UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-250 OLA-1
FLORIDA POWER & LIGHT COMPANY	)	50-251 OLA-1
	)	
(Turkey Point Plant, Units 3 and 4)	)	(Vessel Flux Reduction)

TESTIMONY OF YI-HSIUNG HSII
REGARDING CONTENTION (d)

Q.1. Please state your name, address, occupation and qualifications.

A.1. My name is Yi-Hsiung Hsii. My business address is U.S. Nuclear Regulatory Commission, Washington, DC 20555. I am a Nuclear Engineer in the Reactor Systems Branch of the Division of PWR Licensing-A in the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. Formerly, I was in the Core Performance Branch of the Division of Systems Integration. A summary of my professional qualifications and experience is attached.

Q.2. What is the purpose of your testimony?

A.2. The purpose of this testimony is to address Contention (d) which states:

> The proposed decrease in the departure in the nucleate boiling ratio (DNBR) would significantly and adversely affect the margin of safety for the operation of the reactors. The restriction of the DNBR safety limit is intended to prevent overheating of the fuel and possible cladding perforation, which would result in the release of fission products from

> the fuel. If the minimum allowable DNBR is reduced from 1.3 to 1.7 (sic: 1.17) as proposed, this would authorize operation of the fuel much closer to the upper boundary of the nucleate boiling regime. Thus, the safety margin will be significantly reduced. Operation above the boundary of the nucleate boiling regime could result in excessive cladding temperatures because of the departure from the nucleate boiling (DNB) and the resultant sharp reduction in heat transfer coefficient. Thus, the proposed amendment will both significantly reduce the safety margin and significantly increase the probability of serious consequences from an accident.

In its August 16, 1985 Order denying the Licensee's Motion for Summary Disposition of Contention (d), the Licensing Board set forth three issues:

(i) Whether the DNBR of 1.17 which the amendments impose on the OFA fuel in Units 3 and 4 compensates for the three uncertainties outlined by the Staff in its December 23, 1983 SER on the amendments, at 4.

(ii) Whether, if the DNBR of 1.17 does not compensate for those uncertainties, the SRP's 95/95 standard, or a comparable one, is somehow satisfied.

(iii) Whether, if that standard is not being satisfied, the reduction in the margin of safety has been significant.

This testimony addresses these issues as well as the questions posed by the Board in its Memorandum, dated November 18, 1985, which set forth the basis for the Board's denial of Licensee's second motion for summary disposition of Contention (d).

Q.3. What is the definition of DNBR?

A.3. Departure from Nucleate Boiling Ratio (DNBR) is defined as the critical heat flux divided by the actual heat flux. Critical heat flux (CHF) is the maximum heat flux occurring just before a change of boiling heat transfer mode results in a large increase in fuel cladding temperature.

Q.4. What is a DNBR limit or design limit and how is it derived?

A.4. A DNBR limit is the quantity imposed on a CHF correlation as the specified acceptable fuel design limit to ensure with a 95 percent probability at 95 percent confidence level, as specified in NUREG-0800, "Standard Review Plan" (SRP), Section 4.4, that the hot fuel rod in the core will not experience departure from nucleate boiling during normal operation and anticipated operational occurrences. The terms DNBR limit, design limit or allowable DNBR limit are synonymous.

If the true CHF value could be calculated and the actual heat flux is precisely known, the exact DNBR could be determined and a design DNBR limit of 1.0 would ensure DNB would be avoided. However, because CHF is calculated using an empirical correlation developed based on experimental CHF data and because of random variations in the data upon which the correlation is based, the exact CHF can not be predicted. A DNBR limit greater than 1.0 is therefore imposed to account for this uncertainty. The DNBR limit for a correlation is the value which ensures with a 95 percent probability at 95 percent confidence level that DNB will be avoided when the DNBR calculated with the correlation is greater than this value.

The DNBR limit for a correlation depends upon the ability of the correlation to predict the measured CHF data. For every CHF test data point, a CHF prediction is made using the correlation and a comparison is made between the measured and the predicted CHF values. A probability distribution of the measured-to-predicted CHF ratios is obtained for all the CHF data points. Statistical analysis is performed to obtain the estimated mean and standard deviation of the measured-to-predicted CHF ratio population. The DNBR limit is derived from the one-side tolerance limit using the acceptance criterion of 95 percent probability at the 95 percent confidence level specified in the Standard Review Plan. The only uncertainty affecting the DNBR limit is due to the inability of the CHF correlation to precisely calculate the experimental data upon which the correlation is based. No other uncertainties (or penalties) are included in the DNBR limit.

Q.5. How were the DNBR limits of 1.3 and 1.17 used at Turkey Point derived?

A.5. The 1.3 DNBR limit was derived from CHF test data used to develop the W-3 correlation. The original W-3 correlation was developed from CHF tests conducted with water flowing inside heated tubes. Subsequent modifications were made to the W-3 correlation, designated as W-3 L-Grid correlation, to apply to the test results representative of the L-Grid LOPAR fuel design.

The Westinghouse Rod Bundle CHF correlation, WRB-1, is a more recent correlation developed based on the CHF test data of the rod bundle representative of the reactor fuel assembly geometry and operating ranges. WRB-1 was originally approved for the 15x15 and 17x17 standard R-mixing vane grid LOPAR fuel designs. The approval was later extended to the 17x17 OFA fuel design based on additional data from the 17x17 OFA CHF test.

The use of a lower DNBR limit of 1.17 for the WRB-1 correlation reflects a correlation capable of predicting CHF data with less uncertainty. The correlation results from a better understanding of the CHF phenomenon, a better correlation formulation and an improved CHF test facility that yields more accurate measured CHF data. These factors result in a narrower probability distribution of the measured-to-predicted CHF ratios and result in a smaller estimated standard deviation. In addition, the large data base of more than 1100 data points used to obtain the WRB-1 correlation has resulted in requiring a smaller multiple of the estimated standard deviation in deriving the DNBR limit. The net result is a lower DNBR limit which still ensures with a 95 percent probability at 95 percent confidence level that DNB will be avoided. Therefore, imposing a DNBR limit of 1.17 for the WRB-1 correlation as the specified acceptable fuel design limit (SAFDL) provides the same assurance that the departure from nucleate boiling will not occur as the DNBR limit of 1.3 for the W-3 correlation.

Q.6. Is the DNBR limit of 1.17 for the WRB-1 correlation applicable to the 15x15 OFA fuel design?

A.6. The differences between the OFA and R-grid LOPAR fuel are the fuel pin diameters and the mixing vane spacer grid designs. The 17x17 OFA has a pin outer diameter of 0.36 inches versus 0.374 inches for the R-grid LOPAR 17x17 fuel; the 14x14 OFA and 15x15 OFA have pin diameters of 0.40 inches and 0.422 inches, respectively, compared to 0.422 inches for both 14x14 and 15x15 R-Grid LOPAR fuel. The OFA spacer grid has straps thicker and higher than the straps used in the LOPAR grids.

As discussed in the previous question, the WRB-1 correlation has previously been approved for application to the 15x15 and 17x17 R-grid LOPAR fuel and 17x17 OFA fuel with a DNBR limit of 1.17. To justify the application of the WRB-1 correlation to both the 14x14 OFA and 15x15 OFA fuel designs, Westinghouse submitted additional CHF test data from test assemblies representative of the 14x14 OFA for Staff review. No CHF data are available for the 15x15 OFA.

The additional 14x14 OFA data have shown that WRB-1 is applicable to the 14x14 OFA with the same DNBR limit of 1.17. Since the 15x15 OFA has a similar mixing vane grid design as that of the 14x14 and 17x17 OFA, and since the pin diameter, rod pitch, heated length and grid spacing of the 15x15 OFA are within the applicability range of the WRB-1 correlation, application of the WRB-1 correlation to 15x15 OFA fuel is acceptable with the same DNBR limit of 1.17.

Generic acceptance of the 1.17 DNBR limit for the application of the WRB-1 correlation to both 14x14 and 15x15 OFA is documented in a Safety Evaluation, dated June 29, 1984. Letter to E. P. Rahe, Jr., of Westinghouse, Acceptance for Referencing of Licensing Topical Report-WCAP-8762(P)/WCAP-8763(NP), Supplement 1, "Basis for the Applicability of the WRB-1 correlation to 15x15 OFA and 14x14 OFA Fuel."

Q.7. What effect does the use of 1.17 DNBR limit for WRB-1 versus a 1.3 DNBR limit for W-3 have on the plant's safety margin?

A.7. The DNBR limits are imposed for the respective CHF correlations as the specified acceptable fuel design limits to ensure with a 95 percent probability at a 95 percent confidence level, as specified in NUREG-0800, "Standard Review Plan" (SRP), Section 4.4, that the hot fuel rod in the core will not experience departure from nucleate boiling during normal operation and anticipated operation occurrences. The difference in the DNBR limits reflects the use of different CHF correlations with differing capabilities to predict CHF data. Both the 1.17 limit for WRB-1 and 1.3 for W-3 meet the 95/95 standard. Therefore, there is no reduction in safety margin.

Q.8. What is a calculated minimum DNBR and how does it differ from a design DNBR?

A.8. The "calculated minimum" DNBR is the lowest value of the DNBRs calculated from the predictive computer analysis using the THINC code for all transients.

DNBR value changes during a transient or accident. The minimum DNBR value for each of the anticipated transients is calculated using the THINC subchannel thermal hydraulic code and a CHF correlation such as WRB-1. The resulting minimum DNBR is the calculated minimum DNBR for the particular transient. After the minimum DNBR's of all the transients are calculated, the lowest value of all "minimum DNBR's" is referred to as the "calculated minimum DNBR." In Section 3 of the December 23, 1983 Safety Evaluation (SE), the term "Safety Analysis minimum DNBR limit" was used to indicate that the calculated minimum DNBR for each in the safety analysis is greater than or equal to this value. The Staff's use of the term minimum DNBR <u>limit</u> in the SE is confusing and was not intended to refer to the design DNBR limit.

Q.9. What are the procedures and/or techniques used to ascertain the "calculated minimum" DNBR including any assumptions and uncertainties?

A.9. The calculation of the minimum DNBR is performed through the use of approved computer codes and correlations. The minimum DNBR for each of the anticipated transients is calculated using the THINC subchannel thermal hydraulic code and a CHF correlation such as WRB-1. The input to the THINC code includes a geometry model representing the reactor core, fuel assemblies and subchannels. Reactor conditions during the transients, including the values of reactor power, pressure, coolant flow rate, inlet temperature and power distribution, are also input into the THINC code. In providing input to the THINC code, uncertainties of all important process and design parameters are accounted for by using a conservative value for each parameter.

The conservative value of a parameter is the nominal value plus or minus the uncertainty of the parameter. Conservatism in this case, means that use of this value in the analysis results in a lower DNBR compared to the DNBR calculated without considering the uncertainty. The addition or subtraction of an uncertainty from the nominal value to obtain the conservative value depends on whether a higher or lower value of the parameter would give a lower DNBR. For example, a lower flow rate would result in lower DNBR and the flow uncertainty is subtracted to give the conservative value of flow rate. A higher inlet temperature would result in a lower DNBR and the temperature uncertainty is added to give the conservative value of inlet temperature. The uncertainty value of each parameter is obtained by either a bounding value or a value with a 95% probability at a 95% confidence level.

The underlying assumption of the input of all uncertainties at their conservative values of the process and design parameters into the THINC computer code (and therefore resulting in the much lower calculated DNBR) is that all the adverse effects would occur at the same time. This is a very conservative approach because it is not likely that all adverse effects occur simultaneously. Therefore, the calculated minimum DNBR for each transient would be lower than the true value expected during the transient, and is a conservative value. The "calculated minimum" DNBR is the lowest value of the minimum DNBRs calculated for all transients and is therefore also a conservative value.

Q.10. How are uncertainties not included in the THINC code calculation accounted for in the DNBR analysis?

A.10. For all Westinghouse plants, any uncertainty important to the calculation of minimum DNBR but not included in the input to the THINC computer code is converted to a "penalty." This penalty is a reduction in DNBR which is applied to the DNBR calculated by the THINC code. The value of a penalty is a result of a separate analysis in which the physical phenomonon being considered has been converted to an equivalent DNBR. For example, fuel rod bowing reduces the DNBR but the fuel rod bowing is not directly modeled in the core or fuel assembly geometric modeling in THINC. Therefore a rod bow penalty is calculated separately. The difference in hydraulic resistances of the OFA and the LOPAR fuel designs is not modeled for a transitional mixed core and therefore a mixed core penalty is calculated. These penalties are applied when assessing whether the SRP's 95/95 standard is met. Each penalty value is either a bounding value or is evaluated using a 95/95 criterion. This assures that when the penalties are applied in the safety analysis the resulting DNBR will be conservative.

Q.11. How is compliance with the Standard Review Plan Criterion that the hot rod in the core will not experience DNB with a 95% probability at a 95% confidence level assured?

A.11. To assure compliance with the Standard Review Plan Criterion that the hot rod in the core will not experience DNB with a 95% probability at a 95% percent confidence level (95/95), the minimum DNBR calculated, with the uncertainties in the values of process parameters, core design parameters and calculation methods used in the DNBR calculation accounted for, must be greater than the 95/95 DNBR limit of the CHF correlation used (for example 1.17 for WRB-1). Each uncertainty value is either a bounding value or at least a 95/95 limit value.

As discussed in A.9 and A.10, the uncertainties of those parameters used in the THINC thermal hydraulic calculations are treated by inputting the conservative values into the THINC computer input. The resulting DNBR calculated by the THINC code is called the calculated DNBR. Uncertainties not included in the THINC computer calculations are treated as penalties (e.g., rod bow penalty).

Generally, there are two approaches to account for these penalties. One, a new 95/95 DNBR limit (SAFDL) is derived by summing up the CHF correlations 95/95 limit (for example 1.17 for WRB-1) and the total penalty. The THINC calculated DNBR is then compared to the new DNBR limit. If the calculated DNBR is greater than the new DNBR limit, the 95/95 standard is met. Or two, the 95/95 DNBR limit (SAFDL) remains unchanged as the CHF correlation's 95/95 limit (e.g., 1.17) and the THINC calculated DNBR is reduced by the total penalty. If the reduced calculated DNBR is greater than the 95/95 DNBR limit for the correlation used in the calculation, the SRP 95/95 standard is more than met.

With respect to the second approach, it is a common practice that no actual subtraction of the penalty is done to reduce the calculated DNBR. Rather, the safety analysis is performed without the penalty. The minimum DNBR for each anticipated transient is calculated with THINC code and the "calculated minimum DNBR" is used to calculate a DNBR margin.

A DNBR margin is the percentage difference between the calculated minimum DNBR and the design DNBR limit which is strictly the CHF correlation 95/95 limit. The DNBR margin is then

compared to the total penalty. If the margin is greater than the penalty, the SRP 95/95 standard is met.

Q.12. What model is used to determine the DNBR for a transitional mixed core?

A.12. A homogenous core model is used to calculate DNBR for a transitional mixed core containing LOPAR and OFA fuel. The effects of the mixed core are accounted for by applying a penalty.

A more precise approach to calculate the minimum DNBR for a mixed core would be to perform the calculations with a model representing the mixed core. However, using a homogenous core model to calculate the mixed core minimum DNBR is also acceptable as long as the effect of a mixed core on DNBR is accurately accounted for by a suitable quantity for mixed core penalty.

The mixed core penalty accounts for the fact that coexistence of two different fuel designs having different hydraulic resistance characteristics affects the cross flow between the different fuel bundles in such a way that the fuel design having the higher grid resistance will have less flow. Since the OFA fuel has higher grid resistance, more flow would be diverted to the LOPAR fuel. Since the plant specific safety analysis was performed with the assumption of either a whole

core of OFA or a whole core of LOPAR fuel, a penalty is applied to the OFA analysis results to account for this decreased flow. In other words, the DNBR calculated for a whole core of OFA is reduced by the mixed core penalty. No penalty is applied to the LOPAR fuel since a mixed core configuration is advantageous to LOPAR fuel in that more flow is diverted into the LOPAR fuel.

The mixed core penalty is determined from a sensitivity study performed with the THINC code in which a variety of bundle configurations are modeled and the DNBR's are calculated for various reactor conditions. The percent difference in the DNBR between a homogenous core configuration and a mixed core configuration is calculated at each condition. A bounding value of these differences is used as the mixed core penalty. Therefore, applying the mixed core penalty to the DNBR calculated with a homogenous core configuration ensures a more conservative DNBR than that calculated with a mixed core model.

The homogenous core approach and mixed core penalty have been approved for Westinghouse on a generic basis and are documented in two reports dated January 24, 1983 ("Supplemental Acceptance Number 2 for Referencing of Licensing Topical Report WCAP-9500" and "WCAP-4401/9402"). This approach has also been used at various plants having transitional mixed cores.

Q.13. Is a DNBR limit of 1.17 acceptable for OFA fuel in a mixed core?

A.13. Since the DNBR calculation is performed with a homogenous core model during a transitional mixed core, a mixed core penalty is applied to the calculated minimum DNBR to account for the CHF effect due to the difference in the hydraulic resistances of different fuel design. The DNBR limit of 1.17 remains adequate and the 95/95 standard is met if there is sufficient margin between the design DNBR and the calculated minimum DNBR to compensate for the mixed core penalty.

Q.14. How was Turkey Point analysis performed?

A.14. The minimum DNBR in the Turkey Point safety analysis was calculated using the THINC subchannel thermal hydraulic code and the WRB-1 correlation for the OFA fuel (the W-3 correlation for the LOPAR fuel). The minimum DNBR was calculated for each of the anticipated transients based on a homogenous core model.

The uncertainties of the process parameters and core design parameters were treated by using the conservative values of these parameters in the imput to do THINC computer code. The "calculated minimum" DNBR is then obtained. Since a homogenous core of the 15 x 15 OFA fuel was assumed in providing the input to the THINC code, a mixed core penalty was assessed. Since the fuel rod bowing effect and the applicability of the WRB-1 correlation to the 15 x 15 OFA was not considered in the THINC code input, penalties for these factors were also assessed.

The assessment of penalties against the calculated minimum DNBR is not unique to Turkey Point, but is used at all Westinghouse plants.

As stated in the Staff's December 23, 1983 SE, the three penalties the Licensee's calculated minimum DNBR value must make allowance for above the design DNBR limit of 1.17 are: (a) a rod bow penaltv of 5.5 percent of DNBR, (b) a transitional mixed core penalty of 3 percent and (c) an uncertainty of less than 2 percent for the application of the WRB-1 correlation to the 15x15 OFA fuel design. SE § 3.

Q.15. How was the 5.5 percent rod bow penalty derived?

A.15. The rod bow penalty accounts for the fact that fuel rod bowing results in reduction of the critical heat flux and therefore reduction in DNBR. Since the Licensee's safety analysis was performed without the assumption of fuel rod bowing in the input to the computer program, the resulting calculated DNBR should be reduced by 5.5 percent to account for the rod bow uncertainty.

The 5.5 percent rod bow penalty was derived based on an approved method described in a Westinghouse topical report

WCAP-8691, Revision 1, Fuel Rod Bow Evaluation, July 1, 1979. This method has been used for most plants of Westinghouse designs. The penalty derived using this method is a 95/95 tolerance limit. Furthermore, the manner in which the effect of fuel rod bowing on DNBR is applied as a rod blow penalty is also conservative. The underlying assumption is that the largest rod bowing occurs at the hot channel fuel rods and at the location of the minimum DNBR. The minimum DNBR generally occurs at the upper portion of the core whereas the rod bowing usually occurs at the lower portion of the core. Also, rod bowing does not occur at every fuel rod. Data show that severe rod bowing generally occurs at the fuel rods having high burnup, whereas the hot channel with highest power peaking factor generally occurs with low burnup fuel. Therefore, the assumptions of the largest rod bowing occuring at the hot channel rods and at the minimum DNBR locations is conservative.

Q.16. How was the 3 percent penalty for a transitional mixed core of 15 x 15 LOPAR and OFA fuel derived?

A.16. The 3 percent mixed core penalty is based on a sensitivity study performed specifically for the 15 x 15 OFA and 15 x 15 LOPAR fuel mixed core. The study was done with the approved method described in a Westinghouse submittal (E.P. Rahe, Jr. to J. R. Miller, "Supplement to WCAP-9500 and WCAP-9401/9402: NRC Safety Evaluation Report (SER) Mixed Core Compability Item 5-Supplemental Information," August 17, 1982).

The sensitivity study was performed with the THINC code by using a homogenous core model and various mixed core models, including the worst mixed core configuration where one OFA assembly is completely surrounded by LOPAR assemblies. The difference in the DNBR calculated with a homogenous OFA model and mixed core models are calculated for the cases analyzed at various reactor operating conditions. The results showed the maximum difference is less than 3 percent. Thus, a 3 percent mixed core penalty is used as a bounding value.

Q.17. How was the 2% penalty for application of WRB-1 to 15 x 15 OFA derived?

A.17. As discussed in a A.6 above, WRB-1 was previously approved for application to 15 x 15 and 17 x 17 R-Grid LOPAR fuel and 17 x 17 OFA fuel with a DNBR limit of 1.17. Additional CHF test data for the 14 x 14 OFA with a DNBR limit of 1.17 has provided bases for the applications of WRB-1 to the 14 x 14 OFA.

Since the 15 x 15 OFA and the 15 x 15 R-Grid LOPAR fuel designs have the same fuel diameter, rod-pitch, heated length and grid spacing, the only difference is in the grid designs. On the other hand, the 15 x 15 OFA and the 14 x 14 OFA have the same grid designs, the only difference is the fuel rod diameters which are 0.422 inches and 0.4 inches, respectively. Since WRB-1 is applicable to both the 15 x 15 R-Grid LOPAR fuel and

14 x 14 OFA, it would also be applicable to the 15 x 15 OFA. However, the Staff identified the lack of specific 15 x 15 OFA CHF data as an element of uncertainty. Based on engineering judgment, it was concluded that the uncertainty would not be greater than 2%. Before the generic review of of the application of WRB-1 to both the 14 x 14 and the 15 x 15 OFA fuel designs, the Staff used a 2 percent penalty for the evaluation of the Turkey Point amendment as a conservative measure to account for the lack of the specific 15 x 15 OFA CHF data. Because the generic review of the application of WRB-1 to both the 14 x 14 and 15 x 15 OFA designs is now complete, there is no need for the 2 percent penalty.

Q.18. Are the rod bow penalty, the mixed core penalty, and the penalty for application of WRB-1 to the 15 x 15 OFA independent?

A.18. The penalty for the application of WRB-1 to the 15 x 15 OFA has no relationship to either rod bow penalty or mixed core penalty because the correlation was developed without the consideration of, and was not influenced by, rod bowing or the mixed core configuration. Therefore, the penalty for application of WRB-1 is independent of the rod bow and mixed core penalties.

A mixed core configuration does not increase fuel rod bowing or the rod bow penalty on DNBR. Fuel rod bowing reduces the subchannel rod-to-rod gap (gap closure). Test data show that

there is no noticeable effect on CHF when the gap closure is less than 54 percent (gap closure is defined as the percent of reduction from the straight rod-to-rod gap due to rod bowing). However, greater gap closure results in a reduction in CHF. The exact mechanism of the adverse rod bow effect on CHF is not known but the evidence from the bow-to-contact test data suggests that the reduction in CHF due to rod bow is a highly localized phenomenon caused by the starvation of coolant in the vicinity of the point of contact. Even though the fuel bundle coolant flow rate has an effect on the subchannel CHF without rod bowing, the test data show that the "bow effect parameter" (a measure of the difference between the unbowed CHF and bowed CHF) is not noticeably affected by the coolant flow rate. Indeed, the bow effect parameter has been correlated with only the system pressure and the hot pin heat flux. The effect of the coolant flow rate is not needed in the correlation.

In a transitional mixed core containing fuel assemblies of different design, the flow reduction in the higher resistance assembly is a global (bundle) phenomenon. For the mixed core of OFA-LOPAR fuel designs, the flow reduction through the OFA is approximately 2 to 3 percent. The reduction of flow rate of this magnitude would not affect the localized phenomenon of CHF reduction due to rod bow. Thus, although there may be a physical relationship between the reduction in DNBR due to rod bowing and the flow reduction due to fuel bundle hydraulic resistance, the effect is of a lower order and, as a valid engineering assumption, can be neglected. Thus, it is the Staff's technical judgment that for the engineering calculations which determine the DNBR limit it is acceptable to assume that there is no interaction between the effects of fuel rod bowing on CHF and the flow changes caused by a mixed core configuration. Therefore, the rod bow penalty and the mixed core penalty are independent of each other.

Q.19. What is the total penalty to account for the effects of rod bow, the hydraulics of the mixed core and application of WRB-1 to the 15 x 15 OFA?

A.19. The total penalty for rod bow (5.5%), the mixed core (3%) and the application of the WRB-1 correlation to the 15x15 OFA (2%) is obtained from simple summation and is 10.5%. It is a common engineering practice to simply sum up the uncertainties (or penalties) since each uncertainty is a conservative value and is independent. In addition, there is only a small difference between the result calculated by summation and the 10.84% penalty calculated by the following formula: 1.055 x 1.03 x 1.02 - 1.0 = 0.10838.

Q.20. What is the calculated minimum DNBR in the Turkey Point safety analysis for OFA fuel and does it meet the Standard Review Plan's 95/95 standard?

A.20. For Turkey Point OFA fuel, the calculated minimum DNBR is 1.34. Since the design DNBR limit for the WRB-1 CHF correlation is

1.17, the DNBR margin between 1.34 and 1.17 is 12.7%, which is greater than the 10.5 percent total penalty calculated for the plant. Therefore the SRP's 95/95 standard is met.

Q.21. Does the DNBR limit of 1.17 which the amendments impose on OFA fuel in Turkey Point Units 3 and 4 compensate for the three uncertainties associated with rod bow, the mixed core and the application of WRB-1?

A.21. No. The design DNBR limit of 1.17 for the WRB-1 CHF correlation is derived from the measured to predicted CHF ratio to ensure that there is a 95 percent probability at a 95 percent confidence level that DNB will not occur. The DNBR limit of 1.17 is considered a specified acceptable fuel design limit (SAFDL) for normal operation and anticipated operational occurrences as discussed in General Design Criterion 10 of 10 CFR 50, Appendix A. The 1.17 design limit does not compensate for any uncertainties related to the THINC computer code DNBR calculation nor does it compensate for the three penalties in question.

Q.22. Since the DNBR of 1.17 does not compensate for the uncertainties of rod bow, the mixed core and the application of WRB-1 to the 15 x 15 OFA, is the SRP's 95/95 standard or a comparable one, somehow satisfied?

A.22. Yes. The minimum DNBR calculated by the THINC computer code for all anticipated operational transients in 1.34. This 1.34

minimum DNBR is calculated with the uncertainties of all parameters important to DNBR calculations included in the input to THINC code. The three uncertainties associated with rod bow, the mixed core or application of WBR-1 were not included in the calculation of 1.34. However, the calculated minimum DNBR 1.34 is 12.7% higher than the design DNBR limit of 1.17 for the WRB-1 correlation. This 12.7% DNBR margin is larger than the total penalty of 10.5% (or 10.84%, as noted in A.19) for the three penalties in question. Therefore, the SRP's 95/95 standard is met.

Q.23. How are three penalties included in the Technical Specifications?

A.23. The license requirement is set forth in TS 2.1.1, Safety Limits on Reactor Core, which specifies that the combination of thermal power, pressurizer pressure and the highest operating loop coolant temperature (T_{avg}) shall not exceed the limits shown in Figure 2.1-1. The safety limits shown in TS Figure 2.1-1 were established through the safety analysis which has a DNBR margin of 12.7% to compensate for the total penalty of 10.5% for the rod bow penalty, the mixed core penalty and the penalty for applications of WRB-1 to the 15 x 15 OFA. These safety limits provide assurance that the 95/95 standard is met. Any change to the analysis which would alter the curves in TS Figure 2.1-1 would require prior NRC approval. While it would be preferable to refer to all penalties instead of the rod bow penalty alone in the TS Bases, it is not necessary. Bases are only summaries.

Q.24. Does the use of a design DNBR of 1.17 for OFA fuel result in a significant reduction in safety margin for the plant?

A.24. No. The safety margin is not determined by a specific value of DNBR limit, but a DNBR limit which provides a protection against DNB with a 95/95 standard. Since both 1.17 for WRB-1 and OFA fuel and 1.3 for W-3 and LOPAR fuel meet the 95/95 standard and provide the same degree of assurance that DNB will not occur, there is no reduction in safety margin provided by the 95/95 standard. Because the Licensee's calculated minimum DNBR of 1.34, even if penalized for uncertainties totalling 10.5%, is still greater than the 1.17 specified acceptable fuel design limit, the calculated minimum DNBR of 1.34 more than meets the 95/95 standard. Thus, the margin of safety provided by the standard has not been reduced.

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PROFESSIONAL QUALIFICATIONS

I am a Nuclear Engineer in the Reactor Systems Branch of the Division of PWR Licensing-A in the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. Prior to my current assignment, I was in the Core Performance Branch of the Division of Systems Integration. I have been working as a technical reviewer on the safety evaluation reports and reload method topical reports on core thermal hydraulics submitted by applicants and licensees. I also serve as technical monitor and project manager of a few technical assistance programs undertaken by the national laboratories.

I graduated from Taiwan University with a BS in Mechanical Engineering. Later, I attended North Carolina State University, where I received a Ph.D in Mechanical Engineering in 1972. I am a registered Professional Engineer, Certificate Number 10352, in the State of Virgina.

Prior to joining the NRC staff in January 1981, I was employed by the Babcock and Wilcox Company for a total of eleven years. From January 1967 to August 1968 I was employed as an Engineer in the Thermal Analysis Group. From 1971 to 1981, I was employed as a Senior Engineer and then Principal Engineer in the Technical Staff Section. My work at B&W included PWR core thermal hydraulic design analysis, and development of computer codes in the areas of containment systems, reactor system transients, and fuel pin thermal performance analysis, as well as general-purpose heat transfer codes.