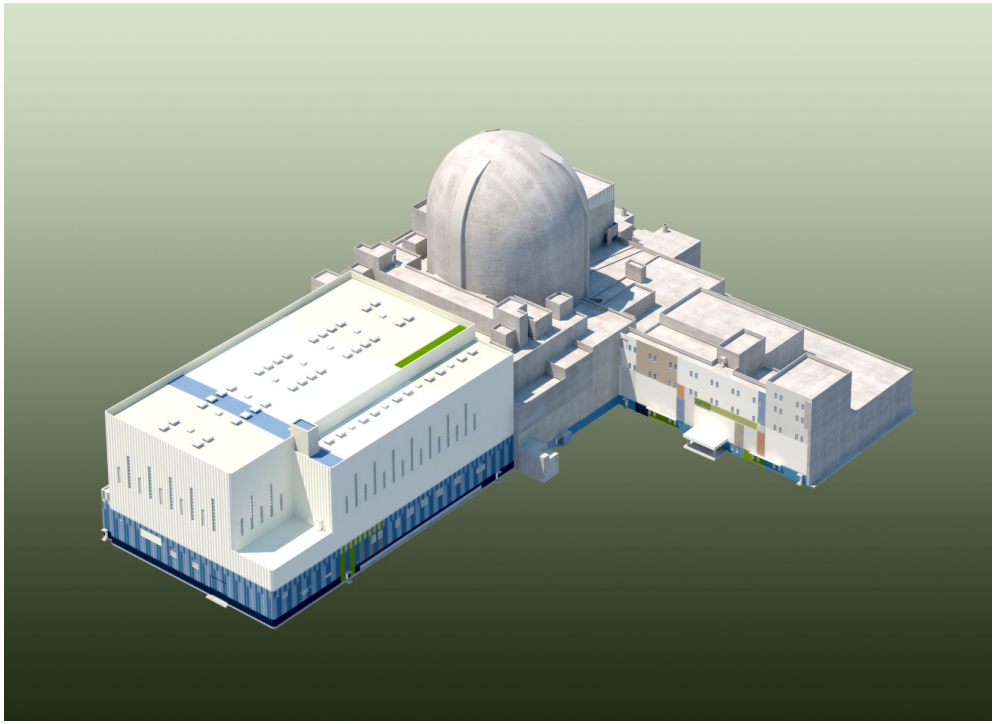
APR1400 Piping Design (Piping Stress Analysis)



KEPCO/KHNP

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Graded Approach

- Other design certification application (DCA) approaches used Design Acceptance Criteria (DAC) for piping design – Reduced DCA analysis
- Since APR1400 design "Essentially Complete" allows for alternate approach – Graded Approach
  - More in-depth analysis on DC application
  - Reduced number of piping runs analyzed
- Document methodology of completing detailed design for all systems
- First DCA to perform graded approach
- Follows guidance of SECY 90-377

Graded Approach

- Piping design makes use of a graded approach based on the safety significance of piping to determine the level of design details.
  - ASME Section III, Class 1 piping: Fatigue analysis and environmental fatigue analysis are performed for RCS main loop, Pressurizer Surge Line, RCS branch piping (Safety Injection and Shutdown Cooling).
  - ASME Section III, Class 2 and 3 piping: Stress analysis for Main Steam and Main Feedwater piping located inside Containment Building and outside to the first 6-way restraint beyond the isolation valves are performed.
- Leak Before Break (LBB) and Piping Hazard Analysis have been performed. (Details included in Safety Analysis presentation)

Design Features

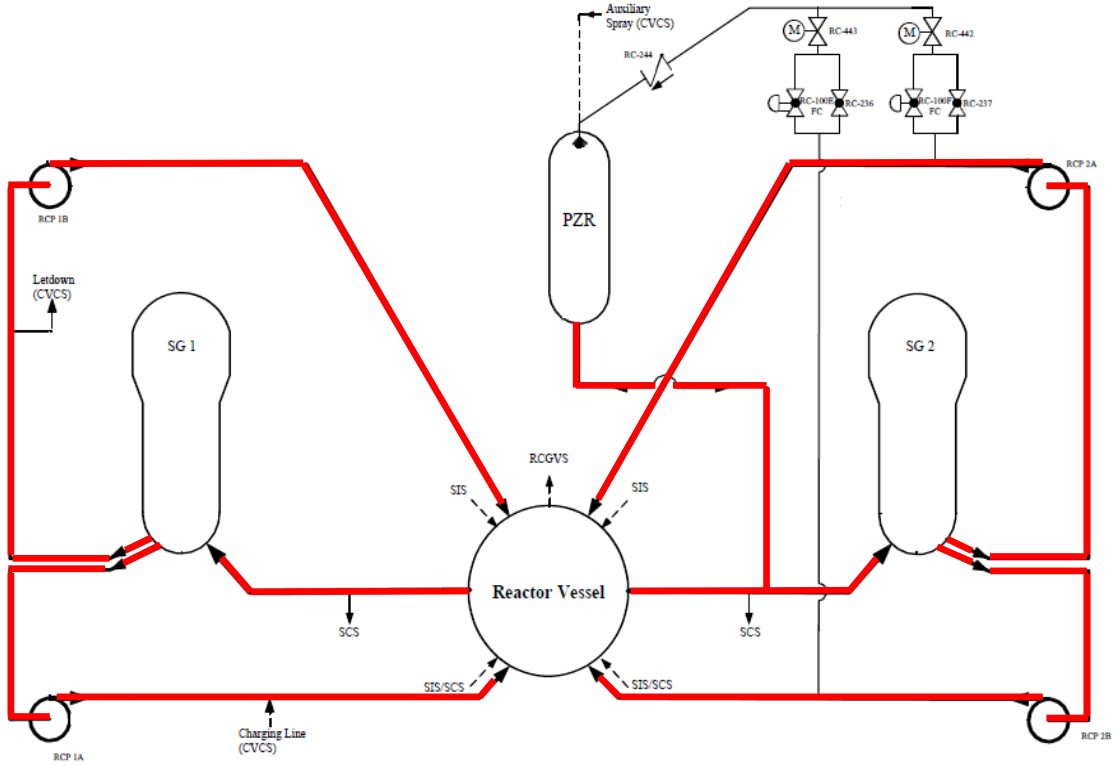
Piping Class	System	Description	Location	Design Status	Design Criteria*
RCS Pressure Boundary - Class 1 (including connected Class 2 piping)	RCS Hot Leg	RV to SG	Inside Containment	Environmental Fatigue is under evaluation	ASME Sec. III, NB-3600/3200
	RCS Cold Leg	SG-RCP-RV	Inside Containment		ASME Sec. III, NB-3600/3200
	Surge Line	PZR to Hot Leg	Inside Containment		ASME Sec. III, NB-3600/3200
	RCS Branch Lines	RCS to RCB Penetration	Inside Containment	Completed	ASME Sec. III, NB/NC-3600
Class 2&3	Main Steam (MS)	SG to MSIV House Penetration	Inside/Outside Containment	Completed	ASME Sec. III, NC/ND-3600
	Feedwater (FW)	SG to MSIV House Penetration	Inside/Outside Containment	Completed	ASME Sec. III, NC/ND-3600

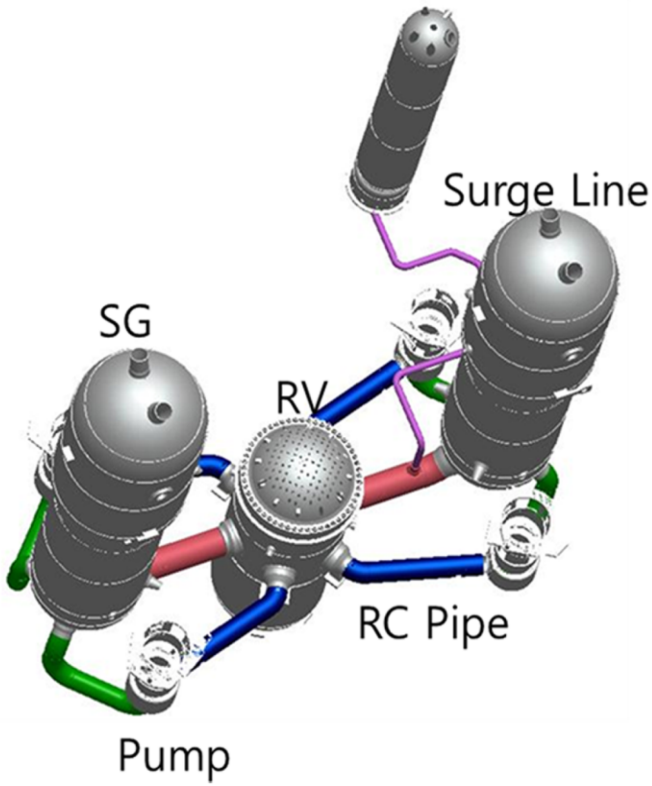
* ASME Sect. III, 2007 Edition with 2008 Addenda

Design Features

Service Level	Loads Analyzed	
Design	Pressure Weight	Other Sustained Mechanical Loads
Normal/Upset (A/B)	Pressure Weight Dynamic Fluid Load Thermal Expansion Building Settlement	Thermal Expansion Anchor Motion Cyclic Thermal Load Seismic Inertial Load Thermal Stratification Other Sustained Mechanical Loads
Emergency (C)	Pressure Weight	Dynamic Fluid Load
Faulted (D)	Pressure Weight Dynamic Fluid Load Thermal Expansion Thermal Expansion Anchor Motion	Cyclic Thermal Load Seismic Inertial Load Thermal Stratification High Energy Line Break Load Seismic Anchor Motion

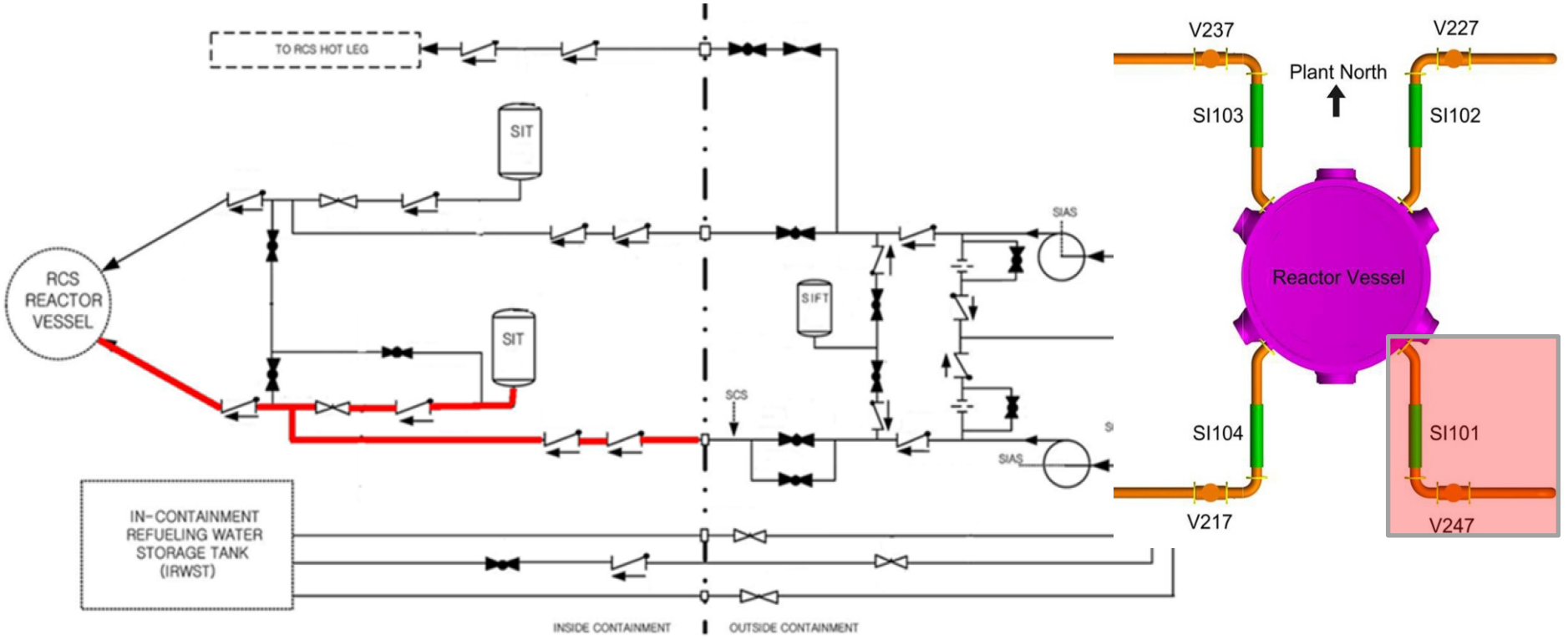
Design Features – RCS Main Loop & Surge Line





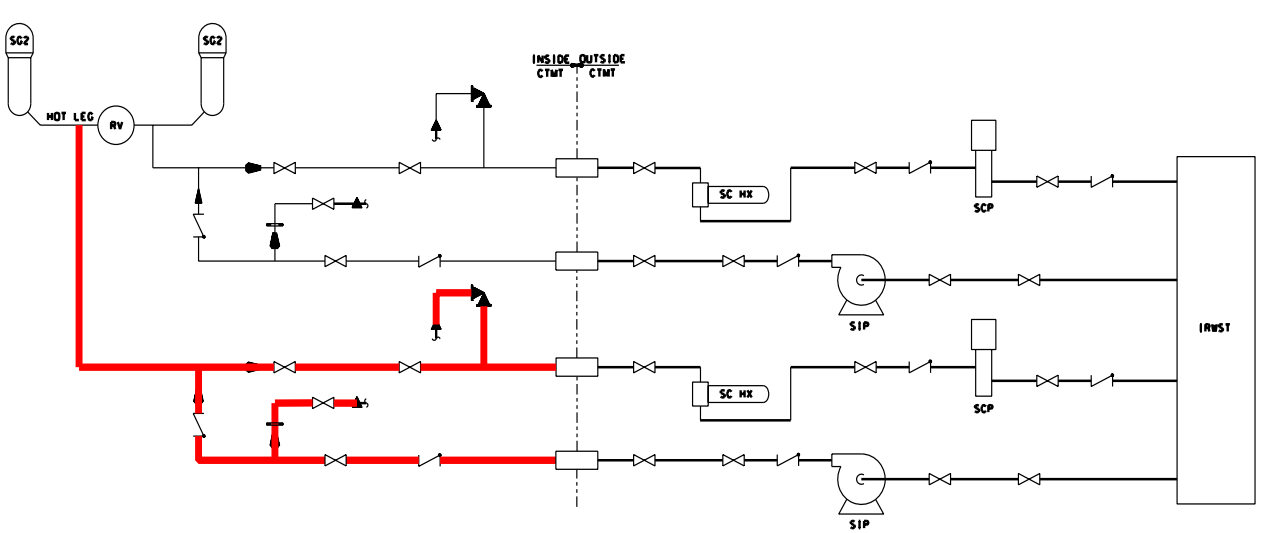
Design Features – RCS Branch Piping

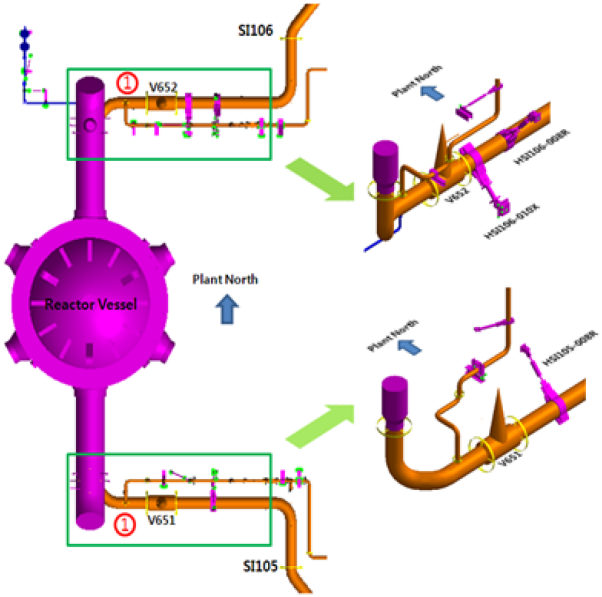
- Direct Vessel Injection (DVI)

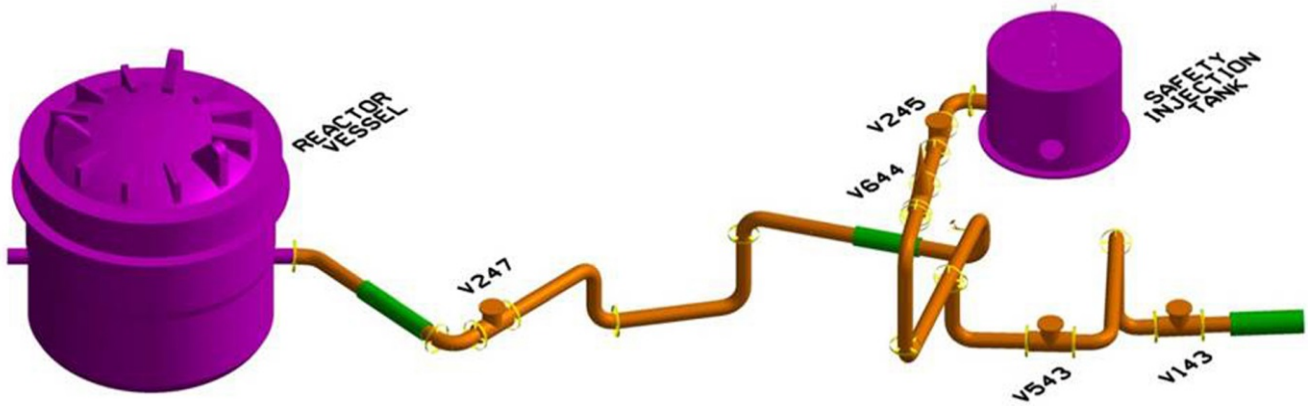


Design Features – RCS Branch Piping

- Shutdown Cooling (SC) Piping

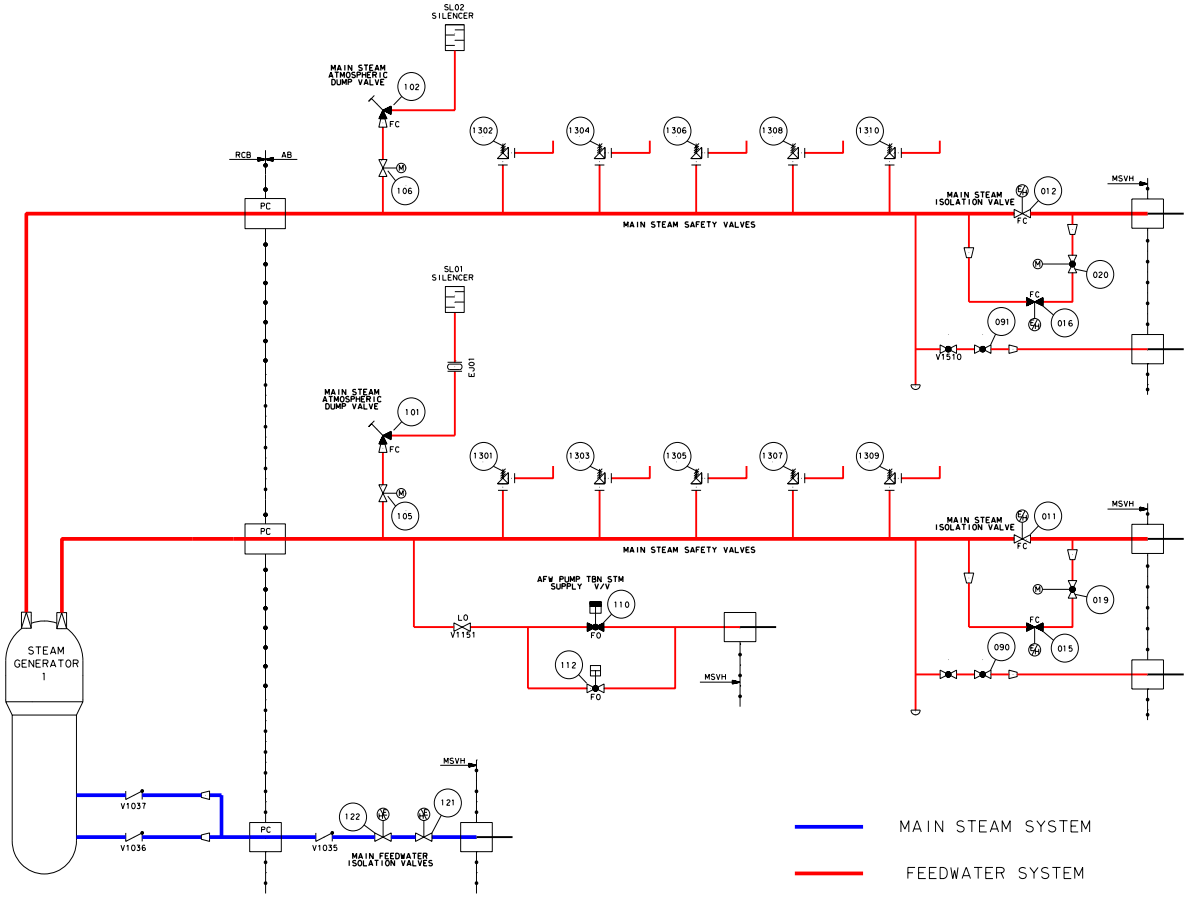


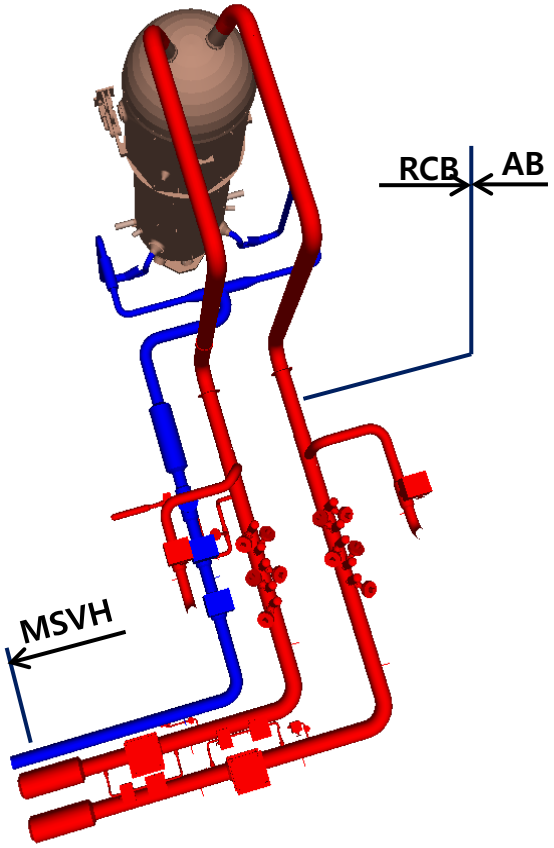




Design Features – Class 2&3

- Main Steam and Main Feedwater Piping
- From SG Nozzle to outside RCB to the first 6-way restraint beyond the isolation valve





Design Features – Results (RCS Piping)

TS

Design Features – Results (RCS Branch Piping)

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Design Features – Results (RCS Branch Piping)

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Design Features – Results (MS Inside Containment)

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Design Features – Results (MS Outside Containment)

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Design Features – Results (FW Inside Containment)

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Design Features – Results (FW Outside Containment)

TS

Design Review Status

❖ Confirmatory or unresolved-closed issues will be successfully closed in Phase II.

- Branch piping analysis
- Consideration of support mass
- Pipe support gap with regard to radial growth of the pipe due to temperature
- Piping analysis outside containment
- Environmental Fatigue Analysis in accordance with RG 1.207

Summary

- Essentially Complete design allows for more desirable (higher confidence) Graded Approach.
- Design analysis has demonstrated compliance to piping design requirements for Class 1, 2&3 piping with margin.
- NRC through audits and face-to-face meetings has good understanding of KHNP's design methodology, processes, and acceptance criteria.
- Sufficient information will be provided to support a safety determination and to meet the applicable requirement of 10 CFR 52.47.

Abbreviation (APR1400 Piping Design)

CUF	Cumulative Usage Factor
MSIVH	Main Steam Valve House
PZR	Pressurizer
RCB	Reactor Containment Building
RCP	Reactor Coolant Pump
RTD	Resistance Temperature Detector
SG	Steam Generator

P_b	Primary Bending Stress
P_e	Secondary Expansion Stress
P_L	Primary Local Membrane Stress
P_m	Primary General Membrane Stress
Q	Secondary Membrane plus Bending Stress
S_A	Allowable Stress Range for Expansion Stresses
S_c	Material Allowable at Minimum (cold) Temperature
S_h	Material Allowable at Temperature
S_m	Allowable Stress Intensity
S_u	Tensile Strength
S_y	Yield Strength