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**Advanced Passive 1000 (AP1000)  
Generic Technical Specification Traveler (GTST)**

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**Title: Changes related to Section 3.1.1, Shutdown Margin (SDM)**

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**I. Technical Specifications Task Force (TSTF) Travelers, Approved Since Revision 2 of STS NUREG-1431, and Used to Develop this GTST**

**TSTF Number and Title:**

TSTF-425, Rev. 3, Relocate Surveillance Frequencies to Licensee Control – RITSTF Initiative 5b

**STS NUREGs Affected:**

NUREG-1430, -1431, -1432, -1433, -1434

**NRC Approval Date:**

18-Mar-09

**TSTF Classification:**

Technical change

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**II. Reference Combined License (RCOL) Standard Departures (Std. Dep.), RCOL COL Items, and RCOL Plant-Specific Technical Specifications (PTS) Changes Used to Develop this GTST**

**RCOL Std. Dep. Number and Title:**

None

**RCOL COL Item Number and Title:**

None

**RCOL PTS Change Number and Title:**

VEGP LAR DOC A011: Statements referring to “OPDMS inoperable” is revised to “OPDMS not monitoring parameters.”

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**III. Comments on Relations Among TSTFs, RCOL Std. Dep., RCOL COL Items, and RCOL PTS Changes**

This section discusses the considered changes that are: (1) applicable to operating reactor designs, but not to the AP1000 design; (2) already incorporated in the GTS; or (3) superseded by another change.

TSTF-425 is deferred for future consideration.

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**IV. Additional Changes Proposed as Part of this GTST (modifications proposed by NRC staff and/or clear editorial changes or deviations identified by preparer of GTST)**

In the "References" section of the Bases, "Accident Analysis" was changed to "Accident Analyses" in Reference 2.

**APOG Recommended Changes to Improve the Bases**

Throughout the Bases, references to Sections and Chapters of the FSAR do not include the "FSAR" clarifier. Since these Section and Chapter references are to an external document, it is appropriate to include the "FSAR" modifier. (DOC A003)

The discussion in the "Surveillance Requirements" section of the Bases is recommended to be revised clarifying the MODES when the surveillance is required. The first sentence in the 2nd paragraph is recommended to be revised adding "MODE 2 with  $k_{eff} < 1.0$  and in" to state "In MODE 2 with  $k_{eff} < 1.0$  and in MODE 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering at least the listed reactivity effects."

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## **V. Applicability**

### **Affected Generic Technical Specifications and Bases:**

Section 3.1.1, SHUTDOWN MARGIN (SDM)

### **Changes to the Generic Technical Specifications and Bases:**

Bases 3.1.1, BACKGROUND, fourth paragraph, “OPDMS is inoperable” is replaced with “OPDMS is not monitoring parameters.” (DOC A011)

In the “Surveillance Requirements” section of the Bases, the first sentence in the 2nd paragraph is recommended to be revised adding “MODE 2 with  $k_{\text{eff}} < 1.0$  and in” to state “In MODE 2 with  $k_{\text{eff}} < 1.0$  and in MODE 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering at least the listed reactivity effects.” (APOG Comment)

The acronym “FSAR” is added to modify “Section” and “Chapter” in references to the FSAR throughout the Bases. (DOC A003)

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**VI. Traveler Information****Description of TSTF changes:**

NA

**Rationale for TSTF changes:**

NA

**Description of changes in RCOL Std. Dep., RCOL COL Item(s), and RCOL PTS Changes:****VEGP LAR DOC A011**

Statements referring to “OPDMS inoperable” are replaced with “OPDMS is not monitoring parameters.”

**Rationale for changes in RCOL Std. Dep., RCOL COL Item(s), and RCOL PTS Changes:****VEGP LAR DOC A011**

The On-Line Power Distribution Monitoring System (OPDMS) is not safety related and does not have a safety function. OPDMS is an advanced core monitoring and support package. With OPDMS operating, the power distribution parameters are continuously computed and displayed, and compared against their limit. The TS definition of Operable is applied to assure a system is “capable of performing its specified safety function(s).” As such the use of the defined term is not appropriate for the OPDMS. Additionally, there is no requirement for maintaining its non-safety related capability.

The online monitoring capability of OPDMS is utilized when complying with TS 3.2.5, OPDMS-Monitored Parameters. The parameters required to meet LCO 3.2.5 are only applicable when OPDMS is providing the monitoring for compliance with the applicable limits. When OPDMS is not being utilized, the limits of TS 3.1.6, 3.2.1, 3.2.2, 3.2.3, and 3.2.4 are applicable (note that certain Actions of TS 3.1.4 also impose requirements of TS 3.2.1 and 3.2.2 when OPDMS is not being utilized). The current use of “OPERABLE” (and “inoperable”) in referencing whether OPDMS is being utilized, is misleading and is more appropriately revised to “monitoring” (and “not monitoring”).

**Description of additional changes proposed by NRC staff/preparer of GTST:**

The acronym “FSAR” is added to modify “Section” and “Chapter” in references to the FSAR throughout the Bases. (DOC A003)

The discussion in the “Surveillance Requirements” section of the Bases is recommended to be revised clarifying the MODES when the surveillance is required. The first sentence in the 2nd paragraph is recommended to be revised adding “MODE 2 with  $k_{eff} < 1.0$  and in” to state “In MODE 2 with  $k_{eff} < 1.0$  and in MODE 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering at least the listed reactivity effects.”

**Rationale for additional changes proposed by NRC staff/preparer of GTST:**

Since Bases references to FSAR Sections and Chapters are to an external document, it is appropriate to include the “FSAR” modifier.

The revision to the “Surveillance Requirements” section in the Bases makes the discussion in the Bases consistent with the “Applicability” section in the Specifications. This additional information clarifies when the surveillance is performed and reduces potential misunderstanding and misapplication.

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## **VII. GTST Safety Evaluation**

### **Technical Analysis:**

#### Replacing “OPDMS is inoperable” with “OPDMS is not monitoring parameters”

The Bases for this Section is revised to state “OPDMS is not monitoring parameters” replacing “OPDMS is inoperable” consistent with the changes made in TS 3.2.5, OPDMS - Monitoring Parameters.”

In TS, the term “Operable” is applied to assure that a system is “capable of performing its specified safety function(s).” OPDMS is not safety related and does not have a safety function. It is a core monitoring and support package. As described, when OPDMS is operating, the power distribution parameters are continuously computed and displayed, and compared against their limit. It is, therefore, appropriate to use the terms “OPDMS is monitoring” and “OPDMS is not monitoring.”

#### Clarifying MODE applicability in SR 3.1.1.1 discussion

The change to the first sentence of the 2nd paragraph in the “Surveillance Requirements” section of the Bases is acceptable, since it makes the discussion in the Bases consistent with the Specifications and removes any ambiguity.

#### Remaining Changes

The remaining changes are editorial, clarifying, grammatical, or otherwise considered administrative. These changes do not affect the technical content, but improve the readability, implementation, and understanding of the requirements, and are therefore acceptable.

Having found that this GTST’s proposed changes to the GTS and Bases are acceptable, the NRC staff concludes that AP1000 STS Subsection 3.1.1 is an acceptable model Specification for the AP1000 standard reactor design.

### **References to Previous NRC Safety Evaluation Reports (SERs):**

None

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**VIII. Review Information****Evaluator Comments:**

None

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**Review Information:**

Availability for public review and comment on Revision 0 of this traveler approved by NRC staff on 5/20/2014.

**APOG Comments (Ref. 7) and Resolutions**

1. (Internal #3) Throughout the Bases, references to Sections and Chapters of the FSAR do not include the "FSAR" modifier. Since these Section and Chapter references are to an external document, it is appropriate to include the "FSAR" modifier. This is resolved by adding the "FSAR" modifier as appropriate.
1. (Internal #65) 3.1.01, Pg. 07, the first sentence in the second paragraph of the "Technical Analysis" of Section VII in the GTST was deleted. The sentence discussed the use of the term "OPDMS operable" and "OPDMS inoperable." This discussion was not necessary because it did not add to the analysis presented.
2. (Internal #66) 3.1.01, Pg. 25, the first sentence in the 2nd paragraph of the discussion in the "Surveillance Requirements" section of the Bases was revised to reduce the potential for misunderstanding and misapplication. The phrase, "MODE 2 with  $k_{eff} < 1.0$  and in" was added.

**NRC Final Approval Date:** 12/4/2015

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**NRC Contact:**

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**IX. Evaluator Comments for Consideration in Finalizing Technical Specifications and Bases**

None

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**X. References Used in GTST**

1. AP1000 DCD, Revision 19, Section 16, "Technical Specifications," June 2011 (ML11171A500).
2. Southern Nuclear Operating Company, Vogtle Electric Generating Plant, Unit 3 and 4, Technical Specifications Upgrade License Amendment Request, February 24, 2011 (ML12065A057).
3. RAI Letter No. 01 Related to License Amendment Request (LAR) 12-002 for the Vogtle Electric Generating Plant Units 3 and 4 Combined Licenses, September 7, 2012 (ML12251A355).
4. Southern Nuclear Operating Company, Vogtle Electric Generating Plant, Units 3 and 4, Response to Request for Additional Information Letter No. 01 Related to License Amendment Request LAR-12-002, ND-12-2015, October 04, 2012 (ML12286A363 and ML12286A360).
5. NRC Safety Evaluation (SE) for Amendment No. 13 to Combined License (COL) No. NPF-91 for Vogtle Electric Generating Plant (VEGP) Unit 3, and Amendment No. 13 to COL No. NPF-92 for VEGP Unit 4, September 9, 2013 (ADAMS Package Accession No. ML13238A337), which contains:

ML13238A355,	Cover Letter - Issuance of License Amendment No. 13 for Vogtle Units 3 and 4 (LAR 12-002).
ML13238A359,	Enclosure 1 - Amendment No. 13 to COL No. NPF-91
ML13239A256,	Enclosure 2 - Amendment No. 13 to COL No. NPF-92
ML13239A284,	Enclosure 3 - Revised plant-specific TS pages (Attachment to Amendment No. 13)
ML13239A287,	Enclosure 4 - Safety Evaluation (SE), and Attachment 1 - Acronyms
ML13239A288,	SE Attachment 2 - Table A - Administrative Changes
ML13239A319,	SE Attachment 3 - Table M - More Restrictive Changes
ML13239A333,	SE Attachment 4 - Table R - Relocated Specifications
ML13239A331,	SE Attachment 5 - Table D - Detail Removed Changes
ML13239A316,	SE Attachment 6 - Table L - Less Restrictive Changes

The following documents were subsequently issued to correct an administrative error in Enclosure 3:

ML13277A616,	Letter - Correction To The Attachment (Replacement Pages) - Vogtle Electric Generating Plant Units 3 and 4- Issuance of Amendment Re: Technical Specifications Upgrade (LAR 12-002) (TAC No. RP9402)
ML13277A637,	Enclosure 3 - Revised plant-specific TS pages (Attachment to Amendment No. 13) (corrected)

6. TSTF-GG-05-01, "Writer's Guide for Plant-Specific Improved Technical Specifications," June 2005.

7. APOG-2014-008, APOG (AP1000 Utilities) Comments on AP1000 Standardized Technical Specifications (STS) Generic Technical Specification Travelers (GTSTs), Docket ID NRC-2014-0147, September 22, 2014 (ML14265A493).
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**XI. MARKUP of the Applicable GTS Subsection for Preparation of the STS NUREG**

The entire section of the Specifications and the Bases associated with this GTST is presented next.

Changes to the Specifications and Bases are denoted as follows: Deleted portions are marked in strikethrough red font, and inserted portions in bold blue font.

## 3.1 REACTIVITY CONTROL SYSTEMS

## 3.1.1 SHUTDOWN MARGIN (SDM)

LCO 3.1.1            The SDM shall be within the limits specified in the COLR.

APPLICABILITY:    MODE 2 with  $k_{\text{eff}} < 1.0$ ,  
MODES 3, 4, and 5.

## ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. SDM not within limits.	A.1    Initiate boration to restore SDM to within limits.	15 minutes

## SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.1.1.1    Verify SDM to be within limits.	24 hours

## 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 shutdown under cold conditions. Maintenance of the SDM ensures that postulated reactivity events will not damage the fuel.

SDM requirements provide sufficient reactivity margin to assure 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 Rod Cluster Control Assemblies (RCCAs), assuming that the single rod cluster assembly 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 Plant Control System (PLS) 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 PLS, 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 rod of highest reactivity worth remains fully withdrawn. The soluble boron system can compensate for fuel depletion during operation and xenon burnout reactivity changes and maintain the reactor subcritical under cold conditions.

During power operation, SDM is calculated and monitored by the Online Power Distribution Monitoring System (OPDMS) and controlled by operating with RCCAs sufficiently withdrawn to meet the SDM requirement. When the OPDMS is ~~inoperable~~ **not monitoring parameters**, SDM control is ensured by operating within the limits of LCO 3.1.5 "Shutdown Bank Insertion Limits," and LCO 3.1.6, "Control Bank Insertion Limits." When the unit is in the shutdown and refueling modes, the SDM requirements are met by adjustments to the RCS boron concentration.

## BASES

APPLICABLE  
SAFETY  
ANALYSES

The minimum required SDM is assumed as an initial condition in safety analyses. The safety analyses (Ref. 2) establish an SDM that ensures that 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, transients, and Design Basis Events;
- b. The reactivity transients associated with postulated accident conditions are controllable within acceptable limits (departures from nucleate boiling ratio (DNBR), fuel centerline temperature limits for AOOs, and  $\leq 280$  cal/gm energy deposition for the rod ejection accident); and
- c. The reactor will be maintained sufficiently subcritical to preclude inadvertent criticality in the shutdown condition.

The most limiting accidents for the SDM requirements are based on a main steam line break (SLB) and inadvertent opening of a steam generator (SG) relief or safety valve, as described in the accident analyses (Ref. 2). The increased steam flow in the main steam system causes an increased energy removal from the affected 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 (MTC), this cooldown causes an increase in core reactivity. 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 SLB or opening of an SG relief or safety valve, a post trip return to power may occur; however, no fuel damage occurs as a result of the post trip return to power, and the THERMAL POWER does not violate the Safety Limit (SL) requirement of SL 2.1.1.



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BASES

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## APPLICABLE SAFETY ANALYSES (continued)

In addition to the limiting SLB and inadvertent opening of an SG relief or safety valve transients, the SDM requirement must also protect against:

- a. Inadvertent boron dilution;
- b. An uncontrolled rod withdrawal from subcritical or low power condition;
- c. 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 when critical boron concentrations are highest.

The uncontrolled rod withdrawal transient is terminated by a high neutron flux trip. Power level, RCS pressure, linear heat rate, and the DNBR do not exceed allowable limits.

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.

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

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LCO

SDM is a core design condition that can be ensured during operation through calculations by the OPDMS and RCCA positioning and through the soluble boron concentration.

BASES

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## LCO (continued)

The SLB and the boron dilution accidents (Ref. 2) are the most limiting analyses that establish the SDM value of the LCO. For SLB accidents, if the LCO is violated, there is a potential to exceed the DNBR limit and to exceed 10 CFR 50.34 limits (Ref. 3). For the boron dilution accident, if the LCO is violated, the minimum required time assumed for automatic action to terminate dilution may no longer be applicable.

APPLICABILITY

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In MODE 2 with  $k_{\text{eff}} < 1.0$ , and 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."

ACTIONS

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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 concentrated solution. The operator should begin boration with the best source available for the plant conditions.

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 hot shutdown conditions when boron concentration is highest at 1502 ppm. Assuming that a value of 1.0%  $\Delta k/k$  must be recovered and the boration flow rate is 100 gpm, it is possible to increase the boron concentration of the RCS by 111 ppm in approximately 21 minutes utilizing boric acid solution having a concentration of 4375 ppm. If a boron worth of 9 pcm/ppm is assumed, this combination of parameters will increase the SDM by 1.0%  $\Delta k/k$ . These boration parameters of 100 gpm and 4375 ppm represent typical values and are provided for the purpose of offering a specific example.

## BASES

SURVEILLANCE  
REQUIREMENTSSR 3.1.1.1

In MODES 1 and 2 with  $k_{\text{eff}} \geq 1.0$ , SDM is verified by observing that the requirements of LCO 3.1.5 and LCO 3.1.6 are met. In the event that an RCCA is known to be untrippable, however, SDM verification must account for the worth of both the untrippable RCCA as well as another RCCA of maximum worth.

In **MODE 2 with  $k_{\text{eff}} < 1.0$  and in** MODES 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering at least the listed reactivity effects:

- a. RCS boron concentration;
- b. RCCA and GRCA 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).

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.
2. **FSAR** Chapter 15, "Accident Analysis."
3. 10 CFR 50.34.

**XII. Applicable STS Subsection After Incorporation of this GTST's Modifications**

The entire subsection of the Specifications and the Bases associated with this GTST, following incorporation of the modifications, is presented next.

## 3.1 REACTIVITY CONTROL SYSTEMS

## 3.1.1 SHUTDOWN MARGIN (SDM)

LCO 3.1.1            The SDM shall be within the limits specified in the COLR.

APPLICABILITY:    MODE 2 with  $k_{\text{eff}} < 1.0$ ,  
MODES 3, 4, and 5.

## ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. SDM not within limits.	A.1    Initiate boration to restore SDM to within limits.	15 minutes

## SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.1.1.1    Verify SDM to be within limits.	24 hours

## B 3.1 REACTIVITY CONTROL SYSTEMS

### B 3.1.1 SHUTDOWN MARGIN (SDM)

#### BASES

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

SDM requirements provide sufficient reactivity margin to assure 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 Rod Cluster Control Assemblies (RCCAs), assuming that the single rod cluster assembly 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 Plant Control System (PLS) 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 PLS, 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 rod of highest reactivity worth remains fully withdrawn. The soluble boron system can compensate for fuel depletion during operation and xenon burnout reactivity changes and maintain the reactor subcritical under cold conditions.

During power operation, SDM is calculated and monitored by the Online Power Distribution Monitoring System (OPDMS) and controlled by operating with RCCAs sufficiently withdrawn to meet the SDM requirement. When the OPDMS is not monitoring parameters, SDM control is ensured by operating within the limits of LCO 3.1.5 "Shutdown Bank Insertion Limits," and LCO 3.1.6, "Control Bank Insertion Limits." When the unit is in the shutdown and refueling modes, the SDM requirements are met by adjustments to the RCS boron concentration.

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BASES

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APPLICABLE  
SAFETY  
ANALYSES

The minimum required SDM is assumed as an initial condition in safety analyses. The safety analyses (Ref. 2) establish an SDM that ensures that 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, transients, and Design Basis Events;
- b. The reactivity transients associated with postulated accident conditions are controllable within acceptable limits (departures from nucleate boiling ratio (DNBR), fuel centerline temperature limits for AOOs, and  $\leq 280$  cal/gm energy deposition for the rod ejection accident); and
- c. The reactor will be maintained sufficiently subcritical to preclude inadvertent criticality in the shutdown condition.

The most limiting accidents for the SDM requirements are based on a main steam line break (SLB) and inadvertent opening of a steam generator (SG) relief or safety valve, as described in the accident analyses (Ref. 2). The increased steam flow in the main steam system causes an increased energy removal from the affected 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 (MTC), this cooldown causes an increase in core reactivity. 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 SLB or opening of an SG relief or safety valve, a post trip return to power may occur; however, no fuel damage occurs as a result of the post trip return to power, and the THERMAL POWER does not violate the Safety Limit (SL) requirement of SL 2.1.1.

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BASES

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## APPLICABLE SAFETY ANALYSES (continued)

In addition to the limiting SLB and inadvertent opening of an SG relief or safety valve transients, the SDM requirement must also protect against:

- a. Inadvertent boron dilution;
- b. An uncontrolled rod withdrawal from subcritical or low power condition;
- c. 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 when critical boron concentrations are highest.

The uncontrolled rod withdrawal transient is terminated by a high neutron flux trip. Power level, RCS pressure, linear heat rate, and the DNBR do not exceed allowable limits.

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.

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

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LCO

SDM is a core design condition that can be ensured during operation through calculations by the OPDMS and RCCA positioning and through the soluble boron concentration.



BASES

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## LCO (continued)

The SLB and the boron dilution accidents (Ref. 2) are the most limiting analyses that establish the SDM value of the LCO. For SLB accidents, if the LCO is violated, there is a potential to exceed the DNBR limit and to exceed 10 CFR 50.34 limits (Ref. 3). For the boron dilution accident, if the LCO is violated, the minimum required time assumed for automatic action to terminate dilution may no longer be applicable.

APPLICABILITY

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In MODE 2 with  $k_{\text{eff}} < 1.0$ , and 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."

ACTIONS

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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 concentrated solution. The operator should begin boration with the best source available for the plant conditions.

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 hot shutdown conditions when boron concentration is highest at 1502 ppm. Assuming that a value of 1.0%  $\Delta k/k$  must be recovered and the boration flow rate is 100 gpm, it is possible to increase the boron concentration of the RCS by 111 ppm in approximately 21 minutes utilizing boric acid solution having a concentration of 4375 ppm. If a boron worth of 9 pcm/ppm is assumed, this combination of parameters will increase the SDM by 1.0%  $\Delta k/k$ . These boration parameters of 100 gpm and 4375 ppm represent typical values and are provided for the purpose of offering a specific example.

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BASES

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SURVEILLANCE  
REQUIREMENTSSR 3.1.1.1

In MODES 1 and 2 with  $k_{\text{eff}} \geq 1.0$ , SDM is verified by observing that the requirements of LCO 3.1.5 and LCO 3.1.6 are met. In the event that an RCCA is known to be untrippable, however, SDM verification must account for the worth of both the untrippable RCCA as well as another RCCA of maximum worth.

In MODE 2 with  $k_{\text{eff}} < 1.0$  and in MODES 3, 4, and 5, the SDM is verified by performing a reactivity balance calculation, considering at least the listed reactivity effects:

- a. RCS boron concentration;
- b. RCCA and GRCA 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).

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.

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REFERENCES

1. 10 CFR 50, Appendix A, GDC 26.
  2. FSAR Chapter 15, "Accident Analyses."
  3. 10 CFR 50.34.
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