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ABWR SSAR
MAIN STEAM, FEEDWATER AND SRVDL
PIPING SYSTEMS
DESIGN CRITERIA AND
ANALYSIS METHODS

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THE CONTENTS OF THIS REPORT

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1.0 PURPOSE

The purpose of this engineering report is to document the engineering requirements used in design and analysis of the advanced BWR (ABWR) main steam, safety/relief valve discharge and feedwater piping systems.

2.0 MAIN STEAM PIPING

2.1 Description

The main steam piping addressed in this report is main steam line A, which runs from the reactor pressure vessel nozzle through the drywell and containment penetration to the outboard main steam isolation valve.

2.2 Boundaries

The boundaries of the main steam piping include the following:

a. The circumferential welded joints at the reactor pressure vessel nozzle and at the inboard isolation valve.

b. The containment sleeve head fitting connection to the main steam piping.

c. The face of the first flange in bolted safety-relief valve connections (the bolts shall be part of the valve).

d. The branch connections where the branch pipes weld to the branch nozzles on the main steam pipes.

2.3 Pipe Attached Components

The main steam isolation valves and safety/relief valves shall be included in the analysis. Small branch lines such as instrument and drain lines are not included in the analysis.

3.0 SAFETY/RELIEF VALVE DISCHARGE PIPING

3.1 Description

The piping addressed in this report consists of four safety/relief valve discharge lines attached to main steam line A, and each one extending from the flange connecting to the safety/relief valve to the first anchor at the diaphragm floor penetration. One wetwell safety/relief valve discharge line extending from the diaphragm floor penetration to the x-quencher in the suppression pool is also addressed in this report.

3.2 Boundaries

The boundaries of the SRV discharge piping include the following:

a. The discharge piping from the safety/relief valve discharge flange to the penetration anchor at the diaphragm floor. This includes the piping connecting the vacuum breaker.

b. The discharge piping from the penetration at the diaphragm floor to the X-quencher in the suppression pool.

c. The diaphragm floor penetration sleeve head fitting connection to the safety/relief valve discharge pipe.

3.3 Pipe Attached Components

The valves, vacuum breakers and X-quenchers shall be included in the analysis. Small branch lines such as instrument and drain lines are not included in the analysis.

4.0. FEEDWATER PIPING

4.1 Description

The piping addressed in this report consists of Feedwater Line A running from the reactor pressure vessel to the containment penetration anchor.

4.2 Boundaries

The boundaries of the feedwater piping include the following:

a. The circumferential welded joint at the reactor pressure vessel nozzle.

b. The circumferential welded joints to all intermediate valves in the feedwater piping.

c. The containment sleeve head fitting connection to the feedwater piping.

d. The weld at branch connections where the branch pipe welds to the branch nozzle on the run pipe.

4.3 Pipe Attached Components

The inboard check and gate valves shall be included in the analysis. Small branch lines such as instrument and drain lines are not included in the analysis.

5.0 DESIGN REQUIREMENTS

5.1 Design Conditions

5.1.1 Piping Design Pressures and Temperatures

The design and operating pressures and temperatures for the main steam, safety/relief valve discharge and feedwater piping are given in Table 2 and are referenced from the document listed in Paragraph 6.n.

5.1.2 Pressure-Temperature Duty Cycles

For main steam and safety/relief valve discharge piping, the pressure-temperature duty cycles to be used in the fatigue analysis are specified in reference document 6.d.

For feedwater piping, the pressure-temperature duty cycles to be used in the fatigue analysis are specified in reference document 6.e.

5.2 ASME Code Classification and Requirements

5.2.1 The main steam pipe connecting the Reactor Pressure Vessel to the isolation valve outside the containment (within the boundaries defined in Paragraph 2.2) is classified as Class 1, Seismic Category I piping and shall meet the requirements for ASME Section III, Class 1 piping components as specified in reference documents 6.a and 6.b.

5.2.2 The feedwater pipe connecting the Reactor Pressure Vessel to the isolation check valve outside the containment (within the boundaries defined in Paragraph 4.2) is classified as Class 1, Seismic Category I piping and shall meet the requirements for ASME Section III, Class 1 piping components as specified in reference documents 6.a and 6.b.

5.2.3 The main steam and feedwater piping supports are classified as Class 1, Seismic Category I supporting structures and shall meet the requirements of ASME Section III, NF per reference documents 6.a and 6.b.

5.2.4 The safety/relief (S/R) valve discharge piping from the flange connecting to the S/R valve to the diaphragm floor penetration anchor is classified as Class 3, Seismic Category I piping and shall meet the requirements for ASME Section III, Class 3 piping components as specified in reference documents 6.a and 6.b.

5.2.5 The safety/relief valve discharge piping supports for the piping described in Paragraph 5.2.4 are classified as Class 3, Seismic Category I supporting structures and shall meet the requirements of ASME Section III, NF per reference documents 6.a and 6.b.

5.2.6 The safety/relief valve discharge piping from the diaphragm floor penetration to the quencher in the suppression pool is classified as Class 2, Seismic Category I piping and shall meet the requirements for ASME Section III, Class 2 piping components as spccified in reference documents 6.a and 6.b.

5.2.7 The safety/relief valve discharge piping supports for the piping described in Paragraph 5.2.6 are classified as Class 2, Seismic Category I supporting struciures and shall meet the requirements of ASME Section III, NF per reference documents 6.a and 6.b.

5.3 <u>Analytical Methods</u>

5.3.1 <u>General</u>

All static and dynamic analysis of piping covered by this specification shall be done in accordance with reference documents 6.a, 6.b and 6.c.

5.3.2 Modeling

5.3.2.1 Mathematical models for piping systems shall be constructed to reflect the dynamic characteristics of the system. The continuous system shall be modeled as an assemblage of pipe elements (straight sections, elbows, and bends) supported by hangers and anchors, and restrained by pipe guides, struts and snubbers. Pipe and hydrodynamic masses are lumped at the nodes and connected by the weightless elastic beam elements which reflect the physical properties of the corresponding piping segment. The node points are selected to coincide with the locations of large masses, such as valves, and with locations of significant geometry changes. All concentrated weights on the piping system, such as the valves, are modeled as lumped mass rigid systems if their fundamental frequencies are greater than the cut-off frequency. The torsional effects of valve operators and other equipment with offset centers of gravity with respect to the piping center line shall be included in the analytical model.

5.3.2.2 If a branch pipe is small, such that the ratio between pipe diameters of branch line to main line is less than one-third, the branch line can be excluded from the piping model of the main line.

5.3.2.3 All pipe guides, restraints and snubbers shall be modeled with a representative stiffness. The stiffness of the supporting structures shall be considered in the analysis.

5.3.3 Cut-Off Frequency for Dynamic Analysis

5.3.3.1 For seismic loads, the dynamic analysis shall include all modes up to a frequency of 33 Hertz.

5.3.3.2 For all other dynamic loads, the dynamic analysis shall include all modes up to a frequency of 60 Hertz.

5.3.3.3 High frequency modes (modes with frequencies greater than 60 Hz) are included in accordance with reference 6.c.

5.3.4 Input Response Spectra

For a subsystem analysis of a secondary system, the input floor response spectra, obtained from a time history analysis of the primary system, shall be peak broadened by ±10 percent to account for modeling uncertainties in the primary and secondary systems.

5.3.5 Dynamic Analysis

5.3.5.1 The response of the piping system to all seismic and dynamic loads filtered through the building structure shall be determined by use of one of the following methods:

a. A response spectrum analysis using an envelope of the response spectra of all of the piping support points for each orthogonal direction of excitation.

b. A multiple response spectrum analysis using the individual response spectrum at each pipe support point for each orthogonal direction of excitation. The response between two or more support groups may be combined by the SRSS method if a support group is defined by supports that have the same time history input.

c. A time history analysis using either the direct integration or modal superposition method.

5.3.5.2 The response of the piping system to dynamic loads not filtered through the building structure (such as pressure waves inside the piping) shall be by direct integration time history analysis.

5.3.5.3 Damping coefficients in terms of percent critical damping to be used in the dynamic analysis are given in Table 1 and are referenced from reference documents 6.a, 6.c, and 6.o.

5.3.6 Response Spectrum Analysis

5.3.6.1 The response spectrum method is a modal superposition analysis in which only the peak values of the inertial response are obtained. The modal responses are combined using the square root of the sum of squares (SRSS) rule to get the total inertial response. Closely spaced modes are combined in accordance with reference 6.c.

5.3.6.2 The support movement of multiple-supported piping subject to seismic and hydrodynamic loads shall be considered. The maximum displacement of each support point can be computed by either time history analysis or response spectrum analysis for the supporting structures. The support displacement loads shall be computed from static analyses in which the displacements are applied at the supports.

5.3.6.3 The inertia and displacement loads are dynamic in nature and their peak values are not expected to occur at the same time. Therefore, the inertia and displacement loads are combined by the SRSS method.

5.3.7 Seismic Loads

5.3.7.1 The seismic analysis shall be performed using the multiple response spectra analysis method. The piping seismic input loads are the appropriately damped and peak broadened horizontal and vertical response spectra at all piping support attachment points. Three sets of inertial results, one for each of the two horizontal seismic excitations and one for the vertical excitation shall be calculated.

5.3.7.2 The total seismic inertial response shall be calculated by combining the colinear responses due to the three orthogonal components of seismic excitation by the square-root-of-the-sum-of-the-squares (SRSS) method.

5.3.7.3 The seismic differential building movement analysis shall be performed for each of the three orthogonal directions and the results shall be combined by the SRSS method.

5.3.8 Hydrodynamic Loads

5.3.8.1 The piping systems shall be analyzed for the hydrodynamic loads due to reactor building vibration (RBV) caused by S/R valve blowdown and LOCA events. The Hydrodynamic loads analysis shall be performed using the envelope or multiple response spectra method. The analysis for each Hydrodynamic load shall be performed using the three orthogonal components of response spectra at all support attachment points.

5.3.8.2 The total inertial response shall be calculated by combining the colinear responses due to the three orthogonal components of excitation by the SRSS method.

5.3.8.3 The differential building movement analysis shall be performed for each hydrodynamic load case in all three orthogonal directions and the results shall be combined by the SRSS method.

5.3.9 Concurrent Dynamic Loads

5.3.9.1 The colinear responses of concurrent dynamic loads shall be combined by the SRSS method.

5.3.10 Thermal Analysis

The thermal expansion analysis of the piping shall account for the predicted radial and vertical movement of the RPV nozzle and building structure due to the temperature and pressure changes in the vessel.

5.4 Design Loads

5.4.1 Seismic Loads

The Safe Shutdown Earthquake (SSE) response spectra and building displacements to be used for the design of the piping systems are contained in the documents referenced in Paragraph 2.f. The operating basis earthquake

(OBE) response spectra shall be one-half of SSE response spectra. The piping fatigue analysis shall be based on five OBE events with 10 stress cycles per event.

5.4.2 Hydrodynamic Loads

Response spectra and building displacements for Hydrodynamic loads due to S/R valve blowdown and LOCA:

a. SRV loads are contained in the document referenced in Paragraph 6.g.

b. LOCA loads are contained in the document referenced in Paragraph 6.g.

5.4.3 Other Loads

5.4.3.1 Safety/Relief Valve Lift Acoustic Load

Safety/relief valve opening time of 20 msec shall be used to calculate the safety-relief valve discharge forcing function acting on the piping. The safety/relief valve set pressure and flow rate are given in the document referenced in Paragraph 6.m.

5.4.3.2 Turbine Stop Valve Closure Acoustic Load

Turbine stop valve closure time and steam flow rate are given in the document referenced in Paragraph 6.m and shall be used to calculate the loads on the piping system due to turbine stop valve closure.

5.4.4 Flooded Load

The main steam line shall be designed such that it may be flooded with cold water. The weight analysis shall confirm that this flooded load condition is acceptable. The flooded load condition shall be included in the piping fatigue analysis per reference 6.d.

5.4.5 Thermal Stratification Load

The feedwater line shall be analyzed for two thermal stratification load cases: (1) thermal stratification in the piping at the RPV nozzle, and (2) thermal stratification in the feedwater header piping. These loads are to be included in the piping fatigue analysis per reference 6.e, and are also to be included in the evaluations of the head fitting and RPV nozzles. The temperature differences for each load are given in reference 6.e.

5.5 Load Combinations and Acceptance Criteria

5.5.1 Piping

Table 3 contains the primary stress load combinations and acceptance criteria for ASME Section III, Classes 1 and 3 (drywell) piping. Table 4 contains the load combinations and acceptance criteria for ASME Section III, Class 2 (wetwell) piping.

5.5.2 Head Fittings

Table 5 contains the load combinations for the Main Steam Head fitting. Table 6 contains the load combinations for the Feedwater Head fitting. Table 7 contains the load combinations for the Diaphragm Floor Head fitting.

5.5.3 Snubbers and Struts

Tables 8 and 14 contain the load combinations and acceptance criteria for snubbers and struts. The acceptance criteria are per ASME III, Subsection NF and Appendix F (referenced in Paragraph 6.b).

5.5.4 Guide

The load combinations for the guide are listed in Table 9. The guide shall be provided by the reactor building designer. The calculated guide loads shall be used to design the Guide.

5.5.5 Main Steam Isolation Val' ı

The load combinations and acceptance criteria for MSIV end loads are given in Table 10.

5.5.6 Feedwater Valves

The load combinations and acceptance criteria for feedwater valve accelerations are given in Table 11.

5.5.7 Safety Relief Valves

The load combinations and acceptance criteria for safety relief valve flange moments are given in Table 12.

5.5.8 Reactor Pressure Vessel Nozzles

The load combinations and acceptance criteria are given in Table 13.

5.6 Materials

5.6.1 Main Steam Piping

The material for the piping shall be as listed below.

a. Piping - ASTM/ASME SA333 Gr. 6
b. Fittings - ASTM/ASME SA420
c. Forged Fittings and Flanges - ASTM/ASME SA350 LF2

5.6.2 Safety/Relief Valve Discharge Piping

The material for the piping shall be as listed below.

		Drywell Piping	Wetwell Piping
a.	Piping -	ASTM/ASME SA333 Gr. 6, Sch. 80	ASTM/ASME SA 376 smls. TP316 .05% max. carbon
b.	Fittings -	ASTM/ASME SA420	ASTM/ASME SA 403 TP 316 .05% max. carbon
c.	Forged Fittings and Flanges -	ASTM/ASME SA350 LF2	

5.6.3 Feedwater Piping

The material for the piping shall be as listed below.

a. Piping - ASTM/ASME SA333 Gr. 6, Schedule 100
b. Fittings - ASTM/ASME SA420
c. Forged Fittings and Flanges - ASTM/ASME SA350 LF2

6.0 REFERENCE DOCUMENTS

a. ABWR SSAR

b. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code 1986 Edition
Section II, Material Specifications
Section III, Nuclear Power Plant Components, Division 1

(1) Subsection NCA, General Requirements
(2) Subsection NB, Class 1 Components
(3) Subsection NC, Class 2 Components
(4) Subsection ND, Class 3 Components
(5) Subsection NF, Component Supports
(6) Appendix F

c. USNRC Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants"

USNRC Regulatory Guide 1.92, "Combination of Closely Spaced Modes in Response Spectrum Method of Analysis"

USNRC SRP Section 3.7.2, Rev. 0 August 1989, High Frequency Modes

d. "Reactor Cycles," G.E. Document No. 796E243

"Main Steam and RCIC Press/Temp Cycle Chart and Load Set," G.E. Document No. 103E1415

e. "Feedwater MITI Class 1 and 3 Piping Cycles," G.E. Document No. 796E852

"Feedwater Press/Temp Cyc Chart and Load Set," G.E. Document No. 103E1414

f. "Seismic Soil - Structure Interaction Analysis for Reactor Building Complex of ABWR Standard Plant," G.E. Document No. xxxxx

g. "Response of Structures to Containment Loads," G.E. Document No. 299X700-001

h. Reactor Vessel Assembly Drawing, G.E. Doc. No. 795E997

i. Reactor Vessel Nozzles Drawing, G.E. Doc. No. 112D3124

j. Main Steam Isolation Valve - ERS, G.E. Doc. No. 23A6241

k. Safety/Relief Valve - ERS, G.E. Doc. No. 23A6074

l. Feedwater Check and Gate Valves - ERS, G.E. Doc. No. 23A6089

m. Nuclear Boiler System - Design Specification, G.E. Doc. No. 22A8446

n. Nuclear Boiler System - P&ID, G.E. Doc. No. 795E877

o. ASME Code Case N-411-1, Alternative Damping Values for Response Spectra Analysis of Class 1, 2, and 3 Piping, Section III, Division 1.

Table 1
DAMPING VALUES

Component	Damping Value (Percent)* Level B	Level D
Smaller diameter piping systems (<12 inch diameter)	1.0	2.0
Pump, Valve, and large diameter piping systems	2.0	3.0
Snubber	4.0	7.0
Strut	4.0	7.0
Anchor, Guide, Hanger	1.0	2.0

*Damping values of ASME code case N-411-1 (Ref. 6.0) may be used with the Enveloped response spectra method of analysis.

Table 2

DESIGN AND OPERATING PRESSURES AND TEMPERATURES

System	Pressure (psig)		Temperature (°F)	
	Design	Normal Operating	Design	Normal Operating
Main Steam	1250	1050	575	552
Feedwater	1250	1100	575	420
Safety Relief Valve Discharge Line	540	0	480	135

Table 3

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR
ASME SECTION III - CLASS 1 AND 3 (DRYWELL) PIPING

Service Level	Load Combinations	Acceptance Criteria	
		Class 1	Class 3
Design	PD+W	1.5 Sm	1.5 Sh
Level B	PP+W+RV1+OBE PP+W+RV2+OBE PP+W+TSV+OBE	1.8 Sm 1.5 Sy	1.8 Sh 1.5 Sy
Level C	PP+W+CHUG+RV1 PP+W+CHUG+RV2	2.25 Sm 1.8 Sy	2.25 Sh 1.8 Sy
Level D	PP+W+SSE+CHUG+RV1 PP+W+SSE+CHUG+RV2 PP+W+SSE+CO+RV1 PP+W+SSE+CO+RV2 PP+W+SSE+TSV PP+W+SSE+AP PP+W+RV1+TSV PP+W+RV2+TSV	3.0 Sm 2.0 Sy	3.0 Sh 2.0 Sy

NOTES:

1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484, Revision 1)
2. Anchor Motions not included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend given on sheet 30

Table 4

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR
ASME SECTION III CLASS 2 WETWELL PIPING

Service Level	Load Combination	Acceptance Criteria
Design	PD+W	1.5 Sh
Level A&B	PP, W, RV1, OBE	1.8 Sh
	PP, W, RV2, ADJQ, OBE	1.5 Sy
	PP, W, AIRC, OBE	
	PP, W, WJET, OBE	
Level C	PP, W, CHUG, CHUGW, RV1	2.25 Sh
	PP, W, CHUG, CHUGW, RV2, ADJQ	1.8 Sy
	PP, W, CHUG, CHUGW, AIRC	
	PP, W, CHUG, CHUGW, WJET	
Level D	PP, W, SSE, CHUG, CHUGW, RV2, ADJQ	3.0 Sh
	PP, W, SSE, CHUG, CHUGW, RV1	2.0 Sy
	PP, W, SSE, CHUG, CHUGW, AIRC	
	PP, W, SSE, CHUG, CHUGW, WJET	
	PP, W, SSE, CO, COW, RV1	
	PP, W, SSE, CO, COW, RV2, ADJQ	
	PP, W, SSE, CO, COW, AIRC	
	PP, W, SSE, CO, COW, WJET	
	PP, W, SSE, WJETMV	
	PP, W, SSE, AIRBB, PSWLY	
	PP, W, SSE, AP	

NOTES:

1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484, Rev. 1)
2. Anchor Motions not included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend given on sheet 30.

Table 5

LOAD COMBINATIONS FOR MAIN STEAM HEAD FITTING

Service Level	Load Combination
Design/A&B (Primary)	W, RV2, OBE W, RV1, OBE W, TSV, OBE
Level A&B (Primary+Secondary)	W, RV2, TE, OBE W, RV1, TE, OBE W, TSV, TE, OBE
Level C (Primary)	W, CHUG, RV2 W, CHUG, RV1 W, CHUG, TSV
Level D (Primary)	W, RV2, SSE W, RV1, SSE W, TSV, SSE
Level D (Primary)	W, CHUG, SSE, RV2 W, CHUG, SSE, RV1 ~~W, CHUG, SSE, TSV~~ W, CO, SSE, RV2 W, CO, SSE, RV1 ~~W, CO, SSE, TSV~~ W, SSE, AP W, RV1, TSV W, RV2, TSV W, SSE, TSV

NOTES:

1. Dynamic loads combined by SRSS method.
2. Anchor Motions included in above primary plus secondary load combination.
3. Level C loads are for SBL. This includes VLC and Chugging, Chugging controls.
4. Load definition legend is given on sheet 30.

Table 6

LOAD COMBINATIONS FOR FEEDWATER HEAD FITTING

Service Level	Load Combination
Design/A&B Level A&B (Primary+Secondary)	W, RV2, OBE W, RV2, OBE, TE W, TE, STRAH W, TE, STRAN
Level C	W, CHUG, RV2
Level D	W, CHUG, SSE, RV2 W, CO, SSE, RV2 W, SSE, AP

NOTES:

1. Dynamic loads combined by SRSS method.
2. Anchor Motions included in above primary plus secondary load combination.
3. Level C loads are for SBL. This includes VLC and Chugging, Chugging controls.
4. Load definition legend is given on sheet 30.

Table 7

LOAD COMBINATIONS FOR DIAPHRAGM FLOOR HEAD FITTING

Service Level	Load Combination
Design	W, RV1, OBE
Level A&B	W, TSV, OBE
	W, RV2, ADJQ, OBE
	W, AIRC, OBE
	W, WJET, OBE
Level C	W, CHUG, CHUGW, RV1
	W, CHUG, CHUGW, RV2, ADJQ
	W, CHUG, CHUGW, AIRC
	W, CHUG, CHUGW, WJET
Level D	W, SSE, CHUG, CHUGW, RV2, ADJQ
	W, SSE, CHUG, CHUGW, RV1
	W, SSE, CHUG, CHUGW, AIRC
	W, SSE, CHUG, CHUGW, WJET
	W, SSE, CO, COW, RV1
	W, SSE, CO, COW, RV2, ADJQ
	W, SSE, CO, COW, AIRC
	W, SSE, CO, COW, WJET
	W, SSE, WJETMV
	W, SSE, AIRBB, PSWLY
	W, SSE, AP

NOTES:

1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484)
2. Anchor motions not included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend is given on sheet 30.

Table 8

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR SNUBBERS

Service Level	Load Combinations	Acceptance Criteria
Design Level B	RV1+OBE RV2+OBE TSV+OBE	1.0 x snubber rated load
Level C	CHUG+RV1 CHUG+RV2	1.33 x snubber rated load
Level D	SSE+CHUG+RV1 SSE+CHUG+RV2 SSE+CO+RV1 SSE+CO+RV2 SSE+TSV SSE+AP RV1+TSV RV2+TSV	1.5 x snubber rated load

NOTES:

1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484)
2. Anchor Motions are included in abovc load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend is given on sheet 30.

Table 9

LOAD COMBINATIONS FOR GUIDES

Service Level	Load Combinations
Design	W+TE+STRAH W+TE+STRAN
Level B	W+TE+TSV+OBE W+TE+RV1+OBE W+TE+RV2+OBE
Level C	W+TE+CHUG+RV1 W+TE+CHUG+RV2
Level D	W+TE+SSE+CHUG+RV1 W+TE+SSE+CHUG+RV2 W+TE+SSE+CO+RV1 W+TE+SSE+CO+RV2 W+TE+SSE+TSV W+TE+SSE+AP W+TE+RV1+TSV W+TE+RV2+TSV

NOTES:

1. Dynamic loads combined by SRSS. (Per SSAR reference to NUREG-0484, Rev. 1)
2. Anchor Motions are included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend given on sheet 30.

Table 10

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA
FOR MSIV AT VALVE ENDS

Service Level	Load Combinations	Acceptance Criteria
Design	PD + W + TE	MA/2Z < 0.75 Sm SQRT (MB^2+MC^2) < 0.75 Sm FA + PD/4t < 0.75 Sm
Level B	PP, W, TE, RV1, OBE PP, W, TE, RV2, OBE PP, W, TE, TSV, OBE	MA/2Z < 2.0 Sm SQRT (MB^2+MC^2) < 2.0 Sm FA + PD/4t < 2.0 Sm
Level C	PP, W, TE, CHUG, RV1 PP, W, TE, CHUG, RV2	MA/2Z < 2.0 Sm SQRT (MB^2+MC^2) < 2.0 Sm FA + PD/4t < 2.0 Sm
Level D	PP, W, TE, SSE, CHUG, RV1 PP, W, TE, SSE, CHUG, RV2 PP, W, TE, SSE, CO, RV1 PP, W, TE, SSE, CO, RV2 PP, W, TE, SSE, TSV PP, W, TE, SSE, AP PP, W, TE, RV1, TSV PP, W, TE, RV2, TSV	MA/2Z < 2.0 Sm SQRT (MB^2+MC^2) < 2.0 Sm FA + PD/4t < 2.0 Sm

NOTES:

1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484)
2. Anchor Motions are included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend is given on sheet 30.

Table 11

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA
FOR FEEDWATER VALVES

Service Level	Load Combinations	Acceptance Criteria Feedwater Valves
Design Level B	RV1+OBE RV2+OBE	3g limit in each of the three orthogonal directions
Level C	CHUG+RV1 CHUG+RV2	
Level D	SSE+CHUG+RV2 SSE+CO+RV2 SSE+AP	

NOTES:

1. Dynamic loads are combined by SRSS method.
2. Level C loads are for SBL. This includes VLC and Chugging, Chugging controls.
3. Load definition legend is given on sheet 30.

Table 12

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA
FOR SAFETY RELIEF VALVE - INLET AND OUTLET FLANGES

Purpose Of Limit	Operating Condition	Load Combinations	Acceptance Criteria Max. Applied Moment (K-in)	Basis of Acceptance Criteria
Code Structural Integrity	Level A&B	W+TE(MY&MZ)	Inlet: 355 Outlet: 355	ASME III - Appendix XI
Ditto		W+TE+RV1+OBE W+TE+RV2+OBE W+TE+TSV+OBE	Inlet: 850 Outlet: 735	ASME III - NB 3658.1 ASME III - ND 3658.1
Ditto	Level C	W+TE+CHUG+RV1 W+TE+CHUG+RV2	Inlet: 1350 Outlet: 1110	ASME III - NB 3658.2 ASME III - ND 3658.2
Ditto	Level D	W+TE+SSE+CHUG+RV1 W+TE+SSE+CHUG+RV2 W+TE+SSE+CO+RV1 W+TE+SSE+CO+RV2 W+TE+SSE+TSV W+TE+SSE+AP W+TE+RV1+TSV W+TE+RV2+TSV	Inlet: 1350 Outlet: 1110	ASME III - NB 3658.3 ASME III - ND 3658.3
Leakage	Level A&B	W+TE (MX+MY+MZ)	Outlet: 215	Limit is 320 K-in minus 104 K-in for fitup
Structural/ Operability	Level C	W+TEMAX(MX+MY+MZ)	Inlet: 355 Outlet: 355	Same as Level A&B Same as Level A&B
Structural/ Operability	Level D	W+TEMAX(MX+MY+MZ)	Inlet: 695 Outlet: 495	Limit = 800,000 in-lbs minus 104 K-in for fitup Limit = 600,000 in-lbs minus 104 K-in for fitup

NOTES:
1. Dynamic loads combined by SRSS. (SSAR refers to NUREG-0484)
2. Anchor Motions are included in above.
3. Level C loads are for SBL. This includes VLC and Chugging. Chugging controls.
4. Load definition legend is given on sheet 30.

Table 13

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA
FOR REACTOR PRESSURE VESSEL NOZZLES

Operating Condition	Load Combination	Acceptance Criteria[1]
Design	PD, W, RV2, OBE PD, W, TSV, OBE PD, W, RV1, OBE	M/Z+F/A+PS < 1.5 Sm[2]
Level B[3]	PP, W, RV2, TE, TSV, RV1, OBE PP, TE, STRAH, STRAN	M/Z+F/A+PS < 3.0 Sm
Level C	PP, W, CHUG, RV1 PP, W, CHUG, RV2	M/Z+F/A+PS < 1.8 Sm and 1.5 Sy
Level D	PP+W+SSE+CHUG+RV1 PP+W+SSE+CHUG+RV2 PP+W+SSE+CO+RV1 PP+W+SSE+CO+RV2 PP+W+SSE+TSV PP+W+SSE+AP PP+W+RV1+TSV PP+W+RV2+TSV	M/Z+F/A+PS < Su

NOTES:

1. The term for bending stress in the acceptance criteria equations (M/Z) shall be increased by the addition of two factors:
   (a) A shape factor to account for the geometry of the RPV nozzle at the point of consideration.
   (b) A factor, not greater than 1.2, to ensure adequate margin in piping loads applied to RPV nozzle.

2. The terms in the above stress equation are defined as follows:

   M = MR+(d)HR, where: $MR = (MX^2+MY^2+MZ^2)^{0.5}$, is applied moment, HR, $(FB^2 + FC^2)^{0.5}$, is applied shear, and d is distance from point where HR is applied to section of RPV nozzle under consideration.
   Z = Section modulus of RPV nozzle at location under consideration.
   F = Axial force at pipe-nozzle interface
   A = Cross sectional area of RPV nozzle at location under consideration.
   PS = Longitudinal pressure stress plus radial pressure stress at locatio of RPV nozzle under consideration.

3. Anchor motions are included in Level B load combinations.

4. Load definition legend is given on sheet 30.

Table 14

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR STRUTS

Service Level	Load Combinations	Acceptance Criteria
Design	W+TE	1.0 x Equipment Rating
Level B	W+TE+RV1+OBE W+TE+RV2+ADJQ+OBE W+TE+AIRC+OBE W+TE+WJET+OBE	1.0 x Equipment Rating
Level C	W+TE+CHUG+CHUGW+RV1 W+TE+CHUG+CHUGW+RV2+ADJQ W+TE+CHUG+CHUGW+AIRC W+TE+CHUG+CHUGW+WJET	1.33 x Equipment Rating
Level D	W+TE+SSE+CHUG+CHUGW+RV2+ADJQ W+TE+SSE+CHUG+CHUGW+RV1 W+TE+SSE+CHUG+CHUGW+AIRC W+TE+SSE+CHUG+CHUGW+WJET W+TE+SSE+CO+COW+RV1 W+TE+SSE+CO+COW+RV2+ADJQ W+TE+SSE+CO+COW+AIRC W+TE+SSE+CO+COW+WJET W+TE+SSE+WJETMV W+TE+SSE+AIRBB+PSWLY W+TE+SSE+AP	1.5 x Equipment Rating

NOTES:

1. Dynamic loads combined by SRSS. (Per SSAR reference to NUREG-0484, Rev. 1)
2. Anchor Motions are included in above load combinations.
3. Level C loads are for SBL. This includes VLC and Chugging, Chugging controls.
4. Load definition legend given on sheet 30.

LOAD DEFINITION LEGEND:

ADJQ	Air clearing load from active quencher acting on adjacent inactive quencher
AIRBB	Air bubble from main vent opening
AIRC	Air clearing load from active quencher acting on that same quencher's arms
AP	Reactor Building Vibration (RBV) loads from Annulus Pressurization loads due to postulated main steam line, feedwater line and residual heat removal pipe breaks
CHUG	RBV dynamic loads on structures, systems and components induced by chugging
CHUGW	Chugging wetwell pressure load
CO	Hydrodynamic loads from condensation oscillation
COW	Condensation oscillation wetwell pressure load
OBE	Operating Basis Earthquake
PD	Design Pressure
PP	Peak Pressure
PSWLY	Pool Swell
RV1	Safety Relief Valve lift fluid transient, applies only to main steam and safety/relief valve discharge lines
RV2	Hydrodynamic loads induced by discharge of all safety/relief valves

LOAD DEFINITION LEGEND (Continued)

SSE	Safe shutdown earthquake
STRAH	Loads due to thermal stratification in the feedwater header piping
STRAN	Loads due to thermal stratification in the feedwater piping at the RPV nozzle
TE	Thermal expansion
TSV	Turbine stop valve closure induced loads on main steam line
VLC	Vent Line Clearing Hydrodynamic load
W	Weight
WJET	Water jet load from active quencher acting on adjacent inactive quencher
WJETMV	Water jet from main vent opening