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.:	**200-8225**
SRP Section:	**03.08.02 - Steel Containment**
Application Section:	**03.08.02**
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Question No. 03.08.02-2

Appendix A to 10 CFR Part 50, General Design Criteria (GDC) 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment penetrations. Standard Review Plan (SRP) 3.8.2, Section II specifies the procedures used for the analysis and design of the containment penetrations with emphasis on the extent of compliance with Article CC-3300 of Section III, Division 1, of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, with additional guidance provided in Regulatory Guide 1.57, “Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components.”

DCD Tier 2, Section 3.8.2.4, “Design and Analysis Procedures,” describes the design and analysis procedures for the equipment hatch, personnel airlocks, electrical penetrations, and process piping penetrations. The staff noted that Section 3.8.2.4 did not adequately describe the design and analysis approach for the various penetrations. Per Appendix A to 10 CFR Part 50, GDC 1, 2, 4, 16 and 50; and SRP 3.8.2, the applicant is requested to describe to the extent possible, the design methodology for these penetrations in the application, including the models, boundary conditions, how loadings are applied, the analysis approach for the various loadings, and how stresses are determined including the approach to check for buckling. The description for the analysis of the various loads should include loads from internal and external pressures; applied end loads from attached process piping or attachment to adjacent structures for the fuel transfer tube; and containment interface displacements and seismic inertial loadings at the attachment points to the containment.

For penetrations that are considered to be a vendor designed component, a description should still be provided of the criteria to be used for the analysis and design of the penetrations. This description should summarize, to the extent possible, the key analysis and design aspects discussed above, consistent with ASME Code Section III, Division 1, Subsection NE, provisions applicable to containment penetrations and the existing criteria in the DCD. It should be noted that even if the design of the containment penetrations are not completed or finalized at this time, SRP 3.8.1 and 3.8.2 indicates that the ultimate pressure capacity of the containment,

including its penetrations, need to be determined. Therefore, some analysis of the critical containment penetrations (e.g., equipment hatch and/or personnel airlocks) would be needed to address the ultimate pressure capacity evaluation of the containment and Section 19 PRA/accident evaluations.

Response

DCD Tier 2, Section 3.8.2.4.2 will be revised to describe the design methodology, including the models, boundary conditions, how loadings are applied, the analysis approach for the various loadings, and how stresses are determined, for process piping penetrations, as indicated in the attachment associated with this response.

The equipment hatch, personnel airlocks, and electrical penetrations mentioned in DCD Tier 2, Subsection 3.8.2.4.1 are vendor designed components. The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations. The key design aspects and criteria for the equipment hatch and personnel airlocks will be described in DCD Tier 2 Subsection 3.8.2.4.1.

Impact on DCD

DCD Tier 2, Subsection 3.8.2.4.1 and 3.8.2.4.2 will be revised as indicated in the attachment associated with this response.

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.

c. Severe accident load due to (as applicable):

1) Pressure load generated from 100 percent fuel clad metal-water reaction

2) Pressure loads generated by hydrogen burning

3.8.2.3.2 Load Combinations for Instrument and Process Piping Penetrations

The load combinations for instrument and process piping penetrations are given in Table 3.8-4.

3.8.2.4 Design and Analysis Procedures

3.8.2.4.1 Equipment Hatch, Personnel Airlocks, and Electrical Penetrations

The equipment hatch, personnel airlocks, and electrical penetrations are designed as pressure-retaining components. The portions of the sleeves not backed by concrete are analyzed and designed according to the provisions of ASME Section III, Division 1, Subsection NE 3000.

Insert A

3.8.2.4.2 Process Piping Penetrations

The entire penetration assembly including the sleeve, head fitting, and attached portion of pipe is designed for the loads described in Subsections 3.8.2.3.1 and 3.8.2.3.2 by the finite element computer program ANSYS. ~~The boundary conditions for the model are considered fixed against all degrees of freedom at the containment building wall. The computer program is also used to evaluate thermal gradient. The final stress analysis of the piping penetration assemblies including metal fatigue evaluation is performed by this computer program~~.

Insert B

Insert A

The equipment hatch, personnel airlocks, and electrical penetrations are vendor designed components. The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations (COL 3.8(11)). The major design aspects and criteria for the equipment hatch and personnel airlocks are as follows.

The equipment hatch design consists of a flanged cover bolted to a matching flanged cylindrical sleeve embedded into the reactor containment building. The equipment hatch closure head and sleeve shall be evaluated for design and service conditions in accordance with the requirements of NE 3000. The closure head spherical shell thickness shall be adequate for the design pressure in accordance with the rules of NE 3133.4. The head flange and sleeve flange shall meet the rules of NE 3326.2 and Appendix XI 3260. The swing bolts shall provide adequate bolt area for all preload, design and service conditions.

The personnel airlock design consists of a cylindrical shell having a bulkhead and pressure retaining door at each end. The personnel airlock pressure retaining components shall be evaluated for design and service conditions in accordance with the requirements of NE 3000. The airlock door plate thickness and stiffeners, and the bulkhead plate and stiffeners shall be adequate for the design condition in accordance with the stress limits of NE 3221. The airlock shell thickness shall meet the requirements of NE 3133 and NE 3324 for the external and internal pressure conditions.

Insert B (1/3)

The penetration assemblies allow process piping to pass through the containment structure or other building walls or floors.

Each penetration assembly may consist of the following components:

a) Portion of the process or instrument piping
b) The penetration sleeve, which encloses the process piping and which is embedded and anchored in the wall or floor.
c) The head fitting (forged flued head or flat plate ring), which is welded to both the process pipe and the penetration sleeve. A typical piping penetration assembly configuration is shown in Figure 3.8-8.

A finite element analysis program is used for the axisymmetric structural analysis of the piping penetration assemblies. The model will generate automatic mesh, and imposed loads and thermal conditions are input to the model to perform FEM structural analysis. The pipe outside diameter, pipe wall thickness, sleeve outer diameter, sleeve wall thickness, head fitting thickness, and insulation thickness are considered in the analysis model.

Boundary conditions can be classified into 3 categories for performance of the stress analysis of the piping penetration assembly; 1) stress boundary at the penetration assembly section connected to piping where the stress distribution is applied corresponding to its location against the imposed force, 2) inner surface of the pipe and sleeve where pressure is acting normal to the surface, and therefore stresses normal to the surfaces are applied as pressure for the boundary condition, and 3)a fixed point at the concrete wall.

The forces and moments imposed at the penetration assembly boundaries are due to the following:

a) Internal and external operating and design pressures and temperature;
b) Process piping reactions due to (as applicable):
   1. Weight
   2. Safe shutdown earthquake (SSE)
   3. Thermal expansion and relative dynamic displacements
   4. Hydraulic transients and other non-seismic dynamic loads
   5. Pipe rupture and jet impingement
c) Maximum reactor containment building pressure during severe accidents.

The penetration assemblies are required to meet the stress limits under the worst loading combinations for design, normal and upset, emergency, faulted, and testing component conditions, in accordance with the requirements and provisions of ASME Code Section III.

Insert B -Continued (2/3)

Loading combinations must be formed in a way that will assure the highest resultant stress. For the sleeve anchors, the types of loads applicable for each condition will be as stated in Table CC-3230-1 of Section III, Division 2 (Table SNB 3230-1 of KEPIC SNB). For the ASME Class MC Components, the applicable loads for each condition and load combination are as listed below and those presented in Table 3.8-3.

a) Design Conditions: Design pressures and temperatures, plus loads due to weight

b) Normal & Upset Conditions;

1. Expansion Stress Evaluation: Loads due to operating temperature, thermal expansion and relative dynamic displacements

2. Primary-plus-Secondary Stress Evaluation: Operating pressures and temperatures, plus loads due to: weight, thermal expansion and relative dynamic displacements, and hydraulic transients, as applicable

c) Emergency Conditions: Operating pressures and temperatures, plus loads due to weight and hydraulic transients, as applicable

d) Faulted Conditions;

1. Operating pressures and temperatures, plus loads due to pipe rupture and jet impingement
2. Process piping maximum operating pressure applied in the annulus between the process piping and the penetration sleeve
3. Weight, thermal expansion, SSE and hydraulic transients

e) Test Conditions: In accordance with the applicable requirements of the ASME Code, Section III.

f) Fatigue Conditions: For the metal fatigue evaluation, pressure-range and load-range combinations must be formed in a way that will assure cyclic stress optimization. For the formation of these load-range combinations the loads listed in the subsection above b) 2 will be used. Contribution from thermal transients will also be considered. With the exception of the pressure and temperature values, the numerical values of the load components for each penetration assembly are obtained from appropriate stress analysis reports for the corresponding piping systems.

g) Severe Accident Conditions for MC Component: Maximum reactor containment building pressure plus loads due to weight

Insert B -Continued (3/3)

The mechanical forces and moments are applied to the penetration assembly at each boundary. In addition to the mechanical loads, loads due to the design and operating pressure within the piping penetration annulus are applied. The loads and their combination methods are specified in the project unique penetration specification. These loads consist of the design and operating pressure, weight, earthquake, hydraulic transients, SRV, condensation oscillation, chugging, thermal expansion, and relative seismic displacements. Stress optimization is achieved by analyzing the penetration for the worst load combination for each loading condition (i.e., design, normal and upset, emergency and faulted).

The penetration assemblies are to be analyzed for the various design and operating component conditions, and the resulting stresses are to be within the specified allowable limits. The allowable stress limits associated with each service load category are as stated below and as presented in Table 3.8-3.

a) Stress Limits for Process Piping: In accordance with the Piping System Design Specification
b) Stress Limits for Penetration Sleeve Anchors: In accordance with Division 2 of the ASME Code, Section III.
c) Stress Limits for Penetration Sleeves and Head Fittings: For MC penetration sleeves and head fittings, the allowable stress limits shall be as specified in Subarticle NE-3200 of the ASME Code, Section III, for Class MC components.

COL 3.8(7) The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.

COL 3.8(8) The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.

COL 3.8(9) The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.

COL 3.8.(10) The COL applicant is to provide the following soil information for the APR1400 site: 1) elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) moisture content, Atterberg limits, grain size analyses, and soil classification, 4) construction sequence and loading history, and 5) excavation and dewatering programs.

COL 3.8(11) The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations.

3.8.7 References

1. 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission.

2. ASME Section III, Subsection NE, “Class MC Components,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

3. ASME Section III, Division 2, “Code for Concrete Containments,” Subsection CC, American Society of Mechanical Engineers, 2001 Edition with 2003 Addenda.

4. Regulatory Guide 1.35, “Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment,” Rev. 3, U.S. Nuclear Regulatory Commission, July 1990.

5. Regulatory Guide 1.35.1, “Determining Prestressing Forces for Inspection of Prestressed Concrete Containments,” U.S. Nuclear Regulatory Commission, July 1990.