

# Piping Design

- Introduction
- COL Information Items
- Status of Piping System Design
- Environmental Fatigue Analysis

# Introduction

# Purpose of Meeting

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- **Three issues has been identified resulting from the NRC docket review.**
  - Application of DAC to environmental fatigue evaluation
  - Consistency of COL information with the APR1400 piping design
  - Timeline for completion of piping design for audit
- **To discuss KHNP approaches to the followings**
  - Scope of piping design
  - Methodology of environmental fatigue analysis
  - Schedule of piping design completion

# COL Information Items

# COL Information Items of piping design in DCD 3.12.7

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- COL 3.12(1) The COL applicant is to prepare design reports for ASME Class 1, 2, and 3.
  - Design reports should be completed based on the As-built information and hence identified as a COL.
- COL 3.12(2) The COL applicant is to design the piping exposed to wind and/or tornado, if any, to the plant design basis loads.
  - The load of wind and tornado should be determined as site specific design information.
- COL 3.12(3) The COL applicant is to perform fatigue evaluations of ASME Class 1 piping.
  - This item will be deleted from COL information.
- COL 3.12(4) The COL applicant is to perform stress evaluations for ASME Class 2 and 3 piping.
  - This item will be deleted from COL information.

# COL Information Items of piping design in DCD 3.12.7

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- COL 3.12(5) The COL applicant is to perform fatigue evaluations of environmental impact on ASME Class 1 piping, using methods acceptable to the NRC at the time of evaluation.
  - This item will be revised according to the result of this meeting.
- COL 3.12(6) The COL applicant is to perform the piping stress analysis including the thermal stratification effect on the SCS suction line.
  - This item will be deleted from COL information.
- COL 3.12(7) The COL applicant is to determine maximum radial thermal expansion at its design temperature.
  - This item will be deleted from COL information.

# Status of Piping System Design

# ASME Class 1 Piping

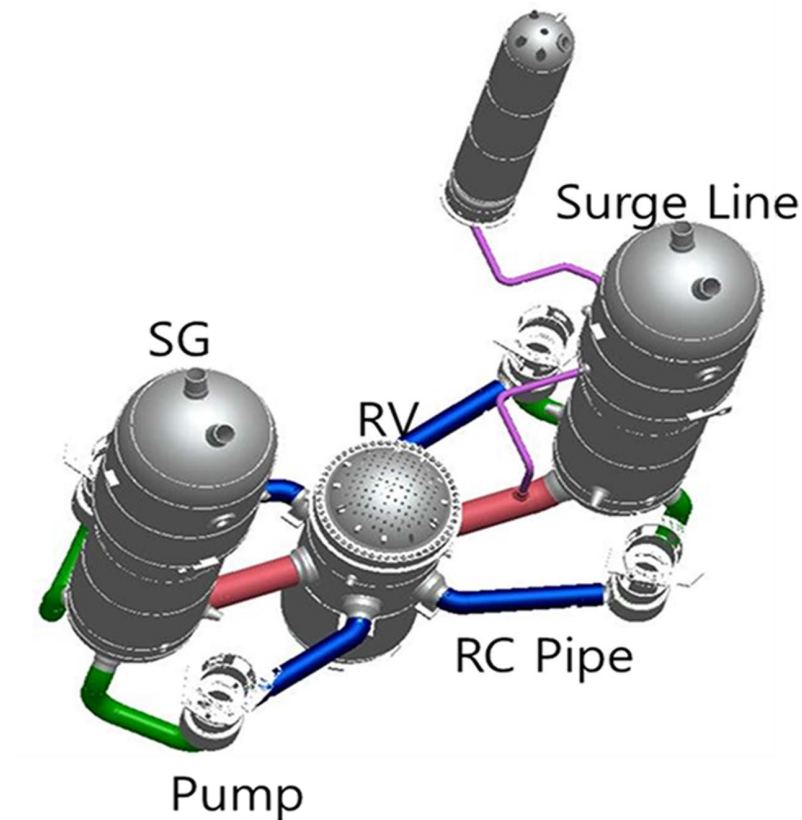
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- **ASME Class 1 Piping : Total 15 piping systems**
  - 2 are Reactor Coolant piping : RCS Primary piping and Surge line
  - 13 are RCS branch piping : DVI, SC, Spray, Drain(& letdown), Charging, and Gas vent line.
- **Graded Approach for Class 1 Piping**
  - Issues considered in engineering qualitative evaluation
    - Safety Function
    - Risk and consequence of safety
    - RCS Integrity
    - Piping size and layout
  - Selected Piping Systems for fatigue analysis : Primary piping, Surge, DVI, and SC lines.
  - The justification for APR1400 graded approach is addressed in DCD 14.3.2.3.

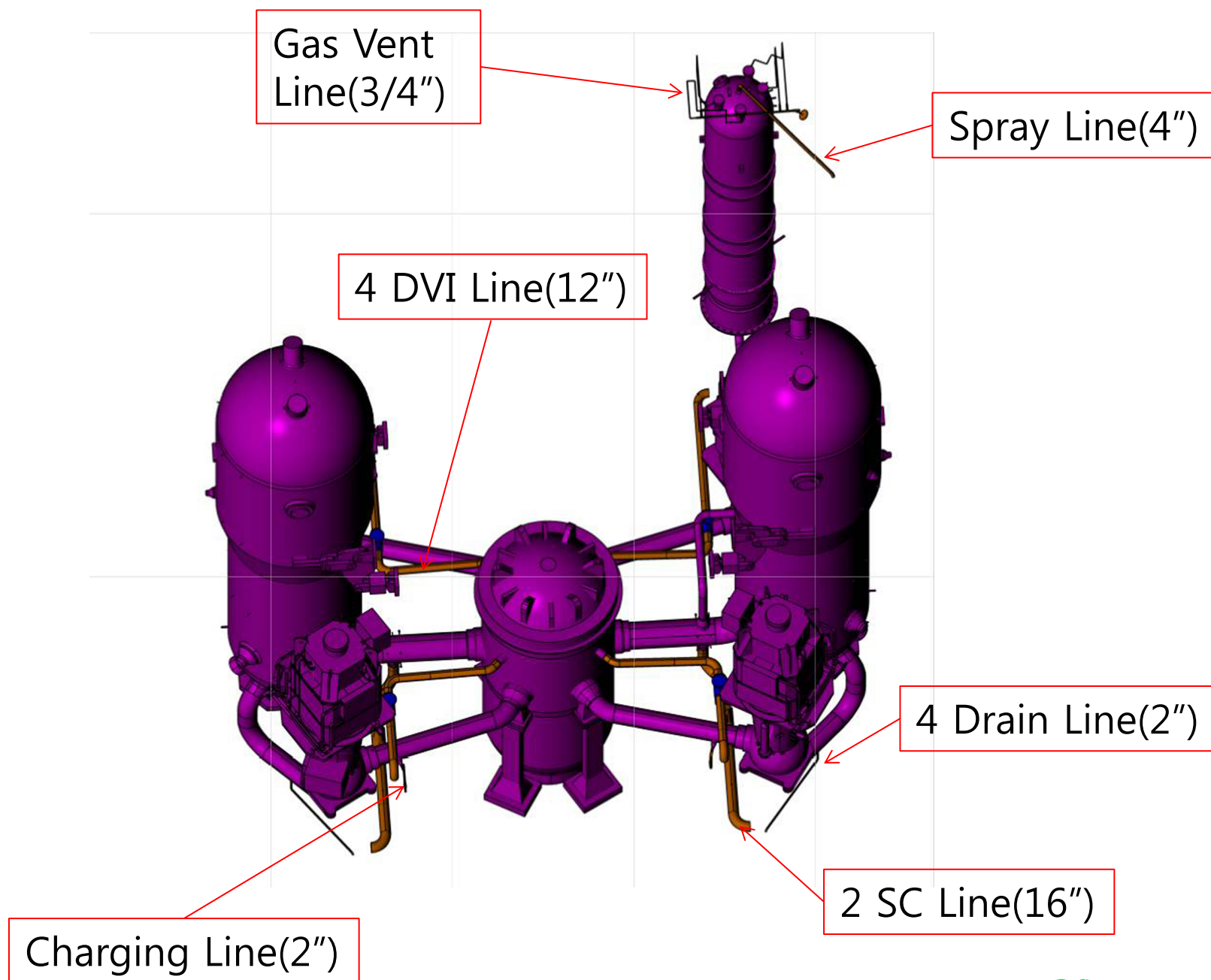


# Reactor Coolant Pipe and Fittings

- **Stress Summary Report for RCS piping and surge line**
  - RC(Reactor Coolant) Pipe, including 7 type nozzles (Surge, SC, Charging, Spray, Drain, RTD and Pressure measurement)
  - Surge Line, including 2 nozzles (RTD and Sampling)



# RCS Branch Piping System(Class 1)



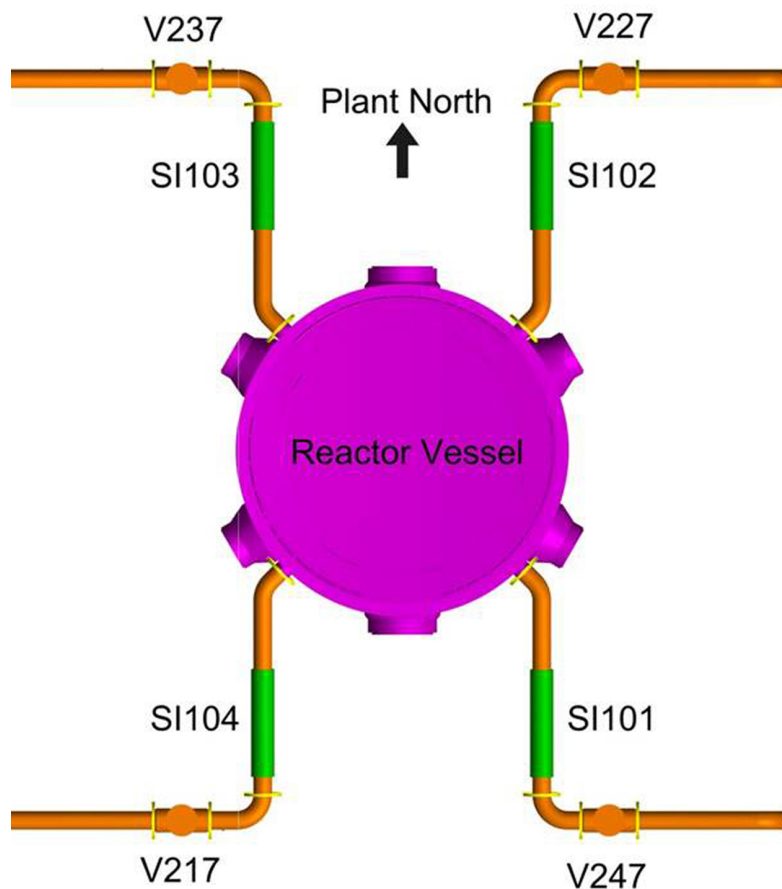
# Status of RCS Branch Piping, Main Steam, and Main Feedwater Piping

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- Structural stress analyses are completed for all class 1 RCS branch piping for the evaluation of RCS integrity.
- Two representative RCS branch piping are selected for Class 1 piping fatigue analysis. (DVI and SC line)
- MS/FW piping analysis inside containment are completed.
- The analysis of MS/FW piping up to 6 way rigid restraint beyond the isolation valves are being prepared. (1 Division)
- These calculations include most design methodology addressed in DCD 3.12.

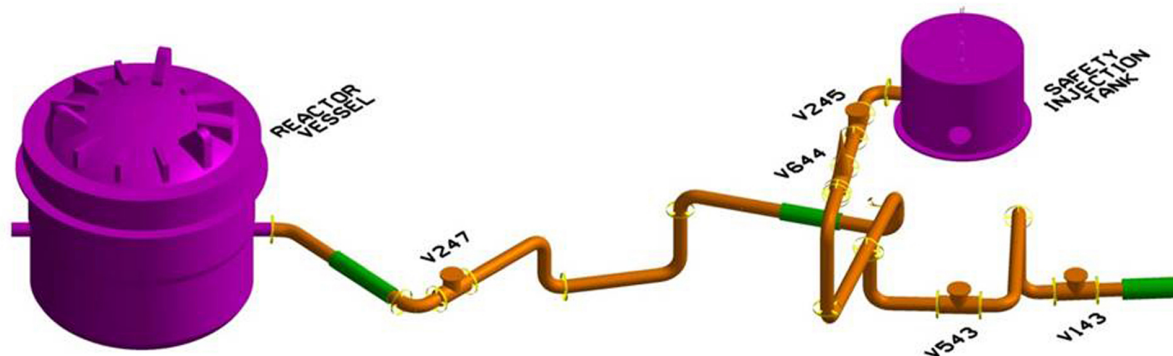
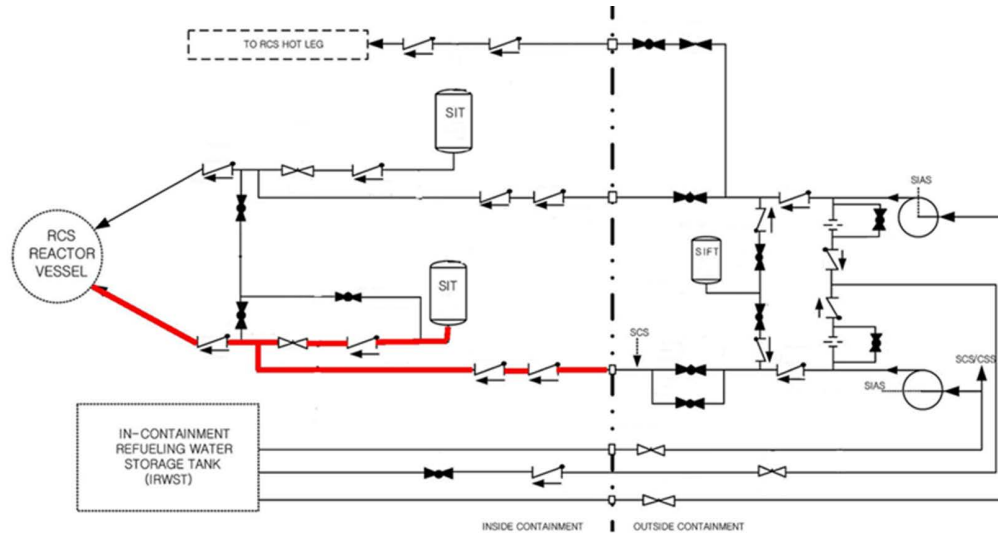
# Representative RCS Branch Piping

- Direct vessel injection system: There are four symmetric Safety Injection System piping from containment penetration to Reactor Vessel – SI101/102/103/104 (Class 1&2)



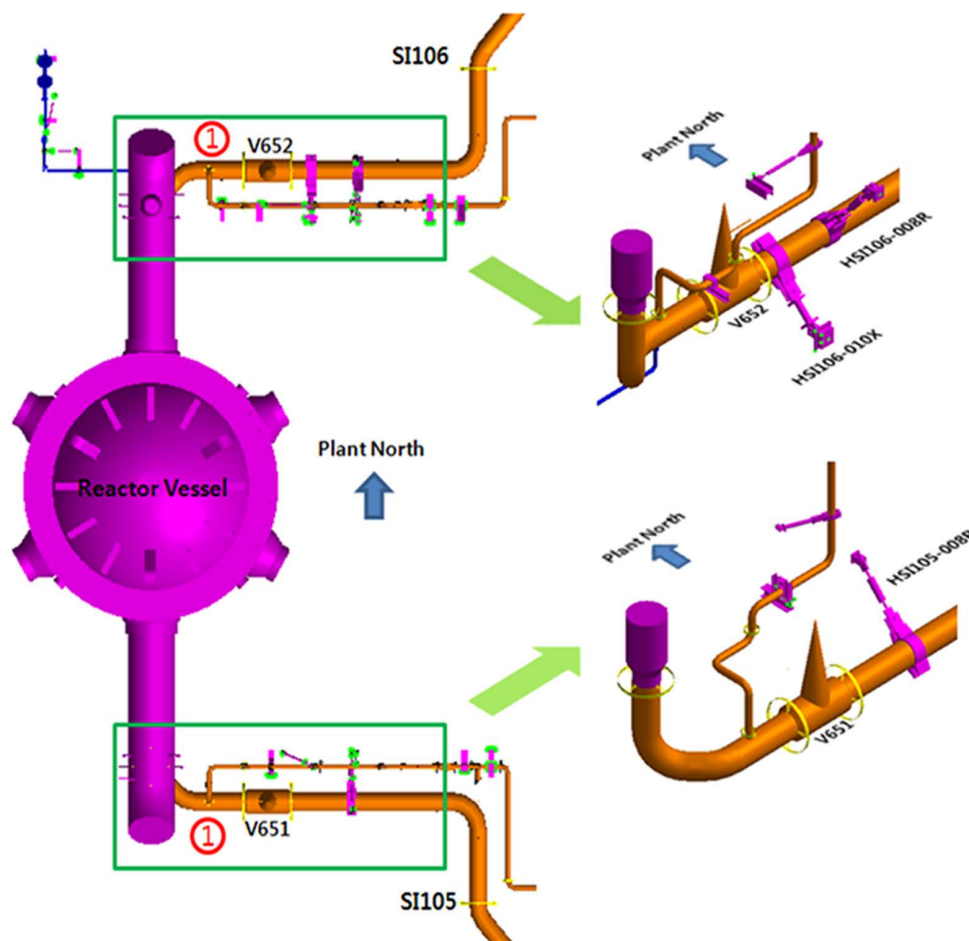
# Representative RCS Branch Piping

- SI101 has been selected as a representative case for SI system.



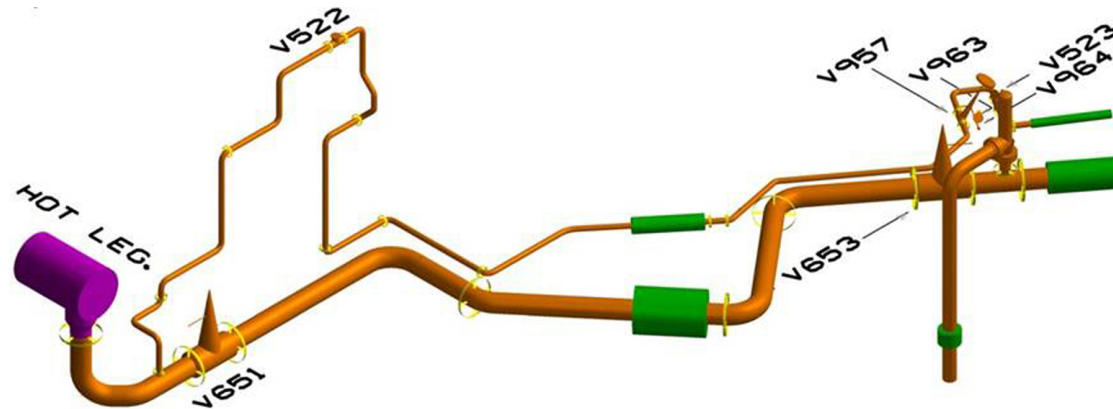
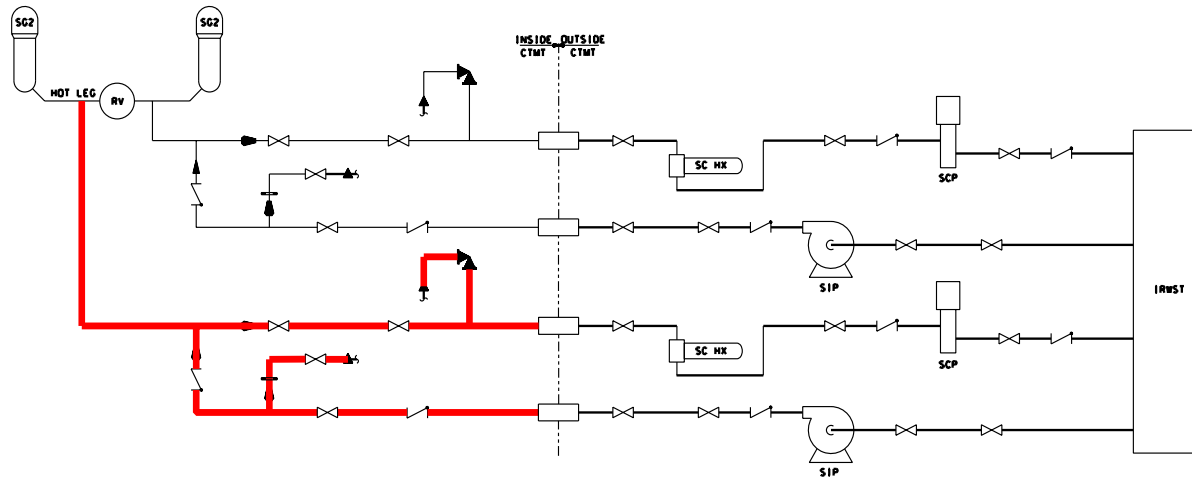
# Representative RCS Branch Piping

- There are two symmetric Shutdown Cooling System piping from containment penetration to Hot Leg (Class 1&2).



# Representative RCS Branch Piping

- SI105 has been selected as a representative case for SC system.





# Summary of Piping System Design

Class	Scope	Design Information	Schedule
ASME Class 1	Reactor Coolant Loop Piping	Summary Stress Report <sup>&lt;1&gt;</sup>	06/30/2015
	Surge Line	Summary Stress Report <sup>&lt;1&gt;</sup>	05/30/2015
	RCS Branch Piping <sup>&lt;2&gt;</sup>	SC piping Stress Analysis Calculation <sup>&lt;1&gt;</sup>	07/31/2015
		SI(DVI) piping Stress Analysis Calculation <sup>&lt;1&gt;</sup>	08/31/2015
ASME Class 2&3	MS and FW Piping	Piping Stress Analysis Calculation	12/30/2015 <sup>&lt;3&gt;</sup>

- Analyses include structural stress and fatigue, but exclude environmental fatigue evaluation.
- The structural analysis of all RCS branch piping have been performed for RCS integrity evaluation except for fatigue analysis. The results are available now for audit.
- The results inside containment are available now for audit. Outside containment within the first 6-way rigid restraint beyond the isolation valves



# Environmental Fatigue Analysis

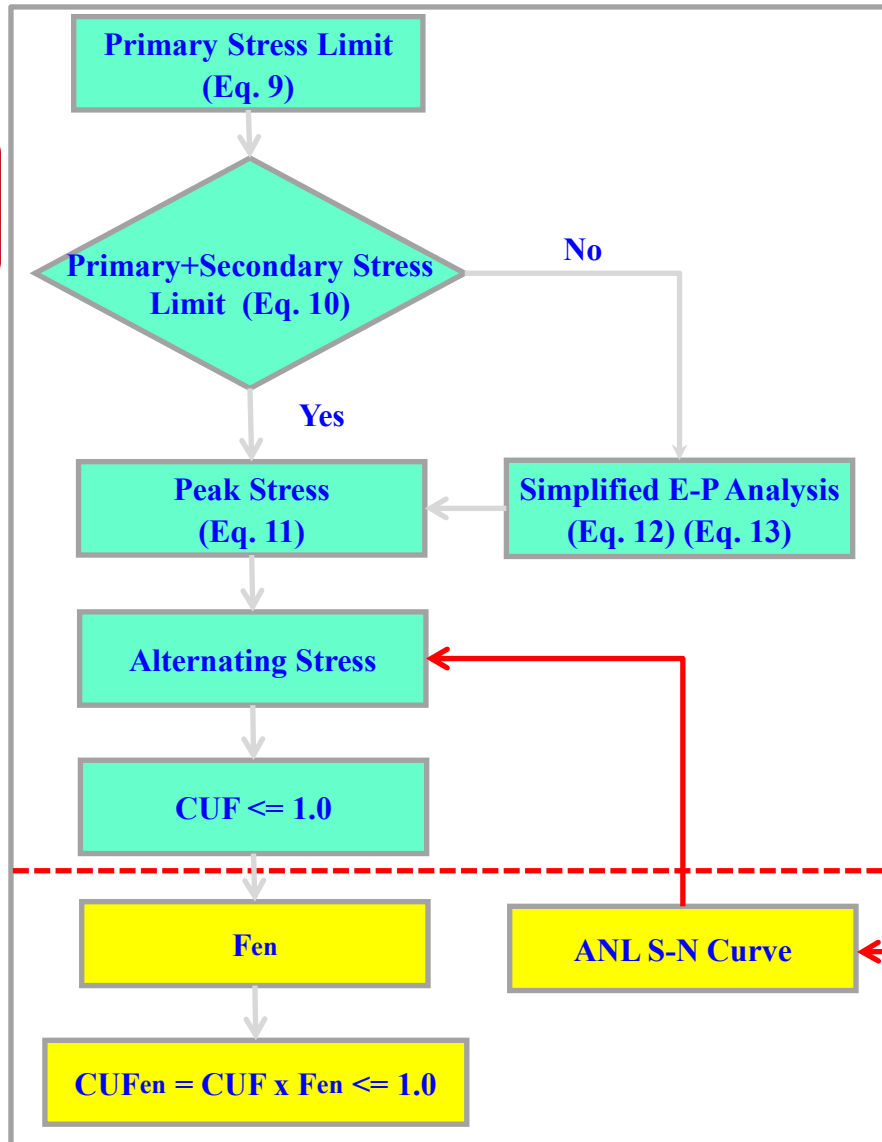
# Current Status of Environmental Fatigue

- Environmental Fatigue for Class 1 is applied to DAC for APR1400 DC with the following justification.
  - RG 1.207(NUREG/CR-6909) is under revision.
  - ASME Codes & Standards have not been developed yet.
- Design ITAAC : Tier 1 Table 2.3-2

Piping Systems and Components ITAAC

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The ASME Section III Class 1 piping systems and components for systems identified in Table 2.3-1 are evaluated for fatigue usage factor in reactor coolant environments.	1. Environmental Fatigue analysis of the ASME Section III Class 1 piping systems and components identified in Table 2.3-1 will be performed. [Design ITAAC]	1. Report(s) exist and conclude that the fatigue usage factors for ASME Section III Class 1 piping systems and components for systems identified in Table 2.3-1 are evaluated for reactor coolant environments.

# Evaluation Procedure for RCS Branch Piping Environmental Fatigue Analysis(NB-3600)



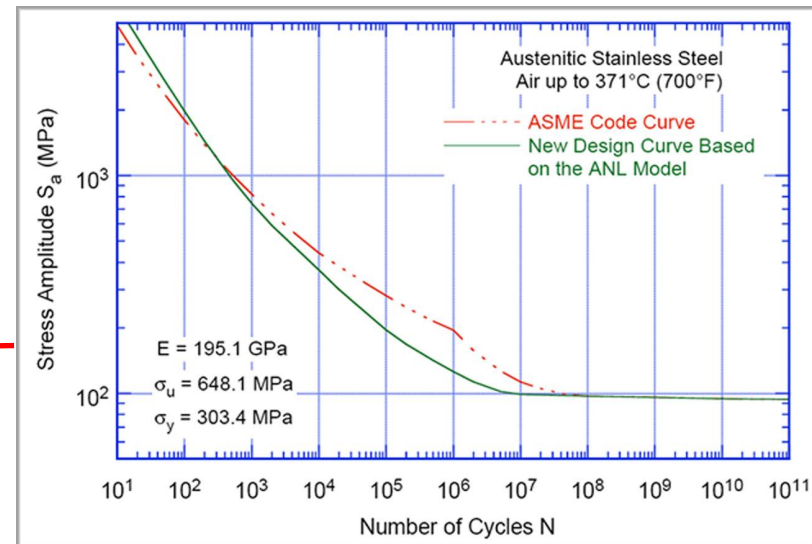
## ➤ Environmental Fatigue Correction Factor (F<sub>en</sub>)

$$F_{en} = N_A / N_w$$

N<sub>A</sub> : Fatigue Life in air at room temperature

N<sub>w</sub> : Fatigue Life in water at service temperature

$$➤ CUF_{en} = U_1 \times F_{en,1} + U_2 \times F_{en,2} + \dots + U_n \times F_{en,n}$$



# Clarification Items

- Applicability of up to date design approach

Technical Standard	Current	Up to date
Regulatory Guide 1.207	Rev.0	Rev.1
NUREG/CR-6909	Rev.0	Rev.1
Procedure to determine strain rate	ASME Draft Code Case (Rev.18), "Procedure to determine strain rate and $F_{en}$ "	TBD <sup>&lt;1&gt;</sup>

<1> To be determined

# Forecast Schedule for Environmental Fatigue Analysis

Class	Scope	Design Information	Schedule	
			Current Standards	Up to date Standards
ASME Class 1	Reactor Coolant Loop Piping	Environmental Fatigue Evaluation Report	03/30/2016	TBD <sup>&lt;1&gt;</sup>
	Surge Line	Environmental Fatigue Evaluation Report	03/30/2016	TBD <sup>&lt;1&gt;</sup>
	RCS Branch Piping	Environmental Fatigue Evaluation Report <sup>&lt;2&gt;</sup>	03/30/2016	TBD <sup>&lt;1&gt;</sup>

<1> To be determined.

<2> The environmental fatigue of SI101 and SI105 will be evaluated after the fatigue analyses.

# Thank You!