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.: **487-8609**

SRP Section: **05.02.02 – Overpressure Protection**

Application Section:

Date of RAI Issue: **05/18/2016**

Question No. 05.02.02-7

General Design Criterion (GDC) 15 requires that the reactor coolant system and associated auxiliary, control, and protection systems be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

NRC staff issued RAI 233-8244, Question 5.2.2-1 during the review of Section 5.2.2 of the APR1400 Design Control Document (DCD). In Question 5.2.2-1, items b and c, NRC staff questioned the methodology for the analysis of the limiting events where low temperature overpressure protection (LTOP) is utilized. The KHNP response to RAI 233-8244 (ML15348A083), Question 5.2.2-1, items b and c, did not alleviate NRC staff concerns because:

1. The RAI response did not include a discussion of the evaluation model.
2. The RAI response did not contain information regarding the input parameters used in the analyses.

NRC staff requests that KHNP:

1. Describe the analysis methodology, and any computer codes used to analyze the limiting LTOP event(s).
2. Describe the input parameters and assumptions used in the analysis of the limiting LTOP event(s). In particular, explain why the chosen inputs are suitably conservative.

Response

1. Mass Addition Transient during low temperature condition

   1) Method of Analysis

Hand calculation is used for the case of mass addition. The RCS pressure transient is calculated based on a mass balance on the RCS through the delivery of various pumps such as Safety Injection Pump (SIP) and Charging Pump(CHP) at very small time intervals. After each time increment, the RCS pressure is obtained by considering the variation of specific volume assuming a constant RCS volume and temperature. The specific volume of the RCS is changed due to the RCS mass change induced by actuation of pumps and LTOP relief valves. If mass is added to the RCS in a water-solid condition, the addition makes RCS pressure increase rapidly, the SCS suction line relief valve opens at its setpoint, and then it will reduce the increase rate of the RCS pressure. The calculation will be terminated after ensuring no-increase in RCS pressure.

2) Basic Data & Assumptions

a. The RCS water temperature is assumed to be constant, because the mass addition transient occurs at a short period of time enough to assume isothermal condition in the RCS.

b. The potential transients for the mass input to the RCS are as follows:

i) Safety injection flow due to inadvertent SIAS.
ii) Charging pump operation.

Only one charging pump is assumed to operate. There are two centrifugal charging pumps and one auxiliary charging pump in CVCS. Only one CCP runs during all plant operational modes and the other CCP is in standby mode. This standby CCP does not run during any modes of operation except for switching operation. And the ACP does not contribute mass addition during LTOP events. Therefore only one CCP is considered to operate in calculating mass addition during LTOP conditions. Additionally the CVCS charging line has charging flow restricting orifices to limit the charging flow when the RCS pressure is low.

c. The RCS is assumed to be water solid with no steam bubble in the pressurizer. If mass is added to the RCS in a water-solid condition, the addition makes RCS pressure increase rapidly. However, the operator is instructed to avoid water-solid conditions whenever possible.

d. The LTOP relief valve set pressure is 37.3 kg/cm^2g(530 psig). In this analysis, the uncertainty of instrument used in relief valve set pressure test is considered. Therefore the relief valve set pressure used in this calculation is 37.3 kg/cm^2g + 0.4 kg/cm^2 = 37.7 kg/cm^2g = 38.7 kg/cm^2A(530 psig + 6 psi = 536 psig = 551 psia).

e. The pressurizer pressure provides the representative RCS pressure. The reactor vessel bottom pressure is obtained considering the elevation difference between the pressurizer top and the reactor vessel bottom.

f. Initial pressurizer pressure (at t = 0) is assumed to be 450 psia.

g. It is assumed that only one LTOP relief valve(SI-179 or 189) opens for this analysis. This is more conservative than two valves opening and reduces the exit flow from the RCS, which tends to increase the RCS peak pressure.

h. The letdown system is considered to be isolated and no flow exits from the RCS except the LTOP relief valve.

3) Input parameters

Input parameter	Value	Remark
RSC water temperature	120˚F	The lower RCS temperature results in the faster system pressurization. The RCS temperature is assumed to be 120˚F, which is the lowest temperature before entering operational mode 6.
RCS volume	minimum	Minimum volume makes the system pressurization faster with the same mass input.
Temperature of the fluid relieved from the relief valve	350˚F	350˚F instead of 120˚F minimizes the fluid mass flowrate exiting through the relief valve.

2. Energy Addition Transient during low temperature condition

1) Method of Analysis

The OVERP computer code is used in this analysis. The code is used to simulate pressure transients in the RCS resulting from a RCP start when the RCS is water solid and the steam generator secondary temperature is greater than the RCS temperature. RCS pressure is computed as a function of total system energy content and specific volume. When the RCS is a closed (no mass flux) system the specific volume remains constant. When relief valve discharges mass from the system, the computed RCS pressure after each time increment considers the mass release and energy convection. Since the relief valve flowrate is a function of its inlet pressure, RCS pressure is used to calculate valve flowrate. If energy is added to the RCS in a water-solid condition, the addition makes RCS pressure increase rapidly, the SCS suction line relief valve opens at its setpoint, and then it will reduce the increase rate of the RCS pressure. The calculation will be terminated after ensuring no-increase in RCS pressure.

2) Basic Data & Assumptions

a. Initial secondary-to-primary temperature differential of 250°F is assumed.

b. The sources of energy input to the RCS are as follows:

(1) Heat transfer from the secondary side of steam generator to the primary side due to an inadvertent RCP operation when the secondary temperature is higher than the primary temperature.
(2) RCP Heat
(3) Pressurizer Heater
(4) Core Decay Heat

c. It is assumed that one RCP is inadvertently started resulting in the initiation of this transient. The simultaneous startup of more than one RCP is procedurally precluded since the operator starts only one RCP at a time and a second RCP is not started until system pressure is stabilized.

d. The RCS is assumed to be water solid with no steam bubble in the pressurizer. If energy is added to the RCS in a water-solid condition, the addition makes RCS pressure increase rapidly. However, the operator is instructed to avoid water-solid conditions whenever possible.

e. The LTOP relief valve set pressure is 37.3 kg/cm^{2}g(530 psig). In this analysis, the uncertainty of instrument used in relief valve set pressure test is considered. Therefore the relief valve set pressure used in this calculation is 37.3 kg/cm^{2}g + 0.4 kg/cm^2 = 37.7 kg/cm^{2}g = 38.7 kg/cm^{2}A(530 psig + 6 psi = 536 psig = 551 psia).

f. The pressurizer pressure provides the representative RCS pressure. The reactor vessel bottom pressure is obtained considering the elevation difference between the pressurizer top and the reactor vessel bottom.

g. Initial pressurizer pressure (at t = 0) is assumed to be 450 psia.

h. It is assumed that only one LTOP relief valve(SI-179 or 189) opens for this analysis. This is more conservative than two valves opening and reduces the exit flow from the RCS, which tends to increase the RCS peak pressure.

i. The letdown system is considered to be isolated and no flow exits from the RCS except the LTOP relief valve.

3) Input parameters

Input parameter	Value	Remark
Initial secondary-to-primary temperature differential	250°F	Shutdown cooling is initiated at 350°F. It is assumed that the secondary side of steam generators remain at 350°F

		while the RCS is cooled to a refueling temperature of 120°F. To the difference of 230 °F, some margin is added for conservatism.
RSC water temperature	100°F	Based on the 250°F temperature difference, the RCS water properties are obtained at 100°F.

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 Environmental Report.