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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-10

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for dynamic loads. DCD Tier 2, Section 3.12.3.4, "Time-History Method," states that for the dynamic response of piping systems, the time-history analysis may be performed using the modal superposition method.

1. The applicant is requested to identify which piping systems are evaluated using time history analysis. In addition, the applicant is requested to indicate whether the analyses are linear or non-linear and specify the time-history analysis technique used (modal superposition method, direct integration method in the time domain, or the complex frequency response method in the frequency domain).

2. CD Tier 2, Section 3.7.2.1.2, “Time-History Methods,” for the modal superposition method refers to ASCE Standard 4-98. ASCE 4-98 discusses an alternate method for considering the number of modes in a modal superposition analysis and states that the number of modes included should be sufficient to ensure that inclusion of all remaining modes does not result in more than a 10 percent increase in the total response of interest. The current NRC technical position, as described in RG 1.92, Revision 2 and Revision 3, is that this approach is “non-conservative and should not be used.” The applicant is requested to verify that when modal superposition time history analysis is used, its use conforms to the guidance described in RG 1.92, Revision 2 or 3, or justify an alternative approach.

Response

1. The specific time history analysis technique for the piping systems is the linear modal superposition method. For each piping system, dynamic loads, except seismic and IRWST hydrodynamic loads, are evaluated using time history analysis. The graded approach for piping systems that are evaluated using time history analysis are as follows:

Piping System	Dynamic load evaluated using time history analysis
Main Steam	Operation of the main steam atmospheric dump valve due to upset condition from 100% load
	Sudden closure of the turbine stop valve due to upset condition from 100% load
	Operation of the main steam safety valves due to upset condition from 100% load
	Pipe break transient due to postulated pipe break in the MS system inside and outside reactor containment
	RCS branch line break load
Feedwater	Transient due to trip of three (3) main feedwater pumps on a Valves Wide Open (VWO) condition
	Transient due to postulated line break in the FW System on a Valves Wide Open (VWO) condition (outside reactor containment)
	Transient due to trip of a startup feedwater pump
	RCS branch line break load
Safety Injection/Shutdown Cooling	Branch line pipe break loads
	Relief valve discharge loads
Reactor Coolant Loop including Surge line	Branch line pipe break loads

2. PIPESTRESS and ADLPIPE are the analysis programs used for piping systems in the APR1400. These programs use the left-out-force (LOF) method and missing mass correction (MMC) method to calculate the effects of the high frequency rigid modes. The modal superposition method to evaluate the piping systems is used in accordance with RG 1.92, Rev. 3 and are sufficient to ensure that inclusion of all remaining modes do not result in more than a 10 percent increase in the total response of interest.

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.

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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-11

According to SRP Section 3.9.2.II.2.A(ii), an equivalent static load method is acceptable if certain criteria are met. DCD Tier 2, Section 3.12.3.6, "Small-Bore Piping Method," states that for small-bore piping, either the equivalent static load method or the modal response spectrum method is used.

1. he applicant is requested to justify that, when the equivalent static load method is used, the use of a simplified model is realistic and the results are conservative as described in SRP Section 3.9.2.II.2.A(ii)(1).
2. he applicant is also requested to clarify in the DCD that, when the equivalent static load method is used, the design and simplified analysis accounts for the relative motion between all points of support, as described in SRP Section 3.9.2.II.2.A(ii)(2).
3. The applicant is requested that DCD Tier 2, Section 3.12.3.6, "Small-Bore Piping Method" be revised to describe how the provisions of SRP Section 3.9.2.II.2.A(ii) are addressed or to justify an alternative approach.

Response

In order to use the equivalent static load method, SRP Section 3.9.2.II.2.A(ii) must be satisfied, which includes subsection 3.9.2.II.2.A(ii)(1) and (2). If the equivalent static load method is not applied, then the modal response spectrum is used as described in DCD Subsection 3.12.3.6. KHNP will revise the current wording of Section 3.12.3.6 to delete reference to producing conservative results for the equivalent static load method since it is only part of the necessary criteria and replace it by referencing the entire SRP Section 3.9.2.II.2.A(ii) for applying the equivalent static load method.

Impact on DCD

DCD Tier 2, Subsection 3.12.3.6 will be revised as shown in the Attachment.

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.

3.12.3.6 Small-Bore Piping System Method

A small-bore piping system is defined as ASME Class 1 piping less than or equal to nominal diameter (DN) 25 (nominal pipe size [NPS] 1) and smaller, and the other classes of piping with nominal diameter DN 50 (NPS 2) and smaller. These small-bore piping systems are analyzed using the response spectrum method or the equivalent static load method.

The modal response spectrum method is described in Subsections 3.12.3.2 and 3.12.3.3, and used when the equivalent static method cannot be justified.

is applied based on SRP 3.9.2.II.2.A(ii) (Reference 32).

The equivalent static load method ~~produces conservative results in responses.~~ The masses of piping, its contents, and any in-line component are considered as lumped masses at their center of gravity locations. The static forces for the equivalent static load method are determined by multiplying the contributing mass by a seismic acceleration (g factor) at each location. To obtain an equivalent static load of a small-bore piping system, which is represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. This static force analysis is performed for all three spatial components of seismic excitation, and the results of these static analyses are combined by the SRSS method.

3.12.3.7 Non-Seismic/Seismic Interaction (II/I)

The APR1400 is designed to minimize the interactions of seismic Category I piping systems with non-seismic Category I piping system and to protect seismic Category I piping systems from adverse interactions with a non-seismic Category I piping system. A non-seismic Category I piping system whose continuous function is not required but whose failure could adversely affect the safety function of structures, systems, and components (SSCs) is seismically designed. The primary method of protecting a seismic Category I piping system is its isolation from a non-seismic Category I piping system. If isolation of the seismic Category I piping system is not feasible or practical, adjacent non-seismic Category I piping is classified as seismic Category II and analyzed in accordance with the same seismic design criteria applicable to the seismic Category I piping and pipe supports.

Similarly, for non-seismic piping attached to seismic piping, the dynamic effects of the non-seismic piping account for the modeling of the seismic piping. The attached non-seismic

28. IEEE Std. 344-2004 (R2009), “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations,” Institute of Electrical and Electronics Engineers, 2005.

29. Welding Research Council Bulletins 353, “Position Paper on Nuclear Plant Pipe Support,” May 1990.

30. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water (ALWR) Designs,” U.S. Nuclear Regulatory Commission, 1993.

32. NUREG-0800, Standard Review Plan, Section 3.9.2, "Dynamic Testing and Analysis of Systems, Structures, and Components," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007

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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-12

According to SRP Section 3.12, Subsection II.B.iii, computer programs used in the piping analysis and pipe support design are to be benchmarked with the appropriate NRC benchmarks. DCD Tier 2, Section 3.12.4.3, "Piping Benchmark Program," states that piping benchmark problems in NUREG/CR-1677, Volume 1 and 2, issued August 1980, are used to validate the PIPESTRESS and ADLPIPE computer programs used in piping system analysis. PIPESTRESS and ADLPIPE, however, are only two of the programs listed in DCD Tier 2, Section 3.12.4.1, for piping analysis and pipe support design. The applicant is requested to discuss benchmark programs for the remainder of computer programs listed in DCD Tier 2, Section 3.12.4.1.

Response

Bench mark problems of NUREG/CR-1677 are developed for verifying the adequacy of computer programs used for the dynamic analysis and design piping systems. PIPESTRESS and ADLPIPE are computer programs used for the analysis of piping systems. The usage of the remainder of the computer programs in Section 3.12.4.1 is as follows:

- ANSYS is used in the application for Class 1 piping in the area of fatigue: steady-state and transient heat transfer and fluid flow.
- RELAP5/MOD 3.3 and RELAP5/MOD 3.1 are used to generate input data for piping analysis.
  - RELAP5/MOD 3.3 is used for the analysis of dynamic behavior, such as water hammer and safety/relief valve discharge, by modeling the fluid flow.
  - RELAP5/MOD 3.1 is used to analyze rapid transients, such as pipe break and valve quick opening, by modeling the fluid flow.

- GTSTRUDL is used for structural analysis of piping supports, including base plate flexibility, anchor bolt checks, and the calculation of weld leg sizes.

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.

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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-13

ASME Boiler and Pressure Vessel Code (BPV Code) Section III, as mandated by 10 CFR 50.55a, requires that the effects of seismic and thermal movements of pipe restraints such as equipment nozzles, pipe supports, pipe anchors, and pipe headers (in the case of decoupled pipe branches) are considered in the piping analysis. According to DCD Tier 2, Section 3.12.5.3.3, “Thermal Expansion,” and Section 3.12.5.3.4, “Seismic,” thermal anchor movements (TAMs) and seismic anchor movements (SAMs) less than 1.6 mm (1/16 inch) may be excluded from the piping analysis. The applicant is requested to provide additional information on its approach to demonstrate that when the piping analysis has excluded thermal or seismic pipe restraint movement(s), adequate gap(s) exist in the as-built pipe supports to accommodate the excluded movement(s), including addressing applicable additive loads. It is also suggested that the applicant combine its response with staff RAI xx-8278, Question 28123, which requested similar information specific just to TAMs.

Response

The procedure to identify adequate gaps in the as-built pipe supports is described in the response to RAI 311-8278, Question 03.12-4. According to DCD Tier 2, Section 3.12.5.3.3, “Thermal Expansion,” and Section 3.12.5.3.4, “Seismic,” thermal anchor movements (TAMs) and seismic anchor movements (SAMs) less than 1.6 mm (1/16 inch) may be excluded from the piping analysis when acceptable gaps in the pipe supports allow. In other words, TAMs and SAMs are not excluded from the piping analysis when acceptable gaps in the pipe supports do not allow. For example, a piping system using clamp-type supports cannot exclude TAMs and SAMs less than 1.6 mm (1/16 inch) from the piping analysis since clamp-type supports have no gaps. Because excluding TAMs and SAMs less than 1.6 mm (1/16 inch) from the piping analysis is determined by the support type and the existence of adequate gaps, (and as-built gaps are not determined at the design stage), the related sentences stated in DCD Tier 2, Section 3.12.5.3.3 and Section 3.12.5.3.4 will be deleted.

Impact on DCD

DCD Tier 2, Subsections 3.12.5.3.3 and 3.12.5.3.4 will be revised as shown in the Attachment.

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.

3.12.5.3 Loadings and Load Combination

3.12.5.3.1 Pressure

Internal design pressure, P, is used in the design and analysis of ASME Class 1, 2, and 3 piping (Reference 1). Minimum pipe wall thicknesses are determined using the formulations of NB/NC/ND-3640 and the design pressure. The applicable design and maximum service level pressures are used in load combinations as identified in Tables 3.12-1 and 3.12-2.

3.12.5.3.2 Mechanical Loads

The weight of the piping system, its contents, any insulation and in-line equipment, and any other mechanical loads identified in the design specification are considered in the piping analysis. The weight of water during hydrostatic testing is considered for steam or air-filled piping systems.

3.12.5.3.3 Thermal Expansion

The effect of linear thermal expansion range during various operating modes is considered along with thermal movements of terminal equipment nozzles, anchors, or restraints (thermal anchor movements) corresponding to the operating modes. The stress-free temperature is taken as 21 °C (70 °F). The piping systems operating at a temperature of 65 °C (150 °F) (Reference 1) and below are not analyzed for the effects of linear thermal expansion.

~~Thermal anchor movements less than or equal to 1.6 mm (1/16 in) may be excluded from analysis since this represents the industry practice when acceptable gaps in pipe supports allow (Reference 29).~~

3.12.5.3.4 Seismic

The effects of seismic inertial loads and anchor movements are included in the design analysis. The ground motion of the operating basis earthquake (OBE) for the APR1400 is equal to one-third of the ground motion of the SSE. Per Appendix S to 10 CFR Part 50, the OBE load case does not require explicit design analysis. In the event of an earthquake that meets or exceeds the OBE ground motion, plant shutdown is required and seismic Category I piping and supports are inspected to provide reasonable assurance that no functional damage has occurred. The design of the APR1400 seismic Category I piping and supports includes analysis of the inertial and anchor movement ~~(greater than 1.59 mm (1/16 inch))~~ effects of the SSE event. These loads are Service Level D loads.

Fatigue effects due to earthquake loads are addressed in Table 3.12-1. Tables 3.12-1 and 3.12-2 identify SSE inertial and displacement loads in various load combinations for ASME Class 1, 2, and 3 piping and piping supports.

3.12.5.3.5 Fluid Transient Loads

The relief/safety valve thrust loads for open or closed systems are functions of valve opening, flow rate, flow area, and fluid properties. The analysis of these loads is usually accomplished using static loads as input to the piping analysis with appropriate dynamic load factors. Dynamic analysis of relief valve thrusts is used when static analysis produces undesirably conservative results. These loads are considered in Service Level B or D load combinations.

The water hammer phenomenon involves the rapid change in fluid flow creating a "shock wave" effect in the piping system. They are usually set in motion by rapid actuation of control valves, relief valves, and check valves. Rapid start or trip of a pump or turbine can also initiate such a phenomenon. The water hammer phenomenon is analyzed using dynamic analysis methods. The water hammer loads are considered in Level B, or D service load combinations.

The fluid transient loads are identified as dynamic fluid loads in Tables 3.12-1 and 3.12-2.

3.12.5.3.6 Wind/Tornado Loads

ASME Class 1, 2, and 3 piping for the APR1400 within the DC scope is not exposed to wind or tornado loads. The COL applicant is to design those piping exposed to wind and/or tornado, if any, to the plant design basis loads (COL 3.12(2)).

28. IEEE Std. 344-2004 (R2009), “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations,” Institute of Electrical and Electronics Engineers, 2005.

29. ~~Welding Research Council Bulletins 353, “Position Paper on Nuclear Plant Pipe Support,” May 1990.~~

30. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water (ALWR) Designs,” U.S. Nuclear Regulatory Commission, 1993.

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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-14

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for seismic loads.

DCD Tier 2, Subsection 3.12.3.2.4, “Modal Combination,” shows that closely spaced modes are combined with the grouping method of Regulatory Guide (RG) 1.92, Revision 1. The grouping method is described in Subsection C.1.2.1 of RG 1.92, Revision 1. The same statement is made in DCD Tier 2, Section 3.9.2.2.6, “Combination of Modal Responses.” In contrast, DCD Tier 2, Section 3.12.5.5, "Combination of Modal Responses," shows that closely spaced modes are combined with the 10-percent method of RG 1.92, Revision 1. The 10-percent method is described in Subsection C.1.2.2 of RG 1.92, Revision 1. The applicant is requested to explain this difference and revise the DCD as appropriate.

Response

DCD Tier 2, Subsection 3.12.5.5 will be revised to delete reference to using the 10-percent method since the grouping method is used for combining closely spaced modes in the APR1400 piping analyses, as stated in Subsections 3.12.3.2.4 and 3.9.2.2.6.

Impact on DCD

DCD Tier 2, Subsection 3.12.5.5 will be revised as shown in the Attachment.

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.

3.12.5.4 Damping Values

Damping values in Table 3 of NRC RG 1.61 (Reference 7) are used for dynamic response spectra and time-history analyses.

Frequency-dependent damping values identified in Figure 1 of NRC RG 1.61 may also be used for USM response spectra analysis provided the five restrictions identified in C.2 of NRC RG 1.61 (Reference 7) are maintained.

3.12.5.5 Combination of Modal Responses

Seismic responses to each mode are calculated in accordance with the method described in NRC RG 1.92 (Reference 9) and combined with other responses. Seismic responses to periodic modal response with sufficiently separated frequencies are combined by SRSS. Closely spaced frequencies are combined by the ~~10 percent~~ grouping method.

3.12.5.6 High-Frequency Modes

PIPESTRESS and ADLPIPE computer programs use left-out-force (LOF) and missing mass correction (MMC) methods to calculate the effect of high-frequency rigid modes (References 11 and 18). The result obtained from this method is multiplied by scalar amplitude that is equivalent to the highest spectral acceleration for frequencies, which is greater than the last natural frequency being calculated by LOF and MMC methods regarding the corresponding directional spectrum.

3.12.5.7 Fatigue Evaluation of ASME Code Class 1 Piping

Fatigue evaluation of ASME Class 1 piping systems is performed for loadings caused by thermal and pressure transients, thermal stratification, and other cyclic events including earthquakes. Fatigue evaluation of ASME Class 1 piping greater than DN 25 (NPS 1) is performed per ASME Section III, Subsection NB-3653. The COL applicant is to perform fatigue evaluation of ASME Class 1 piping (COL 3.12(3)).

The fatigue evaluation considering the effects of the reactor coolant environment in ASME Class 1 piping follows the guidance in NRC RG 1.207 (Reference 19).

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.:	**334-8373**
SRP Section:	**03.12 – ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**3.12.5.9**
Date of RAI Issue:	**12/14/2015**

Question No. 03.12-15

NRC Bulletin (BL) 88-08, “Thermal Stresses in Piping Connected to Reactor Cooling Systems,” issued June 22, 1988, requests licensees to identify and evaluate the piping system connected to the RCS susceptible to thermal stratification, cycling, and striping (TASCS) to ensure that the piping will not be subjected to unacceptable thermal stresses. The bulletin recommended nondestructive examinations of potentially affected pipes to assure that no flaws exist, as well as the development and implementation of a program to provide continuing assurance of piping integrity. Ways to provide this assurance include designing the system to withstand the cycles and stresses from valve leakage, instrumenting the piping to detect adverse temperature distributions and establishing appropriate limits, and providing a means to monitor pressure differentials that may lead to valve leakage.

While the applicant was not an addressee of this bulletin, the operating experience described in the bulletin should be incorporated in the design in accordance with 10 CFR 52.47(a)(22). As such, SRP Section 3.12 includes criteria related to this bulletin, to the extent that the issue applies to a given design.

In DCD Tier 2, Section 3.12.5.9, the applicant indicated that APR1400 conforms with the requirements in BL 88-08 for all piping connected to the RCS and that data available from the reference plant have been evaluated and incorporated into the design of the APR1400.

The applicant is requested to provide the following additional information to support the staff's finding related to this provision in SRP Section 3.12 and the requirement in 10 CFR 52.47(a)(22). To the extent that the response addresses programmatic or operational activities that are outside the scope of design certification, the applicant should describe these and include in the DCD a provision for COL applicants to describe these activities.

1. Identify all piping connected to the RCS susceptible to TASCS and discuss the methodology followed for evaluating the effects of TASCS.

2. Discuss features in the design that provide assurance against thermal stratification and thermal oscillation.
3. Discuss whether a program has been established to monitor temperature distributions in affected piping and establish appropriate temperature limits.
4. Discuss means to monitor pressure differentials that may lead to valve leakage.
5. Identify the “reference plant” mentioned in DCD Tier 2, Section 3.12.5.9 and discuss its similarities to the APR1400.
6. Discuss the data collected from the reference plant and the methodology followed in using these data for the evaluation of TASCS in the APR1400 design.

Response

In 1987 and 1988, thermal fatigue cracking and leakage in several PWR plants resulted in the issuance of NRC Bulletin 88-08. In each of these events, the cracking was attributed to thermal cycling mechanisms not considered in initial plant design. The cracking was found in normally stagnant non-isolable lines attached to RCS piping.

1. According to EPRI’s Report ‘Materials Reliability Program: Management of Thermal Fatigue in Normally Stagnant Non-isolable Reactor Coolant System Branch Lines (MRP-146)’, the following lines, at a minimum, should be considered for PWR plants. An assessment should include all normally stagnant lines attached to the reactor coolant piping that are greater than one-inch nominal diameter to determine if actions are required to prevent thermal fatigue cracking:

   - Safety injection lines
   - Charging lines that are not in service (either permanently or on a cycle-by-cycle basis) - generally pertains to Westinghouse plants
   - Drain lines
   - Excess letdown lines (if this line exists in a specific plant configuration)
   - Residual heat removal (RHR) suction lines, (also called decay heat removal (DHR) lines for B&W plants and shutdown cooling suction lines for CE plants)
   - Any other normally stagnant lines with nominal diameter greater than one inch.

   APR1400 has the following design features:

   - Safety injection lines through the direct vessel injection (DVI) nozzle intersect at a side orientation
   - No charging lines that are not in service
   - RCS drain lines are 2 inches and are not susceptible to TASCS because of the long length of vertical line.
   - No excess letdown lines
   - Common lines for shutdown cooling (SDC) suction lines and safety injection lines to hot leg injection intersect at the bottom orientation

   As a result, the following lines connected to the RCS are considered to be still susceptible to TASCS:

   - Safety injection (SI) lines through the DVI nozzle
   - Shutdown cooling suction (SCS) lines

KHNP has evaluated the TASCS of the SI lines and SCS lines caused by the turbulence at the piping penetrations. For conservatism, a small amount of in-leakage to the RCS from the SI lines is assumed, though no actual in-leakage to the RCS is expected. This assumption provides conservative results for the SI lines. The pressure in the SI system is always lower than the normal RCS operating pressure because the SI system has a dedicated safety injection pump (there are no connection lines from the charging pump) in the APR1400. Therefore, there is actually no in-leakage to the RCS from the safety injection lines in the APR1400.

For the analysis of the turbulence/swirl penetration effects, the following approach is applied to the APR1400 instead of the approaches described in MRP-146. First, a thermal hydraulic analysis was performed using the commercial three-dimensional CFD Code (FLUENT) to find the temperature distribution inside the piping for the SI lines and SCS lines. Then, the effects of thermal stratification on the piping were evaluated.

2. As mentioned above, an analysis was performed to confirm that there are no adverse impacts on both of the applicable lines of the APR1400 due to the thermal stratification and thermal oscillation. The detailed analysis results are documented in the proprietary report 1-310-P460-001, Rev. 0 which was provided for review as part of the recent piping design audit.

3. Since there is no possibility of in-leakage to the RCS from the SI lines and SCS lines in the APR1400 due to the pressure differences, temperature monitoring is not necessary.

4. Since the APR1400 design precludes in-leakage to the RCS, monitoring the pressure differentials that may lead to valve leakage is also not necessary.

5. The “reference plant” mentioned in DCD Tier 2, Section 3.12.5.9 is Shin-Kori Units 3 & 4 (SKN 3&4) in Korea. The primary system operating parameters of the APR1400 are identical to those of SKN 3&4. The piping layout of the APR1400 is also the same as SKN 3&4.

6. Temperature and pressure data were not collected from the reference plant. The analyzed temperature distributions inside the relevant piping of the APR1400 would be the same as the reference plant (SKN 3&4) because the operating conditions and the piping layout are the same. Using the reference plant’s temperature distribution, the piping analysis of thermal stratification for the SIS and SCS were evaluated for the APR1400.

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 any Technical Specifications.

Impact on Technical/Topical/Environmental Reports

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