Non-Proprietary

Level of Detail for Piping Stress Analyses

Pre-Application Review Meeting

May 02, 2014

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I. Introduction

Purpose of Meeting

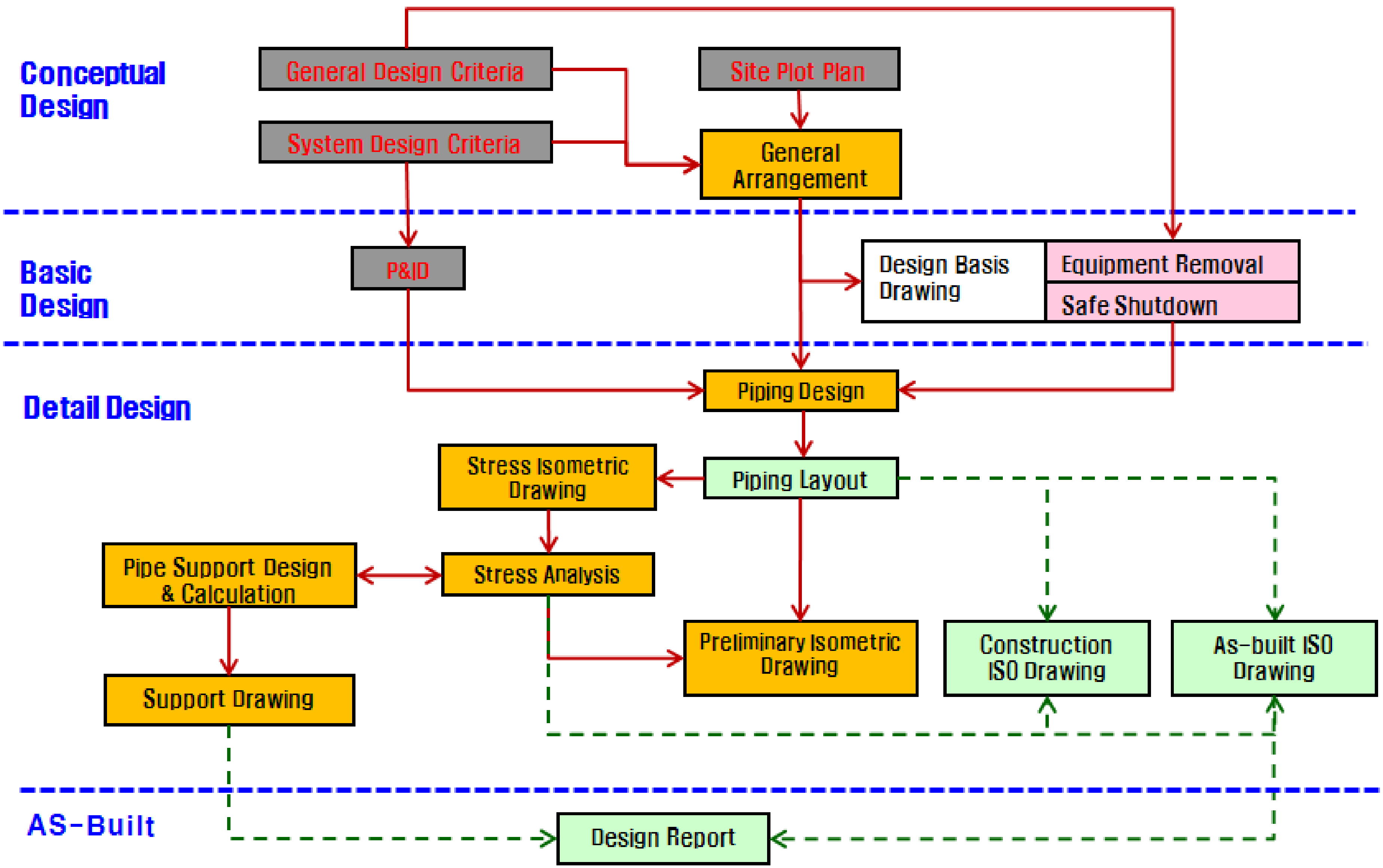
- ❖ KHNP needs to better understand the NRC's recent communications* and clarify the scope of piping design work to be completed for the APR1400 DC application.

  - NRC has recently provided a clarification on the level of detail for piping design in DC application: a heavy reliance on DAC may no longer be appropriate for the APR1400 DC application.

  - No comments were identified during the acceptance review of the APR1400 DCD.

*Piping Level of Detail for Design Certification (March 4, 2014)

Piping Design Work Flow



Piping Stress Analysis Work Flow

Stress Isometric Drawing	Preparation for Analysis	Preliminary stress Analysis	Stress Calculation	Interface Information Transmittal
• Piping & Instrument Diagram (P&ID) • Preliminary Routing	• Vendor Information –Physical Interface, Nozzle Loads, Displacements • Piping System Design Specification (PSDS) –Define Loads –Operating Modes –Design Requirements • Line Index –Line Size, Material, Wall Thickness –Design Pressure, Temperature • Seismic FRS • Dynamic Transient Loads • Etc.	• Perform Analysis for –Weight –Thermal Expansion –Seismic –Dynamic Transient –Etc.	Documentation • Validate Stress Analysis Results for –Code Requirements –Regulatory Requirements –Vendor Interface –Other Design Requirements • Support Design	• Preliminary loadings for penetrations and equipment nozzles • Etc.

II. Current Design Approach for APR1400

Application of DAC to Piping Stress Analysis

- KHNP has applied DAC to piping stress analysis based on the following NRC guidance:
  - SECY 92-053 “Use of design acceptance criteria during 10 CFR Part 52 design certification reviews”
  - RG 1.206 C.III.5 “Design Acceptance Criteria”
  - RG 1.215 “Guidance for ITAAC Closure Under 10 CFR Part 52”
  - NEI 08-1 “Industry Guideline for the ITAAC Closure process Under 10 CFR Part 52”

- Completion of piping design based on the reference plant (SKN3&4) design is impractical due to the following reasons:
  - Higher Seismic Loads
  - Unavailability of Vendor Information
  - Change of General Arrangement
  - Change of ASME Code Edition

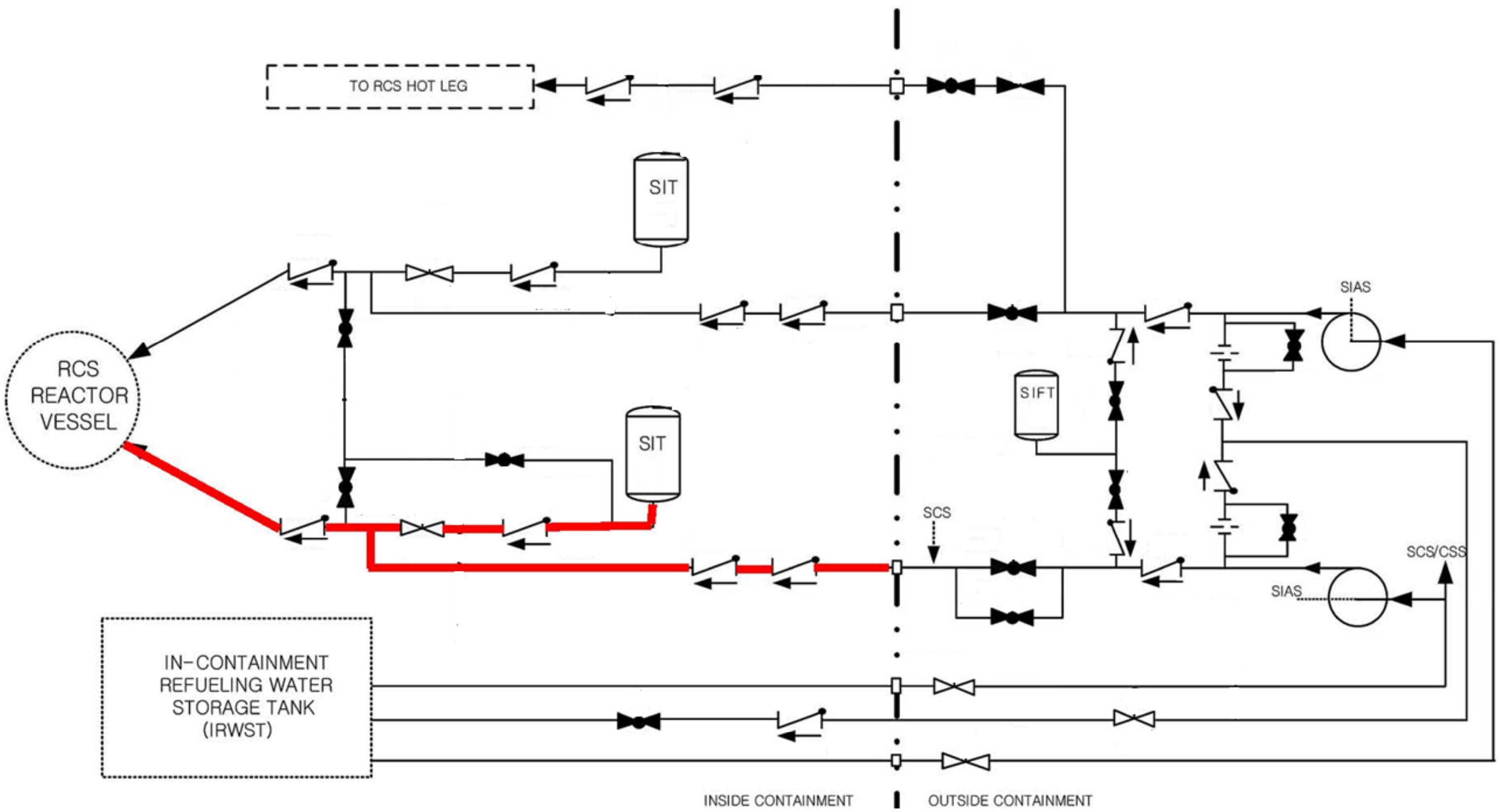
- To enable NRC safety determination, DAC & ITAAC has been identified in DCD Tier 1, Table 2.3 & 2.4 with two sample calculations.

Summary of Piping Design Level of Detail

Class	Scope	Design Completion	Sample Calculation	DAC Closure	ITAAC
ASME Class 1	RCS Piping	DAC	Surge Line	COL	Tier 1 Table 2.4.2-4
	RCS Branch Piping	DAC	One Subsystem	COL	Tier 1 Table 2.4.2-4, 2.4.4~7-4
ASME Class 2&3	All Piping	DAC	One Subsystem	COL	Tier 1 Table 2.3-1

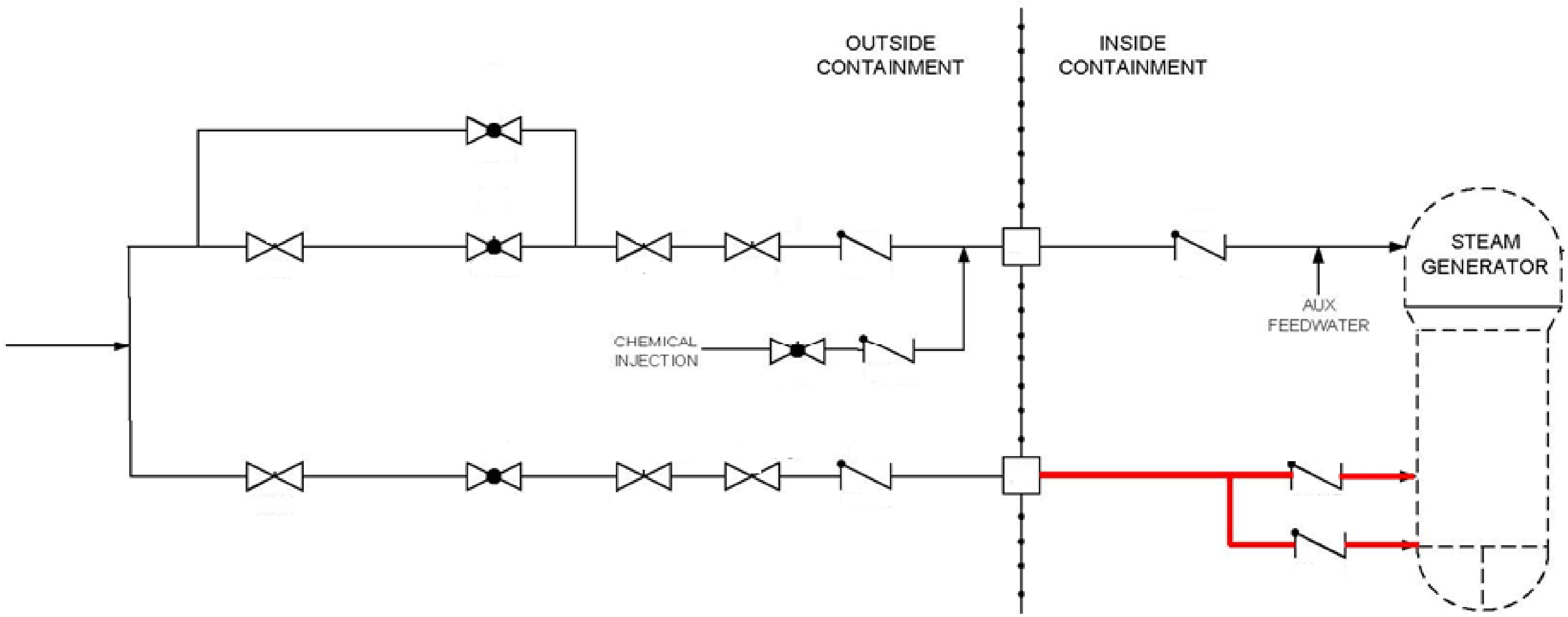
Sample Calculation

❖ Two representative piping systems were selected for sample calculations.
  - Direct vessel injection system from reactor vessel to containment penetration – SI101(Class 1&2)



Sample Calculation (Cont'd)

- Feedwater system from steam generator to containment penetration – FW101(Class 2)



Sample Calculation Conformance Table with regard to DCD 3.12

Chapter	Title	Subsystem		Remark
		FW101	SI101	
3.12	Piping Design Review			
3.12.1	Introduction	o	o	
3.12.2	Codes and Standards	o	o	
3.12.2.1	ASME Boiler and Pressure Vessel Code	o	o	
3.12.2.2	ASME Code Cases	N/A	N/A	
3.12.2.3	Piping System Design Specification and Design Report		o	Design Spec.
3.12.3	Piping Analysis Methods			
3.12.3.1	Experimental Stress Analysis Method	N/A	N/A	
3.12.3.2	Modal Response Spectrum Method	o	o	
3.12.3.2.1	General	o	o	
3.12.3.2.2	Floor Response Spectrum	o	o	
3.12.3.2.3	Uniform Support Motion Method	o	o	
3.12.3.2.4	Modal Combination	o	o	
3.12.3.2.5	Directional Combination	o	o	
3.12.3.2.6	Seismic Anchor Motion Analysis Method	o	o	
3.12.3.3	Independent Support Motion Method	N/A	N/A	
3.12.3.4	Time-History Method	o	o	
3.12.3.5	Inelastic Analysis Method	N/A	N/A	
3.12.3.6	Small-Bore Piping System Method	N/A	N/A	
3.12.3.7	Non-seismic/Seismic Interaction (II/I)	N/A	N/A	
3.12.3.8	Seismic Category I Buried Piping			COL Item

Sample Calculation Conformance Table with regard to DCD 3.12 (Cont'd)

Chapter	Title	Subsystem		Remark
		FW101	SI101	
3.12.4	Piping Modeling Technique			
3.12.4.1	Computer Codes	o	o	
3.12.4.2	Dynamic Piping Model	o	o	
3.12.4.3	Piping Benchmark Program			DST (Program Vendor)
3.12.4.4	Decoupling Criteria	N/A	o	
3.12.5	Piping Stress Analysis Criteria			
3.12.5.1	Seismic Input Envelope vs. Site-Specific Spectra	N/A	N/A	
3.12.5.2	Design Transients	o	o	
3.12.5.3	Loadings and Load Combination			
3.12.5.3.1	Pressure	o	o	
3.12.5.3.2	Mechanical Loads	o	o	
3.12.5.3.3	Thermal Expansion	o	o	
3.12.5.3.4	Seismic	o	o	
3.12.5.3.5	Fluid Transient Loads	o	N/A	
3.12.5.3.6	Wind/Tornado Loads			COL Item
3.12.5.3.7	Design Basis Pipe Break Loads	o	o	
3.12.5.3.8	Thermal and Pressure Transient Loads	N/A	o	
3.12.5.3.9	Hydrostatic Pressure Tests	o	N/A	
3.12.5.3.10	Load Combinations	o	o	
3.12.5.4	Damping Values	o	o	
3.12.5.5	Combination of Modal Responses	o	o	
3.12.5.6	High-Frequency Modes	o	o	
3.12.5.7	Fatigue Evaluation of ASME Code Class 1 Piping	o	o	
3.12.5.8	Fatigue Evaluation of ASME Code Class 2 and 3 Piping	o	o	

Sample Calculation Conformance Table with regard to DCD 3.12 (Cont'd)

Chapter	Title	Subsystem		Remark
		FW101	SI101	
3.12.5.9	Thermal Oscillations in Piping Connected to the Reactor Coolant System	N/A	o	
3.12.5.10	Thermal Stratification			Surge Line
3.12.5.11	Safety Relief Valve Design, Installation, and Testing	N/A	N/A	
3.12.5.12	Functional Capability	o	o	
3.12.5.13	Combination of Inertial and Seismic Anchor Motion Eff ects	o	o	
3.12.5.14	Operating-Basis Earthquake as a Design Load	N/A	N/A	
3.12.5.15	Welded Attachments	N/A	o	
3.12.5.16	Modal Damping for Composite Structures	N/A	N/A	
3.12.5.17	Minimum Temperature for Thermal Analyses	o	o	
3.12.5.18	Intersystem Loss-of-Coolant Accident	o	o	
3.12.5.19	Effects of Environment on Fatigue Design	N/A	x	
3.12.6	Piping Support Design Criteria	o	o	

III. Proposed Design Approach for APR1400

Application of Graded Approach

KHNP will revise DCD to incorporate a graded approach as follows:

- High Safety Significant Piping
  - All class 1 piping
  - MS & FW lines to the first 6-way rigid restraint beyond the isolation valves
  - Piping systems design and stress analyses will be completed except for environmental fatigue evaluation

- Lower Safety Significant Piping
  - Class 2&3 piping selected by Expert Panel through the failure mode & effect analysis(FMEA) based on pipe hazard analysis of SKN 3&4 and safety significance of each piping.
    - Detailed method and procedure of selecting class 2&3 piping will be proposed in the next PARM.
    - A list of Class 2&3 piping packages to address the piping DAC will be provided in the DCD.
    - The selected packages are considered to provide NRC with sufficient information to make a safety determination for resolving DAC.
  - Design documents and drawings will be prepared.
  - Piping stress analyses will be performed by COL applicants

Piping Design Scope of Work to be Completed

Description	Documents / Drawings	Current Status	Forecast date	Class 1	Class 2&3	
				>1″	≤2″	≥2.5″
Functional design criteria for mechanical systems and components	System Design Criteria (SDC)	Issued for DC	Completed	x	x	x
Preliminary system design description	System Functional Description (SFD)	Issued for DC	Completed	x	x	x
Piping design methodology	DCD Tier 2, ch3.12	Issued for DC	Completed	x	x	x
Simplified piping & instrumentation diagrams	Piping & Instrument Diagram (P&ID)	Issued for DC	Completed	x		x
Process flow diagrams or descriptions	DCD Tier 2	Issued for DC	Completed	x		x
Key piping parameters	Piping Design Table (PDT) Line Index	Issued for DC Not issued	Completed 12/2014	x x		x

Piping Design Scope of Work to be Completed (cont'd)

Description	Documents / Drawings	Current Status	Forecast date	Class 1	Class 2&3	
				>1″	≤2″	≥2.5″
Plant layout and arrangement information	• GA Drawings • Piping Isometric drawing	Issued for DC 27 piping Subsystems connected to major components	Completed Completed except for Lower Safety Significant Piping	x x		x x[1]
Design specifications for major components connected to piping systems	• Valve specification • Pump specification	Not issued	12/2014 12/2014	x x		
Preliminary piping stress analyses	• Summary report for class 1, 2&3 • Design report for Class 1	Two sample calculations	12/2015 12/2015 (excluding environmental fatigue)	x x		x[2]

1. Lower Safety Significant piping will be completed 12/2015
2. For MS & FW piping to the first 6-way rigid restraint beyond the isolation valves

Documents/Drawings Development

Documents/ Drawings	For review	For audit	Class 1	Class 2&3	
			>1"	≤2"	≥2.5"
Design reports for Class 1 piping[1]		x	x		
Summary report s of stress analysis results for class 1, 2&3 piping (TeR) [1]	x		x		x^2
Piping isometric drawings		x	x		x^3
Line Index		x	x		x^2
Valve/Pump Specifications		x	x		

1. Excluding environmental fatigue evaluation
2. For MS & FW piping to the first 6-way rigid restraint beyond the isolation valves
3. For Lower Safety Significant piping

Clarification Items

❖ Environmental Fatigue Evaluation for Class 1 Piping

- NUREG/CR-6909 (RG 1.207) is under revision.
- ASME Codes & Standards have not been developed yet.

IV. Open Discussion