow regime model
- New control blocks added to improve functionality
- Govier horizontal flow regime map and stratified flow friction model
- Chexal-Lellouche drift flux model
- Method of characteristics enthalpy option
- Noncondensable gas flow model
- 3D kinetics
- 5-equation nonequilibrium model

Explain how you comply with the following conditions:

> Organizations with NRC-approved RETRAN-02 methodologies can use the RETRAN-3D code in the RETRAN-02 mode without additional NRC approval, provided that none of the new RETRAN-3D models listed in the definition are used. Organizations with NRC-approved RETRAN-02 methodologies must obtain NRC approval prior to applying any of the new RETRAN-3D models listed above for updated final safety analysis report (UFSAR) Chapter 15 licensing basis applications. Organizations without NRC-approved RETRAN-02 methologies must obtain NRC approval for such methodologies or a specific application before applying the RETRAN-02 code or the RETRAN-3D code for UFSAR Chapter 15 licensing basis applications. Generic Letter 83-11 provides additional guidance in this area. Licensees who specifically reference RETRAN-02 in their Technical Specifications will have to request a Technical Specification change to use RETRAN-3D.
>
> The RETRAN-3D five-equation, or nonequilibrium, model uses flow regime maps and flow pattern dependent heat transfer and interfacial area models to simulate the heat and mass transfer processes between phases. A licensee wishing to apply the five-equation model will have to justify its use outside areas of operation where assessment has been documented. This may include either separate effects or integral systems assessment that cover the range of conditions encountered by the application of interest. An assessment of the uncertainties must also be provided. The model is approved subject to these conditions.

Assessment performed in support of use of RETRAN-3D must also address consistency between the RETRAN-3D calculations and any auxiliary calculations that are a part of the overall methodology, such as, Departure from Nucleate Boiling or Critical Power Ratio. The NRC staff concludes that the lack of a detailed RETRAN-3D specific user guideline document mandates a statement on the user's experience and qualification with the code when analyses are submitted in support of licensing actions. This statement is expected to be consistent with the guidance of Generic Letter 83-11.

Application of the RETRAN-02 or RETRAN-3D codes for best estimate analysis of UFSAR Chapter 15 licensing basis events may require additional code and model assessment, and an evaluation of uncertainties to assure accurate prediction of best estimate response. This condition is based on the absence, in the best estimate analysis approach, of the conservative assumptions in traditional UFSAR Chapter 15 licensing basis analyses. For each use of RETRAN-3D in a licensing calculation, it will be necessary for a valid approach to assessment to be submitted, which is expected to include a phenomena identification and ranking table (PIRT) for each use of the code and the appropriate assessment cases and their results. The scope of the PIRT and validation/assessment will be commensurate with the complexity of the application.

C. Page 2 of Attachment 3 in the letter dated October 12, 2000, specifies two different sets of acceptance criteria for the DYNODE and RETRAN-3D comparison. One is for parameter trend and one is for key parameters comparisons. It is not clear how the two different sets of acceptance criteria are applied to the code comparisons. You are requested to provide a description of the applications of acceptance criteria in the code comparisons and justify its adequacy for the NRC staff approval. Also, key parameters acceptance criteria allow the differences in parameters calculated by DYNODE and RETRAN-3D to be within the following ranges: 30 psi for steam generator or pressurizer pressure, 0.14 for minimum departure from nucleate boiling ratio (MDNBR),4 ^{0}F for peak clad temperature. Explain how the ranges of the parameters (especially, 0.14 for MDNBR with consideration of use of the HTP critical heat flux correlation) are determined and how these uncertainties are considered in establishing the limiting peak pressurizer pressure, minimum DNBR and peak clad temperature for the USAR accident analyses. Also, you are requested to identify any results of the DYNODE and RETRAN-3D code comparisons that do not meet the key parameters acceptance criteria and provide reasons in terms of code modeling assumptions for the NRC staff to review.

D. Describe which accidents are intended to be analyzed in the future using DYNODE and RETRAN-3D in the 2D mode. Justify the adequacy of the application of these codes regarding accident conditions analyzed.

1. As a result of generic review of the RETRAN-3D code, the staff limits the use of the code to certain conditions. Since the licensee proposes to use RETRAN-3D in a RETRAN-02 mode, the licensee is requested to address its compliance with each applicable items of the following conditions identified for use of RETRAN-3D.

Staff reviews of previous versions of RETRAN have resulted in a number of limitations and conditions on use of the code. As a part of the review of RETRAN-3D, the staff has examined the limitations and conditions on the use of the earlier version to determine which are still applicable to RETRAN-3D and which have been responded to through the new models and additions in RETRAN-3D. The staff's evaluation of the limitations and conditions on use follows. Each condition is stated followed by the staff's position on that condition.

1. Multidimensional neutronic space-time effects cannot be simulated as the maximum number of dimensions is one. Conservative usage has to be demonstrated.

Staff position: RETRAN-3D has been modified to include a 3-dimensional nodal kinetics model based on the analytic nodalization method similar to accepted codes. The code has been assessed by calculation of the response of the SPERT prompt-critical tests and has been confirmed by the staff by comparisons with calculations performed with the NESTLE and TORT codes. The staff concludes that the code can adequately predict the response to prompt-critical events such as the PWR rod ejection accident and the BWR rod drop accident. If void generation occurs from an initially un-voided case, the user will have to justify crediting this negative feedback in the analysis.

The code was used by a participant in the Nuclear Energy Agency's International Standard Problem calculation of a hypothetical Main Steamline Break (MSLB) at the Three Mile Island Unit 1 plant. The results of the calculation comparison indicates that RETRAN-3D is comparable to any of the other participating codes.

RETRAN-3D is approved for main steamline break analyses subject to the following conditions. Thermal-hydraulic effects can have a large impact on the cross section evaluation and thus, on the resulting power distribution and magnitude. Therefore, the licensee must justify the primary side nodalization for mixing in the vessel and core. The licensee must also evaluate the uncertainties in the modeling.

2. There is no source term in the neutronics and the maximum number of energy groups is two. The space-time options assume an initially critical system. Initial conditions with zero fission power cannot be simulated by the kinetics. The neutronic models should not be started from subcritical or with zero fission power without further justification.

Staff position: The basic models in RETRAN-3D are unchanged and, therefore, this condition of use applies.

3. A boron transport model is unavailable. User input models will have to be reviewed on an individual basis.

Staff position: As noted previously in this report, boron transport is handled as a "contaminant" by the "general transport model." This model uses first order accurate upwind difference scheme with an implicit temporal differencing. This approach is well known for being highly diffusive, especially if the Courant limit is exceeded. Since RETRAN-3D has the same model as RETRAN-02 MOD003 and subsequent versions that have been approved for use, the RETRAN-3D model is also approved with the caveat that the potential to produce misleading results with this scheme necessitates careful review of the results for any case where boron transport/dilution is important.

4. Moving control rod banks are assumed to travel together. The BWR plant qualification work shows that this is an acceptable approximation.

Staff position: The control bank limitation is applied only to the one-dimensional kinetics model. The staff agrees that the 3-dimensional kinetics model need not be restricted in this way.

5. The metal-water heat generation model is for slab geometry. The reaction rate is therefore underpredicted for cylindrical cladding. Justification will have to be provided for specific analyses.

Staff position: The basic models in RETRAN-3D are unchanged and, therefore, this condition of use applies. However, since RETRAN-3D is not being reviewed for Loss-of-Coolant Accident analysis, where core uncovery and heatup are significant, this condition does not occur in the transients for which application of RETRAN-3D has been reviewed.

6. Equilibrium thermodynamics is assumed for the thermal-hydraulics field equations although there are nonequilibrium models for the pressurizer and the subcooled boiling region.

Staff position: The RETRAN-3D five equation model permits thermal-hydraulic nonequilibrium between the liquid and vapor phases. While it allows subcooled liquid and saturated steam to be concurrently present, it does not account for subcooled liquid and superheated vapor being concurrently present. Use of the code is not approved for loss-of-coolant accident (LOCA). Also, the user must be aware of this limitation and avoid conditions which will place subcooled liquid and superheated vapor in contact.

7. While the vector momentum model allows the simulation of some vector momentum flux effects in complex geometry, the thermal-hydraulics are basically one-dimensional.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this comment still applies.

8. Further justification is required for the use of the homogeneous slip options with BWRs.

Staff position: RETRAN-3D has five slip equation options for the user to choose from, three of which are retained from RETRAN-02 for compatibility. The recommended model options are based on the Chexal-Lellouche drift flux correlation. The first is the algebraic slip model, which is approved for use with BWR bundle geometry as given in condition (9). The second is a form of the dynamic slip model that uses the Chexal-Lellouche drift flux correlation to evaluate the interfacial friction approved in condition (10). The user must justify the use of any other slip options.

9. The drift flux correlation used was originally calibrated to BWR situations and the qualification work for both this option and for the dynamic slip option only cover BWRs. The drift flux option can be approved for BWR bundle geometry if the conditions of (16) are met.

Staff position: The Chexal-Lellouche drift flux model has been used in comparisons with FRIGG-2 and FRIGG-4 void fraction data and is acceptable for use in BWR bundle geometry.

10. The profile effect on the interphase drag (among all the profile effects) is neglected in the dynamic slip option. Form loss is also neglected for the slip velocity. For the acceptability of these approximations refer to (17).

Staff position: Form loss terms have been included in the RETRAN-3D dynamic slip model. The Taugl form of the dynamic slip equation also includes profile effects in the interphase drag model. These RETRAN-3D model improvements adequately address the concerns and the model is approved for use when the Chexal-Lellouche model is used to compute the interphase friction. Approval is subject to the conditions given in (16) for the Chexal-Lellouche drift flux correlation. Users must justify use of any other dynamic slip option.

11. Only one-dimensional heat conduction is modeled. The use of the optional gap linear thermal expansion model requires further justification.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use still applies.

12. Air is assumed to be an ideal gas with a constant specific heat representative of that at containment conditions. It is restricted to separated and single-phase vapor volumes. There are no other noncondensables.

Staff position: RETRAN-3D has been extended to include a general noncondensable gas capability which resolves the original concern. However, the noncondensable gas flow model is approved for use subject to the following restriction.

As noted in Section III.3.0 of the RETRAN-3D Theory Manual, Reference 4, none of the models available for calculating critical flow are appropriate when noncondensable gases are present. Consequently, the code automatically bypasses the critical flow model when noncondensable gases are present in a junction. Users must confirm that noncondensable flows do not exceed appropriate critical flow values or justify use of values that may exceed critical flow values.

13. The use of the water properties polynomials should be restricted to the subcritical region. Further justification is required for other regions.

Staff position: For enthalpies less than approximately 820 Btu/lbm, the difference between the American Society of Mechanical Engineers (ASME) and RETRAN-3D curve fit values of the specific volume range from less than 0.2 percent to approximately 1.3 percent for pressures ranging from 0.1 to 6,000 psia. Further, for enthalpies greater than 820 Btu/lbm and pressures greater than 4200 psia, the differences in specific volume are also less than 1.0 percent. RETRAN-3D is approved for use with PWR ATWS analyses where the peak pressure resides in the regions described above.

For enthalpies greater than 820 Btu/lbm and pressures between 3200 and 4200 psia, the differences in specific volume increase as the enthalpy increases and the pressure decreases. The maximum error of approximately 3.8 percent occurs at the critical point. PWR ATWS analysis using RETRAN-3D in this region will require additional justification that the difference in specific volume does not adversely affect the calculation of the peak pressure.

14. A number of regime-dependent minimum and maximum heat fluxes are hardwired. The use of the heat transfer correlations should be restricted to situations where the pre-CHF heat transfer or single-phase heat transfer dominates.

Staff position: RETRAN-3D contains both the “forced convection option” contained in RETRAN-02 which is the basis for this restriction, and a second option referred to as the “combination heat transfer map.” If the first option is chosen, the “forced convection option,” approval is granted only for use in pre-CHF and single-phase heat transfer regimes. If the second option is chosen, the “combination heat transfer map,” then there are no discontinuities between successive heat transfer regimes and the appropriate heat transfer value should result. Therefore, the combination heat transfer option is approved for use.

15. The Bennet flow map should only be used for vertical flow within the conditions of the data base and the Beattie two-phase multiplier option requires qualification work.

Staff position: The Beattie two-phase multiplier has been removed from RETRAN-3D. The Govier horizontal flow map has been added to supplement the Bennett map for vertical flow and is acceptable.

16. No separate effects comparison have been presented for the algebraic slip option and it would be prudent to request comparisons with the FRIGG tests before the approval of the algebraic slip option.

Staff position: The algebraic slip option has been modified to include the Chexal-Lellouche drift flux model. Use of the Chexal-Lellouche drift flux model for BWR and PWR applications within the range of conditions covered by the steam-water database used to develop and validate the model is approved. The model has been qualified with data from a number of steady-state and two-component tests. While the small dimensions of the fuel assembly are covered, as noted previously in this report, the data for large pipe diameters, such as reactor coolant system pipes, are not extensive and use of the Chexal-Lellouche model will need justification. Assessment work indicates that the model tends to under predict the void profile in the range of 12 to 17 MPa. In addition, the accuracy of the model in the range of 7.5 to 10 Mpa, which covers BWR ATWS conditions, has not been fully demonstrated. Results of analyses using the model in these ranges must be carefully reviewed.

The Chexal-Lellouche correlation cannot be used in situations where counter-current flow limitation (CCFL) is important unless validation for appropriate geometry and expected flow conditions is provided.

17. While FRIGG tests comparisons have been presented for the dynamic slip option, the issues concerning the Schrock-Grossman round tube data comparisons should be resolved before the dynamic slip option is approved. Plant comparisons using the option should also be required.

Staff position: Assessment analyses, Reference 4, has shown that “the issues concerning the Schrock-Grossman round tube data comparisons” (actually the Bennett round tube data) are due to early prediction of critical heat flux (CHF), which is nearly independent of the slip model used. Since the issue raised in the limitation is not related to the dynamic slip model, the limitation is considered to be resolved. The dynamic slip model is approved for use as given in condition (10).

18. The nonequilibrium pressurizer model has no fluid boundary heat losses, cannot treat thermal stratification in the liquid region and assumes instantaneous spray effectiveness and a constant rainout velocity. A constant L/A is used and flow detail within the component cannot be simulated. There will be a numerical drift in energy due to the inconsistency between the two-region and the mixture energy equations but it should be small. No comparisons were presented involving a full or empty pressurizer. Specific application of this model should justify the lack of fluid boundary heat transfer on a conservative basis.

Staff position: The concern raised in this limitation of use is partially resolved in RETRAN-3D. Wall heat transfer can be included in the RETRAN-3D pressurizer model. Including wall heat transfer resolves this concern.

While the model does not directly account for thermal stratification, its effects can be included by use of normal nodes below the pressurizer volume. The user will have to justify the lack of thermal stratification or the use of normal nodes below the pressurizer should there be an indication that it would be important in the analysis.

The mixture and two-region energy equations are consistent for the implicit solution method where the mixture energy equation is used with the vapor-region energy equation. This eliminates inconsistency between the two-region and mixture energy equations and the concern regarding a potential drift in the region energies.

The staff notes that when a pressurizer fills or drains, a single region exists for which the normal pressure equation of state is used. Lack of numerical discontinuities in validation analyses of filling and draining pressurizers, indicates that the model is functioning properly. It is the responsibility of the code user to justify any numerical discontinuity in the pressurizer during a filling or draining event.

The pressurizer model has options that require user-supplied parameters. Users must provide justification for these model parameters.

19. The nonmechanistic separator model assumes quasistatics (time constant approximately few tenths of seconds) and uses GE BWR6 carryover/carryunder curves for default values. Use of default curves has to be justified for specific applications. As with the pressurizer, a constant L/A is used. The treatment in the off normal flow quadrant is limited and those quadrants should be avoided. Attenuation of pressure waves at low flow/low quality conditions are not simulated well. Specific applications to BWR pressurization transients under those conditions should be justified.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

20. The centrifugal pump head is divided equally between the two junctions of the pump volume. Bingham pump and Westinghouse pump data are used for the default single-phase homologous curves. The SEMISCALE MOD-1 pump and Westinghouse Canada data are for the degradation multiplier approach in the two-phase regime. Use of the default curves has to be justified for specific applications. Pump simulation should be restricted to single-phase conditions.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

21. The jet pump model should be restricted to the forward flow quadrant as the treatment in the other quadrants is conceptually not well founded. Specific modeling of the pump in terms of volumes and junctions is at the user's discretion and should therefore be reviewed with the specific application.

Staff position: Subsequent revisions of RETRAN-02 addressed this limitation. Since RETRAN-3D has the same model as RETRAN-02 MOD003, and subsequent versions, their acceptance applies to RETRAN-3D.

22. The nonmechanistic turbine model assumes symmetrical reaction staging, maximum stage efficiency at design conditions, a constant L/A and a pressure behavior dictated by a constant loss coefficient. It should only be used for quasistatic conditions and in the normal operating quadrant.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

23. The subcooled void model is a nonmechanistic profile fit using a modification of EPRI recommendations for the bubble departure point. It is used only for the void reactivity computation and has no direct effect on the thermal-hydraulics. Comparisons have only been presented for BWR situations. The model should be restricted to the conditions of the qualification data base. Sensitivity studies should be requested for specific applications. The profile blending algorithm used will be reviewed when submitted as part of the new manual (MOD003) modifications.

Staff position: The profile blending algorithm approved for RETRAN-02 MOD003 is used in RETRAN-3D, therefore, this condition has been satisfied.

24. The bubble rise model assumes a linear void profile, a constant rise velocity (but adjustable through the control system), a constant L/A, thermodynamic equilibrium, and makes no attempt to mitigate layering effects. The bubble mass equation assumes zero junction slip which is contrary to the dynamic and algebraic slip model. The model has limited application and each application must be separately justified.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies. However, the layering effects encountered in RETRAN-02 can be eliminated using the RETRAN-3D stack model. This partially resolves the concern by resolving the layering limitation through use of the stack model.

25. The transport delay model should be restricted to situations with a dominant flow direction.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies. The appropriate application of the model is for one-dimensional flow. The user will have to justify use of this option in the absence of a dominant flow direction.

26. The stand-alone auxiliary DNBR model is very approximate and is limited to solving a one-dimensional steady-state simplified HEM energy equation. It should be restricted to indicating trends.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

27. Phase separation and heat addition cannot be treated simultaneously in the enthalpy transport model. For heat addition with multidirectional, multifunction volumes, the enthalpy transport model should not be used without further justification. Approval of this model will require submittal of the new manual (MOD003) modifications.

Staff position: A number of the simplifying assumptions in the RETRAN-02 enthalpy transport model have been eliminated in RETRAN-3D, which now allows multiple inlet and outlet flows and eliminates the simplifying assumptions related to mass distribution and pressure change effects. This condition has been adequately addressed.

28. The local conditions heat transfer model assumes saturated fluid conditions, one-dimensional heat conduction and a linear void profile. If the heat transfer is from a local condition volume to another fluid volume, that fluid volume should be restricted to a nonseparated volume. There is no qualification work for this model and its use will therefore require further justification.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

29. The initializer does not absolutely eliminate all ill-posed data and could have differences with the algorithm used for transient calculations. A null transient computation is recommended. A heat transfer surface area adjustment is made and biases are added to feedwater inlet enthalpies in order to justify steady-state heat balances. These adjustments should be reviewed on a specific application basis.

Staff position: The over specified condition is identified by the RETRAN-3D steady-state input checking, resolving the concern regarding ill-posed data. The user must still run null transients to ensure that unwanted control or trip actions are not affecting the transient solution.

RETRAN-3D has available a low power steady-state steam generator initialization option that eliminates the heat conductor area change used in the RETRAN-02 initialization scheme. When this option is used, no adjustments are made to the heat transfer area and this specific concern is resolved. However, either the pressure or temperature is adjusted on the secondary side. These adjustments should be reviewed by the user on a specific application basis. The low power steady-state initialization option is approved for use.

30. Justification of the extrapolation of FRIGG data or other data to secondary-side conditions for PWRs should be provided. Transient analysis of the secondary side must be substantiated. For any transients in which two-phase flow is encountered in the primary, all the two-phase flow models must be justified.

Staff position: The Chexal-Lellouche correlation is approved for use with PWR applications as stated in conditions (10) and (16). The user must justify choosing any other two-phase flow correlation.

31. The pressurizer model requires model qualification work for the situations where the pressurizer either goes solid or completely empties.

Staff position: The pressurizer model is approved for use with filling and draining events as given in condition (18).

32. Transients which involve three-dimensional space-time effects such as rod ejection transients would have to be justified on a conservative basis.

Staff position: The 3-dimensional kinetics model, as noted in limitation 1 above, satisfies this limitation.

33. Transients from subcritical, such as those associated with reactivity anomalies should not be run.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

34. Transients where boron injection is important, such as steamline break will require separate justification for the user-specified boron transport model.

Staff position: The generalized transport model was added to RETRAN-3D to provide the capability to track materials such as boron. Specific application of the model to steam-line break transients must be justified by the user. The model is approved for use as given in condition (3).

35. For transients where mixing and cross flow are important, the use of various cross flow loss coefficients has to be justified on a conservative basis.

Staff position: The basic model in RETRAN-3D is unchanged and, therefore, this condition of use applies.

36. ATWS events will require additional submittals.

Staff position: RETRAN-3D is approved for PWR ATWS analyses as given in condition (13).

37. For PWR transients where the pressurizer goes solid or completely drains, the pressurizer behavior will require comparison against real plant or appropriate experimental data.

Staff position: The pressurizer model is approved for use with filling and draining events as noted in the discussion of conditions (18) and (31).

38. PWR transients, such as steam generator tube rupture, should not be analyzed for two-phase conditions beyond the point where significant voiding occurs on the primary side.

Staff position: The use of slip models for PWR applications is approved for use as given in conditions (16) and (30).

39. BWR transients were asymmetry leads to reverse jet pump flow, such as the one recirculation pump trip, should be avoided.

Staff position: As noted in the discussion of condition (21), this is resolved.

RETRAN-3D USE IN A RETRAN-02 MODE

During the RETRAN-3D review, the applicant suggested an approval of use of RETRAN-3D as a substitute for RETRAN-02 when operated in that mode. The staff has determined that it is not possible to use RETRAN-3D in a pure RETRAN-02 mode. The code's numerical solution scheme and various models have been changed so that there is no exact RETRAN-02 substitution that can be performed. However, the code can be used in a near RETRAN-02 mode provided that the user carefully selects models and options that reduce the divergence from those not available to the RETRAN-02 user.

While functionally equivalent to RETRAN-02, RETRAN-3D is more robust. The following models are always active when using RETRAN-3D:

- Improved transient numerical solution (fully implicit solution of the balance equations, component models and source terms are linearized).
- Improvements to the time-step selection logic.
- Improved water property curve fits.

Other model options have been improved with the improvements being active when the particular option is selected in an input model. For these options, the RETRAN-02 model was replaced by the improved model and there is no backward compatibility option. Consequently, the following improvements, if selected by the user, may be used for RETRAN-02 mode analyses:

- Fully implicit steady-state solution.
- Implicit pressurizer solution.
- Wall friction model revised to use the Colebrook equation, allowing consideration of wall roughness rather than assuming smooth pipe.
- Control system solution revised to solve a coupled system of equations using a Gauss-Seidel method rather than the single pass marching scheme.
- Enthalpy transport model revised by eliminating several simplifying assumptions.

- Improved dynamic slip formulation adding form losses.
- Improved countercurrent flow junction properties.
- Implicit solution of the heat conduction equation.
- Combined heat transfer map updated with an improved set of heat transfer correlations and smoothed transitions.
- Wall friction and hydrostatic head losses included in critical flow pressure.

The new steady-state option available for initializing models with steam generators makes some problems easier to initialize. The low power steam generator steady-state option can be used with RETRAN-02 mode analyses.

A RETRAN-02 mode model must not use any of the new RETRAN-3D features such as:

- Generalized laminar friction model.
- Dynamic gap conductance model.
- Accumulator model.
- Dynamic flow regime model.
- New control blocks added to improve functionality.
- Govier horizontal flow regime map and stratified flow friction model.
- Chexal-Lellouche drift flux model.
- Method of characteristics enthalpy option.
- Noncondensable gas flow model.
- 3D kinetics.
- 5-equation nonequilibrium model.

40. Organizations with NRC-approved RETRAN-02 methodologies can use the RETRAN-3D code in the RETRAN-02 mode without additional NRC approval, provided that none of the new RETRAN-3D models listed in the definition are used. Organizations with NRC-approved RETRAN-02 methodologies must obtain NRC approval prior to applying any of the new RETRAN-3D models listed above for UFSAR Chapter 15 licensing basis applications. Organizations without NRC-approved RETRAN-02 methologies must obtain NRC approval for such methodologies or a specific application before applying the RETRAN-02 code or the RETRAN-3D code for UFSAR Chapter 15 licensing basis applications. Generic Letter 83-11 provides additional guidance in this area. Licensees who specifically reference RETRAN-02 in

their Technical Specifications will have to request a Technical Specification change to use RETRAN-3D.

Additional Conditions of Use

The following additional conditions and limitations have been agreed to by the RETRAN-3D Maintenance Group in a letter dated___________.

BWR ATWS

RETRAN may be used for BWR ATWS subject to the following restrictions:

41. The licensee must validate the chosen void model over the range of pressure, channel inlet flow, and inlet subcooling encountered during the transient that are outside the range of conditions for which assessment is available. Furthermore, the licensee should validate the choice of steam separator model and evaluate its use relative to steam separator performance data relevant to the conditions present during the ATWS simulation. The licensee must also evaluate the uncertainties in the modeling. See Condition (16) and the Staff Position for related information.

Heat, Mass, and Momentum Transfer

42. The RETRAN-3D five-equation, or nonequilibrium, model uses flow regime maps and flow pattern dependent heat transfer and interfacial area models to simulate the heat and mass transfer processes between phases. A licensee wishing to apply the five-equation model will have to justify its use outside areas of operation where assessment has been documented. This may include either separate effects or integral systems assessment that cover the range of conditions encountered by the application of interest. An assessment of the uncertainties must also be provided. The model is approved subject to these conditions.

43. Assessment performed in support of use of RETRAN-3D must also address consistency between the RETRAN-3D calculations and any auxiliary calculations that are a part of the overall methodology, such as, Departure from Nucleate Boiling or Critical Power Ratio.

User Guidelines and User Qualification

44. The staff concludes that the lack of a detailed RETRAN-3D specific user guideline document mandates a statement on the user's experience and qualification with the code when analyses are submitted in support of licensing actions. This statement is expected to be consistent with the guidance of Generic Letter 83-11.

Code Assessment

45. Assessment of the RETRAN-3D code for the models not explicitly approved in this safety evaluation report (SER) will be the responsibility of the licensee or applicant. In addition, application of the RETRAN-02 or RETRAN-3D codes for best estimate analysis of UFSAR Chapter 15 licensing basis events, may require additional code and model assessment, and an evaluation of uncertainties to assure accurate prediction of best estimate response. This

condition is based on the absence, in the best estimate analysis approach, of the conservative assumptions in traditional UFSAR Chapter 15 licensing basis analyses. For each use of RETRAN-3D in a licensing calculation, it will be necessary for a valid approach to assessment to be submitted, which is expected to include a PIRT for each use of the code and the appropriate assessment cases and their results. The scope of the PIRT and validation/assessment will be commensurate with the complexity of the application.

2. Page 2 of Attachment 3 in the letter dated October 12, 2000, specifies two different sets of acceptance criteria for the DYNODE and RETRAN-3D comparison. One is for parameter trend and one is for key parameters comparisons. It is not clear how the two different sets of acceptance criteria are applied to the code comparisons. The licensee is requested to provide a description of the applications of acceptance criteria in the code comparisons and justify its adequacy for the staff approval. Also, key parameters acceptance criteria allow the differences in parameters calculated by DYNODE and RETRAN-3D to be within the following ranges: 30 psi for steam generator or pressurizer pressure, 0.14 for MDNBR,4^{o}F for peak clad temperature. Explain how the ranges of the parameters (especially, 0.14 for MDNBR with consideration of use of the HTP critical heat flux correlation) are determined and how these uncertainties are considered in establishing the limiting peak pressurizer pressure, minimum DNBR and peak clad temperature for the USAR accident analyses. The licensee is also requested to identify any results of the DYNODE and RETRAN-3D code comparisons that do not meet the key parameters acceptance criteria and provide reasons in terms of code modeling assumptions for the staff to review.