

## 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.:** 460-8554  
**Review Section:** 07.01 – Instrumentation and Controls – Introduction  
**Application Section:** 7.1  
**Date of RAI Issue:** 04/19/2016

---

### **Question No. 07.01-53**

Demonstrate how functional diversity is achieved in the APR1400 design to meet the requirements of 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 22.

GDC 22, "Protection system independence" states, "The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function, or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall be used to the extent practical to prevent loss of the protection function." NUREG/CR-6303, "Method for Performing Diversity and Defense-in-Depth Analyses of Reactor Protection Systems" provides guidance for meeting the requirements of GDC 22 for computer-based nuclear reactor protection systems. This NUREG, section 2.6.4, "Functional Diversity," states two systems are functionally diverse if they perform different **physical** functions though they may have overlapping safety effects.

In **RAI 43-7887, Question 07.01-15**, the staff requested the applicant to describe how the requirements of GDC 22 is met for APR1400 Plant Protection System (PPS) and Core Protection Calculator System (CPCS). In the September 24, 2015 response to this RAI (ADAMS Accession No. ML15267A764), the applicant stated that, "The conformance to the requirements of IEEE Std. 603 and GDC 22 regarding independence and functional diversity is described and provided in Sections 7.2.2.3 and 7.3.2.3 as well as in Section 4.1 of Safety I&C System Technical report." The applicant proposed to revise APR1400 FSAR, Tier 2, Section 7.1.2.24 to state: "The applicable I&C systems listed in Table 7.1-1 are designed to meet the requirement of GDC 22 as described in Subsections 7.2.2.3 and 7.3.2.3 as well as in Section 4.1 of the Safety I&C System Technical Report."

The staff finds this response unacceptable. Specifically, APR1000 FSAR, Tier 2, Sections 7.2.2.3 and 7.3.2.3 address independence and Section 4.1 of the Safety I&C System

Technical Report does not discuss functional diversity. Section 4.2.2.1 of Technical Report APR1400-Z-JNR-14001, "Safety I&C System" does state that "Each BP [(bi-stable)] processes the bistable logic in the reverse order to that of the other BP for software functional diversity." However, there was no definition provided for what is meant by "software functional diversity." In accordance with NUREG/CR-6303, designing each BP such that it processes the bistable logic in reverse order does not constitute functional diversity as the BPs do not have different purposes, functions, or actuation means. Also, reversing the processing order does not count as different control logic as mentioned in section 3.2.3. Further, Technical Report APR1400-ZJ-NR-14002, "Diversity and Defense-in-Depth" only discusses functional diversity between safety I&C systems and the diverse protection system and not within the PPS or CPCS. As such, the staff requests the applicant to demonstrate how functional diversity is achieved in the design.

### **Response**

As described in DCD Tier 2 Section 3.1.18, "Criterion 22 – Protection System Independence," functional diversity is incorporated into the system design to prevent a loss of the protective function. This section also describes that the diverse protection system augments the reactor trip and auxiliary feedwater system (AFWS) actuation by using separate and diverse non-Class 1E trip logic from that used by the plant protection system.

The previously submitted response to RAI 43-7887, Question 7.1-15 stated that functional diversity is described in Section 4.1 of the Safety I&C System technical report; however, that reference was not correct. The mark-up associated with this response deletes that reference and should supersede the previous mark-up supplied with RAI 43-7887, Question 7.1-15.

In addition, the term "software functional diversity" will be no longer used in the application document. The response to RAI 50-7911 Question 07.02-2 has been submitted to clarify that the reverse order of operation between two bistable processors (BPs) within a PPS division "increases the degree of software diversity" and included an associated mark-up for Section 4.2.2.1 of the Safety I&C System technical report and Section 6.1.2 of the Diversity and Defense in Depth technical report.

---

### **Impact on DCD**

DCD Tier 2 Section 7.1.2.24 will be revised as indicated in the 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 Report.

**APR1400 DCD TIER 2**7.1.2.21 Conformance with GDC 19

The I&C systems that are applicable to GDC 19, as shown in Table 7.1-1, are designed in accordance with GDC 19. The capabilities with regard to the safe operation of the plant from the MCR during normal and accident conditions are described in Section 7.4.

7.1.2.22 Conformance with GDC 20

The I&C systems that are applicable to GDC 20, as shown in Table 7.1-1, are designed in accordance with GDC 20. The protection function is described in Sections 7.2 and 7.3.

7.1.2.23 Conformance with GDC 21

The I&C systems that are applicable to GDC 21, as shown in Table 7.1-1, are designed in accordance with GDC 21. The protection system is designed to comply with the requirements of IEEE Std. 603. No credible single failure would result in a loss of the protection function.

7.1.2.24 Conformance with GDC 22

~~The I&C systems that are applicable to GDC 22, as shown in Table 7.1-1, are designed in accordance with GDC 22. The protection systems comply with the independence requirements of IEEE Std. 603 except for the CEA position inputs described in Subsection 7.1.2.3.~~

7.1.2.25 Conformance with GDC 23

The I&C systems that are applicable to GDC 23, as shown in Table 7.1-1, are designed in accordance with GDC 23. Failure modes and effects analysis (FMEA) for protection systems is described in Subsections 7.2.3.1 and 7.3.3.1.

7.1.2.26 Conformance with GDC 24

The I&C systems that are applicable to GDC 24, as shown in Table 7.1-1, are designed in accordance with GDC 24. Electrical isolation, physical separation, and communication

The applicable I&C systems listed in Table 7.1-1 are designed to meet the requirement of GDC 22 as described in Subsections 7.2.2.3 and 7.3.2.3 as well as in Item 'k' of Section 3.2, "GDC 22, Protection System Independence" of the Safety I&C System technical report.