Westinghouse Non-Proprietary Class 3

Attachment 2

RAI Responses for WCAP-17661-P/ WCAP-17661-NP, Revision 1

(Non-Proprietary)

RAI Responses for WCAP-17661-P/ WCAP-17661-NP, Revision 1 (Non-Proprietary)

RAI No. 1: Required Actions when both $F_Q^C(z)$ and $F_Q^W(z)$ exceed limits

Background

Under the proposed change for both relaxed axial offset control (RAOC) heat flux hot channel factor ($F_Q(Z)$) Surveillance (TS 3.2.1B) and constant axial offset control (CAOC) $F_Q(Z)$ Surveillance (TS 3.2.1C), Required Actions are now different for Condition A and B. When $F_Q^C(Z)$ is not within limits, reduction of THERMAL POWER is required along with reduction of setpoints and performance of Surveillance Requirement (SR) 3.2.1.1 and SR 3.2.1.2. Whereas, when $F_Q^W(Z)$ is not within limits, two alternative actions may be applicable. Required Action B.1 requires implementation of a different operating space and if an appropriate operating space cannot be implemented, reduction of THERMAL POWER and setpoints and performance of SR 3.2.1.1 and SR 3.2.1.2 are required. The proposed change in Required Action when $F_Q^W(Z)$ exceeds limits is intended to avoid THERMAL POWER reduction through implementation of a different operating space (Required Action B.1).

Issue and Request

Under the proposed change, when $F_Q^C(Z)$ is within limits and $F_Q^W(Z)$ is not within limits, a different operating space may be implemented and a THERMAL POWER reduction will not be required. However, when both $F_Q^C(Z)$ and $F_Q^W(Z)$ are not within limits, Required Action for $F_Q^C(Z)$ will require reduction of THERMAL POWER. The corresponding evaluation and action for $F_Q^W(Z)$ require clarification. For example, Condition A ($F_Q^C(Z)$ not within limit) requires reduction of THERMAL POWER greater than or equal to (≥) 1 percent (%) for each 1% $F_Q^C(Z)$ exceeds the limit, but Condition B ($F_Q^W(Z)$ not within limit) may require reduction of THERMAL POWER which may be evaluated for 5% decrements in the core operating limit report (COLR). Also, implementation of Required Action B.1 is unclear since the action does not involve reduction of THERMAL POWER.

a. Provide a complete explanation and justification for the THERMAL POWER actions that will be taken when *both* $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits including how the COLR evaluations will be used. Discuss the compatibility of actions for $F_Q^C(Z)$ and $F_Q^W(Z)$ and the supporting evaluations in the COLR.

b. Based on the discussion and the need for clarity of the Required Actions when both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed limits, discuss the need for a NOTE in the Required Action column that may be useful for the operators in abiding by these specifications.

Response to RAI No. 1:

Background Information:

During the power distribution measurements taken during power ascension after a refueling, the plant is still conditioning the fuel for full power operation and is not ready to perform the type of load follow power maneuvers that could challenge the F_Q limit. The measured $F_Q^C(Z)$ from power distribution measurements taken at less than 75% RTP after a refueling is used to confirm that the core is loaded correctly and is behaving consistently with predictions. The $F_Q^C(Z)$ obtained from these measurements will normally have ample margin to the F_Q limit, because the measurements are performed at steady state low power conditions, and the core has been designed to meet the F_Q limit under transient conditions at 100% RTP. If $F_Q^C(Z)$ exceeds the F_Q limit, which is an extremely rare occurrence, the core is in a current operating state where the peak power density is greater than the maximum value assumed in the safety analysis, and the Technical Specification (TS) Actions for Condition A would be implemented. $F_Q^W(Z)$ represents the most limiting transient operation within the allowed AFD limits, i.e., all the extreme cases of frequent core power ramping up and down (load follow) to meet the power demand. These types of power maneuvers are not permitted until the fuel is conditioned to full power operation. Even after the fuel is fully conditioned for full power operation, most plants do not load follow, and operate in the base load mode of operation. If $F_Q^W(Z)$ exceeds the F_Q limit, the core is not currently operating in a condition that exceeds the bounds of the safety analysis. Rather, an $F_Q^W(Z)$ violation indicates that the next 31 EFPD of potential transient operation within the allowed AFD operational space cannot be supported, and the Technical Specification (TS) Actions for Condition B would be followed.

Although the example COLRs in Appendices C and F of WCAP-17661-P identify the F_Q limits separately for $F_Q^C(Z)$ and $F_Q^W(Z)$, the practice for Westinghouse NSSS plants is to define the F_Q limit as the same function for both $F_Q^C(Z)$ and $F_Q^W(Z)$. The F_Q limit is based on the peak local power density assumed in the plant safety analysis. Therefore, there is effectively only one F_Q limit that is applicable to both $F_Q^C(Z)$ and $F_Q^W(Z)$.

Response to 1a:

Since $F_Q^W(Z)$ is always greater than $F_Q^C(Z)$ in any single power distribution measurement, and the applicable COLR F_Q limits are the same, any situation where $F_Q^C(Z)$ exceeds the F_Q limit will result in $F_Q^W(Z)$ exceeding the limit as well.

Clearly, if $F_Q^C(Z)$ exceeds the COLR F_Q limit, this requires a more immediate corrective response than if only $F_Q^W(Z)$ exceeds the limit. Hence, the TS Completion Time for completing the THERMAL POWER reduction in Required Action A.1 is only 15 minutes. In the situation where only Condition B ($F_Q^W(Z)$ not within limit) is entered, the Completion Time for the associated Required Actions B.1 or B.2.1 is 4 hours.

Therefore, if both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, Required Action A.1 will be completed first due to the 15 minute Completion Time. Once the power level is reduced below that specified by Required Action A.1, the current operating peak power density will be restored to less than the value assumed in the safety analysis. However, this Required Action may not ensure that the $F_Q^W(Z)$ limit is met.

New Required Actions for Condition B are proposed to either implement a new operating space or a reduction in THERMAL POWER, and are required in order to ensure compliance with the $F_Q^W(Z)$ limit during future operation under transient conditions. The COLR will provide the available options in terms of implementing a new operating space or a new limit on the maximum *allowed* THERMAL POWER for the purpose of restoring compliance with the $F_Q^W(Z)$ limit. An important distinction between Required Actions A.1 and proposed B.2.1 is that Required Action A.1 requires a reduction of the current operating power level, regardless of what that current operating power level is at the time the surveillance is performed, while proposed Required Action B.2.1 establishes a new THERMAL POWER limit which is less than the RATED THERMAL POWER.

If an F_Q surveillance is performed at 100% RTP conditions, and both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, the option to reduce the THERMAL POWER limit in accordance with proposed Required Action B.2.1 instead of implementing a new operating space in accordance with proposed Required Action B.1, will result in a further power reduction after Required Action A.1 has been completed. However, this further power reduction would be permitted to occur over the next 4 hours. In the event the evaluated THERMAL POWER reduction in the COLR for proposed Required Action B.2.1 did not result in a further power reduction (for example, if both Condition A and Condition B were entered at less than 100% RTP conditions), then the THERMAL POWER level established as a result of completing Required Action A.1 will take precedence, and will establish the effective operating power level limit for the unit until both Conditions A and B are exited.

A revised markup of the Bases for TS 3.2.1B and 3.2.1C that contains the paragraph above, is included in Attachments 4 and 6 to the RAI responses.

Response to 1b:

The Required Actions for Conditions A and B are different because of the differences in both the immediate severity associated with violating the $F_Q^C(Z)$ limit, versus the $F_Q^W(Z)$ limit, and because there will be significant differences in the amount of margin needed to restore compliance with their respective F_Q limits. In situations where both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed the COLR F_Q limits, compliance with both limits must be restored. Therefore, it is necessary to comply with the Required Actions associated with both Conditions A and B. There is no fundamental incompatibility between the Required Actions for Conditions A and B, since both sets of Required Actions can be met within their associated Completion Times. Since both Conditions A and B require the completion of both SR 3.2.1.1 and SR 3.2.1.2 prior to increasing power above their respective power limits, this ensures that both $F_Q^C(Z)$ and $F_Q^W(Z)$ are assessed and restored to compliance with their respective limits, in the event that either, or both of those parameters exceed their F_Q limit. Therefore a clarifying NOTE to the Required Actions is not necessary.

RAI No. 2: Need to perform SR 3.2.1.2 when $F_Q^C(Z)$ not within limit following refueling prior to THERMAL POWER exceeding 75% rated thermal power (RTP)

Background

Under the proposed change for SR 3.2.1.2, "Verify $F_Q^W(Z)$ is within limit," the first frequency is revised whereby instead of conducting the surveillance "Once after each refueling prior to THERMAL POWER exceeding 75% RTP [rated thermal power]" the requirement will be "Once after each refueling within [24] hours after achieving equilibrium conditions *after* [emphasis added] THERMAL POWER exceeds 75% RTP." This change makes the SR for $F_Q^C(Z)$ and $F_Q^W(Z)$ different, i.e., following refueling, $F_Q^C(Z)$ is checked prior to exceeding 75% RTP whereas $F_Q^W(Z)$ is checked after exceeding 75% RTP. The primary justification for not conducting the surveillance for $F_Q^W(Z)$ below 75% RTP is that, during power ascension, $F_Q^W(Z)$ calculations are not reliable at such power levels.

Issue and Request

The justification for not conducting the $F_Q^W(Z)$ surveillance following refueling prior to exceeding the 75% RTP seems valid and appropriate. However, because of the change, an apparent contradiction is noted. Condition A, $F_Q^C(Z)$ not within limit, may occur prior to THERMAL POWER exceeding 75% RTP. Required Action A.4, "Perform SR 3.2.1.1 and SR 3.2.1.2," will involve unnecessary performance of SR 3.2.1.2.

Provide either an explanation or correction for this situation.

Response to RAI No. 2:

In response to this RAI, the **bold** text will be added to the Note for Condition A and will read as follows:

...........NOTE...............

Required Action A.4
shall be completed
whenever this Condition
is entered. **SR 3.2.1.2 is not required**
to be performed if this Condition is entered
prior to THERMAL POWER
exceeding 75% RTP after a
refueling.

A revised markup of TS 3.2.1B and 3.2.1C is included in Attachments 3 and 5 to the RAI responses.

RAI No. 3: Changes to SR 3.2.1.2

Background

Section 3.2.5 states (Page 3-16):

> The first Frequency for SR 3.2.1.2 [currently requiring performance of $F_Q^W(Z)$ surveillance "Once after each refueling prior to THERMAL POWER exceeding 75% RTP"] will be changed to state that $F_Q^W(Z)$ must be verified to be within its limit following each refueling within 24 hours <u>after</u> achieving equilibrium conditions after thermal power exceeds 75% RTP... This change is justified since initial startups following a refueling are slow and tightly controlled due to startup ramp rate limitations and fuel conditioning requirements. Consequently, the initial startup following a refueling will not result in non-equilibrium power shapes that could challenge the $F_Q^W(Z)$ limit. Also, core power distribution measurements taken at low powers (< 50% RTP) to confirm that the core is loaded properly will provide ample indication that the core is operating consistent with expectations. The new Frequency will ensure that verification of $F_Q^W(Z)$ is performed within a reasonable time period and prior to extended non-equilibrium operation at power levels where the maximum permitted peak linear heat rate could potentially be challenged.

Page B-1 provides a BASES[1] definition of equilibrium conditions: "being at a stable reactor power (i.e., within plus or minus (±) 1% RTP) and at stable axial flux conditions (i.e., with an axial flux difference variability of± 1% over the previous 24 hours."

Issue and Request

It is not clear that the "new Frequency will ensure that verification of $F_Q^W(Z)$ is performed... *prior to extended non-equilibrium* [emphasis added] operation at power levels where the maximum permitted peak linear heat rate could potentially be challenged," because the new surveillance requirement would permit operation above 75% RTP, *prior to achieving equilibrium conditions*, without performing an initial surveillance. Therefore, as acknowledged in the proposed BASES, "In the absence of these Frequency conditions (discussed above) it is possible to operate for 31 EFPD without verification of $F_Q^W(Z)$."

The current version of the SR establishes an unambiguous requirement to verify $F_Q^W(Z)$ prior to exceeding 75% RTP and generally every 31 EFPD thereafter (or in accordance with the Surveillance Frequency Control Program). The improved TS should also establish an unambiguous requirement to perform an initial surveillance, followed by periodic surveillances on an appropriately justified frequency.

a. Provide analyses of past data of initial surveillance of $F_Q^W(Z)$ prior to exceeding 75% RTP following a refueling to demonstrate that surveillance at low power levels can be challenging with respect to obtaining an accurate transient F_Q margin assessment.

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[1] NRC staff reviews the proposed BASES for information only and issues requests to obtain clarification and improve the interpretability of the proposed TS; however, plant-specific BASES are administratively controlled and the NRC staff does not intend to extend approval to the BASES provided in WCAP-17661-P Appendices, or to any plant proposing to implement WCAP-17661-P.

b. Justify the 24 hours for completing the surveillance after achieving the equilibrium condition, particularly since 24 hours has elapsed to establish an equilibrium condition.

Response to RAI No. 3:

Response to 3a:

Historically, the issue and difficultly associated with performing $F_Q{}^W(Z)$ surveillances at reduced power levels has been the fact that the predicted surveillance factors used in the current methodology to convert the measured $F_Q{}^C(Z)$ into $F_Q{}^W(Z)$ (i.e., the W(Z) functions) have been generated assuming that the surveillance is performed at 100% RTP, with all control rods fully withdrawn from the core. The denominator of the W(z) function is currently defined as the predicted steady state $F_Q(Z)$ distribution at the plant conditions when the surveillance is performed, times the power level at the plant conditions when the surveillance is performed (see Equation 3-9 on page 3-3 of WCAP-17661-P). In order to perform an accurate $F_Q{}^W(Z)$ surveillance at reduced power levels during the initial startup following a refueling, using the current F_Q surveillance methods, it has been necessary to generate specific part power W(Z) functions at the expected plant conditions when the surveillance is performed.

Rather than presenting the results from specific part power flux maps (which would almost always be at non-equilibrium conditions) in response to RAI 3.a, Table RAI-3.1 has been provided below, which demonstrates the magnitude of the correction factors that have historically been needed for a typical plant to convert a full power beginning of cycle W(Z) function into a part power W(Z) function. These correction factors account for both the change in relative power when the surveillance is performed, and the predicted change in the steady state axial power shape at reduced power levels. Therefore, in order to generate accurate W(Z) corrections, a transient simulation of the startup must be performed in advance, to simulate the control rod motion and transient xenon conditions expected during the startup. Since the resulting corrections are highly sensitive to control rod position and xenon, any differences between the timing of the actual startup and the simulated startup can result in large errors in the surveillance results, if not corrected prior to the performance of the $F_Q{}^W(Z)$ surveillance.

The revised F_Q surveillance formulation (defined in Equations 5-1 and 5-2 on page 5-1 of WCAP-17661-P) for RAOC plants significantly reduces the overall sensitivity of the $F_Q{}^W(Z)$ surveillance to the power level of the surveillance. The sensitivity to the predicted steady state axial power distribution is completely eliminated, and the core relative power term is incorporated directly into the surveillance equations, and is not part of the predicted surveillance factor data. However, there is still some sensitivity present in the new F_Q surveillance formulation to the plant conditions when the surveillance is performed, and this is represented by the $A_{XY}(Z)$ term (defined in Equation 4-35 on page 4-10 of WCAP-17661-P). Tables 4-3, 4-4, 4-5, and 4-6 in WCAP-17661-P demonstrate the sensitivity of the $A_{XY}(Z)$ term to the relative power when the surveillance is performed, and the lead control rod bank position.

Similarly, for CAOC plants, the new F_Q surveillance formulation is less sensitive to surveillances performed at reduced power conditions, and the analogous correction term applied is called $A_Q(Z)$, which is defined in Equation 7-10 on page 7-3 of WCAP-17661-P. Table 7-1 in WCAP-17661-P shows typical values of $A_Q(Z)$ for surveillances performed at 90% RTP.

Response to 3b:

As noted in Section 5.5 of WCAP-17661-P, the Frequency for performing the initial Surveillance Requirement (SR 3.2.1.2) for $F_Q^W(Z)$ following a refueling that is contained in some plant's Technical Specifications is "within 12 hours of achieving equilibrium conditions *after* [emphasis added] THERMAL POWER exceeds 75% RTP." During a controlled startup following a refueling, the plant is in a startup and testing phase, and is not ready to perform the type of load follow power maneuvers that could challenge the $F_Q^W(Z)$ limit until the fuel is conditioned. The current fuel conditioning limits are implemented to prevent pellet clad interaction (PCI) for current Westinghouse fuel. The fuel conditioning limits restrict the rate at which THERMAL POWER can be increased above [ ]^{a,c}% RTP following a refueling outage, and institute minimum hold times at power levels between [ ]^{a,c}% and [ ]^{a,c}% RTP. For fuel to be conditioned above [ ]^{a,c}% RTP, the plant must have operated in the current cycle at or above the conditioned power level for at least [ ]^{a,c} cumulative hours out of the last [ ]^{a,c} days of power operation. These limitations, combined with the time required to perform a complete flux map with the movable incore detector system make it difficult to achieve true equilibrium conditions and complete the $F_Q^W(Z)$ surveillance within 12 hours during a startup following a refueling. While it is recognized that specific fuel conditioning limits may change in the future, it would still be necessary to condition the fuel after a refueling outage before the type of load follow operation which could challenge the $F_Q^W(Z)$ limit would be permitted.

Plants implement fuel conditioning startup limitations for the first startup after a refueling outage.

In the event the plant were held at a THERMAL POWER greater than or equal to 75% RTP but less than 100% RTP for an extended period after a refueling, the $F_Q^W(Z)$ surveillance would be required within 24 hours of achieving equilibrium conditions at the reduced THERMAL POWER. Thus, if the fuel were conditioned to a lower power level, such that transient operation could be performed at or below the fuel conditioned power level, the $F_Q^W(Z)$ surveillance that was performed after reaching equilibrium at these conditions would conservatively justify the transient operation.

Sustained operation at less than 75% RTP after a refueling would be permitted for up to 31 EFPD before an $F_Q^W(Z)$ surveillance was performed. However, the plant would still be restricted by the fuel conditioning limits for performing unrestricted transient operation above the current fuel conditioned power level.

The allowance of up to 24 hours after achieving equilibrium conditions will provide a more accurate measurement of $F_Q^W(Z)$ by allowing sufficient time to achieve equilibrium conditions and obtain the power distribution measurement (i.e., to perform SR 3.2.1.1 and 3.2.1.2), while still requiring performance of the surveillance before the fuel becomes sufficiently conditioned such that load follow operation can be implemented.

A discussion was added to the Bases for TS 3.2.1B and TS 3.2.1C for SR 3.2.1.1 and SR 3.2.1.2 that incorporates the justification for the 24 hours allowed to perform these Surveillances.

Revised TS Bases markups that reflect this change are included in Attachments 4 and 6 to the RAI Responses.

It should be noted that other Technical Specification SRs contain a Note that allows deferral of the Surveillance, typically for 24 hours, until plant conditions that are required to perform the Surveillance can be achieved, in order for an accurate Surveillance to be performed. Some examples are the Notes to SRs 3.3.1.2, 3.3.1.3, 3.3.1.6, 3.3.2.10, 3.4.1.4, and 3.4.5.3.

Table RAI-3.1 Typical Part Power W(Z) Correction Factors C(Z)

a,c

RAI No. 4: **Treatment of uncertainties in $F_Q^C(Z)$ and $F_Q^W(Z)$ determination and in defining the requirements**

Background

One of the multiplicative factors that determines $F_Q^C(Z)$ and $F_Q^W(Z)$ is the uncertainty U_F which accounts for measurement and manufacturing uncertainties. It is typically 1.0815 (Page 3-2), which is the result of multiplying a measurement uncertainty of 1.05 by a manufacturing uncertainty of 1.03. The sample COLR input given in Appendices C and F do not refer to U_F but do use 1.0815 as one the factors determining the above $F_Q\{Z)$ quantities. It is not stated if these uncertainties represent 1-sigma or a 95/95 uncertainty. The use of a measurement uncertainty is obvious but the use of an uncertainty to account for manufacturing tolerances is less clear.

Another factor defining $F_Q^W(Z)$ is the T(z) function. According to the statement made with respect to Equations 2-23 and 2-24, the T(z) functions are derived with "appropriate uncertainties."

Issue and Request

A better discussion of the treatment of uncertainties in the methodology, in the calculated parameters, and how they are addressed in defining the requirements is appropriate.

a. Explain how uncertainties are taken into account in defining the $F_Q^C(Z)$ and $F_Q^W(Z)$ that are monitored.

b. It is understood that part of the uncertainty is the result of the surveillance measurement of planar radial peaking factor (Fxv(Z)) and part the result of the analysis to obtain T(z). The T(z) uncertainty is expected to be incorporated into the tabulation of these functions but the measurement uncertainty would be explicitly given in the COLR if it is a function of the particular reactor and fuel cycle or explicitly given and explained in the topical report if it is a generic number. Explain which of these options is being recommended and why.

Response to RAI No. 4:

Response to 4a:

The generic measurement uncertainty associated with F_Q measurements performed using the standard moveable incore detector flux mapping system was developed and approved by the NRC in WCAP-7308-L-P-A, "Evaluation of Nuclear Hot Channel Factor Uncertainties." Similarly, the generic engineering uncertainty associated with Westinghouse fuel manufacturing tolerances has been in use since WCAP-8385 "Power Distribution Control and Load Following Procedures," was approved by the NRC in a letter from J. F. Stolz (NRC) to C. Eicheldinger (Westinghouse), "Safety Evaluation of WCAP-8385 (P) and WCAP-8403 (NP)," dated January 31, 1978. These values represent 95/95 uncertainties. The engineering uncertainty for manufacturing tolerances is applied to measurements of $F_Q(Z)$, because analytically derived pin factors are used to obtain the "measured" pin powers from the measured assembly powers. These pin factors are based on calculations that assume nominal design values of pellet enrichment, density, and burnable absorber loading. The engineering uncertainty addresses the effects of variations in the as-built fuel pellet from nominal design values.

The specific uncertainties used at each plant are typically discussed in the Technical Specification Bases for SR 3.2.1.1 and in the Nuclear Design section of the plant's Updated Final Safety Analysis Report, as required by NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition*. The use of 1.05 for the measurement uncertainty and 1.03 for the engineering uncertainty in this topical report is only for the purpose of illustrating typical generic values that are used in most Westinghouse NSSS plants. Plant specific uncertainty values may be different than the generic values for a variety of reasons, including the use of a different incore detector system design.

As discussed with respect to Equations 2-23 and 2-24 in WCAP-17661-P, the calculational uncertainties used in confirming that the transient F_Q limits will be met for a given cycle are also generically determined and approved in WCAP-7308-L-P-A, "Evaluation of Nuclear Hot Channel Factor Uncertainties." A 5% (i.e., 1.05) 95/95 calculational uncertainty and the same 3% (i.e., 1.03) 95/95 engineering uncertainty that are applied to the measurement, are also applied to the maximum calculated transient $F_Q{*}P_{rel}$ values during the nuclear design analysis, when confirming that the F_Q limit is met. As new nuclear design methods are developed and licensed (approved by the NRC), the generic 5% calculational uncertainty is confirmed to remain bounding or is increased as necessary.

Response to 4b:

No explicit uncertainties have been defined or proposed for the T(Z) surveillance factors. The following discussion is provided in support of this approach.

T(Z) is a factor of the total $F_Q^W(Z)$. During the performance of SR 3.2.1.2, $F_Q^W(Z)$ is increased by the 95/95 measurement and manufacturing tolerance uncertainties prior to comparing it to the F_Q limit, as discussed above in the response to RAI 4a. In the case where the generic 5% measurement uncertainty in WCAP-7308-L-P-A is applied to the $F_Q^W(Z)$, the actual 95/95 uncertainty associated with the measured $F_{XY}(Z)$ distribution from the incore detector system is only [ ]^{a,c}, as specified in Table 2-1 (Addendum 1, Revision 1) of WCAP-7308-L-P-A. The application of the 3% manufacturing tolerance uncertainty will also result in some additional conservatism, since the only reason this uncertainty is applied to the measurements is because of the use of the analytically derived pin factors that were based on nominal design characteristics. Any significant change in the assembly average power distribution caused by fuel manufacturing tolerances will be captured directly in the measured power distribution.

The measured steady state $F_{XY}(Z)$ distribution is the only actual measured data provided during the performance of SR 3.2.1.2 in TS 3.2.1B. The measured steady state $F_{XY}(Z)$ distribution is effectively divided by the predicted steady state $F_{XY}(Z)$ distribution at the surveillance condition, which is contained in the denominator of the T(Z) function. As stated on page 4-3 of WCAP-17661-P, the intent of this approach is to normalize the predicted $F_{XY}^{HFP}(Z)$ term shown in Equation 4-4, to account for the effects of measured radial tilts or some other underprediction of the limiting radial peaking factors. Since the predicted radial peaking factors are normalized to measured values (including the application of the conservative measurement and manufacturing uncertainties), the only remaining component of the $F_Q^W(Z)$ surveillance which comes from the calculations is the transient axial $P^{Tr}(Z)$ term (contained in the T(Z) numerator). As discussed in Section 8.4 in WCAP-7308-L-P-A, the predicted axial peaking factor uncertainty with 95/95 statistics is [ ]^{a,c}%. If one statistically combines the independent uncertainty factors associated with the measured radial peaking factors [ ]^{a,c}% and the calculated axial peaking factors [ ]^{a,c}%, the total 95/95 uncertainty associated with this approach is [ ]^{a,c}%, which is bounded by the application of the generic 5% measurement uncertainty to the $F_Q^W(Z)$ result. It is therefore concluded that the $F_Q^W(Z)$ surveillance includes sufficient uncertainty (via application of the 5% measurement uncertainty) to account for any additional uncertainty associated with the calculated T(Z) factor.

Additionally, it should be noted that the T(Z) function is developed at each axial elevation (Z) by taking the maximum result of a large number of Condition I transient simulations (see Equation 4-30 in WCAP-17661-P). The result is a bounding function that is comprised of pointwise worst results from several of the most limiting transient shapes. For example, the T(Z) at an elevation of 2-feet will likely be from a negatively skewed axial power shape, while the T(Z) at 10-feet will likely be from a positively skewed axial power shape. T(Z) values near the middle elevations may be from either type of axial shape. Assuming the calculational uncertainty associated with P(Z) is random in nature, the transient P(Z) at any given axial location associated with any given calculated axial power shape may be overestimated or underestimated. By selecting the maximum value at each Z, the selection process favors results where the calculated T(Z) is more likely to be overestimated. Thus the [ ]^{a,c}% uncertainty allowance for the predicted P(Z) included in the total FQ uncertainty allowance of 5% is highly conservative for T(Z).

RAI No. 5: New Required Action B.1 requiring implementation of a RAOC/CAOC operating space

Background

Under the proposed change, Required Action B.1 states:

> Implement a RAOC/CAOC operating space specified in the COLR that restores $F_Q^W(Z)$ to within its limits.

As stated on Page 3-14 of WCAP-17661-P,

> Pre-analyzed RAOC operating spaces, representing different levels of transient F_Q margin, will be included in the COLR and characterized by transient (T(z) functions) which, in conjunction with measured radial peaking factors, may be used to quantify margin and ensure compliance with the LCO for future non-equilibrium operation. Analogous to the CAOC operating space concept..., a RAOC operating space is a unique combination of AFD [axial flux difference] operating space envelope and control rod bank insertion limits. In the unlikely event that none of the allowed RAOC operating spaces included in the COLR provides sufficient F_Q margin, maximum power level and AFD reductions will be required along with setpoint reductions. The magnitude of the required reductions will be included in the COLR.

In addition, as part of the change for both RAOC and CAOC plants, the NOTE in Condition B stating that Required Action B.4 shall be completed whenever this Condition is entered is deleted. A NOTE in the Required Action column under Required Action B.2.1 is entered stating that Required Action B.2.4 shall be completed whenever Required Action B.2.1 is performed.

(Both B.4 in the previous version and B.2.4 in the revised version are the same Required Action, "Perform SR 3.2.1.1 and SR 3.2.1.2)." In effect, SRs will no longer be applicable when Required Action B.1 is implemented.

Issue and Request

Based on the analysis presented, the use of a different operating space is generally an appropriate approach to gain margin improvement. However, if changing the rod insertion limits (RILs) is part of the new operating space AND that requires movement of control rods to comply, then this approach puts the reactor into a new operating condition.

In addition, in order to understand if the new operating space will provide the needed margin, it is necessary for the reactor engineer to evaluate $F_Q^W(Z)$ using the T(z) for different operating spaces. This must be done within four hours, the TS completion time.

If movement of control rods was required, a reevaluation of $F_Q^C(Z)$ and $F_Q^W(Z)$ will be required to assure that TS requirements are being met. In other words, the NOTE may apply to B.1 for such situations.

Explain the use of Required Action B.1 incorporating the response to the following:

a. Explain what would be done if Required Action B.1 is carried out and requires movement of control rods.

b. Explain if in addition to the T(z) tables there will be tables to show the margin improvement as a function of axial position or some other scheme in the COLR to make it easier for the reactor engineer to determine if Required Action B.1 is sufficient or Required Actions B.2 are necessary.

c. Explain the deletion of the NOTE to perform SR 3.2.1.1 and SR 3.2.1.2 under required Action B.1.

d. Discuss clearly the specific actions (e.g., how are the rod insertion limits imposed) that will be undertaken by the operator in implementing the new operating space and consequently what would constitute a violation of this required action.

Response to RAI No. 5:

Response to 5a and 5c:

If control rod motion is needed as a result of entering Condition B and performing Required Action B.1, the fundamental measured power distribution will change as a result. Based on past operating experience, entry into Condition B is expected to be an unlikely occurrence. Most $F_Q^C(Z)$ and $F_Q^W(Z)$ surveillances are performed at 100% RTP with the control rods near fully withdrawn, so the institution of a new rod insertion limit after entry into Condition B would not result in control rod motion in most cases. It is also considered very unlikely that the withdrawal of control rods (if necessary) would result in an increase in the measured radial peaking factors, $F_{XY}(Z)$. This conclusion is based on current core design practices as demonstrated by historically observed trends in predicted $F_{XY}(Z)$ with control rod insertion for most core designs. However, it is considered plausible that if the measured $F_{XY}(Z)$ peak happened to occur adjacent to or in an assembly containing an inserted control rod, that withdrawal of that control rod could potentially increase the resulting $F_Q^C(Z)$ and $F_Q^W(Z)$ measured values. It is also possible that a revision to the allowed AFD band associated with implementing Required Action B.1 could result in either control rod withdrawal or insertion in some cases, in order to obtain and maintain the AFD within the allowed operating band.

Therefore SR 3.2.1.1 and SR 3.2.1.2 should be performed if the implementation of Required Action B.1 results in the need to move control rods. The Required Actions for Condition B in both Technical Specifications 3.2.1.B and 3.2.1.C will be revised to require the performance of SR 3.2.1.1 and SR 3.2.1.2 if the implementation of a new operating space results in the need to move the control rods in order to comply with a new rod insertion limit. A Completion Time of 72 hours is proposed to ensure that the plant has time to restore equilibrium conditions in the event that control rod motion results in a transient condition. Proposed Required Action B.1 would become Required Action B.1.1 in both Technical Specifications, and a new Required Action B.1.2 would be added to perform SR 3.2.1.1 and 3.2.1.2 with a required Completion Time of 72 hours. A markup of TS 3.2.1B and TS 3.2.1C is provided as Attachments 3 and 5 to the RAI responses.

Response to 5b:

Margin improvement tables are not required to be included in the COLR, since the margin can be determined by applying the new surveillance factors associated with the revised operating space to the power distribution measurement, and since a new Required Action will be added to perform SR 3.2.1.1 and 3.2.1.2, as discussed above, if control rod motion is required as a result of implementing the new operating space. Performing SR 3.2.1.1 and SR 3.2.1.2 will confirm that the required margin has been restored.

Response to 5d:

If a new rod insertion limit resulted in the need to withdraw control rods, that Required Action (A.2) would be completed within 2 hours of implementing the new rod insertion limit, in accordance with the Required Actions of TS 3.1.6 (Control Bank Insertion Limits), for Condition A (Control Bank insertion limits not met). Since the new operating space may not be implemented for up to 4 hours, the total allowed time to reposition the control rods would be within 6 hours after the entry into LCO 3.2.1 Condition B. If the control rods were not repositioned to above the insertion limits associated with the new rod insertion limit within 6 hours of initially identifying the $F_Q^W(Z)$ violation, Condition C of TS 3.1.6 would be entered and the Required Action is to be in Mode 2, with keff < 1 in 6 hours. Since the revised operating space that will be implemented will be contained in the COLR, the implementation of the revised operating space can be performed by the operator.

The implementation of a License Amendment Request (LAR) includes reviewing the procedures that are affected by the LAR. Prior to implementing a LAR, any affected procedures are revised to reflect the Technical Specification changes in the LAR.

The Technical Specification (TS) Surveillance Requirement (SR) that verifies that the Control Banks are above their insertion limits is implemented via a plant procedure.

SR 3.1.6.2 in NUREG-1431, "Standard Technical Specifications, Westinghouse Plants," states:

"Verify each control bank insertion is within the insertion limits specified in the COLR."

The Frequency of SR 3.1.6.2 in NUREG-1431 is "[12 hours or In accordance with the Surveillance Frequency Control Program.] "

If revised Control Bank Insertion Limits are implemented, as allowed by the revised TS Required Actions that are contained in Attachments A and D of WCAP-17661, the revised Control Bank Insertion Limits would be contained in the COLR.

TS SR 3.1.6.2 requires that each control bank insertion is within the insertion limits specified in the COLR, and the revised Control Bank Insertion Limits that are contained in the COLR would be used to determine that this SR is met.

The instrumentation that is used to satisfy SR 3.1.6.2 is the Demand Position Indication System, which is required to be Operable by TS 3.1.7, "Rod Position Indication,' in NUREG-1431.

The Bases for TS SR 3.1.6.2 in NUREG-1431 state:

"Verification of the control bank insertion limits at a Frequency of 12 hours is sufficient to detect control banks that may be approaching the insertion limits since, normally, very little rod motion occurs in 12 hours."

Therefore the Frequency of TS SR 3.1.6.2 is adequate to ensure that the Control Banks are within their insertion limits during normal operation to ensure that the power distribution and reactivity limits defined by the core design peaking factors and shutdown margin assumptions in the safety analyses are maintained.

The Control Rod Insertion Monitor and associated alarms are not credited for satisfying TS SR 3.1.6.2.

If the transient $F_Q^W(Z)$ limit is not met, and the TS Required Actions that allow a new operating space to be implemented with a different set of control rod insertion limits, those limits (i.e., operating space and control rod insertion limits) will always be more restrictive than the primary analyzed operating space. The core conditions allowed by the new operating space will always be a more restrictive subset of those allowed by the primary (or initial) operating space that is assumed in the safety analyses. This is illustrated by the example operating spaces shown in Figures 6-1, 6-2, and 6-3 in WCAP-17661-P. Thus, the implementation of a new, more restrictive, operating space to restore the transient $F_Q^W(Z)$ to within its limit, will not result in any impact to any safety analyses.

As discussed above, the initial safety analysis assumptions regarding the control rod insertion limits will continue to be met, since the revised control rod insertion limits are more restrictive.

RAI No. 6: Effect of Crud Induced Power Shift

Background

Currently, any downward trend in margin (as defined by the minimum margin over all axial locations) is accounted for by applying a penalty factor and requiring additional surveillance. This is specified in a note modifying SR 3.2.1.2, which is proposed to be eliminated. This NOTE monitored increases in $F_Q^W(Z)$ from the previous surveillance and required additional surveillances if measurements indicated that the maximum over z of $F_Q^C(Z)/K(Z)$ has increased since the previous evaluation of $F_Q^C(Z)$.

In lieu of this approach, it is proposed that a penalty factor be applied that takes account of the expected change in margin during the next effective full power minutes as a result of normal changes in burnup. This approach eliminates any action due to the concern over crud induced power shift (CIPS). Reasons are given for this (Page 4-18).

One of the arguments presented is that past trends of $F_Q^C(Z)/K(Z)$ may or may not be indicative of future trends. It is justified to remove monitoring of $F_Q^C(Z)/K(Z)$ for indication of future margin trends if it does not provide the required indication.

Request

It is stated (Page 4-18):

> ... given that CIPS develops slowly and characteristically, it is proposed that its effects on peaking factor be evaluated in a timely fashion following its observed onset.

Although the TS is designed to monitor power peaking, it appears that the licensee will now have full discretion as to how monthly trends due to any anomalous behavior are taken into account.

a. Explain how this would actually take place.

b. Provide data from past experience and additional discussion supporting the statement "past measurement trends of $F_Q^C(Z)/K(Z)$ may or may not be indicative of future margin trends."

Response to RAI No. 6:

Response to 6a:

As discussed in Section 4.5 of WCAP-17661-P, the best indicators of CIPS are the observed measured minus predicted axial offset being more negative than -3% beginning at burnups of 4000 to 8000 mwd/mtu, high predicted sub-cooled boiling rates, flux depressions in the upper spans of high power assemblies, and an indication of lithium return following a power reduction.

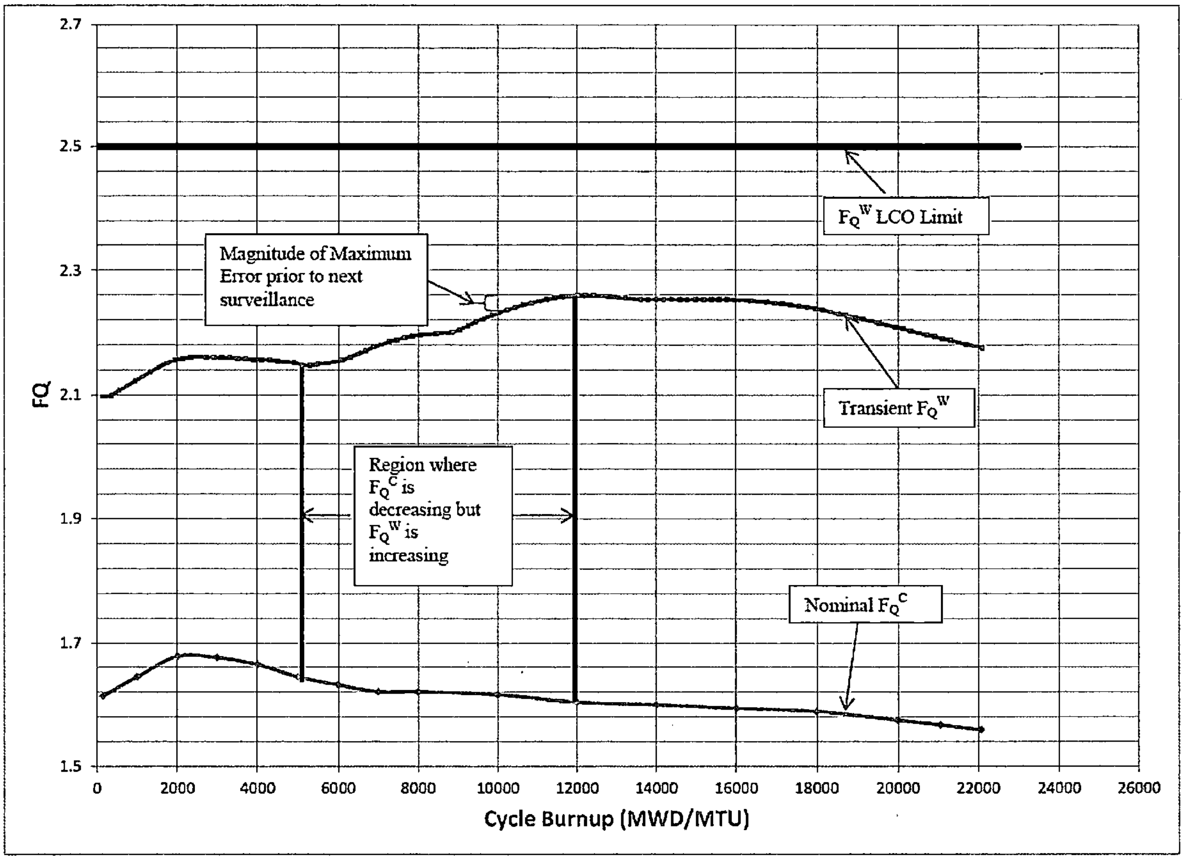
Westinghouse has provided guidance to the industry describing the characteristics of CIPS and other forms of axial offset deviation, and requested to be notified in cases where the measured minus predicted steady state axial offset is more than ±3% in either direction. Nuclear design procedures have been established at Westinghouse both for screening reload cores for CIPS risk, and for evaluating the effect of CIPS on the power distribution surveillance data and other parameters, if it occurs. As noted in Section 4.5 of WCAP-17661-P, both the incidence and magnitude of CIPS events have been significantly reduced, due largely to the addition of CIPS risk to the loading pattern risk assessment process, and advances in predictive capabilities for sub-cooled boiling and crud deposition.

Response to 6b:

An issue has been identified that the use of measured trends in $F_Q^C(Z)$ may not always be indicative of the same margin trend in the measured $F_Q^W(Z)$, particularly when the axial power distribution of the core is in transition from a cosine type shape to a flattened saddle type shape. Figure RAI-6.1 illustrates an example of such a case by comparing the predicted steady state and maximum transient F_Q values for an example cycle.

Furthermore, it must be clarified that the initial onset of CIPS will not necessarily result in observing a decreasing trend in either the $F_Q^C(Z)$ or $F_Q^W(Z)$ margin. The preferential accumulation of boron-containing crud in high power assemblies will tend to decrease the radial peaking ($F_{XY}(Z)$) in the affected elevations of the highest power assemblies. If the nominal predicted AFD is slightly positive, the onset of CIPS may result in the AFD being closer to zero or slightly negative. Both of these factors could result in an increasing trend in margin for $F_Q^C(Z)$, initially. The trend in $F_Q^W(Z)$ is driven largely by the T(Z) or W(Z) surveillance factors, which, as noted in Section 4.5 of WCAP-17661-P, will not include the effects of CIPS if it occurs. Thus, the observation of past trends in margin for either $F_Q^C(Z)$ or $F_Q^W(Z)$ is not very useful in identifying the onset of CIPS. Only in the later stages of a relatively severe CIPS event can it be stated with high confidence that the $F_Q^C(Z)$ margin will be decreasing with burnup.

Figure RAI-6.1 **Comparison of Predicted Trend in $F_Q^C(Z)$ or $F_Q^W(Z)$ as a Function of Cycle Burnup for an Example Plant**



RAI No. 7: Change of Required Action B.2.1 and limitation of THERMAL POWER to < 50% RTP

Background

The improved TS define a new Required Action B.2. When $F_Q^W(Z)$ exceeds its limits, Required Actions B.2.1, B.2.2, B.2.3, and B.2.4 can be implemented instead of Required Action B.1. Required Action B.2.1 limits thermal power to less than RTP by the amount specified in the COLR. If the RAOC operating spaces specified in the COLR are insufficient to ensure margin to the $F_Q^W(Z)$ limits, then the Required Action B.2.1 must be entered and THERMAL POWER must be reduced to less than the thermal power specified in the COLR. Also, AFD limits must be reduced by the amount specified in the COLR.

It is also noted that as a practical matter, the number of discrete reduced power level evaluations included in the COLR will be limited to three or less (an individual utility may opt for additional evaluation levels). Also stated in WCAP-17661-P, if the required margin improvement exceeds the level of any pre-analyzed thermal power limits, the COLR will specify that the thermal power is limited to <50 percent RTP. WCAP-17661-P also states that other TS, such as the Nuclear Enthalpy Rise Hot Channel Factor TS, would also require a power level reduction in the presence of such a large anomaly.

Issue and Request

For situations where necessary margin improvement exceeds the level of any pre-analyzed thermal power limits, the requirement to reduce the thermal power to less than 50 percent RTP is not noted in the Technical Specifications (TS) or in the Bases. Since this type of situation means that a very large and unusual core anomaly is present, clear guidance and justification for the actions should be presented.

a. Explain how the required actions in the COLR for Required Action B.2.1 will be sufficient if $F_Q^W(Z)$ is not within limits. For example, will some limit of power to 50% RTP always be imposed and if so, at what point (vis-a-vis margin needed) would that be required.

b. Since the reduction of thermal power to < 50% RTP is a defined parameter applicable to all Westinghouse plants, explain why this requirement should not be included in the TS and/or Bases.

Response to RAI No. 7:

Response to 7a:

As shown in the example COLRs provided in Appendices C and F of WCAP-17661-P, it is intended that the ultimate power reduction specified in the COLR for Required Action B.2.1 will be to less than 50% RTP, when the measured margin improvement required in the $F_Q^W(Z)$ surveillance exceeds the margin gain for the otherwise calculated combinations of THERMAL POWER and AFD limits. The 50% RTP power threshold is consistent with several other Westinghouse Standard Technical Specifications (NUREG-1431). For example, TS 3.2.2 (Nuclear Enthalpy Rise Hot Channel Factor) contains a Required Action that the power be reduced to less than 50% RTP if the $F_{\Delta H}^N$ limit is not met and is not restored to within the limit within 4 hours. TS 3.2.3A (Axial Flux Difference (CAOC Methodology)) allows the AFD to deviate outside the target AFD band with THERMAL POWER < 50% RTP, subject to the accumulation of penalty deviation time. TS 3.2.3B (Axial Flux Difference (RAOC Methodology)) does not apply when THERMAL POWER < 50% RTP. TS 3.2.4 (Quadrant Power Tilt Ratio) does not apply when THERMAL POWER ≤ 50% RTP.

If $F_Q^W(Z)$ exceeds the F_Q limit, the most likely cause will be the measured radial peaking factors ($F_{XY}(Z)$) being higher than predicted in the original nuclear design analysis. The higher measured radial peaking factors will also affect the measurements of the current operating heat flux hot channel factor, $F_Q^C(Z)$, and the nuclear enthalpy rise hot channel factor, $F_{\Delta H}^N$. If the measured radial peaking factors are high enough so that the $F_Q^C(Z)$ limit is not met, the Required Actions for Condition A require the THERMAL POWER to be reduced as much as necessary to restore compliance of the $F_Q^C(Z)$ limit. This would include reducing THERMAL POWER to less than 50% RTP, if the severity of the observed violation was large enough to require that. Thus, in such a case where the COLR power limitations in Required Action B.2.1 result in power being reduced to less than 50% RTP, compliance with the *current operating* heat flux hot channel factor is ensured, via the measured results of the $F_Q^C(Z)$ surveillance, or by meeting the Required Actions for Condition A of TS 3.2.1B or 3.2.1C. Similarly, compliance with the current operating nuclear enthalpy rise hot channel factor is ensured, via the measured results of the $F_{\Delta H}^N$ surveillance, or by meeting the Required Actions of TS 3.2.2. Therefore, the plant will either be measured to be complying with the TS peaking factors LCO limits, or meeting the Required Actions associated with the $F_Q^C(Z)$ and $F_{\Delta H}^N$ limits to restore compliance with the limits for the current operation.

If the transient $F_Q^W(Z)$ is not met, this would only result in the core operating outside the assumed peaking factor basis in the safety analysis if transient operation were to occur, which results in the plant operating at the edge of the allowed operating space. In the event that the THERMAL POWER is reduced to < 50% RTP per Required Action B.2.1, the transient $F_Q^W(Z)$ limit will be met for the following reasons. As shown in equations 2-19 and 2-20 of WCAP-17661-P, the typical F_Q limit is divided by the relative power level down to 50% RTP and then remains constant at lower power levels. Thus the reduction of THERMAL POWER to less than 50% RTP results in doubling the allowed F_Q limit. Furthermore, the potential for transient operation that significantly disturbs the core xenon distribution is significantly reduced if the maximum power of such transients is limited to <50% RTP.

Response to 7b:

The following paragraph was added to the Bases as the first paragraph for Required Action B.2.1 in TS 3.2.1B:

> When FQ W(Z) exceeds its limit, Required Action B.2.1 may be implemented instead of Required Action B.1. Required Action B.2.1 limits THERMAL POWER to less than RATED THERMAL POWER by the amount specified in the COLR. It also requires reductions in the AFD limits by the amount specified in the COLR. If the RAOC operating spaces specified in the COLR are insufficient to ensure margin to the FQ W(Z) limit, then Required Action B.2.1 must be entered and THERMAL POWER must be limited to less or equal to 50% RTP and AFD limits must be reduced by the amounts specified in the COLR. This maintains an acceptable absolute power density relative to the maximum power density value assumed in the safety analyses.

The following paragraph was added to the Bases as the first paragraph for Required Action B.2.1 in TS 3.2.1C:

> When FQ W(z) exceeds its limit, Required Action B.2.1 may be implemented instead of Required Action B.1. Required Action B.2.1 limits THERMAL POWER to less than RATED THERMAL POWER by the amount specified in the COLR. If the more restrictive CAOC operating spaces specified in the COLR are insufficient to ensure margin to the FQ W(z) limit, the THERMAL POWER must be limited to less than or equal to 50% RTP. This maintains an acceptable absolute power density relative to the maximum power density value assumed in the safety analyses.

The following paragraph was added to the Bases as the second paragraph for Required Action B.2.1 in TS 3.2.1B and TS 3.2.1C:

> "If the required FQ W(z) margin improvement exceeds the margin improvement available from the pre-analyzed THERMAL POWER and AFD reductions provided in the COLR, then THERMAL POWER must be further reduced to less than or equal to 50% RTP. In this case, reducing THERMAL POWER to less than 50% RTP will provide additional margin in the transient FQ by the required change in THERMAL POWER and the increase in the FQ limit. This will ensure that the FQ limit is met during transient operation that may occur at or below 50% RTP."

Revised TS Bases markups that reflect this change are included in Attachments 4 and 6 to the RAI Responses.

RAI No. 8: Implementation of 24-Hour Frequency in TS SR 3.2.1.1 and 3.2.1.2

Background

The Section 3.2.4 states (Pages. 3-14 and 3-15):

> In the improved F_Q TS, the second Frequency will be revised to require verification of $F_Q^C(Z)$ within 24 hours (instead of 12 hours) after achieving equilibrium conditions after exceeding, by ≥ 10% RTP , the THERMAL POWER at which $F_Q^C(Z)$ was last verified. This Frequency of 24 hours is contained in some plant Technical Specifications. (for a few plants, no Frequency is specified) and is a reasonable time period in which to perform this verification given the extremely small likelihood of limiting power shapes or limiting design basis events occurring prior to completion of the surveillance.

The information is repeated in Sections 5.4 and 8.4 and a similar change is proposed for SR 3.2.1.2, related to surveillance of $F_Q^W(Z)$.

The purpose of bracketed information in Standard Technical Specifications is to denote site-specific information, which must be in conformance with the final safety analysis report as updated. Refer to Chapter 16.0, "Technical Specifications," of NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition*, for further details.

Issue and Request

Since Pressurized Water Reactor Owners Group (PWROG) proposes to use WCAP-17661 as a basis to reduce the frequency requirement for these surveillance test intervals, a more thorough technical justification for the change should be provided. The justification should either follow a clearly risk-informed or deterministic approach, rather than provide a qualitative assessment of the likelihood of limiting initial conditions or initiating events.

If risk-informed, the appropriate regulatory guidance should be followed. This would include NRC Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," and RG 1.177, "An Approach for Plant-Specific, Risk-Informed Decision Making: Technical Specifications."

If deterministic, the justification could include consideration of the consequences of a postulated event occurring in a condition in which the extended surveillance interval prevented assurance that operation was within specified limiting conditions, and of additional mitigating features that would ensure that continued operation in such a condition remains otherwise acceptable. Finally, consider whether plant-specific submittal items should be identified, which would justify any facility licensing basis changes required to implement the proposed TS change.

Response to RAI No. 8:

The proposed change allowing the $F_Q^C(Z)$ and $F_Q^W(Z)$ surveillances to be performed within 24 hours (instead of 12 hours) after reaching equilibrium conditions after exceeding by > 10% RTP, the THERMAL POWER at which the surveillances were last performed is not a reduction in the frequency requirement. The same number of surveillances will ultimately be performed. If the unit increases THERMAL POWER by 10% or more since the surveillances were last performed, and then reaches equilibrium conditions, SR 3.2.1.1 and SR 3.2.1.2 are required to be performed regardless of the proposed change in the proposed time of 24 hours to complete the surveillance. The proposed change affects only the time allowed to complete the surveillance, not the total number of surveillances that are performed.

A discussion was added to the Bases for TS 3.2.1B and TS 3.2.1C for SR 3.2.1.1 and SR 3.2.1.2 that incorporates the justification above for the 24 hours allowed to perform these Surveillances.

Revised TS Bases markups that reflect this change are included in Attachments 4 and 6 to the RAI Responses.

The proposed change in time allowed to complete the surveillance from 12 hours to 24 hours applies to situations where the $F_Q^C(Z)$ and potentially the $F_Q^W(Z)$ have already been measured at least once at a reduced power level. The observed margins in the previous surveillances will provide assurance that increasing power up to the next plateau will not exceed the F_Q limit, and that the core is behaving as designed. For example, if a previous $F_Q^C(Z)$ measurement was performed at 70% RTP, then there should be greater than 30% margin available to the F_Q limit from the current operating state. This would be expected to be true for any surveillance of $F_Q^C(Z)$ performed above 50% RTP, since the allowed F_Q limit increases by the inverse of the current relative power level in this range of Power Operation. The nature of thermal feedback from increasing fuel and moderator temperatures will reduce the measured $F_{XY}(Z)$ values with increasing power levels. Therefore, the results of the previous $F_Q^C(Z)$ surveillance provide reasonable assurance that continued power ascension to 100% RTP will not result in the actual operating heat flux hot channel factor exceeding the safety analysis limit.

In addition, the observed margin in the $F_{\Delta H}^N$ measurement required by TS 3.2.2 will confirm that the radial peaking factors are behaving as expected prior to increasing power above 75% RTP.

The successful performance of the $F_Q^C(Z)$ and $F_{\Delta H}^N$ surveillances prior to exceeding 75% RTP following each refueling, in conjunction with the controlled power ascension following a refueling due to the fuel conditioning ramp restrictions, provides a very high level of confidence that the initial operation at 100% RTP following a refueling will not exceed the heat flux hot channel factor assumed in the plant safety analysis, while the fuel is being conditioned. As discussed in the response to RAI No. 3, the Westinghouse fuel conditioning guidelines require at least [ ]^{a,c} cumulative hours of operation at a steady state power level in the last [ ]^{a,c} day period in order for the fuel to be considered fully conditioned. Therefore, the $F_Q^C(Z)$ and $F_Q^W(Z)$ surveillances will be performed at 100% RTP before the fuel is fully conditioned to 100% RTP operation and the type of load follow power maneuvers are permitted that could result in heat flux hot channel factors which may challenge the F_Q limit.

RAI No. 9: Equilibrium vs Stable Conditions

Background

The SR for $F_Q^C(Z)$ requires a measurement "Once after each refueling prior to THERMAL POWER exceeding 75% RTP." According to the BASES (Page B-1), equilibrium conditions are not required for this measurement but rather stable conditions are required. Both equilibrium and stable conditions require that the power be within ± 1% but for equilibrium, this condition must exist for 24 hours. Equilibrium conditions also require that the AFD be within ± 1% for that 24-hour period but stable conditions just require that the AFD be within ± 0.5% during the period of interest (when the measurement is being done).

Issue and Request

All surveillance requirements except for those done prior to exceeding 75% RTP are done at equilibrium conditions whereas for the power ascension surveillance, it is only necessary to have stable conditions.

a. Explain why there is a need for equilibrium conditions during most surveillance; why can't stable conditions suffice?

b. Is there a benefit to defining the same conditions (equilibrium or stable) for conducting all $F_Q^C(Z)$ and $F_Q^W(Z)$ surveillance?

Response to RAI No. 9:

Response to 9a:

Stable conditions can suffice if necessary for particular surveillances of the $F_Q^C(Z)$ taken during the initial power ascension after a refueling, because these surveillances do not involve the application of analytically calculated surveillance factors, such as T(Z) or W(Z), which assume equilibrium conditions. Thus the only potential source of error introduced in the measurement of $F_Q^C(Z)$ is the effect of transient conditions on the radial power distribution during the measurement, which although small, are not negligible, even if stable conditions are met. In addition, the $F_Q^C(Z)$ measurements taken during power ascension are primarily for the purpose of assuring that the core is behaving as expected and that it is safe to proceed up to the next power plateau.

Measurements taken during equilibrium conditions are preferable, since they are more repeatable, and are consistent with the generation of the surveillance factors that are used in the $F_Q^W(Z)$ surveillance. Thus, the measurements that are taken for the purpose of justifying the next 31 EFPD of operation, including the potential for transient load follow operation, are performed under equilibrium conditions.

The Bases for NUREG-1431 were reviewed to determine whether "equilibrium conditions," was previously discussed in any of the Bases.

The NUREG-1431 Bases for Technical Specification 3.2.4, "Quadrant Power Tilt Ratio (QPTR)," contains the following discussion for "equilibrium conditions," in third sentence of the Bases for Required Action A.3, on Page B 3.2.4-3:

"... Equilibrium conditions are achieved when the core is sufficiently stable at intended operating conditions to support flux mapping..."

Based on this Bases discussion that is contained in the Bases for NUREG-1431, the following sentence was added to the fourth paragraph in the Bases for SR 3.2.1.1 and as the second paragraph in Insert 4 in the Bases discussion for SR 3.2.1.2 in the Bases for TS 3.2.1B and TS 3.2.1C:

"Equilibrium conditions are achieved when the core is sufficiently stable at the intended operating conditions required to perform the Surveillance."

Revised TS Bases markups that reflect this change are included in Attachments 4 and 6 to the RAI Responses.

Response to 9b:

While there would potentially be some benefit in terms of simplification to using the same plant condition requirements for all measurements, the cost of that approach could result in unnecessary delays during power ascension to wait for equilibrium, or reduced accuracy in the monthly $F_Q^W(Z)$ surveillances at 100% RTP, if equilibrium conditions do not exist.

RAI No. 10: Required Actions

Background

In Required Action A (and Required Action B.2) there is a Note that states that Required Action A.4 (Required Action B.2.4) "*shall be* [emphasis added] completed whenever the Condition is entered." However, the completion time for Required Action A.4 (or B.2.4) is "prior to increasing THERMAL POWER above the limit of Required Action A.1 (B.2.1)."

Issue and Request

The Required Actions A.4 and B.2.4 are surveillance requirements. Because of the NOTE accompanying these actions, it is not clear if they must be carried out along with the other Required Actions or whether they can wait until a decision is made to increase THERMAL POWER.

Discuss and clarify the timing of the surveillance to be performed to satisfy both the NOTE and the Required Action B.2.4.

Response to RAI No. 10:

Both Notes, as currently worded, could be interpreted to require that SR 3.2.1.1 and SR 3.2.1.2 be completed upon initial entry into Condition A or performance of Required Action B.2.1. The intent of the Note is that the Surveillances be completed prior to increasing the limitation on THERMAL POWER required by Required Actions A.4 and B.2.4.

Revised Technical Specification markups are included as Attachments 3 and 5 to the RAI responses.

RAI No. 11: Interface of WCAP-17661-P changes with TS 3.2.1A, Heat Flux Hot Channel Factor ($F_Q(Z)$) (CAOC-F_{xy} Methodology)

Background

In addition to TS 3.2.1B and TS 3.2.1C, TS 3.2.1A is included for some CAOC plants. No change is proposed for TS 3.2.1A. It is our understanding that some CAOC plants confirm $F_Q(Z)$ indirectly by measuring F_{xy}^M (Z) and then comparing this measurement to an $F_{xy}(Z)$ limit. In the new formulation, the key factor being measured is also $F_{xy}(Z)$.

Issue and Request

In both TS 3.2.1 A and TS 3.2.1C, the key factor being measured is $F_{xy}(Z)$. However, the TS requirements are different. Some of the concept used in TS 3.2.1C is not used in TS 3.2.1A: namely, TS 3.2.1A is not modified to use a different operating space and avoid reduction in THERMAL POWER.

a. Delineate the difference between CAOC- F_{xy} Methodology and CAOC-T(z) Methodology to explain why the changes similar to that considered for TS 3.2.1C are not applicable for TS 3.2.1A.

b. For CAOC plants, when $F_Q(Z)$ is not within limit, $F_Q^C(Z)$ will also be outside the limit. Under the proposed changes, Required Actions for TS 3.2.1A and TS 3.2.1C are different. Explain and justify the merits of the differences in the TS.

Response to RAI No. 11:

Response to 11a and 11b:

WCAP-17661-P addresses the issue in NSAL-09-5, Revision 1 that was identified with TS 3.2.1B. Improvements are also proposed for TS 3.2.1C in order to add the flexibility of implementing a new CAOC operating space, as opposed to the alternative of reducing THERMAL POWER in the event $F_Q^W(Z)$ exceeds the limit, and to clarify the surveillance requirements, consistent with the proposed changes to TS 3.2.1B. There are no issues associated with TS 3.2.1A in NUREG-1431.

The key parameter being measured in TS 3.2.1C is the steady state $F_Q(Z)$ distribution, not the $F_{XY}(Z)$ distribution. The transient $F_Q^W(Z)$ in TS 3.2.1C is established by multiplying the steady state measured $F_Q(Z)$ distribution by analytically determined surveillance factors, as shown in Equations 7-13 and 7-14 of WCAP-17661-P.

In TS 3.2.1A, only a single LCO is defined as $F_Q(Z)$. TS 3.2.1A does not define measured parameters called $F_Q^C(Z)$ and $F_Q^W(Z)$ to verify this limit. However, the Surveillance Requirements in TS 3.2.1A require periodic surveillances to be performed (measurements) of both the steady state $F_Q(Z)$ distribution (which is analogous to $F_Q^C(Z)$ in TS 3.2.1C), and the $F_{XY}(Z)$ distribution. $F_{XY}(Z)$ is measured by performing SR 3.2.1.2 only for the purpose of confirming that the nuclear design calculations for operational power maneuvers remain bounding. SR 3.2.1.2 in TS 3.2.1A is therefore performed for the purpose of confirming that the analyzed values of the transient $F_Q(Z)$ will remain conservative, and as a result, that the $F_Q(Z)$ will be met during transient operation within the allowed AFD operating space. SR 3.2.1.2 in TS 3.2.1A does not determine a specific measured approximation of the transient $F_Q^W(Z)$.

The Required Actions in TS 3.2.1A are more conservative than those in proposed TS 3.2.1C. This is because TS 3.2.1A effectively treats all cases where the $F_Q(Z)$ limit is exceeded as if the plant is currently operating with a peak power density in excess of that that is assumed in the safety analysis. In a case where SR 3.2.1.1 has shown that the current operating steady state $F_Q(Z)$ has met the limit, and SR 3.2.1.2 has determined that the measured $F_{XY}(Z)$ exceeds the $F_{XY}(Z)$ limit, the Required Actions of TS 3.2.1A Condition A require a reduction in THERMAL POWER with a Completion Time of 15 minutes. An analogous Condition in proposed TS 3.2.1.B or TS 3.2.1.C would allow a new operating space or power reduction to be implemented with a Completion Time of 4 hours.

While it has been identified in Section 10.3 of WCAP-17661-P that the F_{XY} limit in TS 3.2.1A SR 3.2.1.2 is sensitive to differences in the measured and predicted steady state axial power distribution, guidance has been issued by Westinghouse that will ensure that any significant and sustained differences in the measured and predicted steady state axial power distribution are evaluated before the F_Q limit can be challenged. The plants that have implemented TS 3.2.1A do not have to implement proposed TS 3.2.1C, since the resulting surveillances required by TS 3.2.1A are valid and conservative. This paragraph clarifies the discussions of TS 3.2.1A contained in WCAP-17661.

In summary, the changes that are proposed for TS 3.2.1C are not applicable to TS 3.2.1A because the fundamental measured parameters are different (with respect to transient F_Q), and because there are no issues associated with TS 3.2.1A that would result in non-conservative $F_Q(Z)$ measurements or Required Actions in the event that the F_Q limit is not met.

RAI No. 12: Impact of the proposed changes on TS 3.2.4, Quadrant Power Tilt Ratio (QPTR)

Background

TS 3.2.4, "Quadrant Power Tilt Ratio (QPTR)," provides limits and conditions and associated surveillance requirements for QPTR. As stated in the Bases for Section 3.2.4, the QPTR limits ensure that nuclear enthalpy rise hot channel factor ($F^N_{\Delta H}$) and $F_Q(Z)$ remain below their limiting values by preventing an undetected change in the gross radial power distribution. The QPTR limit of 1.02, at which corrective action is required, provides a margin of protection for both the departure from nucleate boiling ratio and linear heat generation rate contributing to excessive power peaks resulting from X-Y plane power tilts. A limiting QPTR of 1.02 can be tolerated before the margin for uncertainty in $F_Q(Z)$ and $F^N_{\Delta H}$ is possibly challenged.

Issue and Request

Under the proposed changes, when a different operating space is implemented, QPTR may be affected. Since QPTR provides a margin of protection, assurance is needed that the margin of protection is not being lost or that adequate margin of protection will still be maintained.

a. Discuss the impact of the proposed changes on the QPTR and how the changes may impact the current LCO and SR in TS 3.2.4.

b. If changes are non-negligible, discuss that adequate margin of protection is being maintained.

Response to RAI No. 12:

Response to 12a:

The implementation of a different operating space in the event that the performance of an $F_Q^W(Z)$ surveillance determines that the F_Q limit is not met would not significantly affect the indicated QPTR on the excore detectors, nor would it affect the actual in-core power distribution symmetry. The primary purpose of implementing a different operating space is to allow the use of smaller surveillance factors T(Z) or W(Z), in order to establish the new $F_Q^W(Z)$ associated with transient operation at the edge of the allowed operating space.

The standard QPTR limit of 1.02 was established with the intention of indicating that a detectable change has occurred in the core power distribution symmetry, and to initiate the performance of SR 3.2.1.1, SR 3.2.1.2, and SR 3.2.2.1 using the movable incore detector system to determine the actual margin to safety analysis limits. QPTR indicates only a gross change in the average power of each core quadrant. The TS 3.2.4 Required Action A.1 to reduce THERMAL POWER by $\geq$ 3% from RTP for each 1% of QPTR > 1.00 is precautionary, until such time as the actual margin to the safety analysis limits can be re-assessed and confirmed using the movable incore detector system. As required by Required Action A.5 of TS 3.2.4, once the incore detector surveillances are completed and the safety analysis is re-evaluated, the excore detectors will be normalized to restore the QPTR to within the limit. Once the THERMAL POWER is restored to 100% RTP, SR 3.2.1.1, SR 3.2.1.2, and SR 3.2.2.1 are performed as required by Required Action A.6, to confirm that the safety analysis limits are still met. No minimum margin requirements are specified for the results of SR 3.2.1.1, SR 3.2.1.2, and SR 3.2.2.1, which are required by TS 3.2.4 Condition A, other than that the safety analysis limits must be met using the normal measurement and fuel manufacturing tolerance uncertainties implemented by the plant.

Response to 12b:

In the response to RAI No. 5, it was identified that performing SR 3.2.1.1 and SR 3.2.1.2 will be added as Required Actions with a 72 hour Completion Time, if a new operating space is implemented if $F_Q^W(Z)$ exceeds the F_Q limit, and control rod motion is required to comply with the new operating space. By adding this Required Action, the margin to safety analysis limits will be determined and confirmed after the implementation of a new operating space, including the effects of any existing QPTR. Once this is done, the same initial conditions are established with respect to the continued applicability of TS 3.2.4, as would otherwise have been present before the new operating space was implemented. Therefore, TS 3.2.4 will continue to provide the requisite margin of protection.

RAI No. 13: Additional discussion of methodology

Background

The RAOC-T(Z) methodology is presented in different sections in WCAP-17661-P for the reader to understand the methodological issues. Details and example results are given; however, some aspects of the discussion of the methodology to obtain $F_Q{}^W(Z)$ can be considered lacking.

Issue and Request

Additional discussion on the following aspects is requested in order to fully understand the methodology:

a. Provide the specific assumptions, limitations, implementing procedures, and related guidance associated with the methodology and explain how they have been addressed in defining the new requirements.

b. Discuss the attributes/results of the methodology and relate them to the changes proposed in the Specifications. Discuss each of the changes in the Specifications and their relation to the improved methodology if one exists.

c. Discuss any differences from the results presented for a Westinghouse 4-loop plant that might be expected for different designs.

Response to RAI No. 13:

Response to 13a:

The discussion of the methodology to obtain predicted $F_Q^W(Z)$ was not included because these methods have not changed from previous NRC approved methods. The RAOC analysis methods are the same, except for the concept of potentially analyzing multiple operating spaces for a given unit/cycle, instead of just one operating space. The RAOC analysis methods are defined and approved by the NRC in Part A of WCAP-10216-P-A (which is reference 5 in WCAP-17661-P). The information contained in Part B of WCAP-10216-P-A, which describes the original implementation of the F_Q Surveillance Technical Specification, will be superseded by the Improved F_Q Surveillance Technical Specifications contained in WCAP-17661-P. CAOC analysis methods are defined and approved by the NRC in WCAP-8385, NS-CE-687, and NS-TMA-2198 (which are references 2, 3, and 4 in WCAP-17661-P). WCAP-8385 was approved by the NRC in a letter from J. F. Stolz (NRC) to C. Eicheldinger (Westinghouse), "Safety Evaluation of WCAP-8385 (P) and WCAP-8403 (NP)," dated January 31, 1978. The specific calculations to obtain the peak predicted transient F_Q will continue to be performed using either the 2D/1D synthesis methods (originally approved by the NRC in WCAP-8385 Section 5, and summarized succinctly by Equation 2-10 of WCAP-17661-P), or by using an NRC approved 3D computer code, such as the Westinghouse ANC code (WCAP-10965-P-A). The application of calculational uncertainties is not changing as a result of the development of WCAP-17661-P (see the response to RAI No. 4 for a discussion of the calculational uncertainties). There are no specific assumptions or limitations in the original approved analysis methods that are adversely affected by the changes to the Improved F_Q Surveillance Technical Specifications proposed in WCAP-17661-P.

While specific revisions to the implementing nuclear design procedures have not been completed at this time, there have been sample calculations performed in support of the data contained in WCAP-17661-P. These sample calculations will form the basis for revising the nuclear design procedures to implement the new methodology at Westinghouse.

In the sample calculations discussed above, the predicted transient $F_Q^W(Z)$ power shapes were generated for a sample 4-loop plant using the standard RAOC and CAOC analysis procedures, for multiple operating spaces. The analysis of a different operating space is a relatively simple process that involves changing a few input values in the standard computer runs to define the allowed AFD band and rod insertion limits. Similarly, the margin improvements associated with reducing the maximum allowed power level and AFD band for each defined operating space (Tables 6-10 and 9-7 in WCAP-17661-P) were quantified by changing the applicable inputs defining the maximum allowed power level and AFD band, and then running the standard set of cases, as if it were a new operating space. The automated sequences within the computer codes generate standard transient simulations which operate within the allowed operating space provided in the inputs. The number of specific operating spaces and margin improvement calculations that will be analyzed in advance for any given plant will depend on the plant specific needs.

The calculation of the new surveillance parameters in support of the Improved F_Q Technical Specifications [i.e., T(Z), $A_{XY}(Z)$, $A_Q(Z)$, and the Rj factor] will be performed in accordance with the respective equations used to define these parameters in WCAP-17661-P (i.e., Equations 4-30, 4-35, 7-10, and 5-9 in WCAP-17661-P, respectively). T(Z) may alternatively be determined from currently calculated values of W(Z) using Equation 4-33 in WCAP-17661-P, but this will result in the same T(Z) values as would be obtained from Equation 4-30. The values necessary to calculate these parameters are already determined as part of the RAOC or CAOC analysis.

In the case of $A_{XY}(Z)$ and $A_Q(Z)$, most surveillances will be performed using values of unity, at least for surveillances performed at 100% RTP with all rods out. Specific $A_{XY}(Z)$ and $A_Q(Z)$ values may be provided in the plant COLRs for surveillances that are performed during the initial power ascension following a refueling, as requested by the plant. An option may be implemented in the Westinghouse BEACON Core Monitoring System (WCAP-12472-P-A) to automatically generate $A_{XY}(Z)$ and $A_Q(Z)$ values specific to the conditions where the surveillance is performed using the methods discussed in Sections 4.3.2 and 7.3.2 of WCAP-17661, respectively. The BEACON Core Monitoring System is currently used to perform the F_Q surveillances in many Westinghouse NSSS plants.

As discussed in the Safety Evaluations/Final Safety Evaluations for WCAP-12472-P-A and Addendums 1 through 4, the BEACON™ Core Monitoring System is a core monitoring and support package that uses core power distribution and plant process instrumentation in conjunction with this NRC approved analytical methodology for online generation of calibrated 3-dimensional core power distributions. The BEACON™ system is approved by the NRC for core monitoring activities, including the determination of the measured transient $F_Q^W(Z)$ which is required by SR 3.2.1.2.

The analytical methodologies that are implemented in the BEACON™ system are the same NRC approved methodologies that are implemented in the Westinghouse ANC code (WCAP-10965-P-A Revision 0 through Addendum 2A), which can also be used to calculate the $A_{XY}(Z)$ and $A_Q(Z)$ values contained in the COLR. The determination of the $A_{XY}(Z)$ and $A_Q(Z)$ values by the BEACON™ system can be done in one of two ways as discussed below.

- Since the BEACON™ system is provided with the current plant conditions where the surveillance is performed, and the conditions that were assumed in generating the reference T(Z) or W(Z) surveillance factors. The determination of the $A_{XY}(Z)$ and $A_Q(Z)$ values at the conditions where the surveillance is performed, can be done by calculating two different 3-D power distributions in BEACON™ and solving either Equation 4-35 in WCAP-17661-P for $A_{XY}(Z)$ or Equation 7-10 in WCAP-17661-P for $A_Q(Z)$.

- The reference $F_{XY}(Z)$ and $F_Q(Z)$ functions that are consistent with the T(Z) or W(Z) surveillance factors can be input to the BEACON™ core model. Then the determination of the $A_{XY}(Z)$ and $A_Q(Z)$ values at the conditions where the surveillance is performed, can be done by calculating the 3-D power distribution in BEACON™ at the surveillance conditions and solving either Equation 4-35 in WCAP-17661-P for $A_{XY}(Z)$ or Equation 7-10 in WCAP-17661-P for $A_Q(Z)$.

With either approach the, the determination of the $A_{XY}(Z)$ and $A_Q(Z)$ values at the conditions where the surveillance is performed using the BEACON™ system will be consistent with the current NRC approved methodology for determining 3-D power distributions in WCAP-12472-P-

A and Addendums 1 through 4, and the updated F_Q surveillance methodologies that will be approved in WCAP-17661-P.

The Rj factor is currently already calculated by Westinghouse in support of the current F_Q Technical Specification Surveillance methodology, as shown in Equation 5-9 of WCAP-17661-P. Rj quantifies the maximum *predicted* decrease in the transient $F_Q^W(Z)$ margin over the next period of operation prior to the next performance of SR 3.2.1.2, from any point forward in the cycle. In the revised F_Q surveillance methodology contained in WCAP-17661, no minimum value will be imposed on the value of Rj, except that Rj will never be specified as being less than 1.0, even if it is predicted that the transient $F_Q^W(Z)$ margin will increase during the next Frequency when SR 3.2.1.2 is performed. The actual calculated Rj penalty will be applied to all $F_Q^W(Z)$ surveillances, instead of focusing the application of the penalty during the performance of any individual surveillance on an observed decrease in $F_Q^C(Z)$ margin from the previous performance of SR 3.2.1.2.

As discussed at the bottom of page 5-8 of WCAP-17661-P, the Rj factors are calculated in accordance with the Surveillance Frequency applied in SR 3.2.1.2. The proposed versions of SR 3.2.1.2 in WCAP-17661-P TS 3.2.1B and TS 3.2.1C have been developed with the recognition that some plants may have the SR 3.2.1.2 Frequency in a Surveillance Frequency Control Program. It is also possible that some plants may elect to perform SR 3.2.1.2 more frequently than required, during times in the cycle when the $F_Q^W(Z)$ margin is limited, or for other reasons. As a minimum, the Rj penalty factor function provided in the COLR will support the SR 3.2.1.2 required Frequency. If a plant elects to perform SR 3.2.1.2 more frequently than required, either for all or part of a cycle, an appropriate Rj penalty factor may optionally be developed to support that Frequency, and would also be provided in the COLR. For example, if a plant notifies Westinghouse that it intends to perform SR 3.2.1.2 on an optional 7 EFPD Frequency during parts of the cycle, an Rj function applicable to the 7 EFPD Frequency may be provided in the COLR in addition to the standard 31 EFPD Rj penalty. The Rj penalty for the optional 7 EFPD Frequency would be calculated in the same manner as the 31 EFPD Rj penalty, except that it would be based on the maximum predicted decrease in transient $F_Q^W(Z)$ margin for the next 7 EFPDs of operation (instead of the next 31 EFPDs). While performing the Surveillance on a 7 EFPD Frequency, the 7 EFPD Rj function would be used by the plant. If the plant decides to revert back to the required 31 EFPD Frequency for SR 3.2.1.2, the 31 EFPD Rj function would be used for the first Surveillance performed prior to increasing the Frequency back to 31 EFPDs (i.e., based on the planned time interval before the next performance of SR 3.2.1.2).

The following is the specific justification for basing the calculated Rj factor on only the *predicted* trend in the future transient $F_Q^W(Z)$ margin, and not including the effect of measurements from past operation or additional uncertainty.

The purpose of the Rj factor is to ensure that the $F_Q^W(Z)$ limit will not be exceeded prior to the performance of the next $F_Q^W(Z)$ surveillance. Rj is not used in the plant safety analysis. The measured trend in the transient $F_Q^W(Z)$ margin is significantly affected by the burnup dependent behavior of the predicted surveillance factors T(Z) and W(Z). In other words, the predicted T(Z) and W(Z) surveillance factors affect both the predictions and measurements of the transient $F_Q^W(Z)$ margin by the same amount. Only the radial component of the measured power distribution ($F_{XY}(Z)$) affects the transient $F_Q^W(Z)$ margin for RAOC plants. This steady state radial component varies much more slowly with burnup than the $F_Q^W(Z)$ value, which is affected by both radial and axial trends.

As discussed in the response to RAI No. 6, it has been shown that trends in $F_Q^C(Z)$ margin do not always correlate with trends in the $F_Q^W(Z)$ margin, because of the effect of the surveillance factor variations with burnup. Furthermore, the observed trend in $F_Q^C(Z)$ margin for the *past* 31 EFPDs of operation may not be indicative of the expected decrease or increase in $F_Q^W(Z)$ margin over the *next* 31 EFPDs of operation. The $F_Q^C(Z)$ margin may increase during one 31 EFPD period and then decrease during the next 31 EFPD period, and it may even oscillate in both directions over several 31 EFPD surveillances. These increases and decreases in observed $F_Q^C(Z)$ margin may be real (due to fuel depletion effects), however they may also be due to the random uncertainties associated with all power distribution measurements. They could also be due to minor operational differences, such as operating at a few percent different AFD (within the allowed AFD band) between 31 EFPD power distribution surveillances.

See the response to RAI 4b, regarding the uncertainties for the T(Z) surveillance factors.

In the event there is some unpredicted, but real anomaly occurring in the core, which results in the $F_Q^W(Z)$ margin decreasing faster than predicted, the anomaly will most likely develop slowly and be observable over several power distribution measurements before the F_Q limit is actually challenged (e.g., CIPS). Guidance has been issued by Westinghouse for identifying slowly developing radial and axial power anomalies such as CIPS, and evaluating the effect of their occurrence before the F_Q limit is challenged. Quadrant Power Tilt Ratio (QPTR) monitoring will ensure that any more rapidly developing disturbances in the radial power distribution are identified between 31 EFPD surveillances, and the Required Actions for exceeding the QPTR limit require that the $F_Q^C(Z)$ and $F_Q^W(Z)$ surveillances be performed to determine the current operating margin. Finally, it should be noted that the calculations performed to develop the predicted Rj penalties are conservative, because they base the penalty for the next 31 EFPD of operation on the most conservative result obtained from 1/8 month interval segments in the next 31 EFPDs (see equation 5-9 in WCAP-17661-P).

Response to 13b:

The key attributes/improvements of the revised F_Q Technical Specification Surveillance methodology can be summarized as follows, and related to the specific changes in the Technical Specifications 3.2.1B and 3.2.1C:

1) The formulation for determining the measured transient $F_Q^W(Z)$ in RAOC plants has been revised to be less sensitive to the ability to predict the actual steady state axial power shape conditions where the surveillances are performed.

   This is related to the use of the new T(Z) surveillance factor, which no longer includes the steady state axial power shape in the denominator, relative to the original W(Z) factor.

2) Correction factors have been defined for the new F_Q surveillance equations which correct the results for any remaining errors associated with the actual plant conditions where the surveillance is performed, which may differ from the predicted surveillance condition. These factors are the $A_{XY}(Z)$ factors for RAOC plants and the $A_Q(Z)$ factors for CAOC plants, which have been added to the respective equations used to perform the

$F_Q^W(Z)$ surveillance (see equations 5-1, 5-2, 8-1, and 8-2 in WCAP-17661-P). Multiple methods have been presented for representing the $A_{XY}(Z)$ and $A_Q(Z)$ factors. This includes the very simple assumption of unity for the factors, all the way up to rigorous calculation of the factors at the specific conditions of each surveillance.

3) The F_Q surveillance equations have been changed to appropriately correct for the performance of surveillances at part power conditions. This is done by moving the relative power term of the condition where the surveillance is performed out of the surveillance factors (i.e., T(Z) and W(Z)) and into the actual surveillance equations (see equations 5-1, 5-2, 8-1, and 8-2 in WCAP-17661-P). For power levels less than 50% RTP, the F_Q limits are correctly evaluated at the 50% RTP power level.

4) Required Actions for cases where $F_Q^W(Z)$ exceeds the F_Q limit have been more rigorously defined, and eliminate all reliance on "rules of thumb" that may not be strictly applicable in all situations. This is implemented through the possible application of new RAOC or CAOC operating spaces, or through the pre-defined limitations on power and AFD provided in the COLR, which are rigorously calculated using the standard NRC approved analysis methods. These changes ensure that corrective actions taken in the rare circumstances when $F_Q^W(Z)$ exceeds the F_Q limit will be effective at restoring the necessary margin.

5) The application of the burnup dependent penalty factor (Rj) to account for predicted decreases in the transient $F_Q^W(Z)$ margin during the next 31 EFPDs has been modified to apply to all surveillances, independent of the trends in measured $F_Q^C(Z)$ margin. This is implemented by incorporating Rj into the surveillance equations (see equations 5-1, 5-2, 8-1, and 8-2 in WCAP-17661-P) and eliminating the conditional application of the penalty factor in the Technical Specification surveillances. This improvement corrects cases where the measured trend in $F_Q^C(Z)$ margin from the previous 31 EFPDs may be increasing, but the trend in $F_Q^W(Z)$ margin is decreasing due to changes in the surveillance factor data.

6) Requirements to perform SR 3.2.1.1 and 3.2.1.2 have been clarified in cases where $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed the F_Q limit. In any case where one or both parameters exceed the limit, both surveillances are required to be performed by the Technical Specifications Required Actions.

7) The F_Q surveillance Technical Specifications have been revised to rely on $F_Q^C(Z)$ surveillances during the initial power ascension after a refueling to demonstrate that continued power ascension is justified. The first $F_Q^W(Z)$ surveillance is not specifically required to be performed until 24 hours after the plant reaches equilibrium conditions at a power level greater than 75% RTP. This change recognizes the technical fact that the surveillance factors needed to perform an accurate $F_Q^W(Z)$ surveillance at a very low THERMAL POWER levels are difficult to accurately calculate in advance of the surveillance, and that the most accurate $F_Q^W(Z)$ surveillances will be obtained from equilibrium conditions at greater than 75% RTP. The change is justified by the fact that the $F_Q^C(Z)$ surveillances confirm the core is behaving as predicted, and the initial power ascension after a refueling outage is performed in a slow, controlled manner, until the fuel is conditioned. The first $F_Q^W(Z)$ surveillance that is performed following a refueling justifies operation at 100% RTP over the next 31 EFPDs, under potential transient

operation.

In summary, a number of improvements have been made to the F_Q Technical Specification surveillance methodology for RAOC and CAOC plants, which improve the expected accuracy of the surveillances, and which provide Required Actions that are demonstrated to be effective at restoring the required margin in the event the F_Q limit is exceeded.

Response to 13c:

The choice of a 4-loop Westinghouse plant for performing the demonstration calculations supporting the results shown in WCAP-17661-P does not affect any of the methods or justifications discussed in WCAP-17661-P. Standard RAOC and CAOC calculations are routinely performed for all types of Westinghouse NSSS plants, and for other types of PWRs which are licensed using the Westinghouse safety analysis methodology. In generating a COLR for a different type of plant, or even for a 4-loop plant with a different fuel type or $F_{\Delta H}^{N}$ limit, it would be expected that the rod insertion limits and allowed AFD operating bands could be significantly different than those presented in WCAP-17661-P. Also, the margin gains associated with implementing a different operating space, or a power reduction could be different as well. However, all the methods for performing the calculations remain applicable. Actual violations of the F_Q limit are unlikely based on past operating experience, and will continue to be so in the future. However, the implementation of a more rigorous approach to define the Required Actions in the event of an F_Q violation will ensure that this key safety analysis parameter is expeditiously restored to within it limit, if the limit is not met.

RAI No. 14: Adjustment factor for the radial peaking factor ($A_{XY}(z)$)

Background

Appendix C, "Sample COLR Input for a RAOC Plant," indicates in limit C.2.2.6 that "$A_{XY}(z)$ may be assumed equal to 1.0 or may be determined for specific surveillance conditions using the approved methods listed in TS 5.6.5." This follows discussion contained in Sections 4.3 and 6.4 of the main topical report.

Issue and Request

Regarding Method 2 as described in Licensing Topical Report (LTR) Section 4.3:

a. Provide a comprehensive list of all approved methods that may be used to calculate $A_{XY}(z)$, according to Method 2.

b. Since $A_{XY}(z)$ is a factor used to scale a surveillance value that is used to confirm adherence to a cycle-specific parameter operating limit, its reciprocal could, if applied to the operating limit, be considered a cycle (or, more specifically, situation)-specific scaling factor for a parameter operating limit. The core physics methodology, or computer code, used to calculate this value would need to be referenced in the TS COLR References list, for consistency with Generic Letter 1988-16 guidance.

c. Explain whether $A_{XY}(z)$ is calculated on-site by an implementing licensee, or whether Westinghouse or the PWROG, as supporting vendors, calculate these values.

d. Provide the procedures or engineering guidelines for calculating these values for NRC staff review.

Regarding Methods 3 and 4 as described in LTR Section 4.3:

e. Various passages of text in the LTR appear to acknowledge many shortcomings associated with these methods. For example, Page 6-3 states, "Obviously, this method is somewhat awkward given the large number of values that must be pre-calculated and the need to determine appropriate values for intermediate power levels and rod positions." Explain what benefit offering these methods provide to any implementing licensee: why make this option available?

Regarding $A_{XY}(z)$ in general:

f. The text in Section 4.3 suggests that incorporating an $A_{XY}(z)$ term in the surveillance formulation is optional. For example, Page 4-9 states, "... use of these factors should be an option... " Explain how $A_{XY}(z)$ is applied if its value is greater than 1.

g. Section 6.4 described $A_{XY}(z)$ values for initial power ascension. If the $F_Q^W(z)$ surveillance is not intended to be performed until after a period of equilibrium operation after exceeding a threshold power level, explain why the $A_{XY}(z)$ factors are necessary or desired for initial power ascension.

Response to RAI No. 14:

Response to 14a:

If Method 2 is used to calculate $A_{XY}(Z)$ for a RAOC plant, it will be done using Equation 4-35 in WCAP-17661-P, using an NRC approved 3D nuclear code such as the Westinghouse ANC code (WCAP-10965-P-A) or the Westinghouse BEACON Core Monitoring System (WCAP-12472-P-A). Both codes are capable of calculating the F_{XY} values needed to evaluate the $A_{XY}(Z)$ factor, and are approved by the NRC. An ANC calculation would have to be manually performed by a qualified user, who would input the conditions of the surveillance directly to the code. The calculation could be automated in the BEACON Core Monitoring System, as this code is currently used to perform the F_Q surveillance measurements for many Westinghouse NSSS plants, and the specific plant conditions where the surveillance will be performed would be available from the plant computer interface with the BEACON system. The calculation could also be performed using another NRC approved computer code capable of calculating the necessary F_{XY} values to solve Equation 4-35.

Response to 14b:

It is agreed that WCAP-17661-P would need to be added to the plant specific TS list of COLR references as required by NRC GL 88-16. In addition, the topical report describing the calculational methods used for the RAOC or CAOC analysis would be retained, to support the nuclear design analysis methods that will be used (for example, WCAP-10216-P-A, Part A, for a RAOC plant). The approved nuclear codes and core physics methods topicals used for a particular plant are typically referenced in the Nuclear Design section of the plant's updated final safety analysis report, as required by NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition*.

Response to 14c:

Method 2 of performing the $A_{XY}(Z)$ calculations could be performed either by Westinghouse or another qualified supporting vendor responsible for generating the surveillance data, or it could be performed by the implementing licensee. If method 2 is used, the most likely implementation will be for the calculation to be performed by the implementing licensee during the performance of the surveillance, using an NRC approved computer code such as the BEACON Core Monitoring System (WCAP-12472-P-A). The BEACON Core Monitoring System contains the Westinghouse ANC nuclear methods, in a model which is automatically calibrated to match plant measured data during operation of the plant.

Response to 14d:

Specific implementing procedures or engineering guidelines have not been developed yet, since they need to be consistent with the final NRC approval of the methodology contained in WCAP-17661. However, as stated in Section 4.3.2 of WCAP-17661-P, the calculation of the F_{XY} parameters needed to solve Equation 4-35 involves two straightforward core calculations: one at the reference conditions assumed for the COLR T(Z) values (e.g., 100% RTP, all rods out, equilibrium xenon) and one at the actual conditions of the $F_Q^W(Z)$ surveillance, which may be at a reduced power level and have some control bank insertion. The calculation of F_{XY} radial peaking factors has been a standard part of Westinghouse nuclear design methods ever since synthesis procedures were approved by the NRC in WCAP-8385, "Power Distribution Control and Load Following Procedures."

Response to 14e:

The objective of identifying multiple methods is to provide plants with the maximum flexibility for implementation of the methodology. Method 2 will be very easy to implement once incorporated directly into the BEACON Core Monitoring System. However, Method 1 is acceptable for most $F_Q^W(z)$ surveillances. Methods 3 and 4 are intended for plants that may routinely perform $F_Q^W(z)$ surveillances at conditions significantly different than those assumed in generating the T(Z) surveillance factors, and who do not use the BEACON Core Monitoring System.

However, all of the methods are acceptable and will provide accurate results.

Response to 14f and 14g:

When detailed calculations of $A_{XY}(Z)$ are performed using one of the methods defined in WCAP-17661-P, the function is applied as a direct multiplier to the $F_Q^W(Z)$, as shown in Equations 5-1 and 5-2 of WCAP-17661-P. The value is applied as calculated by the NRC approved nuclear code, irrespective of whether or not the calculated value is greater than, less than, or equal to 1.0. The $A_{XY}(Z)$ factor corrects the analytical T(Z) surveillance factors because the $F_{XY}(Z)$ distribution that is used in the denominator of T(Z) was generated at an assumed condition which is not consistent with the actual conditions where the surveillance is performed. The measured F_{XY} distribution (i.e., $[F_{XY}(z)]^M_{Surv}$) from the movable incore detector system is still incorporated directly into the $F_Q^W(z)$ surveillance result.

The change to the initial performance of SR 3.2.1.2 after a refueling within 24 hours after achieving equilibrium conditions after THERMAL POWER exceeds 75% RTP is necessary so that, future surveillances of $F_Q^W(z)$ will be performed at core conditions that are very close to those used in generating the T(Z) surveillance factors, and there will be no significant error introduced by assuming that $A_{XY}(Z)$ is unity. In this case, it would not be necessary to provide $A_{XY}(Z)$ values in the COLR, or calculate them using Method 2 during the performance of the surveillance.

Attachment 3

Technical Specification 3.2.1B
Heat Flux Hot Channel Factor Markups
(Non-Proprietary)

3.2 POWER DISTRIBUTION LIMITS

3.2.1B Heat Flux Hot Channel Factor ($F_Q(Z)$ (RAOC-~~W~~ T(Z) Methodology)

LCO 3.2.1B $F_Q(Z)$, as approximated by $F_Q^C(Z)$ and $F_Q^W(Z)$, shall be within the limits specified in the COLR.

APPLICABILITY: MODE 1.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. ------------NOTE------------ Required Action A.4 shall be completed whenever this Condition is entered prior to increasing THERMAL POWER above the limit of Required Action A.1. SR 3.2.1.2 is not required to be performed if this Condition is entered prior to THERMAL POWER exceeding 75% RTP after a refueling. ---------------------------------- $F_Q^C(Z)$ not within limit.	A.1	Reduce THERMAL POWER ≥ 1% RTP for each 1% $F_Q^C(Z)$ exceeds limit.	15 minutes after each $F_Q^C(Z)$ determination
	<u>AND</u>		
	A.2	Reduce Power Range Neutron Flux - High trip setpoints ≥ 1% for each 1% ~~$F_Q^C(Z)$ exceeds limit.~~ that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1.	72 hours after each $F_Q^C(Z)$ determination
	<u>AND</u>		
	A.3	Reduce Overpower ΔT trip setpoints ≥ 1% for each 1% ~~$F_Q^C(Z)$ exceeds limit.~~ that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1.	72 hours after each $F_Q^C(Z)$ determination
	<u>AND</u>		
	A.4	Perform SR 3.2.1.1 and SR 3.2.1.2.	Prior to increasing THERMAL POWER above the limit of Required Action A.1

OR
B.2.1 ———NOTE———
Required Action B.2.4 shall be completed whenever Required Action B.2.1 is performed prior to increasing THERMAL POWER above the limit of Required Action B.2.1.

Limit THERMAL POWER to less than RATED THERMAL POWER and reduce AFD limits as specified in the COLR.

Implement a RAOC operating space specified in the COLR that restores $F_Q^W(z)$ to within its limits.
AND
B.1.2 Perform SR 3.2.1.1 and SR 3.2.1.2 if control rod motion is required to comply with the new operating space.

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. ~~-----NOTE----- Required Action B.4 shall be completed whenever this Condition is entered.~~ $F_Q^W(Z)$ not within limits.	B.1 .1 ~~Reduce AFD limits ≥ 1% for each 1% $F_Q^W(Z)$ exceeds limit.~~	4 hours 72 hours 4 hours
	AND	
	B.2 .2 Reduce Power Range Neutron Flux - High trip setpoints ≥ 1% for each 1% that ~~the maximum allowable power of the AFD limits is reduced.~~ THERMAL POWER is limited below RATED THERMAL POWER by Required Action B.2.1.	72 hours
	AND	
	B.~~3~~ 2.3 Reduce Overpower ΔT trip setpoints ≥ 1% for each 1% that ~~the maximum allowable power of the AFD limits is reduced.~~	72 hours
	AND	
	B.~~4~~ 2.4 Perform SR 3.2.1.1 and SR 3.2.1.2.	Prior to increasing THERMAL POWER above the ~~maximum allowable power of the AFD limits~~ limit of Required Action B.2.1
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 2.	6 hours

SURVEILLANCE REQUIREMENTS

~~NOTE~~
~~During power escalation at the beginning of each cycle, THERMAL POWER may be increased until an equilibrium power level has been achieved, at which a power distribution map is obtained.~~

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify $F_Q^C(Z)$ is within limit.	Once after each refueling prior to THERMAL POWER exceeding 75% RTP AND Once within [~~12~~ 24] hours after achieving equilibrium conditions after exceeding, by ≥ 10% RTP, the THERMAL POWER at which $F_Q^C(Z)$ was last verified AND [31 EFPD thereafter OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.2.1.2	-----------------------------NOTE----------------------------- If measurements indicate that the maximum over z [$F_Q^C(Z)$ / K(Z)] has increased since the previous evaluation of $F_Q^C(Z)$: a. Increase $F_Q^W(Z)$ by the greater of a factor of [1.02] or by an appropriate factor specified in the COLR and reverify $F_Q^W(Z)$ is within limits or b. Repeat SR 3.2.1.2 once per 7 EFPD until either a. above is met or two successive flux maps indicate that the maximum over z [$F_Q^C(Z)$ / K(Z)] has not increased. --	
	Verify $F_Q^W(Z)$ is within limit.	Once after each refueling within [24] hours after achieving equilibrium conditions after thermal power exceeds 75% RTP ~~prior to THERMAL POWER exceed-ing 75% RTP~~ <u>AND</u> Once within [~~12~~ 24] hours after achieving equilibrium conditions after exceeding, by ≥ 10% RTP, the THERMAL POWER at which $F_Q^W(Z)$ was last verified <u>AND</u>

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE	FREQUENCY
	[31 EFPD thereafter <u>OR</u> In accordance with the Surveillance Frequency Control Program]

Attachment 4

Technical Specification Bases 3.2.1B
Heat Flux Hot Channel Factor Markups

(Non-Proprietary)

B 3.2 POWER DISTRIBUTION LIMITS

T

B 3.2.1B Heat Flux Hot Channel Factor ($F_Q(Z)$ (RAOC-~~W~~(Z) Methodology)

BASES

BACKGROUND

The purpose of the limits on the values of $F_Q(Z)$ is to limit the local (i.e., pellet) peak power density. The value of $F_Q(Z)$ varies along the axial height (Z) of the core.

$F_Q(Z)$ is defined as the maximum local fuel rod linear power density divided by the average fuel rod linear power density, assuming nominal fuel pellet and fuel rod dimensions. Therefore, $F_Q(Z)$ is a measure of the peak fuel pellet power within the reactor core.

During power operation, the global power distribution is limited by LCO 3.2.3, "AXIAL FLUX DIFFERENCE (AFD)," and LCO 3.2.4, "QUADRANT POWER TILT RATIO(QPTR)," which are directly and continuously measured process variables. These LCOs, along with LCO 3.1.6, "Control Bank Insertion Limits," maintain the core limits on power distributions on a continuous basis.

$F_Q(Z)$ varies with fuel loading patterns, control bank insertion, fuel burnup, and changes in axial power distribution.

$F_Q(Z)$ is measured periodically using the incore detector system. These measurements are generally taken with the core at or near equilibrium conditions.

Using the measured three dimensional power distributions, it is possible to derive a measured value for $F_Q(Z)$. However, because this value represents an equilibrium condition, it does not include the variations in the value of $F_Q(Z)$ which are present during nonequilibrium situations such as load following or power ascension.

the elevation dependent measured planar radial peaking factors, $F_{XY}(z)$, are increased by an elevation dependent factor, $[T(z)]^{COLR}$, that accounts for the expected maximum values of the transient axial power shapes postulated to occur during RAOC operation. Thus, $[T(z)]^{COLR}$ accounts for the worst case non-equilibrium power shapes that are expected for the assumed RAOC operating space.

To account for these possible variations, ~~the equilibrium value of $F_Q(Z)$ is adjusted as $F_Q^W(Z)$ by an elevation dependent factor that accounts for the calculated worst case transient conditions.~~

Core monitoring and control under non-equilibrium conditions are accomplished by operating the core within the limits of the appropriate LCOs, including the limits on AFD, QPTR, and control rod insertion.

The RAOC operating space is defined as the combination of AFD and Control Bank Insertion Limits assumed in the calculation of a particular $[T(z)]^{COLR}$ function. The $[T(z)]^{COLR}$ factors are directly dependent on the AFD and Control Bank Insertion Limit assumptions. The COLR may contain different $[T(z)]^{COLR}$ functions that reflect different operating space assumptions. If the limit on $F_Q(z)$ is exceeded, a more restrictive operating space may be implemented to gain margin for future non-equilibrium operation.

BASES

APPLICABLE SAFETY ANALYSES

This LCO precludes core power distributions that violate the following fuel design criteria:

a. During a large break loss of coolant accident (LOCA), the peak cladding temperature must not exceed 2200°F (Ref. 1),

b. During a loss of forced reactor coolant flow accident, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a departure from nucleate boiling (DNB) condition,

c. During an ejected rod accident, the energy deposition to the fuel must not exceed 280 cal/gm (Ref. 2), and

d. The control rods must be capable of shutting down the reactor with a minimum required SDM with the highest worth control rod stuck fully withdrawn (Ref. 3).

Limits on $F_Q(Z)$ ensure that the value of the initial total peaking factor assumed in the accident analyses remains valid. Other criteria must also be met (e.g., maximum cladding oxidation, maximum hydrogen generation, coolable geometry, and long term cooling). However, the peak cladding temperature is typically most limiting.

$F_Q(Z)$ limits assumed in the LOCA analysis are typically limiting relative to (i.e., lower than) the $F_Q(Z)$ limit assumed in safety analyses for other postulated accidents. Therefore, this LCO provides conservative limits for other postulated accidents

$F_Q(Z)$ satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

The Heat Flux Hot Channel Factor, $F_Q(Z)$, shall be limited by the following relationships:

$F_Q(Z) \leq (CFQ / P)\ K(Z)$ for $P > 0.5$

$F_Q(Z) \leq (CFQ / 0.5)\ K(Z)$ for $P \leq 0.5$

where: CFQ is the $F_Q(Z)$ limit at RTP provided in the COLR,

limit
K(Z) is the normalized FQ(Z) as a function of core height provided in the COLR, and

P = THERMAL POWER / RTP

BASES

LCO (continued)

2.50

For this facility, the actual values of CFQ and K(Z) are given in the COLR; however, CFQ is normally a number on the order of [~~2.32~~], and K(Z) is a function that looks like the one provided in Figure B 3.2.1B-1.

For Relaxed Axial Offset Control operation, $F_Q(Z)$ is approximated by $F_Q^C(Z)$ and $F_Q^W(Z)$. Thus, both $F_Q^C(Z)$ and $F_Q^W(Z)$ must meet the preceding limits on $F_Q(Z)$.

An $F_Q^C(Z)$ evaluation requires obtaining an incore flux map in MODE 1. From the incore flux map results we obtain the measured value ($F_Q^M(Z)$) of $F_Q(Z)$. Then,

$$F_Q^C(Z) = F_Q^M(Z)\ [1.0815]$$

where [1.0815] is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

$F_Q^C(Z)$ is an excellent approximation for $F_Q(Z)$ when the reactor is at the steady state power at which the incore flux map was taken.

The expression for $F_Q^W(Z)$ is:

$$F_Q^W(Z) = \cancel{F_Q^C(Z)\ W(Z)}$$

$$F_{XY}^M(z)\ \frac{[T(z)]^{COLR}}{P}\ A_{XY}(z)\ Rj\ [1.0815]$$

INSERT 1
(next page)

~~where W(Z) is a cycle dependent function that accounts for power distribution transients encountered during normal operation. W(Z) is included in the COLR. The $F_Q^C(Z)$ is calculated at equilibrium conditions.~~

The $F_Q(Z)$ limits define limiting values for core power peaking that precludes peak cladding temperatures above 2200°F during either a large or small break LOCA.

Violating the LCO limits for $F_Q(z)$ could result in unacceptable consequences if a design basis event were to occur while $F_Q(z)$ exceeds its specified limits.

This LCO requires operation within the bounds assumed in the safety analyses. Calculations are performed in the core design process to confirm that the core can be controlled in such a manner during operation that it can stay within the LOCA $F_Q(Z)$ limits. If $F_Q^C(Z)$ cannot be maintained within the LCO limits, reduction of the core power is required , and if $F_Q^W(Z)$ cannot be maintained within the LCO limits, ~~reduction of the AFD limits is required. Note that sufficient reduction of the AFD limits will also result in a reduction of the core power.~~

a more restrictive RAOC operating space must be implemented or core power limits and AFD limits must be reduced.

~~Violating the LCO limits for $F_Q(Z)$ produces unacceptable consequences if a design basis event occurs while $F_Q(Z)$ is outside its specified limits.~~

INSERT 1

The various factors in this expression are defined below:

$F_{XY}^{M}(z)$ is the measured radial peaking factor at axial location z and is equal to the value of $F_Q^M(z)/P^M(z)$, where $P^M(z)$ is the measured core average axial power shape.

$[T(z)]^{COLR}$ is the cycle and burnup dependent function, specified in the COLR, which accounts for power distribution transients encountered during non-equilibrium normal operation. $[T(z)]^{COLR}$ functions are specified for each analyzed RAOC operating space (i.e., each unique combination of AFD limits and Control Bank Insertion Limits). The $[T(z)]^{COLR}$ functions account for the limiting non-equilibrium axial power shapes postulated to occur during normal operation for each RAOC operating space. Limiting power shapes at both full and reduced power operation are considered in determining the maximum values of $[T(z)]^{COLR}$. The $[T(z)]^{COLR}$ functions also account for the following effects: (1) the presence of spacer grids in the fuel assembly, (2) the increase in radial peaking in rodded core planes due to the presence of control rods during non-equilibrium normal operation, (3) the increase in radial peaking that occurs during part-power operation due to reduced fuel and moderator temperatures, and (4) the increase in radial peaking due to non-equilibrium xenon effects. The $[T(z)]^{COLR}$ functions are normally calculated assuming that the Surveillance is performed at nominal RTP conditions with all shutdown and control rods fully withdrawn, i.e., all rods out (ARO). Surveillance specific $[T(z)]^{COLR}$ values may be generated for a given surveillance core condition.

P is the THERMAL POWER / RTP.

$A_{XY}(z)$ is a cycle, burnup, and power dependent function specified in the COLR or determined at the time of the surveillance using an approved 3D core model and the methodology of Reference 6. It adjusts the measured $F_{XY}^{M}(z)$ to the reference core conditions assumed in generating the $[T(z)]^{COLR}$ factors. Normally, this reference core condition is HFP, ARO, EQXE. For simplicity, $A_{XY}(z)$ may be assumed to be 1.0. If, however, margin is needed for a Surveillance performed at conditions different from the reference core conditions, then the appropriate values for $A_{XY}(z)$ may be used. Sub-factors of $A_{XY}(z)$ may also be determined and included in the COLR. These sub-factors are $F_{PC}(z)$ and $F_{RC}(z)$. $F_{PC}(z)$ is a factor that adjusts the measured $F_{XY}^{M}(z)$ to the reference core power (typically RTP) if the Surveillance is performed at part power conditions. $F_{RC}(z)$ is a factor that adjusts the measured $F_{XY}^{M}(z)$ values to the reference rodded condition (typically ARO) if the surveillance condition includes insertion of the lead control bank. When these sub-factors are used, $A_{XY}(z)$ is the product of $F_{PC}(z)$ and $F_{RC}(z)$.

[1.0815] is a factor that accounts for fuel manufacturing tolerances and measurement uncertainty.

Rj is a cycle and burnup dependent analytical factor specified in the COLR that accounts for potential increases in $F_Q^W(z)$ between Surveillances. Rj values are provided for each RAOC operating space.

--REVIEWER'S NOTE--
WCAP-17661-P-A, "Improved RAOC and CAOC F_Q Surveillance Technical Specifications," or other appropriate plant specific methodology, is to be listed in the COLR description in the Administrative Controls Section 5.0 to address the methodology used to derive this factor.

BASES

APPLICABILITY

The $F_Q(Z)$ limits must be maintained in MODE 1 to prevent core power distributions from exceeding the limits assumed in the safety analyses. Applicability in other MODES is not required because there is either insufficient stored energy in the fuel or insufficient energy being transferred to the reactor coolant to require a limit on the distribution of core power.

ACTIONS

A.1

If an F_Q surveillance is performed at 100% RTP conditions, and both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, the option to reduce the THERMAL POWER limit in accordance with proposed Required Action B.2.1 instead of implementing a new operating space in accordance with proposed Required Action B.1, will result in a further power reduction after Required Action A.1 has been completed. However, this further power reduction would be permitted to occur over the next 4 hours. In the event the evaluated THERMAL POWER reduction in the COLR for proposed Required Action B.2.1 did not result in a further power reduction (for example, if both Condition A and Condition B were entered at less than 100% RTP conditions), then the THERMAL POWER level established as a result of completing Required Action A.1 will take precedence, and will establish the effective operating power level limit for the unit until both Conditions A and B are exited.

Reducing THERMAL POWER by ≥ 1% RTP for each 1% by which $F_Q^C(Z)$ exceeds its limit, maintains an acceptable absolute power density. $F_Q^C(Z)$ is $F_Q^M(Z)$ multiplied by a factor accounting for manufacturing tolerances and measurement uncertainties. $F_Q^M(Z)$ is the measured value of $F_Q(Z)$. The Completion Time of 15 minutes provides an acceptable time to reduce power in an orderly manner and without allowing the plant to remain in an unacceptable condition for an extended period of time. The maximum allowable power level initially determined by Required Action A.1 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require power reductions within 15 minutes of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable power level. Decreases in $F_Q^C(Z)$ would allow increasing the maximum allowable power level and increasing power up to this revised limit.

A.2

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1

A reduction of the Power Range Neutron Flux - High trip setpoints by ≥ 1% for each 1% ~~by which $F_Q^C(Z)$ exceeds its limit,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period and the preceding prompt reduction in THERMAL POWER in accordance with Required Action A.1. The maximum allowable Power Range Neutron Flux - High trip setpoints initially determined by Required Action A.2 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require Power Range Neutron Flux - High trip setpoint reductions within 72 hours of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable Power Range Neutron Flux - High trip setpoints. Decreases in $F_Q^C(Z)$ would allow increasing the maximum allowable Power Range Neutron Flux - High trip setpoints.

BASES

ACTIONS (continued)

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1

A.3

Reduction in the Overpower ΔT trip setpoints (value of K_4) by ≥ 1% for each 1% ~~by which $F_Q^C(Z)$ exceeds its limit,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period, and the preceding prompt reduction in THERMAL POWER in accordance with Required Action A.1. The maximum allowable Overpower ΔT trip setpoints initially determined by Required Action A.3 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require Overpower ΔT trip setpoint reductions within 72 hours of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable Overpower ΔT trip setpoints. Decreases in $F_Q^C(Z)$ would allow increasing the maximum allowable Overpower ΔT trip setpoints.

A.4

Verification that $F_Q^C(Z)$ has been restored to within its limit, by performing SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the limit imposed by Required Action A.1~~,~~ ensures that core conditions ~~during~~ operation at higher power levels and future operation are consistent with ~~safety analyses~~ assumptions.

prior to increasing THERMAL POWER above the limit of Required Action A.1. The Note also states that SR 3.2.1.2 is not required to be performed if this Condition is entered prior to THERMAL POWER exceeding 75% RTP after a refueling.

Condition A is modified by a Note that requires Required Action A.4 to be performed whenever the Condition is entered. This ensures that SR 3.2.1.1 and SR 3.2.1.2 will be performed prior to increasing THERMAL POWER above the limit of Required Action A.1, even when Condition A is exited prior to performing Required Action A.4. Performance of SR 3.2.1.1 and SR 3.2.1.2 are necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.

(if required)

B.1 .1

If it is found that the maximum calculated value of $F_Q(Z)$ that can occur during normal maneuvers, $F_Q^W(Z)$, exceeds its specified limits, there exists a potential for $F_Q^C(Z)$ to become excessively high if a normal operational transient occurs. ~~Reducing the AFD by ≥ 1% for each 1% by which $F_Q^W(Z)$ exceeds its limit within the allowed Completion Time of 4 hours, restricts the axial flux distribution such that even if a transient occurred, core peaking factors are not exceeded.~~

Implementing a more restrictive RAOC operating space, as specified in the COLR, within the allowed Completion Time of 4 hours will restrict the AFD such that peaking factor limits will not be exceeded during non-equilibrium normal operation. Several RAOC operating spaces, representing successively smaller AFD envelopes and, optionally, shallower Control Bank Insertion Limits, may be specified in the COLR. The corresponding T(z) functions for these operating spaces can be used to determine which RAOC operating space will result in acceptable non-equilibrium operation within the $F_Q^W(z)$ limit.

BASES

ACTIONS (continued)

~~The implicit assumption is that if W(Z) values were recalculated (consistent with the reduced AFD limits), then $F_Q^C(Z)$ times the recalculated W(Z) values would meet the $F_Q(Z)$ limit. Note that complying with this action (of reducing AFD limits) may also result in a power reduction. Hence the need for Required Actions B.2, B.3 and B.4.~~

INSERT 2 (Next Page)

B.~~2~~ .2

the

A reduction of the Power Range Neutron Flux-High trip setpoints by ≥ 1% for each 1% by which the maximum allowable power is reduced~~,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period and the preceding prompt reduction in THERMAL POWER ~~as a result of reducing~~ limit and AFD limits in accordance with Required Action B.~~1~~ 2.1.

B.~~3~~ 2.3

the

Reduction in the Overpower ΔT trip setpoints value of K_4 by ≥ 1% for each 1% by which the maximum allowable power is reduced~~,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period, and the preceding prompt reduction in THERMAL POWER limit and ~~as a result of reducing~~ AFD limits in accordance with Required Action B.~~1~~ 2.1.

B.~~4~~ 2.4

Verification that $F_Q^W(Z)$ has been restored to within its limit, by performing SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the maximum allowable power limit imposed by Required Action B.~~1~~ 2.1 ensures that core conditions during operation at higher power levels and future operation are consistent with safety analyses assumptions.

~~Condition B is modified by a Note that requires Required Action B.4 to be performed whenever the Condition is entered. This ensures that SR 3.2.1.1 and SR 3.2.1.2 will be performed prior to increasing THERMAL POWER above the limit of Required Action B.1, even when Condition A is exited prior to performing Required Action B.4. Performance of SR 3.2.1.1 and SR 3.2.1.2 are necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.~~

INSERT 2

B.1.2

If it is found that the maximum calculated value of $F_Q(Z)$ that can occur during normal maneuvers, $F_Q^W(Z)$, exceeds its specified limits, there exists a potential for $F_Q^C(Z)$ to become excessively high if a normal operational transient occurs. As discussed above, Required Action B.1.1 requires that a new RAOC operating space be implemented to restore $F_Q^W(Z)$ to within its limits. Required Action B.1.2 requires that SR 3.2.1.1 and SR 3.2.1.2 be performed if control rod motion occurs as a result of implementing the new RAOC operating space in accordance with Required Action B.1.1. The performance of SR 3.2.1.1 and SR 3.2.1.2 is necessary to assure $F_Q(Z)$ is properly evaluated after any rod motion resulting from the implementation of a new RAOC operating space in accordance with Required Action B.1.1.

B.2.1

When $F_Q^W(Z)$ exceeds its limit, Required Action B.2.1 may be implemented instead of Required Action B.1. Required Action B.2.1 limits THERMAL POWER to less than RATED THERMAL POWER by the amount specified in the COLR. It also requires reductions in the AFD limits by the amount specified in the COLR. If the RAOC operating spaces specified in the COLR are insufficient to ensure margin to the $F_Q^W(Z)$ limit, then Required Action B.2.1 must be entered and THERMAL POWER must be limited to less than or equal to 50% RTP and AFD limits must be reduced by the amounts specified in the COLR. This maintains an acceptable absolute power density relative to the maximum power density value assumed in the safety analyses.

If the required $F_Q^W(z)$ margin improvement exceeds the margin improvement available from the pre-analyzed THERMAL POWER and AFD reductions provided in the COLR, then THERMAL POWER must be further reduced to less than or equal to 50% RTP. In this case, reducing THERMAL POWER to less than or equal to 50% RTP will provide additional margin in the transient F_Q by the required change in THERMAL POWER and the increase in the F_Q limit. This will ensure that the F_Q limit is met during transient operation that may occur at or below 50% RTP.

The Completion Time of 4 hours provides an acceptable time to reduce the THERMAL POWER and AFD limits in an orderly manner to preclude entering an unacceptable condition during future non-equilibrium operation. The limit on THERMAL POWER initially determined by Required Action B.2.1 may be affected by subsequent determinations of $F_Q^W(Z)$ and would require power reductions within 4 hours of the $F_Q^W(Z)$ determination, if necessary to comply with the decreased THERMAL POWER limit. Decreases in $F_Q^W(Z)$ would allow increasing the THERMAL POWER limit and increasing THERMAL POWER up to this revised limit.

Required Action B.2.1 is modified by a Note that states Required Action B.2.4 shall be completed whenever Required Action B.2.1 is performed prior to increasing THERMAL POWER above the limit of Required Action B.2.1. Required Action B.2.4 requires the performance of SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the limit established by Required Action B.2.1. The Note ensures that the SRs will be performed even if Condition B may be exited prior to performing Required Action B.2.4. The performance of SR 3.2.1.1 and SR 3.2.1.2 is necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.

If an F_Q surveillance is performed at 100% RTP conditions, and both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, the option to reduce the THERMAL POWER limit in accordance with proposed Required Action B.2.1 instead of implementing a new operating space in accordance with proposed Required Action B.1, will result in a further power reduction after Required Action A.1 has been completed. However, this further power reduction would be permitted to occur over the next 4 hours. In the event the evaluated THERMAL POWER reduction in the COLR for proposed Required Action B.2.1 did not result in a further power reduction (for example, if both Condition A and Condition B were entered at less than 100% RTP conditions), then the THERMAL POWER level established as a result of completing Required Action A.1 will take precedence, and will establish the effective operating power level limit for the unit until both Conditions A and B are exited.

BASES

ACTIONS (continued)

2.4

C.1

If Required Actions A.1 through A.4 or B.1 through B.~~4~~ are not met within their associated Completion Times, the plant must be placed in a mode or condition in which the LCO requirements are not applicable. This is done by placing the plant in at least MODE 2 within 6 hours.

This allowed Completion Time is reasonable based on operating experience regarding the amount of time it takes to reach MODE 2 from full power operation in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

~~SR 3.2.1.1 and SR 3.2.1.2 are modified by a Note. The Note applies during the first power ascension after a refueling. It states that THERMAL POWER may be increased until an equilibrium power level has been achieved at which a power distribution map can be obtained. This allowance is modified, however, by one of the Frequency conditions that requires verification that $F_Q^C(Z)$ and $F_Q^W(Z)$ are within their specified limits after a power rise of more than 10% RTP over the THERMAL POWER at which they were last verified to be within specified limits. Because $F_Q^C(Z)$ and $F_Q^W(Z)$ could not have previously been measured in this reload core, there is a second Frequency condition, applicable only for reload cores, that requires determination of these parameters before exceeding 75% RTP. This ensures that some determination of $F_Q^C(Z)$ and $F_Q^W(Z)$ are made at a lower power level at which adequate margin is available before going to 100% RTP. Also, this Frequency condition, together with the Frequency condition requiring verification of $F_Q^C(Z)$ and $F_Q^W(Z)$ following a power increase of more than 10%, ensures that they are verified as soon as RTP (or any other level for extended operation) is achieved. In the absence of these Frequency conditions, it is possible to increase power to RTP and operate for 31 days without verification of $F_Q^C(Z)$ and $F_Q^W(Z)$. The Frequency condition is not intended to require verification of these parameters after every 10% increase in power level above the last verification. It only requires verification after a power level is achieved for extended operation that is 10% higher than that power at which $F_Q(Z)$ was last measured.~~

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.1

Verification that $F_Q^C(Z)$ is within its specified limits involves increasing $F_Q^M(Z)$ to allow for manufacturing tolerance and measurement uncertainties in order to obtain $F_Q^C(Z)$. Specifically, $F_Q^M(Z)$ is the measured value of $F_Q(Z)$ obtained from incore flux map results and $F_Q^C(Z) = F_Q^M(Z)$ [1.0815] (Ref. 4). $F_Q^C(Z)$ is then compared to its specified limits.

The limit with which $F_Q^C(Z)$ is compared varies inversely with power above 50% RTP and directly with a function called K(Z) provided in the COLR.

some determination of $F_Q^C(Z)$ is made prior to achieving a significant power level where the peak linear heat rate could approach the limits assumed in the safety analyses.

following a refueling

Performing this Surveillance in MODE 1 prior to exceeding 75% RTP ensures that ~~the $F_Q^C(Z)$ limit is met when RTP is achieved, because peaking factors generally decrease as power level is increased.~~

initial or most recent

If THERMAL POWER has been increased by ≥ 10% RTP since the ~~last~~ determination of $F_Q^C(Z)$, another evaluation of this factor is required [~~12~~] 24 hours after achieving equilibrium conditions at this higher power level (to ensure that $F_Q^C(Z)$ values are being reduced sufficiently with power increase to stay within the LCO limits).

This Frequency condition is not intended to require verification of these parameters after every 10% increase in RTP above the THERMAL POWER at which the last verification was performed. It only requires verification after a THERMAL POWER is achieved for extended operation that is 10% higher than the THERMAL POWER at which $F_Q^C(Z)$ was last measured.

[The Frequency of 31 EFPD is adequate to monitor the change of power distribution with core burnup because such changes are slow and well controlled when the plant is operated in accordance with the Technical Specifications (TS).

In the absence of these Frequency conditions (discussed above) it is possible to operate for 31 EFPD without verification of $F_Q^C(Z)$.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-------------------------------REVIEWER'S NOTE--------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
--]

Equilibrium conditions are achieved when the core is sufficiently stable at the intended operating conditions required to perform the Surveillance.

The allowance of up to 24 hours after achieving equilibrium conditions at the increased THERMAL POWER level to complete the next $F_Q^C(Z)$ surveillance applies to situations where the $F_Q^C(Z)$ has already been measured at least once at a reduced THERMAL POWER level. The observed margin in the previous surveillance will provide assurance that increasing power up to the next plateau will not exceed the F_Q limit, and that the core is behaving as designed.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.2

The nuclear design process includes calculations performed to determine that the core can be operated within the $F_Q(Z)$ limits. Because flux maps are taken in steady state conditions, the variations in power distribution resulting from normal operational maneuvers are not present in the flux map data. These variations are, however, conservatively calculated by considering a wide range of unit maneuvers in normal operation. ~~The maximum peaking factor increase over steady state values, calculated as a function of core elevation, Z, is called W(Z). Multiplying the measured total peaking factor, $F_Q^C(Z)$, by W(Z) gives the maximum $F_Q(Z)$ calculated to occur in normal operation, $F_Q^W(Z)$.~~

INSERT 3
(Next Page)

The limit with which $F_Q^W(Z)$ is compared varies inversely with power above 50% RTP and directly with the function K(Z) provided in the COLR.

[T(z)]^{COLR} functions are specified

The ~~W(Z) curve is provided~~ in the COLR for discrete core elevations. Flux map data are typically taken for 30 to 75 core elevations. $F_Q^W(Z)$ evaluations are not applicable for ~~the following~~ axial core regions, measured in percent of core height:

a. Lower core region, from 0 to 15% inclusive, ~~and~~

b. Upper core region, from 85 to 100% inclusive,

c. Grid plane regions, ± 2% inclusive, and
d. Core plane regions, within ± 2% of the bank demand position of the control banks.

These regions

~~The top and bottom 15%~~ of the core are excluded from the evaluation because of the low probability that they ~~these regions~~ would be more limiting in the safety analyses and because of the difficulty of making a precise measurement in these regions.

The excluded regions at the top and bottom of the core are specified in the COLR and are defined to ensure that the minimum margin location is adequately surveilled. A slightly smaller exclusion zone may be specified, if necessary, to include the limiting margin location in the surveilled region of the core.

~~This Surveillance has been modified by a Note that may require that more frequent surveillances be performed. If $F_Q^W(Z)$ is evaluated, an evaluation of the expression below is required to account for any increase to $F_Q^M(Z)$ that may occur and cause the $F_Q(Z)$ limit to be exceeded before the next required $F_Q(Z)$ evaluation.~~

~~If the two most recent $F_Q(Z)$ evaluations show an increase in the expression maximum over z [$F_Q^C(Z)$ / K(Z)], it is required to meet the $F_Q(Z)$ limit with the last $F_Q^W(Z)$ increased by the greater of a factor of [1.02] or by an appropriate factor specified in the COLR (Ref. 5)~~

INSERT 3

The measured $F_Q(z)$ can be determined through a synthesis of the measured planar radial peaking factors, $F_{XY}^M(z)$, and the measured core average axial power shape, $P^M(z)$. Thus, $F_Q^C(z)$ is given by the following expression:

$$F_Q^C(z) = F_{XY}^M(z)\ P^M(z)\ [1.0815] = F_Q^M(z)\ [1.0815]$$

For RAOC operation, the analytical $[T(z)]^{COLR}$ functions, specified in the COLR for each RAOC operating space, are used together with the measured $F_{XY}(z)$ values to estimate $F_Q(z)$ for non-equilibrium operation within the RAOC operating space. When the $F_{XY}(z)$ values are measured at HFP ARO conditions ($A_{XY}(z)$ equals 1.0), $F_Q^W(z)$ is given by the following expression:

$$F_Q^W(z) = F_{XY}^M(z)\ [T(z)]^{COLR}\ Rj\ [1.0815]$$

Non-equilibrium operation can result in significant changes to the axial power shape. To a lesser extent, non-equilibrium operation can increase the radial peaking factors, $F_{XY}(z)$, through control rod insertion and through reduced Doppler and moderator feedback at part-power conditions.

The $[T(z)]^{COLR}$ functions quantify these effects for the range of power shapes, control rod insertion, and power levels characteristic of the operating space. Multiplying $[T(z)]^{COLR}$ by the measured full power, unrodded $F_{XY}^M(z)$ value, and the factor that accounts for manufacturing and measurement uncertainties gives $F_Q^W(z)$, the maximum total peaking factor postulated for non-equilibrium RAOC operation.

BASES

SURVEILLANCE REQUIREMENTS (continued)

~~-----REVIEWER'S NOTE-----~~
~~WCAP-10216-P-A, Rev. 1A, "Relaxation of Constant Axial Offset Control and F_Q Surveillance Technical Specification," February 1994, or other appropriate plant specific methodology, is to be listed in the COLR description in the Administrative Controls Section 5.0 to address the methodology used to derive this factor.~~
~~----------~~

~~or to evaluate $F_Q(Z)$ more frequently, each 7 EFPD. These alternative requirements prevent $F_Q(Z)$ from exceeding its limit for any significant period of time without detection.~~

~~Performing the Surveillance in MODE 1 prior to exceeding 75% RTP ensures that the $F_Q(Z)$ limit is met when RTP is achieved, because peaking factors are generally decreased as power level is increased.~~

~~$F_Q(Z)$ is verified at power levels ≥ 10% RTP above the THERMAL POWER of its last verification, [12] hours after achieving equilibrium conditions to ensure that $F_Q(Z)$ is within its limit at higher power levels.~~

INSERT 4
(Next Page)

In the absence of these Frequency conditions (discussed above) it is possible to operate for 31 EFPD without verification of $F_Q^W(z)$.

~~[~~ The Surveillance Frequency of 31 EFPD is adequate to monitor the change of power distribution with core burnup. The Surveillance may be done more frequently if required by the results of $F_Q(Z)$ evaluations.

The Frequency of 31 EFPD is adequate to monitor the change of power distribution because such a change is sufficiently slow, when the plant is operated in accordance with the TS, to preclude adverse peaking factors between 31 day surveillances.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----REVIEWER'S NOTE-----
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
----------]

INSERT 4

SR 3.2.1.2 requires a Surveillance of $F_Q^W(z)$ during the initial startup following each refueling within [24] hours after achieving equilibrium conditions after exceeding 75% RTP. THERMAL POWER levels below 75% are typically non-limiting with respect to the limit for $F_Q^W(z)$. Also, initial startups following a refueling are slow and well controlled due to startup ramp rate limitations and fuel conditioning requirements. Furthermore, startup physics testing and flux symmetry measurements, also performed at low power, provide confirmation that the core is operating as expected. Consequently, the initial startup following a refueling will not result in non-equilibrium power shapes that could challenge the $F_Q^W(z)$ limit. This Frequency ensures that verification of $F_Q^W(z)$ is performed prior to extended operation at power levels where the maximum permitted peak LHR could be challenged by non-equilibrium operation.

Equilibrium conditions are achieved when the core is sufficiently stable at the intended operating conditions required to perform the Surveillance.

If a previous Surveillance of $F_Q^W(z)$ was performed at part power conditions, SR 3.2.1.2 also requires that $F_Q^W(z)$ be verified at power levels ≥ 10% RTP above the THERMAL POWER of its last verification within [24] hours after achieving equilibrium conditions. This ensures that $F_Q^W(z)$ is within its limit using radial peaking factors measured at the higher power level.

The allowance of up to 24 hours after achieving equilibrium conditions will provide a more accurate measurement of $F_Q^W(Z)$ by allowing sufficient time to achieve equilibrium conditions and obtain the power distribution measurement while still requiring performance of the surveillance before the fuel becomes sufficiently conditioned such that load follow operation can be implemented.

BASES

REFERENCES

1. 10 CFR 50.46, 1974.
2. Regulatory Guide 1.77, Rev. 0, May 1974.
3. 10 CFR 50, Appendix A, GDC 26.
4. WCAP-7308-L-P-A, "Evaluation of Nuclear Hot Channel Factor Uncertainties," June 1988.
5. WCAP-10216-P-A, Rev. 1A, "Relaxation of Constant Axial Offset Control (and) F_Q Surveillance Technical Specification," February 1994.
6. WCAP-17661-P-A, "Improved RAOC and CAOC F_Q Surveillance Technical Specifications," (date to be determined).

Insert new Figure (Next Page)

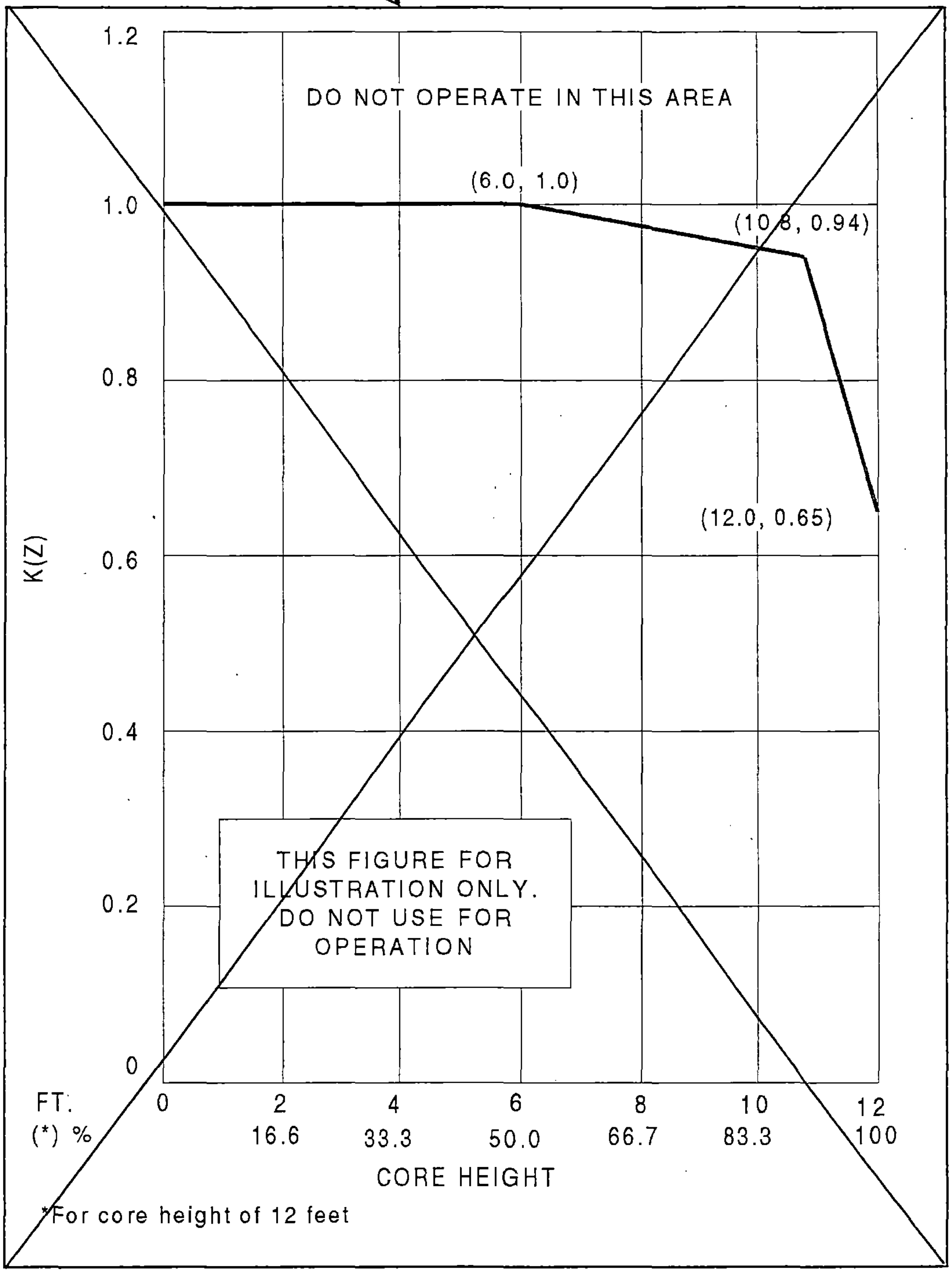
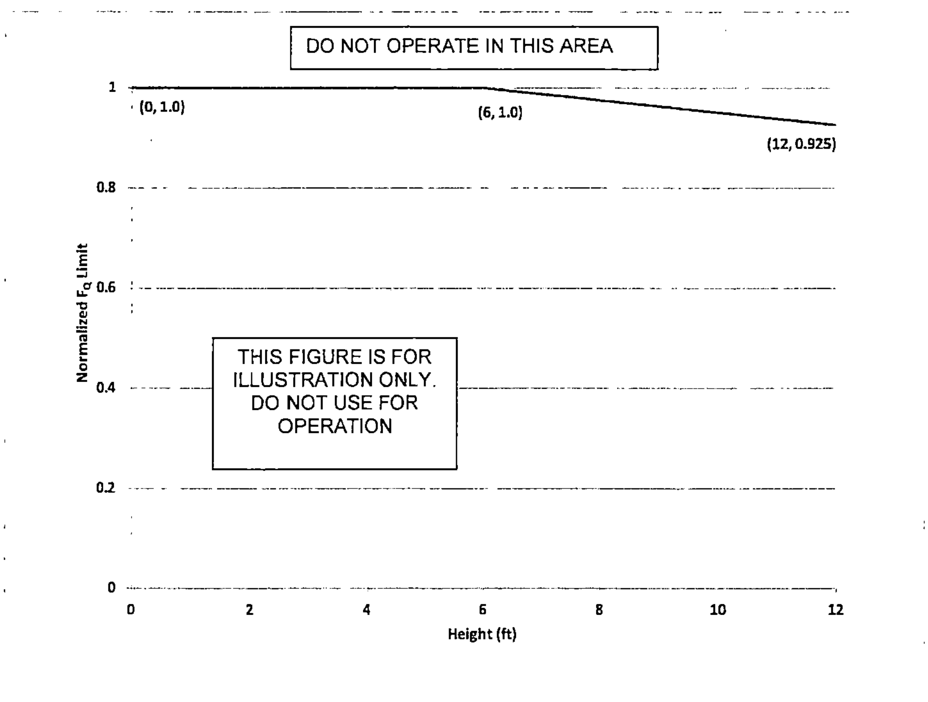


Figure B 3.2.1B-1 (page 1 of 1)
K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height


DO NOT OPERATE IN THIS AREA
1
(0, 1.0)
(6, 1.0)
(12, 0.925)
0.8
0.6
0.4
0.2
0
Normalized F_Q Limit
THIS FIGURE IS FOR ILLUSTRATION ONLY. DO NOT USE FOR OPERATION
0
2
4
6
8
10
12
Height (ft)

Attachment 5

Technical Specification 3.2.1C
Heat Flux Hot Channel Factor Markups
(Non-Proprietary)

3.2 POWER DISTRIBUTION LIMITS

3.2.1C Heat Flux Hot Channel Factor ($F_Q(Z)$ (CAOC-W(Z) Methodology)

LCO 3.2.1C $F_Q(Z)$, as approximated by $F_Q^C(Z)$ and $F_Q^W(Z)$, shall be within the limits specified in the COLR.

APPLICABILITY: MODE 1.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. ------------NOTE------------ Required Action A.4 shall be completed whenever this Condition is entered prior to increasing THERMAL POWER above the limit of Required Action A.1. SR 3.2.1.2 is not required to be performed if this Condition is entered prior to THERMAL POWER exceeding 75% RTP after a refueling. ------------------------------- $F_Q^C(Z)$ not within limit.	A.1 Reduce THERMAL POWER ≥ 1% RTP for each 1% $F_Q^C(Z)$ exceeds limit.	15 minutes after each $F_Q^C(Z)$ determination
	<u>AND</u>	
	A.2 Reduce Power Range Neutron Flux - High trip setpoints ≥ 1% for each 1% ~~$F_Q^C(Z)$ exceeds limit.~~ that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1.	72 hours after each $F_Q^C(Z)$ determination
	<u>AND</u>	
	A.3 Reduce Overpower ΔT trip setpoints ≥ 1% for each 1% ~~$F_Q^C(Z)$ exceeds limit.~~	72 hours after each $F_Q^C(Z)$ determination
	<u>AND</u>	
	A.4 Perform SR 3.2.1.1 and SR 3.2.1.2.	Prior to increasing THERMAL POWER above the limit of Required Action A.1

OR
B.2.1 ——NOTE——
Required Action B.2.4 shall be completed whenever Required Action B.2.1 is performed prior to increasing THERMAL POWER above the limit of Required Action B.2.1.

Limit THERMAL POWER to less than RATED THERMAL POWER as specified in the COLR.

Implement a CAOC operating space specified in the COLR that restores $F_Q^W(z)$ to within its limits.
AND
B.1.2 Perform SR 3.2.1.1 and SR 3.2.1.2 if control rod motion is required to comply with the new operating space.

~~ACTIONS (continued)~~

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. ~~------NOTE------ Required Action B.4 shall be completed whenever this Condition is entered.~~ $F_Q^W(Z)$ not within limits.	.1 B.~~1~~ ~~Reduce THERMAL POWER ≥ 1% RTP for each 1% $F_Q^W(Z)$ exceeds limit.~~	4 hours 72 hours 4 hours
	AND	
	B.2 .2 Reduce Power Range Neutron Flux - High trip setpoints ≥ 1% for each 1% ~~$F_Q^W(Z)$ exceeds limit.~~ that THERMAL POWER is limited below RATED THERMAL POWER by Required Action B.2.1.	72 hours
	AND	
	B.~~3~~ 2.3 Reduce Overpower ΔT trip setpoints ≥ 1% for each 1% ~~$F_Q^W(Z)$ exceeds limit.~~	72 hours
	AND	
	B.~~4~~ 2.4 Perform SR 3.2.1.1 and SR 3.2.1.2.	Prior to increasing THERMAL POWER above the limit of Required Action B.~~1~~ 2.1
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 2.	6 hours

SURVEILLANCE REQUIREMENTS

-----------------------------------NOTE-----------------------------------
During power escalation at the beginning of each cycle, THERMAL POWER may be increased until an equilibrium power level has been achieved, at which a power distribution map is obtained.

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify $F_Q^C(Z)$ is within limit.	Once after each refueling prior to THERMAL POWER exceeding 75% RTP AND Once within [~~12~~] 24 hours after achieving equilibrium conditions after exceeding, by ≥ 10% RTP, the THERMAL POWER at which $F_Q^C(Z)$ was last verified AND [31 EFPD thereafter OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.2.1.2	~~NOTE~~ ~~If measurements indicate that the maximum over z [$F_Q^C(Z)$ / K(Z)] has increased since the previous evaluation of $F_Q^C(Z)$:~~ ~~a. Increase $F_Q^W(Z)$ by the greater of a factor of [1.02] or by an appropriate factor specified in the COLR and reverify $F_Q^W(Z)$ is within limits or~~ ~~b. Repeat SR 3.2.1.2 once per 7 EFPD until either a. above is met or two successive flux maps indicate that the maximum over z [$F_Q^C(Z)$ / K(Z)] has not increased.~~ Verify $F_Q^W(Z)$ is within limit.	Once after each refueling within [24] hours after achieving equilibrium conditions after THERMAL POWER exceeds 75% RTP ~~Once after each refueling prior to THERMAL POWER exceeding 75% RTP~~ AND Once within [~~12~~ 24] hours after achieving equilibrium conditions after exceeding, by ≥ 10% RTP, the THERMAL POWER at which $F_Q^W(Z)$ was last verified AND

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE	FREQUENCY
	[31 EFPD thereafter <u>OR</u> In accordance with the Surveillance Frequency Control Program]

Attachment 6

Technical Specification Bases 3.2.1C
Heat Flux Hot Channel Factor Markups
(Non-Proprietary)

B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.1C Heat Flux Hot Channel Factor ($F_Q(Z)$ (CAOC-W(Z) Methodology)

BASES

BACKGROUND

The purpose of the limits on the values of $F_Q(Z)$ is to limit the local (i.e., pellet) peak power density. The value of $F_Q(Z)$ varies along the axial height (Z) of the core.

$F_Q(Z)$ is defined as the maximum local fuel rod linear power density divided by the average fuel rod linear power density, assuming nominal fuel pellet and fuel rod dimensions. Therefore, $F_Q(Z)$ is a measure of the peak fuel pellet power within the reactor core.

During power operation, the global power distribution is limited by LCO 3.2.3, "AXIAL FLUX DIFFERENCE (AFD)," and LCO 3.2.4, "QUADRANT POWER TILT RATIO (QPTR)," which are directly and continuously measured process variables. These LCOs, along with LCO 3.1.6, "Control Bank Insertion Limits," maintain the core limits on power distributions on a continuous basis.

$F_Q(Z)$ varies with fuel loading patterns, control bank insertion, fuel burnup, and changes in axial power distribution.

$F_Q(Z)$ is measured periodically using the incore detector system. These measurements are generally taken with the core at or near equilibrium conditions.

Using the measured three dimensional power distributions, it is possible to derive a measured value for $F_Q(Z)$. However, because this value represents a equilibrium condition, it does not include the variations in the value of $F_Q(Z)$ which are present during nonequilibrium situations such as load following or power ascension.

To account for these possible variations, the equilibrium value of $F_Q(Z)$ is adjusted as $F_Q^W(Z)$ by an elevation dependent factor that accounts for the calculated worst case transient conditions.

Core monitoring and control under non-equilibrium conditions are accomplished by operating the core within the limits of the appropriate LCOs, including the limits on AFD, QPTR, and control rod insertion.

In the unlikely event that measurements indicate that the limit for $F_Q^W(z)$ could be exceeded during future non-equilibrium operation, a more restrictive CAOC operating space specified in the Core Operating Limits Report (COLR) may be implemented to restore margin to the $F_Q^W(z)$ limit. A CAOC operating space is a unique combination of an allowable AFD band and Control Bank Insertion Limits. A more restrictive CAOC operating space would employ a narrower AFD band, shallower Control Bank Insertion Limits, or a combination of the two. W(z) functions for each CAOC operating space are specified in the COLR. If none of the CAOC operating spaces provides adequate margin to the $F_Q^W(z)$ limit, then THERMAL POWER must be limited to less than RATED THERMAL POWER.

BASES

APPLICABLE SAFETY ANALYSES

This LCO precludes core power distributions that violate the following fuel design criteria:

a. During a large break loss of coolant accident (LOCA), the peak cladding temperature must not exceed 2200°F (Ref. 1),

b. During a loss of forced reactor coolant flow accident, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a departure from nucleate boiling (DNB) condition,

c. During an ejected rod accident, the energy deposition to the fuel must not exceed 280 cal/gm (Ref. 2), and

d. The control rods must be capable of shutting down the reactor with a minimum required SDM with the highest worth control rod stuck fully withdrawn (Ref. 3).

Limits on $F_Q(Z)$ ensure that the value of the initial total peaking factor assumed in the accident analyses remains valid. Other criteria must also be met (e.g., maximum cladding oxidation, maximum hydrogen generation, coolable geometry, and long term cooling). However, the peak cladding temperature is typically most limiting.

$F_Q(Z)$ limits assumed in the LOCA analysis are typically limiting relative to (i.e., lower than) the $F_Q(Z)$ limit assumed in safety analyses for other postulated accidents. Therefore, this LCO provides conservative limits for other postulated accidents.

$F_Q(Z)$ satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

The Heat Flux Hot Channel Factor, $F_Q(Z)$, shall be limited by the following relationships:

$F_Q(Z) \leq (CFQ/P) K(Z)$ for $P > 0.5$

$F_Q(Z) \leq (CFQ/0.5) K(Z)$ for $P \leq 0.5$

where: CFQ is the $F_Q(Z)$ limit at RTP provided in the COLR,

K(Z) is the normalized $F_Q(Z)$ limit as a function of core height provided in the COLR, and

P = THERMAL POWER/RTP

BASES

LCO (continued)

50

For this facility, the actual values of CFQ and K(Z) are given in the COLR; however, CFQ is normally a number on the order of [2.~~32~~], and K(Z) is a function that looks like the one provided in Figure B 3.2.1C-1.

For Constant Axial Offset Control operation, $F_Q(Z)$ is approximated by $F_Q^C(Z)$ and $F_Q^W(Z)$. Thus, both $F_Q^C(Z)$ and $F_Q^W(Z)$ must meet the preceding limits on $F_Q(Z)$.

An $F_Q^C(Z)$ evaluation requires obtaining an incore flux map in MODE 1. From the incore flux map results we obtain the measured value ($F_Q^M(Z)$) of $F_Q(Z)$. Then,

$$F_Q^C(Z) = F_Q^M(Z)\ [1.0815]$$

where [1.0815] is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

$F_Q^C(Z)$ is an excellent approximation for $F_Q(Z)$ when the reactor is at the steady state power at which the incore flux map was taken.

INSERT 1
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The expression for $F_Q^W(Z)$ is:

$$\frac{[W(z)]^{COLR}\ A_Q(z)\ Rj}{P}$$

$$F_Q^W(Z) = F_Q^C(Z)\ \cancel{W(Z)}$$

~~where W(Z) is a cycle dependent function that accounts for power distribution transients encountered during normal operation. W(Z) is included in the COLR. The $F_Q^C(Z)$ is calculated at equilibrium conditions.~~

The $F_Q(Z)$ limits define limiting values for core power peaking that precludes peak cladding temperatures above 2200°F during either a large or small break LOCA.

Violating the $F_Q(z)$ LCO limits could result in unacceptable consequences if a design basis event were to occur while $F_Q(z)$ exceeds its specified limits.

This LCO requires operation within the bounds assumed in the safety analyses. Calculations are performed in the core design process to confirm that the core can be controlled in such a manner during operation that it can stay within the LOCA $F_Q(Z)$ limits. ~~If $F_Q^C(Z)$ cannot be maintained within the LCO limits, reduction of the core power is required.~~

~~Violating the LCO limits for $F_Q(Z)$ produces unacceptable consequences if a design basis event occurs while $F_Q(Z)$ is outside its specified limits.~~

INSERT 1

$[W(z)]^{COLR}$ is the cycle and burnup dependent function, specified in the COLR, which accounts for power distribution transients encountered during non-equilibrium normal operation. $[W(z)]^{COLR}$ functions are specified for each analyzed CAOC operating space (i.e., each unique combination of AFD band and Control Bank Insertion Limits). The $[W(z)]^{COLR}$ functions account for the limiting non-equilibrium axial power shapes postulated to occur during normal operation for each CAOC operating space. Limiting power shapes at both full and reduced power operation are considered in determining the maximum values of $[W(z)]^{COLR}$. The $[W(z)]^{COLR}$ functions also account for the following effects: (1) the increase in radial peaking in rodded core planes due to the presence of control rods during non-equilibrium normal operation, (2) the increase in radial peaking that occurs during part-power operation due to reduced fuel and moderator temperatures, and (3) the increase in radial peaking due to non-equilibrium xenon effects. The $[W(z)]^{COLR}$ functions are normally calculated assuming that the Surveillance is performed at the Target Axial Offset core conditions. Surveillance specific $[W(z)]^{COLR}$ values may be generated for a given surveillance core condition.

P is the THERMAL POWER / RTP.

$A_Q(z)$ is a cycle, burnup, and power dependent function specified in the COLR or determined at the time of the surveillance using an approved 3D core model and the methodology of Reference 6. It adjusts the measured $F_Q^M(z)$ to the Target Axial Offset core conditions. For simplicity, $A_Q(z)$ may be assumed to be 1.0 when the surveillance is performed at the target AO. If, however, margin is needed for a Surveillance performed at conditions different from the Target AO core conditions, then the appropriate values for $A_Q(z)$ may be used.

Rj is a cycle and burnup dependent analytical factor specified in the COLR that accounts for potential increases in $F_Q^W(z)$ between Surveillances. Rj values are provided for each CAOC operating space.

-----------------------------------REVIEWER'S NOTE-----------------------------------

WCAP-17661-P-A, "Improved RAOC and CAOC F_Q Surveillance Technical Specifications," or other appropriate plant specific methodology, is to be listed in the COLR description in the Administrative Controls Section 5.0 to address the methodology used to derive this factor.

BASES

APPLICABILITY

The $F_Q(Z)$ limits must be maintained in MODE 1 to prevent core power distributions from exceeding the limits assumed in the safety analyses. Applicability in other MODES is not required because there is either insufficient stored energy in the fuel or insufficient energy being transferred to the reactor coolant to require a limit on the distribution of core power.

ACTIONS

A.1

If an F_Q surveillance is performed at 100% RTP conditions, and both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, the option to reduce the THERMAL POWER limit in accordance with proposed Required Action B.2.1 instead of implementing a new operating space in accordance with proposed Required Action B.1, will result in a further power reduction after Required Action A.1 has been completed. However, this further power reduction would be permitted to occur over the next 4 hours. In the event the evaluated THERMAL POWER reduction in the COLR for proposed Required Action B.2.1 did not result in a further power reduction (for example, if both Condition A and Condition B were entered at less than 100% RTP conditions), then the THERMAL POWER level established as a result of completing Required Action A.1 will take precedence, and will establish the effective operating power level limit for the unit until both Conditions A and B are exited.

Reducing THERMAL POWER by ≥ 1% RTP for each 1% by which $F_Q^C(Z)$ exceeds its limit, maintains an acceptable absolute power density. $F_Q^C(Z)$ is $F_Q^M(Z)$ multiplied by a factor accounting for manufacturing tolerances and measurement uncertainties. $F_Q^M(Z)$ is the measured value of $F_Q(Z)$. The Completion Time of 15 minutes provides an acceptable time to reduce power in an orderly manner and without allowing the plant to remain in an unacceptable condition for an extended period of time. The maximum allowable power level initially determined by Required Action A.1 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require power reductions within 15 minutes of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable power level. Decreases in $F_Q^C(Z)$ would allow increasing the maximum allowable power level and increasing power up to this revised limit.

A.2

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1

A reduction of the Power Range Neutron Flux - High trip setpoints by ≥ 1% for each 1% ~~by which $F_Q^C(Z)$ exceeds its limit,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period and the preceding prompt reduction in THERMAL POWER in accordance with Required Action A.1. The maximum allowable Power Range Neutron Flux – High trip setpoints initially determined by Required Action A.2 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require Power Range Neutron Flux – High trip setpoint reductions within 72 hours of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable Power Range Neutron Flux – High trip setpoints. Decreases in $F_Q^C(Z)$ would allow increasing the maximum allowable Power Range Neutron Flux – High trip setpoints.

BASES

ACTIONS (continued)

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action A.1

A.3

Reduction in the Overpower ΔT trip setpoints (value of K_4) by ≥ 1% for each 1% ~~by which~~ ~~$F_Q^C(Z)$~~ ~~exceeds its limit~~, is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period, and the preceding prompt reduction in THERMAL POWER in accordance with Required Action A.1. The maximum allowable Overpower ΔT trip setpoints initially determined by Required Action A.3 may be affected by subsequent determinations of $F_Q^C(Z)$ and would require Overpower ΔT trip setpoint reductions within 72 hours of the $F_Q^C(Z)$ determination, if necessary to comply with the decreased maximum allowable Overpower ΔT trip setpoints. Decreases in $F_Q^C(Z)$ would allow increasing the maximum Overpower ΔT trip setpoints.

A.4

Verification that $F_Q^C(Z)$ has been restored to within its limit, by performing SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the limit imposed by Required Action A.1~~,~~ ensures that core conditions ~~during operation~~ at higher power levels and future operation are consistent with safety ~~analyses assumptions~~.

prior to increasing THERMAL POWER above the limit of Required Action A.1. The Note also states that SR 3.2.1.2 is not required to be performed if this Condition is entered prior to THERMAL POWER exceeding 75% RTP after a refueling.

Condition A is modified by a Note that requires ~~Required~~ Action A.4 to be performed whenever the Condition is entered~~.~~ This ensures that SR 3.2.1.1 and SR 3.2.1.2 will be performed prior to increasing THERMAL POWER above the limit of Required Action A.1, even when Condition A is exited prior to performing Required Action A.4. Performance of SR 3.2.1.1 and SR 3.2.1.2 are necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.

(if required)

B.1 .1

If it is found that the maximum calculated value of $F_Q(Z)$ that can occur during normal maneuvers, $F_Q^W(Z)$, exceeds its specified limits, there exists a potential for $F_Q^C(Z)$ to become excessively high if a normal operational

INSERT 2 (Next Page)

BASES

ACTIONS (continued)

transient occurs. ~~Reducing the THERMAL POWER by ≥ 1% RTP for each 1% by which $F_Q^W(Z)$ exceeds its limit within the allowed Completion Time of 4 hours, maintains an acceptable absolute power density such that even if a transient occurred, core peaking factors are not exceeded.~~

INSERT 3 (Next Page)

B.2 .2

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action B.2.1

A reduction of the Power Range Neutron Flux-High trip setpoints by ≥ 1% for each 1% ~~by which $F_Q^W(Z)$ exceeds its limit,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period and the preceding prompt reduction in the THERMAL POWER limit in accordance with Required Action B.~~1~~ 2.1.

B.~~3~~ 2.3

that THERMAL POWER is limited below RATED THERMAL POWER by Required Action B.2.1

Reduction in the Overpower ΔT trip setpoints value of K_4 by ≥ 1% for each 1% ~~by which $F_Q^W(Z)$ exceeds its limit,~~ is a conservative action for protection against the consequences of severe transients with unanalyzed power distributions. The Completion Time of 72 hours is sufficient considering the small likelihood of a severe transient in this time period, and the preceding prompt reduction in the THERMAL POWER limit in accordance with Required Action B.~~1~~ 2.1.

B.~~4~~ 2.4

Verification that $F_Q^W(Z)$ has been restored to within its limit, by performing SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the limit imposed by Required Action B.~~1~~ 2.1 ensures that core conditions during operation at higher power levels and future operation are consistent with safety analyses assumptions.

~~Condition B is modified by a Note that requires Required Action B.4 to be performed whenever the Condition is entered. This ensures that SR 3.2.1.1 and SR 3.2.1.2 will be performed prior to increasing THERMAL POWER above the limit of Required Action B.1, even when Condition A is exited prior to performing Required Action B.4. Performance of SR 3.2.1.1 and SR 3.2.1.2 are necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.~~

INSERT 2

Implementing a more restrictive CAOC operating space, specified in the COLR, within the allowed Completion Time of 4 hours will restrict the AFD such that core peaking factor limits will not be exceeded during non-equilibrium normal operation. Several CAOC operating spaces, representing successively smaller AFD bands and, optionally, shallower Control Bank Insertion Limits, may be specified in the COLR. The corresponding $[W(z)]^{COLR}$ functions for these operating spaces can be used to determine which CAOC operating space would result in acceptable non-equilibrium operation within the $F_Q^W(z)$ limit.

INSERT 3

B.1.2

If it is found that the maximum calculated value of $F_Q(Z)$ that can occur during normal maneuvers, $F_Q^W(Z)$, exceeds its specified limits, there exists a potential for $F_Q^C(Z)$ to become excessively high if a normal operational transient occurs. As discussed above, Required Action B.1.1 requires that a new CAOC operating space be implemented to restore $F_Q^W(Z)$ to within its limits. Required Action B.1.2 requires that SR 3.2.1.1 and SR 3.2.1.2 be performed if control rod motion occurs as a result of implementing the new CAOC operating space in accordance with Required Action B.1.1. The performance of SR 3.2.1.1 and SR 3.2.1.2 is necessary to assure $F_Q(Z)$ is properly evaluated after any rod motion resulting from the implementation of a new CAOC operating space in accordance with Required Action B.1.1.

B.2.1

When $F_Q^W(z)$ exceeds its limit, Required Action B.2.1 may be implemented instead of Required Action B.1. Required Action B.2.1 limits THERMAL POWER to less than RATED THERMAL POWER by the amount specified in the COLR. If the more restrictive CAOC operating spaces specified in the COLR are insufficient to ensure margin to the $F_Q^W(z)$ limit, the THERMAL POWER must be limited to less than or equal to 50% RTP. This maintains an acceptable absolute power density relative to the maximum power density value assumed in the safety analyses.

If the required $F_Q^W(z)$ margin improvement exceeds the margin improvement available from the pre-analyzed THERMAL POWER and AFD reductions provided in the COLR, then THERMAL POWER must be further reduced to less than or equal to 50% RTP. In this case, reducing THERMAL POWER to less than or equal to 50% RTP will provide additional margin in the transient F_Q by the required change in THERMAL POWER and the increase in the F_Q limit. This will ensure that the F_Q limit is met during transient operation that may occur at or below 50% RTP.

INSERT 3 (continued)

The Completion Time of 4 hours provides an acceptable time to reduce power in an orderly manner to preclude entering an unacceptable condition during future non-equilibrium operation. The limit on THERMAL POWER initially determined by Required Action B.2.1 may be affected by subsequent determinations of $F_Q^W(z)$ and would require power reductions within 4 hours of the $F_Q^W(z)$ determination, if necessary to comply with the decreased THERMAL POWER limit. Decreases in $F_Q^W(z)$ would allow increasing the THERMAL POWER limit and increasing THERMAL POWER up to this revised limit.

Required Action B.2.1 is modified by a Note that states Required Action B.2.4 shall be completed whenever Required Action B.2.1 is performed prior to increasing THERMAL POWER above the limit of Required Action B.2.1. Required Action B.2.4 requires the performance of SR 3.2.1.1 and SR 3.2.1.2 prior to increasing THERMAL POWER above the limit established by Required Action B.2.1. The Note ensures that the SRs will be performed even if Condition B may be exited prior to performing Required Action B.2.4. The performance of SR 3.2.1.1 and SR 3.2.1.2 is necessary to assure $F_Q(Z)$ is properly evaluated prior to increasing THERMAL POWER.

If an F_Q surveillance is performed at 100% RTP conditions, and both $F_Q^C(Z)$ and $F_Q^W(Z)$ exceed their limits, the option to reduce the THERMAL POWER limit in accordance with proposed Required Action B.2.1 instead of implementing a new operating space in accordance with proposed Required Action B.1, will result in a further power reduction after Required Action A.1 has been completed. However, this further power reduction would be permitted to occur over the next 4 hours. In the event the evaluated THERMAL POWER reduction in the COLR for proposed Required Action B.2.1 did not result in a further power reduction (for example, if both Condition A and Condition B were entered at less than 100% RTP conditions), then the THERMAL POWER level established as a result of completing Required Action A.1 will take precedence, and will establish the effective operating power level limit for the unit until both Conditions A and B are exited.

BASES

ACTIONS (continued)

2.4

C.1

If Required Actions A.1 through A.4 or B.1 through B.4 are not met within their associated Completion Times, the plant must be placed in a mode or condition in which the LCO requirements are not applicable. This is done by placing the plant in at least MODE 2 within 6 hours.

This allowed Completion Time is reasonable based on operating experience regarding the amount of time it takes to reach MODE 2 from full power operation in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.2.1.1 and SR 3.2.1.2 are modified by a Note. The Note applies during the first power ascension after a refueling. It states that THERMAL POWER may be increased until an equilibrium power level has been achieved at which a power distribution map can be obtained. This allowance is modified, however, by one of the Frequency conditions that requires verification that $F_Q^C(Z)$ and $F_Q^W(Z)$ are within their specified limits after a power rise of more than 10% RTP over the THERMAL POWER at which they were last verified to be within specified limits. Because $F_Q^C(Z)$ and $F_Q^W(Z)$ could not have previously been measured in this reload core, there is a second Frequency condition, applicable only for reload cores, that requires determination of these parameters before exceeding 75% RTP. This ensures that some determination of $F_Q^C(Z)$ and $F_Q^W(Z)$ are made at a lower power level at which adequate margin is available before going to 100% RTP. Also, this Frequency condition, together with the Frequency condition requiring verification of $F_Q^C(Z)$ and $F_Q^W(Z)$ following a power increase of more than 10%, ensures that they are verified as soon as RTP (or any other level for extended operation) is achieved. In the absence of these Frequency conditions, it is possible to increase power to RTP and operate for 31 days without verification of $F_Q^C(Z)$ and $F_Q^W(Z)$. The Frequency condition is not intended to require verification of these parameters after every 10% increase in power level above the last verification. It only requires verification after a power level is achieved for extended operation that is 10% higher than that power at which $F_Q(Z)$ was last measured.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.1

some determination of $F_Q^C(z)$ is made prior to achieving a significant power level where the peak linear heat rate could approach the limits assumed in the safety analyses.

This Frequency condition is not intended to require verification of these parameters after every 10% increase in RTP above the THERMAL POWER at which the last verification was performed. It only requires verification after a power level is achieved for extended operation that is 10% higher than the THERMAL POWER at which $F_Q^C(z)$ was last measured.

Verification that $F_Q^C(Z)$ is within its specified limits involves increasing $F_Q^M(Z)$ to allow for manufacturing tolerance and measurement uncertainties in order to obtain $F_Q^C(Z)$. Specifically, $F_Q^M(Z)$ is the measured value of $F_Q(Z)$ obtained from incore flux map results and $F_Q^C(Z) = F_Q^M(Z)$ [1.0815] (Ref. 4). $F_Q^C(Z)$ is then compared to its specified limits.

The limit with which $F_Q^C(Z)$ is compared varies inversely with power above 50% RTP and directly with a function called K(Z) provided in the COLR.

Performing this Surveillance in MODE 1 prior to exceeding 75% RTP following a refueling ensures that ~~the $F_Q^C(Z)$ limit is met when RTP is achieved, because peaking factors generally decrease as power level is increased.~~

24

If THERMAL POWER has been increased by ≥ 10% RTP since the ~~last~~ initial or most recent determination of $F_Q^C(Z)$, another evaluation of this factor is required [~~12~~] hours after achieving equilibrium conditions at this higher power level (to ensure that $F_Q^C(Z)$ values are being reduced sufficiently with power increase to stay within the LCO limits).

In the absence of these Frequency conditions (discussed above) it is possible to operate for 31 EFPD without verification of $F_Q^C(z)$.

[The Frequency of 31 EFPD is adequate to monitor the change of power distribution with core burnup because such changes are slow and well controlled when the plant is operated in accordance with the Technical Specifications (TS).

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
--]

Equilibrium conditions are achieved when the core is sufficiently stable at the intended operating conditions required to perform the Surveillance.

The allowance of up to 24 hours after achieving equilibrium conditions at the increased THERMAL POWER level to complete the next $F_Q^C(Z)$ surveillance applies to situations where the $F_Q^C(Z)$ has already been measured at least once at a reduced THERMAL POWER level. The observed margin in the previous surveillance will provide assurance that increasing power up to the next plateau will not exceed the F_Q limit, and that the core is behaving as designed.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.2

The nuclear design process includes calculations performed to determine that the core can be operated within the $F_Q(Z)$ limits. Because flux maps are taken in steady state conditions, the variations in power distribution resulting from normal operational maneuvers are not present in the flux map data. These variations are, however, conservatively calculated by considering a wide range of unit maneuvers in normal operation. The maximum peaking factor increase over steady state values, calculated as a function of core elevation, Z, is called ~~W(Z)~~. Multiplying the measured total peaking factor, $F_Q^C(Z)$, by ~~W(Z)~~ gives the maximum $F_Q(Z)$ calculated to occur in normal operation, $F_Q^W(Z)$.

[W(z)]^{COLR}

The limit with which $F_Q^W(Z)$ is compared varies inversely with power above 50% RTP and directly with the function K(Z) provided in the COLR.

[W(z)]^{COLR} factors are

The ~~W(Z) curve is~~ provided in the COLR for discrete core elevations. Flux map data are typically taken for 30 to 75 core elevations. $F_Q^W(Z)$ evaluations are not applicable for ~~the following axial core regions, measured in percent of core height:~~

axial core regions near the top and bottom of the core. The excluded regions, usually the top and bottom [15]%, are specified in the COLR and are defined to ensure that the minimum margin location is adequately surveilled. A slightly smaller exclusion zone may be specified, if necessary, to include the limiting margin location in the surveilled region of the core.

~~a. Lower core region, from 0 to 15% inclusive and~~

~~b. Upper core region, from 85 to 100% inclusive.~~

These regions

they

~~The top and bottom 15%~~ of the core are excluded from the evaluation because of the low probability that ~~these regions~~ would be more limiting in the safety analyses and because of the difficulty of making a precise measurement in these regions.

~~This Surveillance has been modified by a Note that may require that more frequent surveillances be performed. If $F_Q^W(Z)$ is evaluated, an evaluation of the expression below is required to account for any increase to $F_Q^M(Z)$ that may occur and cause the $F_Q(Z)$ limit to be exceeded before the next required $F_Q(Z)$ evaluation.~~

~~If the two most recent $F_Q(Z)$ evaluations show an increase in the expression~~

~~maximum over z $[F_Q^C(Z) / K(Z)]$,~~

~~it is required to meet the $F_Q(Z)$ limit with the last $F_Q^W(Z)$ increased by the greater of a factor of [1.02] or by an appropriate factor specified in the COLR (Ref. 5)~~

BASES

SURVEILLANCE REQUIREMENTS (continued)

~~-----REVIEWER'S NOTE-----~~
~~WCAP-10216-P-A, Rev. 1A, Relaxation of Constant Axial Offset Control and F_Q Surveillance Technical Specification, February 1994, or other appropriate plant specific methodology, is to be listed in the COLR description in the Administrative Controls Section 5.0 to address the methodology used to derive this factor.~~
~~-----~~

INSERT 4
(Next Page)

~~or to evaluate $F_Q(Z)$ more frequently, each 7 EFPD. These alternative requirements prevent $F_Q(Z)$ from exceeding its limit for any significant period of time without detection.~~

~~Performing the Surveillance in MODE 1 prior to exceeding 75% RTP ensures that the $F_Q(Z)$ limit is met when RTP is achieved, because peaking factors are generally decreased as power level is increased.~~

In the absence of these Frequency conditions (discussed above) it is possible to operate for 31 EFPD without verification of $F_Q^W(z)$.

~~$F_Q(Z)$ is verified at power levels ≥ 10% RTP above the THERMAL POWER of its last verification, [12] hours after achieving equilibrium conditions to ensure that $F_Q(Z)$ is within its limit at higher power levels.~~

~~[~~The Surveillance Frequency of 31 EFPD is adequate to monitor the change of power distribution with core burnup. The Surveillance may be done more frequently if required by the results of $F_Q(Z)$ evaluations.

The Frequency of 31 EFPD is adequate to monitor the change of power distribution because such a change is sufficiently slow, when the plant is operated in accordance with the TS, to preclude adverse peaking factors between 31 day surveillances.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----REVIEWER'S NOTE-----
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
-----]

INSERT 4

SR 3.2.1.2 requires a Surveillance of $F_Q^W(z)$ during the initial startup following each refueling within [24] hours after achieving equilibrium conditions after exceeding 75% RTP. THERMAL POWER levels below 75% are typically non-limiting with respect to the limit for $F_Q^W(z)$. Also, initial startups following a refueling are slow and well controlled due to startup ramp rate limitations and fuel conditioning requirements. Furthermore, startup physics testing and flux symmetry measurements, also performed at low power, provide confirmation that the core is operating as expected.. Consequently, the initial startup following a refueling will not result in non-equilibrium power shapes that could challenge the $F_Q^W(z)$ limit. This Frequency ensures that verification of $F_Q^W(z)$ is performed prior to extended operation at power levels where the maximum permitted peak LHR could be challenged by non-equilibrium operation.

Equilibrium conditions are achieved when the core is sufficiently stable at the intended operating conditions required to perform the Surveillance.

If a previous Surveillance of $F_Q^W(z)$ was performed at part power conditions, SR 3.2.1.2 also requires that $F_Q^W(z)$ be verified at power levels ≥ 10% RTP above the THERMAL POWER of its last verification within [24] hours after achieving equilibrium conditions. This ensures that $F_Q^W(z)$ is within its limit using radial peaking factors measured at the higher power level.

The allowance of up to 24 hours after achieving equilibrium conditions will provide a more accurate measurement of $F_Q^W(Z)$ by allowing sufficient time to achieve equilibrium conditions and obtain the power distribution measurement while still requiring performance of the surveillance before the fuel becomes sufficiently conditioned such that load follow operation can be implemented.

BASES

REFERENCES

1. 10 CFR 50.46, 1974.

2. Regulatory Guide 1.77, Rev. 0, May 1974.

3. 10 CFR 50, Appendix A, GDC 26.

4. WCAP-7308-L-P-A, "Evaluation of Nuclear Hot Channel Factor Uncertainties," June 1988.

5. WCAP-10216-P-A, Rev. 1A, "Relaxation of Constant Axial Offset Control (and) F_Q Surveillance Technical Specification," February 1994.

6. WCAP-17661-P-A, "Improved RAOC and CAOC F_Q Surveillance Technical Specifications," (date to be determined).

Insert new Figure
(Next Page)

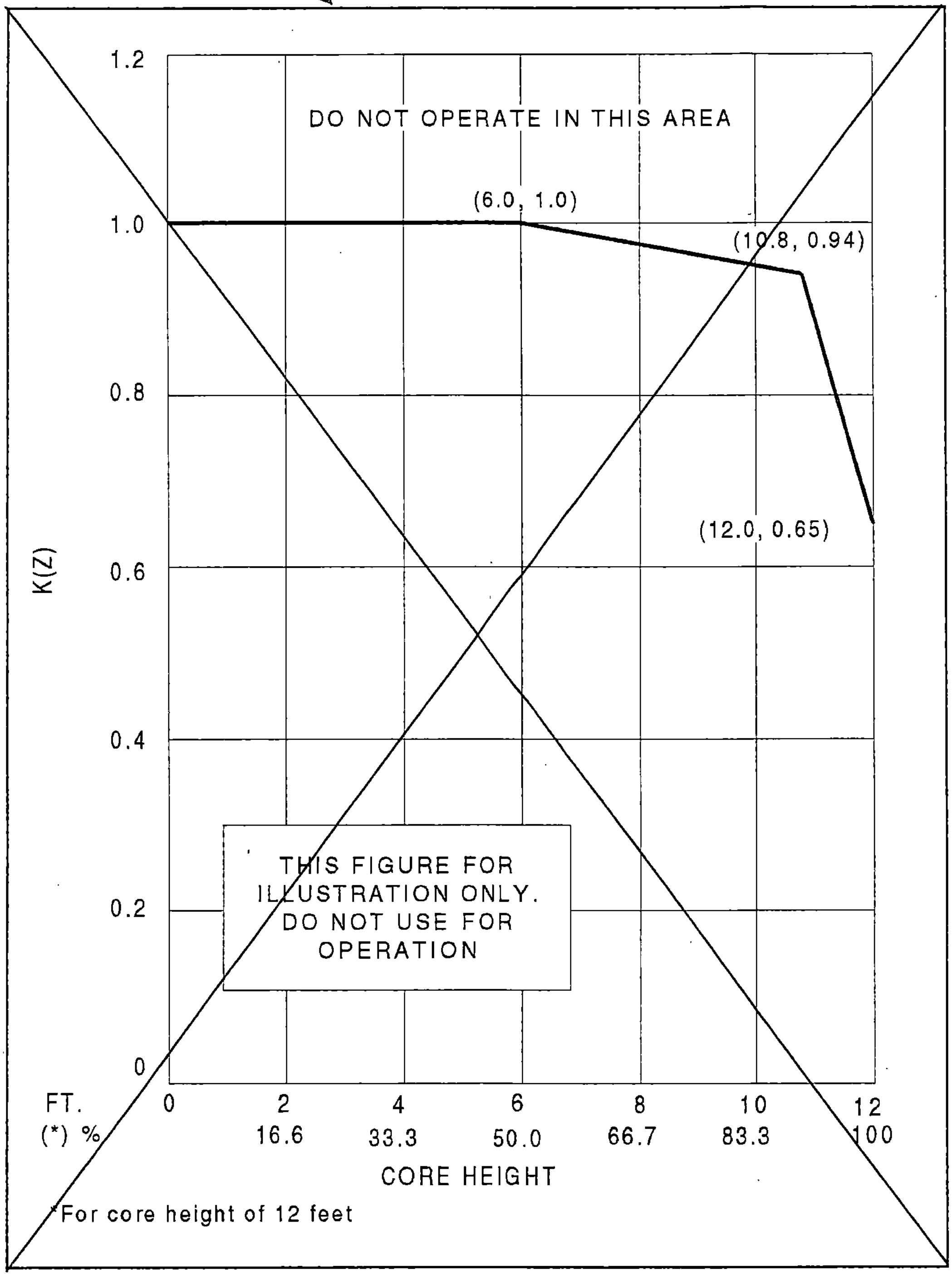
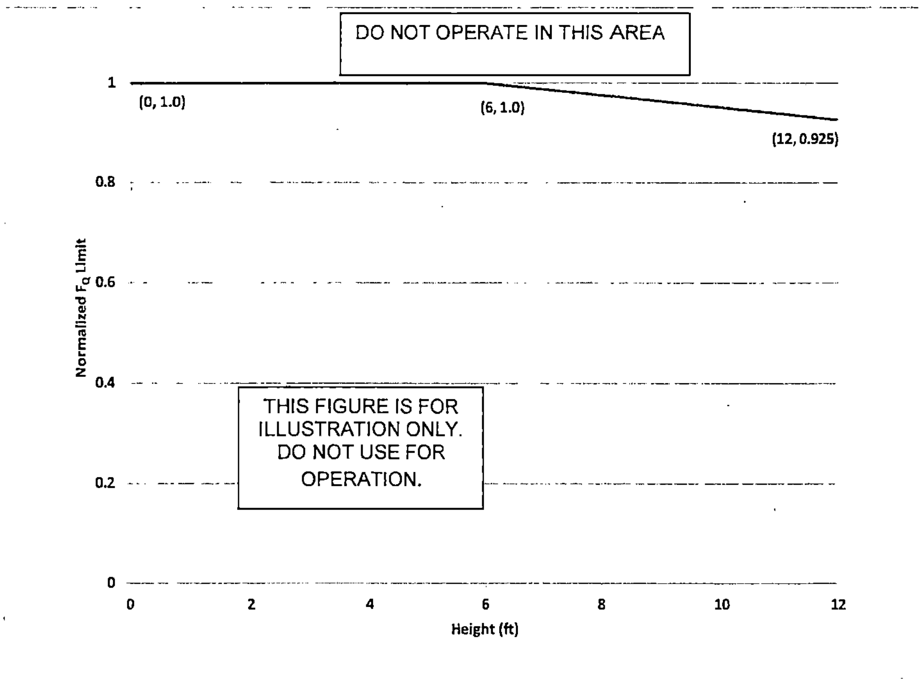


Figure B 3.2.1C-1 (page 1 of 1)
K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height



DO NOT OPERATE IN THIS AREA
1
(0, 1.0)
(6, 1.0)
(12, 0.925)
0.8
0.6
0.4
0.2
0
Normalized F_Q Limit
THIS FIGURE IS FOR ILLUSTRATION ONLY. DO NOT USE FOR OPERATION.
0
2
4
6
8
10
12
Height (ft)