B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.1 Linear Heat Rate (LHR)

BASES

BACKGROUND

The purpose of this Limiting Condition for Operation (LCO) is to limit the core power distribution to the initial values assumed in the accident analyses. Operation within the limits imposed by this LCO either limits or prevents potential fuel cladding failures that could breach the primary fission product barrier and release fission products to the reactor coolant in the event of a loss of coolant accident (LOCA), loss of flow accident (LOFA), ejected control element assembly (CEA) accident, or other postulated accident requiring termination by a Reactor Protective System trip function. This LCO limits the amount of damage to the fuel cladding during an accident by ensuring that the plant is operating within acceptable bounding conditions at the onset of a transient.

Methods of controlling the power distribution include:

a. Using CEAs to alter the axial power distribution;

b. Decreasing CEA insertion by boration, thereby improving the radial power distribution; and

c. Correcting less than optimum conditions (e.g., a CEA drop or misoperation of the unit) that cause margin degradations.

The core power distribution is controlled so that, in conjunction with other core operating parameters (e.g., CEA insertion and alignment limits), the power distribution satisfies this LCO. The limiting safety system settings (LSSS) and this LCO are based on the accident analyses (Reference 1, Chapter 14), so that specified acceptable fuel design limits (SAFDLs) are not exceeded as a result of anticipated operational occurrences (AOOs), and the limits of acceptable consequences are not exceeded for other postulated accidents.

Limiting power distribution skewing over time also minimizes the xenon distribution skewing, which is a significant factor in controlling the axial power distribution.

BASES

Power distribution is a product of multiple parameters, various combinations of which may produce acceptable power distributions. Operation within the design limits of power distribution is accomplished by generating operating limits on linear heat rate (LHR) and departure from nucleate boiling (DNB).

The limits on LHR, Total Integrated Radial Peaking Factor (F_r^T), AZIMUTHAL POWER TILT (T_q), and AXIAL SHAPE INDEX (ASI) represent limits within which the LHR algorithms are valid. These limits are obtained directly from the core reload analysis.

Below 20% power, ASI limits for the LHR and DNB LCO are not required. At low powers, the axial power distribution (APD) trip will limit the allowed ASI during operation. The core reload analysis verifies that ASI limits for the LHR and DNB LCOs are not necessary below 20% power.

Either of the two core power distribution monitoring systems, the Excore Detector Monitoring System or the Incore Detector Monitoring System, provides adequate monitoring of the core power distribution and is capable of verifying that the LHR is within its limits. At high power, the detector alarms maintain the peak LHR below the LHR LCO limit based on the LOCA analysis only. At low power, the non-LOCA LHR LCO limits are more restrictive. Operation within the axial shape index limits of the excore DNB LCO assure that these non-LOCA LHR LCO limits will not be reached. The Excore Detector Monitoring System performs this function by continuously monitoring ASI with the OPERABLE quadrant symmetric excore neutron flux detectors and verifying that the ASI is maintained within the allowable limits specified in the Core Operating Limit Report (COLR).

In conjunction with the use of the Excore Detector Monitoring System and in establishing ASI limits, the following assumptions are made:

a. The CEA insertion limits of LCOs 3.1.5 and 3.1.6 are satisfied;

b. The T_q restrictions of LCO 3.2.4 are satisfied; and

c. F_r^T is within the limits of LCO 3.2.3.

The Incore Detector Monitoring System continuously provides a more direct measure of the peaking factors and alarms that have been established for the individual incore detector segments, ensuring that the peak LHRs are maintained within the limits specified in the COLR. The setpoints for these alarms include allowances described in the COLR.

APPLICABLE SAFETY ANALYSES

The fuel cladding must not sustain damage as a result of normal operation and AOOs (Reference 1, Appendix 1C, Criterion 6). The power distribution and CEA insertion and alignment LCOs preclude core power distributions that violate the following fuel design criteria:

a. During a LOCA, peak cladding temperature must not exceed 2200°F (Reference 2);

b. During a LOFA, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a DNB condition;

c. During an ejected CEA accident, the energy input to the fuel must not exceed the accepted limits (Reference 1, Section 14.13); and

d. The control rods must be capable of shutting down the reactor with a minimum required SHUTDOWN MARGIN (SDM) with the highest worth control rod stuck fully withdrawn (Reference 1, Appendix 1C, Criterion 29).

The power density at any point in the core must be limited to maintain the fuel design criteria (Reference 2). This is accomplished by maintaining the power distribution and reactor coolant conditions so that the peak LHR and DNB parameters are within operating limits supported by accident analyses (Reference 1, Chapter 14), with due regard for the correlations between measured quantities, the power distribution, and uncertainties in determining the power distribution.

Fuel cladding failure during a LOCA is limited by restricting the maximum linear heat generation rate (LHGR) so that the peak cladding temperature does not exceed 2200°F (Reference 2). High peak cladding temperatures are assumed to cause severe cladding failure by oxidation due to a Zirconium-water reaction.

The LCOs governing LHR, ASI, and the Reactor Coolant System (RCS) ensure that these criteria are met as long as the core is operated within the ASI, F_r^T, and T_q limits specified in the COLR. The latter are process variables that characterize the three-dimensional power distribution of the reactor core. Operation within the limits for these variables ensures that their actual values are within the ranges used in the accident analyses.

Below 20% power, ASI limits for the LHR and DNB LCO are not required. At low powers, the APD trip will limit the allowed ASI during operation. The core reload analysis verifies that ASI limits for the LHR and DNB LCOs are not necessary below 20% power.

Fuel cladding damage does not normally occur while the unit is operating at conditions outside the limits of these LCOs during normal operation. Fuel cladding damage could result, however, if an accident or AOO occurs from initial conditions outside the limits of these LCOs. The potential for fuel cladding damage exists because changes in the power distribution can cause increased power peaking and can correspondingly increase local LHR.

The LHR satisfies 10 CFR 50.36(c)(2)(ii), Criterion 2.

LCO

The power distribution LCO limits are based on correlations between power peaking and certain measured variables used as inputs to the LHR and DNB ratio operating limits. The power distribution LCO limits, except T_q, are provided in the COLR. The limitation on the LHR ensures that, in the event of a LOCA, the peak temperature of the fuel cladding does not exceed 2200°F. However, fuel cladding damage does not normally occur when outside the LCO limit if an accident does not occur.

APPLICABILITY

In MODE 1, power distribution must be maintained within the limits assumed in the accident analysis to ensure that fuel damage does not result following an AOO. In other MODEs, this LCO does not apply because there is not sufficient

BASES

THERMAL POWER to require a limit on the core power distribution.

ACTIONS

A.1

With the LHR exceeding its limit, excessive fuel damage could occur following an accident. In this Condition, prompt action must be taken to restore the LHR to within the specified limits. One hour to restore the LHR to within its specified limits is reasonable and ensures that the core does not continue to operate in this Condition. The 1-hour Completion Time also allows the operator sufficient time for evaluating core conditions and for initiating proper corrective actions.

B.1

If the LHR cannot be returned to within its specified limits, THERMAL POWER must be reduced. Since ASI limits for LHR are not required below 20% Rated Thermal Power (RTP), then the actions of A.1 can be met by reducing power to < 20% RTP. Reducing THERMAL POWER to < 20% RTP provides reasonable assurance that the core is operating farther from thermal limits and places the core in a conservative condition. This action is also consistent with the required actions for the SAFDL on DNB. The allowed Completion Time of 6 hours is reasonable, based on operating experience, to reach the applicable power level from full power MODE 1 conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

A Note was added to the Surveillance Requirements (SRs) to require LHR to be determined by either the Excore Detector Monitoring System or the Incore Detector Monitoring System.

SR 3.2.1.1

Deleted.

SR 3.2.1.2

This SR requires verification that the ASI alarm setpoints are within the limits specified in the COLR. Performance of this SR ensures that the Excore Detector Monitoring System can accurately monitor the LHR, and provide alarms when LHR is not within limits. Therefore, this SR is only applicable when the Excore Detector Monitoring System is being used to determine the LHR. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

The SR is modified by a Note that states that the SR is only applicable when the Excore Detection Monitoring System is being used to determine LHR. The reason for the Note is that the excore detectors input neutron flux information into the ASI calculation.

SR 3.2.1.3 and SR 3.2.1.4

Continuous monitoring of the LHR is provided by the Incore Detector Monitoring System and the Excore Detector Monitoring System. Either of these two core power distribution monitoring systems provides adequate monitoring of the core power distribution and is capable of verifying that the LHR does not exceed its specified limits.

Performance of these SRs verifies that the Incore Detector Monitoring System can accurately monitor LHR. Therefore, they are only applicable when the Incore Detector Monitoring System is being used to determine the LHR.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The SRs are modified by two Notes. Note 1 allows the SRs to be performed only when the Incore Detector Monitoring System is being used to determine LHR. Note 2 states that the SRs are not required to be performed when THERMAL POWER is < 20% RTP. The accuracy of the neutron flux information from the incore detectors is not reliable at THERMAL POWER < 20% RTP.

REFERENCES

1. Updated Final Safety Analysis Report (UFSAR)
2. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Plants"

B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.3 Total Integrated Radial Peaking Factor (F_r^T)

BASES

BACKGROUND

The purpose of this LCO is to limit the core power distribution to the initial values assumed in the accident analyses. Operation within the limits imposed by this LCO either limits or prevents potential fuel cladding failures that could breach the primary fission product barrier and release fission products to the reactor coolant in the event of a LOCA, LOFA, ejected control element assembly (CEA) accident, or other postulated accident requiring termination by a Reactor Protective System trip function. This LCO limits the amount of damage to the fuel cladding during an accident by ensuring that the plant is operating within acceptable bounding conditions at the onset of a transient.

Methods of controlling the power distribution include:

a. The use of CEAs to alter the axial power distribution;

b. Decreasing CEA insertion by boration, thereby improving the radial power distribution; and

c. Correcting off-optimum conditions (e.g., a CEA drop or misoperation of the unit) that cause margin degradations.

The core power distribution is controlled so that, in conjunction with other core operating parameters (e.g., CEA insertion and alignment limits), the power distribution does not result in violation of this LCO. The LSSS and this LCO are based on the accident analyses (Reference 1, Chapter 14), so that SAFDLs are not exceeded as a result of AOOs, and the limits of acceptable consequences are not exceeded for other postulated accidents.

Limiting power distribution skewing over time also minimizes the xenon distribution skewing, which is a significant factor in controlling the axial power distribution.

Power distribution is a product of multiple parameters, various combinations of which may produce acceptable power distributions. Operation within the design limits of power distribution is accomplished by generating operating limits on the LHR and DNB.

The limits on LHR, F_r^T, T_q, and ASI represent limits within which the LHR algorithms are valid. These limits are obtained directly from the core reload analysis.

Either of the two core power distribution monitoring systems, the Excore Detector Monitoring System or the Incore Detector Monitoring System, provide adequate monitoring of the core power distribution and are capable of verifying that the LHR does not exceed its limits. The Excore Detector Monitoring System performs this function by continuously monitoring the ASI with the OPERABLE quadrant symmetric excore neutron flux detectors and verifying that the ASI is maintained within the allowable limits specified in the COLR.

In conjunction with the use of the Excore Detector Monitoring System and in establishing the ASI limits, the following conditions are assumed:

a. The CEA insertion limits of LCOs 3.1.5 and 3.1.6 are satisfied;

b. The T_q restrictions of LCO 3.2.4 are satisfied; and

c. F_r^T does not exceed the limits of LCO 3.2.3.

APPLICABLE SAFETY ANALYSES

The fuel cladding must not sustain damage as a result of normal operation and AOOs (Reference 1, Appendix 1C, Criterion 6). The power distribution and CEA insertion and alignment LCOs preclude core power distributions that violate the following fuel design criteria:

a. During a LOCA, peak cladding temperature must not exceed 2200°F (Reference 2);

b. During a LOFA, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a DNB condition;

c. During an ejected CEA accident, the energy input to the fuel must not exceed the accepted limits (Reference 1, Section 14.13); and

d. The control rods must be capable of shutting down the reactor with a minimum required SDM with the highest worth control rod stuck fully withdrawn (Reference 1, Appendix 1C, Criterion 29).

The power density at any point in the core must be limited to maintain the fuel design criteria (Reference 2). This is accomplished by maintaining the power distribution and reactor coolant conditions so that the peak LHR and DNB parameters are within operating limits supported by the accident analyses (Reference 1, Chapter 14), with due regard for the correlations between measured quantities, the power distribution, and uncertainties in the determination of power distribution.

Fuel cladding failure during a LOCA is limited by restricting the maximum LHGR so that the peak cladding temperature does not exceed 2200°F (Reference 2). High peak cladding temperatures are assumed to cause severe cladding failure by oxidation due to a Zirconium-water reaction.

The LCOs governing LHR, ASI, and the RCS ensure that these criteria are met as long as the core is operated within the ASI and F_r^T limits specified in the COLR, and within the T_q limits. The latter are process variables that characterize the three-dimensional power distribution of the reactor core. Operation within the limits for these variables ensures that their actual values are within the range used in the accident analysis.

Fuel cladding damage does not normally occur while at conditions outside the limits of these LCOs during normal operation. Fuel cladding damage could result, however, if an accident or AOO occurs from initial conditions outside the limits of these LCOs. This potential for fuel cladding damage exists because changes in the power distribution cause increased power peaking and correspondingly increased local LHR.

F_r^T satisfies 10 CFR 50.36(c)(2)(ii), Criterion 2.

BASES

LCO

The LCO limits for power distribution are based on correlations between power peaking and measured variables used as inputs to LHR and DNB ratio operating limits. The LCO limits for power distribution, except T_q, are provided in the COLR. The limitation on the LHR ensures that, in the event of a LOCA, the peak temperature of the fuel cladding does not exceed 2200°F.

APPLICABILITY

In MODE 1, power distribution must be maintained within the limits assumed in the accident analysis to ensure that fuel damage does not result following an AOO. In other MODEs, this LCO does not apply because there is not sufficient THERMAL POWER to require a limit on the core power distribution.

ACTIONS

A.1

The limitations on F_r^T provided in the COLR ensure that the assumptions used in the analysis for establishing the ASI, LCO, and LSSS remain valid during operation at the various allowable CEA group insertion limits. If F_r^T exceeds its basic limitation (F_r^T > all rods out, full power limit), 6 hours is provided to restore F_r^T to within limits. The combination of THERMAL POWER and F_r^T must be brought to within the limits established in the COLR and the CEAs must be withdrawn to or above the long-term steady state insertions limits of Technical Specification 3.1.6. Six hours to return F_r^T to within its limits is reasonable and is sufficiently short to minimize the time F_r^T is not within limits.

B.1

If F_r^T cannot be returned to within its limit, THERMAL POWER must be reduced to MODE 2. A change to MODE 2 provides reasonable assurance that the core is operating within its thermal limits and places the core in a conservative condition. The allowed Completion Time of 6 hours is reasonable, based on operating experience, to reach MODE 2 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.2.3.1

The periodic SR to determine the calculated F_r^T ensures that F_r^T remains within the range assumed in the analysis throughout the fuel cycle. Determining the measured F_r^T once after each fuel loading prior to exceeding 70% RTP ensures that the core is properly loaded.

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

The power distribution map can only be obtained after THERMAL POWER exceeds 20% RTP because the incore detectors are not reliable below 20% RTP.

The SR is modified by a Note that requires the incore detectors to be used to determine F_r^T by using them to obtain a power distribution map with all full length CEAs above the long-term steady state insertion limits, as specified in the COLR.

REFERENCES

1. UFSAR
2. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Plants"

B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.4 AZIMUTHAL POWER TILT (T_q)

BASES

BACKGROUND

The purpose of this LCO is to limit the core power distribution to the initial values assumed in the accident analyses. Operation within the limits imposed by this LCO limits or prevents potential fuel cladding failures that could breach the primary fission product barrier and release fission products to the reactor coolant in the event of a LOCA, LOFA, ejected control element assembly (CEA) accident, or other postulated accident requiring termination by a Reactor Protective System trip function. This LCO limits the amount of damage to the fuel cladding during an accident by ensuring that the plant is operating within acceptable bounding conditions at the onset of a transient.

Methods of controlling the power distribution include:

a. Using CEAs to alter the axial power distribution;

b. Decreasing CEA insertion by boration, thereby improving the radial power distribution; and

c. Correcting off-optimum conditions (e.g., a CEA drop or misoperation of the unit) that cause margin degradations.

The core power distribution is controlled so that, in conjunction with other core operating parameters (e.g., CEA insertion and alignment limits), the power distribution does not result in violation of this LCO. The LSSS and this LCO are based on the accident analyses (Reference 1, Chapter 14), so that SAFDLs are not exceeded as a result of AOOs, and the limits of acceptable consequences are not exceeded for other postulated accidents.

Limiting power distribution skewing over time also minimizes the xenon distribution skewing, which is a significant factor in controlling the axial power distribution.

Power distribution is a product of multiple parameters, various combinations of which may produce acceptable power distributions. Operation within the design limits of power distribution is accomplished by generating operating limits for LHR and DNB.

The limits on LHR, F_r^T, T_q, and ASI represent limits within which the LHR algorithms are valid. These limits are obtained directly from the core reload analysis.

Either of the two core power distribution monitoring systems, the Excore Detector Monitoring System or the Incore Detector Monitoring System, provides adequate monitoring of the core power distribution and is capable of verifying that the LCO limits are not exceeded. The Excore Detector Monitoring System performs this function by continuously monitoring ASI with OPERABLE quadrant symmetric excore neutron detectors and by verifying ASI is maintained within the limits specified in the COLR.

In conjunction with the use of the Excore Detector Monitoring System and in establishing the ASI limits, the following assumptions are made:

a. The CEA insertion limits of LCOs 3.1.5 and 3.1.6 are satisfied;

b. The T_q restrictions of LCO 3.2.4 are satisfied; and

c. F_r^T does not exceed the limits of LCO 3.2.3.

The Incore Detector Monitoring System continuously provides a more direct measure of the peaking factors, and the alarms that have been established for the individual incore detector segments ensure that the peak LHRs are maintained within the limits specified in the COLR. The setpoints for these alarms include allowances described in the COLR.

APPLICABLE SAFETY ANALYSES

The fuel cladding must not sustain damage as a result of normal operation or AOOs (Reference 1, Appendix 1C, Criterion 6). The power distribution and CEA insertion and alignment LCOs preclude core power distributions that violate the following fuel design criteria:

a. During a LOCA, peak cladding temperature must not exceed 2200°F (Reference 2);

b. During a LOFA, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a DNB condition;

c. During an ejected CEA accident, the energy input to the fuel must not exceed the accepted limits (Reference 1, Section 14.13); and

d. The control rods must be capable of shutting down the reactor with a minimum required SDM with the highest worth control rod stuck fully withdrawn (Reference 1, Appendix 1C, Criterion 29).

The power density at any point in the core must be limited to maintain the fuel design criteria (Reference 2). This process is accomplished by maintaining the power distribution and reactor coolant conditions so that the peak LHR and DNB parameters are within operating limits supported by the accident analysis (Reference 1, Chapter 14), with due regard for the correlations between measured quantities, the power distribution, and uncertainties in determining the power distribution.

Fuel cladding failure during a LOCA is limited by restricting the maximum LHGR so that the peak cladding temperature does not exceed 2200°F (Reference 2). High peak cladding temperatures are assumed to cause severe cladding failure by oxidation due to a Zirconium-water reaction.

The LCOs governing LHR, ASI, and the RCS ensure that these criteria are met as long as the core is operated within the ASI and F_r^T limits specified in the COLR, and within the T_q limits. The latter are process variables that characterize the three-dimensional power distribution of the reactor core. Operation within the limits for these variables ensures that their actual values are within the range used in the accident analyses.

Fuel cladding damage does not normally occur while the reactor is operating at conditions outside these LCOs during otherwise normal operation. Fuel cladding damage could result, however, if an accident or AOO occurs from initial conditions outside the limits of these LCOs. Changes in the power distribution cause increased power peaking and correspondingly increased local LHRs.

The T_q satisfies 10 CFR 50.36(c)(2)(ii), Criterion 2.

LCO

The power distribution LCO limits are based on correlations between power peaking and the measured variables used as inputs to the LHR and DNB ratio operating limits. The power distribution LCO limits, except T_q, are provided in the COLR. The limits on LHR ensure that in the event of a LOCA, the peak temperature of the fuel cladding does not exceed 2200°F.

APPLICABILITY

In MODE 1 with THERMAL POWER > 50% RTP, T_q must be maintained within the limits assumed in the accident analysis to ensure that fuel damage does not result following an AOO. In other MODEs, this LCO does not apply because THERMAL POWER is not sufficient to require a limit on T_q.

ACTIONS

A.1 and A.2

If the measured T_q is > 0.03 and < 0.10, the calculation of T_q may be nonconservative. T_q must be restored within 4 hours, or F_r^T must be determined to be within the limits of LCO 3.2.3 within 4 hours, and determined to be within these limits every 8 hours thereafter, as long as T_q is out-of-limits. Four hours is sufficient time to allow the operator to reposition CEAs, and significant radial xenon redistribution cannot occur within this time. The 8 hour Completion Time ensures changes in F_r^T can be identified before the limits of LCO 3.2.3 are exceeded.

B.1

With T_q > 0.10, it must be restored to ≤ 0.10 with 2 hours. F_r^T must be verified to be within its specified limits to ensure that acceptable flux peaking factors are maintained. Operation may proceed for a total of 2 hours, after the Condition is entered, while attempts are made to restore T_q to within its limit.

If the tilt is generated due to a CEA misalignment, operating at ≤ 50% RTP allows for the recovery of the CEA. Except as a result of CEA misalignment, T_q > 0.10 is not expected; if it occurs, continued operation of the reactor may be necessary to discover the cause of the tilt. If this procedure is followed, operation is restricted to only those conditions required to identify the cause of the tilt. It is necessary to account explicitly for power asymmetries because the radial power peaking factor used in core power distribution calculations is based on an untilted power distribution.

If T_q is not restored to within its limits, the reactor continues to operate with an axial power distribution mismatch. Continued operation in this configuration may induce an axial xenon oscillation that causes increased LHRs when the xenon redistributes. If T_q cannot be restored to within its limits within 2 hours, reactor power must be reduced.

C.1

If Required Actions and associated Completion Times of Condition A or B are not met, THERMAL POWER must be reduced to ≤ 50% RTP. This requirement provides conservative protection from increased peaking due to potential xenon redistribution and provides reasonable assurance that the core is operating within its thermal limits and places the core in a conservative condition. Four hours is a reasonable time to reach 50% RTP in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.2.4.1

T_q is determined using the incore and excore detectors. When one excore channel is inoperable and THERMAL POWER is > 75% RTP, the incore detectors shall be used. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

REFERENCES

1. UFSAR
2. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Plants"

B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.5 AXIAL SHAPE INDEX (ASI)

BASES

BACKGROUND

The purpose of this LCO is to limit the core power distribution to the initial values assumed in the accident analysis. Operation within the limits imposed by this LCO either limits or prevents potential fuel cladding failures that could breach the primary fission product barrier and release fission products to the reactor coolant in the event of a LOCA, LOFA, ejected control element assembly (CEA) accident, or other postulated accident requiring termination by a Reactor Protective System trip function. This LCO limits the amount of damage to the fuel cladding during an accident by ensuring that the plant is operating within acceptable bounding conditions at the onset of a transient.

Methods of controlling the power distribution include:

a. Using CEAs to alter the axial power distribution;

b. Decreasing CEA insertion by boration, thereby improving the radial power distribution; and

c. Correcting off optimum conditions (e.g., a CEA drop or misoperation of the unit) that cause margin degradations.

The core power distribution is controlled so that, in conjunction with other core operating parameters (e.g., CEA insertion and alignment limits), the power distribution does not result in violation of this LCO. The LSSS and this LCO are based on the accident analyses (Reference 1, Chapter 14), so that SAFDLs are not exceeded as a result of AOOs, and the limits of acceptable consequences are not exceeded for other postulated accidents.

Limiting power distribution skewing over time also minimizes the xenon distribution skewing, which is a significant factor in controlling the axial power distribution.

Power distribution is a product of multiple parameters, various combinations of which may produce acceptable power distributions. Operation within the design limits of power distribution is accomplished by generating operating limits on LHR and DNB.

BASES

The limits on LHR, F_r^T, T_q, and ASI represent limits within which the LHR algorithms are valid. These limits are obtained directly from the core reload analysis.

Below 20% power, ASI limits for the LHR and DNB LCO are not required. At low powers, the APD trip will limit the allowed ASI during operation. The core reload analysis verifies that ASI limits for the LHR and DNB LCOs are not necessary below 20% power.

Either of the two core power distribution monitoring systems, the Excore Detector Monitoring System and the Incore Detector Monitoring System, provide adequate monitoring of the core power distribution and are capable of verifying that the LHR does not exceed its limits. The Excore Detector Monitoring System performs this function by continuously monitoring the ASI with the OPERABLE quadrant symmetric excore neutron flux detectors and verifying that the ASI is maintained within the allowable limits specified in the COLR.

In conjunction with the use of the Excore Detector Monitoring System and in establishing the ASI limits, the following conditions are assumed:

a. The CEA insertion limits of LCOs 3.1.5 and 3.1.6 are satisfied;

b. The T_q restrictions of LCO 3.2.4 are satisfied; and

c. F_r^T does not exceed the limits of LCO 3.2.3.

The Incore Detector Monitoring System continuously provides a more direct measure of the peaking factors, and the alarms that have been established for the individual incore detector segments ensure that the peak LHR is maintained within the limits specified in the COLR. The setpoints for these alarms include allowances described in the COLR.

APPLICABLE SAFETY ANALYSES

The fuel cladding must not sustain damage as a result of normal operation or AOOs (Reference 1, Appendix 1C, Criterion 6). The power distribution and CEA insertion and alignment LCOs prevent core power distributions from reaching levels that violate the following fuel design criteria:

a. During a LOCA, peak cladding temperature must not exceed 2200°F (Reference 2);

b. During a LOFA, there must be at least 95% probability at the 95% confidence level (the 95/95 DNB criterion) that the hot fuel rod in the core does not experience a DNB condition;

c. During an ejected CEA accident, the energy input to the fuel must not exceed the acceptable limits (Reference 1, Section 14.13); and

d. The control rods must be capable of shutting down the reactor with a minimum required SDM with the highest worth control rod stuck fully withdrawn (Reference 1, Appendix 1C, Criterion 29).

The power density at any point in the core must be limited to maintain the fuel design criteria (Reference 2). This limitation is accomplished by maintaining the power distribution and reactor coolant conditions so that the peak LHR and DNB parameters are within operating limits supported by the accident analyses (Reference 1, Chapter 14), with due regard for the correlations among measured quantities, the power distribution, and uncertainties in the determination of power distribution.

Fuel cladding failure during a LOCA is limited by restricting the maximum LHGR so that the peak cladding temperature does not exceed 2200°F (Reference 2). High peak cladding temperatures are assumed to cause severe cladding failure by oxidation due to a Zirconium-water reaction.

The LCOs governing LHR, ASI, and the RCS ensure that these criteria are met as long as the core is operated within the ASI and F_r^T limits specified in the COLR, and within the T_q limits. The latter are process variables that characterize the three-dimensional power distribution of the reactor core. Operation within the limits for these variables ensures that their actual values are within the ranges used in the accident analyses.

BASES

Below 20% power, ASI limits for the LHR and DNB LCO are not required. At low powers, the APD trip will limit the allowed ASI during operation. The core reload analysis verifies that ASI limits for the LHR and DNB LCOs are not necessary below 20% power.

Fuel cladding damage does not normally occur while the reactor is operating at conditions outside these LCOs during normal operation. Fuel cladding damage results, however, when an accident or AOO occurs from initial conditions outside the limits of these LCOs. This potential for fuel cladding damage exists because changes in the power distribution can cause increased power peaking and correspondingly increased local LHRs.

The ASI satisfies 10 CFR 50.36(c)(2)(ii), Criterion 2.

LCO

The power distribution LCO limits are based on correlations between power peaking and certain measured variables used as inputs to the LHR and DNB ratio operating limits. These power distribution LCO limits, except T_q, are provided in the COLR. The limitation on LHR ensures that in the event of a LOCA, the peak temperature of the fuel cladding does not exceed 2200°F.

The limitation on ASI, along with the limitations of LCO 3.3.1, represents a conservative envelope of operating conditions consistent with the assumptions that have been analytically-demonstrated adequate for maintaining an acceptable minimum DNB ratio throughout all AOOs. Of these, the loss of flow transient is the most limiting. Operation of the core with conditions within the specified limits ensures that an acceptable minimum margin from DNB conditions is maintained in the event of any AOO, including a loss of flow transient.

APPLICABILITY

In MODE 1 with THERMAL POWER > 20% RTP, power distribution must be maintained within the limits assumed in the accident analyses to ensure that fuel damage does not result following an AOO. In other MODEs, this LCO does not apply because THERMAL POWER is not sufficient to require a limit on the core power distribution. Below 20% RTP, the incore detector accuracy is not reliable.

ACTIONS

A.1

Operating the core within ASI limits specified in the COLR and within the limits of LCO 3.3.1 ensures an acceptable margin for DNB and for maintaining local power density in the event of an AOO. Maintaining ASI within limits also ensures that the limits of Reference 2 are not exceeded during accidents. The Required Actions to restore ASI must be completed within 2 hours to limit the duration the plant is operated outside the initial conditions assumed in the accident analyses. In addition, this Completion Time is sufficiently short that the xenon distribution in the core cannot change significantly.

B.1

If the ASI cannot be restored to within its specified limits, or ASI cannot be determined because of Excore Detector Monitoring System inoperability, core power must be reduced. Reducing THERMAL POWER to ≤ 20% RTP provides reasonable assurance that the core is operating farther from thermal limits and places the core in a conservative condition. Four hours is a reasonable amount of time, based on operating experience, to reduce THERMAL POWER to ≤ 20% RTP in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.2.5.1

Verifying that the ASI is within the specified limits provides reasonable assurance that the core is not approaching DNB conditions. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

REFERENCES

1. UFSAR
2. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Plants"