REVISED 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.:	**198-8208**
SRP Section:	**14.02 - Initial Test Program - Design Certification and New License Applicants**
Application Section:	**14.02.12.2.11**
Date of RAI Issue:	**09/04/2015**

Question No. 14.02-35

Clarify whether the Post-Core Ex-Core Neutron Flux Monitoring System (ENFMS) Test described in APR1400 FSAR Tier 2, Section 14.2.12.2.11 is only applicable to the non-safety channels of the ENFMS.

Criterion XI, “Test Control,” of Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” to 10 CFR Part 50 states, in part, that a test program shall be established to assure that all testing required to demonstrate that SSCs will perform satisfactorily in service is identified and performed in accordance with written test procedures, which incorporate the requirements and acceptance limits contained in applicable design requirements. RG 1.68, “Initial Test Programs for Nuclear Power Plants” provides guidance on the initial test program.

APR1400 FSAR Tier 2, Section 14.2.12.2.11 describes the post-core ENFMS test. The acceptance criteria for this test states that the “[ENFMS] performs as described in Subsection 7.7.1.1.h.” APR1400 FSAR Tier 2 Subsection 7.7.1.1 h., "Ex-core neutron flux monitoring system (non-safety channel)," only describes the operation of the non-safety channels of the ENFMS. As such, it is not clear to the staff whether this test is only applicable to the non-safety channels or whether it is also supposed to test the safety channels. The staff requests the applicant to clarify the scope of this test (i.e. whether it is for both safety and non-safety channels of the ENFMS or just the non-safety channels). In addition, if this test is only applicable to the non-safety channel of the ENFMS, the staff requests the applicant to identify where the safety channels of the ENFMS are tested in the post core initial test program.

Response – (Rev. 2)

Section 14.2.12.2.11 was deleted as discussed in Rev.1 of the response to this RAI because the operability of the ex-core detector system is verified with actual neutron sources in other relevant DCD sections.

The startup channels are used during initial fuel loading. The startup channels and safety log power channels are used during initial criticality. Both the safety linear power and control channels are used during power operation. Power distribution is needed from 20% power. The safety linear power channels are used to generate core power distribution. The non-safety in-core detectors are also used to generate the core power distribution.

The table below details the operability verification of the ex-core and in-core detector systems with actual neutron sources or by plant startup conditions after the systems' pre-operational tests, described in Section 14.2.12.1.25 and Section 14.2.12.1.26, are performed.

Neutron Detector / Channel	Test Description	Relevant DCD Section
Ex-core / Startup Channel	The operability of the startup channel will be verified before the initial fuel loading in accordance with Prerequisite 2.8. Actual neutron sources are used in the calibration. Detector response check and noise elimination are the main purposes of the setup and calibration check.	14.2.12.2.1 Initial Fuel Loading[1)]
Ex-core / Startup Channel	The final calibration of the startup channel is conducted before the initial criticality. The detector is calibrated to have a signal to noise ratio greater than 2.	14.2.12.3.1 Initial Criticality Test[2)]
Ex-core / Safety Log Power Channel (Wide Range)	During the initial criticality, a minimum of 1 decade of overlap is checked between the startup and safety log power channels.	14.2.12.3.1 Initial Criticality Test[2)]
Ex-core / Safety Linear Power Channel	During the power ascension test, the safety linear power channels are calibrated based on plant reference powers.	14.2.12.4.27 Ex-Core Neutron Flux Monitoring System Calibration[3)]
Ex-core / Control Channel	During the power ascension test, the control channels are calibrated based on plant reference powers.	14.2.12.4.27 Ex-Core Neutron Flux Monitoring System Calibration[3)]

Neutron Detector / Channel	Test Description	Relevant DCD Section
Ex-core / Safety Linear Power Channel (Power Distribution)	Ex-core safety linear power channels are used in the Core Protection Calculator System (CPCS) to generate the axial power distribution. The power distribution with the ex-core detector is calibrated based on the power distribution generated with in-core detectors at 20% and 50% power plateaus during the power ascension test.	14.2.12.4.12 CPC Power Distribution Test
In-core Detectors	The operability of the fixed in-core detector system is verified at 20%, 50%, 80%, and 100% power plateaus during the power ascension test.	14.2.12.4.16 In-Core Detector Test

Notes:
1) Refer to RAI 524-8697, Question 14.02-69 response for the Initial Fuel Loading Test, 14.2.12.2.1.
2) Refer to RAI 524-8697, Question 14.02-69 response for the Initial Criticality Test, 14.2.12.3.1.
3) A newly added test to incorporate the ex-core tests of safety linear power channel and control channel.

Impact on DCD

DCD Tier 2, Rev.1, Table 14.2-7 will be revised and Section 14.2.12.4.27 will be added as indicated in the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specification.

Impact on Technical/Topical/Environmental Reports

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

The shutdown cooling system is in service to provide coolant circulation to provide reasonable assurance of adequate mixing and a means of controlling water temperature. The in-containment refueling water storage tank (IRWST) is in service and contains borated water at a volume and concentration conforming to the Technical Specifications. Applicable administrative controls are used to prevent unauthorized alteration of system lineups or change to the boron concentration in the reactor coolant system (RCS).

Minimum instrumentation for fuel loading consists of two temporary source-range channels installed in the reactor vessel or one temporary channel and one permanently installed ex-core nuclear channel in the event that one of the temporary channels becomes inoperative. Both temporary and permanent channels ~~are response checked with a neutron source.~~ The temporary channels display neutron count rate on a count rate meter installed in the containment and are monitored by personnel conducting the fuel loading operation. The permanent channel displays neutron count rate on a meter and strip chart recorder located in the main control room and is monitored by licensed operators. In addition, at least one temporary channel and one permanent channel are equipped with audible rate indicators in two locations, a temporary channel in the containment and a permanent or temporary channel in the main control room.

Continuous area radiation monitoring is provided during fuel handling and fuel loading operations. Permanently installed radiation monitors display radiation levels in the main control room and are monitored by licensed operators.

are required for calibration and for response check with a neutron source.

14.2.10.1.1 Safe Loading Criteria

Criteria for the safe loading of fuel require that loading operations stop immediately if:

a. The neutron count rate from either temporary nuclear channel unexpectedly doubles during any single loading step, excluding an anticipated change due to detector and/or source movement or spatial effects (i.e., fuel assembly coupling source with a detector).

b. The neutron count rate on any individual nuclear channel increases by a factor of 5 during any single loading step, excluding anticipated changes due to detector

4.2 ALMS alarm setpoints

4.3 RCS temperature and pressure

5.0 ACCEPTANCE CRITERIA

5.1 The ALMS ~~performs as described in Subsection 7.7.1.5~~shall performed leak/crack detection functions.

Section 14.2.12.2.11 will be deleted.

5.2 The ALMS alarm setpoints have been adjusted as necessary.

5.3 The baseline data of background noise shall be obtained

14.2.12.2.11 Post-Core Ex-Core Neutron Flux Monitoring System Test

1.0 ~~OBJECTIVE~~OBJECTIVES

1.1 To verify the proper functional performance of the ex-core neutron flux monitoring system

1.2 To verify the proper performance of the audio and visual indicators

2.0 PREREQUISITES

2.1 Construction activities on the ex-core neutron flux monitoring system have been completed.

2.2 Ex-core neutron flux monitoring system instrumentation has been calibrated.

2.3 External test equipment has been calibrated and is operational.

2.4 Support systems required for the operation of the ex-core neutron flux monitoring system are operational.

2.5 Check source is available.

3.0 TEST METHOD

3.1 Using appropriate test instrumentation, simulate and vary input signals to the startup, safety, and control channels of the ex-core neutron flux monitoring system.

3.2 Monitor and record all output signals as a function of variable inputs provided by test instrumentation.

3.3 Record the performance of audio and visual indicators in response to changing input signals.

3.4 Using a check source, verify calibration of the startup, safety, and control channels.

4.0 DATA REQUIRED

4.1 Values of input and output signals for correlation purposes, as required

4.2 Values of all output signals triggering audio and visual alarms

4.3 Channel response to the check source

5.0 ACCEPTANCE CRITERIA

5.1 The ex-core neutron flux monitoring system performs as described in Subsection 7.7.1.1 h.

5.2 Safety channel operate as designed

5.3 Startup and control channel operate as designed

Section 14.2.12.2.11 will be deleted.

5.3 Interface between safety channel and startup and control channel should be satisfied

5.4 Boron Dilution Alarm System(BDAS) operate as designed

14.2.12.3 Low-Power Physics Test

Section 14.2.12.2.11 will be deleted.

14.2.12.3.1 Low-Power Biological Shield Survey Test

1.0 ~~OBJECTIVE~~OBJECTIVES

1.1 To ~~measure~~ demonstrate the effectiveness of the radiation ~~in accessible locations of the plant outside the biological~~ shield

1.2 To obtain baseline levels for comparison with future measurements of radioactivity level buildup with operation

2.0 PREREQUISITES

2.1 Radiation survey instruments ~~are~~have been calibrated.

2.2 Background radiation levels have been measured in designated locations prior to initial criticality.

3.0 TEST METHOD

3.1 Measure gamma and neutron dose rates during low-power (<5 percent rated thermal power ~~[RTP]~~) operation~~.~~

4.0 DATA REQUIRED

4.1 Power level

4.2 Gamma and neutron dose rates at each specified location

Table 14.2-2

Post-Core Hot Functional Tests

Subsection	Test
14.2.12.2.1	Post-core hot functional test controlling document
14.2.12.2.2	~~Loose parts monitoring system~~NSSS Integrity Monitoring System (post-core)
14.2.12.2.3	Reactor coolant system flow measurements
14.2.12.2.4	Post-core control element drive mechanism performance
14.2.12.2.5	Post-core reactor coolant and secondary water chemistry data
14.2.12.2.6	Post-core pressurizer spray valve and control adjustments
14.2.12.2.7	Post-core reactor coolant system leak rate measurement
14.2.12.2.8	Post-core in-core instrumentation test
14.2.12.2.9	Post-core instrument correlation
14.2.12.2.10	Post-core acoustic leak monitor system test
~~14.2.12.2.11~~	~~Post-core ex-core neutron flux monitoring system test~~

Delete

Refer to RAI 524-8697 - Question 14.02-69 Response_Rev.1

Table 14.2-7 (13 of 18)

RG 1.68 APP. A	Subsection #	Individual Test
1.p.6	14.2.12.1.91 14.2.12.1.92	Containment polar crane test Fuel handling area cranes test
1.p.7	14.2.12.1.91 14.2.12.1.92	Containment polar crane test Fuel handling area cranes test
2.a	14.2.12.2.1	Post-core hot functional test controlling document
2.b	14.2.12.2.4	Post-core control element drive mechanism performance
2.c	14.2.12.1.24 14.2.12.2.4	Plant protection system test Post-core control element drive mechanism performance
2.d	14.2.12.2.7	Post-core reactor coolant system leak rate measurement
2.e	14.2.12.2.1 14.2.12.2.5	Post-core hot functional test controlling document Post-core reactor coolant and secondary water chemistry data
2.f	14.2.12.2.2 14.2.12.2.3 14.2.12.2.10	~~Loose parts~~/NSSS integrity monitoring system (post-core) Reactor coolant system flow measurements Post-core acoustic leak monitor system test
2.g	~~14.2.12.2.11~~	~~Post-core ex-core neutron flux monitoring system test~~
2.h	14.2.12.2.8	Post-core in-core instrumentation test
3	14.2.10.1 14.2.12.3.5	Shutdown and regulating CEA group worth test Critical boron concentration test
4.a	14.2.12.3.2 14.2.12.3.5	Isothermal temperature coefficient test Critical boron concentration test
4.b	14.2.10.2.1	Shutdown and
4.c	14.2.12.2.9 ~~14.2.12.2.11~~	Post-core instrument correlation ~~Post-core ex-core neutron flux monitoring system test~~
4.d	14.2.12.2.9 ~~14.2.12.2.11~~	Post-core instrument correlation ~~Post-core ex-core neutron flux monitoring system test~~
4.e	14.2.12.4.10 14.2.12.1.24 14.2.12.4.9	Steady-state core performance test e oper Biological shield survey test
4.f	14.2.12.1.106	Process and effluent radiological monitoring system test
4.g	14.2.12.4.4	Reactor coolant and secondary chemistry and radiochemistry test
4.h	14.2.12.4.9	Biological shield survey test

Initial Fuel Loading

Safe Criticality Criteria

Plant Protection System Test

14.2.12.4.27 Ex-Core Neutron Flux Monitoring System Calibration

1.0 OBJECTIVE

1.1 To calibrate the ex-core linear powers of the safety channels and the ex-core control powers to agree with the reactor thermal power.

2.0 PREREQUISITES

2.1 Reactor thermal power is verified.

2.2 Ex-core neutron detectors and support systems are operational.

3.0 TEST METHOD

3.1 Plant is maintained in stable condition.

3.2 Measure the reactor thermal power and ex-core powers.

3.3 Adjust the ex-core linear powers of the safety channels to meet the reactor thermal power. Variable Overpower Trip (VOPT) of the Plant Protection System (PPS) should be bypassed for the channel during adjustment.

3.4 Adjust the ex-core control powers channels to meet the reactor thermal power. Un-select the control channel in Reactor Regulating System (RRS) during adjustment.

4.0 DATA REQUIRED

4.1 Ex-core linear powers of the safety channels

4.2 Ex-core control powers

4.3 Reactor thermal power

5.0 ACCEPTANCE CRITERIA

5.1 Ex-core linear powers of the safety channels are adjusted within ±0.5% of the reactor thermal power.

5.2 Ex-core control powers are adjusted within ±2% of the reactor thermal power.

Table 14.2-7 (16 of 18)

RG 1.68 APP. A	Subsection #	Individual Test
5.q	14.2.12.4.3 14.2.12.4.14 14.2.12.4.17	Control systems checkout test Core protection calculator verification Core operating limit supervisory system verification
5.r	14.2.12.4.1 14.2.12.4.3 14.2.12.4.8 14.2.12.4.13	Variable Tavg (isothermal temperature coefficient and power coefficient) test Control systems checkout test Loss of offsite power test Feedwater and auxiliary feedwater system test
5.s	14.2.12.1.3 14.2.12.1.63 14.2.12.4.5 14.2.12.4.15	Pressurizer pilot-operated safety relief valve test Main steam safety valve test Turbine trip test Main steam atmospheric dump and turbine bypass valve test
5.t	14.2.12.4.15	Main steam atmospheric dump and turbine bypass valve test
5.u	-	Exception The turbine trip test from full power results in essentially similar dynamic plant response and should provide reasonable assurance that primary and secondary safety valves do not lift open during the test. For these reasons, the plant response to automatic closure of all MSIVs from full power is not demonstrated.
5.v	14.2.12.4.2 14.2.12.4.5 14.2.12.4.13	Unit load transient test Turbine trip test Feedwater and auxiliary feedwater system test
5.w	14.2.12.4.20	Penetration temperature survey test
5.x	14.2.12.4.21	HVAC capability test
5.y	14.2.12.4.3 14.2.12.4.11 14.2.12.4.12 14.2.12.4.14 14.2.12.4.16 14.2.12.4.17	Control systems checkout test Intercomparison of plant protection system, core protection calculator, information processing system, and qualified information and alarm system inputs Verification of CPC power distribution related constants test Core protection calculator verification In-core detector test Core operating limit supervisory system verification
5.z	14.2.12.1.18 14.2.12.1.19	Process radiation monitor subsystem test Gas stripper effluent radiation monitor subsystem test

14.2.12.4.27

Ex-Core Neutron Flux Monitoring System Calibration