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

Title: Changes related to Section 3.1.2, Core Reactivity

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

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 A006:	The LCO statement for TS 3.1.2, “Core Reactivity,” is revised to delete “normalized” as the modifier to “predicted values.”
VEGP LAR DOC A007:	The second surveillance frequency for TS 3.1.2, “Core Reactivity,” SR 3.1.2 has a Note that is revised to include the phrase “to be performed” such that it states: “Only required to be performed after 60 EFPD.”
VEGP LAR DOC A008:	TS 3.1.2, “Core Reactivity,” SR 3.1.2.1 Frequency is revised to add “Once” as the lead in to “Prior to entering MODE 1 after each refueling.”

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(1) applicable to operating reactor designs, but not to the AP1000 design; (2) already incorporated in the GTS; or (3) superseded by another change.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.

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)

Editorial Change:

In 6th line of the "Applicable Safety Analyses" section in the Bases, "calculation models" is replaced with "calculational models."

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

APOG Recommended Changes to Improve the Bases

1. Revise TS 3.1.2 Bases Background last paragraph to provide more complete description of core reactivity.

2. Revise TS 3.1.2 Required Action B.1 Bases to replace "SR 3.1.1.1" with "LCO 3.1.1 Required Action A.1."

3. Make the following editorial changes:

   Make the following changes to the Applicable Safety Analyses:

   > If the measured and predicted RCS boron concentrations for identical core conditions at ~~beginning of cycle (~~BOC~~)~~ do not agree, then...

   Make the following changes to SR 3.1.2.1 Surveillance Requirements Bases:

   > .... 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 ....

4. 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)

V. Applicability

Affected Generic Technical Specifications and Bases:

Section 3.1.2, Core Reactivity

Changes to the Generic Technical Specifications and Bases:

LCO description is revised to delete the word “normalized” as modifier to “predicted values.” (DOC A006)

The first surveillance frequency of SR 3.1.2.1 is revised to state “Once prior to entering MODE 1 after each refueling.” (DOC A008)

The Note to the second surveillance frequency of SR 3.1.2.1 is revised to state “Only required to be performed after 60 EFPD.” (DOC A007)

The “Background” section in the Bases is revised to provide a more complete description of core reactivity. (APOG Comment)

Required Action B.1 in Bases was revised replacing “SR 3.1.1.1” with “LCO 3.1.1 Required Action A.1.” (APOG Comment)

Editorial changes were made in “Applicable Safety Analyses” and “Surveillance Requirements SR 3.1.2.1” sections of the Bases. (APOG Comment)

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

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 A006:

The LCO statement for TS 3.1.2, "Core Reactivity," is revised to delete "normalized" as the modifier to "predicted values." The revised LCO description states: The measured core reactivity shall be within +/-1% Δk/k of the predicted values."

VEGP LAR DOC A007:

The second surveillance frequency for TS 3.1.2, "Core Reactivity," SR 3.1.2 has a Note that is revised to include the phrase "to be performed" such that it states: "Only required to be performed after 60 EFPD."

VEGP LAR DOC A008:

TS 3.1.2, "Core Reactivity," SR 3.1.2.1 Frequency is revised to add "Once" as the lead in to "Prior to entering MODE 1 after each refueling." The revised Surveillance Frequency states: "Once prior to entering MODE 1 after each refueling."

Rationale for changes in RCOL Std. Dep., RCOL COL Item(s), and RCOL PTS Changes:

VEGP LAR DOC A006:

SR 3.1.2.1 requires an initial beginning of cycle measurement of core reactivity and a comparison to predicted values. "Normalization" is allowed (but not required) up to 60 effective full power days (EFPD) after each fuel loading. The LCO requirement is not intended to be explicitly tied solely to "normalized" predicted values. Even if normalization of predicted values is made, this simply becomes the new predicted value. Therefore, eliminating "normalized" as the modifier to "predicted values" in the LCO statement provides the more appropriate intent and clarifies such as to preclude potential misapplication.

The overall intent of the current LCO and associated SR is considered to be consistent with the proposed revision. The current Bases are consistent with this change. Furthermore, this change results in consistency with the LCO 3.1.2 statement in NUREG-1431.

VEGP LAR DOC A007:

As described in STS Writer's Guide, when a Surveillance is noted as "only required" or "not required" it must be accompanied by either "to be met" or "to be performed." The frequency for SR 3.1.2.1 is vague in not explicitly providing the requisite clarifier. "To be performed" is the appropriate intent since the exception is intended solely to convey the timing of the SR performance and not an exception to meeting the core reactivity acceptance criterion. This is appropriately described in the Bases for SR 3.1.2.1.

These changes (wording preferences, editorial changes, reformatting, revised numbering, etc.) are made to provide clarification and for consistency with the STS Writer's Guide.

VEGP LAR DOC A008:

As described in the STS Writer's Guide, the frequency of performance is always implied as "once per" unless otherwise stated. The above frequencies are vague in not explicitly stating "once." TS Section 1.4, Frequency, Example 1.4-2 describes that "The use of 'Once' indicates a single performance will satisfy the specified Frequency."

Since the described SRs do not include the clarifier "once," a potential misreading of the frequency could lead to performance prior to establishing the stated condition (i.e., each entry into Mode 1; each criticality; each entry into Mode 4).

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

1. Editorial Change:

   In the 6th line of the 4th paragraph of the "Applicable Safety Analyses" section in the Bases, "calculation models" is replaced with "calculational models."

2. The last paragraph of the "Background" section in the Bases is revised as follows:

   When the core is producing THERMAL POWER, the fuel **and burnable absorbers are** ~~is~~ being depleted and excess reactivity **(except possibly near beginning of cycle (BOC))** is decreasing. As the fuel **and burnable absorber** deplete~~s~~, the RCS boron concentration is ~~reduced~~ **adjusted** to compensate **for the net core** reactivity change while ~~and~~ maintain**ing** constant THERMAL POWER.

3. Action B.1 in Bases is revised as follows:

   If the SDM for MODE 3 is not met, then the boration required by ~~SR 3.1.1.1~~ **LCO 3.1.1 Required Action A.1** would occur.

4. Editorial changes:

   Make the following changes to the Applicable Safety Analyses:

   > If the measured and predicted RCS boron concentrations for identical core conditions at ~~beginning of cycle (~~BOC~~)~~ do not agree, then...

   Make the following changes to SR 3.1.2.1 Surveillance Requirements Bases:

.... 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 ....

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

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

Changes in the last paragraph of the “Background” section of the Bases provide a more complete description of core reactivity. The paragraph currently does not include descriptions of burnable absorbers depletion and does not mention the fact that boron concentration may actually increase at BOC (as shown in AP1000 DCD Figure 4.3-3).

Revision to Required Action B.1 Bases corrects an error in the Bases discussion. SR 3.1.1.1 does not require boration but Required Action A.1 for TS 3.1.1 does.

Changing “calculation model' to “calculational models” makes the use of the term consistent throughout this section.

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

The remaining changes are editorial. They provide improved clarity, consistency, and operator usability.

VII. GTST Safety Evaluation

Technical Analysis:

Deletion of the modifier “normalization” in the LCO description

The LCO requirement is not intended to be explicitly tied solely to “normalized” predicted values. The normalization of predicted values is allowed and when it is made, this simply becomes the new predicted value. Therefore, eliminating “normalized” as the modifier to “predicted values” in the LCO statement provides the more appropriate intent and clarifies such as to preclude potential misapplication. “Normalization” is not required up to 60 effective full power days (EFPD) after each refueling.

This change, i.e. deletion of the modifier “normalization,” is consistent with Standard Technical Specification for Westinghouse Plants, NUREG-1431, Rev. 4. Accordingly, for AP1000 STS, this change will preclude potential misapplication and the intent of the specification will be clear. The change is therefore acceptable.

Revision to Surveillance Frequency of SR 3.1.2.1 for verification of measured core reactivity

Adding “once” as the lead in to define the surveillance frequency, i.e. revising the Frequency to state: “Once prior to entering MODE 1 after each refueling”, clarifies the intent of this Surveillance. In this case, a single performance will satisfy the specified frequency. Without the clarifier “once”, a misinterpretation is possible where the surveillance is performed for each entry into MODE 1. Accordingly, this change will provide a better understood surveillance frequency for AP1000, will avoid misinterpretation, and is acceptable.

Adding “to be performed” in the Note to the second frequency clarifies the intent of the Note in more specific terms. As stated in the VEGP amendment request, the appropriate intent is solely to convey the timing of the SR performance and not an exception to meeting the core reactivity criterion. This wording is also consistent with the STS Writer’s Guide. This change will also provide clarity to the surveillance requirement for AP1000 and is acceptable.

Revising last paragraph in the “Background” section of the Bases

The revision to the last paragraph provides a more complete description of core reactivity. Previous description did neither mention depletion of burnable absorbers nor the fact that boron concentration may actually increase at BOC. These changes are consistent with the wording found in plant-specific TS bases and will make the Bases discussion consistent with the AP1000 DCD, and are, therefore acceptable.

Revision to Required Action B.1 in Bases

Replacing “SR 3.1.1.1” with “LCO 3.1.1 Required Action A.1” corrects an error. This revision makes the discussion correctly refer to Required Action A.1 and is acceptable.

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

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.

2. (Internal #67) 3.1.02, Pg. 25, The last paragraph in the “Background” section in the Bases was revised to provide a more complete description of core reactivity. This discussion now includes description of burnable absorbers depletions and the increase of boron concentration at BOC.

3. (Internal # 69) 3.1.02, Pg. 28, Required Action B.1 in Bases was revised to correctly refer to Required Action A.1.

4. (Internal #68 and 70) 3.1.02, Pg. 25 and 3.1.02, pg. 28, Editorial changes.

NRC Final Approval Date: 12/4/2015

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

None

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).

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

3.1.2 Core Reactivity

LCO 3.1.2 The measured core reactivity shall be within ±1% Δk/k of the ~~normalized~~ predicted values.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Measured core reactivity not within limit.	A.1 Re-evaluate core design and safety analysis, and determine that the reactor core is acceptable for continued operation. <u>AND</u> A.2 Establish appropriate operating restrictions and SRs.	7 days 7 days
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	6 hours

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.1.2.1	----------NOTE---------- The predicted reactivity values may be adjusted (normalized) to correspond to the measured core reactivity prior to exceeding a fuel burnup of 60 effective full power days (EFPD) after each fuel loading. -------------------- Verify measured core reactivity is within ±1% Δk/k of predicted values.	**Once prior**~~Prior~~ to entering MODE 1 after each refueling AND --------NOTE-------- Only required **to be performed** after 60 EFPD ----------------------- 31 EFPD thereafter

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. Therefore, reactivity balance is used as a measure of the predicted versus measured core reactivity during power operation. The periodic confirmation of core reactivity is necessary to ensure that Design Basis Accident (DBA) and transient safety analyses remain valid. A large reactivity difference could be the result of unanticipated changes in fuel, control rod worth, or operation at conditions not consistent with those assumed in the predictions of core reactivity and could potentially result in a loss of SDM 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 rod height, temperature, pressure, and power), provides a convenient method of ensuring that core reactivity is within design expectations and that the calculation 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 a negative moderator temperature coefficient, the

BASES

BACKGROUND (continued)

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.

When the core is producing THERMAL POWER, the fuel **and burnable absorbers are** ~~is~~ being depleted and excess reactivity **(except possibly near beginning of cycle (BOC))** is decreasing. As the fuel **and burnable absorber** deplete~~s~~, the RCS boron concentration is **adjusted**~~reduced~~ to compensate **for the net core** reactivity **change while** ~~and~~ maintain**ing** 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. Certain accident evaluations (Ref. 2) are, therefore, dependent upon accurate evaluation of core reactivity. In particular, SDM and reactivity transients, such as control rod withdrawal accidents or rod ejection accidents, are sensitive to accurate predictions 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 provides additional assurance that the nuclear methods provide an accurate representation of the core reactivity.

Design calculations and safety analysis 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 a 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 calculation**al** models used to predict soluble boron requirements may not

BASES

APPLICABLE SAFETY ANALYSES (continued)

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.

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.

Core reactivity satisfies Criterion 2 of 10 CFR 50.36(c)(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 Conditions of 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 DBA and transient analyses are no longer valid, or that the uncertainties in the Nuclear Design Methodology are larger than expected. A limit on the reactivity balance of ± 1% Δk/k has been established based on engineering judgment. A 1% deviation in reactivity from that predicted is larger than expected for normal operation and should therefore be evaluated.

When measured core reactivity is within 1% Δk/k 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.

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 MODE 3, 4, and 5 because the reactor is shutdown 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 during the first startup following 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 DBA 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

BASES

ACTIONS (continued)

SRs are necessary to ensure the reactor core is acceptable for continued operation, then they must be defined.

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

B.1

If the core reactivity cannot be restored to within the 1% Δk/k limit, 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 the boration required by **LCO 3.1.1 Required Action A.1** ~~SR 3.1.1.1~~ would occur. 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 control rod 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 (EFPDs) 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 EFPDs following the initial 60 EFPDs after entering MODE 1 is acceptable based on the slow rate of core changes due to fuel depletion and the presence of other indicators (QPTR, AFD, etc.) for prompt indication of an anomaly.

BASES

REFERENCES

1. 10 CFR 50, Appendix A, GDC 26, GDC 28, and GDC 29.
2. **FSAR** Chapter 15, "Accident Analyse~~i~~s."

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

3.1.2 Core Reactivity

LCO 3.1.2 The measured core reactivity shall be within ±1% Δk/k of the predicted values.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Measured core reactivity not within limit.	A.1 Re-evaluate core design and safety analysis, and determine that the reactor core is acceptable for continued operation. <u>AND</u> A.2 Establish appropriate operating restrictions and SRs.	7 days 7 days
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	6 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2.1	--------------------------------NOTE------------------------------- The predicted reactivity values may be adjusted (normalized) to correspond to the measured core reactivity prior to exceeding a fuel burnup of 60 effective full power days (EFPD) after each fuel loading. --- Verify measured core reactivity is within ±1% Δk/k of predicted values.	Once prior to entering MODE 1 after each refueling <u>AND</u> --------NOTE-------- Only required to be performed after 60 EFPD ------------------------ 31 EFPD thereafter

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. Therefore, reactivity balance is used as a measure of the predicted versus measured core reactivity during power operation. The periodic confirmation of core reactivity is necessary to ensure that Design Basis Accident (DBA) and transient safety analyses remain valid. A large reactivity difference could be the result of unanticipated changes in fuel, control rod worth, or operation at conditions not consistent with those assumed in the predictions of core reactivity and could potentially result in a loss of SDM 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 rod height, temperature, pressure, and power), provides a convenient method of ensuring that core reactivity is within design expectations and that the calculation 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 a negative moderator temperature coefficient, the

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BACKGROUND (continued)

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.

When the core is producing THERMAL POWER, the fuel and burnable absorbers are being depleted and excess reactivity (except possibly near beginning of cycle (BOC)) is decreasing. As the fuel and burnable absorber deplete, the RCS boron concentration is adjusted to compensate for the net core reactivity change while maintaining 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. Certain accident evaluations (Ref. 2) are, therefore, dependent upon accurate evaluation of core reactivity. In particular, SDM and reactivity transients, such as control rod withdrawal accidents or rod ejection accidents, are sensitive to accurate predictions 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 provides additional assurance that the nuclear methods provide an accurate representation of the core reactivity.

Design calculations and safety analysis 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 a normalization for the calculational models used to predict core reactivity. If the measured and predicted RCS boron concentrations for identical core conditions at 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

BASES

APPLICABLE SAFETY ANALYSES (continued)

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.

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.

Core reactivity satisfies Criterion 2 of 10 CFR 50.36(c)(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 Conditions of 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 DBA and transient analyses are no longer valid, or that the uncertainties in the Nuclear Design Methodology are larger than expected. A limit on the reactivity balance of ± 1% $\Delta k/k$ has been established based on engineering judgment. A 1% deviation in reactivity from that predicted is larger than expected for normal operation and should therefore be evaluated.

When measured core reactivity is within 1% $\Delta k/k$ 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.

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 MODE 3, 4, and 5 because the reactor is shutdown 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 during the first startup following 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 DBA 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

BASES

ACTIONS (continued)

SRs are necessary to ensure the reactor core is acceptable for continued operation, then they must be defined.

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

B.1

If the core reactivity cannot be restored to within the 1% Δk/k limit, 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 the boration required by LCO 3.1.1 Required Action A.1 would occur. 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 control rod 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 (EFPDs) 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 EFPDs following the initial 60 EFPDs after entering MODE 1 is acceptable based on the slow rate of core changes due to fuel depletion and the presence of other indicators (QPTR, AFD, etc.) for prompt indication of an anomaly.

BASES

REFERENCES

1. 10 CFR 50, Appendix A, GDC 26, GDC 28, and GDC 29.
2. FSAR Chapter 15, “Accident Analyses.”