GE Nuclear Energy

General Electric Company
P. O. Box 780, Wilmington, NC 28402

NEDO-32505-A
Revision 1
July 1999

R–Factor Calculation Method for GE11, GE12 and GE13 Fuel

Approved: ______________________
S. P. Congdon, Manager
Nuclear Methods

Notice

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20666-0001

MFN-046-98

January 11,1999

Mr. Glen A. Watford, Manager
Nuclear Fuel Engineering
General Electric Company
P. 0. Box 780
Wilmington, North Carolina 28402

SUBJECT: ACCEPTANCE FOR REFERENCING OF LICENSING TOPICAL REPORT NEDC-32505P, REVISION 1, "R-FACTOR CALCULATION METHOD FOR GE11, GE12 AND GE13 FUEL" (TAC NO. M99070 AND M95081)

Dear Mr. Watford

The staff has reviewed the subject report submitted by GE Nuclear Energy (GENE) by letters dated October 20, 1995, for NEDC-32505P and June 5, 1997, for NEDC-32505P, Revision 1, respectively. These submittals provide the description of the revised R-factor method to account for the part length rods in the fuel bundle of the core design, and is part of the GE reload licensing application. The staff has found the subject report to be acceptable for referencing in license applications to extent specified and under the limitations stated in the enclosed report and the U. S. Nuclear Regulatory Commission (NRC) technical evaluation. The evaluation defines the basis for acceptance of the report.

The staff will not repeat its review of the matters described in the GENE Topical Report NEDC-32505P, Revision 1 and found acceptable when this letter request appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. NRC acceptance applies only to the matters described in the GENE Topical Report NEDC-32505P, Revision 1. In accordance with procedures established in NUREG-0390, the NRC requests that GE publish accepted versions of the submittal, proprietary and non-proprietary, within 3 months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed evaluation between the title page and the abstract and an -A (designating accepted) following the report identification symbol.

If the NRC's criteria or regulations change so that its conclusions that the submittal is acceptable is invalidated, GE and/or the applicant referencing the submittal will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the submittal without revision of the respective documentation.

Sincerely,

Thomas H. Essig, Acting Chief
Generic Issues and Environmental Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Enclosure:
R-Factor Calculation Method for GE11, GE12 and GE13 Evaluation

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

ENCLOSURE-1

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATING TO GENERAL ELECTRIC LICENSING TOPICAL REPORT NEDC-32505P-REVISION 1, "R-FACTOR CALCULATION METHOD FOR GE11, GE12 AND GE13 FUEL"

1 INTRODUCTION

By a letter dated October 20, 1995, from J. F. Klapproth (GE) to USNRC, General Electric Nuclear Energy (GENE) submitted licensing topical report (Reference 1), NEDC-32505P, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," for NRC review and acceptance. The licensing topical report will be referenced in reload core safety analyses. Subsequently, by a letter dated June 5, 1997, from R. J. Reda (GENE) to USNRC, GENE submitted Revision I to NEDC-32505P (Reference 2) correcting Figure 1, the normalization of the representative controlled axial power shapes for rod power integration for GE11 fuel. The licensing topical report describes the revised R-factor method to account for the part length rods (PLRs) in the fuel bundle of the core design by substituting rod-integrated powers for the lattice peaking factors while still preserving the existing R-factor formula and weighting function practice.

2 EVALUATION

The R-factor is a number which characterizes the local peaking pattern relative to any given rod. The R-factor is an input to the GEXL correlations which accounts for the effects of the fuel power distributions and the fuel assembly and channel geometry on the fuel assembly critical power distribution. The R-factor, as well as its calculation method, is defined in the topical report, NEDE-10958-PA (Reference 3), and is referred to as the reference R-factor calculation method versus the proposed revised R-factor calculation method (References 1 and 2). The reference method does not reflect the real performance of the PLRs because the lattice R- factors are averaged over the axial direction. This results in an unrealistically large difference in

R-factors between the PLRs and the remaining rods which would require a large additive constant. The revised R-factor calculation method substitutes rod-integrated powers for the lattice peaking factors and adds correction factors to preserve the existing R-factor formula and weighting function practice. When there are no PLRS, the revised method produces the same answer as the reference method.

During the course of the review, the staff requested additional information (RAI) (References 7 and 8). GENE responsed in References 4, 5, 6 and 9, and the evaluation of the responses is summarized as follows:

(1) The necessity of the correction factors for GE11 and GE13 fuel as an independent function of the weighting factors in the existing R-factor formula is justified by the ATLAS tests where two ATLAS peaking patterns are constructed which result in boiling transition on the same rod for some rod locations. In the first pattern, the adjacent rod will have a relatively lower power, and in the second pattern, the adjacent rod will have a higher power. If the weighting factors Wi are correct, both patterns will require the same additive constant for that rod. These tests have shown that if the adjacent rod peaking factor is less than certain number, a constant additive constant cannot be constructed, because the weighting factor, W,, is too large for the adjacent rod. Therefore, a correction factor, qj, was introduced which reduces the weighting factor when the adjacent rod power is less than a certain peaking factor. The data supporting the generation of the correction factors for the GE11/13 designs is summarized in Tables 4-1 and 4-2 of Reference 5. The correction factors have been verified by performing a series of ATLAS tests in which lower power rods have been inserted adjacent to the limiting critical power rod. GENE has further justified the change of the correction factor with decreasing adjacent rod peaking in terms of the critical power prediction by data taken for the 84 LTA (NEDE-30866, an experimental 8x8 assembly) using the improved GE11/13 correction factor to show the improvement of the critical power prediction. The justification for the lower weighting factors for GE12 is summarized in Table 3-1 of Reference 5 by two ATLAS peaking patterns, both of which experienced boiling transition on the same rod position. The difference in the critical power between the two peaking patterns at the same flow and inlet subcooling condition is due to the change in power of the rod experiencing boiling transition and the change in the relative peaking of the adjacent rod. The new weighting scheme gives critical power changes which are closer to the changes obtained from the data. The staff has reviewed the responses to the staff

concern and found that the ATLAS test data provides acceptable justification for the new weighting factor for GE12 fuel and the correction factor for GE11/13 fuel in the R-factor calculation.

(2) The rod integrated power (IPi) for the R-factor calculation is provided in an integral equation as a function of the relative axial power shape and lattice peaking for rod *l* in lattice *l* at exposure and void fraction of a specific axial location z. Also, the axial shapes for power integration for GE11/12/13 are given in Figure 1 of Reference 2 and Figures 4-1 and 4-2 of Reference 6, respectively. The staff has reviewed the responses to the rod integrated power in the revised R-factor calculation and found that the approach is acceptable because a correction factor in NEDE-32505P accounts for the difference in the PLR rod peaking obtained with average distribution and the inlet peak distribution which is conservative due to maximizing the peaking in the PLR for all cases.

(3) The revised R-factor definition was used to calculate the R-factor for each unique ATLAS test configuration. This R-factor was then used to calculate the critical power for each test point. Comparisons between the measured and calculated critical power values were then used to formulate the GEXL uncertainty. The correction factors for GE11/13 fuel and the new weighting factors were selected to more accurately simulate the critical power behavior as measured in ATLAS, so they were indeed selected to reduce the GEXL uncertainty. The GEXL uncertainty was determined over the full range of operating conditions, which includes variations in bundle flow, inlet subcooling and system pressure. In the case of GE12 fuel, the test data base, and hence, the uncertainty data base extend over the full range of expected normal operation. Based on the above information, the staff has found the clarification for improving the GEXL uncertainty using the revised R-factor definition is acceptable.

(4) The GEXL data base does include critical power tests performed on the part length rods. The amount of data is limited because it is difficult to find inlet flow and subcooling conditions where the dryout location occurs at the third spacer grid from the top, where the part length rods end. Dryout location at the third spacer only occurs at high inlet flows combined with inlet peak power distribution. The test data for the part length rod critical power was obtained in ATLAS test number ATA041A. The test data show that when dryout occurs on the part length rods, the GEXL correlation yields a conservative estimate of the critical power. We have

reviewed GENE's response to the staff concern on the GEXL data base including the part length rods and found the clarification is acceptable because the conservative estimate of the critical power based on the data comparison between the ATLAS data and GEXL simulation.

Based on our review of the responses to the staff's concerns, we conclude that the method proposed in the GENE topical report, NEDC-32505P, Revision 1, is acceptable.

3 CONCLUSION

Based on our review, the staff concludes that the revised R-factor method proposed in the topical report, NEDC-32505P, Revision 1, is acceptable for referencing in license applications for those GE fuels supported by the ATLAS test data. However, if new fuel is introduced, GENE must confirm that the revised R-factor method is still valid based on new test data.

4 REFERENCES

1. GE Letter JFK95-093 MFN-239-95 dated October 20, 1995 from J. F. Klapproth to USNRC transmitting a topical report, NEDC-32505P, 'R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," November 1995.

2. GE Letter RJR-97-072 MFN-021-97 dated June 5, 1997 form R. J. Reda to USNRC transmitting a topical report, NEDC-32505, Revision 1, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," June 1997.

3. General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation and Design Application, NEDE-10958-PA, January 1977.

4. GE Letter RJR-96-100 MFN-146-96 from R. J. Reda to USNRC, Responses to Request for Additional Information, R-factor Calculation Method, NEDC-32505P and GEXL Correlation, August 30, 1996.

5. GE Letter RJR-96-111 MFN-152-96 from R. J. Reda to USNRC, Revised Responses to NRC Request for Additional Information, R-factor Calculation Method, NEDE-32505P and GEXL Correlation, September 20, 1996.

6. GE Letter RJR-98-004 MFN-006-98 from G. A. Watford to USNRC, Responses to NRC Request for Additional Information, R-factor Calculation Method, NEDC-32505P, Revision 1, January 17, 1998.

7. Letter from Robert C. Jones to R. J. Reda, Request for Additional Information for R-factor calculation Method NEDC-32505P and GEXL Correlation, dated August 14, 1996.

8. Letter from Timothy E. Collins to G.A. Watford, Request for Additional Information for R-Factor Calculation Method, NEDC-32505P, Revision 1, November 5, 1997.

9. GE Letter MFN-042-98 and GAW-98-020 from G. A. Watford, Additional Information Associated with R-Factor Calculation Method for GE11, GE12 and GE13 Fuel Topical Report NEDC-32505P-Revision 1, November 2, 1998.

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1. Introduction

The R–factor is an input to the GEXL correlations which accounts for the effects of the fuel rod power distributions and the fuel assembly and channel geometry on the fuel assembly critical power. Its formulation for a given fuel rod location depends on the power of that fuel rod, as well as the power of the surrounding fuel rods. In addition, there is an additive constant applied to each fuel rod location which is dependent on the fuel assembly and channel geometry.

Differences between the improved R–factor calculation method (used for GE11, GE12 and GE13) and the reference* R–factor calculation method (used for GE6, GE7, GE8, GE9 and GE10) are summarized as follows:

- In the calculation of rod R–factors, local power peakings are first integrated axially and then R–factors are calculated based on these integrated rod powers. [[ ]]
- [[]]
- [[]]
- [[]]
- [[]]

* Appendix III, *General Electric Thermal Analysis Basis Data, Correlation and Design Application, and Design Application,* NEDE-10958-PA, January 1977

2. Improved R-factor Calculational Process

Local two–dimensional fuel rod power distributions vary axially in BWR fuel assemblies due to axial variations in nuclear design, exposure, void fraction and control state. These factors are considered when calculating the axially integrated powers for individual rods. The two–dimensional distribution of integrated rod powers for a bundle is then used to calculate individual rod R–factors. The bundle R–factor for a particular bundle average exposure and control fraction is the maximum of all of the individual fuel rod R–factors. The steps used in the improved R–factor calculational process are as follows:

1. Obtain relative 2D rod–by–rod power distributions from the lattice physics code*, which are a function of lattice nuclear design, average exposure, void fraction and control state.
2. [[ ]]
3. Calculate an R–factor for each individual fuel rod. [[ ]]
4. The bundle R–factor is the maximum value of all the individual rod R–factors.
5. Repeat these calculations for each desired bundle average exposure, control fraction and channel bow.

* *Steady–State Nuclear Methods*, NEDE–30130–PA, April 1985.

3. Bundle Average Axial Distributions

A 25–node axial shape is used to define a bundle axial relative power shape for the purposes of calculating R–factors. This shape is a function of control fraction. Bundle axial void fraction and bundle axial relative exposure shapes are used to determine two–dimensional radial distributions as a function of axial height.

- [[ ]]

- [[ ]]

- The **bundle axial relative exposure shape** is defined as that shape which is uniquely consistent with the uncontrolled axial relative power shape assuming uniform fuel density; and

- The **bundle axial void fraction shape** is defined as a shape which is consistent with the uncontrolled axial relative power shape and gives a prototypical bundle average void fraction.

For example, Figure 1 provides a summary of these normalized axial shapes for GE11 fuel. Power shapes for GE12 and GE13 are generated using the same procedure as described above.

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Figure 1. GE11 Axial Shapes for Rod Power Integration (Normalized)

4. R-Factor Distribution

[[ ]]

The R–factor for the i^{th} rod is calculated from the equation:

[[ ]] (Eq. 1)

where: [[

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5. R–factor Calculation Examples

Using the procedures defined in the previous sections, R–factors are calculated for different lattice locations in a bundle as a function of fuel assembly exposure, control state and channel bow using Equation 1. The following example is for a 10x10 lattice (GE12).

Consider Equation 1 for the various cases as shown in Figure 2:

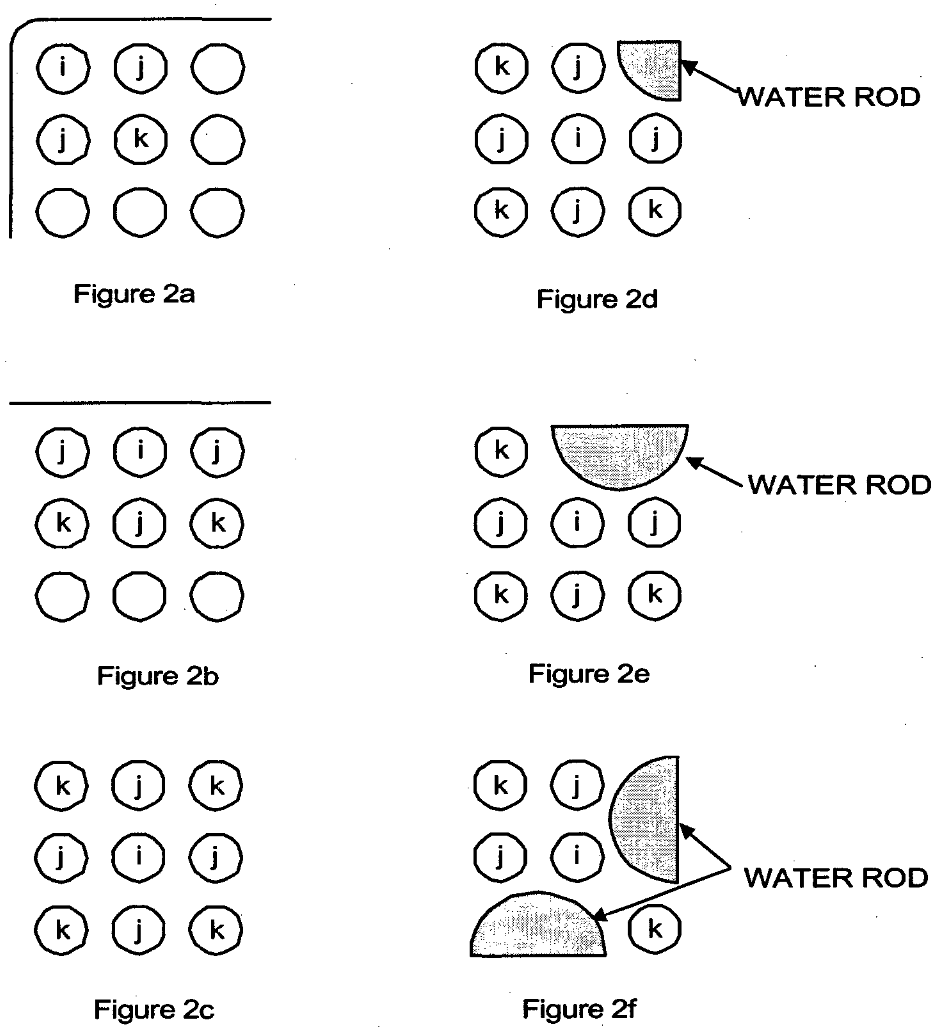

Figure 2. Identification of Rods in Positions Adjacent to Rod I

Corner Rod:

Applying Equation 1 to a corner rod (as in Figure 2a),

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Side Rod:

Applying Equation 1 to a side rod (as in Figure 2b),

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Interior Rod:

Applying Equation 1 to an interior rod (as in Figure 2c),

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If there are two unheated lattice positions (as in Figure 2e),

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If there are four unheated lattice positions (as in Figure 2f),

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A summary of the R-factor calculational method for each GE12 lattice position (as identified in Figure 3) is given in Table 1.

Table 1. R-Factor Calculation by Lattice Position

Lattice Position	Apply Figure	Use Equation
1,1	2a	2
1,2	2b	3
1,3	2b	3
1,4	2b	3
1,5	2b	3
2,2	2c	4
2,3	2c	4
2,4	2c	4
2,5	2c	4
3,3	2c	4
3,4	2c	4
3,5	2d	5
3,3A	2d	5
3,4A	2e	6
3,5A	2e	6
4,4	2c	4
4,5	2e	6
5,5	2f	7

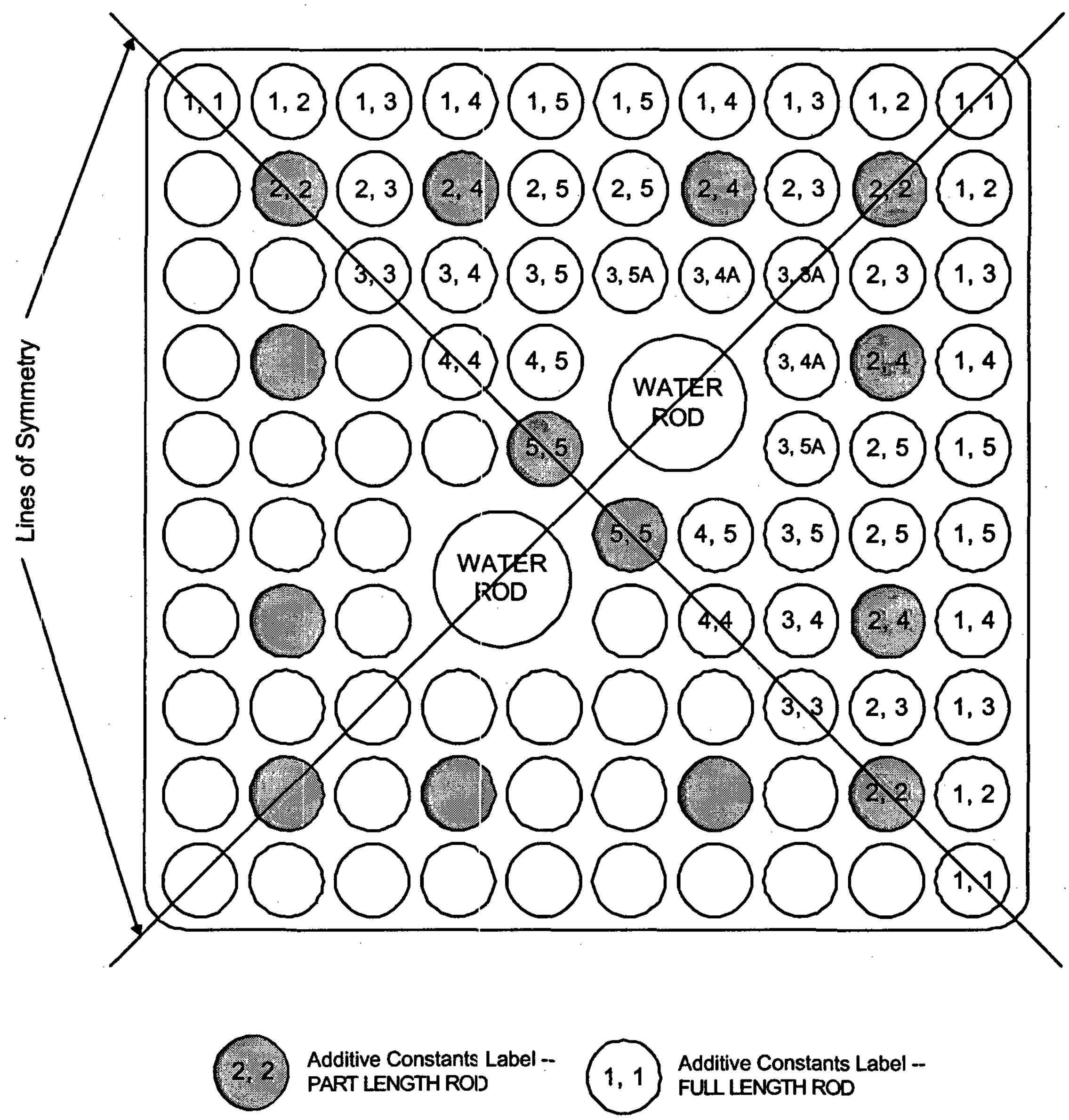

Figure 3. GE12 10 X 10 Lattice

6. Fuel Assembly R-factor

The fuel assembly R-factor is determined in accordance with Equation 8 for any specified fuel assembly exposure, control state and channel bow.

$$R = \overline{Max}\left[R_i\right] \qquad \text{taken over all i} \qquad \text{(Eq-8)}$$

The normal process for treating control states is to calculate fuel assembly R-factors as a function of exposure for

- Fully uncontrolled conditions.
- Fully controlled conditions.
- [[ ]]

At any fuel assembly exposure, the value of fuel assembly R-factor for any control fraction is determined through a linear fit of these [[]] of R-factors as illustrated in Figure 4.

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Figure 4. R-Factor for the Partially Controlled Assembly

Appendix A

Responses to the
Request for Additional Information
for GE Topical Report, NEDC–32505P
"R–factor Calculation Method for GE11, GE12 and GE13"

(See also Appendix B for Revised Responses)

August 30, 1996

Question 1

Provide the justification for changing the definition of the R–factor calculation method stated in NEDC–32505P from the reference R–factor calculation method described in GETAB and identify the advantages resulting from the differences between the improved R–factor calculation method and the reference R–factor calculation method.

Response

The change in R–factor calculation method was necessitated by the addition of part length rods in the GE11 and later product lines. An idealized example can be used to demonstrate the reason for the improved R–factor method: Assume a bundle in which all of the fuel rods have the same linear heat generation rate and that all of the additive constants, l_i are equal to 0. Calculating of the R–factors using the reference method in GETAB shows how the method yields unrealistic results.

[[]] This difference in R–factors between the part length rods and the remaining rods is unrealistically large, and does not reflect the real performance of the PLRs (it is non–conservative for the PLR, and would require a large additive constant). Therefore it was necessary to change the evaluation system, [[ ]] The reason for choosing this procedure was twofold. First, it preserves the existing R–factor formula and weighting function practice. Second, the new method reduces to the same answer as the reference method when there are no part length rods. The R–factor distribution using the new method is shown in Table 1–2. This distribution reflects the fact that the part length rods generate less power and shows that the part length rods are closer in critical power performance to the remaining full length rods.

Table 1–1
R–factor Distribution Using Reference Method (GE11 Design)

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Table 1–2
R–Factor Distribution Using Revised Method

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Question 2

Provide the basis for the new correction factors in the improved R–factor calculation method and justify that the correction factors are only applicable to both GE11 and GE13 but not for GE12. Provide the method to generate the correction factors.

Response

[[.

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Question 3

Provide justification that the weighting factor is not a function of the correction factors for adjacent low power and/or water rods. Provide the method to obtain this weighting factor.

Response

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Table 3–1
Change in Critical Power Calculation for GE12 Fuel

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[[

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Figure 3–1

Effective Weighting Factor versus Adjacent Rod Peaking

Question 4

Provide the description of the test data used to support the generation of the correction factors and the weighting factors.

Response

[[ ]]

[[

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Figure 4–1
GE11/13 Bundle

[[ ]]

Table 4–1

Peaking Factor Distributions For ATLAS Tests A, B, and C

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Table 4–2

Summary of Critical Power for ATLAS Test Series 014

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Question 5

Provide the method used to treat the R–factor calculation in terms of the axial power shape, local exposure and void fraction. If bounding values (e.g., power shape) are used, provide justification for the values used.

Response

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[[ ]]

Question 6

What do the correction factors depend on and under what conditions will they change. If they change, how will the resulting change in GEXL uncertainty be accounted for?

Response

The correction factors have been developed for the GE11 and GE13 product lines and are applied for all GE11 and GE13 applications. They do not change and are simply a function of the peaking factor of the adjacent fuel rod. The GEXL correlation statistics have been developed using the correction factors. There is no reason to change the GEXL uncertainty because the correction factors do not change.

Question 7

How was the GEXL uncertainty using this new R–factor definition determined? Were the weighting factors and correction factors determined before the comparisons with the data were made? That is, were the weighting factor and correction factors selected to minimize the GEXL uncertainty? Was the GEXL uncertainty determined over the full range of operating conditions (pressure, inlet subcooling, etc.)?.

Response

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Question 8

Does the GEXL database include data for part–length rods and if not, how is the GEXL uncertainty justified for these rods

Response

[[ ]]

Question 9

Is the GEXL correlation uncertainty different for the part–length and full–length rods? If so, how is this accounted for in the GEXL uncertainty?

Response

The same GEXL uncertainty is used for all rods in the bundle, including the part length rods. As stated above, special efforts were made to ensure that the critical power estimate for the part length rods are conservative. This is accomplished by adjusting the additive constant for the part length rod.

Appendix B

Responses to the Request for Additional Information for GE Topical Report, NEDC–32505P "R–factor Calculation Method for GE11, GE12 and GE13"

(Revision of August 30, 1996 Responses)

September 20, 1996

Question 1

Provide the justification for changing the definition of the R–factor calculation method stated in NEDC–32505P from the reference R–factor calculation method described in GETAB and identify the advantages resulting from the differences between the improved R–factor calculation method and the reference R–factor calculation method.

Response

The change in R–factor calculation method was necessitated by the addition of part length rods in the GE11 and later product lines. An idealized example can be used to demonstrate the reason for the improved R–factor method: Assume a bundle in which all of the fuel rods have the same linear heat generation rate and that all of the additive constants, l_i are equal to 0. Calculating of the R–factors using the reference method in GETAB shows how the method yields unrealistic results.

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Table 1–1

R–factor Distribution Using Reference Method (GE11 Design)

[[

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Table 1–2
R–Factor Distribution Using Revised Method

[[

]]

Question 2

Provide the basis for the new correction factors in the improved R–factor calculation method and justify that the correction factors are only applicable to both GE11 and GE13 but not for GE12. Provide the method to generate the correction factors.

Response

[[

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[[ ]]

Question 3

Provide justification that the weighting factor is not a function of the correction factors for adjacent low power and/or water rods. Provide the method to obtain this weighting factor.

Response

[[

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[[ ]]

Table 3–1
Change in Critical Power Calculation for GE12 Fuel

[[

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[[

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Figure 3–1

Effective Weighting Factor versus Adjacent Rod Peaking

Question 4

Provide the description of the test data used to support the generation of the correction factors and the weighting factors.

Response

The data supporting the selection of the weighting factors for the GE12 design is documented in the response to Question 3. [[]]

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Figure 4–1

GE11/13 Bundle

[[ ]]

Table 4–1
Peaking Factor Distributions For ATLAS Tests A, B, and C

[[

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Table 4–2
Summary of Critical Power for ATLAS Test Series 014

[[

Figure 4–2. Correction Factor Versus Adjacent Rod Peaking

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[[

]]

Question 5

Provide the method used to treat the R–factor calculation in terms of the axial power shape, local exposure and void fraction. If bounding values (e.g., power shape) are used, provide justification for the values used.

Response

[[

]]

[[ ]]

Question 6

What do the correction factors depend on and under what conditions will they change. If they change, how will the resulting change in GEXL uncertainty be accounted for?

Response

The correction factors have been developed for the GE11 and GE13 product lines and are applied for all GE11 and GE13 applications. They do not change and are simply a function of the peaking factor of the adjacent fuel rod. The GEXL correlation statistics have been developed using the correction factors. There is no reason to change the GEXL uncertainty because the correction factors do not change.

Question 7

How was the GEXL uncertainty using this new R–factor definition determined? Were the weighting factors and correction factors determined before the comparisons with the data were made? That is, were the weighting factor and correction factors selected to minimize the GEXL uncertainty? Was the GEXL uncertainty determined over the full range of operating conditions (pressure, inlet subcooling, etc.)?

Response

[[

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Question 8

Does the GEXL database include data for part–length rods and if not, how is the GEXL uncertainty justified for these

Response

[[

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Figure 8-1 A Comparison of the Part Length Rod Critical Power Compared to the GEXL Prediction

Question 9

Is the GEXL correlation uncertainty different for the part–length and full–length rods? If so, how is this accounted for in the GEXL uncertainty?

Response

The same GEXL uncertainty is used for all rods in the bundle, including the part length rods. As stated above, special efforts were made to ensure that the critical power estimate for the part length rods are conservative. This is accomplished by adjusting the additive constant for the part length rod.

Appendix C

Responses to the Request for Additional Information for GE Topical Report, NEDC–32505P "R–factor Calculation Method for GE11, GE12 and GE13"

January 17, 1998

Question 1

On Page 4 of the topical report, the first bullet states that in the reference method, R-factor are calculated first at each axial node and then integrated axially. It appears that the reference method does not reflect explicitly in the reference NEDE-10958-PA Appendix III. Please describe the difference from the proposed R-factor calculation without considering the part-length rods (PLRs).

Response

The difference in R-factor calculation between the proposed method and the reference method is described in the answer to question 1 dated August 30, 1996. The proposed change in methodology was necessitated by the introduction of the part length rods where the reference method did not work. Without part length rods the proposed method reduces to the same R-factors as the reference method

Question 2

On page 4 of the topical report, the fifth bullet states that in the reference method and for GE12, these corrections are not applied. Explain why the correction factors are still in the Equation 1 of the proposed method.

Response

[[

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Question 3

On page 5 of the topical report, Section 3 (Bundle Average Axial Distributions) states that a 25-node axial shape is used to define a bundle axial relative power shape for the purposes of calculating R-factors and is a function of control fraction. Explain the reason for defining the uncontrolled bundle axial relative power shape and describe its application to the proposed R-factor calculation method versus the controlled axial power shape.

Response

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Figure 3-1. Controlled and uncontrolled cross sectional peaking patterns

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Figure 3-2. Comparison of calculated critical powers for a controlled bundle using GEXL/R-factor methods and subchannel code

Question 4

Describe how the Figure 1 in the topical report is generated for GE11 axial Shape for rod power integration and its application to the rod integrated power (IP_i) in the R-factor calculation with respect to the response to RAI Question 5 for the performing the integration. Define P(z) and p(l,E,V) and explain their roles in the IP_i. Also provide similar axial shape figures for GE12 and GE13.

Response

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Figure 4-1. Axial shape for power integration for GE12 product line (GEXL10)

[[

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Figure 4-2. Axial shape for power integration for GE13 product line (GEXL09)

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Question 5

Identify the ATLAS test reports used to support the new weighting factor for GE12 fuel and correction factors for GE11/GE13 fuel stated in the response to the staff RAI including the particular tests in the ATLAS report used in Table 3-1 for GE12 fuel, in Table 4-1 for GE11/GE13, in Figure 8-1 and the test result used to response to Question 7.

Response

[[

3.]]

Question 6

On page 10 of the response provide justification that (1) 0.7 in Table 4-2 is the best result; (2) the extrapolation from 0.8 to 0.6 and those less than 0.6 in Figure 4-2 are conservative to be used for R-factor calculation for GE11/13, and (3) the improvement in the critical power prediction described in the example given in Tables 4-3 and 4-4 is realistic. Does Item 3 improvement using Tables 4-3 and 4-4 example base on assumed Figure 4-2 data? and is an future test planned to verify the accuracy based on assumption in no data or inadequate data condition?

Response

[[

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Question 7

In the response to Question 7 does the overall uncertainty reduction include the inadequate or no data available in the relative low rod power peaking condition relating to use of the Figure 4-2 information? Provide a table to show the reduction of the overall uncertainty and the contribution due to the new correction factors used.

Response

[[ ]]

Appendix D

Additional Information Associated with R-Factor Calculation Method for GE11, GE12 and GE13 Fuel Topical Report NEDC-32505P, Revision 1

November 2, 1998

In the report "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel" NEDC-32505, Revision 1, June 1997, the R-factor for the i^{th} rod is calculated from the equation:

[[

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and in the response to question 4 (January 17, 1998) it is stated that:

[[

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[[ ]]

Provide the justification for changing the definition of the R–factor calculation method stated in NEDC–32505P from the reference R–factor calculation method described in GETAB and identify the advantages resulting from the differences between the improved R–factor calculation method and the reference R–factor calculation method.

Response

The change in R–factor calculation method was necessitated by the addition of part length rods in the GE11 and later product lines. An idealized example can be used to demonstrate the reason for the improved R–factor method: Assume a bundle in which all of the fuel rods have the same linear heat generation rate and that all of the additive constants, l_i are equal to 0. Calculating of the R–factors using the reference method in GETAB shows how the method yields unrealistic results.

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[1] In the original letter "revised Responses to NRC Request for Additional Information, R–factor Calculation Method, NEDC–32505P and GEXL Correlation (TAC No. 95081), Sep. 20, 1996" in the details of the calculation of the lower R-factors for the rods next to the water rods was not includes, as it has no bearing on the R-factor methodology for the part length rods. It is included here for completeness.

Table 1–1. R–factor Distribution in Fully Rodded Region Using Reference Method (GE11 Design)

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Table 1–2. R–factor Distribution in the Region Above the Part Length Rods Using Reference Method (GE11 Design)

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Table 1–3. R–factor Distribution Using Reference Method (GE11 Design)

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Table 1–4. Integrated Rod Peaking Using Revised Method

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Table 1–5. Correction Factors Using Revised Method

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Table 1–6. R–Factor Distribution Using Revised Method

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