REVISED 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.:	**378-8442**
SRP Section:	**06.02.01.01.A – PWR Dry Containments, Including Subatmospheric Containments**
Application Section:	**6.2.1.1 Containment Structure**
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Question No. 06.02.01.01.A-9

Containment Peak Pressure/Temperature Analyses for APR1400

General Design Criteria (GDC) 50, “Containment design basis”, and GDC 16, “Containment design”, of Appendix A to 10 CFR Part 50, “ECCS Evaluation Models” require, in part, that the reactor containment structure and associated heat removal system shall be designed with sufficient margin to accommodate the calculated pressure and temperature conditions resulting from any loss-of-coolant accident (LOCA). GDC 38, “Containment heat removal,” of Appendix A to 10 CFR Part 50 requires, in part, that the containment heat removal system shall rapidly reduce the containment pressure following any LOCA, lessening the challenge to the containment integrity. In this context, the staff seeks the following additional information to gain safety insights into the applicant’s limiting peak pressure/temperature analyses for the containment. The applicant is also requested to update the APR1400 DCD accordingly.

NUREG-0800, SRP Section 6.2.1.1A, “PWR Dry Containments, including Subatmospheric Containments,” Acceptance Criterion No. 1 specifies that the containment design pressure should provide at least a 10% margin above the accepted peak calculated containment pressure following a LOCA, or a steam line or feedwater line break, to satisfy the GDC 16 and 50 requirements for sufficient design margin. The calculations referenced in DCD Tier 2, Section 6.2.1.1 show a greater than 10% margin to the containment design pressure (60 psig) for all LOCA and main steam line break (MSLB) cases analyzed. However, preliminary confirmatory calculations performed by the staff for the limiting double-ended discharge leg slot break (DEDLSB) LOCA case using a multi-node MELCOR model yield a peak pressure higher than the value (51.09 psig) calculated by the applicant’s single-node GOTHIC model for the containment atmosphere region, such that the resulting margin to the design pressure is significantly less than 10%. The staff’s multi-node confirmatory calculations also resulted in a much higher (380.9 °F) peak containment temperature for the limiting MSLB case, as compared to 333.41 °F from the applicant’s single-node model, as documented in DCD Tier 2 Table 6.2.1-2. DCD Tier 2 Section 6.2.1.1.3.3 acknowledges that the MSLB containment temperature exceeds the containment design temperature (290.0 °F) for a period prior to containment spray (CS) actuation. Figures 6.2.1-6 through 6.2.1-15 show that the containment temperature exceeds the containment design temperature for a couple of minutes for all MSLB cases analyzed.

In order for the staff to understand the discrepancies in the calculated pressure and temperature and reconcile the differences between the two models, please provide a full accounting of the input data, sensitivity coefficients (inertial lengths, loss coefficients, etc.), assumptions used to capture the heat transfer correlations used in containment or mass and energy release, in addition to any other assumptions or uncertainties not listed in Section 6.2.1.1 that could adversely impact the design margins in the containment peak pressure or temperature. Also address any potential impact of excessive heating on the containment integrity and equipment qualifications for other safety-related systems.

Response – (Rev. 1)

The technical report (TeR) APR1400-Z-A-NR-14007-P, Rev. 1, “Mass and Energy Release Methodologies for LOCA and MSLB,” provides the descriptions of the GOTHIC containment model used in the Containment P/T analysis.

In this response, primary considerations used in the GOTHIC model are provided for the NRC’s staff to identify the discrepancies between the KHNP’s GOTHIC model and the MELCORE model for the confirmatory analysis. It includes the primary variables and models used in the GOTHIC model that impact on the containment maximum pressure and temperature, such as volume sizes of the containment atmosphere region and IRWST, active and passive heat sinks, initial conditions, and heat transfer models on structures and the pool surface.

The detailed description of the GOTHIC model and the analysis methodology with the associated requirements are provided in the Appendix A and Appendix G of the TeR, respectively.

1. Containment Model

   Containment Volume

   The containment is divided into two regions, the containment atmosphere region and the IRWST region, and the containment atmosphere region is divided again into the containment atmosphere volume and water trap volume. Each of the volumes uses its minimum value within the ranges estimated in consideration of the dimension uncertainty. The size of each volume is summarized below:

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Section A.2.3.1 in the Appendix A of the TeR presents the volume input data for each of the model's control volumes in detail.

Passive Heat Sinks

A total of 18 passive heat structures are modeled in the containment atmosphere volume. Assumptions used in modeling passive heat sink are described in Appendix A Section A.2.3.3 of the TeR. The material type, thickness, surface area, and surface condition of each structure are provided in Table A-3A of the TeR in detail.

Active Heat Sinks

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2. Boundary Conditions

M/E releases

GOTHIC flow boundary conditions are used to model the break flow to the containment. The time history break flow is added to the containment volume as the form of mass flow rate (lb/s) with specific enthalpy (Btu/lb). Table 4-2 and Table 4-8 in the TeR present the M/E releases for the LOCA and MSLB that yield the maximum containment pressure and temperature, respectively.

Containment Structures

The outer surfaces of the containment shell (wall and dome) are modeled as adiabatic to prevent heat release to the outside of the containment building. In addition, the surface of the containment floor such as basemat that may be flooded during an accident is conservatively assumed to be insulated.

CS Heat Exchangers

A containment spray (CS) heat exchanger is modeled using a GOTHIC heat exchanger component with a specified inlet flow (7,200 gpm) and temperature (110 ^{o}F) of the shell (cooling) side. Section A.2.3.4 and Table A-5 of the TeR details the design specification of the CS heat exchanger and the secondary side inlet conditions.

3. Initial Conditions

The upper-bound pressure and temperature and lower-bound relative humidity at a normal operating condition are chosen as the initial conditions to yield highest peak containment pressure and temperature. The initial values are listed in the following table. Appendix C.1 of the TeR provides the bounding analysis to determine the conservative initial conditions.

Parameter	Unit	Initial value
Pressure	psia	16.12
Temperature	°F	120.0
Relative Humidity	%	100.0

4. Key Modeling Characteristics

The principal submodels used in containment P/T analysis include break flow model for M/E release, heat transfer model applied to structure's surface and interphase heat transfer model. Followings are the key modeling characteristics of these models.

Break flow model

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Wall heat transfer model

The wall heat transfer model with the GOTHIC Tagami/Uchida option is used to calculate condensing heat transfer rate on the structure' surface. Natural convection is chosen as the heat transfer correlation for sensible heat transfer on structure surfaces. Forced convection is not allowed and the radiation heat transfer to the containment structures from the atmosphere is conservatively neglected.

Interphase Heat transfer Model (Liquid / Vapor / Droplet)

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In addition, KHNP performed various sensitivity studies designed to define the postulated limiting breaks and, subsequently, the bases for the assumptions, initial conditions and modeling characteristics in view of containment peak pressure and temperature. It includes bounding analyses to determine conservative initial conditions, containment noding sensitivity, break flow's droplet discharge duration, time step sensitivity, and containment spray effectiveness. The results of the sensitivity studies are provided in the Appendix C of the TeR.

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 Report

There is no impact on any Technical, Topical and Environmental Report.