RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**190-8058**
SRP Section:	**16 – Technical Specifications**
Application Section:	**16.3.2 – Power Distribution Limits**
Date of RAI Issue:	**09/01/2015**

Question No. 16-81

Justify the deviation in the Frequency for Surveillance Requirement (SR) 3.2.2.1.

The Frequency in the STS reads "…but prior to operations above 70% RTP." The generic TS text reads "…but prior to operations above 80% RTP."

The justification is required to ensure the SR is performed at the correct power level (percent RTP).

Response

The 80% RTP was determined from ANSI/ANS-19.6.1-2005, "Reload Startup Physics Tests for Pressurized Water Reactors." There is no compromise in plant safety since all the design analysis, (including COLSS/CPCS overall uncertainty analysis), will be based on 80% RTP and a conservative Fxy. An additional penalty will be installed at the COLSS/CPCS prior to the 80% Fxy measurement during the startup test period. It is also judged to be more economical to measure Fxy at a higher power plateau since it can take several hours to perform the measurement due to the requirement for equilibrium Xenon conditions.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

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Question No. 16-82

Clarify the wording in the Note for Required Actions B.1, B.2, and B.3 in generic Technical Specification (TS) 3.2.3, which is inconsistent with the wording in the STS.

The STS Note reads “All subsequent Required Actions must be completed if power reduction commences...” The Note in the generic TS reads “Required Actions up to B.3 must be completed…” This wording may mislead an operator to believe that Required Actions up to but not including B.3 must be completed.

This clarification is required to ensure that the appropriate Required Actions are completed as warranted.

Response

The wording in the NOTE for Required Actions B.1, B.2 and B.3 will be changed from “Required Actions up to B.3…” to “All subsequent Required Actions...” for clarification as described in the STS.

Impact on DCD

Same as the changes described in Impact on Technical Specifications.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

TS 3.2.3 Page 3.2.3-2 will be revised as indicated in the attachment.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

All subsequent Required Actions

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Measured T_q > 0.10.	NOTE ~~Required Actions up to B.3~~ must be completed if power reduction commences prior to restoring T_q to ≤ 0.10.	
	B.1 Reduce THERMAL POWER to ≤ 50 % RTP.	4 hours
	AND	
	B.2 Reduce variable overpower trip (VOPT) setpoints to ≤ 55 % RTP.	8 hours
	AND	
	B.3 Restore the measured T_q to less than the T_q allowance used in the CPCs.	Prior to increasing THERMAL POWER NOTE Correct the cause of the out of limit condition prior to increasing THERMAL POWER. Subsequent power operation > 50 % RTP may proceed provided that the measured Tq is verified ≤ 0.10 at least once per hour for 12 hours, or until verified at ≥ 95 % RTP.
C. Required Actions and associated Completion Times not met.	C.1 Reduce THERMAL POWER to ≤ 20 % RTP.	6 hours

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Question No. 16-83

Justify the deviation from the STS in the Bases for Technical Specification (TS) 3.2.1 Linear Heat Rate (LHR), 3.2.3 Azimuthal Power Tilt (Tq), and 3.2.4 Departure from Nucleate Boiling Ratio (DNBR).

The second paragraphs in Surveillance Requirement (SR) 3.2.1.2 and SR 3.2.3.2 and the paragraph for SR 3.2.4.2 omit a sentence that is contained in the STS. The sentence in the STS contains information as to why the Frequency is 31 days and reads “The Surveillance Frequency for testing protection systems was extended to 92 days by CEN 327. Monitoring systems were not addressed in CEN 327; therefore, this Frequency remains at 31 days.”

This justification is required to ensure the accuracy and completeness of the Bases.

Response

KHNP could not locate the referenced wording in Revision 4 of the STS for SR 3.2.1.2, 3.2.3.2 or 3.2.4.2; rather the current DCD wording that the 31-day Frequency for performing these surveillances is determined based on historical testing frequency of the reactor monitoring system appears consistent. However, the phrase, “protection and” will be deleted since these surveillances in the DCD do not include the protection system.

Impact on DCD

Same as the changes described in Impact on Technical Specifications.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Page B 3.2.1-7, B 3.2.3-7 and B 3.2.4-8 will be revised as indicated in the attachment.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.2.1.1

With the COLSS out of service, the operator must monitor the LHR with each OPERABLE local power density channel.

A 2-hour Frequency is sufficient to allow the operator to identify trends that would result in an approach to the LHR limits.

This SR is modified by a Note that states that the SR is applicable only when the COLSS is out of service. Continuous monitoring of the LHR is provided by the COLSS, which calculates core power and core power operating limits based on the LHR and continuously displays these limits to the operator. A COLSS margin alarm is annunciated in the event that the THERMAL POWER exceeds the core power operating limit based on LHR.

SR 3.2.1.2

Verification that the COLSS margin alarm actuates at a THERMAL POWER level equal to or less than the core power operating limit based on the LHR (W/cm) ensures the operator is alerted when conditions approach the LHR operating limit.

The 31-day Frequency for performance of this SR is consistent with the historical testing Frequency of reactor ~~protection and~~ monitoring systems.

REFERENCES

1. DCD Tier 2, Chapter 15.

2. DCD Tier 2, Chapter 6.

3. APR1400-F-C-TR-12002-P, Rev. 0, "KCE-1 Critical Heat Flux Correlation for PLUS7 Thermal Design," November 2012.

4. 10 CFR Part 50, Appendix A, GDC 10.

5. 10 CFR 50.46.

6. NUREG-0800, Rev. 3, March 2007.

7. 10 CFR Part 50, Appendix A, GDC 26.

BASES

ACTIONS (continued)

The provision to allow discontinuation of the Surveillance after verifying that T_q less than or equal to 0.1 at least once per hour for 12 hours or until T_q is verified to be within its specified limit at a THERMAL POWER greater than or equal to 95 % RTP provides an acceptable exit from this action after the measured T_q has been returned to an acceptable value.

C.1

If the measured T_q cannot be restored or determined within its specified limit, core power must be reduced. Reduction of core power to less than 20 % RTP ensures that the core is operating within its thermal limits and places the core in a conservative condition based on the trip setpoints generated by the CPCs, which assume a minimum core power of 20 % RTP. Six hours is a reasonable time to reach 20 % RTP in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.2.3.1

Continuous monitoring of the measured T_q by the incore nuclear detectors is provided by the COLSS. A COLSS alarm is annunciated in the event that the measured T_q exceeds the value used in the CPCs.

With the COLSS out of service, the operator must calculate T_q and verify that it is within its specified limits. The 12-hour Frequency is sufficient to identify slowly developing T_q's before they exceed the limits of this LCO. Also, the 12-hour Frequency prevents significant xenon redistribution.

SR 3.2.3.2

Verification that the COLSS T_q alarm actuates at a value less than the value used in the CPCs ensures that the operator is alerted if T_q approaches its operating limit.

The 31-day Frequency for performance of this SR is consistent with the historical testing Frequency of reactor protection and monitoring systems.

SR 3.2.3.3

Independent confirmation of the validity of the COLSS calculated T_q ensures that the COLSS accurately identifies T_q's. The 31-day Frequency for performance of this SR is consistent with the historical testing Frequency of reactor ~~protection and~~ monitoring systems.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.2.4.1

With the COLSS out of service, the operator must monitor the DNBR as indicated on any of the OPERABLE DNBR CHANNELS of the CPCs to verify that the DNBR is within the specified limits in Figure 3.2.4-2 or 3.2.4-3 of the COLR, as applicable. A 2-hour Frequency is adequate to allow the operator to identify trends in conditions that would result in an approach to the DNBR limit.

This SR is modified by a Note that states that the SR is only applicable when the COLSS is out of service. Continuous monitoring of the DNBR is provided by the COLSS, which calculates core power and core power operating limits based on the DNBR and continuously displays these limits to the operator. A COLSS margin alarm is annunciated in the event that the THERMAL POWER exceeds the core power operating limit based on the DNBR.

SR 3.2.4.2

Verification that the COLSS margin alarm actuates at a power level equal to or less than the core power operating limit, as calculated by the COLSS, based on the DNBR, ensures that the operator is alerted when operating conditions approach the DNBR operating limit. The 31-day Frequency for performance of this SR is consistent with the historical testing Frequency of reactor ~~protection and~~ monitoring systems.

REFERENCES

1. DCD Tier 2, Chapter 15.
2. DCD Tier 2, Chapter 6.
3. APR1400-F-C-TR-12002-P, Rev. 0, "KCE-1 Critical Heat Flux Correlation for PLUS7 Thermal Design," November 2012.
4. 10 CFR Part 50, Appendix A, GDC 10.
5. 10 CFR 50.46.
6. NUREG-0800, Rev. 3, March 2007.
7. 10 CFR Part 50, Appendix A, GDC 26.

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Application Section:	**16.3.2 – Power Distribution Limits**
Date of RAI Issue:	**09/01/2015**

Question No. 16-84

Justify the deviation from the STS in the Bases for generic Technical Specification (TS) 3.2.1 Linear Heat Rate (LHR).

In the third paragraph of the Background section on page B 3.2.1-2, a sentence in the STS Bases has been omitted from the generic TS Bases. The sentence reads “This penalty is correlated with the amount of rod bow determined from the maximum average assembly burnup of the batch.”

This justification is required to ensure the accuracy and completeness of the TS Bases.

Response

In the current DCD Rev. 0, this sentence is already stated on page B 3.2.1-2; see the underlined portion in the attachment.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

BASES

BACKGROUND (continued)

Proximity to the DNB condition is expressed by the DNB ratio (DNBR), defined as the ratio of the cladding surface heat flux required to cause DNB to the actual cladding surface heat flux. The minimum DNBR value during both normal operation and AOOs is calculated by the KCE-1 Correlation (Reference 3) and corrected for such factors as rod bow and grid spacers. It is accepted as an appropriate margin to DNB for all operating conditions.

There are two systems that monitor core power distribution online: the Core Operating Limit Supervisory System (COLSS) and the core protection calculators (CPCs). The COLSS and CPCs that monitor the core power distribution are capable of verifying that the LHR and the DNBR do not exceed their limits. The COLSS performs this function by continuously monitoring the core power distribution and calculating core power operating limits corresponding to the allowable peak LHR and DNBR. The CPCs perform this function by continuously calculating an actual value of DNBR and local power density (LPD) for comparison with the respective trip setpoints.

A DNBR penalty factor is included in both the COLSS and CPC DNBR calculations to accommodate the effects of rod bow. The amount of rod bow in each assembly is dependent upon the average burnup experienced by that assembly. Fuel assemblies that incur higher than average burnup experience a greater magnitude of rod bow. Conversely, fuel assemblies that receive lower than average burnup experience less rod bow. In design calculations for a reload core, each batch of fuel is assigned a penalty applied to the maximum integrated planar radial power peak of the batch. This penalty is correlated with the amount of rod bow determined from the maximum average assembly burnup of the batch. A single net penalty for the COLSS and CPCs is then determined from the penalties associated with each batch that comprises a core reload, accounting for the offsetting margins due to the lower radial power peaks in the higher burnup batches.

The COLSS indicates continuously to the operator how far the core is from the operating limits and provides an audible alarm if an operating limit is exceeded. Such a condition signifies a reduction in the capability of the plant to withstand an anticipated transient, but does not necessarily imply an immediate violation of fuel design limits. If the margin to fuel design limits continues to decrease, the RPS ensures that the SAFDLs are not exceeded during AOOs by initiating reactor trips.

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RAI No.: **190-8058**

SRP Section: **16 – Technical Specifications**

Application Section: **16.3.2 – Power Distribution Limits**

Date of RAI Issue: **09/01/2015**

Question No. 16-85

Justify the deviation from the STS in the Bases for generic Technical Specification (TS) 3.2.1 Linear Heat Rate (LHR), or remove it.

In the fourth paragraph of the "Actions" section on page B 3.2.1-6, the generic TS Bases contain an interpretation of the action requirements, which is not in the STS, in an instruction that reads "If LHR cannot be monitored every 15 minutes, assume that there is an adverse trend."

The generic TS 3.2.1 Actions B and C appear as follows:

B. One OPERABLE core protection calculator (CPC) calculated LHR not within region of acceptable operation when the COLSS is out of service.	B.1 Determine trend in LHR. AND B.2.1 With an adverse trend, restore LHR to within limit. OR B.2.2 With no adverse trend, restore LHR to within limit.	Once per 15 minutes 1 hour 4 hours
C. Required Action and associated Completion Time not met.	C.1 Reduce THERMAL POWER to ≤ 20 % RTP.	6 hours

The Bases can only describe, and explain the reasons for, TS requirements, not provide direction that changes the meaning of the requirements, which the proposed sentence does. The above action requirements contain no text related to a situation in which LHR cannot be monitored. If the trend in LHR cannot be determined every 15 minutes as required by Required Action B.1, then Required Action C.1 applies and must be carried out. Although the operator may assume an adverse trend exists, Required Action B.2.1 cannot be assumed to apply instead of Required Action C.1 based solely on by the proposed instruction located in the Bases.

This justification is required to ensure the accuracy and clarity of the generic TS and the associated Bases.

Response

The sentence, “If LHR cannot be monitored every 15 minutes, assume that there is an adverse trend” will be deleted from the Bases for TS 3.2.1.

Impact on DCD

Same as the changes described in Impact on Technical Specifications.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Page B 3.2.1-6 will be revised as indicated in the attachment.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

BASES

ACTIONS (continued)

When operating with the COLSS out of service and LHR not within the region of acceptable operation, there is a possibility of a slow undetectable transient that degrades the LHR slowly over the 4-hour period and is then followed by an AOO or an accident. To remedy this, the CPC calculated values of LHR are monitored every 15 minutes when the COLSS is out of service and LHR not within the region of acceptable operation. The 15-minute Frequency is adequate to allow the operator to identify an adverse trend in conditions that could result in an approach to the LHR limit.

Also, a maximum allowable change in the CPC calculated LHR ensures that further degradation requires the operators to take immediate action to restore LHR to within limit or reduce reactor power to comply with the Technical Specifications (TS).

With an adverse trend, one hour is allowed for restoring LHR to within limit if the COLSS is not restored to OPERABLE status.

Implementation of this requirement ensures that reductions in core thermal margin are quickly detected, and if necessary, results in a decrease in reactor power and subsequent compliance with the existing COLSS out of service TS limits. ~~If LHR cannot be monitored every 15 minutes, assume that there is an adverse trend.~~

With no adverse trend, four hours is allowed to restore the LHR to within limit if the COLSS is not restored to OPERABLE status. This duration is reasonable because the Frequency of the CPC determination of LHR is increased and if operation is maintained steady, the likelihood of exceeding the LHR limit during this period is not increased. The likelihood of induced reactor transients from an early power reduction is also decreased.

C.1

If the LHR cannot be returned to within its limit or the LHR cannot be determined because of the COLSS and CPC inoperability, core power must be reduced. Reduction of core power to less than 20 % RTP ensures that the core is operating within its thermal limits and places the core in a conservative condition based on the trip setpoints generated by the CPCs, which assume a minimum core power of 20 % RTP. The allowed Completion Time of 6 hours is reasonable, based on operating experience, to reach 20 % RTP in an orderly manner and without challenging plant systems.

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Question No. 16-86

Clarify the text in the Bases for generic Technical Specification (TS) 3.2.3 Azimuthal Power Tilt (Tq).

In the first paragraph of the Bases for Required Actions B1, B.2, and B.3 on page B 3.2.3-5, the generic TS Bases text begins with the phrase “Required Actions B1, B.2, and B.3 are modified by a Note that requires Action B.5 be performed…” The actual Note does not state this because there is no Required Action B.5. The actual Note states “Required Actions up to B.3 must be completed…” (The wording of this generic TS Required Actions Note is unclear as described by a separate question.)

The applicant is requested to ensure the Bases accurately reflects the resolution of the staff’s question regarding the clarity of this generic TS Required Actions Note.

This clarification is required to ensure the accuracy of the TS Bases.

Response

The first sentence of the Bases for Required Actions B.1, B.2 and B.3, will be changed from “Action B.5” to “all subsequent actions” to be consistent with the STS.

Impact on DCD

Same as the changes described in Impact on Technical Specifications.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Page B 3.2.3-5 will be revised as indicated in the attachment.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

BASES

APPLICABILITY

Power distribution is a concern any time the reactor is critical. The power distribution LCOs, however, are only applicable in MODE 1 above 20 % RTP. The reasons these LCOs are not applicable below 20 % RTP are:

a. The incore neutron detectors that provide input to the COLSS, which then calculates the operating limits, are inaccurate due to the poor signal to noise ratios at relatively low core power levels.

b. As a result of this inaccuracy, the CPCs assume minimum core power of 20 % RTP when generating LPD and DNBR trip signals. When core power is below 20 % RTP, the core is operating well below its thermal limits and the resultant CPC calculated LPD and DNBR trips are highly conservative.

ACTIONS

A.1 and A.2

If the measured T_q is greater than the T_q allowance used in the CPCs but less than or equal to 0.1, non-conservative trip setpoints may be calculated. Required Action A.1 restores T_q to within its specified limits by repositioning the CEAs, and the reactor may return to normal operation. A Completion Time of 2 hours is sufficient time to allow the operator to reposition the CEAs because significant radial xenon redistribution does not occur within this time.

If the T_q cannot be restored within 2 hours, the T_q allowance in the CPCs must be adjusted, per Required Action A.2, to be equal to or greater than the measured value of T_q to ensure that the design safety margins are maintained.

all subsequent actions

B.1, B.2 and B.3

Required Actions B.1, B.2, and B.3 are modified by a Note that requires ~~Action B.5~~ be performed if power reduction commences prior to restoring T_q less than or equal to 0.1. This requirement ensures that corrective action is taken before unrestricted power operation resumes.

If the measured T_q is greater than 0.1, THERMAL POWER is reduced to less than or equal to 50 % RTP within 4 hours. The 4 hours allows enough time to take action to restore T_q prior to reducing power and limits the probability of operation with a power distribution out of limits. Such actions include performing SR 3.2.3.2, which provides a value of T_q that can be used in subsequent actions.