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Point Beach Nuclear Plant
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NPL 2001-0036

10 CFR 50.90

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Document Control Desk
U.S. NUCLEAR REGULATORY COMMISSION
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Ladies/Gentlemen:

DOCKETS 50-266 AND 50-301
SUPPLEMENT 1 TO TECHNICAL SPECIFICATIONS CHANGE REQUEST 216
INDIVIDUAL ROD POSITION INDICATION OPERABILITY
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

By submittal dated November 20, 2000, Nuclear Management Company (Licensee) requested amendments to Facility Operating Licenses DPR-24 and DPR-27 for Point Beach Nuclear Power Plant, Units 1 and 2, respectively, to incorporate changes to the plant Operating Licenses and Technical Specifications. The purpose of the proposed amendments was to implement changes to the Technical Specifications (TS) to increase the allowable deviation in individual rod position indication (IRPI). We requested approval of the proposed amendments by April 2001.

During a conference call between Jack Gadzala (NMC) and Margaret Chatterton (NRC) on January 4, 2001, NRC staff expressed concern with the scheduler aspects of the review process, based on the staff's initial assessment of the proposed amendments regarding power operation greater than 85 % power. In response to the staff's concerns, and to help ensure that the amendment request can by approved by April 2001, we are withdrawing the portions of the proposed changes that deal with power operation greater than 85% power. In their place, a more restrictive limit is being proposed. Attachments 1 through 4 contain our revised submittal. We intend to resubmit the withdrawn portions as a separate amendment request at a later date.

As discussed in the initial submittal, the existing TS for IRPI deviation is not sufficiently conservative at certain power levels. As a result, administrative controls were placed on reactor operation that limit allowed IRPI deviations to values that are more restrictive than the current Technical Specifications. These administrative controls are interim restrictions until the amendments are approved to incorporate revised allowable rod position deviation criteria for the IRPI system into the Technical Specifications. The proposed amendments, as supplemented herein, will incorporate these administrative controls into the TS. These administrative controls do not conflict with any Technical Specification and have been evaluated to ensure that the controls do not result in any significant hazards.

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Attached are a description of changes, safety evaluation, Technical Specifications, and related bases pages markups supporting the requested changes, and corresponding pages incorporating the proposed changes.

Our evaluation concluded that the revisions proposed in this supplement are bounded by the no significant hazards consideration that was provided in our original amendment request dated November 20, 2000.

We have determined that this additional information for the proposed amendments does not involve a significant hazards consideration, authorize a significant change in the types or total amounts of effluent release, or result in any significant increase in individual or cumulative occupational radiation exposure. Therefore, we conclude that the proposed amendments meet the categorical exclusion requirements of 10 CFR 51.22(c)(9) and that an environmental impact appraisal need not be prepared.

We request approval of the proposed amendments by April 2001.

Sincerely,

Mark E. Reddemann
Site Vice President

Subscribed to and sworn before me
on this 6 day of February, 2001

Notary Public, State of Wisconsin

My Commission expires on Oct. 17, 2004.

JG/jlk

Attachments

cc: NRC Regional Administrator
NRC Resident Inspector
NRC Project Manager
PSCW

DESCRIPTION OF CHANGES
SUPPLEMENT 1 TO TECHNICAL SPECIFICATIONS CHANGE REQUEST 216
INDIVIDUAL ROD POSITION INDICATION OPERABILITY
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

Introduction

In accordance with the requirements of 10 CFR 50.90, Nuclear Management Company (licensee) hereby requests amendments to facility operating licenses DPR-24 and DPR-27, for Point Beach Nuclear Plant, Units 1 and 2, respectively.

This proposed amendments would revise Technical Specifications 15.3.10-B.1, 15.3.10-C.1.c (2) and 15.3.10-D to change the allowable deviation in individual rod position indication (IRPI) from the bank demand position and add a note allowing for a one hour thermal soak, following rod motion, prior to verifying limits.

Rod Operability and Bank Alignment Limits

Proposed Technical Specification 15.3.10-B.1 provides Limiting Conditions for Operation of the rod operability and bank alignment limits. This Specification defines allowed deviation limits between rod indicated position and bank demand position. The following changes to this Specification are proposed (additions are double-underlined; deletions are strike-through):

B. ROD OPERABILITY AND BANK ALIGNMENT LIMITS

NOTE: One hour is allowed following rod motion prior to verifying rod operability and bank alignment limits.

1. During power and low power operation, all shutdown and control rods shall be operable~~, with all individual indicated rod positions within twelve steps of their bank demand position, except when bank demand position is ≤30 steps or ≥215 steps. In this case, all individual indicated rod positions shall be within 24 steps of their bank demand position~~ and positioned within the allowed rod misalignment between the individual indicated rod positions and the bank demand position as follows;

   i) For operation ≤ 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±24 steps.
   ii) For operation > 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±12 steps.

Rod Position Indication

Proposed Technical Specification 15.3.10-C.1.c (2) provides shiftly requirements for verifying rod position indication of the most withdrawn rod and the least withdrawn rod, within an affected bank, when bank demand position indication is inoperable. The following changes to this Specification are proposed (additions are double-underlined; deletions are strike-through):

C. ROD POSITION INDICATION

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1.c. If bank demand position indication, for one or more banks, is determined to be inoperable, perform the following actions:

(1) Once per shift verify that all RPIs for the affected banks are operable;
AND

(2) Once per shift verify that the most withdrawn rod and the least withdrawn rod of the affected banks are ~~≤12 steps apart, except when the bank demand position is ≤30 steps or ≥215 steps. In this case, once per shift verify that the most withdrawn rod and the least withdrawn rod of the affected banks are ≤24 steps apart;~~ within the allowed rod misalignment in accordance with TS 15.3.10.B.1.

Bank Insertion Limits

Proposed Technical Specification 15.3.10-D adds a corresponding note allowing for a one hour thermal soak prior to verifying limits (similar to proposed Technical Specification15.3.10-B):

D. BANK INSERTION LIMITS

NOTE: One hour is allowed following rod motion prior to verifying bank insertion limits.

Basis for Changes

The magnitude of control rod indicated misalignment is a parameter used to establish the initial conditions for accident evaluation. The proposed limits allow an indicated misalignment based on: limitations in power level, group step counter demand position, and the confirmed presence of margin in measured peaking factors. Analysis with rod misalignments of ±24 steps showed that the increase in peaking factors will be accommodated at or below 85 percent of rated thermal power. Analysis also showed that above 85 percent of rated thermal power, peaking factors can be accommodated with rod misalignments up to ±12 steps. Adherence to the conditions in the proposed Technical Specification will ensure that the plant conditions are consistent with the assumptions and initial conditions used in the safety analysis.

Point Beach has experienced difficulty maintaining the indicated differences within limits for many control rods due to inherent temperature instability of the IRPI system. The primary contributor to the temperature instability is the change in control rod drive shaft magnetic permeability due to the cooling of the drive shaft upon withdrawal. Temperature equilibration is reached in approximately one hour. Therefore, specifications 15.3.10-B and 15.3.10-D have been modified to allow up to one hour after control rod motion to verify control rod position. This time period is based on the time deemed necessary to allow the control rod drive shaft to reach thermal equilibrium. Due to changes in the magnetic permeability of the drive shaft as a function of temperature, the indicated position is expected to change with time as the drive shaft cools on withdrawal. The one hour time period is consistent with NRC approved time extensions at other plants, specifically Salem Units 1 and 2 (Amendment dated March 19, 1986) and Indian Point Unit 3, and allows for the position indication to stabilize prior to taking any action.

Bases Changes

Technical Specification Bases changes are being made to reflect the proposed Technical Specification changes. The discussion on rod misalignment error (page 15.2.10-13) and the conditions for hot channel factor limits to be met (page 15.3.10-15) are being revised to support the proposed changes. The proposed changes are attached.

SAFETY EVALUATION
SUPPLEMENT 1 TO TECHNICAL SPECIFICATIONS CHANGE REQUEST 216
INDIVIDUAL ROD POSITION INDICATION OPERABILITY
POINT BEACH NUCLEAR PLANT UNITS 1 AND 2

Introduction

In accordance with the requirements of 10 CFR 50.90, Nuclear Management Company (licensee) hereby requests amendments to facility operating licenses DPR-24 and DPR-27, for Point Beach Nuclear Plant, Units 1 and 2, respectively. The purpose of the proposed amendments is to implement changes to the Technical Specifications (TS) to revise the allowable deviation in individual rod position indication (IRPI).

The allowed deviation limits are supported by the analyses and provide for limiting time periods when the system is not fully operable.

System Description

The IRPI system derives the control rod position signal from measurements using a linear variable differential transmitter (LVDT). An analog signal is produced for each Rod Cluster Control Assembly (RCCA) by its associated LVDT. The control rod drive shaft varies the amount of magnetic coupling between the primary and secondary windings of the coils and generates an analog signal proportional to the rod position. As a control rod is raised by its magnetic jacks, the magnetic permeability of the control rod drive shaft causes an increase in magnetic coupling. Thus, an analog signal that is proportional to the control rod position is derived. The LVDT signal is conditioned and displayed on individual indicators mounted on the control boards and on the Plant Computer display.

Safety Evaluation

The current licensing basis for a misaligned rod is an indicated ±12 step difference between the bank demand position and the individual rod position indicator above 30 steps and below 215 steps. Point Beach Units 1 & 2 have experienced difficulty maintaining the indicated differences of less than ±12 steps for many control rods due to inherent temperature instability of the IRPI system. The primary contributor to the temperature instability is the change in control rod drive shaft magnetic permeability due to the cooling of the drive shaft upon withdrawal. While temperature equilibration will be reached in approximately one hour, it is difficult to calibrate the IRPI for the wide variety of conditions and rod positions that can be experienced during power operation. The existing TS for IRPI deviation is not sufficiently conservative at certain power levels. As a result, administrative controls were placed on reactor operation that limit allowed IRPI deviations to values that are more restrictive than the current Technical Specifications. The proposed amendments will increase the allowable rod misalignment criteria in the Technical Specifications.

Westinghouse has performed an evaluation for increasing the indicated control rod misalignment from the current limit of ±12 steps (WCAP-15432, Revision 1). The number and type of rod misalignments were limited by the performance of an evaluation of the Failure Mode and Effects Analysis (FMEA) performed for the rod control system (Reference 1 of WCAP-15432 Rev 1). The evaluation was limited to single failures within the rod control system logic cabinets, power cabinets and the control rod drive mechanisms themselves. Multiple failures were not considered as reasonable precursors for rod misalignment since there is frequent surveillance of rod position to limit such occurrences. The evaluation concluded that there were six categories of failure mechanisms that warranted investigation. These categories are described in Section 2.0 of WCAP-15432 Rev 1. As a result of these failure mode categories, eight different cases of misalignment were analyzed. These cases involved single and multiple rod misalignments in a single group in either the insertion or withdrawal directions. These misalignments can be asymmetric. Other cases involved all rods in a group misaligned from the group step counter demand position. While this type of misalignment did not result in a rod to rod deviation, either the group did not move in the correct direction or the correct group did not move, which for the purpose of this evaluation was considered a misalignment from the demand position. This type of misalignment is symmetric. The eight cases are described in detail in Section 3.3 of WCAP-15432 Rev 1. Finally, two fuel cycles were evaluated, the current Unit 1 Cycle 26 and a "future" or "bounding" cycle based on higher enrichments and peaking factors. The cycle characteristics are summarized in Table 3.1 of WCAP-15432 Rev 1.

The margin requirements are 4.0% in $F_{\Delta H}$ and 10.0 % in $F_Q(Z)$ for a maximum control rod misalignment of 24 steps indicated. The increases in the limits for F_Q and $F_{\Delta H}$ exceed these values prior to operation at or below 85 percent of rated power (for P = 85 %, the quantity [1.0 + 0.3(1 - P)] equals 1.045 or an increase of 4.5 % in $F_{\Delta H}$ and 1/P equals 1.176 or an increase of 17.6 % in F_Q). Therefore, the increase in allowed indicated misalignment of 24 steps is considered reasonable and acceptable at or below 85 percent of rated power.

The WCAP includes an analysis of permissible increases in indicated misalignment for operation above 85 percent of rated power based on available margin to F_Q and $F_{\Delta H}$. However, this analysis will not be required for the amendment requests as proposed in this supplement. We plan to submit this analysis in a separate amendment request at a later date. For the changes proposed in this supplement, the indicated misalignment will be limited to ±12 steps for operation above 85 percent of rated power. This is a more restrictive change with respect to the current Technical Specifications and is consistent with the results of the WCAP analysis.

Specifications 15.3.10-B and 15.3.10-D have been modified to allow up to one hour after control rod motion to verify control rod position. This time period is based on the time deemed necessary to allow the control rod drive shaft to reach thermal equilibrium. Due to changes in the magnetic permeability of the drive shaft as a function of temperature, the indicated position is expected to change with time as the drive shaft cools on withdrawal. The one hour time period is consistent with NRC approved time extensions at other plants, specifically Salem Units 1 and 2 (Amendment dated March 19, 1986) and Indian Point Unit 3, and allows for the position indication to stabilize prior to taking any action.

Conclusion

WCAP-15432 Rev 1 documents an evaluation of the effects of increasing the allowed control rod misalignment from ±12 steps indicated to less than or equal to ±18 steps indicated for operation at power levels greater than 85 percent of rated power with Bank D demand position less than 215 steps; or to less than or equal to ±24 steps indicated for operation at power levels greater than 85 percent of rated power with Bank D demand position greater than or equal to 215 steps withdrawn. For operation at or below 85 percent of rated power with a control rod misalignment of less than or equal ±24 steps, no confirmation of the existence of core peaking factor margin is necessary. Based on this evaluation, the proposed changes to Technical Specifications to reflect margin requirements in measured core peaking factors are acceptable. However, the evaluation for power levels above 85 percent will not be used at this time.

Technical Specification 15.3.10-B.1, Rod Operability and Bank Alignment Limits, should be modified to reflect the following allowances for rod misalignment:

1. Less than or equal to 85 percent power and D Bank at any demand position, indicated misalignments of less than or equal to ±24 steps are allowable.
2. Greater than 85 percent of rated power and D Bank at any demand position, indicated misalignments of less than or equal to ±12 steps are allowable.

Provided that the margin requirements are satisfied, the Westinghouse evaluation concluded that no additional changes to plant procedures were necessary.

TECHNICAL SPECIFICATIONS PAGE MARKUPS
TECHNICAL SPECIFICATIONS CHANGE REQUEST 216
INDIVIDUAL ROD POSITION INDICATION OPERABILITY
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

The attached page markups reflect the changes proposed to the current Point Beach Technical Specifications (additions are double-underlined; deletions are strike-through.

15.3.10 CONTROL ROD AND POWER DISTRIBUTION LIMITS

Applicability

Applies to the operation of the control rods and to core power distribution limits.

Objective

To insure (1) core subcriticality after a reactor trip, (2) a limit on potential reactivity insertions from a hypothetical rod cluster control assembly (RCCA) ejection, and (3) an acceptable core power distribution during power operation.

Specification

A. SHUTDOWN MARGIN

1. The shutdown margin shall exceed the applicable value as shown in Figure 15.3.10-2 under all steady-state operating conditions from 350°F to full power. If the shutdown margin is less than the applicable value of Figure 15.3.10-2, within 15 minutes initiate boration to restore the shutdown margin.

2. A shutdown margin of at least 1% $\Delta k/k$ shall be maintained when the reactor coolant temperature is less than 350°F. If the shutdown margin is less than this limit, within 15 minutes initiate boration to restore the shutdown margin.

B. ROD OPERABILITY AND BANK ALIGNMENT LIMITS

NOTE: One hour is allowed following rod motion prior to verifying rod operability and bank alignment limits.

1. During power and low power operation, all shutdown and control rods shall be operable~~, with all individual indicated rod positions within twelve steps of their bank demand position, except when bank demand position is ≤30 steps or ≥215 steps. In this case, all individual indicated rod positions shall be within 24 steps of their bank demand position~~ and positioned within the allowed rod misalignment between the individual indicated rod positions and the bank demand position as follows;

   i) For operation ≤ 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±24 steps.
   ii) For operation > 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±12 steps.

   If an RCCA does not step in upon demand, up to six hours is allowed to determine whether the problem with stepping is an electrical problem. If the problem cannot be resolved within six hours, the RCCA shall be declared inoperable until it has been verified that it will step in or would drop upon demand.

a. Rod Operability Requirements

(1) If one rod is determined to be untrippable, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2;
OR
(b) Within one hour restore the shutdown margin by boration;
OR
(c) Within six hours be in hot shutdown.

(2) If sustained power operation with an untrippable rod is desired, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;
AND
(b) Within six hours, adjust the insertion limits to reflect the worth of the untrippable rod.

(c) If the above actions and associated completion times are not met, be in hot shutdown within six hours.

(3) If more than one rod is determined to be untrippable, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;
AND
(b) Within six hours be in hot shutdown.

b. Rod Bank Alignment Limits

(1) If it has been determined that one rod is not within alignment limits, and the indicated misalignment is not being caused by malfunctioning rod position indication, within one hour restore the rod to within alignment limits; OR perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;
AND

(b) Within eight hours reduce thermal power to ≤75 percent of rated thermal power;
AND

(c) Verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2 once per twelve hours;
AND

(d) Within 72 hours verify that measured values of FQ(Z) are within limits;
AND

(e) Within 72 hours verify that FNΔH is within limits;

(f) If the above actions and associated completion times are not met, be in hot shutdown within the following six hours.

(g) In order to subsequently increase thermal power above 75 percent of rated thermal power with the existing rod misalignment, perform an analysis to determine the hot channel factors and the resulting allowable power level in accordance with TS 15.3.10.E.

(2) If it has been determined that more than one rod is not within alignment limits and the misalignments are not being caused by malfunctioning rod position indication, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;
AND

(b) Be in hot shutdown within six hours.

C. ROD POSITION INDICATION

NOTE: Separate entry into TS 15.3.10.C.1.a, b, or c is allowed for each inoperable rod position indicator and each bank of demand position indication.

1. During power operation ≥10 percent of rated thermal power, the rod position indication system and the bank demand position indication system shall be operable.

a. If one or more rod position indicators (RPI) are determined to be inoperable, perform the following actions:

(1) Within eight hours verify the position of the rods with inoperable RPIs by using movable incore detectors;
AND
(2) Once per shift check the position of the rods with inoperable RPIs by using excore detectors, or thermocouples, or movable incore detectors;

(3) If the above actions and associated completion times are not met, perform the actions in accordance with TS 15.3.10.B.1.b.

b. If one or more rods with inoperable RPIs have been moved in excess of 24 steps in one direction since the last determination of the rod's position, perform the following actions:

(1) Within four hours check the position of the rods with inoperable RPIs by using excore detectors, or thermocouples, or movable incore detectors;

(2) If the above action and associated completion time is not met, perform the actions in accordance with TS 15.3.10.B.1.b.

c. If bank demand position indication, for one or more banks, is determined to be inoperable, perform the following actions:

(1) Once per shift verify that all RPIs for the affected banks are operable;
AND
(2) Once per shift verify that the most withdrawn rod and the least withdrawn rod of the affected banks are ~~≤12 steps apart, except when the bank demand position is ≤30 steps or ≥215 steps. In this case, once per shift verify that the most withdrawn rod and the least withdrawn rod of the affected banks are ≤24 steps apart;~~ within the allowed rod misalignment in accordance with TS 15.3.10.B.1.

(3) If the above actions and associated completion times are not met, perform the actions in accordance with TS 15.3.10.B.1.b.

D. BANK INSERTION LIMITS

NOTE: One hour is allowed following rod motion prior to verifying bank insertion limits.

1. When the reactor is critical, the shutdown banks shall be fully withdrawn. Fully withdrawn is defined as a bank position equal to or greater than 225 steps. This definition is applicable to shutdown and control banks.

If this condition is not met, perform the following actions:

a. Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; <u>OR</u> within one hour restore the shutdown margin by boration;

distribution viewpoint. If the misalignment condition cannot be readily corrected, the specified reduction in power to 75% will insure that design margins to core limits will be maintained under both steady-state and anticipated transient conditions. The eight (8) hour permissible limit on rod misalignment at rated power is short with respect to the probability of an independent accident.

Insert

~~Because the rod position indicator system may have a 12 step error when a misalignment of 24 steps is occurring, the Specification allows only an indicated misalignment of 12 steps. However, when the bank demand position is greater than or equal to 215 steps, or, less than or equal to 30 steps, the consequences of a misalignment are much less severe. The differential worth of an individual RCCA is less, and the resultant perturbation on power distributions is less than when the bank is in its high differential worth region. At the top and bottom of the core, an indicated 24 step misalignment may be representing an actual misalignment of 36 steps.~~

The failure of an LVDT in itself does not reduce the shutdown capability of the rods, but it does reduce the operator's capability for determining the position of that rod by direct means. The operator has available to him the excore detector recordings, incore thermocouple readings and periodic incore flux traces for indirectly determining rod position and flux tilts should the rod with the inoperable LVDT become malpositioned. The excore and incore instrumentation will not necessarily recognize a misalignment of 24 steps because the concomitant increase in power density will normally be less than 1% for a 24 step misalignment. The excore and incore instrumentation will, however, detect any rod misalignment which is sufficient to cause a significant increase in hot channel factors and/or any significant loss in shutdown capability. The increased surveillance of the core if one or more rod position indicator channels is out-of-service serves to guard against any significant loss in shutdown margin or margin to core thermal limits.

The history of malpositioned RCCA's indicates that in nearly all such cases, the malpositioning occurred during bank movement. Checking rod position after bank motion exceeds 24 steps will verify that the RCCA with the inoperable LVDT is moving properly with its bank and the bank step counter. Malpositioning of an RCCA in a stationary bank is very rare, and if it does occur, it is usually gross slippage which will be seen by external detectors. Should it go undetected, the time between the rod position checks performed every shift is short with respect to the probability of occurrence of another independent undetected situation which would further reduce the shutdown capability of the rods.

Any combination of misaligned rods below 10% rated power will not exceed the design limits. For this reason, it is not necessary to check the position of rods with inoperable LVDTs below 10% power; plus, the incore instrumentation is not effective for determining rod position until the power level is above approximately 5%.

Power Distribution

During power operation, the global power distribution is limited by TS 15.3.10.E.2, "Axial Flux Difference," and TS 15.3.10.E.3, "Quadrant Power Tilt," which are directly and continuously measured process variables. These specifications, along with TS 15.3.10.D, "Bank Insertion Limits," maintain the core limits on power distributions on a continuous basis.

As a result of the increased peaking factors allowed by the new 422V+ fuel, a new column was added to TS 15.3.10.E.1.a. The full power $F^N_{\Delta H}$ peaking factor design limit (radial peaking factor) for 422V+ fuel will increase to 1.77 from the 1.70 value for the OFA fuel. The maximum $F_Q(Z)$ peaking factor limit (total peaking factor) for 422V+ fuel will increase to 2.60 from the 2.50 value for the OFA fuel. The OFA fuel design will retain the current $F^N_{\Delta H}$ and $F_Q(Z)$ peaking factors of 1.70 and 2.50, respectively. In addition, the K(Z) envelope for the new 422V+ fuel was modified and a new TS figure 15.3.10-3a was developed and inserted in the Technical Specifications. The K(Z) envelope in TS Figure 15.3.10-3 remains for the OFA fuel.

The purpose of the limits on the values of $F_Q(Z)$, the height dependent heat flux hot channel factor, is to limit the local 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.

$F_Q(Z)$ 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 steady state conditions.

The purpose of the limits on $F^N_{\Delta H}$, the nuclear enthalpy rise hot channel factor, is to ensure that the fuel design criteria are not exceeded and the accident analysis assumptions remain valid. The design limits on local and integrated fuel rod peak power density are expressed in terms of hot channel factors. Control of the core power distribution with respect to these factors ensures that local conditions in the fuel rods and coolant channels do not challenge core integrity at any location during either normal operation or a postulated accident analyzed in the safety analyses.

$F^N_{\Delta H}$, Nuclear Enthalpy Rise Hot Channel Factor, is defined as the ratio of the integral of linear power along a fuel rod to the average fuel rod power. Imposed limits pertain to the maximum $F^N_{\Delta H}$ in the core, that is the fuel rod with the highest integrated power. It should be noted that $F^N_{\Delta H}$ is based on an integral and is used as such in the DNB calculations. Local heat flux is obtained by using hot channel and adjacent channel explicit power shapes which take into account variations in horizontal (x-y) power shapes throughout the core. Thus, the horizontal power shape at the point of maximum heat flux is not necessarily directly related to $F^N_{\Delta H}$.

$F^N_{\Delta H}$ is sensitive to fuel loading patterns, bank insertion, and fuel burnup. $F^N_{\Delta H}$ typically increases with control bank insertion and typically decreases with fuel burnup.

$F^N_{\Delta H}$ is not directly measurable but is inferred from a power distribution map obtained with the movable incore detector system. Specifically, the results of the three dimensional power distribution map are analyzed by a computer to determine $F^N_{\Delta H}$. This factor is calculated at least monthly. However, during power operation, the global power distribution is monitored by TS 15.3.10.E.2, "Axial Flux Difference," and TS 15.3.10.E.3, "Quadrant Power Tilt," which address directly and continuously measured process variables.

It has been determined that, provided the following conditions are observed, the hot channel factor limits will be met:

Insert

~~1. Control rods in a single bank move together with no individual rod insertion differing by more than 24 steps from the bank demand position, when the bank demand position is between 30 steps and 215 steps. A misalignment of 36 steps is allowed when the bank position is less than or equal to 30 steps, or, when the bank position is greater than or equal to 215 steps, due to the small worth and consequential effects of an individual rod misalignment.~~

2. Control rod banks are sequenced with overlapping banks as described in Figure 15.3.10-1.

3. Control bank insertion limits are not violated.

4. Axial power distribution control procedures, which are given in terms of flux difference control and control bank insertion limits, are observed. Flux difference refers to the difference in signals between the top and bottom halves of two-section excore neutron detectors. The flux difference is a measure of the axial offset which is defined as the difference in normalized power between the top and bottom halves of the core.

The permitted relaxation of $F^N_{\Delta H}$ allows radial power shape changes with rod insertion to the insertion limits. It has been determined that provided the above four conditions are observed, these hot channel factor limits are met. In Specification 15.3.10.E.1.a, F_Q is arbitrarily limited for $p \leq 0.5$.

The upper bound envelope F_Q (defined in 15.3.10.E) times the normalized peaking factor axial dependence of Figure 15.3.10-3 for OFA and Upgraded OFA Fuel and Figure 15.3.10-3a for 422V+ Fuel (consistent with the Technical Specifications on power distribution control as given in Section 15.3.10) was used in the large and small break LOCA analyses. The envelope was determined based on allowable power density distributions at full power restricted to axial flux difference (ΔI) values consistent with those in Specification 15.3.10.E.2.

The results of the analyses based on this upper bound envelope indicate a peak clad temperature of less than the 2200^{O}F limit. When an F_Q measurement is taken, both experimental error and manufacturing tolerance must be taken into account. Five percent is the appropriate allowance for a full core map taken with the moveable incore detector flux mapping system and three percent is the appropriate allowance for manufacturing tolerance. In the design limit of $F^N{}_{\Delta H}$, there is eight percent allowance for uncertainties which means that normal operation of the core is expected to result in a design $F^N{}_{\Delta H} \leq 1.70/1.08$ for OFA and Upgraded OFA fuel and 1.77/1.08 for 422V+ fuel. The logic behind the larger uncertainty in this case is as follows:

(a) Normal perturbations in the radial power shape (i.e., rod misalignment) affect $F^N{}_{\Delta H}$, in most cases without necessarily affecting F_Q.

(b) While the operator has a direct influence on F_Q through movement of rods, and can limit it to the desired value, he has no direct control over $F^N{}_{\Delta H}$.

(c) An error in the predictions for radial power shape which may be detected during startup physics tests can be compensated for in F_Q by tighter axial control; but compensation for $F^N{}_{\Delta H}$ is less readily available.

Measurements of the hot channel factors are required as part of startup physics tests, at least each full power month operation, and whenever abnormal power distribution conditions require a reduction of core power to a level based upon measured hot channel factors. The incore map taken following initial loading provides confirmation of the basic nuclear design bases including proper fuel loading patterns. The periodic monthly incore mapping provides additional assurance that the nuclear design bases remain inviolate and identify operational anomalies which would, otherwise, affect these bases.

The measured hot channel factors are increased as follows:

(a) The measurement of total peaking factor, F_Q^{meas}, shall be increased by three percent to account for manufacturing tolerance and further increased by five percent to account for measurement error.

(b) The measurement of enthalpy rise hot channel factor, $F^N{}_{\Delta H}$ shall be increased by four percent to account for measurement error.

Axial Power Distribution

The limits on axial flux difference (AFD) assure that the axial power distribution is maintained such that the $F_Q(Z)$ upper bound envelope of F_Q^{LIMIT} times the normalized axial peaking factor [K(Z)] is not exceeded during either normal operation or in the event of xenon redistribution following power changes. This ensures that the power distributions assumed in the large and small break LOCA analyses will bound those that occur during plant operation.

Provisions for monitoring the AFD on an automatic basis are derived from the plant process computer through the AFD monitor alarm. The computer determines the AFD for each of the operable excore channels and provides a computer alarm if the AFD for at least 2 of 4 or 2 of 3 operable excore channels are outside the AFD limits and the reactor power is greater than 50 percent of Rated Power.

Quadrant Tilt

The quadrant tilt limit ensures that the gross radial power distribution remains consistent with the design values used in the safety analyses. Precise radial power distribution measurements are made during startup testing, after refueling, and periodically during power operation.

The power density at any point in the core must be limited so that the fuel design criteria are maintained. Together, specifications associated with axial flux difference, quadrant tilt, and control rod insertion limits provide limits on process variables that characterize and control the three dimensional power distribution of the reactor core. Control of these variables ensures that the core operates within the fuel design criteria and that the power distribution remains within the bounds used in the safety analyses.

The excore detectors are somewhat insensitive to disturbances near the core center or on the major axes. It is therefore possible that a five percent tilt might actually be present in the core when the excore detectors respond with a two percent indicated quadrant tilt. On the other hand, they are overly responsive to disturbances near the periphery on the 45^{O} axes.

Tilt restrictions are not applicable during the startup and initial testing of a reload core which may have an inherent tilt. During this time sufficient testing is performed at reduced power to verify that the hot channel factor limits are met and the nuclear channels are properly aligned. The excore detectors are normally aligned indicating no quadrant power tilt because they are used to alarm on a rapidly developing tilt. Tilts which develop slowly are more accurately and readily discerned by incore measurements. The excore detectors serve as the prime indication of a quadrant power tilt. If a channel fails, is out-of-service for testing, or is unreliable, two hours is a short time with respect to the probability of an unsafe quadrant power tilt developing. Two hours gives the operating personnel sufficient time to have the problem investigated and/or put into operation one of several possible alternative methods of determining tilt.

Physics Tests Exceptions

The primary purpose of the at-power and low power physics tests is to permit relaxations of existing specifications to allow performance of instrumentation calibration tests and special physics tests. The at-power specification allows selected control rods and shutdown rods to be positions outside their specified alignment and insertion limits to conduct physics tested at power. The power level is limited to ≤85 percent of rated thermal power and the power range neutron flux trip setpoint is set at maximum of 90 percent of rated thermal power. Operation with thermal power ≤85 percent of rated thermal power during physics tests provides an acceptable thermal margin when one or more of the applicable specifications is not being met. The Power Range Neutron Flux - High trip setpoint is reduced so that a similar margin exists between the steady-state condition and the trip setpoint that exists during normal operation at rated thermal power.

The low power specification allows selected control and shutdown rods to be positioned outside of their specified alignment and insertion limits to conduct physics tests at low power. If power exceeds two percent, as indicated by nuclear instrumentation, during the performance of low power physics tests, the only acceptable action is to open the reactor trip breakers to prevent operation of the reactor beyond its design limits. Immediately opening the reactor trip breakers will shut down the reactor and prevent operation of the reactor outside of its design limits. If the RCS lowest loop average temperature falls below the minimum temperature for criticality, the temperature should be restored within 15 minutes because operation with the reactor critical and temperature below the minimum temperature for criticality could violate the assumptions for accidents analyzed in the safety analyses. If the temperature cannot be restored within 15 minutes, the plant must be made subcritical within an additional 15 minutes. This action will place the plant in a safe condition in an orderly manner without challenging plant systems.

Bases
Insert A

The specifications of 15.3.10 ensure that (1) acceptable power distribution limits are maintained, (2) the minimum shutdown margin is maintained, and (3) the potential effects of rod misalignment on associated accident analyses are limited. Operability of the control rod position indicators is required to determine control rod position and thereby ensure compliance with the control rod alignment and insertion limits. Permitted control rod misalignments (as indicated by the RPI System within one hour after control rod motion) are; a) ± 12 steps of the bank demand position (if power level is greater than 85 percent of rated power, and b) ± 24 steps of the bank demand position (if the power level is less than or equal to 85 percent of rated power). For power levels less than or equal to 85 percent of rated power, the peaking factor margin does not have to be verified on an explicit basis. This is due to the rate of peaking factor margin increase (due to the peaking factor limit increasing) as the power level decreases being greater than the peaking factor margin loss (due to the increased control rod misalignment). This effect is described in WCAP-15432 Rev. 1. These limits are applicable to all shutdown and control rods (of all banks) over the range of 0 to 230 steps withdrawn inclusive.

The comparison of bank demand position and RPI System may take place at any time up to one hour after rod motion, at any power level. This allows up to one hour of thermal soak time to allow the control rod drive shaft to reach a thermal equilibrium and thus present a consistent position indication. A similar time period (up to one hour after rod motion) is allowed for comparison of the bank insertion limits and the RPI System. This comparison is sufficient to verify that the control rods are above the insertion limits and thus assures the presence of sufficient shutdown margin to satisfy the assumptions of the safety analyses.

The action statements which permit limited variation from the basic requirements are accompanied by additional restrictions which ensure that the original criteria are met. Actual misalignment of a rod requires measurement of peaking factors (to confirm acceptability) or a restriction in thermal power; either of these restrictions provides assurance of fuel rod integrity during continued operation. The reactivity worth of a misaligned rod is limited for the remainder of the fuel cycle to prevent exceeding the assumption used in the accident analysis.

Bases
Insert B

1. Control rods in a single bank move together with no individual rod insertion differing by more than 24 steps from the bank demand position (operation at greater than 85 percent of rated power), nor more than 36 steps (operation at less than or equal to 85 percent of rated power). An indicated misalignment limit of 12 steps precludes a rod misalignment of greater than 24 steps with consideration of instrumentation error; 24 steps indicated misalignment corresponds to 36 steps with instrumentation error.

INCORPORATION OF PROPOSED CHANGES
TECHNICAL SPECIFICATIONS CHANGE REQUEST 206
INDIVIDUAL ROD POSITION INDICATION OPERABILITY
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

The attached pages reflect the incorporation of changes proposed to the current Point Beach Technical Specifications.

15.3.10 CONTROL ROD AND POWER DISTRIBUTION LIMITS

Applicability

Applies to the operation of the control rods and to core power distribution limits.

Objective

To insure (1) core subcriticality after a reactor trip, (2) a limit on potential reactivity insertions from a hypothetical rod cluster control assembly (RCCA) ejection, and (3) an acceptable core power distribution during power operation.

Specification

A. SHUTDOWN MARGIN

1. The shutdown margin shall exceed the applicable value as shown in Figure 15.3.10-2 under all steady-state operating conditions from 350°F to full power. If the shutdown margin is less than the applicable value of Figure 15.3.10-2, within 15 minutes initiate boration to restore the shutdown margin.

2. A shutdown margin of at least 1% $\Delta k/k$ shall be maintained when the reactor coolant temperature is less than 350°F. If the shutdown margin is less than this limit, within 15 minutes initiate boration to restore the shutdown margin.

B. ROD OPERABILITY AND BANK ALIGNMENT LIMITS

NOTE: One hour is allowed following rod motion prior to verifying rod operability and bank alignment limits.

1. During power and low power operation, all shutdown and control rods shall be operable and positioned within the allowed rod misalignment between the individual indicated rod positions and the bank demand position as follows;

   i) For operation ≤ 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±24 steps.
   ii) For operation > 85 percent of rated power, the allowed indicated misalignment between the bank demand position and the individual indicated rod position shall be ≤ ±12 steps.

   If an RCCA does not step in upon demand, up to six hours is allowed to determine whether the problem with stepping is an electrical problem. If the problem cannot be resolved within six hours, the RCCA shall be declared inoperable until it has been verified that it will step in or would drop upon demand.

   a. Rod Operability Requirements

(1) If one rod is determined to be untrippable, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; <u>OR</u>
(b) Within one hour restore the shutdown margin by boration; <u>OR</u>
(c) Within six hours be in hot shutdown.

(2) If sustained power operation with an untrippable rod is desired, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; <u>OR</u> within one hour restore the shutdown margin by boration; <u>AND</u>
(b) Within six hours, adjust the insertion limits to reflect the worth of the untrippable rod.

(c) If the above actions and associated completion times are not met, be in hot shutdown within six hours.

(3) If more than one rod is determined to be untrippable, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; <u>OR</u> within one hour restore the shutdown margin by boration; <u>AND</u>
(b) Within six hours be in hot shutdown.

b. <u>Rod Bank Alignment Limits</u>

(1) If it has been determined that one rod is not within alignment limits, and the indicated misalignment is not being caused by malfunctioning rod position indication, within one hour restore the rod to within alignment limits; <u>OR</u> perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; <u>OR</u> within one hour restore the shutdown margin by boration; <u>AND</u>

(b) Within eight hours reduce thermal power to ≤ 75 percent of rated thermal power;
AND

(c) Verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2 once per twelve hours;
AND

(d) Within 72 hours verify that measured values of FQ(Z) are within limits;
AND

(e) Within 72 hours verify that FNΔH is within limits;

(f) If the above actions and associated completion times are not met, be in hot shutdown within the following six hours.

(g) In order to subsequently increase thermal power above 75 percent of rated thermal power with the existing rod misalignment, perform an analysis to determine the hot channel factors and the resulting allowable power level in accordance with TS 15.3.10.E.

(2) If it has been determined that more than one rod is not within alignment limits and the misalignments are not being caused by malfunctioning rod position indication, perform the following actions:

(a) Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;
AND

(b) Be in hot shutdown within six hours.

C. ROD POSITION INDICATION

NOTE: Separate entry into TS 15.3.10.C.1.a, b, or c is allowed for each inoperable rod position indicator and each bank of demand position indication.

1. During power operation ≥ 10 percent of rated thermal power, the rod position indication system and the bank demand position indication system shall be operable.

a. If one or more rod position indicators (RPI) are determined to be inoperable, perform the following actions:

(1) Within eight hours verify the position of the rods with inoperable RPIs by using movable incore detectors;
AND

(2) Once per shift check the position of the rods with inoperable RPIs by using excore detectors, or thermocouples, or movable incore detectors;

(3) If the above actions and associated completion times are not met, perform the actions in accordance with TS 15.3.10.B.1.b.

b. If one or more rods with inoperable RPIs have been moved in excess of 24 steps in one direction since the last determination of the rod's position, perform the following actions:

(1) Within four hours check the position of the rods with inoperable RPIs by using excore detectors, or thermocouples, or movable incore detectors;

(2) If the above action and associated completion time is not met, perform the actions in accordance with TS 15.3.10.B.1.b.

c. If bank demand position indication, for one or more banks, is determined to be inoperable, perform the following actions:

(1) Once per shift verify that all RPIs for the affected banks are operable;
AND
(2) Once per shift verify that the most withdrawn rod and the least withdrawn rod of the affected banks are within the allowed rod misalignment in accordance with TS 15.3.10.B.1.

(3) If the above actions and associated completion times are not met, perform the actions in accordance with TS 15.3.10.B.1.b.

D. BANK INSERTION LIMITS

NOTE: One hour is allowed following rod motion prior to verifying bank insertion limits.

1. When the reactor is critical, the shutdown banks shall be fully withdrawn. Fully withdrawn is defined as a bank position equal to or greater than 225 steps. This definition is applicable to shutdown and control banks.

If this condition is not met, perform the following actions:

a. Within one hour verify that the shutdown margin exceeds the applicable value as shown in Figure 15.3.10-2; OR within one hour restore the shutdown margin by boration;

distribution viewpoint. If the misalignment condition cannot be readily corrected, the specified reduction in power to 75% will insure that design margins to core limits will be maintained under both steady-state and anticipated transient conditions. The eight (8) hour permissible limit on rod misalignment at rated power is short with respect to the probability of an independent accident.

The specifications of 15.3.10 ensure that (1) acceptable power distribution limits are maintained, (2) the minimum shutdown margin is maintained, and (3) the potential effects of rod misalignment on associated accident analyses are limited. Operability of the control rod position indicators is required to determine control rod position and thereby ensure compliance with the control rod alignment and insertion limits. Permitted control rod misalignments (as indicated by the RPI System within one hour after control rod motion) are; a) ±12 steps of the bank demand position (if power level is greater than 85 percent of rated power), and b) ±24 steps of the bank demand position (if the power level is less than or equal to 85 percent of rated power). For power levels less than or equal to 85 percent of rated power, the peaking factor margin does not have to be verified on an explicit basis. This is due to the rate of peaking factor margin increase (due to the peaking factor limit increasing) as the power level decreases being greater than the peaking factor margin loss (due to the increased control rod misalignment). This effect is described in WCAP-15432 Rev. 1. These limits are applicable to all shutdown and control rods (of all banks) over the range of 0 to 230 steps withdrawn inclusive.

The comparison of bank demand position and RPI System may take place at any time up to one hour after rod motion, at any power level. This allows up to one hour of thermal soak time to allow the control rod drive shaft to reach a thermal equilibrium and thus present a consistent position indication. A similar time period (up to one hour after rod motion) is allowed for comparison of the bank insertion limits and the RPI System. This comparison is sufficient to verify that the control rods are above the insertion limits and thus assures the presence of sufficient shutdown margin to satisfy the assumptions of the safety analyses.

The action statements which permit limited variation from the basic requirements are accompanied by additional restrictions which ensure that the original criteria are met. Actual misalignment of a rod requires measurement of peaking factors (to confirm acceptability) or a restriction in thermal power; either of these restrictions provides assurance of fuel rod integrity during continued operation. The reactivity worth of a misaligned rod is limited for the remainder of the fuel cycle to prevent exceeding the assumption used in the accident analysis.

The failure of an LVDT in itself does not reduce the shutdown capability of the rods, but it does reduce the operator's capability for determining the position of that rod by direct means. The operator has available to him the excore detector recordings, incore thermocouple readings and periodic incore flux traces for indirectly determining rod position and flux tilts should the rod with the inoperable LVDT become malpositioned. The excore and incore instrumentation will not necessarily recognize a misalignment of 24 steps because the concomitant increase in power density will normally be less than 1% for a 24 step misalignment. The excore and incore instrumentation will, however, detect any rod misalignment which is sufficient to cause a significant increase in hot channel factors and/or any significant loss in shutdown capability. The increased surveillance of the core if one or more rod position indicator channels is out-of-service serves to guard against any significant loss in shutdown margin or margin to core thermal limits.

The history of malpositioned RCCA's indicates that in nearly all such cases, the malpositioning occurred during bank movement. Checking rod position after bank motion exceeds 24 steps will verify that the RCCA with the inoperable LVDT is moving properly with its bank and the bank step counter. Malpositioning of an RCCA in a stationary bank is very rare, and if it does occur, it is usually gross slippage which will be seen by external detectors. Should it go undetected, the time between the rod position checks performed every shift is short with respect to the probability of occurrence of another independent undetected situation which would further reduce the shutdown capability of the rods.

Any combination of misaligned rods below 10% rated power will not exceed the design limits. For this reason, it is not necessary to check the position of rods with inoperable LVDTs below 10% power; plus, the incore instrumentation is not effective for determining rod position until the power level is above approximately 5%.

Power Distribution

During power operation, the global power distribution is limited by TS 15.3.10.E.2, "Axial Flux Difference," and TS 15.3.10.E.3, "Quadrant Power Tilt," which are directly and continuously measured process variables. These specifications, along with TS 15.3.10.D, "Bank Insertion Limits," maintain the core limits on power distributions on a continuous basis.

As a result of the increased peaking factors allowed by the new 422V+ fuel, a new column was added to TS 15.3.10.E.1.a. The full power $F^N_{\Delta H}$ peaking factor design limit (radial peaking factor) for 422V+ fuel will increase to 1.77 from the 1.70 value for the OFA fuel. The maximum $F_Q(Z)$ peaking factor limit (total peaking factor) for 422V+ fuel will increase to 2.60 from the 2.50 value for the OFA fuel. The OFA fuel design will retain the current $F^N_{\Delta H}$ and $F_Q(Z)$ peaking factors of 1.70 and 2.50, respectively. In addition, the K(Z) envelope for the new 422V+ fuel was modified and a new TS figure 15.3.10-3a was developed and inserted in the Technical Specifications. The K(Z) envelope in TS Figure 15.3.10-3 remains for the OFA fuel.

The purpose of the limits on the values of $F_Q(Z)$, the height dependent heat flux hot channel factor, is to limit the local 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.

$F_Q(Z)$ 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 steady state conditions.

The purpose of the limits on $F^N_{\Delta H}$, the nuclear enthalpy rise hot channel factor, is to ensure that the fuel design criteria are not exceeded and the accident analysis assumptions remain valid. The design limits on local and integrated fuel rod peak power density are expressed in terms of hot channel factors. Control of the core power distribution with respect to these factors ensures that local conditions in the fuel rods and coolant channels do not challenge core integrity at any location during either normal operation or a postulated accident analyzed in the safety analyses.

$F^N_{\Delta H}$, Nuclear Enthalpy Rise Hot Channel Factor, is defined as the ratio of the integral of linear power along a fuel rod to the average fuel rod power. Imposed limits pertain to the maximum $F^N_{\Delta H}$ in the core, that is the fuel rod with the highest integrated power. It should be noted that $F^N_{\Delta H}$ is based on an integral and is used as such in the DNB calculations. Local heat flux is obtained by using hot channel and adjacent channel explicit power shapes which take into account variations in horizontal (x-y) power shapes throughout the core. Thus, the horizontal power shape at the point of maximum heat flux is not necessarily directly related to $F^N_{\Delta H}$.

$F^N_{\Delta H}$ is sensitive to fuel loading patterns, bank insertion, and fuel burnup. $F^N_{\Delta H}$ typically increases with control bank insertion and typically decreases with fuel burnup.

$F^N_{\Delta H}$ is not directly measurable but is inferred from a power distribution map obtained with the movable incore detector system. Specifically, the results of the three dimensional power distribution map are analyzed by a computer to determine $F^N_{\Delta H}$. This factor is calculated at least monthly. However, during power operation, the global power distribution is monitored by TS 15.3.10.E.2, "Axial Flux Difference," and TS 15.3.10.E.3, "Quadrant Power Tilt," which address directly and continuously measured process variables.

It has been determined that, provided the following conditions are observed, the hot channel factor limits will be met:

1. Control rods in a single bank move together with no individual rod insertion differing by more than 24 steps from the bank demand position (operation at greater than 85 percent of rated power), nor more than 36 steps (operation at less than or equal to 85 percent of rated power). An indicated misalignment limit of 12 steps precludes a rod misalignment of greater than 24 steps with consideration of instrumentation error; 24 steps indicated misalignment corresponds to 36 steps with instrumentation error.

2. Control rod banks are sequenced with overlapping banks as described in Figure 15.3.10-1.

3. Control bank insertion limits are not violated.

4. Axial power distribution control procedures, which are given in terms of flux difference control and control bank insertion limits, are observed. Flux difference refers to the difference in signals between the top and bottom halves of two-section excore neutron detectors. The flux difference is a measure of the axial offset which is defined as the difference in normalized power between the top and bottom halves of the core.

The permitted relaxation of $F^N_{\Delta H}$ allows radial power shape changes with rod insertion to the insertion limits. It has been determined that provided the above four conditions are observed, these hot channel factor limits are met. In Specification 15.3.10.E.1.a, F_Q is arbitrarily limited for $p \leq 0.5$.

The upper bound envelope F_Q (defined in 15.3.10.E) times the normalized peaking factor axial dependence of Figure 15.3.10-3 for OFA and Upgraded OFA Fuel and Figure 15.3.10-3a for 422V+ Fuel (consistent with the Technical Specifications on power distribution control as given in Section 15.3.10) was used in the large and small break LOCA analyses. The envelope was determined based on allowable power density distributions at full power restricted to axial flux difference (ΔI) values consistent with those in Specification 15.3.10.E.2.

The results of the analyses based on this upper bound envelope indicate a peak clad temperature of less than the 2200°F limit. When an F_Q measurement is taken, both experimental error and manufacturing tolerance must be taken into account. Five percent is the appropriate allowance for a full core map taken with the moveable incore detector flux mapping system and three percent is the appropriate allowance for manufacturing tolerance. In the design limit of $F^N_{\Delta H}$, there is eight percent allowance for uncertainties which means that normal operation of the core is expected to result in a design $F^N_{\Delta H} \leq 1.70/1.08$ for OFA and Upgraded OFA fuel and 1.77/1.08 for 422V+ fuel. The logic behind the larger uncertainty in this case is as follows:

(a) Normal perturbations in the radial power shape (i.e., rod misalignment) affect $F^N_{\Delta H}$, in most cases without necessarily affecting F_Q.

(b) While the operator has a direct influence on F_Q through movement of rods, and can limit it to the desired value, he has no direct control over $F^N_{\Delta H}$.

(c) An error in the predictions for radial power shape which may be detected during startup physics tests can be compensated for in F_Q by tighter axial control; but compensation for $F^N_{\Delta H}$ is less readily available.

Measurements of the hot channel factors are required as part of startup physics tests, at least each full power month operation, and whenever abnormal power distribution conditions require a reduction of core power to a level based upon measured hot channel factors. The incore map taken following initial loading provides confirmation of the basic nuclear design bases including proper fuel loading patterns. The periodic monthly incore mapping provides additional assurance that the nuclear design bases remain inviolate and identify operational anomalies which would, otherwise, affect these bases.

The measured hot channel factors are increased as follows:

(a) The measurement of total peaking factor, F_Q^{meas}, shall be increased by three percent to account for manufacturing tolerance and further increased by five percent to account for measurement error.

(b) The measurement of enthalpy rise hot channel factor, $F^N_{\Delta H}$ shall be increased by four percent to account for measurement error.

Axial Power Distribution

The limits on axial flux difference (AFD) assure that the axial power distribution is maintained such that the $F_Q(Z)$ upper bound envelope of F_Q^{LIMIT} times the normalized axial peaking factor [K(Z)] is not exceeded during either normal operation or in the event of xenon redistribution following power changes. This ensures that the power distributions assumed in the large and small break LOCA analyses will bound those that occur during plant operation.

Provisions for monitoring the AFD on an automatic basis are derived from the plant process computer through the AFD monitor alarm. The computer determines the AFD for each of the operable excore channels and provides a computer alarm if the AFD for at least 2 of 4 or 2 of 3 operable excore channels are outside the AFD limits and the reactor power is greater than 50 percent of Rated Power.

Quadrant Tilt

The quadrant tilt limit ensures that the gross radial power distribution remains consistent with the design values used in the safety analyses. Precise radial power distribution measurements are made during startup testing, after refueling, and periodically during power operation.

The power density at any point in the core must be limited so that the fuel design criteria are maintained. Together, specifications associated with axial flux difference, quadrant tilt, and control rod insertion limits provide limits on process variables that characterize and control the three dimensional power distribution of the reactor core. Control of these variables ensures that the core operates within the fuel design criteria and that the power distribution remains within the bounds used in the safety analyses.

The excore detectors are somewhat insensitive to disturbances near the core center or on the major axes. It is therefore possible that a five percent tilt might actually be present in the core when the excore detectors respond with a two percent indicated quadrant tilt. On the other hand, they are overly responsive to disturbances near the periphery on the 45° axes.

Tilt restrictions are not applicable during the startup and initial testing of a reload core which may have an inherent tilt. During this time sufficient testing is performed at reduced power to verify that the hot channel factor limits are met and the nuclear channels are properly aligned. The excore detectors are normally aligned indicating no quadrant power tilt because they are used to alarm on a rapidly developing tilt. Tilts which develop slowly are more accurately and readily discerned by incore measurements. The excore detectors serve as the prime indication of a quadrant power tilt. If a channel fails, is out-of-service for testing, or is unreliable, two hours is a short time with respect to the probability of an unsafe quadrant power tilt developing. Two hours gives the operating personnel sufficient time to have the problem investigated and/or put into operation one of several possible alternative methods of determining tilt.

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The low power specification allows selected control and shutdown rods to be positioned outside of their specified alignment and insertion limits to conduct physics tests at low power. If power exceeds two percent, as indicated by nuclear instrumentation, during the performance of low power physics tests, the only acceptable action is to open the reactor trip breakers to prevent operation of the reactor beyond its design limits. Immediately opening the reactor trip breakers will shut down the reactor and prevent operation of the reactor outside of its design limits. If the RCS lowest loop average temperature falls below the minimum temperature for criticality, the temperature should be restored within 15 minutes because operation with the reactor critical and temperature below the minimum temperature for criticality could violate the assumptions for accidents analyzed in the safety analyses. If the temperature cannot be restored within 15 minutes, the plant must be made subcritical within an additional 15 minutes. This action will place the plant in a safe condition in an orderly manner without challenging plant systems.