Evaluation of Main Steam and Feedwater Piping applied to the graded approach for the APR1400

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ABSTRACT

This report is in response to the Question No. 03.12-2 in RAI No. 35-7955, and provides summary information on the piping analysis approach and results as well as methodology of the piping analysis, necessary to support safety determination of the Main Steam (MS) and Feedwater (FW) piping systems. To demonstrate that the subject piping, which has been structurally evaluated based on the graded approach described in DCD Tier 2, Section 14.3.2.3, conforms to the requirements of ASME B&PV Code, Section III, mandated by 10CFR50.55a, the following information is provided:

- A tabulated, quantitative summary of the calculated maximum stresses and fatigue usage factors (if applicable) with a comparison to ASME B&PV Code allowable for each Code equation.
- For equipment nozzles, a tabulated quantitative summary of the calculated reaction loads compared to the specific nozzle allowable values.
- For containment penetrations, quantitative maximum calculated results compared to the allowable values.

Based on the review of summary information and component design drawings provided in this report, it is concluded that the APR1400 Main Steam and Feedwater piping that are included in the scope of Class 2 piping system design based on the graded approach, demonstrates the conformance to the requirements of ASME B&PV Code, Section III.

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1.0 INTRODUCTION

1.1 Graded Approach

Design of Class 1, 2 and 3 piping and components contained in the piping subsystems shall comply with the requirements of ASME Section III (Reference 9.1), subsections NB, NC and ND, respectively, for the conditions described in Section 5.0 of this report. In determination of the scope of piping system and component design for APR1400 DC, the concept of graded approach consistent with SECY-90-377 is taken as documented in DCD Tier 2, Subsection 14.3.2.3.

Piping subsystems analyzed for design certification are selected based on the safety significance. The scope of design for ASME code Class 2 piping includes MS and main FW piping located inside the containment building. MS and main FW piping is the largest ASME Class 2 piping connected to the steam generators and has the highest structural load. The scope of design for MS and main FW piping outside the containment building covers piping (1 Division) from the containment penetration anchors to MSVH (Main Steam Valve House) penetration anchors beyond isolation valves which are located in the break exclusion area in auxiliary building. This report summarizes the stress analyses results for Class 2 piping based on the graded approach.

1.2 Scope of Report

The scope of this report consists of the documentation of Code (NC-3650) compliance of the Class 2 piping components identified on the analytical drawings for the ten representative piping subsystems, namely, MS101 thru MS104, FW101, FW102, MS271, MS272, FW209 and FW219, for which boundaries are described in Figure 1.3-1, 1.3-2, 1.3-3, 1.3-4, 1.3-5, 1.3-6, 1.3-7, 1.3-8, 1.3-9 and 1.3-10, respectively.

1.3 Piping Subsystem Description

1.3.1 MS101

The subject piping subsystem is routed from SG 2 steam outlet nozzle to containment shell penetration.

TS

Figure 1.3-1 Subsystem MS101 Boundary

1.3.2 MS102

The subject piping subsystem is routed from SG 2 steam outlet nozzle to containment shell penetration.

TS

Figure 1.3-2 Subsystem MS102 Boundary

1.3.3 MS103 :

The subject piping subsystem is routed from SG 1 steam outlet nozzle to containment shell penetration.

TS

Figure 1.3-3 Subsystem MS103 Boundary

1.3.4 MS104 :

The subject piping subsystem is routed from SG 1 steam outlet nozzle to containment shell penetration.

TS

Figure 1.3-4 Subsystem MS104 Boundary

1.3.5 FW101 :

The subject piping subsystem is routed from SG 1 economizer nozzle to containment shell penetration.

TS

Figure 1.3-5 Subsystem FW101 Boundary

1.3.6 FW102 :

The subject piping subsystem is routed from SG 2 economizer nozzle to containment shell penetration.

TS

Figure 1.3-6 Subsystem FW102 Boundary

1.3.7 MS271

The subject piping subsystem is routed from containment penetration anchor to MSVH(Main Steam Valve House) penetration anchors.

TS

Figure 1.3-7 Subsystem MS271 Boundary

1.3.8 MS272 :

The subject piping subsystem is routed from containment penetration anchor to MSVH(Main Steam Valve House) penetration anchors.

TS

Figure 1.3-8 Subsystem MS272 Boundary

1.3.9 FW209

The subject piping subsystem is routed from containment penetration anchor to MSVH(Main Steam Valve House) penetration anchors.

TS

Figure 1.3-9 Subsystem FW209 Boundary

1.3.10 FW219

The subject piping subsystem is routed from containment penetration anchor to MSVH(Main Steam Valve House) penetration anchors.

TS

Figure 1.3-10 Subsystem FW219 Boundary

2.0 SUMMARY OF RESULTS AND CONCLUSIONS

2.1 Conclusions

The class 2 piping systems which are applied to the grade approach were designed to the requirements of the ASME Boiler and Pressure Vessel Code, Section III, 2007 Edition with 2008 Addenda in accordance with the requirements of NC-3600, Service Loadings, Operating Conditions and Test Conditions as specified in the Design Specification.

From the results summarized in this report, it is concluded that the class 2 piping systems of MS101, MS102, MS103, MS104, FW101, FW102, MS271, MS272, FW209 and FW219 satisfy all of the requirements of the Design Specification (Reference 9.5).

2.2 MS101

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.2-1

Location of Highest Stress in MS101

TS

2.3 MS102

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.3-1

Location of Highest Stress in MS102

TS

2.4 MS103

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.4-1

Location of Highest Stress in MS103

TS

2.5 MS104

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.5-1

Location of Highest Stress in MS104

TS

2.6 FW101

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.6-1

Location of Highest Stress in FW101

TS

2.7 FW102

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.7-1

Location of Highest Stress in FW102

TS

2.8 MS271

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.8-1

Location of Highest Stress in MS271

TS

2.9 MS272

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.9-1

Location of Highest Stress in MS272

TS

2.10 FW209

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.10-1

Location of Highest Stress in FW209

TS

2.11 FW219

All pipe stresses meet applicable Code allowables.

The highest stress for each Code equation is tabulated below.

Table 2.11-1

Location of Highest Stress in FW219

TS

[ ]

3.0 NOMENCALTURE

SG	Steam Generator
MS	Main steam
FW	Main FeedWater
S_c	Basic material allowable stress value at room temperature
S_h	Basic material allowable stress value at normal service temperature
S_y	Yield strength
S_a	Allowable stress range for expansion stresses

4.0 ASSUMPTIONS AND OPEN ITEMS

4.1 Assumptions

The vendor information in this report is assumed based on the reference plant.

4.2 Open Items

The small bore branch piping of the main line is not included in this analysis based on the decoupling criteria, which is not designed in DC design stage. The small bore piping should be evaluated after the design is accomplished.

5.0 ACCEPTANCE CRITERIA

5.1 Design Basis for Thermal and Mechanical Loading

The thermal and mechanical loading evaluations of all piping products, used in the design of these subsystems, are performed in accordance with the design rules specified in Paragraphs NC-3652, NC-3653, and NC-3655 for Class 2 piping. The design basis and acceptance criteria listed in Tables 5.1-1 of this report are used as a basis for the calculations.

Table 5.1-1 Code Allowable

Source of Criterion	Allowable Stress	Condition
NC-3652	1.5 S_h	Design
NC-3653	Lesser of 1.8 S_h and 1.5 S_y (for Occasional Loads) SA = f(1.25 S_c + 0.25 S_h) (for Thermal Expansion) S_h + S_A (for Sustained Loads including Thermal Expansion)	Service Level A/B
NC-3655	Lesser of 3.0 S_h and 2.0 S_y	Service Level D
NC-3655(b)(4)	6.0 S_h	Service Level D

5.2 Functional Capability Criteria

These piping subsystems (or a portion of this piping subsystem) are designated as “Required for Safe Shutdown” per Section 902 of the system PSDS(Reference 9.5). The requirements for assurance of functional capability are provided in Section 902 of the general PSDS(Reference 9.5).

a. Piping functional capability is assured by verifying that the maximum stress in Eq.(9) of ASME B&PV Code, Section III NC-3650, regardless of service level, does not exceed Service C limits.

b. Based on NUREG-1367, functional capability of a piping system is assured by meeting the present code(ASME B&PV Code, Section III NC/ND-3650) Eq.(9), Level D, stress limit of 2Sy, provided that:

- Dynamic loads are reversing. This includes loads due to earthquake and pressure wave loads(not slug-flow fluid hammer).

- Dynamic moments are calculated using an elastic response spectrum analysis with ±15% peak broadening and not more than 5% damping.

- Steady-state(e.g., weight) stresses including non-reversing dynamic loads do not exceed 0.25 Sy.
- Do/t(pipe outer diameter divided by thickness) does not exceed 50.
- External pressure does not exceed internal pressure.

5.3 High Energy Line Pipe Break Postulation Criteria

The portions of the subsystem designated as High Energy Lines requiring break postulation per Reference 9.7 are designed using the acceptance criteria specified below.

Table 5.3-1 Pipe Break Location

Source of Requirement	Acceptance Criteria
Reference 9.7	ASME NC, Eq.(9)+ Eq.(10) $\leq$ $0.8(1.8S_h+S_A)$

Note : See applicable Code paragraphs for nomenclature.

6.0 LOADS AND LOAD COMBINATIONS

6.1 Design Basis for Thermal and Mechanical Loading

6.1.1 Thermal Loading (TRNG)

6.1.1.1 Thermal Expansion Modes

This piping subsystem contains ASME Code, Section III, piping and the applicable design basis thermal expansion modes are defined in the System (Reference 9.5). The thermal expansion modes are interpreted using the rules specified in the General PSDS (Reference 9.5).

6.1.1.2 Equipment Nozzle Movement (RCS Nozzle Movement)

RCS Nozzle Movements induced by thermal loading are used in stress analysis.

6.1.2 Normal Operation Weight Loading (WGHT)

Normal Operation Weight Loading is that loading due to the weight of the pipe metal, insulation and its contents during the subsystem normal operating service conditions, all valves and in-line equipment, and any significant support or restraint hardware that is directly supported by the pipe.

6.1.3 IRWST Hydro Dynamics Inertia Loading (IRWST)

IRWST Hydro Dynamics Inertia Loading is the inertia portion of the total loading induced by POSRV operation. The inertia loading is the result of excitation amplified by building response motion.

6.1.4 Safe Shutdown Earthquake Inertia Loading (SSE)

Safe Shutdown Earthquake Inertia Loading is the inertia portion of the total loading induced by Safe Shutdown Earthquake excitation amplified by building response motion.

6.1.5 RCS Branch Line Pipe Break Loading (BLPB)

Branch Line Pipe Break Loading is the total loading that is induced by the vibration of unbroken RCS branch line. The subject vibration is the result of excitations of reactor vessel, hot and cold legs, pressurizer and steam generator caused by a RCS branch line pipe break.

6.1.6 Safe Shutdown Earthquake Building Displacement Loading (SSBD)

Safe Shutdown Earthquake Building Displacement load analysis is performed and the maximum building displacements of the building structure are included the seismic analysis report for the applicable building.

6.1.7 Safe Shutdown Earthquake RCS Header Displacement Loading (SSHD)

Safe Shutdown Earthquake RCS Header Displacement load analysis is performed and the maximum header displacements of the RCS are included in the report of interface requirements for RCS branch piping for the applicable RCS header.

6.1.8 Feedwater Pump Trip Loading (FWPT)

Feedwater Pump Trip Loading is the total loading that is induced by Water hammer due to Feedwater Pump Trip.

6.1.9 Turbine Main Stop Valve Closure Loading (TSVC)

Turbine Main Stop Valve Closure Loading is the total loading that is induced by Steam hammer due to Valve fast closure.

6.1.10 Postulated Line Break in FW System (FWLB)

Postulated Line Break Loading in FW System is the total loading that is induced by Line Break in FW System.

6.1.11 Postulated Line Break in FW System (MSLB)

Postulated Line Break Loading in MS System is the total loading that is induced by Line Break in MS System.

6.1.12 Safety Relief Valve Transient Loading(SRV)

Safety Relief Valve Transient Loading is the total loading that is induced by safety relief valve actuation.

6.1.13 Atmospheric Dump Valve Transient Loading(ADV)

Atmospheric Dump Valve Transient Loading is the total loading that is induced by dump valve actuation.

6.1.14 Aux Feedwater Pump Turbine Driven Line Break in MS System (AFPTLB)

Postulated Line Break Loading in MS System is the total loading that is induced by Line Break in MS System.

6.1.15 Drip Leg Line Break in MS System (DRLB)

Postulated Line Break Loading in MS System is the total loading that is induced by Line Break in MS System.

6.1.16 Coincident Pressure Loadings

Two coincident internal pressure loading cases are used for primary load design. Two cases are listed below. Specific descriptions concerning the combination of these pressure loading conditions with the individual primary loadings identified are contained in Section 6.2.

Table 6.1-1 Pressure

Load Abbreviation	Description
DPRE	Individual component design pressure per Reference 9.5
PPRS	Individual component peak pressure coincident with service level being considered per Reference 9.5

6.2 Loading Combination

The combined loadings described in Table 6.2-1, 6.2-2, 6.2-3, 6.2-4, 6.2-5 and 6.2-6 are used as a design basis for all NC-3650. These conditions address all requirements specified in Reference 9.5.

6.2.1 Main Steam piping inside the containment building

Table 6.2-1 MS101, MS102, MS103, MS104 Load Combination TS

6.2.2 Main Feedwater piping inside the containment building

Table 6.2-2 FW101, FW102 Load Combination TS

6.2.3 Main Steam piping inside the Auxiliary building

Table 6.2-3 MS271 Load Combination TS

6.2.4 Main Steam piping inside the Auxiliary building

Table 6.2-4 MS272 Load Combination TS

6.2.5 Main Feedwater piping inside the Auxiliary building

Table 6.2-5 FW209 Load Combination TS

[ ]

6.2.6 Main Feedwater piping inside the Auxiliary building

Table 6.2-6 FW219 Load Combination TS

[ ]

7.0 ANANYSIS RESULT

7.1 MS101

7.1.1 Subsystem Plot

TS

Figure 7.1-1 Subsystem MS101 Plot

7.1.2 Pipe Data Sheet

TS

Figure 7.1-2 Subsystem MS101 Pipe Data Sheet

7.1.3 Piping Stress Evaluation Results

7.1.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the main steam outlet nozzle against maximum nozzle load criteria.

7.1.3.1.1 Criteria Check

Table 7.1-1 Criteria Check at Main Steam Outlet Nozzle in MS101

TS

7.1.3.1.2 Loads Check

Table 7.1-2 Load Check at Main Steam Outlet Nozzle in MS101

TS

7.1.3.1.3 Conclusion

Base on the above evaluation, it can be concluded that loads applying on SG steam outlet nozzle safe end are within the allowable, and therefore acceptable.

7.1.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.1-3 The Stress at the Flued Head Penetration Anchor in MS101

TS

7.1.3.3 Branch Pipe Connection

There is no Branch Pipe Connection in this piping subsystem.

7.1.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.1-4 The Stress at the Pipe Support Location in MS101

TS

7.1.3.5 Valve

There is no valve in this piping subsystem.

7.1.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.2 MS102

7.2.1 Subsystem Plot

TS

Figure 7.2-1 Subsystem MS102 Plot

7.2.2 Pipe Data Sheet

TS

Figure 7.2-2 Subsystem MS102 Pipe Data Sheet

7.2.3 Piping Stress Evaluation Results

7.2.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the main steam outlet nozzle against maximum nozzle load criteria.

7.2.3.1.1 Criteria Check

Table 7.2-1 Criteria Check at Main Steam Outlet Nozzle in MS102 TS

7.2.3.1.2 Loads Check

Table 7.2-2 Load Check at Main Steam Outlet Nozzle in MS102

TS

7.2.3.1.3 Conclusion

Base on the above evaluation, it can be concluded that loads applying on SG steam outlet nozzle safe end are within the allowable, and therefore acceptable.

7.2.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.2-3 The Stress at the Flued Head Penetration Anchor in MS102

TS

7.2.3.3 Branch Pipe Connection

There is no Branch Pipe Connection in this piping subsystem.

7.2.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.2-4 The Stress at the Pipe Support Location in MS102

TS

7.2.3.5 Valve

There is no valve in this piping subsystem.

7.2.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.3 MS103

7.3.1 Subsystem Plot

TS

Figure 7.3-1 Subsystem MS103 Plot

7.3.2 Pipe Data Sheet

TS

Figure 7.3-2 Subsystem MS103 Pipe Data Sheet

7.3.3 Piping Stress Evaluation Results

7.3.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the main steam outlet nozzle against maximum nozzle load criteria.

7.3.3.1.1 Criteria Check

Table 7.3-1 Criteria Check at Main Steam Outlet Nozzle in MS103

TS

7.3.3.1.2 Loads Check

Table 7.3-2 Load Check at Main Steam Outlet Nozzle in MS103

TS

7.3.3.1.3 Conclusion

Base on the above evaluation, it can be concluded that loads applying on SG steam outlet nozzle safe end are within the allowable, and therefore acceptable.

7.3.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.3-3 The Stress at the Flued Head Penetration Anchor in MS103 TS

7.3.3.3 Branch Pipe Connection

There is no Branch Pipe Connection in this piping subsystem.

7.3.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.3-4 The Stress at the Pipe Support Location in MS103

TS

7.3.3.5 Valve

There is no valve in this piping subsystem.

7.3.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.4 MS104

7.4.1 Subsystem Plot

TS

Figure 7.4-1 Subsystem MS104 Plot

7.4.2 Pipe Data Sheet

TS

Figure 7.4-2 Subsystem MS104 Pipe Data Sheet

7.4.3 Piping Stress Evaluation Results

7.4.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the main steam outlet nozzle against maximum nozzle load criteria.

7.4.3.1.1 Criteria Check

Table 7.4-1 Criteria Check at Main Steam Outlet Nozzle in MS104

TS

7.4.3.1.2 Loads Check

TS

Table 7.4-2 Load Check at Main Steam Outlet Nozzle in MS104

7.4.3.1.3 Conclusion

Base on the above evaluation, it can be concluded that loads applying on SG steam outlet nozzle safe end are within the allowable, and therefore acceptable.

7.4.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.4-3 The Stress at the Flued Head Penetration Anchor in MS104

TS

7.4.3.3 Branch Pipe Connection

There is no Branch Pipe Connection in this piping subsystem.

7.4.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.4-4 The Stress at the Pipe Support Location in MS104

TS

7.4.3.5 Valve

There is no valve in this piping subsystem.

7.4.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.5 FW101

7.5.1 Subsystem Plot

TS

Figure 7.5-1 Subsystem FW101 Plot

7.5.2 Pipe Data Sheet

TS

Figure 7.5-2 Subsystem FW101 Pipe Data Sheet

7.5.3 Piping Stress Evaluation Results

7.5.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the S/G feedwater economizer nozzle against maximum nozzle load criteria.

7.5.3.1.1 Criteria Check

Table 7.5-1 Criteria Check at Main Feedwater Economizer Nozzle in FW101

TS

7.5.3.1.2 Conclusion

Base on the above evaluation, it can be concluded that loads applying on S/G feedwater economizer nozzle safe ends are within the allowable, and therefore acceptable.

7.5.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.5-2 The Stress at the Flued Head Penetration Anchor in FW101 TS

7.5.3.3 Branch Pipe Connection

The stresses at the branch pipe connection meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.5-3 The Stress at Branch Pipe Connection in FW101 TS

7.5.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.5-4 The Stress at Pipe Support Location in FW101 (1/4)

TS

Table 7.5-4 The Stress at Pipe Support Location in FW101 (2/4)

TS

Table 7.5-4 The Stress at Pipe Support Location in FW101 (3/4)

TS

Table 7.5-4 The Stress at Pipe Support Location in FW101 (4/4)

TS

7.5.3.5 Valve

The stresses calculated at the valve location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.5-5 The Stress at the Valve Location in FW101 (1/2)

TS

Table 7.5-5 The Stress at the Valve Location in FW101 (2/2)

TS

7.5.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.6 FW102

7.6.1 Subsystem Plot

TS

Figure 7.6-1 Subsystem FW102 Plot

7.6.2 Pipe Data Sheet

TS

Figure 7.6-2 Subsystem FW102 Pipe Data Sheet

7.6.3 Piping Stress Evaluation Results

7.6.3.1 Nozzle Load

The purpose of this evaluation is to check the loads at safe-end of the S/G feedwater economizer nozzle against maximum nozzle load criteria.

7.6.3.1.1 Criteria Check

Table 7.6-1 Criteria Check at Main Feedwater Economizer Nozzle in FW102

TS

7.6.3.1.2 Conclusion

Base on the above evaluation, it can be concluded that loads applying on S/G feedwater economizer nozzle safe ends are within the allowable, and therefore acceptable.

7.6.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.6-2 The Stress at the Flued Head Penetration Anchor in FW102 TS

7.6.3.3 Branch Pipe Connection

The stresses at the branch pipe connection meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.6-3 The Stress at Branch Pipe Connection in FW102 TS

7.6.3.4 Pipe Support

The stresses calculated at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.6-4 The Stress at Pipe Support Location in FW102 (1/4)

TS

Table 7.6-4 The Stress at Pipe Support Location in FW102 (2/4)

TS

Table 7.6-4 The Stress at Pipe Support Location in FW102 (3/4)

TS

Table 7.6-4 The Stress at Pipe Support Location in FW102 (4/4)

TS

7.6.3.5 Valve

The stresses calculated at the valve location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.6-5 The Stress at the Valve Location in FW102 (1/2)

TS

Table 7.6-5 The Stress at the Valve Location in FW102 (2/2)

TS

7.6.3.6 Flanged Connection

There is no flanged connection in this piping subsystem.

7.7 MS271

7.7.1 Subsystem Plot

TS

Figure 7.7-1 Subsystem MS271 Plot

7.7.2 Pipe Data Sheet

TS

Figure 7.7-2 Subsystem MS271 Pipe Data Sheet

7.7.3 Piping Stress Evaluation Results

7.7.3.1 Nozzle Load

There is no nozzle in this piping subsystem.

7.7.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.7-1 The Stress at Flued Head Penetration Anchor in MS271 (1/2)

TS

Table 7.7-1 The Stress at Flued Head Penetration Anchor in MS271 (2/2)

TS

7.7.3.3 Penetration Sleeve Anchor Allowable Load Check

7.7.3.3.1 Purpose

The piping penetration anchor is checked to verify to meet the structural integrity not to exceed allowable loads in accordance with the criteria in the applicable codes for the given loads.

7.7.3.3.2 Piping Information

Piping Information

Penetration No.	PC-0612
Side A Subsystem	1-325-P397-MS271, Rev. 04, Node Point 5
Side B Subsystem	1-314-P397-MS103, Rev. 04, Node Point N037

7.7.3.3.3 Analysis Input

Inputs used for the analysis are provided in the following table. Applied loads such as SSE, Pipe Break, Weight, Pressure, etc., are combined to envelop worst case scenario and separate piping loads for both sides of the penetration are considered to the analysis model acting at the same time.

Table 7.7-2 Load Input for Penetration Assembly

TS

7.7.3.3.4 Allowable Load Check for Penetration Assembly

Following table summarizes analysis result for the piping penetration assembly of main steam line. Fatigue evaluation is performed for the MC component to have the result meeting the allowable factor.

Applicable Codes

Piping and Head fitting	ASME Sec. III, Subsection NC
Sleeve	ASME Sec. III, Subsection NE

Table 7.7-3 Allowable Load Check for Penetration Assembly

TS

[ ] TS

Figure 7.7-3 Penetration Assembly Model – MS System

7.7.3.4 Branch Pipe Connection

The stresses calculated at branch pipe connections meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.7-4 The Stress at Branch Pipe Connection in MS271 (1/4) TS

Table 7.7-4 The Stress at Branch Pipe Connection in MS271 (2/4)

TS

Table 7.7-4 The Stress at Branch Pipe Connection in MS271 (3/4) TS

Table 7.7-4 The Stress at Branch Pipe Connection in MS271 (4/4)

TS

7.7.3.5 Pipe Support

The stresses at the support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.7-5 The Stress at Pipe Support Location in MS271 (1/3) TS

Table 7.7-5 The Stress at Pipe Support Location in MS271 (2/3) TS

Table 7.7-5 The Stress at Pipe Support Location in MS271 (3/3)

TS

7.7.3.6 Valve

The stresses at valve connections meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.7-6 The Stress at Valve Location in MS271 (1/5)

TS

Table 7.7-6 The Stress at Valve Location in MS271 (2/5) TS

Table 7.7-6 The Stress at Valve Location in MS271 (3/5)

TS

Table 7.7-6 The Stress at Valve Location in MS271 (4/5) TS

Table 7.7-6 The Stress at Valve Location in MS271 (5/5) TS

7.7.3.7 Flanged Connection

The stresses at flanged connections meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.7-7 The Stress at Flanged Connection in MS271 (1/4) TS

Table 7.7-7 The Stress at Flanged Connection in MS271 (2/4)

TS

Table 7.7-7 The Stress at Flanged Connection in MS271 (3/4)

TS

Table 7.7-7 The Stress at Flanged Connection in MS271 (4/4) TS

7.8 MS272

7.8.1 Subsystem Plot

TS

Figure 7.8-1 Subsystem MS272 Plot

7.8.2 Pipe Data Sheet

TS

Figure 7.8-2 Subsystem MS272 Pipe Data Sheet

7.8.3 Piping Stress Evaluation Results

7.8.3.1 Nozzle Load

There is no nozzle in this piping subsystem.

7.8.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.8-1 The Stress at Flued Head Penetration Anchor in MS272 (1/2)

TS

Table 7.8-1 The Stress at Flued Head Penetration Anchor in MS272 (2/2)

[ ]

7.8.3.3 Penetration Sleeve Anchor Allowable Load Check

7.8.3.3.1 Purpose

The piping penetration anchor is checked to verify to meet the structural integrity not to exceed allowable loads in accordance with the criteria in the applicable codes for the given loads.

7.8.3.3.2 Piping Information

Piping Information

Penetration No.	PC-0611
Side A Subsystem	1-325-P397-MS272, Rev. 04, Node Point 5
Side B Subsystem	1-314-P397-MS104, Rev. 04, Node Point N037

7.8.3.3.3 Analysis Input

Inputs used for the analysis are provided in the following table. Applied loads such as SSE, Pipe Break, Weight, Pressure, etc., are combined to envelop worst case scenario and separate piping loads for both sides of the penetration are considered to the analysis model acting at the same time.

Table 7.8-2 Load Input for Penetration Assembly

TS

7.8.3.3.4 Allowable Load Check for Penetration Assembly

Following table summarizes analysis result for the piping penetration assembly of main steam line. Fatigue evaluation is performed for the MC component to have the result meeting the allowable factor.

Applicable Codes

Piping and Head fitting	ASME Sec. III, Subsection NC
Sleeve	ASME Sec. III, Subsection NE

TS

Table 7.8-3 Allowable Load Check for Penetration Assembly

TS

Figure 7.8-3 Penetration Assembly Model – MS System

7.8.3.4 Branch Pipe Connection

The stresses at branch pipe connection meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.8-4 The Stress at Branch Pipe Connection in MS272 (1/4)

TS

Table 7.8-4 The Stress at Branch Pipe Connection in MS272 (2/4)

TS

Table 7.8-4 The Stress at Branch Pipe Connection in MS272 (3/4)

TS

Table 7.8-4 The Stress at Branch Pipe Connection in MS272 (4/4)

7.8.3.5 Pipe Support

The stresses at the support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.8-5 The Stress at Pipe Support Location in MS272 (1/4)

TS

Table 7.8-5 The Stress at Pipe Support Location in MS272 (2/4)

TS

Table 7.8-5 The Stress at Pipe Support Location in MS272 (3/4)

TS

Table 7.8-5 The Stress at Pipe Support Location in MS272 (4/4)

7.8.3.6 Valve

The stresses at valve connections meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.8-6 The Stress at Valve Location in MS272 (1/4)

TS

Table 7.8-6 The Stress at Valve Location in MS272 (2/4)

TS

Table 7.8-6 The Stress at Valve Location in MS272 (3/4)

TS

Table 7.8-6 The Stress at Valve Location in MS272 (4/4)

7.8.3.7 Flanged Connection

The stresses at flanged connection meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.8-7 The Stress at Flanged Connection in MS272 (1/4)

TS

Table 7.8-7 The Stress at Flanged Connection in MS272 (2/4)

TS

Table 7.8-7 The Stress at Flanged Connection in MS272 (3/4)

TS

Table 7.8-7 The Stress at Flanged Connection in MS272 (4/4)

7.9 FW209

7.9.1 Subsystem Plot

TS

Figure 7.9-1 Subsystem FW209 Plot

7.9.2 Pipe Data Sheet

TS

Figure 7.9-2 Subsystem FW209 Pipe Data Sheet

7.9.3 Piping Stress Evaluation Results

7.9.3.1 Nozzle Load

There is no nozzle in this piping subsystem.

7.9.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.9-1 The Stress at Flued Head Penetration Anchor in FW209

7.9.3.3 Penetration Sleeve Anchor Allowable Load Check

7.9.3.3.1 Purpose

The piping penetration anchor is checked to verify to meet the structural integrity not to exceed allowable loads in accordance with the criteria in the applicable codes for the given loads.

7.9.3.3.2 Piping Information

Piping Information

Penetration No.	PC-0511
Side A Subsystem	1-325-P397-FW209, Rev. 03, Node Point 5
Side B Subsystem	1-315-P397-FW101, Rev. 06, Node Point N165

7.9.3.3.3 Analysis Input

Inputs used for the analysis are provided in the following table. Applied loads such as SSE, Pipe Break, Weight, Pressure, etc., are combined to envelop worst case scenario and separate piping loads for both sides of the penetration are considered to the analysis model acting at the same time.

Table 7.9-2 Load Input for Penetration Assembly

TS

7.9.3.3.4 Allowable Load Check for Penetration Assembly

Following table summarizes analysis result for the piping penetration assembly of main steam line. Fatigue evaluation is performed for the MC component to have the result meeting the allowable factor.

Applicable Codes

Piping and Head fitting	ASME Sec. III, Subsection NC
Sleeve	ASME Sec. III, Subsection NE

Table 7.9-3 Allowable Load Check for Penetration Assembly

TS

TS

Figure 7.9-3 Penetration Assembly Model – FW System

7.9.3.4 Branch Pipe Connection

There is no branch pipe connection in this piping subsystem.

7.9.3.5 Pipe Support

The stresses at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.9-4 The Stress at the Pipe Support Location in FW209

TS

7.9.3.6 Valve

The stresses at valve connection meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.9-5 The Stress at Valve Location in FW209 (1/2)

TS

Table 7.9-5 The Stress at Valve Location in FW209 (2/2)

7.9.3.7 Flanged Connection

There is no flange connection in this piping subsystem.

7.10 FW219

7.10.1 Subsystem Plot

TS

Figure 7.10-1 Subsystem FW219 Plot

7.10.2 Pipe Data Sheet

TS

Figure 7.10-2 Subsystem FW219 Pipe Data Sheet

7.10.3 Piping Stress Evaluation Results

7.10.3.1 Nozzle Load

There is no nozzle in this piping subsystem.

7.10.3.2 Flued Head Penetration Anchor

The stresses at the flued head penetration anchor meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.10-1 The Stress at Flued Head Penetration Anchor in FW219

TS

7.10.3.3 Penetration Sleeve Anchor Allowable Load Check

7.10.3.3.1 Purpose

The piping penetration anchor is checked to verify to meet the structural integrity not to exceed allowable loads in accordance with the criteria in the applicable codes for the given loads.

7.10.3.3.2 Piping Information

Piping Information

Penetration No.	PC-0512
Side A Subsystem	1-325-P397-FW219, Rev. 03, Node Point 5
Side B Subsystem	1-315-P397-AF101, Rev. 03, Node Point 425

7.10.3.3.3 Analysis Input

Inputs used for the analysis are provided in the following table. Applied loads such as SSE, Pipe Break, Weight, Pressure, etc., are combined to envelop worst case scenario and separate piping loads for both sides of the penetration are considered to the analysis model acting at the same time.

TS

Table 7.10-2 Load Input for Penetration Assembly

7.10.3.3.4 Allowable Load Check for Penetration Assembly

Following table summarizes analysis result for the piping penetration assembly of main steam line. Fatigue evaluation is performed for the MC component to have the result meeting the allowable factor.

Applicable Codes

Piping and Head fitting	ASME Sec. III, Subsection NC
Sleeve	ASME Sec. III, Subsection NE

Table 7.10-3 Allowable Load Check for Penetration Assembly

TS

TS

Figure 7.10-3 Penetration Assembly Model – FW System

7.10.3.4 Branch Pipe Connection

There is no branch pipe connection in this piping subsystem.

7.10.3.5 Pipe Support

The stresses at the pipe support location meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

Table 7.10-4 The Stress at Pipe Support Location in FW219 (1/3)

TS

TS

Table 7.10-4 The Stress at Pipe Support Location in FW219 (2/3)

TS

Table 7.10-4 The Stress at Pipe Support Location in FW219 (3/3)

7.10.3.6 Valve

The stresses at valve connections meet all stress limitations specified in paragraphs NC-3650. The stress for each Code equation is tabulated below.

TS

Table 7.10-5 The Stress at Valve Location in FW219 (1/2)

TS

Table 7.10-5 The Stress at Valve Location in FW219 (2/2)

7.10.3.7 Flanged Connection

There is no flange connection in this piping subsystem.

8.0 COMPUTER CODE

8.1 PIPESTRESS 3.9.0

PIPESTRESS is a piping analysis program that is applied to the static and dynamic analyses including response spectra and time-history analyses. PIPESTRESS is used for the analysis of ASME Section III, Class 1, 2, and 3 as well as ASME B31.1 and B31.3 piping systems.

9.0 REFERENCE

1. ASME B&PV Code Section III, 2007 Edition with 2008 Addenda.

2. APR1400 DC Piping Stress Reports for Subsystem 1MS101, 1MS102, 1MS103, 1MS104, 1FW101, 1FW102,1MS271, 1MS272, 1FW209 and 1FW219:
   Calculation No. 1-314-P397-MS101, Rev. 7, dated 05/15/17.
   Calculation No. 1-314-P397-MS102, Rev. 4, dated 04/20/17.
   Calculation No. 1-314-P397-MS103, Rev. 4, dated 04/20/17.
   Calculation No. 1-314-P397-MS104, Rev. 4, dated 04/20/17.
   Calculation No. 1-313-P397-FW101, Rev. 7, dated 05/15/17.
   Calculation No. 1-313-P397-FW102, Rev. 4, dated 04/20/17.
   Calculation No. 1-325-P397-MS271, Rev. 4, dated 07/18/17.
   Calculation No. 1-325-P397-MS272, Rev. 4, dated 07/18/17.
   Calculation No. 1-325-P397-FW209, Rev. 3, dated 04/20/17.
   Calculation No. 1-325-P397-FW219, Rev. 3, dated 04/20/17.

3. Piping and Instrumentation Diagram for MS System and FW System:
   Drawing No. 1-521-M105-001, Rev. 1 dated 01/08/16.
   Drawing No. 1-541-M105-003, Rev. 1, dated 05/22/17.

4. Piping Design Tables and Standard Details, 1-037-P443-001, Rev. 4, dated 08/25/15.

5. Piping System Design Specification (PSDS) :
   General PSDS, 1-037-N407-001, Rev. 1, dated 12/30/14
   IRWST System PSDS, 1-447-N407-001, Rev. 1, dated 02/28/12
   MS System PSDS, 1-521-M407-001, Rev. 0, dated 06/29/15
   FW System PSDS, 1-541-M407-001, Rev. 1, dated 07/30/15

6. PIPESTRESS Computer Program /
   KEPCO E&C Register No. : E-P-PD-1338-3.9.0/DC, and User's Manual.

7. Standard Review Plan, Section 3.6.2, Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping.