KHNPDCDRAIsPEm Resource

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Cc: Lee, Samuel; Ciocco, Jeff; Curran, Gordon; McKirgan, John; Ward, William
Subject: APR1400 Design Certification Application RAI 233-8244 (05.02.02 - Overpressure Protection)
Attachments: APR1400 DC RAI 233 SRSB 8244.pdf

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs. However, KHNP requests, and we grant, 45 days to respond to this RAI. We may adjust the schedule accordingly.

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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REQUEST FOR ADDITIONAL INFORMATION 233-8244

Issue Date: 10/02/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 05.02.02 - Overpressure Protection
Application Section: 5.2.2, 5.4.10 and 6.4.14

QUESTIONS

05.02.02-1

General Design Criterion (GDC) 15, as it relates to designing the Reactor Coolant System (RCS) and associated auxiliary, control, and protection systems with sufficient margin to assure that the design conditions of the reactor coolant pressure boundaries (RCPB) are not exceeded during any condition of normal operation, including anticipated operational occurrences (AOOs).

As indicated in NUREG-0800, Section 5.2.2, "Overpressure Protection," SRP Acceptance Criteria 3.B, to assure sufficient overpressure protection, the designs of the safety valves should have sufficient capacity to limit the pressure to less than 110 percent of the RCPB design pressure during the most severe AOO with reactor scram, as specified by ASME Code Article NB-7000. Also, sufficient available margin should account for uncertainties in the design and operation of the plant assuming:

i. The reactor is operating at a power level that will produce the most severe overpressurization transient,

ii. All system and core parameters have values within normal operating range, including uncertainties and technical specification limits that produce the highest anticipated pressure,

iii. The second safety-grade signal from the reactor protection system initiates the reactor scram,

iv. The discharge flow is based on the rated capacities specified in ASME Code Article NB-7000 for each type of valve, and

v. The design of the safety valves should have sufficient capacity to limit the pressure to less than 110 percent of the RCPB design pressure during the most severe infrequent event, as specified by ASME Code Article NB-7000.

APR1400 DCD, Section 5.2.2, “Overpressure Protection,” provides KHNP’s description of how the APR1400 design complies with these regulatory requirements. In this section, KHNP states that analyses were performed for pressurizer pilot-operated safety relief valves (POSRV) and low temperature over pressure (LTOP) design to evaluate the components capability to provide sufficient overprotection protection. However, the staff is unable to locate any detailed description of these in the DCD and wishes to review the applicant’s analyses (including assumptions, inputs, and results) referred to in DCD Section 5.2.2, as follows:

- DCD Section 5.2.2.1.1, "Design Bases for Overpressure Protection of the Reactor Coolant System," states, “In order to determine the appropriate pressurizer POSRV

capacity, a sensitivity study was performed with the worst-case initial condition and nuclear parameters to conservatively evaluate the effect of valve capacity on the maximum RCS pressure during the design basis event. As shown in Figure 5.2.2-1, "Optimized Pressurizer POSRV Capacity," the design POSRV capacity is determined at the point where an additional increase in the capacity has a negligible effect on reducing the maximum RCS pressure during the loss-of-load transient." The staff is unable to locate this sensitivity study used to define the POSRV design during worst case loss-of-load transient and develop optimized POSRV capacity shown in Figure 5.2.2-1.

CE System 80+ DCD (Appendix 5A) and other operating CE plants contain an assessment documenting the adequacy of overpressure protection provided for System 80+ Standard Design steam generators and reactor coolant system. In comparison, APR1400 does not include a similar assessment verifying the overpressure protection is conservatively estimated for relevant AOOs and accidents. Therefore, the staff expects KHNP to provide a description of the method/assumptions used to adequately design POSRV and develop Figure 5.2.2-1, similar to Appendix 5A of System 80+ DCD.

- Guidelines in SRP Section 5.2.2, SRP Acceptance Criteria 4, state the system for overpressure protection during low-temperature phases of plant operation should be designed in accordance with the requirements of Branch Technical Position (BTP) 5-2, "Overpressurization Protection of Pressurized-Water Reactors While Operating at Low Temperatures."

  DCD Section 5.2.2.2.2.1, "Limiting Transients," states, "The most limiting transients are determined by the conservative analyses, which maximize mass and energy additions to the RCS."

  KHNP Technical Report APR1400-Z-M-NR-14008, Rev.0, "Pressure-Temperature Limits Methodology for RCS Heatup and Cooldown," specifies the maximum pressure for LTOP is limited to 43.9 kg/cm^{2}A (625 psia), 20 percent of RCS hydraulic test pressure of 219.7 kg/cm^{2}A (3,125 psia). The technical report concludes that the relief valve set-pressure is determined to be lower than the LTOP limiting pressure of 43.9 kg/cm2A (625 psia).

  However, neither the DCD, nor the technical report specify the pressures obtained as result of the mass and energy addition transients or describe which transient is more severe. The staff is unable to confirm that the use of either shutdown cooling system (SCS) relief valve will provide sufficient pressure relief capacity to mitigate the most limiting LTOP events. Therefore, the staff expects KHNP to provide description of the analysis and, more specifically provide the mass and energy addition transient results.

- Section 5.2.2.2.2.1 states, "The analyses demonstrate that the SCS suction line relief valve (SI-179 or SI-189) provides sufficient pressure relief capacity to mitigate the most limiting LTOP events identified above." DCD Section 5.2.2.2.2.1 further states, "The maximum $\triangle$T for energy addition transient is assumed to be 139 °C (250 °F), which is greater than the value allowed by Subsections 3.4.6 and 3.4.7 in Technical Specifications (Chapter 16) during the LTOP mode. However, the operational procedures direct the operator to maintain the $\triangle$T below approximately 11.1 °C (20 °F)." The staff is unable to locate any details regarding this referenced analysis to justify use of SCS for LTOP condition, nor a justification for not meeting the TS.

- As indicated in DCD Tier 2, Section 5.4.10.3, [Pressurizer] "Design Evaluation," it is demonstrated by analysis in accordance with requirements for ASME Section III, Class 1 vessels that the pressurizer is adequate for all normal operating and transient conditions expected during the life of the facility. The staff is unable to locate this analysis referenced in DCD in order to verify that the pressurizer is adequately sized and spray capacity is sufficient to preclude the POSRVs from actuating during normal operation. The staff requests additional sizing details and provide access to the analysis referenced in DCD.

05.02.02-2

General Design Criterion (GDC) 15, as it relates to designing the RCS and associated auxiliary, control, and protection systems with sufficient margin to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including AOOs. The staff reviews Tier 1 content, including ITAAC, to ensure that all Tier 1 information is consistent with Tier 2 information since all Tier 1 information is derived from Tier 2.

In accordance with Section 5.2.2 of NUREG-0800, for pressurized water reactors (PWRs), the area of review for operation at power includes pressurizer, safety and relief valves (SRVs), and the piping from these valves to a quench tank or to containment atmosphere on the primary side, as well as steam generator SRVs on the secondary side.

a. DCD Tier 1, Table 2.4.1-1, "Reactor Coolant System Equipment and Piping Location/Characteristics," indicates that the pressurizer piping downstream of and excluding pressurizer pilot operated safety relief valves is classified as non-seismic. However, DCD Tier 2, Table 3.2-1, "Classification of Structures, Systems, and Components," Item 79.g., indicates that "POSRV piping" is classified as "I/II". The staff is unable to determine what seismic classification is applied to the POSRV discharge piping or locate any classification breaks on figures in DCD. In addition, an inconsistency may exist between Tier 1 and 2 regarding this piping classification. The applicant should verify the proper classification is applied to the POSRV discharge piping and update the DCD for consistency.

b. DCD Section 5.2.2.3, "Flow Diagrams," provides the reference to flow diagrams for the overpressure components and states, "The flow diagram showing the in-containment refueling water storage tank (IRWST) is given in Figure 6.8-3." DCD Tier 1, Figure 2.4.2-1 shows the discharge of the POSRV into the IRWST. Figure 6.8-3, "In-containment Water Storage System Flow Diagram," shows the piping connections for the SCS relief valve discharge, but the staff is unable to locate the POSRV discharge connections to the IWRST. The applicant is requested to verify the location of the POSRV discharge connection to IRWST in Figure 6.8-3. In addition, an inconsistency may exist between Tier 1 and 2 regarding this piping configuration. The applicant should verify the proper configuration and update DCD for consistency.

05.02.02-3

10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are 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 will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations. The staff reviews Tier 1 content, including ITAAC, to ensure that all Tier 1 information is consistent with Tier 2 information since all Tier 1 information is derived from Tier 2.

DCD Tier 1, Table 2.4.1-4, “Reactor Coolant System ITAAC,” Item 9.a, includes an acceptance criteria indicating “Maximum opening time (including dead time) of the POSRVs is 0.5/5 seconds (hydraulic/manual). Maximum closing time (including dead time) of the POSRVs is 0.9/9 seconds (hydraulic/manual).” While opening time of 0.5 seconds is consistent with DCD Tier 2, Table 5.4.14-1, Pilot-Operated Safety Relief Valve Parameters,” and technical specification for the POSRV design, the staff is unable to locate any detail or definition of the manual actuation response time in Tier 2 or the safety significance of not meeting manual response time.

The staff requests KHNP to provide additional details (basis and assumptions) for the POSRV manual actuation response times of 5 seconds and 9 seconds.

05.02.02-4

GDC 15, as it relates to designing the RCS and associated auxiliary, control, and protection systems with sufficient margin to assure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including AOOs.

As indicated in NUREG-0800, Section 5.2.2, "Overpressure Protection," SRP Acceptance Criteria 3.B, to assure sufficient overpressure protection, the designs of the safety valves should have sufficient capacity to limit the pressure to less than 110 percent of the RCPB design pressure during the most severe AOO with reactor scram, as specified by ASME Code Article NB-7000. Also, sufficient available margin should account for uncertainties in the design and operation of the plant assuming:

i. The reactor is operating at a power level that will produce the most severe overpressurization transient,

ii. All system and core parameters have values within normal operating range, including uncertainties and technical specification limits that produce the highest anticipated pressure,

iii. The second safety-grade signal from the reactor protection system initiates the reactor scram,

iv. The discharge flow is based on the rated capacities specified in ASME III for each type of valve, and

v. The design of the safety valves should have sufficient capacity to limit the pressure to less than 110 percent of the RCPB design pressure during the most severe infrequent event, as specified by ASME Code Article NB-7000.

To demonstrate compliance with these regulatory requirements, the APR-1400 DCD displays the worst-case transient in Figures 5.2.2-2, “Steam Generator Pressure Normalized to Design Pressure vs. Time for the Worst-Case Loss-of-Load Event,” 5.2.2-3, “Primary Pressure Normalized to Design Pressure vs. Time for the Worst-Case Loss-of-Load Event,” and 5.2.2-4, “Reactor Power Normalized to 100% of Rated Power vs. Time for the Worst-Case Loss-of-Load Event,” but lacks clear description of the transients and assumptions made to develop figures. DCD Section 5.2.2.1.1, “Design Bases for Overpressure Protection of the Reactor Coolant System,” indicates, “The pressurizer POSRVs, MSSVs, and RPS are designed to maintain the RCS pressure below 110 percent of design pressure during the worst-case loss-of-load event with a delayed reactor trip.” The DCD also specifies peak reactor coolant and steam generator pressures are limited to less than 110 percent of design pressures during the worst-case transient (Figures 5.2.2-2, 5.2.2-3, and 5.2.2-4). The staff is unable to locate a clear description of “worst-case loss-of-load event” in the DCD and unable to determine the method or assumptions used to develop Figures 5.2.2-2, 5.2.2-3, and 5.2.2-4.

The APR1400 DCD omitted an assessment to verify the overpressure protection is conservatively estimated for relevant AOOs and accidents. Therefore, the staff expects KHNP to provide an evaluation. Staff notes the System 80+ Appendix 5A, defining the “worst-case loss-of-load event with a delayed reactor trip”, describing the method/assumptions used to adequately design overpressure protection components, and providing basis for Figures 5.2.2-2, 5.2.2-3, and 5.2.2-4. CE System 80+ DCD (Appendix 5A) and other operating CE plants contain an assessment documenting the adequacy of overpressure protection provided for System 80+ Standard Design steam generators and reactor coolant system. These are examples the staff has found acceptable in the past.

05.02.02-5

GDC 30 requires that the reactor coolant pressure boundary be designed, fabricated, erected and tested to the highest quality standards practical. Application of GDC 30 to overpressure protection system provides assurance that the reactor coolant pressure boundary will have an extremely low probability of failure because of manufacturing or design defects. As indicated in NUREG-0800, Section 5.2.2, SRP Acceptance Criteria 5, states that the performance of tests and inspections should occur before operation and during startup to functionally demonstrate that the over pressure protection system, as installed, meets all design requirements.

DCD Section 5.2.2.10, "Testing and Inspection," describes testing and inspection applied to the pressurizer POSRV's and main steam safety valves (MSSVs) providing a list of verification testing to be performed for operability of the pressurizer POSRVs. DCD Section 5.2.2.10 further references DCD Chapter 14 for specifying preservice testing. DCD Tier 2, Section 14.2.12.1.3, "Pressurizer Pilot-Operated Safety Relief Valve Test," contains POSRV tests to verify the open/closing pressure and opening response time. Compared to Chapter 14, the Section 5.2.10 verification testing seems to contain additional pre-service testing (setpoint, response time, leak test, position indicator, closing time, etc…).

In addition, DCD Tier 2, Section 14.2.12.1.3 contains a reference to Section 5.4.14, "Safety and Relief Valves," for performance acceptance criteria, but much of the performance description is located in Section 5.2.2 of DCD.

The staff requests applicant to define the complete preservice testing to be performed on the POSRVs and update the DCD accordingly.

05.02.02-6

In accordance of NUREG-0800 (Section 5.2.2), Review Procedures, 1.B.iii, NRC reviews the capacities, setpoints, and setpoint tolerances for all primary and secondary SRVs or other overpressure protection system devices. The reviewer verifies that these constraints are adequate to provide overpressure protection to the RCPB at critical values of pressure and temperature based on RCPB material parameters.

Section 5.2.2.9, "System Reliability," states, "The pressurizer POSRVs are pilot-operated mechanisms and cannot fail closed if the setpoint pressure is exceeded. The force of the spring on the main valve disc area is designed to resist the inward pressure force of 2.0 kg/cm^2 D (29 psid)." Since the main valve disc is not spring loaded, the staff is unable to determine which spring is being referenced in this paragraph. Therefore, the staff requests applicant to provide additional details on the main valve spring on the main disc and update the DCD as appropriate.