# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

**Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD**

**Docket No. 52-046**

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| **RAI No.:** | **302-8341** |
| **SRP Section:** | **15.05.01-15.05.02 - Inadvertent Operation of ECCS and Chemical and Volume Control System Malfunction that Increases Reactor Coolant Inventory** |
| **Application Section:** | **15.05.01-15.05.02** |
| **Date of RAI Issue:** | **11/10/2015** |

## Question No. 15.05.01-1

GDC 15 requires that the reactor coolant system (RCS) and its associted auxiliary control and protection systems be designed with sufficient margin to assure that the desgin conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences (AOOs). Additionally, sections 15.5.1-15.5.2 of the Standard Review Plan (NUREG-0800) state that the parameters used in the analytical model should be suitably conservative.

The Chemical and Volume Control System (CVCS) malfunction that increases RCS inventory event, analyzed in DCD Section 15.5.2, credits use of the pressurizer pilot operated safety relief valves (POSRVs) and main steam safety valves (MSSVs) to limit overpressure in the RCS and main steam system. Design parameters for the POSRVs and MSSVs are available in DCD Table 5.5.14-1 and DCD Table 10.3.2-1, respectively. However, it is not clear that the modeling of these valves in the safety analyses is suitably conservative with respect to the design parameters. NRC staff requests the following additional information:

1. Open and close pressures, open and close dead times, and relief capacity for the POSRVS and MSSVs as assumed in the safety analyses (CESECC-III)
2. Explain why each parameter is suitably conservative

## Response

1. Open and close pressures, open and close dead times, and relief capacity for the POSRVs and MSSVs as assumed in the safety analyses (CESECC-III) are as follows;

| Parameter | POSRV | MSSV | | |
|---|---|---|---|---|
| | | 1st Bank | 2nd Bank | 3rd Bank |
| Open/Close Pressure $Kg/cm^2A$ (psia) | 177.13/159.32 (2,519.4/2,266) | 86.88/78.19 (1,235.66/1,112.09) | 89.14/80.23 (1,267.9/1,141.11) | 90.97/81.87 (1,293.9/1,164.51) |
| Open/Close Dead Time sec | 0.25/0.45 | - | - | - |
| Relief Capacity lb/hr | Minimum 540,000 | Minimum $19x10^6$ | | |

2. The reason why each parameter is suitable conservative is as follows;

**POSRV**

The open pressure for the POSRV is 2,470 psia, and the uncertainty is ± 49.4 psi. For conservatism, the open pressure for the POSRV is determined as 2,519.4 (2,470 + 49.4) psia, and the relief capacity is assumed as a minimum, because a higher open pressure and less relief capacity would cause maximum peak pressure in the RCS. The close pressure for the POSRV is 13% ± 74.1 psi, therefore, the close pressure for the POSRV is determined as 2,266 (2519.4 x 0.87 + 74.1) psia.

**MSSV**

The open pressures for the 1st/ 2nd/3rd MSSV bank are 1,174/1,205/1,230 psig with an uncertainty of ± 4%, respectively. For conservatism, the open pressure of the 1st MSSV bank is determined as 1,235.66 (1,174 x 1.04 + 14.7) psia, and the relief capacity is assumed as a minimum, because a higher open pressure and less relief capacity would cause maximum peak pressure in the SG. Blowdown for the MSSV is 10%, therefore, the close pressure for the MSSV is determined as 1,112.09 (1,235.66 x 0.9) psia.

Open/close pressures for the 2nd and 3rd MSSV bank are determined the same way as the 1st MSSV bank.

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**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 Reports.

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## Question No. 15.05.01-2

GDC 15 requires that the reactor coolant system (RCS) and its associted auxiliary control and protection systems be designed with sufficient margin to assure that the desgin conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences (AOOs). Additionally, sections 15.5.1-15.5.2 of the Standard Review Plan (NUREG-0800) state that the parameters used in the analytical model should be suitably conservative.

The Chemical and Volume Control System (CVCS) malfunction that increases RCS inventory event, analyzed in DCD Section 15.5.2, considers the impact of single failures. Based on the discussion provided in DCD Section 15.5.2, it is not clear if the pressurizer heaters were considered in the analysis. NRC staff requests DCD Section 15.5.2 be updated to describe the behavior of the pressurizer heaters during the event and describe how the assumed behavior is suitably conservative.

## Response

All pressurizer heaters (proportional and backup) are assumed to be "OFF" due to the PLCS malfunction. And PPCS is also assumed in the manual mode with both the proportional and backup heaters turned off. These assumptions delay the reactor trip, and maximize the increase in RCS inventory conservatively, because the pressure transient is primarily due to an increase in RCS coolant inventory for the significant portion of the event, and not to thermal expansion. The failure of PPCS and PLCS are described in DCD Section 15.5.2.1.

**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**

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## Question No. 15.05.01-3

GDC 15 requires that the reactor coolant system (RCS) and its 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 (AOOs). Additionally, acceptance criteria identified in sections 15.5.1-15.5.2 of the Standard Review Plan (NUREG-0800) prohibit the escalation of an AOO to a more serious incident without other incidents occurring independently. Additional background on the non-escalation criteria is available in Regulatory Information Summary (RIS) 2005-29 "Anticipated Transient that Could Develop into More Serious Events."

The Chemical and Volume Control System (CVCS) malfunction that increases RCS inventory event, analyzed in DCD Section 15.5.2, has the potential to fill the pressurizer causing liquid to pass through the POSRVs, damaging the valves and preventing their closure. DCD Section 15.5.2 does not discuss the potential for pressurizer overfill caused by CVCS malfunction. Additionally, DCD Figures 15.5.2-1 through 15.5.2-12 do not present letdown/charging flows. Based on the relatively stable RCS temperature there is no change in the RCS fluid volume due to thermal expansion/contraction. Therefore, NRC staff expects the pressurizer volume to continue to increase until charging flow is isolated. However, the application lacks sufficient information for NRC staff to determine the behavior of the charging/letdown flow during the CVCS malfunction event. NRC staff, therefore, cannot determine if the analysis presented
in DCD Section 15.5.2 is sufficient to address the non-escalation criteria of the standard review
plan. NRC staff requests that DCD Section 15.5.2 be updated with appropriate language and figures, and Table 15.5.2-1 be updated as appropriate, to address the non-escalation criteria.

## Response

### Pressurizer Solidification

A loss of offsite power is assumed to occur on turbine trip, which in turn, is assumed to occur on the reactor trip. And the charging pump stops on loss of power, therefore, the charging flow will be zero after loss of power. Considering no additional charging flow into the RCS after a loss of AC power, simultaneous opening of POSRVs during the transient, and the total pressurizer volume of 2,429.58 $ft^3$, the pressurizer will not be filled solid with water as a result of the PLCS malfunction transient. But this scenario is selected in terms of the primary system integrity.

If the other scenario is selected in terms of pressurizer solid condition, no LOOP should be assumed after reactor trip to maximize the net increase in the RCS inventory. Even though the pressurizer experiences the solid condition and the water or two phase mixture passes through the POSRVs, there is no safety concern in terms of pressurizer solid condition because of the qualified design of PORSVs against water or two phase mixture passage.

### Behavior of the Charging/Letdown Flow

Section 15.5.2.1 provides the behavior of the charging/letdown flow during the CVCS malfunction event as follows;

> "When in the automatic mode, the pressurizer level control system (PLCS) responds to changes in pressurizer level by changing charging and letdown flows to maintain the programmed level. Normally, one charging pump is running. The other charging pump is key-locked to prevent simultaneous operation of both charging pumps except pump switching operation. If the pressurizer level controller fails low or the level setpoint fails high, a low level signal can be transmitted to the controller. In response, the controller will control the charging flow control valve for the maximum charging and close the letdown orifice isolation valves, CH-110Y and CH-100Z, for the minimum letdown with CH-110X open resulting in the minimum rate of mass discharge of the RCS."

In addition, DCD Section 15.5.2.3.2 provides that the maximum charging flow to the RCS due to one operating pump is 681.37 L/min (180 gpm), and the minimum letdown flow is 151.4 L/min (40 gpm).

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There is no impact on the DCD

**Impact on PRA**

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