DCD Section 3.6.2 Issues

KEPCO/KHNP

June 30, 2015

MEB Issue List for APR1400 DCD Section 3.6.2

Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

- Background
- Resolution Summary
  - 3.6.2.1.4.3.1 (2)
  - 3.6.2.1.4.1.1 (5)
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- Status of Jet Impingement Analysis

Background

- DCD Section 3.6.2
  - Background
    - Title 10 of Code of Federal Regulations (10 CFR) Part 50 Appendix A, General Design Criterion 4 requires that “structures, systems, and components shall be appropriately protected against dynamic effects including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #1

  - DCD Tier 2, Subsection 3.6.2.1.4.3.1, Items (a) through (f) describe the design requirements for the high-energy piping in the break exclusion area. However, this section does not address whether the design also meets the requirements of the ASME Section III, NE-1120. The applicant is to clarify whether the design of the high-energy piping in the break exclusion areas meets the requirements of the ASME Section III, NE-1120.

– Resolution

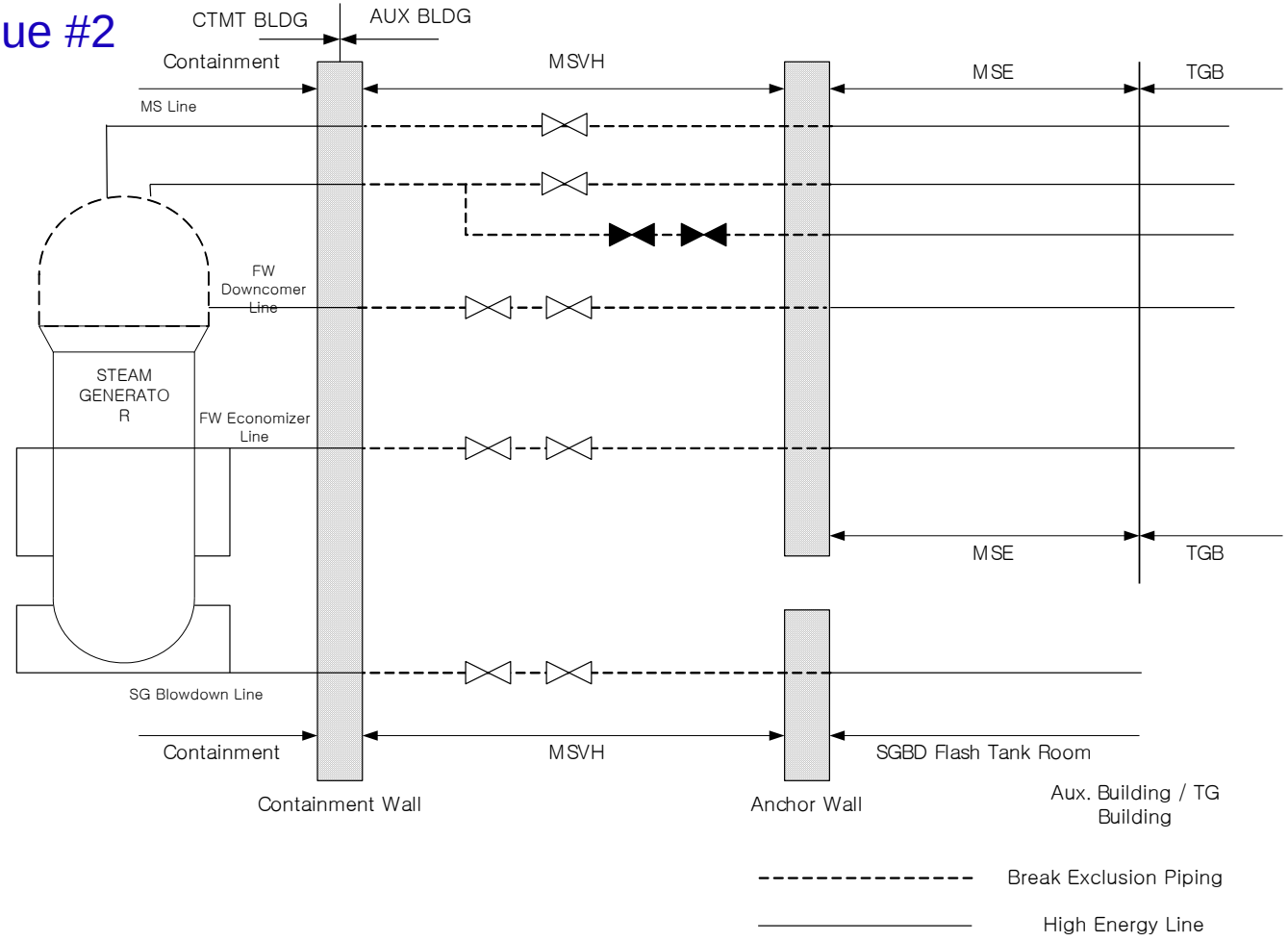
  - The high-energy piping in break exclusion area is designed according to ASME Section III, NE-1120. DCD section 3.6.2.1.4.3.1 will be revised to specify compliance to that BTP 3-4 requirement.

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #2
    - DCD Tier 2, Subsection 3.6.2.1.4.3.2 states that cracks are not postulated in moderate-energy ASME Section Class 2 piping from the containment wall to and including the inboard or outboard isolation valves. This statement is consistent with the staff's guideline as described in BTP 3-4 Part B, Subsection A(ii). However, the break exclusion area for high-energy ASME Section Class 2 piping described in DCD Tier 2, Subsection 3.6.2.1.4.3.1 is between the containment penetration wall and auxiliary building anchor wall beyond isolation valves.
  - Resolution
    - For high-energy ASME Section Class 2 piping from the containment wall up to and including the inboard or outboard isolation valves, both pipe break and pipe cracks do not need to be postulated by meeting the ASME Section III, NE-1120. Pipe break exclusion expands to the auxiliary building anchor wall beyond the isolation valve by meeting additional requirements specified. DCD Section 3.6.2.1.4.3.1 will be revised for consistency with 3.6.2.1.4.3.2.

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #2



Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #3

  - DCD Tier 2, Subsection 3.6.2.1.4.1.1 states that a terminal end is defined as an extremity of a piping run that connects to structures, components, or pipe anchor that acts as a rigid constraint to piping motion and thermal expansion for Class 1 piping. However, it is not clear whether other piping geometric configurations (e.g., a branch connection to a main piping run) as identified in Footnote 3 of BTP 3-4 are also applicable to APR1400 design and therefore, should be considered as terminal ends for postulating pipe ruptures. In addition, the applicant is to address whether the same terminal end definition is also applicable to the piping systems (e.g., Class 2 piping) identified in other subsections throughout DCD Tier 2, Section 3.6.2.

– Resolution

  - Branch lines connected to main piping line are also considered as a terminal end according to Footnote 3 of BTP 3-4. The definition of terminal end is applicable to all Class 1, 2, and 3 APR1400 piping systems. Additional clarity on terminal ends will be added to DCD Subsection 3.6.2.1.4.1.1.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #4

  - For non-seismically analyzed ASME B31.1 piping attached to seismic piping, the applicant states that the attached non-seismic piping up to the analyzed/unanalyzed boundary is designed not to cause a failure of the seismic piping during a seismic event.
  - The applicant is to describe how “the analyzed/unanalyzed boundary” is determined for the APR1400 piping design.

– Resolution

  - The seismically analyzed/unanalyzed boundary is defined as the interface between the safety and non-safety piping and is usually designed with an anchor at that location. However, in instances where installation of an anchor is not feasible at the Code break interface, then the seismic Category I design is extended to the first anchor point.
  - For example, the Main Steam Valve House (MSVH) wall is designed as anchor wall and is “the analyzed/unanalyzed boundary”.

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #5
    - The applicant is to clarify whether the design criteria for a structure that separates a high-energy line from an essential component is consistent with the staff's guideline described in BTP 3-4, Part B, Item A(iii)(4). Specifically, if a structure separates a high-energy line from an essential component, the separating structure should be designed to withstand the consequences of the pipe break in the high-energy line that produces the greatest effect at the structure, irrespective of the fact that the criteria identified in DCD Tier 2, Subsection 3.6.2.1.4.1.1 might not need such a break location to be postulated.
  - Resolution
    - In accordance with BTP 3-4, structures separating a high-energy line from an essential component are designed to withstand the consequences of a pipe break including associated pipe whip, jet impingement and sub-compartment pressurization.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #6

  - The applicant is to clarify that appropriate pipe breaks and leakage cracks (whichever results in the most severe environment) are to be included in the design bases for environmental qualification of the safety-related electrical and mechanical equipment both inside and outside the containment as delineated in BTP 3-4, Part B, Item A(iii)(5). If not, justification for the departure should be provided.

– Resolution

  - Pipe breaks and cracks which result in the most severe environment are analyzed to determine the design conditions for environmental qualification of mechanical and electrical equipment. The results are described in Tier 2 Tables 3.11-2 and 3.11-3.

Public Meeting

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #7
    - The applicant is to clarify whether its criteria used for postulating breaks in complex system is consistent with the staff's guideline described in BTP 3-4, Part B, Item A(iv). Specifically, for complex systems such as those containing arrangements of headers and parallel piping running between headers, all such piping should be identified and included within a designated run for the purposes of break postulation.
  - Resolution
    - The postulated pipe break locations are selected in accordance with BTP 3-4, Part B, Item A(iv). For the selection of break locations in the complex piping system all pipes are identified and included. Detailed break locations taking account of piping system configuration will be described in the pipe rupture hazard analysis report.

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #8
    - The applicant is to clarify the criterion used for determining the crack locations for Class 1 piping. Item (a) of DCD Tier 2, Subsection 3.6.2.1.4.1.2 states that through-wall leakage cracks are not postulated at locations where, for Class 1 piping, the calculated value of S is less than 0.4 times the stress or usage limits. The applicant is to define the stress value "S."
    - In addition, the applicant is to clarify the criterion of "0.4 times the stress or usage limits" and to justify any departure from the staff's guidelines as described in BTP 3-4, Part B, Item A(v)(1).
  - Resolution
    - For Class 1 piping, the calculated value of stress range (from Equation (10) in ASME Section III, Division 1, NB-3653) is less than $1.2S_m$. This section of the DCD will be revised to reflect this through-wall crack criteria for Class 1 piping.

Resolution Summary

- DCD Tier 2 Section 3.6.2
  - Issue #9
    - The applicant is to clarify the criterion used for determining the crack locations for Class 2 and 3 piping or seismically analyzed ASME B31.1 piping. Item (b) of DCD Tier 2, Subsection 3.6.2.1.4.1.2 states that through-wall leakage cracks are not postulated at locations where the calculated value of S is less than 0.4 times the stress limits. The applicant is to define the stress value "S."
  - Resolution
    - For Class 2, Class 3 piping and seismically analyzed non-safety related ASME B31.1 piping, the calculated stress (from the sum of Equations (9) and (10) in ASME Section III, Division 1, NC/ND-3653) is less than 0.4 times the summation of the stress limits in NC/ND-3653. This section of the DCD will be revised to reflect this through-wall crack criteria for Class 2 and 3 piping.
    - Through-wall cracks for non-seismically designed ASME B31.1 piping are assumed at the locations that result in severe environmental conditions.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #10

  - DCD Tier 2, Subsection 3.6.2.1.4.2 (b), “Crack Configuration,” states that through-wall cracks are postulated at those axial locations specified in DCD Tier 2, Subsection 3.6.2.1.4.1.2. It further states that for high-energy piping, through-wall cracks are postulated in those circumferential locations that result in the most severe environmental consequences. However, it should be noted that, according to the staff’s guideline as described in BTP 3-4, Part B, Item B(iii)(2) for the moderate-energy fluid system piping, leakage cracks should be postulated at axial and circumferential locations that result in the most severe environmental consequences.

– Resolution

  - Through-wall cracks in moderate-energy piping are postulated at axial and circumferential locations that result in the most severe environmental consequences as described in BTP 3-4. DCD subsection 3.6.2.1.4.2 will be updated to include that moderate-energy piping cracks are postulated in axial locations as well as circumferential locations.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #11

  - With respect to the method of dynamic analysis of unrestricted pipes, DCD Tier 2, Subsection 3.6.2.3.2.2 discusses the assessment of the impact of unrestrained pipe on a barrier (e.g., the division wall). However, it does not address the impact of unrestrained pipe on adjacent pipe. The applicant is to discuss whether its methodology used for evaluating the impact of unrestrained pipe on adjacent pipe is consistent with the staff's guideline as delineated in SRP 3.6.2 Section III.2.

– Resolution

  - The impact of an unrestrained pipe on an adjacent pipe is considered in high-energy line break analysis. An unrestrained broken pipe is postulated to cause a rupture to an adjacent pipe if the diameter and wall thickness is smaller than the whipping pipe. A through-wall crack is postulated if the impacted pipe has a nominal pipe diameter larger or equal to the whipping pipe, but has a thinner wall thickness. If the impacted pipe diameter and wall thickness is equal to or greater than the whipping pipe, then the pressure boundary is postulated to remain intact. DCD Section 3.6.2.3.2.2 will be updated to include the methodology for evaluating the damage from an unrestrained whipping pipe. This is consistent with SRP 3.6.2 Section III.2.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #12

  - DCD Tier 2, Subsection 3.6.1.2.1.2, “Barriers and Shields,” states that where adequate protection does not exist due to separation, additional barriers, deflectors, or shields are provided as necessary to protect the nearby essential SSCs.
  - Moreover, DCD Tier 2, Section 3.6.11 discusses the importance of protective features such as pipe whip restraints in providing reasonable assurance of safe shutdown capability following a postulated high-energy line break. However, the staff noted that the relevant DCD Tier 2 subsections including Subsection 3.2.1 do not clearly address the seismic classification, design code, and allowable stress associated with these protective features.

– Resolution

  - The information of protective devices (barriers, shields, and whip restraints) will be described in the pipe rupture hazard analysis report.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #13

  - The applicant is to clarify whether its criteria for determining the initial condition of a piping which is pressurized during operation at power is to be the greater of the contained energy at either hot standby or 102 percent power as delineated in SRP 3.6.2 Section III.2.A.

– Resolution

  - For the APR1400 high-energy line break analysis, the initial conditions used are the higher energy operating condition of 102 percent power or hot standby condition in accordance with SRP Section III.2.A. Hot standby conditions are used for the main steam piping.

Resolution Summary

- DCD Tier 2 Section 3.6.2

– Issue #16

  - DCD Tier 2, Subsection 3.6.2.1.1 provides an outline of the pipe rupture analysis report. The staff reviewed the outline of the applicant's pipe rupture analysis report and determined that the applicant is to clarify whether the postulated crack locations for both high-energy line and moderate-energy line are to be identified in the pipe rupture analysis report.

– Resolution

  - Crack locations for high and moderate energy piping will be identified in the pipe rupture hazard analysis report.

Status of Jet Impingement Analysis

Tasks	Status
● Review EPRI, AREVA, GE and related technical papers - Bounding jet force and jet impingement loads - Blast wave characteristics - Jet oscillation and amplification due to feedback resonance	Complete
● Incorporate Solution Adaptive meshing for the CFD analyses	Complete
● CFD V&V including calculation and documentation	Complete
● CFD Analyses (Unconfined domain jet) - Zone of influence & Pressure distribution	Complete
● CFD Analyses (confined domain jet, with blast reflection effect)	Complete
● Liquid/Two-phase Jet Estimation (using NUREG/CR-2913)	Complete
● Feedback Amplification/Resonance Estimation	On-going
● Completion of Analyses	**Mid. of July**
● Submission of the TeR	**September**