Duke Energy

M. S. Tuckman
Executive Vice President
Nuclear Generation

Duke Energy Corporation
526 South Church Street
P.O. Box 1006 (EC07H)
Charlotte, NC 28201-1006
(704) 382-2200 OFFICE
(704) 382-4360 FAX

September 9, 2002

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

ATTENTION: Document Control Desk

SUBJECT: Duke Energy Corporation
McGuire Nuclear Station - Units 1 and 2
Docket Nos. 50-369 and 50-370
Catawba Nuclear Station - Units 1 and 2
Docket Nos. 50-413 and 50-414
Topical Report DPC-NE-2009, Revision 2 - Updates to Chapters 2, 4, and 5 (TAC Nos. MB4502, MB4503, MB4504, MB4505)

Response to NRC Request for Additional Information

By letter dated July 26, 2002, the NRC requested additional information regarding Topical Report DPC-NE-2009, Revision 2, "Updates to Chapters 2, 4, and 5." The questions contained in the July 26, 2002 NRC letter, and the corresponding Duke answers, are provided in the attachment to this letter.

If there are any questions or additional information is needed on this matter, please call A. Jones-Young at (704) 382-3154.

Very truly yours,

M. S Tuckman

M.S. Tuckman

ATTACHMENT

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xc:

L.A. Reyes, Regional Administrator
U.S. Nuclear Regulatory Commission, Region II
Atlanta Federal Center
61 Forsyth St., SWW, Suite 23T85
Atlanta GA 30303

C.P. Patel, NRC Project Manager (CNS)
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Mail Stop 08-H12
Washington, DC 20555

R.E. Martin, NRC Project Manager (MNS)
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Mail Stop 08-H12
Washington, DC 20555

D.J. Roberts, NRC Senior Resident Inspector (CNS)

S.M. Shaeffer, NRC Senior Resident Inspector (MNS)

bxc:

M. T. Cash
R. M. Gribble
K. R. Epperson
G. D. Gilbert
C. J. Thomas
L. E. Nicholson
A. D. Jones-Young
ELL

ATTACHMENT

REQUEST FOR ADDITIONAL INFORMATION

LICENSE AMENDMENT REQUEST APPLICABLE TO

REVISIONS TO TOPICAL REPORT DPC-NE-2009, REVISION 2

CATAWBA NUCKEAR STATION, UNITS 1 AND 2

MCGUIRE NUCLEAR STATION, UNITS 1 AND 2

DUKE ENERGY CORPORATION

The staff has reviewed Duke Energy Corporation's submittal dated February 28, 2002, "Topical Report DPC-NE-2009, Revision 2 - Updates to Chapters 2, 4, and 5" and has identified a need for the following information.

1. Section 5.3 of DPC-NE-2009, Revision 2, states that the WRB2-M critical heat flux (CHF) correlation will be used for the robust fuel assembly (RFA) design, whereas the BWU-N CHF correlation will be applied for the non-mixing vane span of the RFA fuel.

    A. Discuss the applicability of the BWU-N correlation to the RFA non-mixing vane span. The discussion should include whether the RFA fuel design is within the range of test assemblies data base used to develop the BWU-N correlation. The test assemblies data base parameters include the fuel diameter, pitch, hydraulic diameters, grid design (grid thickness, height, and vane design), grid spacing, and heated length.

    B. The WRB-2M correlation described in WCAP-15025-P-A, "Modified WRB-2 Correlation, WRB-2M, for Predicting Critical Heat Flux In 17x17 Rod Bundles with Modified LPD Mixing Vane Grids," is applicable to the 17x17 fuel with 0.374 inch outer diameter rods and modified low pressure drop grids, with or without modified intermediate flow mixing grids. Is the WRB-2M correlation not applicable to the RFA non-mixing vane span? Why is the BWU-N correlation used?

C. Discuss how two different correlations are applied to the different spans of a fuel assembly. Is the VIPRE-01 code programmed to automatically perform the switch in the correlations? Has verification and validation been done to ensure correctness of the VIPRE-01 in the correlation switch?

2. For the transition cores with co-existence of the RFA and Mark-BW fuel designs, Section 5.7 of Revision 2 of the report, states that a transition core departure from nucleate boiling ratio penalty for the RFA design is determined using the 8 channel RFA/Mark-BW transition core model for the initial transition reload cycles, and using the 75 channel model for subsequent cycles where RFA fuel composes greater than 80 percent of the assemblies in the core.

   Explain why it is necessary to use different core models depending on whether the RFA fuel composes greater than 80 percent of the assemblies.

1. *Section 5.3 of DPC-NE-2009, Revision 2, states that the WRB2-M critical heat flux (CHF) correlation will be used for the robust fuel assembly (RFA) design, whereas the BWU-N CHF correlation will be applied for the non-mixing vane span of the RFA fuel.*
   A. *Discuss the applicability of the BWU-N correlation to the RFA non-mixing vane span. The discussion should include whether the RFA fuel design is within the range of test assemblies data base used to develop the BWU-N correlation. The test assemblies data base parameters include the fuel diameter, pitch, hydraulic diameters, grid design (grid thickness, height, and vane design), grid spacing, and heated length.*

The BWU-N correlation is based on local conditions (pressure, mass flux, local quality) that bound the operation of the RFA fuel at McGuire and Catawba. The following table compares the geometry parameters for the RFA design against the BWU-N correlation:

Parameter	RFA Fuel	BWU-N Database
Fuel Diameter	0.374	0.379 - 0.430
Rod Pitch	0.496	0.501 - 0.590
Hydraulic Diameter	0.375 - 0.464	0.39 - 0.60
*Grid Spacing (inches)	20.5	21.0
Heated Length (feet)	12	6 - 12

* - In the span of interest

BWU-N is one of a series of CHF correlations developed to apply to PWR cores with mixing or non-mixing vane spacer grids. In each of the approved correlations, the correlated independent variables were the thermal-hydraulic local conditions (pressure, mass velocity and equilibrium thermodynamic quality at CHF), axial flux shape (via the F factor), heated length, and the grid axial spacing. The geometric independent variables such as rod diameter, pitch to diameter ratio, hydraulic or heated diameters were found to be non-correlated (that is, there was no sensitivity in CHF level for geometric independent variables) and thus these parameters were not needed as part of the correlation.

Even though the geometric variables were found to be non-correlated, it would be improper to make large extrapolations of these geometric variables. Only very small extrapolations are necessary to apply BWU-N to RFA fuel. This is shown in the following table:

Geometric Variable	RFA Application	BWU-N Data Base	Difference, %
Pin Pitch, in.	0.496	0.501	1.0
Rod Diameter, in.	0.374	0.379	1.3
Pitch to Diameter Ratio	0.496/0.374 = 1.326	0.501/0.379 = 1.322	0.3
Unit Hydraulic Diameter, in.	0.4635	0.4642	0.2

The grid design is the same in that BWU-N is being applied to the RFA fuel only above a non-mixing vane grid. There are no vanes present on the grid in question. The grid heights and thickness are within 0.026 and 0.003 inches, respectively. As explained above, these parameters have no significant impact on the CHF performance in a non-mixing vane span.

Table 4-3 of Reference 1 limits BWU-N to Non-Mixing Grids. Thus, the use of BWU-N is based on:

1. the geometric similarity of the designs
2. the fact that the geometric variables are not included (needed) in the base BWU correlations and
3. the fact that BWU-N results in conservative levels of CHF compared to the mixing vane correlations.

In summary, CHF performance is influenced by the presence or absence of mixing vanes and the local conditions. There are no specific grid features to enhance thermal performance in the span of interest and the local conditions are bounded. Therefore, BWU-N can be applied to the non-mixing vane span of the RFA assembly and will predict lower CHF (conservative) than the mixing vane grid correlations.

B. *The WRB-2M correlation described in WCAP-15025-P-A, "Modified WRB-2 Correlation, WRB-2M, for Predicting Critical Heat Flux In 17x17 Rod Bundles with Modified LPD Mixing Vane Grids," is*

applicable to the 17x17 fuel with 0.374 inch outer diameter rods and modified low pressure drop grids, with or without modified intermediate flow mixing grids. Is the WRB-2M correlation not applicable to the RFA non-mixing vane span? Why is the BWU-N correlation used?

The WRB-2M correlation was developed from fuel with mixing vane modified LPD mid-grids, modified LDP IFM grids, and non-vaned end grids. All the CHF data from the test program documented in WCAP-15025-P-A was in a region above one of the mixing vane grid types. Therefore, the WRB-2M correlation is directly applicable to regions of the fuel above a modified LPD mixing vane grid of either type. The very bottom span of the RFA fuel assembly (lower ~21 inches of the heated length) is above an Inconel grid without any type of mixing vane. For this region of the fuel assembly, Duke considers the use of the BWU-N non-mixing vane grid correlation to be appropriate and conservative as discussed in the answer to question 1 (A).

C. *Discuss how two different correlations are applied to the different spans of a fuel assembly. Is the VIPRE-01 code programmed to automatically perform the switch in the correlations? Has verification and validation been done to ensure correctness of the VIPRE-01 in the correlation switch?*

The VIPRE-01 computer code solves the sets of equations for the geometry modeled and the boundary conditions specified to determine a converged fluid solution. This converged fluid solution yields the local conditions at each node and elevation modeled. After the fluid solution is converged, all the inputs for the CHF correlation (local pressure, mass flux, enthalpy, etc.) are fixed and the DNBR calculation is performed. Therefore, the calculation of CHF and DNBR has no effect on the converged fluid solution.

Due to this, VIPRE-01 has the built-in capability to calculate DNBR with multiple CHF correlations. Each correlation is applied to all channels at all elevations. Since the switch in this case is based solely on grid type and elevation, two options are available to apply the BWU-N correlation:

- manually overlay the output of the code after selecting both correlations
- program the code to automatically switch based on grid elevation inputs

For the current application of BWU-N on the RFA fuel, the manual process was used. The automatic switching from WRB-2M to BWU-N was not programmed into VIPRE-01. However, the VIPRE-01 code has been programmed by Duke to automatically perform the switch in other applications such as the Mark-BW (BWU-N to BWU-Z) and the Advanced Mark-BW (BWU-N to BWU-Z/MSM) and may be added to this application (RFA) in the future.

The verification and validation of the manual overlay process is performed by the independent review of the calculation results in the standard quality assurance process. The verification and validation of an automatic switchover by elevation is performed in the code revision process by performing independent calculations of the correct critical heat flux value from the local fluid conditions in the channel. This independent calculation by elevation of the critical heat flux is compared against the code output for cases to confirm the switch is being performed correctly.

2. *For the transition cores with co-existence of the RFA and Mark-BW fuel designs, Section 5.7 of Revision 2 of the report, states that a transition core departure from nucleate boiling ratio penalty for the RFA design is determined using the 8 channel RFA/Mark-BW transition core model for the initial transition reload cycles, and using the 75 channel model for subsequent cycles where RFA fuel composes greater than 80 percent of the assemblies in the core.*

   Explain why it is necessary to use different core models depending on whether the RFA fuel composes greater than 80 percent of the assemblies.

   The RFA fuel assembly contains 3 extra grids, the IFM grids, compared to the Mark-BW assembly. These extra grids in the upper span force flow out of the RFA assemblies and into the surrounding Mark-BW assemblies. In the 8 channel model, the single hot assembly (RFA) is

modeled by the first 7 channels and the remainder of the core (Mark-BW fuel) is lumped into one single channel. Therefore, in the 8 channel transition model, there is one RFA assembly surrounded by 192 Mark-BW assemblies. This maximizes the hydraulic difference in transition cores and creates a very bounding penalty for the RFAs.

The loss of flow in the upper spans of the RFA is the major element of the DNB penalty. This hydraulic effect of flow reduction in the RFA is a direct function of the number of RFA and Mark-BW assemblies incore. As subsequent cores of RFA fuel are loaded, only a few Mark-BW assemblies remain. As fewer Mark-BWs are present, the simple 8 channel model becomes overly conservative for the RFAs in transition. The only option to better reflect the physical effects of the last transition cycles is to increase the detail in VIPRE-01 to the 75 channel model. This more detailed model better represents the hydraulic effects of cores where most of the fuel is RFA where a small fraction (less than 20% or fewer than 38 assemblies) of the core is Mark-BW. The 80% value was selected because it corresponds to approximately two batches of RFA fuel residing incore. With this more detailed 75 channel model, a conservative penalty is still determined in the same manner as with the 8 channel model.

This approach of using a more detailed transition core model was discussed previously in Reference 2 [response to Question 2] for Mark-BW/OFA transition at McGuire/Catawba and Reference 3 [response to Question 2(d)] for the Mark-B11/Mark-B10 transition at Oconee.

References

1) BAW-10199P-A, August, 1996, "The BWU CHF Correlations", D. A. Farnsworth and G. A. Meyer.
2) Letter from M.S. Tuckman to USNRC, Supplemental Information to Assist in Review of Topical Reports DPC-NE-3000 and DPC-NE-2004, August 29, 1991 (included in Attachment D of DPC-NE-2004P-A, Revision 1)
3) Letter from M.S Tuckman to USNRC, Response to NRC Request for Additional Information on Appendix D to Topical Report DPC-NE-2005-P, "Duke Power Company Thermal-Hydraulic Statistical Core Design Methodology, September 21, 1998 (included in Appendix D of DPC-NE-2005P-A, Revision 2)