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RELAXATION OF CONSTANT AXIAL OFFSET CONTROL

F_Q SURVEILLANCE TECHNICAL SPECIFICATION

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The F_Q SURVEILLANCE TECHNICAL SPECIFICATION

(Part B of NS-EPR-2649)

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ATTACHMENT

TECHNICAL SPECIFICATION CHANGES

I. INTRODUCTION

Plant operation below the heat flux hot channel factor ($F_Q(z)$) limit assures that peak clad temperature above the 2200°F ECCS acceptance limits is not exceeded during a LOCA event. Currently, periodic plant surveillance on the height dependent radial peaking factor, $F_{xy}(z)$, is required as partial verification that operation will not cause the $F_Q(z)$ limit to be exceeded. In the F_Q Surveillance Technical Specifiction, $F_{xy}(z)$ surveillance has been replaced by $F_Q(z)$ surveillance. Monitoring $F_Q(z)$ and increasing the value for expected plant maneuvers provides a more convenient form of assuring plant operation below the F_Q (z) limit while retaining the intent of using a measured parameter to verify operation below Technical Specification limits.

II. REFORMULATION TO F_Q(Z) SURVEILLANCE

$F_Q(z)$ surveillance is accomplished in the following manner. A full core flux map is taken under equilibrium conditions to determine $F_Q(z)$. This measured $F_Q(z)$ is increased by appropriate uncertainties to account for manufacturing tolerances and measurement uncertainty. The resulting $F_Q(z)$ including uncertainties is called $F_Q^M(z)$. Since $F_Q^M(z)$ was measured under equilibrium conditions, potential increases in $F_Q(z)$ that might arise from changes in the equilibrium power distribution caused by power level changes and control rod movement must also be accounted for. A W(z) function that represents the maximum likely increase in the equilibrium measured $F_Q(z)$ that might arise during power distribution transients will account for nonequilibrium operation.

$F_Q(z)$ surveillance is then accomplished by comparing the product of the measured $F_Q^M(z)$ and the analytically determined W(z) to the $F_Q(z)$ limit.

$$F_Q^M(z) \times W(z) \leq \frac{F_Q^{limit} \times K(z)}{P} \text{ for } P > 0.50$$

$$F_Q^M(z) \times W(z) \leq \frac{F_Q^{limit} \times K(z)}{0.5} \text{ for } P \leq 0.50$$

where K(z) is the normalized $F_Q(z)$ limit and P is the fraction of rated thermal power.

In a plant using CAOC operation, an Allowed Power Level (APL) can then be defined. APL represents the highest percentage of rated thermal power at which the plant can operate and still be assured that $F_Q(z)$ will be maintained below Technical Specifiction limits. APL is determined by taking the $F_Q(z)$ limit and dividing by the product of $F_Q^M(z)$ and W(z).

$$APL = \underset{\text{over } z}{\text{minimum}} \left(\frac{F_Q^{limit} \times K(z)}{F_Q^M(z) \times W(z)} \right) \times 100\%$$

While it is possible for the APL to be defined here as a number greater than 100%, other Technical specifications prevent plant operation above 100% of RATED THERMAL POWER. If APL is less than 100%, operation above APL is allowed to the extent that APDMS surveillance demonstrates or plant operation restrictions insure that the F_Q limit is met.

If the plant is using RAOC operation and $F_Q^M(z) \times W(z)$ exceeds its limit, the allowed ΔI-Power operating space must be reduced to insure operation below the F_Q limit. No allowance for widening the ΔI-Power space over that of Figure 3.2-1 if $F_Q^M(z) \times W(z)$ is below its limit is permited.

III. REVISIONS TO THE TECHNICAL SPECIFICATIONS

A. Surveillance Requirements - Section 4.2.2.2

During normal operation $F_Q(z)$ is shown to be within its limit by comparing the result of a measured $F_Q(z)$ multiplied by a $W(z)$ transient function to the $F_Q(z)$ limit. Periodically a full core flux map is taken under equilibrium conditions to determine a measured $F_Q(z)$. This $F_Q(z)$ is then increased by 3% to account for manufacturing tolerances and further increased by 5% to account for measurement uncertainties. The resulting equilibrium measured $F_Q(z)$ including uncertainties is called $F_Q^M(z)$. To verify operation below the Tech Spec $F_Q(z)$ limit, $F_Q^M(z)$ must be shown to be less than or equal to the $F_Q(z)$ limit divided by the $W(z)$ transient function

$$F_Q^M(z) \leq \frac{F_Q^{\text{limit}} \times K(z)}{P \times W(z)} \quad \text{for } P > 0.5$$

$$F_Q^M(z) \leq \frac{F_Q^{\text{limit}} \times K(z)}{W(z) \times 0.5} \quad \text{for } P \geq 0.5$$

where $K(z)$ is the normalized $F_Q(z)$ limit, P is the fraction of rated thermal power and everything else is as defined previously. $F_Q(z)$ surveillance must be performed when power has been increased by 10% of rated thermal power over the thermal power that $F_Q^M(z)$ was last determined or at least once every 31 effective full power days, whichever occurs first. When verifying that $F_Q^M(z)$ is within its limits, the top and bottom 15% of the core are excluded from consideration due to the difficulty in making a precise measurement for this region and the low probability that this region would be more limiting than the central 70% of the active core.

B. Surveillance Requirements - Section 4.2.2.2.e

Because $F_Q(z)$ surveillance is only required every 31 effective full power days, the Technical Specification takes into account the possibility that $F_Q(z)$ may increase between surveillances. Typically, because of natural feedback effects, $F_Q(z)$ decreases with increasing core burnup. Locations of peak power output in the core are also locations of peak fuel depletion rate in the core. However, cores using large numbers of burnable poison rods or non-standard fuel management techniques may show some small increase in $F_Q(z)$ with core burnup. The Technical Specification requires that when performing $F_Q(z)$ surveillance the resulting $F_Q(z)$ value must be compared to $F_Q(z)$ determined from the previous flux map. If the margin to the $F_Q(z)$ limit has decreased since the previous determination of $F_Q(z)$ then additional action must be taken. The Technical Specification allows two options. If the margin to the $F_Q(z)$ limit has decreased since the previous map, then either the new $F_Q(z)$ must be increased by an additional 2% to account for further increases in $F_Q(z)$ before the next surveillance, or surveillance must be performed every seven full power days. Analysis of both flux maps and predicted $F_Q(z)$ values indicate that $F_Q(z)$ will not increase by more than 1% per month. 2% was chosen as a conservative bound for the maximum possible decrease in margin to the $F_Q(z)$ limit between monthly flux maps that might be encountered during plant operation. The additional 2% penalty or more frequent mapping requirements can be discontinued when two successive flux maps indicate that the margin to the $F_Q(z)$ limit is no longer decreasing.

An example of the modifications to 3/4.2.2 required to incorporate F_Q surveillance for RAOC operation is Section 1 of the attachment.

C. PEAKING FACTOR LIMIT REPORT-SECTION 6.9.1.14

The W(z) function is a plant and cycle dependent function. The W(z) function for a given cycle will be formally reported to the utility and the NRC in the Peaking Factor Limit Report. The Peaking Factor Limit

Report will be supplied at least 60 days prior to cycle initial criticality or 60 days prior to the date the values would become effective unless otherwise exempted by the NRC. Section 2 of the attachment is the changes to the Reporting Requirements section (6.9) of the Technical Specifications requiring a Peaking Factor Limit Report. Section 3 is a sample report for RAOC operation.

D. Axial Power Distribution - Section 3.2.6 (CAOC Plants Only)

In conjunction with the measurement of $F_Q^M(z)$, an Allowed Power Level (APL) is determined. APL is defined as the ratio of the $F_Q(z)$ limit to the product of $F_Q^M(z)$ and $W(z)$.

$$APL = \underset{\text{over } z}{\text{minimum}} \left(\frac{F_Q^{\text{Limit}} \times K(z)}{F_Q^M(z) \times W(z)} \right) \times 100\%$$

The top and the bottom 15% of the core are also excluded from the calculations of APL. Operation at power levels above APL requires the use of the APDMS or operational restrictions (such as Base Load Operation) on the plant.

IV. METHODOLOGY FOR F_Q(Z) AND W(Z) ANALYSIS

A. W(z) Methodology

The W(z) factor represents the largest expected increase in an equilibrium $F_Q(z)$ that can result from changes in ΔI and power level which are allowed in plant operation.

W(z) is defined as:

$$W(z) = \frac{(F_Q(z) \times P)^{\text{maximum, simulated transient}}}{(F_Q(z) \times P)^{\text{equilibrium}}}$$

Changes in the core power distribution caused by control rod insertion, power level changes, axial xenon transients, and radial xenon transients are all included in $W(z)$. In some reload cores, operating flexibility can be maximized by making the $W(z)$ function burnup dependent.

For a plant incorporating CAOC operation, the $W(z)$ function is determined by analyzing a full range of power shapes occurring from simulation of typical load follow operation. Plant maneuvers covering the full range of power levels, core burnups, and operator control strategies are simulated while maintaining the appropriate ΔI band. The specific cases analyzed are those used in the standard Westinghouse $F_Q(z)$ analysis(1,2). Alternatively, other standard F_Q analyses(3,4) could be employed to compute $W(z)$.

For a plant with a RAOC Technical Specification, $W(z)$ is determined based on the transient $F_Q(z)$ resulting from the normal operation analysis of the final ΔI-Power operating space. The methodology for determining the ΔI-Power operating space is discussed in "Relaxation of Constant Axial Offset Control" (Part A of NS-EPR-2649).

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(1) "F_Q Envelope Calculations", C.E. Eicheldinqer letter NS-CE-687; 6/27/74 (Prop.)

(2) F.M. Bordelon, et. al. "Westinghouse Reload Safety Methodology", WCAP-9272. March 1978. (Prop.)

(3) Letter from C. Eicheldinger (Westinghouse), NS-CE-1749 to John F. Stolz (NRC); April 6,, 1978 (Proprietary).

(4) Letter from T.M. Anderson (Westinghouse), NS-TMA-2198, to K. Kniel (NRC); January 31, 1980 (Proprietary).