B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.1 SHUTDOWN MARGIN (SDM)

BASES

BACKGROUND

According to GDC 26 (Ref. 1), the reactivity control systems must be redundant and capable of holding the reactor core subcritical when shut down under cold conditions. Maintenance of the SDM ensures that postulated reactivity events will not damage the fuel.

SDM requirements provide sufficient reactivity margin to ensure that acceptable fuel design limits will not be exceeded for normal shutdown and anticipated operational occurrences (AOOs). As such, the SDM defines the degree of subcriticality that would be obtained immediately following the insertion or scram of all shutdown and control RCCAs, assuming that the single RCCA of highest reactivity worth is fully withdrawn.

The system design requires that two independent reactivity control systems be provided, and that one of these systems be capable of maintaining the core subcritical under cold conditions. These requirements are provided by the use of movable control assemblies and soluble boric acid in the Reactor Coolant System (RCS). The Control Rod Drive Control System can compensate for the reactivity effects of the fuel and water temperature changes accompanying power level changes over the range from full load to no load. In addition, the Control Rod Drive Control System, together with the boration system, provides the SDM during power operation and is capable of making the core subcritical rapidly enough to prevent exceeding acceptable fuel damage limits, assuming that the RCCA of highest reactivity worth remains fully withdrawn. The soluble boron system can compensate for fuel depletion during operation and all xenon burnout reactivity changes and maintain the reactor subcritical under cold conditions.

When the unit is in MODE 1 or MODE 2 with the reactor critical, SDM control is ensured by operating with the shutdown banks fully withdrawn (LCO 3.1.5) and the control banks within the limits of LCO 3.1.6, "Control Bank Insertion Limits." When the unit is in MODE 2 with the reactor subcritical, SDM control is ensured by operating with the shutdown banks fully withdrawn and the control within the estimated critical condition which includes a target Control Bank D position. When the unit is in MODE 3, 4, 5, or 6, the SDM requirements are met by means of adjustments to the RCS boron concentration.

APPLICABLE SAFETY ANALYSES

The minimum required SDM is assumed as an initial condition in safety analyses. The safety analysis (Ref. 2) establishes a SDM that ensures specified acceptable fuel design limits are not exceeded for normal operation and AOOs, with the assumption of the highest worth rod stuck out on scram. For MODE 5, the primary safety analysis that relies on the SDM limits is the boron dilution analysis.

The acceptance criteria for the SDM requirements are that specified acceptable fuel design limits are maintained. This is done by ensuring that:

a. The reactor can be made subcritical from all operating conditions, AOOs, and postulated accidents;

b. The reactivity transients associated with postulated accident conditions are controllable within acceptable limits for the following:

    - Departure from nucleate boiling ratio (DNBR)
    - Fuel centerline temperature limits for AOOs
    - Energy deposition for the rod ejection accident based on the "Interim Acceptance Criterion and Guidance for Reactivity Initiated Accidents" contained Ref. 3; and

c. The reactor will be maintained sufficiently subcritical to preclude inadvertent criticality in the shutdown condition.

The most limiting accident for the SDM requirements is based on a main steam line break (MSLB), as described in the accident analysis (Ref. 2). The increased steam flow resulting from a pipe break in the main steam system causes an increased energy removal from the affected steam generator (SG), and consequently the RCS. This results in a reduction of the reactor coolant temperature. The resultant coolant shrinkage causes a reduction in pressure. In the presence of a negative moderator temperature coefficient, this cooldown causes an increase in core reactivity. As RCS temperature decreases, the severity of an MSLB decreases until MODE 5 is reached. The most limiting MSLB, with respect to potential fuel damage before a reactor trip occurs, is a guillotine break of a main steam line inside containment initiated at the end of core life. The positive reactivity addition from the moderator temperature decrease will terminate when the affected SG boils dry, thus terminating RCS heat removal and cooldown. Following the MSLB, a post trip return to power may occur; however, the SDM requirements serve to mitigate the potential for fuel damage as a result of the post trip return to power.

APPLICABLE SAFETY ANALYSES (continued)

In addition to the limiting MSLB transient, the SDM requirement must also protect against:

a. Inadvertent boron dilution;

b. An uncontrolled rod withdrawal from subcritical or low power condition;

c. Startup of an inactive reactor coolant pump (RCP); and

d. Rod ejection.

Each of these events is discussed below.

In the boron dilution analysis, the required SDM defines the reactivity difference between an initial subcritical boron concentration and the corresponding critical boron concentration. These values, in conjunction with the configuration of the RCS and the assumed dilution flow rate, directly affect the results of the analysis. This event is most limiting near the beginning of core life, when critical boron concentrations are highest.

Depending on the system initial conditions and reactivity insertion rate, the uncontrolled rod withdrawal transient may be terminated by either a Excore High Neutron Flux Rate of Change trip, low DNBR trip or a high pressurizer pressure trip. In all cases, power level, RCS pressure, linear heat rate, and the DNBR do not exceed allowable limits.

The startup of an inactive RCP will not result in a "cold water" criticality, even if the maximum difference in temperature exists between the SG and the core. The maximum positive reactivity addition that can occur due to an inadvertent RCP start is less than half the minimum required SDM. Startup of an idle RCP cannot, therefore, produce a return to power from the hot standby condition.

The ejection of a control rod rapidly adds reactivity to the reactor core, causing both the core power level and heat flux to increase with corresponding increases in reactor coolant temperatures and pressure. The ejection of a rod also produces a time dependent redistribution of core power.

APPLICABLE SAFETY ANALYSES (continued)

Even though it is not directly observed from the control room, SDM is considered an initial condition process variable because it is periodically monitored to ensure that the unit is operating within the bounds of accident analysis assumptions. Therefore, SDM satisfies Criterion 2 of 10 CFR 50.36(d)(2)(ii).

LCO

SDM is a core design condition that can be ensured during operation through control RCCApositioning (control and shutdown banks) and through the soluble boron concentration.

The MSLB and the boron dilution accidents (Ref. 2) are the most limiting analyses that establish the SDM value of the LCO. For MSLB accidents, if the LCO is violated, there is a potential to exceed the DNBR limit and to exceed SRP Section 15.0.1, "Radiological Consequences Analyses Using Alternative Source Terms," limits (Ref. 4). For the boron dilution accident, if the LCO is violated, the assumptions used to determine the anti-dilution PS setpoints may no longer be valid.

APPLICABILITY

In MODES 3, 4, and 5, the SDM requirements are applicable to provide sufficient negative reactivity to meet the assumptions of the safety analyses discussed above. In MODE 6, the shutdown reactivity requirements are given in LCO 3.9.1, "Boron Concentration."

In MODES 1 and 2 SDM is ensured by complying with LCO 3.1.5, "Shutdown Bank Insertion Limits," and LCO 3.1.6 "Control Bank Insertion Limits" or by operating with the shutdown banks fully withdrawn and the control within the estimated critical condition including a target Control Bank D position.

ACTIONS

A.1

If the SDM requirements are not met, boration must be initiated promptly. A Completion Time of 15 minutes is adequate for an operator to correctly align and start the required systems and components. It is assumed that boration will be continued until the SDM requirements are met.

In the determination of the required combination of boration flow rate and boron concentration, there is no unique requirement that must be satisfied. Since it is imperative to raise the boron concentration of the RCS as soon as possible, the boron concentration should be a highly concentrated solution, such as that normally found in the boric acid storage tank, extra boration system (EBS), or the In-containment Refueling Water Storage Tank (IRWST). The operator should borate with the best source available for the plant conditions.

ACTIONS (continued)

In determining the boration flow rate, the time in core life must be considered. For instance, the most difficult time in core life to increase the RCS boron concentration is at the beginning of cycle when the boron concentration may approach or exceed 1500 ppm. Assuming that a value of 1000 pcm must be recovered and a boration flow rate of 45 gpm, it is possible to increase the boron concentration of the RCS by 100 ppm in approximately 27 minutes. If a boron worth of 10 pcm/ppm is assumed, this combination of parameters will increase the SDM by 1000 pcm. These boration parameters of 45 gpm and 1000 ppm represent typical values and are provided for the purpose of offering a specific example.

SURVEILLANCE REQUIREMENTS

SR 3.1.1.1

In MODES 1 and 2, SDM is verified by observing that the requirements of LCO 3.1.5 and LCO 3.1.6 are met. In the event that a RCCA is known to be untrippable, however, SDM verification must account for the worth of the untrippable RCCA as well as another RCCA of maximum worth.

When the unit is in MODE 2 with the reactor subcritical, SDM control is ensured by operating with the shutdown banks fully withdrawn and the control bank within the estimated critical condition which includes a target Control Bank D position.

In MODES 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering the listed reactivity effects:

a. RCS boron concentration;

b. Control bank position;

c. RCS average temperature;

d. Fuel burnup based on gross thermal energy generation;

e. Xenon concentration;

f. Samarium concentration; and

g. Isothermal temperature coefficient (ITC).

BASES

SURVEILLANCE REQUIREMENTS (continued)

Using the ITC accounts for Doppler reactivity in this calculation because the reactor is subcritical and the fuel temperature will be changing at the same rate as the RCS.

The Frequency of 24 hours is based on the generally slow change in required boron concentration and the low probability of an accident occurring without the required SDM. This allows time for the operator to collect the required data, which includes performing a boron concentration analysis, and complete the calculation.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 26, August, 2007.
2. FSAR Chapter 15.
3. NUREG-0800 Section 4.2, Appendix B, March, 2007.

4 SRP Section 15.0.1, "Radiological Consequences Analyses Using Alternative Source Terms," July, 2000.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.2 Core Reactivity

BASES

BACKGROUND

According to GDC 26, GDC 28, and GDC 29 (Ref. 1), reactivity shall be controllable, such that subcriticality is maintained under cold conditions, and acceptable fuel design limits are not exceeded during normal operation and anticipated operational occurrences (AOOs). Therefore, reactivity balance is used as a measure of the predicted versus measured core reactivity during power and startup operation. The periodic confirmation of core reactivity is necessary to ensure that safety analyses for AOOs and postulated accidents remain valid. A large reactivity difference could be the result of unanticipated changes in fuel, RCCA worth, or operation at conditions not consistent with those assumed in the predictions of core reactivity, and could potentially result in a loss of SHUTDOWN MARGIN or violation of acceptable fuel design limits. Comparing predicted versus measured core reactivity validates the nuclear methods used in the safety analysis and supports the SDM demonstrations (LCO 3.1.1, "SHUTDOWN MARGIN (SDM)") in ensuring the reactor can be brought safely to cold, subcritical conditions.

When the reactor core is critical or in normal power operation, a reactivity balance exists and the net reactivity is zero. A comparison of predicted and measured reactivity is convenient under such a balance, since parameters are being maintained relatively stable under steady state power conditions. The positive reactivity inherent in the core design is balanced by the negative reactivity of the control components, thermal feedback, neutron leakage, and materials in the core that absorb neutrons, such as burnable absorbers producing zero net reactivity. Excess reactivity can be inferred from the boron letdown curve (or critical boron curve), which provides an indication of the soluble boron concentration in the Reactor Coolant System (RCS) versus cycle burnup. Periodic measurement of the RCS boron concentration for comparison with the predicted value with other variables fixed (such as RCCA height, temperature, pressure, and power), provides a convenient method of ensuring that core reactivity is within design expectations and that the calculational models used to generate the safety analysis are adequate.

In order to achieve the required fuel cycle energy output, the uranium enrichment, in the new fuel loading and in the fuel remaining from the previous cycle, provides excess positive reactivity beyond that required to sustain steady state operation throughout the cycle. When the reactor is critical at RTP and moderator temperature, the excess positive reactivity is compensated by burnable absorbers (if any), control rods, whatever neutron poisons (mainly xenon and samarium) are present in the fuel, and the RCS boron concentration.

BASES

BACKGROUND (continued)

When the core is producing THERMAL POWER, the fuel is being depleted and excess reactivity is decreasing. Burnable absorbers are also depleting, increasing excess reactivity. However, the fuel typically depletes at a faster rate for an overall decrease in the excess reactivity. As the fuel depletes and burnable absorbers deplete, the RCS boron concentration is adjusted to meet the requirements in the changing reactivity, maintaining a constant THERMAL POWER. The boron letdown curve is based on steady state operation at RTP. Therefore, deviations from the predicted boron letdown curve may indicate deficiencies in the design analysis, deficiencies in the calculational models, or abnormal core conditions, and must be evaluated.

APPLICABLE SAFETY ANALYSES

The acceptance criteria for core reactivity are that the reactivity balance limit ensures plant operation is maintained within the assumptions of the safety analyses.

Accurate prediction of core reactivity is either an explicit or implicit assumption in the accident analysis evaluations. Every accident evaluation (Ref. 2) is, therefore, dependent upon accurate evaluation of core reactivity. In particular, SDM and reactivity transients, such as control RCCA withdrawal accidents or rod ejection accidents, are very sensitive to accurate prediction of core reactivity. These accident analysis evaluations rely on computer codes that have been qualified against available test data, operating plant data, and analytical benchmarks. Monitoring reactivity balance additionally ensures that the nuclear methods provide an accurate representation of the core reactivity.

Design calculations and safety analyses are performed for each fuel cycle for the purpose of predetermining reactivity behavior and the RCS boron concentration requirements for reactivity control during fuel depletion.

The comparison between measured and predicted initial core reactivity provides normalization for the calculational models used to predict core reactivity. If the measured and predicted RCS boron concentrations for identical core conditions at beginning of cycle (BOC) do not agree, then the assumptions used in the reload cycle design analysis or the calculational models used to predict soluble boron requirements may not be accurate. If reasonable agreement between measured and predicted core reactivity exists at BOC, then the prediction may be normalized to the measured boron concentration. Thereafter, any significant deviations in the measured boron concentration from the predicted boron letdown curve that develop during fuel depletion may be an indication that the calculational model is not adequate for core burnups beyond BOC, or that an unexpected change in core conditions has occurred.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The normalization of predicted RCS boron concentration to the measured value is typically performed after reaching RTP following startup from a refueling outage, with the control rods in their normal positions for power operation. The normalization is performed at BOC conditions, so that core reactivity relative to predicted values can be continually monitored and evaluated as core conditions change during the cycle. Therefore, core reactivity satisfies Criterion 2 of 10 CFR 50.36(d)(2)(ii).

LCO

Long term core reactivity behavior is a result of the core physics design and cannot be easily controlled once the core design is fixed. During operation, therefore, the LCO can only be ensured through measurement and tracking, and appropriate actions taken as necessary. Large differences between actual and predicted core reactivity may indicate that the assumptions of the AOO and postulated accident analyses are no longer valid, or that the uncertainties in the Nuclear Design Methodology are larger than expected. Reactivity is sometimes expressed in units of Δk/k; however, alternative units for reactivity are %Δk/k[1] and pcm (percent millirho). The conversions between these units of reactivity are shown below.

$$1\% \frac{\Delta k}{k_1 * k_2} = 0.01 \frac{\Delta k}{k_1 * k_2}$$

$$1\ pcm = 0.00001 \frac{\Delta k}{k_1 * k_2}$$

A limit on the reactivity balance of ± 1000 pcm has been established based on engineering judgment. A 1000 pcm deviation in reactivity from that predicted is larger than expected for normal operation and should therefore be evaluated.

When measured core reactivity is within 1000 pcm of the predicted value at steady state thermal conditions, the core is considered to be operating within acceptable design limits. Since deviations from the limit are normally detected by comparing predicted and measured steady state RCS critical boron concentrations, the difference between measured and predicted values would be approximately 100 ppm (depending on the boron worth) before the limit is reached. These values are well within the uncertainty limits for analysis of boron concentration samples, so that spurious violations of the limit due to uncertainty in measuring the RCS boron concentration are unlikely.

[1] %Δk/(k_1*k_2) simplifies to %Δk/k if one of the reactivity conditions is assumed to be exactly critical (i.e. k = 1.0).

BASES

APPLICABILITY

The limits on core reactivity must be maintained during MODES 1 and 2 because a reactivity balance must exist when the reactor is critical or producing THERMAL POWER. As the fuel depletes, core conditions are changing, and confirmation of the reactivity balance ensures the core is operating as designed. This Specification does not apply in MODES 3, 4, and 5 because the reactor is shut down and the reactivity balance is not changing.

In MODE 6, fuel loading results in a continually changing core reactivity. Boron concentration requirements (LCO 3.9.1, "Boron Concentration") ensure that fuel movements are performed within the bounds of the safety analysis. An SDM demonstration is required after each refueling due to operations that could have altered core reactivity (e.g., fuel movement, control rod replacement, control rod shuffling).

ACTIONS

A.1 and A.2

Should an anomaly develop between measured and predicted core reactivity, an evaluation of the core design and safety analysis must be performed. Core conditions are evaluated to determine their consistency with input to design calculations. Measured core and process parameters are evaluated to determine that they are within the bounds of the safety analysis, and safety analysis calculational models are reviewed to verify that they are adequate for representation of the core conditions. The required Completion Time of 7 days is based on the low probability of a postulated accident occurring during this period, and allows sufficient time to assess the physical condition of the reactor and complete the evaluation of the core design and safety analysis.

Following evaluations of the core design and safety analysis, the cause of the reactivity anomaly may be resolved. If the cause of the reactivity anomaly is a mismatch in core conditions at the time of RCS boron concentration sampling, then a recalculation of the RCS boron concentration requirements may be performed to demonstrate that core reactivity is behaving as expected. If an unexpected physical change in the condition of the core has occurred, it must be evaluated and corrected, if possible. If the cause of the reactivity anomaly is in the calculation technique, then the calculational models must be revised to provide more accurate predictions. If any of these results are demonstrated, and it is concluded that the reactor core is acceptable for continued operation, then the boron letdown curve may be renormalized and power operation may continue. If operational restriction or additional SRs are necessary to ensure the reactor core is acceptable for continued operation, then they must be defined.

BASES

ACTIONS (continued)

The required Completion Time of 7 days is adequate for preparing operating restrictions or Surveillances that may be required to allow continued reactor operation.

B.1

If any required Action and associated Completion time cannot be met the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 6 hours. If the SDM for MODE 3 is not met, then compliance with Required Action A.1 of LCO 3.1.1.1 would result in a boration to restore SDM. The allowed Completion Time is reasonable, based on operating experience, for reaching MODE 3 from full power conditions in an orderly manner and without challenging plant systems

SURVEILLANCE REQUIREMENTS

SR 3.1.2.1

Core reactivity is verified by periodic comparisons of measured and predicted RCS boron concentrations. The comparison is made, considering that other core conditions are fixed or stable, including RCCA position, moderator temperature, fuel temperature, fuel depletion, xenon concentration, and samarium concentration. The Surveillance is performed prior to entering MODE 1 as an initial check on core conditions and design calculations at BOC. The SR is modified by a Note. The Note indicates that the normalization of predicted core reactivity to the measured value must take place within the first 60 effective full power days (EFPD) after each fuel loading. This allows sufficient time for core conditions to reach steady state, but prevents operation for a large fraction of the fuel cycle without establishing a benchmark for the design calculations. The required subsequent Frequency of 31 EFPD, following the initial 60 EFPD after entering MODE 1, is acceptable, based on the slow rate of core changes due to fuel depletion and the presence of other indicators (AZIMUTHAL POWER IMBALANCE, AXIAL OFFSET, etc.) for prompt indication of an anomaly.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 26, GDC 28, and GDC 29, August, 2007.
2. FSAR Chapter 15.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.3 Moderator Temperature Coefficient (MTC)

BASES

BACKGROUND

According to GDC 11 (Ref. 1), the reactor core and its interaction with the Reactor Coolant System (RCS) must be designed for inherently stable power operation, even in the possible event of an accident. In particular, the net reactivity feedback in the system must compensate for any unintended reactivity increases.

The MTC relates a change in core reactivity to a change in reactor coolant temperature (a positive MTC means that reactivity increases with increasing moderator temperature; conversely, a negative MTC means that reactivity decreases with increasing moderator temperature). The reactor is designed to operate with a negative MTC over the largest possible range of fuel cycle operation. Therefore, a coolant temperature increase will cause a reactivity decrease, so that the coolant temperature tends to return toward its initial value. Reactivity increases that cause a coolant temperature increase will thus be self limiting, and stable power operation will result.

MTC values are predicted at selected burnups during the safety evaluation analysis and are confirmed to be acceptable by measurements. Both initial and reload cores are designed so that the beginning of cycle (BOC) MTC is less than zero when THERMAL POWER is ≥ 50% RTP. The actual value of the MTC is dependent on core characteristics, such as fuel loading and reactor coolant soluble boron concentration. The core design may require additional fixed distributed poisons to yield an MTC at BOC within the range analyzed in the plant accident analysis. The end of cycle (EOC) MTC is also limited by the requirements of the accident analysis. Fuel cycles are evaluated to ensure that the MTC does not exceed the EOC limit.

The limitations on MTC are provided to ensure that the value of this coefficient remains within the limiting conditions assumed in the accident and transient analyses.

If the LCO limits are not met, the unit response during transients may not be as predicted. The core could violate criteria that prohibit a return to criticality, or the departure from nucleate boiling ratio criteria of the approved correlation may be violated, which could lead to a loss of the fuel cladding integrity.

BACKGROUND (continued)

The SRs for measurement of the MTC at the beginning and near the end of the fuel cycle are adequate to confirm that the MTC remains within its limits, since this coefficient changes slowly, due principally to the reduction in RCS boron concentration associated with fuel burnup.

APPLICABLE SAFETY ANALYSES

The acceptance criteria for the specified MTC are:

a. The MTC values must remain within the bounds of those used in the accident analysis (Ref. 2); and

b. The MTC must be such that inherently stable power operations result during normal operation and accidents, such as overheating and overcooling events.

FSAR Chapter 15 (Ref. 2), contains analyses of accidents that result in both overheating and overcooling of the reactor core. MTC is one of the controlling parameters for core reactivity in these accidents. Both the most positive value and most negative value of the MTC are important to safety, and both values must be bounded. Values used in the analyses consider worst case conditions to ensure that the accident results are bounding (Ref. 3).

The consequences of accidents that cause core overheating must be evaluated when the MTC is positive. Such accidents include the RCCA withdrawal transient from either zero or RTP, loss of main feedwater flow, and loss of forced reactor coolant flow. The consequences of accidents that cause core overcooling must be evaluated when the MTC is negative. Such accidents include sudden feedwater flow increase and sudden decrease in feedwater temperature.

In order to ensure a bounding accident analysis, the MTC is assumed to be its most limiting value for the analysis conditions appropriate to each accident. The bounding value is determined by considering rodded and unrodded conditions, whether the reactor is at full or zero power, and whether it is the BOC or EOC life. The most conservative combination appropriate to the accident is then used for the analysis (Ref. 2).

MTC values are bounded in reload safety evaluations assuming steady state conditions at BOC and EOC. An EOC measurement is conducted at conditions when the RCS boron concentration reaches approximately 150 ppm. The measured value may be extrapolated to project the EOC value, in order to confirm reload design predictions. MTC satisfies Criterion 2 of 10 CFR 50.36(d)(2)(ii).

BASES

LCO

LCO 3.1.3 requires the MTC to be within specified limits of the COLR to ensure that the core operates within the assumptions of the accident analysis. During the reload core safety evaluation, the MTC is analyzed to determine that its values remain within the bounds of the original accident analysis during operation.

Assumptions made in safety analyses require that the MTC be less positive than a given upper bound and more positive than a given lower bound. The MTC is most positive at BOC; this upper bound must not be exceeded. This maximum upper limit occurs at BOC, all rods out (ARO), hot zero power conditions. At EOC the MTC takes on its most negative value, when the lower bound becomes important. This LCO exists to ensure that both the upper and lower bounds are not exceeded.

During operation, therefore, the conditions of the LCO can only be ensured through measurement. The Surveillance checks at BOC and EOC on MTC provide confirmation that the MTC is behaving as anticipated so that the acceptance criteria are met.

The LCO establishes a maximum positive value that cannot be exceeded. The BOC positive (upper) limit and the EOC negative (lower) limit are established in the COLR to allow specifying limits for each particular cycle. This permits the unit to take advantage of improved fuel management and changes in unit operating schedule.

APPLICABILITY

Technical Specifications place both LCO and SR values on MTC, based on the safety analysis assumptions described above.

In MODE 1, the limits on MTC must be maintained to ensure that any accident initiated from THERMAL POWER operation will not violate the design assumptions of the accident analysis. In MODE 2 with the reactor critical, the upper limit must also be maintained to ensure that startup and subcritical accidents (such as the uncontrolled control rod assembly or group withdrawal) will not violate the assumptions of the accident analysis. The lower MTC limit must be maintained in MODES 2 and 3, in addition to MODE 1, to ensure that cooldown accidents will not violate the assumptions of the accident analysis. In MODES 4, 5, and 6, this LCO is not applicable, since no postulated accidents using the MTC as an analysis assumption are initiated from these MODES.

ACTIONS

A.1

If the upper MTC limit is violated, administrative withdrawal limits for control banks must be established to maintain the MTC within its limits. The MTC becomes more negative with control bank insertion and decreased boron concentration. A Completion Time of 24 hours provides enough time for evaluating the MTC measurement and computing the required bank withdrawal limits.

As cycle burnup is increased, the RCS boron concentration generally decreases. The reduced boron concentration causes the MTC to become more negative. Using physics calculations, the time in cycle life at which the calculated MTC will meet the LCO requirement can be determined. At this point in core life Condition A no longer exists. The unit is no longer in the Required Action, so the administrative withdrawal limits are no longer in effect.

B.1

If the required administrative withdrawal limits at BOC are not established within 24 hours, the unit must be brought to MODE 2 with $k_{eff} < 1.0$ to prevent operation with an MTC that is more positive than that assumed in safety analyses.

The allowed Completion Time of 6 hours is reasonable, based on operating experience, for reaching the required MODE from full power conditions in an orderly manner and without challenging plant systems.

C.1

Exceeding the lower MTC limit means that the assumptions used in safety analysis of EOC accidents that require a bounding negative MTC may not be valid. If the EOC MTC limit is exceeded, the plant must be brought to a MODE or condition in which the LCO requirements are not applicable. To achieve this status, the unit must be brought to at least MODE 4 within 12 hours.

The allowed Completion Time is reasonable, based on operating experience, for reaching the required MODE from full power conditions in an orderly manner and without challenging plant systems.

The SR is performed prior to EOC conditions to ensure that the EOC MTC limit is not exceeded.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.3.1

This SR requires measurement of the MTC at BOC prior to entering MODE 1 after each refueling in order to demonstrate compliance with the most positive MTC LCO. Meeting the requirements of ANS/ANSI-19.6.1-2005 prior to entering MODE 1 ensures that this LCO for the positive MTC limit are met at other reactivity or power conditions by validating the accuracy of the physics predictions over the entire cycle.

The BOC (upper) MTC value for ARO will be inferred from isothermal temperature coefficient measurements obtained during the physics tests after refueling. The ARO value can be directly compared to the BOC MTC limit of the LCO. If required, measurement results and predicted design values can be used to establish administrative withdrawal limits for control banks.

SR 3.1.3.2

In similar fashion, the LCO demands that the MTC be less negative than the specified value at the EOC full power conditions. The EOC MTC measurement may be performed at any THERMAL POWER, but the results must be extrapolated to the conditions at RTP with all banks withdrawn with the expected EOC boron concentration. This is required to have a valid comparison with the LCO value. Because the RTP MTC value gradually becomes more negative with higher core exposure and a decrease in boron concentration the projected EOC MTC may be evaluated before the reactor actually reaches the EOC condition. Performing the Surveillance upon reaching 2/3 of expected projected burnup minimizes the extrapolation errors while providing sufficient warning prior to reaching the EOL (lower) MTC limit. MTC values must be extrapolated and compensated to permit direct comparison to the specified MTC limits.

SR 3.1.3.2 is modified by a Note, which indicates that if the extrapolated MTC is more negative than the EOC COLR limit, the Surveillance must be repeated, and that shutdown must occur prior to exceeding the minimum allowable boron concentration at which MTC is projected to exceed the lower limit.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 11, August, 2007.
2. FSAR Chapter 15.
3. ANSI/ANS-19.6.1-2005, Reload Startup Physics Tests For Pressurized Reactors.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.4 Rod Control Cluster Assembly (RCCA) Group Alignment Limits

BASES

BACKGROUND

The OPERABILITY (i.e., trippability) of the shutdown and control RCCAs is an initial assumption in all safety analyses that assume RCCA insertion upon reactor trip. Maximum RCCA misalignment is an initial assumption in the safety analysis that directly affects core power distributions and assumptions of available SHUTDOWN MARGIN (SDM).

The applicable criteria for these reactivity and power distribution design requirements are 10 CFR 50, Appendix A, GDC 10, "Reactor Design," GDC 26, "Reactivity Control System Redundancy and Capability" (Ref. 1), and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Plants" (Ref. 2).

Mechanical or electrical failures may cause a control or shutdown RCCA to become inoperable or to become misaligned from its group. RCCA inoperability or misalignment may cause increased power peaking, due to the asymmetric reactivity distribution and a reduction in the total available RCCA worth for reactor shutdown. Therefore, RCCA alignment and OPERABILITY are related to core operation in design power peaking limits and the core design requirement of a minimum SDM.

Limits on RCCA alignment have been established, and all RCCA positions are monitored and controlled during power operation to ensure that the power distribution and reactivity limits defined by the design power peaking and SDM limits are preserved.

Rod cluster control assemblies (RCCAs), or rods, are moved by their control rod drive mechanisms (CRDMs). Each CRDM moves its RCCA one step (1 step = 10 mm ~ ⅜ inch) at a time, but at varying rates (steps per minute) depending on the signal output from the Reactor Control, Surveillance, and Limitation System (RCSL).

The RCCAs are divided among control banks and shutdown banks. Each bank may be further subdivided into two groups to provide for precise reactivity control. A group consists of two or more RCCAs that are electrically paralleled to step simultaneously. If a bank of RCCAs consists of two groups, the groups are moved in a staggered fashion, but always within one step of each other. There are four control banks and three shutdown banks.

BASES

BACKGROUND (continued)

The shutdown banks are maintained either in the fully inserted or fully withdrawn position. The control banks are moved in an overlap pattern, using the following withdrawal sequence: When control bank A reaches a predetermined height in the core, control bank B begins to move out with control bank A. Control bank A stops at the position of maximum withdrawal, and control bank B continues to move out. When control bank B reaches a predetermined height, control bank C begins to move out with control bank B. This sequence continues until control banks A, B, and C are at the fully withdrawn position, and control bank D is approximately halfway withdrawn. The insertion sequence is the opposite of the withdrawal sequence. The control RCCAs are arranged in a radially symmetric pattern, so that control bank motion does not introduce radial asymmetries in the core power distributions.

The axial position of shutdown RCCAs and control RCCAs is indicated by two separate and independent indicators, which are the Digital RCCA Position Indication (commonly called group step counters) and the Analog RCCA Position Indication.

The Digital RCCA Position Indication counts the pulses from the Control Rod Drive Control System that moves the RCCAs. The Digital RCCA Position Indication tracks individual RCCA positions and can display the individual RCCA position or the position for each group of RCCAs. Individual RCCAs in a group all receive the same signal to move and should, therefore, all be at the same position indicated by the group position. The Digital RCCA Position Indication is considered highly precise (1 step = 10 mm ~ ⅜ inch). If a RCCA does not move one step for each demand pulse, the Digital RCCA Position Indication may still count the pulse and incorrectly reflect the position of the RCCA.

The Analog RCCA Position Indication provides a totally independent indication of actual RCCA position, but at a lower precision than the step counters. This indicator is based on inductive analog signals from a series of coils spaced along a hollow tube. The Analog RCCA Position Indication is capable of measuring RCCA position within at least ± 8 steps.

APPLICABLE SAFETY ANALYSES

LCO 3.1.4 is required to ensure compliance with the control RCCA alignment and insertion limits established for anticipated operational occurrences (AOOs), and postulated accident conditions.

Control RCCA misalignment events are analyzed in the safety analysis (Ref. 3). The acceptance criteria for addressing control RCCA inoperability or misalignment are that:

BASES

APPLICABLE SAFETY ANALYSES (continued)

a. There will be no violations of:

   1. Specified acceptable fuel design limits; or

   2. Reactor Coolant System (RCS) pressure boundary integrity; and

b. The core remains subcritical after AOOs and postulated accidents.

Two types of misalignment are distinguished. During movement of a control RCCA group, one RCCA may stop moving, while the other RCCAs in the group continue. This condition may cause excessive power peaking. The second type of misalignment occurs if one RCCA fails to insert upon a reactor trip and remains stuck fully withdrawn. This condition requires an evaluation to determine that sufficient reactivity worth is held in the control RCCAs to meet the SDM requirement, with the maximum worth RCCA stuck fully withdrawn.

Analysis is performed as follows with regard to static RCCA misalignment (Ref. 3). With the control banks at their insertion limit and again at the bite position, a power distribution is created at every combination of one and two RCCAs inserted and withdrawn 20 steps from the bank position. Satisfying limits on departure from nucleate boiling ratio in these cases bounds the situation when RCCAs are misaligned from their group by 8 steps. It is assumed that no physical mechanism can cause more than two RCCAs to be misaligned at one time within the time frame between SPND CALIBRATIONS.

Another type of misalignment occurs if one RCCA fails to insert upon a reactor trip and remains stuck fully withdrawn. This condition is assumed in the evaluation to determine that the required SDM is met with the maximum worth RCCA also fully withdrawn (Ref. 3).

The Required Actions in this LCO ensure that either deviations from the alignment limits will be corrected or that THERMAL POWER will be adjusted so that excessive local linear power densities will not occur, and that the requirements on SDM and ejected rod worth are preserved.

BASES

APPLICABLE SAFETY ANALYSES (continued)

Continued operation of the reactor with a misaligned control RCCA is allowed if the limits on AXIAL OFFSET (AO), AZIMUTHAL POWER IMBALANCE (API), Departure from Nucleate Boiling Ratio (DNBR), and Linear Power Density (LPD) are verified to be within their limits and the safety analysis is verified to remain valid. When a control RCCA is misaligned, the assumptions that are used to determine the rod insertion limits, AO limits, and API limits are not preserved. Therefore, the limits may not preserve the design peaking factors, and the self powered neutron detectors (SPNDs) must be used to verify limits. Bases Section 3.2 (Power Distribution Limits) contains more complete discussions of the operating limits.

Shutdown and control RCCA OPERABILITY and alignment are directly related to power distributions and SDM, which are initial conditions assumed in the safety analyses. Therefore, they satisfy Criterion 2 of 10 CFR 50.36(d)(2)(ii).

LCO

The limits on shutdown or control RCCA alignments ensure that the assumptions in the safety analysis will remain valid. The requirements on control RCCA OPERABILITY ensure that upon reactor trip, the assumed reactivity will be available and will be inserted. The control RCCA OPERABILITY requirements (i.e., trippability) are separate from the alignment requirements, which ensure that the RCCAs and banks maintain the correct power distribution and RCCA alignment. The RCCA OPERABILITY requirement is satisfied provided the RCCA will fully insert in the required RCCA drop time assumed in the safety analysis. RCCA control malfunctions that result in the inability to move a RCCA (e.g., RCCA lift coil failures), but that do not impact trippability, do not result in RCCA inoperability.

The requirement to maintain the RCCA alignment to within plus or minus 8 steps is conservative. The minimum misalignment assumed in safety analysis is 20 steps (~8 inches), and in some cases a total misalignment from fully withdrawn to fully inserted is assumed.

Failure to meet the requirements of this LCO may produce unacceptable power peaking factors and LPDs, or unacceptable SDMs, all of which may constitute initial conditions inconsistent with the safety analysis.

BASES

APPLICABILITY

The requirements on RCCA OPERABILITY and RCCA alignment are applicable in MODES 1 and 2 because these are the only MODES in which neutron (or fission) power is generated, and the OPERABILITY (i.e., trippability) and alignment of RCCAs have the potential to affect the safety of the plant. In MODES 3, 4, 5, and 6, the alignment limits do not apply because the control RCCAs are fully inserted and the reactor is shut down and not producing fission power. In the shutdown MODES, the OPERABILITY of the shutdown and control RCCAs have the potential to affect the required SDM, but this effect can be compensated for by an increase in the boron concentration of the RCS. See LCO 3.1.1, "SHUTDOWN MARGIN (SDM)," for SDM in MODES 3, 4, and 5 and LCO 3.9.1, "Boron Concentration," for boron concentration requirements during refueling.

ACTIONS

A.1.1 and A.1.2

When one or more RCCAs are inoperable (i.e., untrippable), there is a possibility that the required SDM may be adversely affected. Under these conditions, it is important to determine the SDM, and if it is less than the required value, initiate boration until the required SDM is recovered. The Completion Time of 1 hour is adequate for determining SDM and, if necessary, for initiating emergency boration and restoring SDM.

In this situation, SDM verification must include the worth of the untrippable RCCA, as well as an RCCA of maximum worth stuck out of the core.

A.2

When one or more RCCAs are inoperable the plant must be brought to a MODE or condition in which the LCO requirements are not applicable. To achieve this status, the unit must be brought to at least MODE 3 within 6 hours.

The allowed Completion Time is reasonable, based on operating experience, for reaching MODE 3 from full power conditions in an orderly manner and without challenging plant systems.

BASES

ACTIONS (continued)

B.1.1 and B.1.2

With one misaligned RCCA, SDM must be verified to be within limit or boration must be initiated to restore SDM to within limit.

In many cases, realigning the remainder of the group to the misaligned RCCA may not be desirable. For example, realigning control bank B to a RCCA that is misaligned 15 steps from the top of the core would require a significant power reduction, since control bank D must be moved fully in and control bank C must be moved in to approximately 100 to 115 steps.

Power operation may continue with one RCCA trippable but misaligned, provided that SDM is verified within 1 hour. The Completion Time of 1 hour represents the time necessary for determining the actual unit SDM and, if necessary, aligning and starting the necessary systems and components to initiate boration.

B.2, B.3, B.4, and B.5

For continued operation with one misaligned RCCA, RTP must be reduced, SDM must periodically be verified within limits, LPD, DNBR, AO, and API must be verified within limits, and the safety analyses must be re-evaluated to confirm continued operation is permissible.

Reduction of power to ≤50% RTP ensures that local power density increases due to a misaligned RCCA will not cause the core design criteria to be exceeded (Ref. 1). The Completion Time of 2 hours gives the operator sufficient time to accomplish an orderly power reduction without challenging the Protection System (PS).

When a RCCA is known to be misaligned, there is a potential to impact the SDM. Since the core conditions can change with time, periodic verification of SDM is required. A Frequency of 12 hours is sufficient to ensure this requirement continues to be met.

ACTIONS (continued)

Performing a flux map using the Aeroball Measurement System, and calibrating the self powered neutron detectors ensures that the SPND constants are updated to reflect any localized power redistributions. This ensures that accurate monitoring of the LPD, DNBR, and AO is maintained. The Completion Time of 12 hours allows sufficient time to obtain an Aeroball Measurement Map and to incorporate calibration constants.

Once current conditions have been verified acceptable, time is available to perform evaluations of accident analysis to determine that core limits will not be exceeded during an AOO or postulated for the duration of operation under these conditions. The accident analyses presented in Chapter 15 (Ref. 3) that may be adversely affected will be evaluated to ensure that the analysis results remain valid for the duration of continued operation under these conditions. A Completion Time of 5 days is sufficient time to obtain the required input data and to perform the analysis.

C.1

When Required Actions cannot be completed within their Completion Time of Condition B, the unit must be brought to a MODE or Condition in which the LCO requirements are not applicable. To achieve this status, the unit must be brought to MODE 3 within 6 hours. The allowed Completion Time of 6 hours is reasonable, based on operating experience, for reaching MODE 3 from full power conditions in an orderly manner and without challenging the plant systems.

D.1.1 and D.1.2

More than one control RCCA becoming misaligned from its group average position is not expected, and has the potential to reduce SDM. Therefore, SDM must be evaluated. One hour allows the operator adequate time to determine SDM. Restoration of the required SDM, if necessary, requires increasing the RCS boron concentration to provide negative reactivity, as described in the Bases or LCO 3.1.1. The required Completion Time of 1 hour for initiating boration is reasonable, based on the time required for potential xenon redistribution, the low probability of an accident occurring, and the steps required to complete the action. This allows the operator sufficient time to align the required valves and start the boric acid pumps. Boration will continue until the required SDM is restored.

BASES

ACTIONS (continued)

D.2

If more than one RCCA is found to be misaligned or becomes misaligned because of bank movement, the unit conditions fall outside of the accident analysis assumptions. Since automatic bank sequencing would continue to cause misalignment, the unit must be brought to a MODE or Condition in which the LCO requirements are not applicable. To achieve this status, the unit must be brought to MODE 3 within 6 hours.

The allowed Completion Time is reasonable, based on operating experience, for reaching MODE 3 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.1.4.1

Verification that individual RCCA positions are within alignment limits at a Frequency of 12 hours provides a history that allows the operator to detect a RCCA that is beginning to deviate from its expected position. The specified Frequency takes into account other RCCA position information that is continuously available to the operator in the control room, so that during actual RCCA motion, deviations can immediately be detected.

SR 3.1.4.2

Verifying each control RCCA is OPERABLE would require that each RCCA be tripped. However, in MODES 1 and 2 with $k_{eff} \geq 1.0$, tripping each control RCCA would result in azimuthal or axial power tilts, or oscillations. Exercising each individual control RCCA every 92 days provides increased confidence that all RCCAs continue to be OPERABLE without exceeding the alignment limit, even if they are not regularly tripped. Moving each control RCCA by 16 steps will not cause radial or axial power tilts, or oscillations, to occur. The 92 day Frequency takes into consideration other information available to the operator in the control room and SR 3.1.4.1, which is performed more frequently and adds to the determination of OPERABILITY of the RCCAs. Between required performances of SR 3.1.4.2 (determination of control RCCA OPERABILITY by movement), if a control RCCA(s) is discovered to be immovable, but remains trippable, the control RCCA(s) is considered to be OPERABLE. At any time, if a control RCCA(s) is immovable, a determination of the trippability (OPERABILITY) of the control RCCA(s) must be made and appropriate action taken.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.1.4.3

Verification of RCCA drop times allows the operator to determine that the maximum RCCA drop time permitted is consistent with the assumed RCCA drop time used in the safety analysis. Measuring RCCA drop times prior to reactor criticality, after each reactor vessel head removal, ensures that the reactor internals and rod drive mechanism will not interfere with RCCA motion or RCCA drop time, and that no degradation in these systems has occurred that would adversely affect control RCCA motion or drop time. This testing is performed with all RCPs operating and the average moderator temperature ≥ 500°F to simulate a reactor trip under actual conditions. Performing rod drop testing at less the temperature specified for hot zero power is conservative due to increased reactor coolant density at lower temperature and the associated increase in rod drop resistance.

This Surveillance is performed prior to criticality after each removal of the reactor head, due to the plant conditions needed to perform the SR and the potential for an unplanned plant transient if the Surveillance were performed with the reactor at power.

REFERENCES

1. 10 CFR 50, Appendix A, August, 2007.
2. 10 CFR 50.46, August, 2007.
3. FSAR Chapter 15.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.5 Shutdown Bank Insertion Limits

BASES

BACKGROUND

The insertion limits of the shutdown bank Rod Control Cluster Assemblies (RCCAs) are initial assumptions in all safety analyses that assume rod insertion upon reactor trip. The insertion limits directly affect core power and fuel burnup distributions and assumptions of available ejected rod worth, SHUTDOWN MARGIN (SDM) and initial reactivity insertion rate.

The applicable criteria for these reactivity and power distribution design requirements are 10 CFR 50, Appendix A, GDC 10, "Reactor Design," GDC 26, "Reactivity Control System Redundancy and Protection," GDC 28, "Reactivity Limits" (Ref. 1), and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors" (Ref. 2). Limits on control rod insertion have been established, and all rod positions are monitored and controlled during power operation to ensure that the power distribution and reactivity limits defined by the design power peaking and SDM limits are preserved.

The RCCAs are divided among four control banks and three shutdown banks. Each shutdown bank may be further subdivided into groups to provide for precise reactivity control. A group consists of two or more RCCAs that are electrically paralleled to step simultaneously. A bank of RCCAs consists of two groups that are moved in a staggered fashion, but always within one step of each other. See LCO 3.1.4, "RCCA Group Alignment Limits," for RCCA alignment requirements, LCO 3.1.6, "Control Bank Insertion Limits," for control bank insertion limits, LCO 3.1.7 "RCCA Position Indication for position indication requirements.

The shutdown banks are fully withdrawn without the core going critical. This provides available negative reactivity in the event of boration errors. The shutdown banks are controlled manually by the control room operator. During normal unit operation, the shutdown banks are either fully withdrawn or fully inserted. The shutdown banks must be completely withdrawn from the core, prior to withdrawing any control banks during an approach to criticality. The shutdown banks are then left in this position until the reactor is shut down. Since the shutdown banks are fully withdrawn, they do not affect core power and burnup distribution, but will add negative reactivity to shut down the reactor upon receipt of a reactor trip signal.

BASES

APPLICABLE SAFETY ANALYSES

On a reactor trip, all RCCAs (shutdown banks and control banks), except the most reactive RCCA, are assumed to insert into the core. The shutdown banks shall be at or above their insertion limits and available to insert the maximum amount of negative reactivity on a reactor trip signal. The control banks may be partially inserted in the core, as allowed by LCO 3.1.6, "Control Bank Insertion Limits." The shutdown bank and control bank insertion limits are established to ensure that a sufficient amount of negative reactivity is available to shut down the reactor and maintain the required SDM (see LCO 3.1.1, "SHUTDOWN MARGIN (SDM)") following a reactor trip from full power. The combination of control banks and shutdown banks (less the most reactive RCCA, which is assumed to be fully withdrawn) is sufficient to take the reactor from 100% RTP conditions at rated temperature to 0% RTP, and to maintain the required SDM at rated no load temperature (Ref. 3). The shutdown bank insertion limit ensures that the shutdown banks do not need to be considered in a control rod ejection event analysis.

The acceptance criteria for addressing shutdown and control rod bank insertion limits and inoperability or misalignment is that:

a. There are no violations of:

    1. Specified acceptable fuel design limits; or

    2. RCS pressure boundary integrity; and

b. The core remains subcritical after accident transients.

As such, the shutdown bank insertion limits affect safety analysis involving core reactivity and SDM (Ref. 3).

The shutdown bank insertion limits preserve an initial condition assumed in the safety analyses and, as such, satisfy Criterion 2 of 10 CFR 50.36(d)(2)(ii).

LCO

The shutdown banks must be within their insertion limits any time the reactor is critical or approaching criticality. This ensures that a sufficient amount of negative reactivity is available to shut down the reactor and maintain the required SDM following a reactor trip.

The shutdown bank insertion limits are defined in the COLR.

BASES

APPLICABILITY

The shutdown banks must be within their insertion limits, with the reactor in MODES 1 and 2. This ensures that a sufficient amount of negative reactivity is available to shut down the reactor and maintain the required SDM following a reactor trip. The shutdown banks do not have to be within their insertion limits in MODE 3, unless an approach to criticality is being made. In other conditions in MODE 3 and MODE 4, 5, or 6, the shutdown banks are fully inserted in the core and contribute to the SDM. Refer to LCO 3.1.1 for SDM requirements in MODES 3, 4, and 5. LCO 3.9.1, "Boron Concentration," ensures adequate SDM in MODE 6.

The Applicability requirements have been modified by a Note indicating the LCO requirement is suspended during SR 3.1.4.2. This SR verifies the freedom of the rods to move, and requires the shutdown bank to move below the LCO limits, which would normally violate the LCO.

ACTIONS

A.1.1, A.1.2, and A.2

When one or more shutdown banks are not within insertion limits, 2 hours is allowed to restore the shutdown banks to within the insertion limits. This is necessary because the available SDM may be significantly reduced, with one or more of the shutdown banks not within their insertion limits. Also, verification of SDM or initiation of boration within 1 hour is required, since the SDM in MODES 1 and 2 is ensured by adhering to the control and shutdown bank insertion limits (see LCO 3.1.1). If shutdown banks are not within their insertion limits, then SDM will be verified by performing a reactivity balance calculation, considering the effects listed in the Bases for SR 3.1.1.1.

The allowed Completion Time of 2 hours provides an acceptable time for evaluating and repairing minor problems without allowing the plant to remain in an unacceptable condition for an extended period of time.

B.1

If any required Action and associated Completion Time is not met, the unit must be brought to a MODE where the LCO is not applicable. The allowed Completion Time of 6 hours is reasonable, based on operating experience, for reaching the required MODE from full power conditions in an orderly manner and without challenging plant systems.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.5.1

Verification that the shutdown banks are within their insertion limits 4 hours prior to an approach to criticality ensures that when the reactor is critical, or being taken critical, the shutdown banks will be available to shut down the reactor, and the required SDM will be maintained following a reactor trip. This SR and Frequency ensure that the shutdown banks are withdrawn before the control banks are withdrawn during a unit startup.

Since the shutdown banks are positioned manually by the control room operator, a verification of shutdown bank position at a Frequency of 12 hours is adequate to ensure that they are within their insertion limits. Also, the 12 hour Frequency takes into account other information available in the control room for the purpose of monitoring the status of shutdown rods.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 10, GDC 26, and GDC 28, August, 2007.
2. 10 CFR 50.46, August, 2007.
3. FSAR Chapter 15.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.6 Control Bank Insertion Limits

BASES

BACKGROUND

The insertion limits of the Control Bank Rod Cluster Control Assemblies (RCCAs) are initial assumptions in all safety analyses that assume RCCA insertion upon reactor trip. The insertion limits directly affect core power distributions, assumptions of available SHUTDOWN MARGIN (SDM), and initial reactivity insertion rate.

The applicable criteria for these reactivity and power distribution design requirements are 10 CFR 50, Appendix A, GDC 10, "Reactor Design," and GDC 26, "Reactivity Limits" (Ref. 1), and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors" (Ref. 2). Limits on Control Bank RCCA insertion have been established, and all RCCA positions are monitored and controlled during power operation to ensure that the power distribution and reactivity limits defined by the design power peaking, ejected RCCA worth, reactivity insertion rate, and SDM limits are preserved.

The RCCAs are divided among four control banks and three shutdown banks. Each shutdown bank may be further subdivided into groups to provide for precise reactivity control. A group consists of two or more RCCAs that are electrically paralleled to step simultaneously. A bank of RCCAs consists of two groups that are moved in a staggered fashion, but always within one step of each other. See LCO 3.1.4, "RCCA Group Alignment Limits," for RCCA OPERABILITY and alignment requirements, LCO 3.1.5, "Shutdown Bank Insertion Limits" for shutdown bank insertion limits, and LCO 3.1.7, "RCCA Position Indication" for position indication requirements.

The Control Bank RCCA groups operate with a predetermined amount of position overlap, in order to approximate a linear relation between RCCA worth and position (integral RCCA worth). The Control Bank RCCA groups are withdrawn and operate in a predetermined sequence. The control bank RCCA group sequence and overlap limits are specified in the COLR.

The control banks are used for precise reactivity control of the reactor. The positions of the control banks are normally automatically controlled by the Reactor Control, Surveillance, and Limitation System (RCSL), but they can also be manually controlled. They are capable of adding negative reactivity very quickly (compared to borating). The control banks must be maintained above designed insertion limits and are typically near the fully withdrawn position during normal full power operations.

BASES

BACKGROUND (continued)

The power density at any point in the core must be limited to maintain specified acceptable fuel design limits, including limits that preserve the criteria specified in 10 CFR 50.46 (Ref. 2). Together, LCO 3.1.4, "RCCA Group Alignment Limits," LCO 3.1.5, "Shutdown Bank Insertion Limits," LCO 3.1.6, "Control Bank Insertion Limits," LCO 3.1.7, "RCCA Position Indication," LCO 3.2.4, "AO," and LCO 3.2.4, "API" provide limits on control component operation and on monitored process variables, which ensure that the core operates within the fuel design criteria.

Operation within the power density limits prevents power peaks that would exceed the loss of coolant accident (LOCA) limits derived by the Emergency Core Cooling Systems analysis. Operation within the API and departure from nucleate boiling (DNB) limits prevents DNB during a loss of forced reactor coolant flow event.

In addition to the LPD, AO, API, and DNBR limits, certain reactivity limits are preserved by regulating RCCA insertion limits. The Control Bank RCCA insertion limits also restrict the ejected RCCA worth to the values assumed in the safety analyses and preserve the minimum required SDM in MODES 1 and 2.

The Control Bank RCCA insertion and alignment limits, API and AO, are process variables that together characterize and control the three dimensional power distribution of the reactor core. Additionally, the Control Bank insertion limits control the reactivity that could be added in the event of a RCCA ejection accident and the Shutdown and Control Bank insertion limits ensure the required SDM is maintained.

Operation within the subject LCO limits will prevent fuel cladding failures that would breach the primary fission product barrier and release fission products to the reactor coolant in the event of a LOCA, loss of flow, ejected RCCA, or other accident requiring termination by a Protection System function.

BASES

APPLICABLE SAFETY ANALYSES

The fuel cladding must not sustain damage as a result of normal operation and anticipated operational occurrences (AOOs). The acceptance criteria for the Control Bank RCCA insertion, AO, and API LCOs preclude core power distributions from occurring that would violate the following fuel design criteria:

a. During a large break LOCA, the peak cladding temperature must not exceed a limit of 2200°F, 10 CFR 50.46 (Ref. 2);

b. During a loss of forced reactor coolant flow accident, there must be at least a 95% probability at a 95% confidence level (the 95/95 DNB criterion) that a DNB condition does not exist with an RCCA inserted into the core;

c. Energy deposition for the rod ejection accident based on the "Interim Acceptance Criterion and Guidance for Reactivity Initiated Accidents" contained in Standard Review Plan (SRP) Section 4.2 Appendix B (Ref. 3), and

d. The RCCAs must be capable of shutting down the reactor with a minimum required SDM, with the highest worth RCCA stuck fully withdrawn, GDC 26 (Ref. 1).

e. The core remains subcritical after accident transients.

Control Bank position, API, and AO are process variables that together characterize and control the three dimensional power distribution of the reactor core.

Fuel cladding damage does not occur when the core is operated outside these LCOs during normal operation. However, fuel cladding damage could result, should an accident occur with simultaneous violation of one or more of these LCOs. Changes in the power distribution can cause increased power peaking and corresponding increased local power densities.

The SDM requirement is ensured by limiting the Control and Shutdown Bank RCCA insertion limits, so that the allowable inserted worth of the RCCAs is such that sufficient reactivity is available in the RCCAs to shut down the reactor to hot zero power with a reactivity margin that assumes the maximum worth RCCA remains fully withdrawn upon trip (Ref. 1).

The most limiting SDM requirements for MODE 1 and 2 conditions are determined by the requirements of several transients, e.g., loss of flow, seized rotor, steam line break, etc.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The measurement of RCCA bank worth performed as part of the Startup Testing Program demonstrates that the core has the expected shutdown capability. Consequently, adherence to LCOs 3.1.5 and 3.1.6 provides assurance that the available SDMs at any time in cycle will exceed the limiting SDM requirements at that time in cycle.

Operation at the insertion limits or AO may approach the maximum allowable linear heat generation rate or peaking factor, with the allowed API present. Operation at the insertion limit may also indicate the maximum ejected RCCA worth could be equal to the limiting value in fuel cycles that have sufficiently high ejected RCCA worths.

The Control and Shutdown Bank RCCA insertion limits ensure that safety analyses assumptions for reactivity insertion rate, SDM, ejected RCCA worth, and power distribution peaking factors are preserved (Ref. 3).

The Control Bank RCCA insertion limits satisfy Criterion 2 of 10 CFR 50.36(d)(2)(ii).

LCO

The limits on Control Bank RCCA sequence, overlap, and physical insertion, as defined in the COLR, must be maintained because they serve the function of preserving power distribution, ensuring that the SDM is maintained, ensuring that ejected RCCA worth is maintained, and ensuring adequate negative reactivity insertion on trip. The overlap between regulating banks provides more uniform rates of reactivity insertion and withdrawal, and is imposed to maintain acceptable power peaking during Control Bank RCCA motion.

APPLICABILITY

The Control Bank RCCA sequence, overlap, and physical insertion limits shall be maintained with the reactor in MODES 1 and MODE 2. These limits must be maintained, since they preserve the assumed power distribution, ejected RCCA worth, SDM, and reactivity rate insertion assumptions. This ensures that a sufficient amount of negative reactivity is available to shut down the reactor and maintain the required SDM following a reactor trip. The control banks do not have to be within their insertion limits in MODE 3, unless an approach to criticality is being made. Applicability in MODES 3, 4, and 5 is not required, since neither the power distribution nor ejected RCCA worth assumptions would be exceeded in these MODES. SDM is preserved in MODES 3, 4, and 5 by adjustments to the soluble boron concentration.

APPLICABILITY (continued)

The Applicability requirements have been modified by a Note indicating the LCO requirement is suspended during SR 3.1.4.2. SR 3.1.4.2 verifies the freedom of the RCCAs to move, and requires the control bank RCCAs to move below the LCO limits, which would normally violate the LCO. The Note also allows the LCO to be not applicable during a partial trip, which inserts a selected RCCA group, specified in the COLR, during loss of load events. This condition is outside of the control bank insertion limits and requires prompt action to restore operation within insertion limits.

ACTIONS

A.1.1, A.1.2, and A.2

Operation beyond the insertion limits may result in a loss of SDM and excessive peaking factors. This restoration can occur in two ways:

a. Reducing power to be consistent with rod position; or

b. Moving rods to be consistent with power.

The insertion limits should not be violated during normal operation; this violation, however, may occur during transients when the operator is manually controlling the RCCAs in response to changing plant conditions. When the Control Bank groups are inserted beyond the insertion limits, actions must be taken to either withdraw the Control Bank groups beyond the insertion limits or to reduce THERMAL POWER to less than or equal to that allowed for the actual RCCA insertion limit. Verification of SDM or initiation of boration to regain SDM is required within 1 hour, since the SDM in MODES 1 and 2 normally ensured by adhering to the control and shutdown bank insertion limits (see LCO 3.1.1, "SHUTDOWN MARGIN (SDM)") has been upset. If control banks are not within their insertion limits, then SDM will be verified by performing a reactivity balance calculation, considering the effects listed in the BASES for SR 3.1.1.1. The allowed Completion Time of 2 hours provides a reasonable time to restore control banks within insertion limits, allowing the operator to deal with current plant conditions while limiting peaking factors to acceptable levels.

BASES

ACTIONS (continued)

B.1.1, B.1.2, and B.2

Similarly, if the control banks are found to be out of sequence or in the wrong overlap configuration, they must be restored to meet the limits.

Operation beyond the LCO limits is allowed for a short time period in order to take conservative action because the simultaneous occurrence of either a LOCA, loss of flow accident, ejected rod accident, or other accident during this short time period, together with an inadequate power distribution or reactivity capability, has an acceptably low probability.

The allowed Completion Time of 2 hours for restoring the banks to within the insertion, sequence, and overlaps limits provides an acceptable time for evaluating and repairing minor problems without allowing the plant to remain in an unacceptable condition for an extended period of time.

C.1

If Required Actions A.1.1, A.1.2, and A.2, or B.1.1, B.1.2, and B.2 cannot be completed within the associated Completion Times, the plant must be brought to MODE 2 with $k_{eff} < 1.0$, where the LCO is not applicable. The allowed Completion Time of 6 hours is reasonable, based on operating experience, for reaching the required MODE from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.1.6.1

This Surveillance is required to ensure that the reactor does not achieve criticality with the control banks below their insertion limits.

The estimated critical condition (ECC) depends upon a number of factors, one of which is xenon concentration. If the ECP was calculated long before criticality, xenon concentration could change to make the ECC substantially in error. Conversely, determining the ECC immediately before criticality could be an unnecessary burden. There are a number of unit parameters requiring operator attention at that point. Performing the ECC calculation within 4 hours prior to criticality avoids a large error from changes in xenon concentration, but allows the operator some flexibility to schedule the ECC calculation with other startup activities.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.1.6.2

Verification of the control bank insertion, sequence, and overlap limits is required to detect control banks that may be approaching the insertion, sequence and overlap limits. During normal operation it is unlikely that this should be a problem since normally, very little rod motion occurs in 12 hours and automatic rod motion is controlled by the Reactor Control, Surveillance and Limitation System (RCSL). The operator is responsible for monitoring each RCSL automatic movement of the control banks and to take manual actions if necessary to maintain insertion, sequence, and overlap limits. A Completion Time of 12 hours is adequate to ensure that the control banks are maintained within insertion, sequence, and overlap limits.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 10, GDC 26, GDC 28, August, 2007.
2. 10 CFR 50.46, August, 2007.
3. FSAR Chapter 15.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.7 Rod Control Cluster Assembly (RCCA) Position Indication

BASES

BACKGROUND

According to GDC 13 (Ref. 1), instrumentation to monitor variables and systems over their operating ranges during normal operation, anticipated operational occurrences, and accident conditions must be OPERABLE. LCO 3.1.7 is required to ensure OPERABILITY of the control rod position indicators to determine control rod positions and thereby ensure compliance with the control rod alignment and insertion limits.

The OPERABILITY, including position indication, of the shutdown and control rods is an initial assumption in all safety analyses that assume rod insertion upon reactor trip. Maximum rod misalignment is an initial assumption in the safety analysis that directly affects core power distributions and assumptions of available SDM. Rod position indication is required to assess OPERABILITY and misalignment.

In addition, the analog rod position indication provides input into the Low DNBR PS functions. The indication is used to detect dropped rods and initiate automatic protection setpoint adjustments to account for these off-normal conditions.

Mechanical or electrical failures may cause a control rod to become inoperable or to become misaligned from its group. Control rod inoperability or misalignment may cause increased power peaking, due to the asymmetric reactivity distribution and a reduction in the total available rod worth for reactor shutdown. Therefore, control rod alignment and OPERABILITY are related to core operation in design power peaking limits and the core design requirement of a minimum SDM.

Limits on control rod alignment and OPERABILITY have been established, and all rod positions are monitored and controlled during power operation to ensure that the power distribution and reactivity limits defined by the design power peaking and SDM limits are preserved.

Rod cluster control assemblies (RCCAs), or rods, are moved out of the core (up or withdrawn) or into the core (down or inserted) by their control rod drive mechanisms. The RCCAs are divided among four control banks and three shutdown banks. Each control bank may be further subdivided into two groups to provide for precise reactivity control. The axial position of shutdown rods and control rods are determined by two separate and independent indications: the Digital Rod Position Indication (commonly called group step counters) and the Analog Rod Position Indication.

BASES

BACKGROUND (continued)

The Digital RCCA Position Indication counts the pulses from the control rod drive control system that moves the RCCA s. The Digital RCCA Position Indication tracks individual RCCA positions and can display the individual RCCA position or the position for each group of RCCAs. Individual RCCAs in a group all receive the same signal to move and should, therefore, all be at the same position indicated by the group position. The Digital RCCA Position Indication is considered highly precise (1 step = 10 mm ~ ⅜ inch). If a RCCA does not move one step for each demand pulse, the Digital RCCA Position Indication may still count the pulse and incorrectly reflect the position of the RCCA.

The Analog RCCA Position Indication provides a totally independent indication of actual RCCA position, but at a lower precision than the step counters. This indication is based on inductive analog signals from a series of coils spaced along a hollow tube. The Analog RCCA Position Indication is capable of measuring RCCA position within at least ± 8 steps.

APPLICABLE SAFETY ANALYSES

Control and shutdown RCCA position accuracy is essential during power operation. Power peaking, ejected rod or SDM limits may be violated in the event of an AOO or postulated accident (Ref. 2), with control or shutdown RCCAs operating outside their limits undetected. Therefore, the acceptance criteria for RCCA position indication is that RCCA positions must be known with sufficient accuracy in order to verify the core is operating within the group sequence, overlap, design peaking limits, ejected rod worth, and with minimum SDM (LCO 3.1.5, "Shutdown Bank Insertion Limits," and LCO 3.1.6, "Control Bank Insertion Limits"). The RCCA positions must also be known in order to verify the alignment limits are preserved (LCO 3.1.4, "RCCA Group Alignment Limits"). Control RCCA positions are continuously monitored to provide operators with information that ensures the plant is operating within the bounds of the accident analysis assumptions.

In addition, RCCA position indication is necessary to support automatic adjustment of Low DNBR protection system setpoints in the event of a sensed RCCA or multiple RCCA drops.

The control RCCA position indicator divisions satisfy Criterion 2 of 10 CFR 50.36(d)(2)(ii). The control RCCA position indicators monitor control RCCA position, which is an initial condition of the accident.

BASES

LCO

The control RCCA position indicators are considered capable of monitoring RCCA position when:

a. The Analog RCCA Position Indication is within 8 steps of the Digital RCCA Position Indication as required by this LCO.

b. For the Analog RCCA Position Indication the primary and secondary coils indicate RCCA position; and

c. The Digital RCCA Position Indication has been calibrated either in the fully inserted position or to the Analog RCCA Position Indication. The 8 step agreement limit between the Digital RCCA Position Indication and the Analog RCCA Position Indication signifies that the Digital RCCA Position Indication is adequately calibrated, and can be used for indication of the measurement of control rod bank position.

A deviation of less than the allowable limit, in position indication for a single control RCCA, ensures high confidence that the position uncertainty of the corresponding control RCCA group is within the assumed values used in the analysis (that specified control RCCA group insertion limits).

These requirements ensure that control RCCA position indication during power operation and PHYSICS TESTS is accurate, and that design assumptions are not challenged.

OPERABILITY of the position indicator divisions ensures that inoperable, misaligned, or mispositioned control RCCAs can be detected. Therefore, power peaking, ejected rod worth, and SDM can be controlled within acceptable limits.

APPLICABILITY

The requirements on the Analog RCCA Position Indication and the Digital RCCA Position Indication are only applicable in MODES 1 and 2 (consistent with LCO 3.1.4, LCO 3.1.5, and LCO 3.1.6), because these are the only MODES in which power is generated, and the OPERABILITY and alignment of RCCAs have the potential to affect the safety of the plant. In the shutdown MODES, the OPERABILITY of the shutdown and control banks has the potential to affect the required SDM, but this effect can be compensated for by an increase in the boron concentration of the Reactor Coolant System.

BASES

ACTIONS

The ACTIONS Table is modified by a Note indicating that a separate Condition entry is allowed for each inoperable RCCA position indicator and each demand position indicator. This is acceptable because the Required Actions for each Condition provide appropriate compensatory actions for each inoperable position indicator.

A.1.1 and A.1.2

When a single RCCA position indication in one or more banks is not capable of measuring RCCA position there is no method for determining the RCCA position. This results in the PS being unable to detect if that RCCA were to inadvertently drop into the core. Operation in this condition for any extended period of time therefore requires that the DNBR trip setpoints be adjusted to account for the possibility that a RCCA may become misaligned beyond the LCO limits or drop into the core undetected. Implementation of the DNBR penalty on the PS setpoint within the Completion Time of 8 hours is adequate since the probability of experiencing a dropped or misaligned RCCA during this period is extremely small.

With the failure of the RCCA position indication, detection of a misalignment may still be done indirectly through use of the Aeroball Measurement System. Additionally, movement of RCCAs with inoperable position indicators increases the potential for creating an undetected misalignment. Based on experience, normal power operation requires little movement of control banks. Therefore a Completion Time of Once per 8 hours (and once within 4 hours when a RCCA is moved in excess of 20 steps) is adequate for allowing full power operation.

A.2

Another option for a single RCCA position indication failure is to reduce power below that which DNBR, power peaking, or xenon oscillations are concerns.

The allowed Completion Time of 8 hours is reasonable, based on operating experience, for reducing power to ≤ 50% RTP from full power conditions without challenging plant systems and allowing for RCCA position determination by Required Action A.1.2 above.

BASES

ACTIONS (continued)

B.1, B.2, and B.3

When more than one Analog RCCA Position Indication in one or more banks fail, additional actions are necessary to ensure that acceptable power distribution limits are maintained, minimum SDM is maintained, and the potential effects of RCCA misalignment on associated accident analyses are limited.

Verifying that at least three rod control cluster assembly units (RCCAUs) are OPERABLE ensures that the majority of the analog RCCA position indicators remain available to provide necessary plant information. Placing the Control Rod Drive Control System in manual assures unplanned RCCA motion will not occur. The immediate Completion Time for placing the Control Rod Drive Control System in manual reflects the urgency with which unplanned RCCA motion must be prevented while in this Condition as well as the need to maintain adequate monitoring of RCCA position.

With the RCCAs under manual control it is now possible to more effectively monitor for a misaligned or dropped RCCA based on changes in RCS T_{AVG} since only minor fluctuations are expected during steady-state operation. A Completion Time of Once per hour is sufficient identify abnormal trends.

B.4

The 24 hour Completion Time provides sufficient time to troubleshoot and restore the Analog RCCA Position Indication to operation while avoiding the plant challenges associated with the shutdown without full RCCA position indication.

C.1.1 and C.1.2

With one Digital RCCA Position Indicator per bank not capable of indicating RCCA position, the RCCA positions can be determined by the Analog RCCA Position Indication. Since normal power operation does not require excessive movement of RCCAs, verification by administrative means the RCCA positions of all affected banks that the most withdrawn RCCA and the least withdrawn RCCA are ≤ 8 steps apart within the allowed Completion Time of once every 8 hours is adequate.

BASES

ACTIONS (continued)

C.2

Reduction of THERMAL POWER to ≤ 50% RTP puts the core into a condition where RCCA position is not significantly affecting core peaking factor limits (Ref. 3). The allowed Completion Time of 8 hours provides an acceptable period of time to verify the RCCA positions per Required Actions C.1.1 and C.1.2 or reduce power to ≤ 50% RTP.

D.1

If the Required Actions cannot be completed within the associated Completion Time, the plant must be brought to a MODE in which the requirement does not apply. To achieve this status, the plant must be brought to MODE 3 within 6 hours. The allowed Completion Time of 6 hours is reasonable, based on operating experience, for reaching MODE 3 from full power conditions in an orderly manner and without challenging the plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.1.7.1

Verification that the analog RCCA position indication agrees with the digital RCCA position within 8 steps ensures that the analog RCCA position indication is operating correctly. Since the analog RCCA position indication does not display the actual RCCA position below 10 steps, only points within the indicated ranges are required in comparison.

This Surveillance is performed prior to reactor criticality after each removal of the reactor head, as there is the potential for unnecessary plant transients if the SR were performed with the reactor at power.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 10, GDC 26, and GDC 28, August, 2007.
2. 10 CFR 50.46, August, 2007.
3. FSAR Chapter 15.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.8 Boron Dilution Protection (BDP)

BASES

BACKGROUND

The primary purpose of the Boron Concentration Measurement System (BCMS) is to mitigate the consequences of the inadvertent addition unborated primary grade water into the Reactor Coolant System (RCS) when the reactor is in MODES 3, 4, 5, and 6. The RCS boron concentration that is measured by the BCMS is continuously compared to one of three pre-established setpoints that is depends on the following conditions:

- Reactor critical;
- Shutdown, with RCPs in operation; and
- Shutdown, without RCPs in operation.

The BCMS setpoint ensures:

- The dilution is terminated when the Protection setpoint is actuated;
- The available SDM is sufficient to shutdown the core with the RCCA with highest worth unable to insert, if at power; and
- The core remains sub-critical if already shutdown.

The BCMS setpoint is periodically adjusted to compensate for core burnup and the indicated boron concentration is periodically compared against boron titration samples and boron isotopic analyses to confirm that the BCMS measured boron concentration is within analysis assumptions. The BCMS instrumentation requirements are specified in Technical Specification 3.3.1 "Protection System."

The volume control tank (VCT) and letdown isolation valves actuate to the isolation position on a signal from the BCMS. The OPERABILITY requirements for these isolation valves help ensure that a dilution path is isolated within the time limits assumed in the safety analyses. Therefore, the OPERABILITY requirements provide assurance that the containment function assumed in the safety analyses will be maintained.

APPLICABLE SAFETY ANALYSES

The BCMS responds to abnormal increases in neutron counts per second (flux rate) and actuates the VCT and letdown isolation valves to mitigate the consequences of an inadvertent boron dilution event as described in FSAR Chapter 15 (Ref. 1). The accident analyses rely on the VCT and letdown isolation valves to terminate a boron dilution event. The IRWST isolation valve is also sent a signal to open to protect the CVCS charging pump and provide uninterrupted flow to the RCP seals but it is not credited in the Chapter 15 accident analyses.

The single failure criterion required to be imposed in the conduct of plant safety analyses was considered in the original design of the VCT and letdown isolation valves. Two valves in series in the charging pump suction line provide assurance that the dilution path could be isolated even if a single failure occurred.

The BDP VCT and letdown isolation valves satisfies Criterion 3 of 10 CFR 50.36(d)(3)(ii) (Ref. 2)

LCO

LCO 3.1.8 provides the requirements for OPERABILITY of the VCT and letdown isolation valves that mitigate the consequences of an inadvertent boron dilution event as described in FSAR Chapter 15 (Ref. 1). The VCT and letdown isolation valves are as follows:

- VCT Outlet (KBA21 AA001)
- Letdown to Charging Pump Suction Header (KBA21 AA017)
- VCT and Letdown to Charging Pump Common Isolation (KBA21 AA009)

This LCO provides assurance that the VCT and letdown isolation valves will perform their designed safety functions to mitigate the consequences of inadvertent boron dilution events.

APPLICABILITY

The VCT and letdown isolation valves must be OPERABLE in MODES 3, 4, 5, and 6 because the safety analysis identifies the VCT and letdown isolation valves as the primary means to mitigate an inadvertent boron dilution of the RCS.

BASES

ACTIONS

A.1 and A.2

If one or more of the VCT and letdown isolation valves are inoperable, the automatic capability for mitigation of dilution events is no longer available. In this case, the isolation valves are required to be restored to OPERABLE status within 8 hours. As an alternative (Required Actions A.1 and A.2), the VCT and letdown return line must be closed and secured within 8 hours to isolate the unborated water sources. The allowed Completion Times are reasonable, based on operating experience, to return the isolation valves to an OPERABLE condition in an orderly manner.

SURVEILLANCE REQUIREMENTS

SR 3.1.8.1

Periodic surveillance testing of VCT and letdown isolation valves is required by the ASME Code. This verifies that the measured performance, receipt of isolation signal to full closure, is within an acceptable tolerance of the performance assumed in the plant safety analysis. SRs are specified in the Inservice Testing Program of the ASME Code.

The ASME Code provides the activities and Frequencies necessary to satisfy the requirements.

SR 3.1.8.2

This periodic surveillance is performed on the VCT and letdown isolation valves to verify that the actuation signal causes the appropriate valves to move to their correct position within the allowable design basis response time.

The 24 month frequency is based on the need to perform this Surveillance under conditions that apply during a plant outage and because of the potential for an unplanned transient if the Surveillance were performed with the reactor at power. The Frequency is acceptable based on consideration of the design reliability of the equipment. The actuation logic is tested as part of Protection System testing.

REFERENCES

1. FSAR Chapter 15.

2. 10 CFR 50.36, Technical Specifications, August, 2007.

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.9 PHYSICS TESTS Exceptions - MODE 2

BASES

BACKGROUND

The primary purpose of the MODE 2 PHYSICS TESTS exceptions is to permit relaxations of existing LCOs to allow certain PHYSICS TESTS to be performed.

Section XI of 10 CFR 50, Appendix B (Ref. 1), requires that a test program be established to ensure that structures, systems, and components will perform satisfactorily in service. All functions necessary to ensure that the specified design conditions are not exceeded during normal operation and anticipated operational occurrences must be tested. This testing is an integral part of the design, construction, and operation of the plant. Requirements for notification of the NRC, for the purpose of conducting tests and experiments, are specified in 10 CFR 50.52 (Ref. 2) and 10 CFR 50.59 (Ref. 3).

The key objectives of a test program are to (Ref. 4):

a. Ensure that the facility has been adequately designed;

b. Validate the analytical models used in the design and analysis;

c. Verify the assumptions used to predict unit response;

d. Ensure that installation of equipment in the facility has been accomplished in accordance with the design; and

e. Verify that the operating and emergency procedures are adequate.

To accomplish these objectives, testing is performed prior to initial criticality, during startup, during low power operations, during power ascension, at high power, and after each refueling. The PHYSICS TESTS requirements for reload fuel cycles ensure that the operating characteristics of the core are consistent with the design predictions and that the core can be operated as designed (Ref. 5).

PHYSICS TESTS procedures are written and approved in accordance with established formats. The procedures include all information necessary to permit a detailed execution of the testing required to ensure that the design intent is met. PHYSICS TESTS are performed in accordance with these procedures and test results are approved prior to continued power escalation and long term power operation.

BASES

BACKGROUND (continued)

The PHYSICS TESTS required for reload fuel cycles (Ref. 5) in MODE 2 are listed below:

a. Critical Boron Concentration - Control Rods Withdrawn;

b. Critical Boron Concentration - Control Rods Inserted;

c. Control Rod Worth;

d. Isothermal Temperature Coefficient (ITC); and

e. Neutron Flux Symmetry.

The first four tests are performed in MODE 2, and the last test can be performed in either MODE 1 or 2. If the neutron flux symmetry test is performed in MODE 1 a PHYSICS TEST Exception is required, however if the test is performed in MODE 2 a PHYSICS TEST Exception is not required. These and other supplementary tests may be required to calibrate the nuclear instrumentation or to diagnose operational problems. These tests may cause the operating controls and process variables to deviate from their LCO requirements during their performance.

a. The Critical Boron Concentration - Control Rods Withdrawn Test measures the critical boron concentration at hot zero power (HZP). With all rods out, the lead control bank is at or near its fully withdrawn position. HZP is where the core is critical ($k_{eff} = 1.0$), and the Reactor Coolant System (RCS) is at design temperature and pressure for zero power. Performance of this test should not violate any of the referenced LCOs.

b. The Critical Boron Concentration - Control Rods Inserted Test measures the critical boron concentration at HZP, with a bank having a worth of at least 1000 pcm when fully inserted into the core. This test is used to measure the boron reactivity coefficient. With the core at HZP and all banks fully withdrawn, the boron concentration of the reactor coolant is gradually lowered in a continuous manner. The selected bank is then inserted to make up for the decreasing boron concentration until the selected bank has been moved over its entire range of travel. The reactivity resulting from each incremental bank movement is measured with a reactivity computer. The difference between the measured critical boron concentration with all rods fully withdrawn and with the bank inserted is determined.

BACKGROUND (continued)

The boron reactivity coefficient is determined by dividing the measured bank worth by the measured boron concentration difference. Performance of this test could violate LCO 3.1.4, "RCCA Group Alignment Limits," LCO 3.1.5, "Shutdown Bank Insertion Limit," or LCO 3.1.6, "Control Bank Insertion Limits."

c. The Control Rod Worth Test is used to measure the reactivity worth of selected control banks. This test is performed at HZP and has three alternative methods of performance. The first method, the Boron Exchange Method, varies the reactor coolant boron concentration and moves the selected control bank in response to the changing boron concentration. The reactivity changes are measured with a reactivity computer. This sequence is repeated for the remaining control banks. The second method, the Rod Swap Method, measures the worth of a predetermined reference bank using the Boron Exchange Method above. The reference bank is then nearly fully inserted into the core. The selected bank is then inserted into the core as the reference bank is withdrawn. The HZP critical conditions are then determined with the selected bank fully inserted into the core. The worth of the selected bank is inferred, based on the position of the reference bank with respect to the selected bank. This sequence is repeated as necessary for the remaining control banks. The third method, the Boron Endpoint Method, moves the selected control bank over its entire length of travel and then varies the reactor coolant boron concentration to achieve HZP criticality again. The difference in boron concentration is the worth of the selected control bank. This sequence is repeated for the remaining control banks. Performance of this test could violate LCO 3.1.3, 3.1.4, LCO 3.1.5, or LCO 3.1.6.

d. The ITC Test measures the ITC of the reactor. This test is performed at HZP and has two methods of performance. The first method, the Slope Method, varies RCS temperature in a slow and continuous manner. The reactivity change is measured with a reactivity computer as a function of the temperature change. The ITC is the slope of the reactivity versus the temperature plot. The test is repeated by reversing the direction of the temperature change, and the final ITC is the average of the two calculated ITCs. The second method, the Endpoint Method, changes the RCS temperature and measures the reactivity at the beginning and end of the temperature change. The ITC is the total reactivity change divided by the total temperature change. The test is repeated by reversing the direction of the temperature change, and the final ITC is the average of the two calculated ITCs. Performance of this test could challenge LCO 3.4.2, "RCS Minimum Temperature for Criticality."

BASES

BACKGROUND (continued)

e. The Flux Symmetry Test measures the degree of azimuthal symmetry of the neutron flux at as low a power level as practical, depending on the test method employed. This test can be performed at HZP (Control Rod Worth Symmetry Method) or at ≤ 30% RTP (Flux Distribution Method). The Control Rod Worth Symmetry Method inserts a control bank, which can then be withdrawn to compensate for the insertion of a single control rod from a symmetric set. The symmetric rods of each set are then tested to evaluate the symmetry of the control rod worth and neutron flux (power distribution). A reactivity computer is used to measure the control rod worths. Performance of this test could violate LCO 3.1.4, LCO 3.1.5, or LCO 3.1.6. The Flux Distribution Method uses the incore flux detectors to measure the azimuthal flux distribution at selected locations with the core at ≤ 30% RTP.

APPLICABLE SAFETY ANALYSES

The fuel is protected by LCOs that preserve the initial conditions of the core assumed during the safety analyses. The purpose of the LCOs that are excepted by this LCO are described in the Bases for the individual LCOs (Ref. 6). The above mentioned PHYSICS TESTS, and other tests that may be required to calibrate nuclear instrumentation or to diagnose operational problems, may require the operating control or process variables to deviate from their LCO limitations.

The requirements for initial testing of the facility, including PHYSICS TESTS have been defined. FSAR Section 14.2 summarizes the zero, low power, and power ascension tests. Requirements for reload fuel cycle PHYSICS TESTS are defined in ANSI/ANS-19.6.1-2005 (Ref. 5). Although these PHYSICS TESTS are generally accomplished within the limits for all LCOs, conditions may occur when one or more LCOs must be suspended to make completion of PHYSICS TESTS possible or practical. This is acceptable as long as the fuel design criteria are not violated. When one or more of the requirements specified in LCO 3.1.4 "RCCA Group Alignment Limits," LCO 3.1.5 "Shutdown Bank Insertion Limits," and LCO 3.1.6 "Control Bank Insertion Limits" are suspended for PHYSICS TESTS, the fuel design criteria are preserved as long as the power level is limited to ≤ 5% RTP, the reactor coolant temperature is maintained ≥ 568°F, and SDM is within the limits provided in the COLR.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The PHYSICS TESTS include measurement of core nuclear parameters or the exercise of control components that affect process variables. Among the process variables involved are AXIAL OFFSET (AO) and AZIMUTHAL POWER IMBALANCE (API), which represent initial conditions of the unit safety analyses. Also involved are the movable control components (control and shutdown rods), which are required to shut down the reactor. The API limit is specified in LCO 3.2.5.

As described in LCO 3.0.7, compliance with Test Exception LCOs is optional, and therefore no criteria of 10 CFR 50.36(d)(2)(ii) apply. Test Exception LCOs provide flexibility to perform certain operations by appropriately modifying requirements of other LCOs. A discussion of the criteria satisfied for the other LCOs is provided in their respective Bases.

LCO

This LCO allows the selected control and shutdown banks/rods to be positioned outside of their specified alignment and insertion limits. Operation beyond specified limits is permitted for the purpose of performing PHYSICS TESTS and poses no threat to fuel integrity, provided the SRs are met.

The requirements of LCO 3.1.3, 3.1.4, LCO 3.1.5, and LCO 3.1.6, may be suspended during the performance of PHYSICS TESTS provided:

a. SDM is within the limits provided in the COLR; and

b. THERMAL POWER is < 5% RTP.

APPLICABILITY

This LCO is applicable when performing low power PHYSICS TESTS. The Applicability is stated as "during PHYSICS TESTS initiated in MODE 2" to ensure that the 5% RTP maximum power level is not exceeded. Should the THERMAL POWER exceed 5% RTP, and consequently the unit enters MODE 1, this Applicability statement prevents exiting this Specification and its Required Actions.

ACTIONS

A.1 and A.2

If the SDM requirement is not met, boration must be initiated promptly. A Completion Time of 15 minutes is adequate for an operator to correctly align and start the required systems and components. The operator should begin boration with the best source available for the plant conditions. Boration will be continued until SDM is within limit.

Suspension of PHYSICS TESTS exceptions requires restoration of each of the applicable LCOs to within specification. The 1 hour Completion Time to suspend PHYSICS TESTS exceptions provides sufficient time to restore SDM to within limit and reflects the low risk of postulated accidents at the conditions that exist during PHYSICS TESTS.

B.1

When THERMAL POWER is > 5% RTP, the only acceptable action is to open the reactor trip breakers (RTBs) to prevent operation of the reactor beyond its design limits. Immediately opening the RTBs will shut down the reactor and prevent operation of the reactor outside of its design limits.

SURVEILLANCE REQUIREMENTS

SR 3.1.9.1

Verification that the THERMAL POWER is ≤ 5% RTP will ensure that the plant is not operating in a condition that could invalidate the safety analyses. Verification of the THERMAL POWER at a Frequency of 30 minutes during the performance of the PHYSICS TESTS will ensure that the initial conditions of the safety analyses are not violated.

SR 3.1.9.2

The SDM is verified by performing a reactivity balance calculation, considering the following reactivity effects:

a. RCS boron concentration;

b. Control bank position;

c. RCS average temperature;

BASES

SURVEILLANCE REQUIREMENTS (continued)

d. Fuel burnup based on gross thermal energy generation;

e. Xenon concentration;

f. Samarium concentration;

g. Isothermal temperature coefficient (ITC), when below the point of adding heat (POAH);

h. Moderate defect, when above the POAH; and

i. Doppler defect, when above the POAH.

Using the ITC accounts for Doppler reactivity in this calculation when the reactor is subcritical or critical but below the POAH and the fuel temperature will be changing at the same rate as the RCS.

The Frequency of 24 hours is based on the generally slow change in required boron concentration and on the low probability of an accident occurring without the required SDM.

REFERENCES

1. 10 CFR 50, Appendix B, Section XI, March, 2006.

2. 10 CFR 50.52 "Licenses, Certifications, and Approvals for Nuclear Power Plants," August, 2007.

3. 10 CFR 50.59 "Changes, Tests and Experiments," August, 2007.

4. Regulatory Guide 1.68, Revision 2, August, 1978.

5. ANSI/ANS-19.6.1-2005, November 29, 2005.

6. ANP-10263P Codes and Methods Applicability Report for the U.S. EPR, August, 2006.