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.:	**136-8081**
SRP Section:	**04.06 – Functional Design of Control Rod Drive System Application Section**
Application Section:	**SRP 4.6**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-1

10 CFR 52.47(b)(1) requires that a DC application contain the proposed ITAAC necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and should operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations. Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria," provides ways to comply with 10 CFR 52.47(b)(1) and states that Tier 1 information should be clear and consistent with Tier 2 information.

DCD Tier 1, Table 2.4.1-2, "Reactor Coolant System Components List," indicates that the CEDMs are qualified for a harsh environment. However, in DCD Tier 2, Table 3.11-3, "Equipment Qualification Equipment List," the environmental condition listed for the CEDM is "N/A."

Please address this inconsistency between the Tier 1 and Tier 2 information, and update the DCD accordingly.

Response

The CEDM assembly except for the Reed Switch Position Indicator (RSPT) is classified as Non Class 1E component of which the environmental qualification according to IEEE Std 323 is not required. So, the indication "N/A" for the CEDM in environmental condition in DCD Tier 2, Table 3.11-3 is appropriate.

In DCD Tier 1, Table 2.4.1-2, the CEDM was indicated with "yes" for harsh environment qualification like other RCS components such as reactor vessel, steam generator in the same table because high temperature and high pressure of the reactor coolant contacting condition was considered as harsh environment. However, the CEDM pressure housing, Reactor Vessel, Steam Generator and Pressurizer are pressure boundary components that are qualified by analysis. Therefore, in view of environmental qualification, the indication “yes” of CEDM, Reactor Vessel, Steam Generator and Pressurizer in Table 2.4.1-2 will be revised to “not applicable” for consistency with the Table 3.11-3 of DCD Tier 2.

Impact on DCD

Table 2.4.1-2 of DCD Tier 1 will be revised as indicated in Attachment.

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 Environmental Reports.

Table 2.4.1-2 (1 of 2)

Reactor Coolant System Components List $\boxed{-}$

Component Name	Item No. [1]	ASME Section III Class	Seismic Category	Class 1E/ Harsh Envir. Qual.	Control/ Display at MCR	Control/ Display at RSR	Control Signal	Active Safety Function	Loss of Motive Power Position
Reactor Vessel	RV	1	I	-/~~Yes~~	-/-[2]	-/-	-	-	-
Steam Generator (primary/secondary)	SG # 1&2	1	I	-/~~Yes~~	-/-	-/-	-	-	-
Pressurizer	PZR	1	I	-/~~Yes~~	-/-	-/-	-	-	-
Reactor Coolant Pumps	RCP 1A, 1B 2A, 2B	1	I	No/Yes	Yes/Yes	Yes/Yes	-[2]	-	-
PZR Backup Heaters	Bank No.1, No.2	1	I	Yes/Yes	Yes/Yes	Yes/Yes	PPCS, PLCS	-	-
Pilot Operated Safety Relief Valves (POSRVs) Main Valves	RC-200, 201 202, 203	1	I	-/Yes	Yes/Yes	-/-	-	Open/Close	
POSRV Motor Operated Isolation Valves (MOV)	RC-120, 121 122, 123 124, 125 126, 127	1	I	No/Yes	Yes/Yes	-/-	-	-	As Is
POSRV Double Motor Operated Pilot Valves (MOV)	RC-130, 131 132, 133 134, 135 136, 137	1	I	Yes[3]/Yes	Yes/Yes	-/-	-	Open/Close	As Is
POSRV Spring-Loaded Pilot Valves	RC-300, 301 302, 303 304, 305 306, 307	1	I	-/Yes	Yes/Yes	-/-	-	Open/Close	

Table 2.4.1-2 (2 of 2)

Component Name	Item No. [1]	ASME Section III Class	Seismic Category	Class 1E/ Harsh Envir. Qual.	Control/ Display at MCR	Control/ Display at RSR	Control Signal	Active Safety Function	Loss of Motive Power Position
PZR Spray Control Valve (AOV)	RC-100E, 100F	1	I	No/No	Yes/Yes	-/-	PPCS	-	Closed
PZR Spray Bypass Valve (Manual)	RC-236, 237	1	I	-/No	-/-	-/-	-	-	-
PZR Spray Isolation Valve (MOV)	RC-442, 443	1	I	No/No	Yes/ Yes	-/-	-	-	As Is
PZR Spray Check Valve	RC-244	1	I	-/No	-/-	-/-	-	-	-
Controlled Bleedoff Isolation Valve (MOV)	RC-430, 431, 432, 433	2	I	No/No	Yes/Yes	-/-	-	-	As Is
Control Element Drive Mechanism	CEDM # 1 ~ 93	1	I	Yes [4]/~~Yes~~ -	Yes/Yes	-	PPS, RPS, DPS, RPCS	-	-

(1) The column "Item No." is information only (not part of certified design).

(2) Dash(-) indicates not applicable.

(3) For motor operated pilot valves.

(4) For Reed Switch Position Transmitter (RSPT)

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-2

GDC 26, "Reactivity Control System Redundancy and Capability," requires two independent reactivity control systems of different design principles that are capable of reliably controlling reactivity changes during normal operation. The control rod drive system (CRDS) is one of those systems, and the areas of review under SRP Section 4.6, "Functional Design of Control Rod Drive System," include functional tests for the CRDS and ensuring that the CRDS cooling system meets design requirements.

In addition, 10 CFR 50.34(b)(6)(iii) requires an applicant to provide plans for preoperational testing, and SRP Section 14.2, "Initial Test Program – Design Certification and New License Applicants," provides guidance for this area of review. SRP Section 14.2 states that the applicant should provide test abstracts of SSCs and unique design features, including tests and acceptance criteria.

a. In a number of instances in the DCD Tier 2, Chapter 14 preoperational tests related to the CRDS, the acceptance criteria are not sufficient to ensure adequacy of the test results. These include:

1. The acceptance criteria for the digital rod control system test in Subsection 14.2.12.1.27 point to DCD Tier 2, Subsections 4.6.1 and 4.6.2. However, these subsections do not provide specific acceptance criteria for DRCS performance.

2. The CEDM cooling system test described in Subsection 14.2.12.1.36 requires verification of system airflow and the proper operation of interlocks and alarms, and the acceptance criterion is that the system performs as described in DCD Tier 2, Subsection 9.4.6.2.1.3. However, Subsection 9.4.6.2.1.3 does not specify the required system airflow rate or the system interlocks and alarms.

3. Part of the test method in Subsection 14.2.12.1.54, “Pre-Core Control Element Drive Mechanism Performance Test,” is balancing the CEDM cooling system as required to maintain the coil temperatures within the specified limits. The acceptance criteria reference DCD Tier 2 Subsection 7.7.1.1 a., but staff cannot find the coil temperatures there or in other portions of the DCD.

4. In Subsection 14.2.12.2.4, “Post-Core Control Element Drive Mechanism Performance,” one acceptance criterion is that insertion and withdrawal times meet design requirements. It is unclear where these required insertion and withdrawal times are located.

For each of the above concerns, please either (1) provide the testing requirements and acceptance criteria in the DCD Tier 2 subsections referenced in the acceptance criteria for the associated test or (2) provide the specific test acceptance criteria for each test method in the Chapter 14 test description. If determination of any of the acceptance criteria is the responsibility of a COL applicant, please identify this in the DCD as appropriate.

b. In addition, in Subsection 14.2.12.2.4, some aspects of Part 4.0, “Data Required,” are unclear or seem to be missing based on other parts of the subsection. These include:

1. Does Point 4.2, “RCS temperature and pressure to be taken during measurement and recording of drop time for each CEA,” mean that, for each measurement, the RCS temperature and pressure are recorded in addition to rod drop time for that corresponding temperature and pressure?

2. Parts 3.0 and 5.0, “Test Method” and “Acceptance Criteria,” indicate that CEA insertion and withdrawal times are examined, yet they aren’t listed in “Data Required.”

3. Part 2.0, “Prerequisites,” says that CEDM coil resistance has been measured. Should the resistance be part of “Data Required”?

Please update DCD Subsection 14.2.12.2.4 to clarify the points described above.

Response

a. 1.

The digital rod control system (DRCS) test in Subsection 14.2.12.1.27 is a pre-operational test of DRCS. This test is not associated with trip functions described in Subsections 4.6.1 and 4.6.2.

DCD Tier 2, Part 4.0 of Subsection 14.2.12.1.27 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 1 to delete “Subsections 4.6.1 and 4.6.2”.

a. 2.

The CEDM cooling subsystem consists of three 50 percent capacity fans. The required airflow rate of CEDM cooling fan is described in DCD Tier 2, paragraph 1.5, “CEDM cooling fan” of Table 9.4.6-1 (2 of 4), “Equipment Parameters for Reactor Containment Building HVAC System and Reactor Containment Building Purge System”. As described in DCD Tier 2, paragraph 1.5 of Table 9.4.6-1 (2 of 4), the required airflow rate of each CEDM cooling fan is 44,000 cfm.

DCD Tier 2, Subsection 9.4.6.2.1.3 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 2 to include alarm set points and the interlock design of the CEDM cooling subsystem.

DCD Tier 2, Subsection 9.4.6.5.1 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 2 to include the Indication and alarm of the CEDM cooling subsystem.

a. 3.

The acceptance criteria of CEDM coil temperature is a mechanical part rather than rod control system.

DCD Tier 2, Subsections 14.2.12.1.54 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 3 to include CEDM coil temperature acceptable limit.

a. 4.

The maximum CEA withdrawal speed is 76.2 cm/min as described in DCD Tier 2, Subsection 15.4.2.3.2. DCD Tier 2, Subsection 4.3.1.11 refers to Subsection 4.3.1.7 and 15.4.2 for maximum CEA withdrawal speed.

Only withdrawal speed is related to safety and is measured by the test of DCD Tier 2, Subsections 14.2.12.2.4. DCD Tier 2, Subsections 14.2.12.2.4 will be revised as shown in RAI 136-8081-04.06-2-Attachment 4 to explain acceptance criterion of CEA withdrawal speed.

b. 1.

The drop time test of CEA is simultaneously performed for all CEAs instead of for each CEA after the measurement of RCS temperature and pressure, which satisfies the description of Point 4.2 of DCD Tier 2, Subsection 14.2.12.2.4.

b. 2.

DCD Tier 2, Part 4.0 of Subsection 14.2.12.2.4 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 4 to list “CEA withdrawal speed”.

“CEA insertion and withdrawal times meet design requirements” in Part 5.0 ACCEPTANCE CRITERIA will be revised as “CEA withdrawal speed meets Subsection 4.3.1.7” as shown in RAI 136-8081 - Question 04.06-2-Attachment 4.

b. 3.

DCD Tier 2, Part 4.0 of Subsection 14.2.12.2.4 will be revised as shown in RAI 136-8081-04.06-2-Attachment 4 to list “CEDM coil resistance”.

Impact on DCD

DCD Tier 2, Subsection 14.2.12.1.27 will be revised as indicated in RAI 136-8081 - Question 04.06-2-Attachment 1.
DCD Tier 2, Subsections 9.4.6.2.1.3 and 9.4.6.5.1 will be revised as indicated in RAI 136-8081 - Question 04.06-2-Attachment 2.
DCD Tier 2, Subsection 14.2.12.1.54 will be revised as indicated in RAI 136-8081 - Question 04.06-2-Attachment 3.
DCD Tier 2, Subsection 14.2.12.2.4 will be revised as shown in RAI 136-8081 - Question 04.06-2-Attachment 4.

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.

2.4 Special test equipment is operational.

2.5 Support systems required for operation of the DRCS are operational.

3.0 TEST METHOD

3.1 Using special test instrumentation, observe the sequence in which withdraw and insert signals are passed to the appropriate CEDM coil. Observe operation of the digital control element assembly (CEA) position indicators.

3.2 Operate the DRCS in all modes. Simulate input signals and observe operation of interlocks and alarms.

4.0 DATA REQUIRED

4.1 CEDM coil current traces

4.2 DRCS totalizer indications

4.3 DRCS operating data

4.4 Interlock and alarm actuation points

5.0 ACCEPTANCE CRITERIA

Subsection 7.7.1.1 a.

5.1 The DRCS performs as described in ~~Subsections 7.7.1.1 a, 4.6.1, and 4.6.2.~~

14.2.12.1.28 Reactor Regulating System Test

1.0 OBJECTIVE

1.1 To demonstrate the proper operation of the reactor regulating system (RRS)

9.4.6.2.1.2 Reactor Cavity Cooling Subsystem

The reactor cavity cooling subsystem maintains the design temperature inside the ICI chase, reactor vessel cavity during normal plant operation.

The reactor cavity cooling subsystem consists of one 100 percent capacity AHU, ductwork, instrumentation and controls. The AHU has a cooling coil and two 100 percent capacity fans. One of two fans in the AHU operates and the other fan is placed on the standby status. Two fans in the AHU are interlocked to start the standby fan automatically when the operating fan is failed. The chilled water for the AHU cooling coil is served from the PCWS. The AHU draws air from outside the primary shield wall and discharges it to the ICI chase for conveying the air to the reactor cavity.

During the LOOP condition, the AHU is powered from the PNS source. The chilled water for the AHU cooling coil is supplied from the PCWS powered from the PNS source.

9.4.6.2.1.3 CEDM Cooling Subsystem

The CEDM cooling subsystem consists of three 50 percent capacity fans with instruments for operation monitoring. This subsystem is located on the integrated head assembly (IHA). The fans draw cooling air into the CEDM cooling shrouds from reactor containment and discharge it into the reactor containment building to remove heat from the CEDM coils and RV head nozzles. The maximum inlet temperature of the CEDM cooling air is 48.9 °C (120 °F). Two of three fans operate alternatively during normal operation.

During the LOOP condition, the fans are powered from the PNS source.

9.4.6.2.2 Reactor Containment Building Purge System

The reactor containment building purge system consists of the following subsystems:

a. High volume purge subsystem

The upper and lower limits for temperature alarm set points are 71.7 °C (161 °F) and 15.6 °C (60 °F), respectively. The alarm set point for the differential pressure has only lower limit of 70 % of the total pressure. The total pressure is provided by the fan supplier.
The interlock design allows to operate only two of three fans at a time. When the differential pressure remains lower than the set point for 30 seconds after a fan starts, differential pressure low is annunciated and the fan stops. Then interlock forces to start the fan in rest so that two of three fans maintain in operating condition.

k. Alarm − CEDM cooling fan outlet temperature low and high

l. Alarm − motor trip of RCFC fans, reactor cavity AHU fans, and fans

m. Indication - CEDM cooling fan differential pressure

n. Alarm - CEDM cooling fan differential pressure low

9.4.6.5.2 Reactor Containment Building Purge System

The instrumentation of the reactor containment building purge system is designed in accordance with the requirements of ASME AG-1.

The following instrumentation is provided in the MCR and RSR:

a. Indication – status of AHU fans, ACU fans, and fans

b. Indication – AHU heating coil outlet temperature

c. Indication – ACU heating coil outlet temperature

d. Indication – ACU carbon adsorber outlet temperature

e. Indication – outlet airflow rate of AHU, low volume purge supply fan, and ACU

f. Indication – position status (open/close) of each containment isolation valve

g. Alarm – AHU heating coil outlet temperature low, high and high-high

h. Alarm – ACU heating coil outlet temperature low, high and high-high

i. Alarm – ACU carbon adsorber outlet temperature high and high-high

j. Alarm – outlet airflow rate low of AHU, low volume purge supply fan, and ACU

k. Alarm – smoke detection at the AHU outlet

l. Alarm – high radioactivity detection at the common exhaust duct of ACUs

3.2 Balance CEDM cooling system as required to maintain the coil temperatures within the specified limits.

3.3 Connect cabling between the reactor bulkhead and the DRCS cabinets and energize the CEDM. Measure and record the dc voltage across the upper gripper coil and across the shunt on the DRCS power switch assembly panel.

3.4 Operate the CEDM and observe count totalizer operation.

4.0 DATA REQUIRED

4.1 CEDM "cold" coil resistance

4.2 CEDM cable resistance

4.3 RCS temperature and pressure

4.4 CEDM coil loop resistance at specified RCS temperature and pressure

4.5 DC voltage across the upper gripper coil at the specified RCS temperature and pressure

4.6 DC voltage across the shunt

4.7 CEDM count totalizer readings

5.0 ACCEPTANCE CRITERIA

5.1 The DRCS performs as described in Subsection 7.7.1.1 a.

5.2 The CEDM coil temperatures (calculated from the measured coil resistances) are less than the maximum allowable temperature of 177˚C (350˚F).

4.0 DATA REQUIRED

4.1 CEA drop time

4.2 RCS temperature and pressure to be taken during measurement and recording of drop time for each CEA

4.3 CEA position and alarm indications

4.4 CEA withdrawal speed

4.5 CEDM coil resistance

5.0 ACCEPTANCE CRITERIA

5.1 The CEDM/CEAs and their associated position indications operate as described in Subsection 7.7.1.1 a.

5.2 CEA drop times are in agreement with the Technical Specifications.

5.3 CEA ~~insertion and~~ withdrawal ~~times meet design requirements.~~ speed meets Subsection 4.3.1.7.

14.2.12.2.5 Post-Core Reactor Coolant and Secondary Water Chemistry Data

1.0 OBJECTIVE

1.1 To maintain the proper water chemistry for the RCS and steam generators during post-core hot functional testing

2.0 PREREQUISITES

2.1 Primary and secondary sampling systems are operable.

2.2 Chemicals to support hot functional testing are available.

2.3 The primary and secondary chemical addition systems are operable.

2.4 Purification ion exchangers are charged with resin.

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-3

GDC 25, "Reactivity Control System Redundancy and Capability," requires, in pertinent part, that the reactivity control system using control rods shall be capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. SRP Section 4.6 states that the test program for the CRDS should include experimental verification of system operation where a single failure (e.g., stuck rod) has been assumed.

However, the staff could not find such experimental verification in the CRDS test descriptions. Please address how system operation is experimentally verified in the event of a single failure, and update the test descriptions in the DCD appropriately

Response

Control rod stuck can happen in two ways. One is an electrical malfunction of the digital rod control system (DRCS) that causes inoperable condition of a control rod. But as described in Subsection 4.6.2.1, malfunction of the DRCS does not disturb the reactor trip function. The other is a mechanical stuck such as a stick to its guide tube or a bending of the control rod. Because each control element drive mechanism (CEDM) operates independently during reactor trip, any one stuck rod does not disturb the trip function of other CEDMs. Therefore, even if a stuck rod is assumed, the existing test method needs not to be changed and any stuck rod can be found by the test.

The trippability of the CEDMs is verified by the surveillance test during normal operation as required per Technical Specification 3.1.5. If a stuck rod exists, it can be found by this surveillance test. Therefore, this surveillance test program can be regarded as an experimental verification of system operation when a stuck rod is assumed. DCD Tier 2, Subsections 4.6.3 will be revised as shown in RAI 136-8081 - Question 04.06-3-Attachment to include the test program required by the surveillance requirement.

Impact on DCD

DCD Tier2, Subsection 4.6.3 will be revised as indicated in RAI 136-8081 - Question 04.06-3-Attachment.

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.

failure of the DRCS does not prevent the reactor trip function from occurring. This is verified by a failure modes and effects analysis (FMEA) of the DRCS. No single failure in the RPS (including the RTSG) can prevent the removal of electrical motive power from the CEDMs.

For the trip function, the CEDMs are essentially passive devices. When power is removed from the CEDM coils, the armature springs automatically disengage the latches from the CEDM driveshafts, allowing insertion of the CEAs by gravity. The CEDMs operate independently of one another when a reactor trip occurs. Therefore, if one CEDM fails to trip, it would not affect the ability of any other CEDM to trip. In the event of a failure of a CEDM, the shutdown capability is retained because sufficient shutdown margin is always maintained in the reactor. Therefore, no single failure can prevent the CEDMs from providing sufficient scram reactivity to achieve a reactor shutdown.

4.6.2.2 Isolation of the CEDMs from Other Equipment

The isolation of the RPS from nonessential elements to provide reasonable assurance of a reactor trip function is addressed in Section 7.2. Control of the CEDM is performed by the DRCS. The interface between the CEDMs and the DRCS is at the DRCS power switches, which provide the isolation of the high-voltage motive power from the low-voltage logic control signal. The interface between the CEDMs and the CEAs involves no nonessential elements.

4.6.2.3 Protection from Common-Cause Failure

Protection of essential systems from the consequences of postulated pipe breaks and associated missiles is provided by physical separation, pipe whip restraints, protective structures and compartments, watertight barriers, isolation capability, or other suitable means, as addressed in Section 3.6.

4.6.3 Testing and Verification of the Control Rod Drive System

The testing and verification of the CEDM is addressed in Subsection 3.9.4.4. The initial startup test is addressed in Chapter 14, which includes hydrostatic test and verifies the reactor trip function and the proper operation of the CEDMs.

Surveillance tests required by Technical Specification verify the reactor trip function with a detection of possible stuck rods.

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-4

GDC 26, "Reactivity Control System Redundancy and Capability," requires two independent reactivity control systems of different design principles to be provided, each of which should be capable of controlling reactivity changes under normal operation. GDC 27, "Combined Reactivity Control Systems Capability," requires that the combined capability of the reactivity control systems, in conjunction with poison addition by the emergency core cooling system, can reliably control reactivity changes to assure that the capability to cool the core is maintained under postulated accident conditions.

Subsection 4.6.5 of the DCD states that the CVCS is not required but is designed for a high degree of redundancy and reliability. However, DCD Tier 2, Section 4.6 does not expand on how the CVCS or the other reactivity control systems provided in the APR1400 design contribute to the redundancy and capability of controlling reactivity changes required by GDC 26. Please clarify how the function of these systems provides redundancy in reactivity control, and include this information in DCD Tier 2, Section 4.6.

Response

As described in Subsections 3.1.22 and 3.1.23 of DCD, the control rod and the soluble boron are two independent reactivity control mechanism during normal, AOO, and postulated accident conditions. Safety injection System (SIS) and CVCS use soluble boron for reactivity control. Subsections 4.6.5 will be revised as shown in RAI 136-8081 - Question 04.06-4-Attachment to describe the conformance to GDC26.

GDC 26 states that "Secondary control system shall be capable of reliably controlling the rate of reactivity changes resulting from planned, normal power changes (including xenon burnout) to assure that acceptable fuel design limits are not exceeded." This is reactivity control during normal operation and the CVCS performs the function.

The CVCS does not have the strict redundancy as the safety systems but it has the redundancy for some components to increase the system availability and reliability. Subsection 9.3.4.3.1 of DCD describes the redundancy of the CVCS. Subsections 4.6.5 will also be revised as shown in RAI 136-8081 - Question 04.06-4-Attachment to refer Subsection 9.3.4.3.1.

Impact on DCD

DCD Tier2, Subsection 4.6.5 will be revised as indicated in RAI 136-8081 - Question 04.06-4-Attachment.

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.

4.6.4 Information for Combined Performance of the Reactivity Control Systems

Table 4.6-1 lists all the design bases events analyzed in Chapter 15 that take credit for two or more reactivity control systems for preventing or mitigating each event. The related reactivity systems are also included in the table.

4.6.5 Evaluation of Combined Performance of the Reactivity Control Systems

The CEDMs and SIS are separate systems (Section 1.2) and totally diverse in design and operation. Because the CEDMs and the SIS are protected from missiles, pipe breaks, and their effects (as delineated in Section 3.6), there are no credible potential common-cause failures that could result in the failure of both the CEDMs and the SIS. Therefore, sufficient reactivity insertion to achieve a reactor shutdown is maintained.

As delineated in Subsection 4.6.4 and Chapter 15, only a limited number of postulated events assume the availability of two reactivity control systems to prevent or mitigate the accident. The evaluations for steam line break (SLB) and CEA ejection, which assume the combined actuation of the CRDS and the SIS, are addressed in Chapter 15. These analyses demonstrate that the CRDS and SIS reliably control reactivity changes to cool the core under postulated accidents in accordance with GDC 27.

As addressed in Subsection 9.3.4.1, the CVCS is a non-safety-related system and is not required to perform any accident mitigation or safe shutdown function. However, the CVCS is designed for a high degree of redundancy and reliability.

as described in Subsection 9.3.4.3.1

4.6.6 Combined License Information

No COL information is required with regard to Section 4.6.

The CEDMs, SIS, and CVCS meet the requirement of two independent reactivity control systems of different design principles in GDC 26. Those reactivity control systems are used to reactivity compensation or to maintain the reactor in the safe condition during normal operation, anticipated operational occurrence, and postulated accident conditions.

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-5

GDC 26, “Reactivity Control System Redundancy and Capability,” and 27, “Combined Reactivity Control Systems Capability,” require, in pertinent part, the redundant reactivity control systems to be capable of reliably controlling reactivity changes. SRP Section 15.0, “Introduction - Transient and Accident Analyses,” states that the applicant should specify only safety-related systems or components for use in mitigating anticipated operational occurrences and postulated accident conditions.

Subsection 4.6.4 of the DCD states that Table 4.6-1 lists all the design basis events (DBEs) analyzed in Chapter 15 that take credit for two or more reactivity control systems for preventing or mitigating each event. As shown in Table 4.6-1, the chemical and volume control system (CVCS) does not appear to be credited for any DBEs, nor should it be per the statement in Chapter 15 that only safety-related systems are credited in the APR1400 safety analyses. Therefore, it is unclear why Subsection 4.6.4 discusses crediting more than two reactivity control systems. Please explain this statement, and make any necessary corrections to it in DCD Subsection 4.6.4.

Response

As described in Section 4.6 of DCD, the CVCS is also one of the reactivity control system of APR1400. Even if the CVCS is not credited in safety analyses of Chapter 15, it can be used based on emergency operation guideline (EOG). If the cooldown is needed or a stuck rod happens during reactor trip, boration by the CVCS can be used to preserve the shutdown margin. The CVCS is included in Table 4.6-1 for this reason.

Because the sentence in Subsection 4.6.4 is not clear, it will be revised as shown in RAI 136-8081 - Question 04.06-5-Attachment to make a correction.

Impact on DCD

DCD Tier 2, Subsection 4.6.4 will be revised as indicated in RAI 136-8081 - Question 04.06-5-Attachment.

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.

require reactivity control systems to operate for preventing or mitigating each event.

4.6.4 Information for Combined Performance of the Reactivity Control Systems

Table 4.6-1 lists all the design bases events analyzed in Chapter 15 that ~~take credit for two or more reactivity control systems for preventing or mitigating each event~~. The related reactivity systems are also included in the table.

4.6.5 Evaluation of Combined Performance of the Reactivity Control Systems

The CEDMs and SIS are separate systems (Section 1.2) and totally diverse in design and operation. Because the CEDMs and the SIS are protected from missiles, pipe breaks, and their effects (as delineated in Section 3.6), there are no credible potential common-cause failures that could result in the failure of both the CEDMs and the SIS. Therefore, sufficient reactivity insertion to achieve a reactor shutdown is maintained.

As delineated in Subsection 4.6.4 and Chapter 15, only a limited number of postulated events assume the availability of two reactivity control systems to prevent or mitigate the accident. The evaluations for steam line break (SLB) and CEA ejection, which assume the combined actuation of the CRDS and the SIS, are addressed in Chapter 15. These analyses demonstrate that the CRDS and SIS reliably control reactivity changes to cool the core under postulated accidents in accordance with GDC 27.

As addressed in Subsection 9.3.4.1, the CVCS is a non-safety-related system and is not required to perform any accident mitigation or safe shutdown function. However, the CVCS is designed for a high degree of redundancy and reliability.

4.6.6 Combined License Information

No COL information is required with regard to Section 4.6.

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-6

GDC 27, “Combined Reactivity Control Systems Capability,” requires that the combined capability of the reactivity control systems, in conjunction with poison addition by the emergency core cooling system, can reliably control reactivity changes to assure that the capability to cool the core is maintained under postulated accident conditions. Evaluation of the combined functional performance of the reactivity systems under accident conditions is performed under SRP Section 4.6.

Subsection 4.6.5 of the DCD suggests that two DBEs assume the availability of two reactivity control systems to prevent or mitigate the accident: steam line break (SLB) and control element assembly (CEA) ejection. However, this is not consistent with Table 4.6-1, which shows that feedwater line break (FLB), loss-of-coolant accident (LOCA), letdown line break (LDLB), and steam generator tube rupture (SGTR) also assume availability of two reactivity control systems. Furthermore, some of the required reactivity control systems for the DBEs listed in Table 4.6-1 appear to be inconsistent with the Chapter 15 analyses. In particular, the FLB, LDLB, and CEA ejection are shown in Table 4.6-1 to require use of the SIS to mitigate the events. However, Chapter 15 analyses do not mention SIS actuation for these three events.

Please explain these apparent inconsistencies and update the DCD as appropriate to ensure that the information presented in Subsection 4.6.5, Table 4.6-1, and the Chapter 15 analyses is consistent.

Response

The SLB and CEA ejection accidents are the examples of the accidents requiring combined reactivity performance. The FLB, LOCA, LDLB, and SGTR also require combined reactivity performance as listed in Table 4.6-1.

Safety analyses in Chapter 15 of DCD do not describe all possible scenarios of the accidents. Subsection 15.2.8.1 of DCD says that “Depending on the break size and location and response of the MFS, the effects of a break can vary from a rapid heatup to a rapid cooldown of the NSSS.” When the cooldown happens during the initial period of the accident, SIS can be actuated.

Subsection 15.6.2.3.2 of DCD says that LDLB event analysis assumes actuation of pressurizer heaters to maximize the break flow and consequently reactor trip does not occur. Without credit of the control systems, reactor trip and safety injection will happen due to decrease of RCS inventory. Therefore, LDLB event is classified as an event requiring CEDM and SIS.

Subsection 15.4.8.3.1 of DCD for CEA ejection analysis says that “Except for radiological release from containment, the analysis of the NSSS response to a CEA ejection does not consider the leakage and the RCS depressurization that would be caused by the rupture of the primary pressure boundary.” When the RCS depressurization happens due to the RCS coolant release to the containment atmosphere, safety injection will be actuated to preserve the RCS inventory. Therefore, SIS is classified as the required system for CEA ejection accident in Table 4.6-1.

As described above, safety analyses in Chapter 15 show that other scenarios different from the limiting cases presented in the DCD are possible. Required reactivity control system in Table 4.6-1 of DCD is prepared with the consideration of such scenarios.

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.

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.:	**136-8081**
SRP Section:	**4.6 – Functional Design of Control Rod Drive System**
Application Section:	**04.06**
Date of RAI Issue:	**08/07/2015**

Question No. 04.06-7

GDC 28, "Reactivity Limits," requires the reactivity control systems to be designed with appropriate limits on the potential amount and rate of reactivity increase to assure that the effects of postulated reactivity accidents can neither result in damage to the reactor coolant boundary nor disturb the core and its support structures to impair significantly the capability to cool the core.

DCD Tier 2, Section 4.6 does not address how the reactivity control systems meet GDC 28. Please indicate how GDC 28 is met, and update DCD Tier 2, Section 4.6 accordingly.

Response

Subsection 3.1.24 of DCD describes the responses to the GDC 28. As described in the subsection, GDC 28 is met with the combined design features of the plant.

Reactivity insertion by the system malfunction or an accident is limited by design and operation of the reactivity control system. Design of control rod material, control element assembly structure, withdrawal speed, and group assignment are the parameters of reactivity limit for control rod. RCS maximum charging capacity is a parameter of reactivity limit for the CVCS. Reactivity insertion is not limited only by their design but also by the operational requirements. LCOs 3.1.5 and 3.1.6 of Technical Specifications of DCD limit the insertion of control rods and LCO 3.1.9 limits the charging flow.

Safety analyses in Chapter 15 of DCD show that limiting reactivity induced by reactivity control system malfunction or other accidents are considered and the results are within acceptance limits. Therefore, Chapter 15 of DCD confirms the compliance with GDC 28. Subsections of 4.6.4 and 4.6.5 refer to Chapter 15 for combined performance of reactivity control system and these can be regarded as compliance of GDC 28.

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.