## Summary of Environmental Fatigue Analysis Results for the US-APWR Reactor Coolant Loop Branch Piping

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### **Revision History**

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### Abstract

This report provides the Environmental Fatigue analyses results of Reactor Coolant Loop (RCL) Branch Piping in support of the US-APWR DCD Review process and complies with USNRC Regulator Guide 1.207 (Reference 2).

Based on the results summarized in this report, it is concluded that the US-APWR RCL Branch Piping satisfies the recommendations for environmental fatigue contained in USNRC Regulatory Guide 1.207.

## Table of Contents

LIST	OF T/	ABLES	.
LIST	OF FI	GURES	. V
LIST	OF A	CRONYMS	VI
1.0	INTR	ODUCTION	1-1
2.0	SUM	MARY OF RESULTS AND CONCLUSION	2-1
3.0	NOM	IENCLATURE	3-1
4.0	ASSI	JMPTIONS AND OPEN ITEMS	1-1
	4.1	Assumptions	1-1
	4.2	Open Items	1-1
5.0	ACCI	EPTANCE CRITERIA	5-1
6.0	CALC	CULATION	3-1
	6.1	Analysis Approach	3-1
	6.2	Basic Consideration	3-1
	6.3	Environmental Fatigue Analysis Methodology	3-2
7.0	СОМ	IPUTER CODE USED IN CULCULATION	7-1
8.0	ENVI	RONMENTAL FATIGUE ANALYSIS RESULTS	3-1
	8.1	RC01 (Pressurizer Surge Line)	3-7
	8.2	RC02 (Pressurizer Spray Line)8-	-22
	8.3	RC03 (Pressurizer Safety Depressurization Valve Line)8-	.33
	8.4	RC04 (Pressurizer Safety Valve Line)8-	40
	8.5	RH01 (RHR Suction Loop A Line)8-	45
	8.6	RH02 (RHR Suction Loop B Line)8-	49
	8.7	RH05 (RHR Return Loop A Line)8-	.53

	8.8	RH06	(RHR Return Loop B Line)	8-57
	8.9	SI01	(Accumulator Loop A Line)	8-61
	8.10	SI02	(Accumulator Loop B Line)	8-64
	8.11	SI05	(DVI A Line)	8-67
	8.12	SI06	(DVI B Line)	8-70
	8.13	CS01	(CVCS Charging Line)	8-73
	8.14	CS02	(CVCS Let Down Line)	8-82
	8.15	CS04	(Seal Injection A Line)	8-94
	8.16	CS05	(Seal Injection B Line)	8-97
	8.17	CS06	(Seal Injection C Line)	8-100
	8.18	CS07	(Seal Injection D Line)	8-103
9.0	REFE	ERENC	ES	9-1

APPENDIX 1 DESIGN TRANSIENTS	41	-	1
------------------------------	----	---	---

### List of Tables

Table 2.0-1	Summary of Environmental Fatigue Evaluation for Class 1 Branch Pining	2-1
Table 3.0-1	Symbol and Definition	3-1
Table 7.0-1	Computer Program Description	7-1
Table 8.0-1	The Results of Environmental Fatigue Evaluation for Class 1 Branch Piping	8-2
Table 8.0-2	The detail of analysis results for most severe point	8-5
Table 8.1-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC01 Pressurizer Surge Line	8-9
Table 8.1-2	Environmental Usage Factor RC01 Pressurizer Surge Line	8-13
Table 8.2-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC02 Pressurizer Spray Line	8-28
Table 8.2-2	Environmental Usage Factor RC02 Pressurizer Spray Line	8-30
Table 8.3-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC03 Pressurizer Safety Depressurization Valve Line	8-37
Table 8.3-2	Environmental Usage Factor RC03 Pressurizer Safety Depressurization Valve Line	8-38
Table 8.4-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC04 Pressurizer Safety Valve Line	8-42
Table 8.4-2	Environmental Usage Factor RC04 Pressurizer Safety Valve Line	8-43
Table 8.5-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RH01 RHR Suction Loop A Line	8-48
Table 8.6-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RH02 RHR Suction Loop B Line	8-52
Table 8.7-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RH05 RHR Return Loop A Line	8-56
Table 8.8-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RH06 RHR Return Loop B Line	8-60
Table 8.9-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for SI01 Accumulator Loop A Line	8-63
Table 8.10-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for SI02 Accumulator Loop B Line	8-66
Table 8.11-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for SI05 DVI A Line	8-69
Table 8.12-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for SI06 DVI B Line	8-72
Table 8.13-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS01 CVCS Charging Line	8-75
Table 8.13-2	Environmental Usage Factor CS01 CS01 CVCS Charging Line	8-78
Table 8.14-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS02 CVCS Let Down Line	8-86
Table 8.14-2	Environmental Usage Factor CS02 CVCS Let Down Line	8-87

Table 8.15-1	Usage Factor based on NUREG/CR-6909 Design Fatigue	8-96
Table 8.16-1	Usage Factor based on NUREG/CR-6909 Design Fatigue	8-99
Table 8.17-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS06 CVCS Seal Injection C Line	8-102
Table 8.18-1	Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS07 CVCS Seal Injection D Line	8-105
Table A1-1	Pressurizer surge line design transients	A1-1
Table A1-2	Pressurizer spray line design transients	A1-8
Table A1-3	Pressurizer safety depressurization valve line design transients	A1-10
Table A1-4	Pressurizer safety valve line design transients	A1-12
Table A1-5	RHRS suction loop A line design transients	A1-14
Table A1-6	RHRS suction loop B line design transients	A1-16
Table A1-7	RHR return line design transients	A1-18
Table A1-8	Accumulator line design transients	A1-20
Table A1-9	DVI line design transients	A1-22
Table A1-10	CVCS charging line design transients	A1-25
Table A1-11	CVCS let down line design transients	A1-28
Table A1-12	CVCS seal injection line design transients	A1-31

## List of Figures

Figure 6.3-1	Environmental Fatigue Analysis Approach	6-7
Figure 6.3-2	Portion for calculating strain rate (1)	6-8
Figure 6.3-3	Portion for calculating strain rate (2)	6-9
Figure 8.1-1	Most sever point for RC01 Pressurizer Surge Line	8-8
Figure 8.1-2	Time history of strain, strain rate and metal temperature	8-17
	for RC01 Pressurizer Surge Line	
Figure 8.2-1	Most sever point for RC02 Pressurizer Spray Line	8-23
Figure 8.2-2	Time history of strain, strain rate and metal temperature	8-32
	for RC02Pressurizer Spray Line	
Figure 8.3-1	Most sever point for RC03 Pressurizer Safety	8-34
	Depressurization Valve Line	
Figure 8.3-2	Time history of strain, strain rate and metal temperature	8-39
	for RC03 Pressurizer Safety Depressurization Valve Line	
Figure 8.4-1	Most sever point for RC04 Pressurizer Safety Valve Line	8-41
Figure 8.4-2	Time history of strain, strain rate and metal temperature	8-44
	for RC04 Pressurizer Safety Valve Line	
Figure 8.5-1	Most sever point for RH01 RHR Suction Loop A Line	8-46
Figure 8.6-1	Most sever point for RH02 RHR Suction Loop B Line	8-50
Figure 8.7-1	Most sever point for RH05 RHR Return Loop A Line	8-54
Figure 8.8-1	Most sever point for RH06 RHR Return Loop B Line	8-58
Figure 8.9-1	Most sever point for SI01 Accumulator Loop A Line	8-62
Figure 8.10-1	Most sever point for SI02 Accumulator Loop B	8-65
Figure 8.11-1	Most sever point for SI05 DVI A Line	8-68
Figure 8.12-1	Most sever point for SI06 DVI B Line	8-71
Figure 8.13-1	Most sever point for CS01 CVCS Charging Line	8-74
Figure 8.13-2	Time history of strain, strain rate and metal temperature	8-81
	for CS01 CVCS Charging Line	
Figure 8.14-1	Most sever point for CS02 CVCS Let Down Line	8-83
Figure 8.14-2	Time history of strain, strain rate and metal temperature	8-88
	for CS02 CVCS Let Down Line	
Figure 8.15-1	Most sever point for CS04 CVCS Seal Injection A Line	8-95
Figure 8.16-1	Most sever point for CS05 CVCS Seal Injection B Line	8-98
Figure 8.17-1	Most sever point for CS06 CVCS Seal Injection C Line	8-101
Figure 8.18-1	Most sever point for CS07 CVCS Seal Injection D Line	8-104

### List of Acronyms

The following list defines the acronyms used in this document.

ANL	Argonne National Laboratory
ASME	American Society of Mechanical Engineers
DCD	Design Control Document
DO	Dissolved oxygen
DVI	Direct Vessel Injection
JSME	Japan Society of Mechanical Engineering
LWR	Light Water Reactor
PZR	Pressurizer
PWR	Pressurized Water Reactor
RCL	Reactor Coolant Loop
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHRS	Residual Heat Removal System
R.G	Regulator Guide
RT	Room Temperature
RV	Reactor Vessel
SIS	Safety Injection System
SG	Steam Generator
USNRC	U.S. Nuclear Regulatory Commission
CVCS	Chemical and Volume Control System

#### 1.0 INTRODUCTION

This report summarizes environmental fatigue analysis for class 1 branch piping in Section III of the ASME Code (Reference 1). It has been prepared in support of the US-APWR DCD Review process and complies with USNRC Regulator Guide 1.207 (Reference 2),.

The pressure boundary of the class 1 branch piping which are in contact with the primary coolant fluid are required to be evaluated for fatigue incorporating the life reduction of the metal components due to the effect of the light-water reactor (LWR) environment.

Environmental fatigue analysis has been performed in accordance with the Regulatory Guide 1.207. The methodology includes calculation of the usage factor in air based on ASME Code analysis procedure with the new fatigue design curve developed from the Argonne National Laboratory (ANL) model, and then employing the environmental correction factor (F<sub>en</sub>) as described in NUREG/CR-6909 (References 3).

This analysis report provides the environmental fatique analysis results for US-APWR Class 1 branch piping. Fatigue analyses in air based on ASME Code Section III had been previously submitted to the USNRC.

The environmental fatigue analyses for other Class 1 components of the US-APWR are documented in a separate report (References 8).

#### 2.0 SUMMARY OF RESULTS AND CONCLUSION

The most limiting results for environmental fatigue for each pipe segment are listed in Table 2-1.

Based on the results summarized in this report, it is concluded that the Class 1 branch piping in Section III of the ASME Code for US-APWR satisfies the recommendations for environmental fatigue contained in USNRC Regulatory Guide 1.207.

#### Table 2.0-1 Summary of Environmental Fatigue Evaluation for Class 1 Branch Piping (1/2)

Piping	Material	Usage Factor in air based on ASME <sup>1)</sup>	NUREG (air) U <sup>2)</sup>	NUREG (LWR) U <sub>en</sub> <sup>3)</sup>
RC01 Pressurizer Surge Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RC02 Pressurizer Spray Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RC03 Pressurizer Safety Depressurization Valve Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RC04 Pressurizer Safety Valve Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RH01 RHR Suction Loop A Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RH02 RHR Suction Loop B Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RH05 RHR Return Loop A Line	SA-312(Sml)TP316 (Austenic stainless steel)			
RH06 RHR Return Loop B Line	SA-312(Sml)TP316 (Austenic stainless steel)			
SI01 Accumulator Loop A Line	SA-312(Sml)TP316 (Austenic stainless steel)			
SI02 Accumulator Loop B Line	SA-312(Sml)TP316 (Austenic stainless steel)			
SI05 DVI A Line	SA-312(Sml)TP316 (Austenic stainless steel)			
SI06 DVI B Line	SA-312(Sml)TP316 (Austenic stainless steel)			
CS01 CVCS Charging Line	SA-312(Sml)TP316 (Austenic stainless steel)			
CS02 CVCS Let Down Line	SA-312(Sml)TP316 (Austenic stainless steel)			
CS04 CVCS Seal Injection A Line	SA-312(Sml)TP316 (Austenic stainless steel)			
CS05 CVCS Seal Injection B Line	SA-312(Sml)TP316 (Austenic stainless steel)			

#### Table 2.0-1 Summary of Environmental Fatigue Evaluation for Class 1 Branch Piping (2/2)

Piping	Material	Usage Factor in air based on ASME <sup>1)</sup>	NUREG (air) U <sup>2)</sup>	NUREG (LWR) U <sub>en</sub> <sup>3)</sup>
CS06 CVCS Seal Injection C	SA-312(Sml)TP316			
Line	(Austenic stainless steel)			
CS07 CVCS Seal Injection D	SA-312(Sml)TP316			
Line	(Austenic stainless steel)			

Note:

- 1) Cumulative usage factor in air based on ASME fatigue design curve
- 2) Cumulative usage factor in air based on NUREG/CR-6909 fatigue design curve
- 3) Cumulative usage factor in LWR environment
- 4) The environmental fatigue requirement is satisfied, because cumulative usage factor based on the NUREG new fatigue curve is less than 0.0689 (See Sec. 8).

#### 3.0 NOMENCLATURE

Table 3.0-1	Symbol	and	Definition
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Symbol	Definition
α	Coefficient of thermal expansion
C <sub>1</sub> ,C <sub>2</sub> ,C <sub>3</sub>	Secondary stress indices
ε	Strain
Ė	Strain rate
$\Delta arepsilon_k$	Increment of strain for the k-th increment segment
$\dot{arepsilon}'_k$	Strain rate for the k-th increment segment
${\cal E}_A$	Strain for transient A
${\cal E}_B$	Strain for transient B
Ė	Transformed strain rate
E	Modulus of elasticity of the material
F <sub>en</sub>	Environmental fatigue correction factor
F <sub>en,nom</sub>	Nominal environmental fatigue correction factor
F <sub>en i</sub>	Environmental fatigue correction factor for "i" <sup>th</sup> stress cycle
$F_{en,k}$	Environmental fatigue correction factor for the k-th increment segment
$F_{en,A}$	Environmental fatigue correction factor for transient A
F <sub>en,B</sub>	Environmental fatigue correction factor for transient B
K <sub>e</sub>	Multiplier in the fatigue (NB-3228.5 of ASME Code)
$K_{1}, K_{2}, K_{3}$	Local stress indices
ni	Number of cycles of load set
Ni	Allowable number of stress cycles
υ	Poisson's ratio
$O^{'}$	Transformed dissolved oxygen
Salt	Alternating stress intensity
Sp	Peak stress intensity
$\Delta \operatorname{Sp}_{\operatorname{dom},k}$	Incremeent of dominant stress of Sp for the k-th increment segment
I T	Temperature for the k-th increment segment
	Absolute value of the range of the temperature difference between the
$\Delta$ I 1	temperature of the outside $T_0$ and the temperature of the inside surface $T_1$ of the piping product assuming moment generating equivalent linear temperature distribution.
$\Delta T_2$	Absolute valve of the range for that partion of the nonlinear thermal gradient through the wall thickness not included in $\Delta T_{1}$ .

Symbol	Definition
T <sub>a</sub> -T <sub>b</sub>	Structual discontinuity temperature difference range
U	Cumulative usage factor in air
Ui	Usage factor in air
U <sub>en</sub>	Cumulative usage factor in LWR environment
U <sub>en i</sub>	Usage factor in LWR environment

#### 4.0 ASSUMPTIONS AND OPEN ITEMS

#### 4.1 Assumptions

There are no assumptions in this analysis Report.

#### 4.2 Open Items

There are no open items in this analysis Report.

#### 5.0 ACCEPTANCE CRITERIA

The usage factor is calculated based on the ASME procedure with the new fatigue design curves, which are provided in NUREG/CR-6909, Appendix A Figure A.3 (Reference 3). The usage factor is multiplied by  $F_{en}$  to obtain the cumulative usage factor in the LWR environment. The acceptance criteria is that the cumulative usage factor in the LWR environment U<sub>en</sub> does not exceed the limit of 1.0.

 $U_{en} = U_1 \cdot F_{en,1} + U_2 \cdot F_{en,2} + U_3 \cdot F_{en,3} + U_i \cdot F_{en,i} \dots + U_n \cdot F_{en,n} \le 1.0$ 

#### 6.0 CALCULATION

#### 6.1 Analysis Approach

USNRC R.G 1.207 describes an acceptable methodology for evaluating environment fatigue effects. The regulatory guide describes the  $F_{en}$  method with "modified rate approach" for calculating  $F_{en}$ , which is provided in NUREG/CR-6909.

The calculated  $F_{en}$  values are then used to incorporate environmental effects into fatigue evaluation in air calculations. This fatigue evaluation employs ASME Code analysis procedures with the new fatigue design curves, which are provided in NUREG/CR-6909, Appendix A, Figures A.3.

Figure 6.1-1 shows the environmental fatigue analysis approach in this report, where P4TEDIA and CEFF-N are MHI proprietary computer code. These codes are described in Section 7.

Except for using the new fatigue design curve, the part of the fatigue analysis using ABAQUS, P4TEDIA and PIPESTRESS in Figure 6.1-1 is the same as the fatigue analysis in air for the class 1 branch piping based on ASME Code Section III which had been submitted to the USNRC (References 6).

The thermal stress ( $\Delta$ T1,  $\Delta$ T2, Ta-Tb) time histories during the transients together with temperature time histories were processed in P4TEDIA and were used as an input for CEFF-N, which performs the F<sub>en</sub> calculations, and environmental fatigue calculations.

#### 6.2 Basic Consideration

NUREG/CR-6909 Appendix A provides the additional guidance for use to determine the parameters. However, it is incomplete for analysis of  $F_{en}$  under the loading histories.

The following analytic procedures associated with F<sub>en</sub> were adopted.

1) The effect of elastic-plastic correction factor (Ke) per NB-3228.5 of ASME Code on strain rate was neglected.

The Ke factor causes a higher strain that increase the strain rate, which in turn lowers the  $F_{en}$ . Thus neglecting Ke is conservative.

2) For load pairs in an environmental usage factor calculation that are based on seismic loading,  $F_{en}$ =1.0.

Seismic loading occurs too quickly for environmental effects.

3) For the transformed temperature, the highest metal temperature for each increment segment in the strain history was used.

NUREG/CR-6909 supports this approach in that the maximum temperature can be used to perform the most conservative evaluation.

- 4) For strain calculation, the modulus of elasticity (E) at the room temperature was used.
- 5) For determination of strain rate by combination of pressure, moment,  $\Delta T_1$ ,  $\Delta T_2$ , and  $T_a-T_b$ , the guidance by JSME (Reference 4) was used.

$$S_{P} = K_{1}C_{1}\frac{P_{o}D_{o}}{2t} + K_{2}C_{2}\frac{D_{o}}{2I}M_{i} + \frac{1}{2(I-v)}K_{3}E|\mathbf{a}|\Delta T_{1}| + K_{3}C_{3}E_{ab} \times |\mathbf{a}_{a}T_{a} - \mathbf{a}_{b}T_{b}| + \frac{1}{I-v}E|\mathbf{a}|\Delta T_{2}|$$
  
Pressure term Moment term  $\Delta T_{1}$ term  $T_{a}$ -T<sub>b</sub> term  $\Delta T_{2}$  term

That is, when  $\Delta T_1$ ,  $\Delta T_2$ , or  $T_a$ - $T_b$  is dominant, the strain rate is calculated from the time history of the dominant strain.

#### 6.3 Environmental Fatigue Analysis Methodology

1) The equation to calculate the environmental fatigue correction factor

Environmental fatigue analysis is performed in accordance with NUREG/CR-6909 (Reference 3), using the environmental fatigue correction factor. The environmental cumulative usage factor  $U_{en}$  is calculated by multiplying the cumulative usage factor in air U (S-N curves are from NUREG/CR-6909) obtained according to the ASME B&PV Code, Section III NB3600 (Reference 1) by the environmental fatigue correction factor  $F_{en}$ .

Environmental cumulative usage factor

$$U_{en} = \sum_{i=1}^{n} U_i \times F_{en,i} \tag{1}$$

Environmental fatigue correction factor

 Austenitic stainless steel  $F_{en nom} = \exp(0.734 - T'O'\dot{\varepsilon}')$ (2) T' = 0 $(T < 150^{\circ}C)$ T' = (T - 150)/175 $(150 \le T < 325^{\circ} \text{C})$  $(T \ge 325^{\circ}C)$ T' = 1 $\dot{\varepsilon}' = 0$  $(\dot{\varepsilon} > 0.4\%/s)$  $(0.0004 \le \dot{\varepsilon} \le 0.4\% / s)$  $\dot{\varepsilon}' = \ln(\dot{\varepsilon}/0.4)$  $\dot{\varepsilon}' = \ln(0.0004/0.4)$   $(\dot{\varepsilon} < 0.0004\%/s)$ (all Do levels) O' = 0.281

#### 2) Threshold

For the peak stress intensity Salt below the threshold of 28.3 ksi in equation (2), the environmental fatigue correction factor,  $F_{en}$ , is 1.0.

$$F_{en,nom} = 1.0$$
  $(S_{alt} \le 28.3 ksi(195 MPa))$  (3)

Here, 28.3ksi is equal to 0.1% strain amplitude.

3) The modified-rate approach

When the terms  $\Delta T_1$ ,  $\Delta T_2$ , and  $(T_a-T_b)$  are dominant, the inner surface temperature of the metal and the strain rate are obtained by reading the results of the processing of P4TEDIA, and the environmental fatigue correction factor Fen is calculated using the modified-rate approach.

The strain  $\varepsilon$ , the weighted denominator in equation (4), is the sum of the strain increments  $\Delta \varepsilon_{k}$ . Then, if the strain history does not show a monotonic increase,  $\varepsilon$  is the sum of the strain increments in the portion for calculating strain rate to be described later, but not the value calculated from the peak stress.

Modified-rate approach



$$\varepsilon = \sum_{k=1}^{n} \Delta \varepsilon_k \tag{5}$$



4) F<sub>en</sub> for a combination of transients

The environmental fatigue correction factor Fen for a combination of transients is calculated by the following equation using the environmental fatigue correction factors F<sub>en,A</sub> and F<sub>en,B</sub> calculated for two transients A and B:

Fen for a combination of transients

$$F_{en} = \frac{F_{en,A} \times \varepsilon_A + F_{en,B} \times \varepsilon_B}{\varepsilon_A + \varepsilon_B}$$
(6)

#### 5) Temperature

6) Strain rate

## Summary of Environmental Fatigue Analysis Results for the US-APWR Reactor Coolant Loop Branch Piping

MUAP-10016-NP (R0)



Figure 6.3-1 Environmental Fatigue Analysis Approach

Figure 6.3-2 Portion for calculating strain rate (1)

Figure 6.3-3 (1/2) Portion for calculating strain rate (2)

Figure 6.3-3(2/2) Portion for calculating strain rate (2)

#### 7.0 COMPUTER CODE USED IN CALCULATION

Table 7-1 below provides a brief description of each of the computer programs used.

No.	Program Name	Version	Description
1	PIPESTRESS	3.6.0	PIPESTRESS is a computer program for the analysis of piping systems. This program is used for the analysis of ASME Code, Section , Class 1, 2, 3 and ASME B31.1 piping systems under various load conditions.
2	ABAQUS	6.7-1	ABAQUS is a general-purpose finite element computer program that performs a wide range of linear and nonlinear engineering simulations. This program is used for temperature distribution analysis and thermal stress analysis according to piping geometries and design transients such as fluid temperature and coefficient of heat transfer.
3	P4TEDIA	1.3	P4TEDIA is an in-house program to obtain temperature difference between in-side and out-side of pipe $\Delta T_1$ , $\Delta T_2$ and temperature difference at structural discontinuous point $T_a$ - $T_b$ . This program uses the thermal distribution analysis results generated by ABAQUS.
4	CEFF-N	1.0	CEFF-N is an in-house program. This program is used for calculating environmental usage factor.

Table 7.0-1	Computer	Program	Description
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All these computer programs were verified and validated in compliance with the MHI quality assurance program. The computer programs were validated using one of the methods described below. Verification tests demonstrate the capability of the computer program to produce valid results for the test problems encompassing the range of permitted usage defined by the program documentation.

- Hand calculations
- Known solution for similar or standard problem
- Acceptable experimental test results
- Published analytical results
- Results from other similar verified programs

#### 8.0 ENVIRONMENTAL FATIGUE ANALYSIS RESULTS

This section summarizes the environmental fatigue evaluation results for the class 1 branch piping.

Maximum  $F_{en}$  is 14.514 for austenitic stainless steels for  $T \ge 325$  °C and  $\dot{\varepsilon} < 0.0004\%$ /s. Therefore, the environmental fatigue analysis was performed for all points of the class 1 branch piping in the case when cumulative usage factor based on the NUREG new fatigue curve was equal or greater than 0.0689 (=1/14.514). All the calculated environmental usage factor are listed in Table 8-1. In this table, only the maximum NUREG (air) cumulative usage factor is listed for each class 1 branch piping in the case when its cumulative usage factor is less than 0.0689.

The details of the most severe environmental fatigue analysis results for each piping are shown in figures and tables listed in Table 8-2.

## Table 8.0-1(1/3) The Results of Environmental Fatigue Evaluation for Class 1 BranchPiping

Piping		Point	Location	NUREG (air) U		NUREG (LWR) U <sub>en</sub>	
				Case1 <sup>1)</sup>	Case2 <sup>1)</sup>	Case1 <sup>1)</sup>	Case2 <sup>1)</sup>
RC01 Pressurizer Surge Line							
(							

Piping	Point	Location	NUREG (air) U	NUREG (LWR) Uan
RC02 Pressurizer Spray Line				en
RC03 Pressurizer Safety Depressurization Valve Line				
DC04				
Pressurizer Safety Valve Line				
RH01 RHR Suction Loop A Line				
RH02 RHR Suction Loop B Line				
RH05 RHR Return Loop A Line				
RH06 RHR Return Loop B Line				
SI01 Accumulator Loop A Line				
SI02 Accumulator Loop B Line				

# Table 8.0-1(2/3)The Results of Environmental Fatigue Evaluation for<br/>Class 1 Branch Piping

Piping	Point	Location	NUREG (air) U	NUREG (LWR) U <sub>en</sub>
SI05 DVI A Line				
SI06 DVI B Line				
CS01 CVCS Charging Line				
CS02 CVCS Let Down Line				
CS04 Seal Injection A Line				
CS05 Seal Injection B Line				
CS06 Seal Injection C Line				
CS07 Seal Injection D Line				

#### Table 8.0-1(3/3) The Results of Environmental Fatigue Evaluation for **Class 1 Branch Piping**

Note:

1) The requirement for environmental fatigue is satisfied, because NUREG(air) cumulative usage factor is less than 0.0689.

	NUREG	NUREG (LWR) U <sub>en</sub>		Detail of Environmental Usage Factor		typical data
Piping	(air) U		Most Sever point	NUREG <sup>1)</sup> (air) U	NUREG <sup>2)</sup> (LWR) U <sub>en</sub>	for F <sub>eni</sub> calculation
RC01 Pressurizer Surge Line (Case1)			Figure 8.1-1	Table 8.1-1	Table 8.1-2	Figure 8.1-2
RC02 Pressurizer Spray Line			Figure 8.2-1	Table 8.2-1	Table 8.2-2	Figure 8.2-2
RC03 Pressurizer Safety Depressurization Valve Line			Figure 8.3-1	Table 8.3-1	Table8.3-2	Figure 8.3-2
RC04 Pressurizer Safety Valve Line			Figure 8.4-1	Table 8.4-1	Table8.4-2	Figure 8.4-2
RH01 RHR Suction Loop A Line			Figure 8.5-1	Table 8.5-1	-	-
RH02 RHR Suction Loop B Line			Figure 8.6-1	Table 8.6-1	-	-
RH05 RHR Return Loop A Line			Figure 8.7-1	Table 8.7-1	-	-
RH06 RHR Return Loop B Line			Figure 8.8-1	Table 8.8-1	-	-
SI01 Accumulator Loop A Line			Figure 8.9-1	Table 8.9-1	-	-
SI02 Accumulator Loop B Line			Figure 8.10-1	Table 8.10-1	-	-
SI05 DVI A Line			Figure 8.11-1	Table8.11-1	-	-
SI06 DVI B Line			Figure 8.12-1	Table 8.12-1	-	-
CS01 CVCS Charging Line			Figure 8.13-1	Table 8.13-1	Table 8.13-2	Figure 8.13-2
CS02 CVCS Let Down Line			Figure 8.14-1	Table 8.14-1	Table 8.14-2	Figure 8.14-2
CS04 CVCS Seal Injection A Line			Figure 8.15-1	Table 8.15-1	-	-
CS05 CVCS Seal Injection B Line			Figure 8.16-1	Table 8.16-1	-	-
CS06 CVCS Seal Injection C Line			Figure 8.17-1	Table 8.17-1	-	-
CS07 CVCS Seal Injection D Line			Figure 8.18-1	Table 8.18-1	-	-

 Table 8.0-2
 The detail of analysis results for most severe point

Note:

- 1) Table 8.1-1 to Table 8.18-1 show the usage factors in air based on the NUREG/CR-6909 fatigue design curve on the most severe point for each piping. The Table lists the stress cycle (transient pair) Salt, number of repetitions that occur for stress cycle "I"(ni), allowable number of cycle for stress cycle "I"(Ni), and partial usage factor in air for stress cycle "I" based on NUREG/CR-6909 fatigue design curve, and cumulative usage factor (U).
- 2) Table 8.1-2 to Table 8 4-2, Table 8.13-2 and Table 8.14-2 show the environmental usage factors on the most severe point for each piping. The Table lists the stress cycle (transient pair) Sp, Salt, each stress of Sp(pressure, moment, ΔT<sub>1</sub>, T<sub>a</sub>-T<sub>b</sub>, ΔT<sub>2</sub>), dominant stress of Sp, partial usage factor in air for stress cycle "I" based on the NUREG/CR-6909 fatigue design curve, environmental fatigue correction factor (F<sub>eni</sub>), partial environmental usage factor (U<sub>eni</sub>), and environmental cumulative usage factor (U<sub>en</sub>).
- 3) Figure 8.1-2 to Figure 8.4-2, Figure 8.13-2 and Figure 8.14-2 show the typical data for F<sub>eni</sub> calculation, such as time history of strain, Strain rate and metal temperature.
- 4) The environmental fatigue requirement is satisfied, because cumulative usage factor based on the NUREG new fatigue curve is less than 0.0689.

#### 8.1 RC01 (Pressurizer Surge Line)

The detail of environmental fatigue analysis results for Pressurizer Surge line is shown in the following tables and figures.

Figure 8.1-1 Most sever point for RC01 Pressurizer Surge Line

Mitsubishi Heavy Industries, LTD.
Load	set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui
	-				
					1
		1		ł	+

## Table 8.1-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC01 Pressurizer Surge Line (Point 1000) (case1) (1/4)

Load	set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	i <sup>2)</sup>	(psi)		Ni	Ui
	,				
					<u> </u>

## Table 8.1-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC01 Pressurizer Surge Line (Point 1000) (case1) (2/4)

Load	set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	i <sup>2)</sup>	(psi)		Ni	Ui
					<u> </u>
				1	

### Table 8.1-1 Usage Factor based on NUREG/CR-6909 DesignFatigue Curve for RC01 Pressurizer Surge Line (Point 1000) (case1) (3/4)

Load	l set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui

#### Table 8.1-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC01 Pressurizer Surge Line (Point 1000) (case1) (4/4)

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-1 of **APPENDIX 1.**

Load	Set 1)	Salt	Sn	Each Stress of Sp					Domin-	NUREG		NUREG
i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> ²)
				(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	(001)	(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	(1991)				
$\left  \right $												

## Table 8.1-2Environmental Usage FactorRC01Pressurizer Surge Line (Point 1000) (case1) (1/4)

Load	Set 1)	Salt	Sn		Each	Stress o	f Sp		Domin-	NUREG		NUREG
i	J	(psi)	(psi)	P (nsi)	M (psi)	ΔT1 (nsi)	ΔT2 (nsi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> ²)
				(poi)	(poi)	(531)	(poi)	(001)				
<u> </u>												
<u></u>												

## Table 8.1-2Environmental Usage FactorRC01Pressurizer Surge Line (Point 1000) (case1) (2/4)

Load	Set 1)	Salt	Sn		Each	Stress o	f Sp		Domin-	NUREG		NUREG
i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2</sup> )
				(poi)	(001)	(201)	(poi)	(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				

## Table 8.1-2Environmental Usage FactorRC01Pressurizer Surge Line (Point 1000) (case1) (3/4)

NUREG
(LWR) U <sub>eni</sub> <sup>2</sup> )
-

## Table 8.1-2Environmental Usage FactorRC01Pressurizer Surge Line (Point 1000) (case1) (4/4)

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.

Figure 8.1-2(1/5) Time history of strain, strain rate and metal temperature for

Figure 8.1-2(2/5) Time history of strain, strain rate and metal temperature for

Figure 8.1-2(3/5) Time history of strain, strain rate and metal temperature for

Figure 8.1-2(4/5) Time history of strain, strain rate and metal temperature for

Figure 8.1-2(5/5) Time history of strain, strain rate and metal temperature for

### 8.2 RC02 (Pressurizer Spray Line)

The detail of environmental fatigue analysis results for Pressurizer Spray line is shown in the following tables and figures.

Figure 8.2-1(1/5) Most sever point for RC02 Pressurizer Spray Line

Figure 8.2-1(2/5) Most sever point for RC02 Pressurizer Spray Line

Figure 8.2-1(3/5) Most sever point for RC02 Pressurizer Spray Line

Figure 8.2-1(4/5) Most sever point for RC02 Pressurizer Spray Line

Figure 8.2-1(5/5) Most sever point for RC02 Pressurizer Spray Line

Load	Set 1)	Salt		NURE(air)	NURE(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	ni	Ni	Ui
		1			

# Table 8.2-1 Usage Factor based on NUREG/CR-6909 DesignFatigue Curve forRC02 Pressurizer Spray Line (Point 4000) (1/2)

Load	Set 1)	Salt		NURE(air)	NURE(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	ni	Ni	Ui

## Table 8.2-1Usage Factor based on NUREG/CR-6909 Design<br/>Fatigue Curve for<br/>RC02 Pressurizer Spray Line (Point 4000) (2/2)

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-2 of APPENDIX 1.

Load	Set 1)	Salt	Sn		Each	Stress o	f Sp		Domin-	NUREG		NUREG
i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup>
<b>F</b>				(201)	(201)	(201)	(poi)					

## Table 8.2-2Environmental Usage FactorRC02Pressurizer Spray Line (Point 4000) (1/2)

Load	Set 1)	Salt	Sn		Each	Stress o	of Sp		Domin-	NUREG		NUREG
i	J	(psi)	(psi)	P (psi)	M (psi)	∆T1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup>

## Table 8.2-2Environmental Usage FactorRC02Pressurizer Spray Line (Point 4000) (2/2)

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.

Figure 8.2-2 Time history of strain, strain rate and metal temperature for

RC02 Pressurizer Spray Line

#### RC03 (Pressurizer Safety Depressurization Valve Line) 8.3

The detail of environmental fatigue analysis results for Pressurizer Safety Depressurization Valve line is shown in the following tables and figures.

Figure 8.3-1(1/3) Most sever point for RC03 Pressurizer Safety Depressurization Valve Line

Figure 8.3-1(2/3) Most sever point for RC03 Pressurizer Safety Depressurization Valve Line

Figure 8.3-1(3/3) Most sever point for RC03 Pressurizer Safety Depressurization Valve Line

#### Table 8.3-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RC03 Pressurizer Safety Depressurization Valve Line (Point 2018)

Load	Set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)		
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	nı	Ni	Ui		

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-3 of APPENDIX 1.

### Table 8.3-2 Environmental Usage FactorRC03 Pressurizer Safety Depressurization Valve (Point 2018)

	Load Set <sup>1)</sup> Salt		Sn	Each Stress of Sp					Domin-	NUREG		NUREG		
C	i	J	(psi) (j	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup>
$\lfloor \ \end{bmatrix}$														

Note:

1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.

2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.

Figure 8.3-2 Time history of strain, strain rate and metal temperature for RC03 Pressurizer Safety Depressurization Valve Line

#### 8.4 RC04 (Pressurizer Safety Valve Line)

The detail of environmental fatigue analysis results for Pressurizer Safety Valve line is shown in the following tables and figures.

Figure 8.4-1 Most sever point for RC04 Pressurizer Safety Valve Line

Table 8.4-1 Usage Factor based on NUREG/CR-6909 Desig	ŋn
Fatigue Curve for	-
RC04 Pressurizer Safety Valve Line (Point 1024)	

Load	Load Set <sup>1)</sup> i <sup>2)</sup> j <sup>2)</sup>		ni	NUREG(air)	NUREG(air) Ui		
i <sup>2)</sup>				Ni			

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-4 of APPENDIX 1.

## Table 8.4-2Environmental Usage FactorRC04Pressurizer Safety Valve Line (Point 1024)

	Load	Set 1)	Salt	Sn		Each	n Stress o	f Sp		Domin-	NUREG		NUREG
$\left( \right)$	i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup>
L													

Note:

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.

Figure 8.4-2 Time history of strain, strain rate and metal temperature for

**RC04 Pressurizer Safety Valve Line**
#### 8.5 RH01 (RHR Suction Loop A Line)

The detail of environmental fatigue analysis results for RHR suction loop A line is shown in the following tables and figures.

Figure 8.5-1(1/2) Most sever point for RH01 RHR Suction Loop A Line

Figure 8.5-1(2/2) Most sever point for RH01 RHR Suction Loop A Line

Load	Set 1)	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui

# Table 8.5-1 Usage Factor based on NUREG/CR-6909 DesignFatigue Curve forRH01 RHR Suction Loop A Line (Point 3000)

Note:

1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.

2) Load Set number i and j mean Load No. of design transient shown in Table A1-5 of APPENDIX 1.

#### 8.6 RH02 (RHR Suction Loop B Line)

The detail of environmental fatigue analysis results for RHR suction loop B line is shown in the following tables and figures.

Figure 8.6-1(1/2) Most sever point for RH02 RHR Suction Loop B Line

Figure 8.6-1(2/2) Most sever point for RH02 RHR Suction Loop B Line

# Table 8.6-1Usage Factor based on NUREG/CR-6909 Design Fatigue<br/>Curve for<br/>RH02 RHR Suction Loop B Line (Point 3000)

Load	Set 1)	Salt		NUREG(air)	air) NUREG(LWR)	
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui	

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-6 of APPENDIX 1.

#### 8.7 RH05 (RHR Return Loop A Line)

The detail of environmental fatigue analysis results for RHR return loop A line is shown in the following tables and figures.

Figure 8.7-1(1/2) Most sever point for RH05 RHR Return Loop A Line

Figure 8.7-1(2/2) Most sever point for RH05 RHR Return Loop A Line

#### Table 8.7-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for RH05 RHR Return Loop A Line (Point 2007)

Load i <sup>2)</sup>	Set <sup>1)</sup> j <sup>2)</sup>	Salt (psi)	ni	NUREG(air) Ni	NUREG(air) Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-7 of APPENDIX 1.

#### 8.8 RH06 (RHR Return Loop B Line)

The detail of environmental fatigue analysis results for RHR return loop B line is shown in the following tables and figures.

Figure 8.8-1(1/2) Most sever point for RH06 RHR Return Loop B Line

Figure 8.8-1(2/2) Most sever point for RH06 RHR Return Loop A Line

# Table 8.8-1 Usage Factor based on NUREG/CR-6909 DesignFatigue Curve forRH06 RHR Return Loop B Line (Point 2007)

Load	Set 1)	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-7 of APPENDIX 1.

#### 8.9 SI01 (Accumulator Loop A Line)

The detail of environmental fatigue analysis results for Accumulator loop A line is shown in the following tables and figures.

Figure 8.9-1 Most sever point for SI01 Accumulator Loop A Line

# Table 8.9-1 Usage Factor based on NUREG/CR-6909 DesignFatigue Curve forSI01 Accumulator Loop A Line (Point 1009)

Load	Load Set <sup>1)</sup>		ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	rii	Ni	Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-8 of APPENDIX 1.

#### 8.10 SI02 (Accumulator Loop B Line)

The detail of environmental fatigue analysis results for Accumulator loop B line is shown in the following tables and figures.

Figure 8.10-1 Most sever point for SI02 Accumulator Loop B Line

# Table 8.10-1Usage Factor based on NUREG/CR-6909 Design<br/>Fatigue Curve for<br/>SI02 Accumulator Loop B Line (Point 1009)

Load	Set 1)	Salt (psi)	Salt	alt ni NURE		NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>		nı	Ni	Ui	

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-8 of APPENDIX 1.

#### 8.11 SI05 (DVI A Line)

The detail of environmental fatigue analysis results for DVI A line is shown in the following tables and figures.

Figure 8.11-1 Most sever point for SI05 DVI A Line

Table 8.11-1	Usage Factor based on NUREG/CR-6909 Design
	Fatigue Curve for
	SI05 DVI A Line (Point 1027)

Load	Set 1)	Salt		t <sup>1)</sup> Salt ni NUREG(air)		NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui	

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-9 of APPENDIX 1.

### 8.12 SI06 (DVI B Line)

The detail of environmental fatigue analysis results for DVI B line is shown in the following tables and figures.

Figure 8.12-1 Most sever point for SI06 DVI B Line

Load	Set 1)	Salt		NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	rii	Ni	Ui

# Table 8.12-1Usage Factor based on NUREG/CR-6909 Design<br/>Fatigue Curve for<br/>SI06 DVI B Line (Point 1027)

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-9 of APPENDIX 1.

#### 8.13 CS01 (CVCS Charging Line)

The detail of environmental fatigue analysis results for CVCS charging line is shown in the following tables and figures.

Figure 8.13-1 Most sever point for CS01 CVCS Charging Line

### Table 8.13-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for

CS01 CVCS Charging Line (Point 2000) (1/3)

Load	Set <sup>1)</sup>	Salt (psi)	ni	NUREG(air) Ni	NUREG(air)
Ι-'	J <sup>-</sup> ″	(psi)		INI	

Load	Load Set <sup>1)</sup>		ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		NI	Ui

#### Table 8.13-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS01 CVCS Charging Line (Point 2000) (3/3)

Load Set <sup>1)</sup>		Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	nı	Ni	Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-10 of APPENDIX 1.

Load Set <sup>1)</sup>		Salt	Sn		Each	n Stress o	of Sp	Domin-	NUREG		NUREG	
i	J	(psi) (psi)	(psi)	P (nsi)	M (psi)	ΔT1 (nsi)	ΔT2 (nsi)	Ta-Tb (nsi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup>
				(001)	(poi)	(001)						

### Table 8.13-2Environmental Usage FactorCS01CVCSCharging Line (Point 2000) (1/2)

Load Set <sup>1)</sup>		Salt	<b>S</b> n		Eacl	n Stress o	of Sp	Domin-	NUREG		NUREG	
i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	ant Stress	(air) Ui	F <sub>eni</sub>	(LWR) U <sub>eni</sub> <sup>2)</sup> _

### Table 8.13-2Environmental Usage FactorCS01CVCSCharging Line (Point 2000) (2/2)

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.
Figure 8.13-2 Time history of strain, strain rate and metal temperature for

CS01 CVCS Charging Line

## 8.14 CS02 (CVCS Let Down Line)

The detail of environmental fatigue analysis results for CVCS let down line is shown in the following tables and figures.

Figure 8.14-1(1/3) Most sever point for CS02 CVCS Let Down Line

Figure 8.14-1(2/3) Most sever point for CS02 CVCS Let Down Line

Figure 8.14-1(3/3) Most sever point for CS02 CVCS Let Down Line

#### Table 8.14-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS02 CVCS Let Down Line (Point 1042)

Load Set <sup>1)</sup>		Salt	NUREG(air)	NUREG(air)	
i <sup>2)</sup>	j <sup>2)</sup>	(psi)	111	Ni	Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-11 of APPENDIX 1.

Loa	d Set	Salt	Sp		Each Stress of Sp			Domin-	NURE G	F.		
i	J	(psi)	(psi)	P (psi)	M (psi)	ΔT1 (psi)	ΔT2 (psi)	Ta-Tb (psi)	Stress	(air) Ui	• eni	$U_{eni}^{(2000)}$
	<u> </u>											
	<u> </u>											

# Table 8.14-2Environmental Usage FactorCS02Let Down Line (Point 1042)

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) For marking "(\*)", the time-history of the strain, strain rate and metal temperature are shown in the following figures.

Figure 8.14-2(1/6) Time history of strain, strain rate and metal temperature for

Figure 8.14-2(2/6) Time history of strain, strain rate and metal temperature for

Figure 8.14-2(3/6) Time history of strain, strain rate and metal temperature for

Figure 8.14-2(4/6) Time history of strain, strain rate and metal temperature for

Figure 8.14-2(5/6) Time history of strain, strain rate and metal temperature for

Figure 8.14-2(6/6) Time history of strain, strain rate and metal temperature for

## 8.15 CS04 (Seal Injection A Line)

The detail of environmental fatigue analysis results for CVCS seal Injection A line is shown in the following tables and figures.

Figure 8.15-1 Most sever point for CS04 CVCS Seal Injection A Line

#### Table 8.15-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS04 CVCS Seal Injection A Line (Point 1075)

Load Set <sup>1)</sup>		Salt		NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui
		ľ			

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-12 of APPENDIX 1.

## 8.16 CS05 (Seal Injection B Line)

The detail of environmental fatigue analysis results for CVCS seal Injection B line is shown in the following tables and figures.

Figure 8.16-1 Most sever point for CS05 CVCS Seal Injection B Line

Load	Set <sup>1)</sup>	Salt	ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui

#### Table 8.16-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS05 CVCS Seal Injection B Line (Point 2000)

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-12 of APPENDIX 1.

## 8.17 CS06 (Seal Injection C Line)

The detail of environmental fatigue analysis results for CVCS seal Injection C line is shown in the following tables and figures.

Figure 8.17-1 Most sever point for CS06 CVCS Seal Injection C Line

#### Table 8.17-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS06 CVCS Seal Injection C Line (Point 1060)

Load	Load Set <sup>1)</sup>		ni	NUREG(air)	NUREG(air)
i <sup>2)</sup>	j <sup>2)</sup>	(psi)		Ni	Ui

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-12 of APPENDIX 1.

## 8.18 CS07 (Seal Injection D Line)

The detail of environmental fatigue analysis results for CVCS seal Injection D line is shown in the following tables and figures.

Figure 8.18-1 Most sever point for CS07 CVCS Seal Injection D Line

#### Table 8.18-1 Usage Factor based on NUREG/CR-6909 Design Fatigue Curve for CS07 CVCS Seal Injection D Line (Point 2000)

Load i <sup>2)</sup>	Load Set <sup>1)</sup>		ni	NUREG(air) Ni	NUREG(air) Ui	

- 1) All other load sets produce zero Ui with the NUREG design fatigue curve in air.
- 2) Load Set number i and j mean Load No. of design transient shown in Table A1-12 of APPENDIX 1.

### 9.0 **REFERENCES**

- 1. ASME Boiler and Pressure Vessel Code, Section III NB-3600 1992 Edition through 1992 Addenda
- 2. U.S. Nuclear Regulatory Commission Regulatory Guide 1.207 "Guidelines for evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components due to the effects of the light-water Reactor Environment for New Reactors" March 2007
- NUREG/CR-6909,"Effect of LWR Coolant Environments on Fatigue Life of Reactor, Materials" (Final Report), ANL-06/08, U.S. Nuclear Regulatory Commission, Washington, DC, February 2007
- 4. "Code for Nuclear Power Generating Facilities, Environmental Fatigue Evaluation Method for Nuclear Power Plants." JSME S NF1, 2006, March 2006
- 5. N0-EE12001 Revision 2 "Class 1 Equipment Design Transient"
- 6. "Summary of Stress Analysis Results for the US-APWR Reactor Coolant Loop Branch Piping" MUAP-09011-P Revision 1
- 7. Design Control Document for US-APWR Chapter 3 Design MUAP-DC005 Rev.1 August, 2008
- 8. "Summary of Environmental Fatigue Analysis Results for the US-APWR Class 1 Components" MUAP-10015-P Revision 0

Level AMarkTransientsOccurrenceLoad No.MarkItan eat-up & cooldown120112041202Plant heat-up 1-insurge1206Plant heat-up 1-outsurge1206Plant heat-up 1-outsurge120120Plant heat-up 2-outsurge120120Plant heat-up 2-outsurge120120Plant heat-up 2-outsurge120120Plant heat-up 2-outsurge120120Plant heat-up 2-outsurge120120Plant heat-up 3-outsurge12011Plant heat-up 3-outsurge120120Plant heat-up 4-insurge12011Plant heat-up 4-insurge12011Plant heat-up 4-insurge120120Plant heat-up 5-insurge120120Plant heat-up 5-insurge12022Plant heat-up 6-insurge12022Plant heat-up 6-insurge12022Plant heat-up 6-insurge12023Plant Cooldown 1-insurge12033Plant Cooldown 2-insurge12033Plant Cooldown 2-insurge12033Plant Cooldown 2-insurge12033Plant Cooldown 3-insurge12033Plant Cooldown 3-insurge12033Plant Cooldown 3-insurge12033Plant Cooldown 4-insurge12033Plant Cooldown 4-insurge12033Plant Cooldown 4-insurge120 <t< th=""><th></th><th>Table A1-1 Pressurizer surge line design tran</th><th>nsients (1/7)</th><th></th></t<>		Table A1-1 Pressurizer surge line design tran	nsients (1/7)	
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Plant heat-up5-outsurge         120         21           Plant heat-up6-insurge         120         24           Plant heat-up6-outsurge         120         23           Plant heat-up6-outsurge         120         23           Plant heat-up6-outsurge         120         23           Plant cooldown1-insurge         120         25           Plant Cooldown1-insurge         120         27           Plant Cooldown1-outsurge         120         29           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown3-insurge         120         33           Plant Cooldown3-outsurge         120         36           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         42           Plant Cooldown4-outsurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44 <t< td=""><td></td><td></td><td>120</td><td>19</td></t<>			120	19
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Hant neat upp indage         120         26           Plant heat-up6-outsurge         120         23           120         25         120         25           Plant Cooldown1-insurge         120         28           Plant Cooldown1-outsurge         120         27           Plant Cooldown1-outsurge         120         29           Plant Cooldown2-insurge         120         34           Plant Cooldown2-outsurge         120         34           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         35           Plant Cooldown4-insurge         120         35           Plant Cooldown4-outsurge         120         40           Plant Cooldown4-outsurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         43		Plant heat-un6-insurge	120	24
Plant heat-up6-outsurge         120         23           120         25           Plant Cooldown1-insurge         120         28           Plant Cooldown1-outsurge         120         30           Plant Cooldown1-outsurge         120         27           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         32           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         33           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         39           Plant Cooldown5-outsurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         44           Plant Cooldown5-outsurge         120         44           Plant Cooldown5-outsurge         120         44           Plant Cooldown5-outsurge         120         44			120	26
Image: Plant Cooldown1-insurge         120         25           Plant Cooldown1-outsurge         120         28           Plant Cooldown1-outsurge         120         27           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown2-outsurge         120         31           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         36           Plant Cooldown3-insurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         42           Plant Cooldown4-insurge         120         42           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         43           Plant Cooldown5-insurge         120         43		Plant heat-up6-outsurge	120	23
Plant Cooldown1-insurge         120         28           120         30           Plant Cooldown1-outsurge         120         27           120         29           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown2-outsurge         120         31           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         36           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         42           Plant Cooldown4-outsurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         44           Plant Cooldown5-outsurge         120         43           Plant Cooldown5-outsurge         120         43			120	25
Plant Cooldown1-outsurge         120         27           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown2-outsurge         120         34           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         36           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         39           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         43		Plant Cooldown1-insurge	120	30
Hant Cooldown1-outsurge         120         29           Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown3-outsurge         120         33           Plant Cooldown3-insurge         120         36           Plant Cooldown3-outsurge         120         38           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         43           Plant Cooldown5-outsurge         120         43		Plant Cooldown1 outourgo	120	27
Plant Cooldown2-insurge         120         32           Plant Cooldown2-outsurge         120         34           Plant Cooldown2-outsurge         120         31           Plant Cooldown3-insurge         120         33           Plant Cooldown3-insurge         120         36           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         42           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         43           Plant Cooldown5-outsurge         120         43			120	29
$I-b-1 = \frac{120}{120} = \frac{34}{34} = \frac{120}{120} = \frac{34}{31} = \frac{120}{120} = \frac{34}{31} = \frac{120}{33} = \frac{34}{120} = \frac{120}{31} = \frac{34}{120} = \frac{120}{31} = \frac{34}{120} = \frac{120}{31} = \frac{34}{120} = \frac{120}{33} = \frac{120}{120} = \frac{34}{32} = \frac{120}{33} = \frac{34}{120} = \frac{34}{120} = \frac{34}{120} = \frac{34}{120} = \frac{120}{120} = \frac{44}{120} = \frac{120}{120} = \frac{120}$		Plant Cooldown2-insurge	120	32
Plant Cooldown2-outsurge $120$ $31$ 1203312033120361203812038120351203712037Plant Cooldown4-insurge1201204012042Plant Cooldown4-outsurge12012041Plant Cooldown5-insurge12012044Plant Cooldown5-outsurge12012043Plant Cooldown5-outsurge120			120	34
I-b-1         120         36           Plant Cooldown3-insurge         120         38           Plant Cooldown3-outsurge         120         35           Plant Cooldown4-insurge         120         37           Plant Cooldown4-insurge         120         40           Plant Cooldown4-outsurge         120         42           Plant Cooldown4-outsurge         120         39           Plant Cooldown5-insurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         43           Plant Cooldown5-outsurge         120         43		Plant Cooldown2-outsurge	120	33
I-b-1     120     38       Plant Cooldown3-outsurge     120     35       Plant Cooldown4-insurge     120     37       Plant Cooldown4-insurge     120     40       Plant Cooldown4-outsurge     120     42       Plant Cooldown5-insurge     120     41       Plant Cooldown5-insurge     120     44       Plant Cooldown5-outsurge     120     43       Plant Cooldown5-outsurge     120     45		Plant Cooldown3-insurge	120	36
Plant Cooldown3-outsurge $120$ $35$ Plant Cooldown4-insurge $120$ $37$ Plant Cooldown4-insurge $120$ $40$ Plant Cooldown4-outsurge $120$ $42$ Plant Cooldown5-insurge $120$ $41$ Plant Cooldown5-insurge $120$ $44$ Plant Cooldown5-outsurge $120$ $44$ Plant Cooldown5-outsurge $120$ $45$	161		120	38
$\frac{120}{120} \frac{37}{40}$ Plant Cooldown4-insurge $\frac{120}{120} \frac{40}{42}$ Plant Cooldown4-outsurge $\frac{120}{120} \frac{39}{41}$ Plant Cooldown5-insurge $\frac{120}{120} \frac{44}{44}$ Plant Cooldown5-outsurge $\frac{120}{120} \frac{43}{45}$	1-0-1	Plant Cooldown3-outsurge	120	35
Plant Cooldown4-insurge         120         42           Plant Cooldown4-outsurge         120         39           Plant Cooldown5-insurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-insurge         120         46           Plant Cooldown5-outsurge         120         43			120	40
Plant Cooldown4-outsurge         120         39           Plant Cooldown5-insurge         120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         46           Plant Cooldown5-outsurge         120         43		Plant Cooldown4-insurge	120	42
120         41           Plant Cooldown5-insurge         120         44           Plant Cooldown5-outsurge         120         46           Plant Cooldown5-outsurge         120         43		Plant Cooldown4-outsurge	120	39
Plant Cooldown5-insurge         120         44           120         46           Plant Cooldown5-outsurge         120         43           120         45			120	41
120         46           Plant Cooldown5-outsurge         120         43           120         45         45		Plant Cooldown5-insurge	120	44
Plant Cooldown5-outsurge			120	46
		Plant Cooldown5-outsurge	120 120	43 45

## APPENDIX 1 DESIGN TRANSIENTS

Mitsubishi Heavy Industries, LTD.

Level	A		
Mark	Transients	Occurrence	Load No.
	Plant Cooldown& insurge	120	48
I_h_1		120	50
	Plant Cooldown6-outsurge	120	47
		120	49
	Plant Cooldown7-insurge	120	52
		120	54
	Plant Cooldown7-outsurge	120	51
		120	53
	Plant Cooldown8-insurge	120	56
		120	58
	Plant Cooldown8-outsurge	120	55
		120	57
	Plant Cooldown9-insurge	120	62
		120	50
I-h-2	Plant Cooldown9-outsurge	120	61
102		120	64
	Plant Cooldown10-insurge	120	66
		120	63
	Plant Cooldown10-outsurge	120	65
	Dient Cooldowr11 ingurgo	120	68
	Plant Cooldown11-insurge	120	70
		120	67
		120	69
	Plant Cooldown12 insurge	120	72
		120	74
	Plant Cooldown12-outsurge	120	71
		120	73
	Ramp load increase between 15% and 100% of full power		
	1st-insurge	600	76
		600	78
	1st-outsurge	600	75
I-c-1		600	79
	2st-insurge	600	76
		600	80
	2st-outsurge	600	77
		600	79

 Table A1-1 Pressurizer surge line design transients (2/7)

Level A	· · · · · · · · · · · · · · · · · · ·	Y	
Mark	Transients	Occurrence	Load No.
	Ramp load increase between 50% and 100% of full power		
	1et incurren	19200	82
	ist-insuige	19200	84
	1st-outsurge	19200	81
I-c-2		19200	85
	2st-insurge	19200	82
		19200	86
	2st-outsurge	19200	83
		19200	85
	Ramp load decrease between 15% and 100% of full power		
	1st-insurge	600	88
		600	90
	1st-outsurge	600	87
		600	93
Id 1	2st-insurge	600	88
1-0-1		600	92
	2st-outsurge	600	03
		000	88
	3th-insurge	000	00 Q/
		600	91
	3th-outsurge	600	93
	Ramp load decrease between 50% and 100% of full power		
	· · · · · · · · · · · · · · · · · · ·	19200	96
	1st-insurge	19200	98
	Act externa	19200	95
I-d-2	1st-outsurge	19200	99
	2 of incurren	19200	96
	2st-insuige	19200	100
	2st outsurge	19200	97
	2st-outsurge	19200	99
	Step load increase of 10% of full power		
	insurge	600	102
l-e		600	104
	outsurge	600	101
		600	103
	Step load decrease of 10% of full power		
	insurge	600	106
I-T		600	108
	outsurge	600	105
		600	107

 Table A1-1 Pressurizer surge line design transients (3/7)

Level A			
Mark	Transients	Occurrence	Load No.
	Large step load decrease with turbine bypass		
		60	110
		60	112
	1st-outsurge	60	109
		60	121
	2st-insurge	60	110
		60	114
	2st-outsurge	60	111
		60	121
	3th-insurge	60	116
		60	113
l-g	3th-outsurge	60	121
Ū		60	110
	4th-Insurge	60	118
	4th-outsurge	60	115
	401-000501ge	60	121
	5th-insurge	60	110
		60	120
	5th-outsurge	60	117
		60	121
	6th-insurge	60	110
		60	122
	6th-outsurge	60	121
	Steady-state fluctuation and load regulation	00	121
		1000000 <sup>2</sup>	124
I-h	insurge	1000000 <sup>2</sup>	126
		1000000 <sup>2</sup>	123
	outsurge	1000000 <sup>2</sup>	125
	Main feedwater cycling		
		2100	128
I-i	Insurge	2100	130
		2100	127
	outsurge	2100	129
		60	131
I-j	Refueling	60	132
	Ramp load increase between 0% and	600	133
I-k	15% of full power	600	134
	Ramp load decrease between 0% and	600	135
1-1	15% of full power	600	136

 Table A1-1 Pressurizer surge line design transients (4/7)

Level A			
Mark	Transients	Occurrence	Load No.
I-m	RCP startun & shutdown	3000	137
l-n	RCF startup & shutdown	3000	138
1-0	Core lifetime extension	60	139
1-0		60	140
l_n	Primary leakage test	120	141
ι-p	Filliary icanaye lest	120	142
١a	Turbine roll test	10	143
i-q		10	144
١r	Boron concentration equalization	39600	145
1-1		39600	146

Table A1-1 Pressurizer surge line design transients (5/7)

Level B			
Mark	Transients	Occurrence	Load No.
	Loss of load		
	incurgo	60	148
ll-a		60	150
	outsurge	60	147
		60	149
	Loss of offsite power		
	1st-insurge	60	152
		60	154
	1st-outsurge	60	151
II-D		60	155
	2nd -insurge	60	152
		60	156
	2nd -outsurge	60	153
		60	155
	Partial loss of reactor coolant flow	20	150
II-c	insurge	30	100
11-0		30	167
	outsurge	30	150
	Reactor trip from full power		100
		60	161
	i) With no inadvertent cooldown	60	162
		30	163
	II) With cooldown and no safety injection	30	164
II-O	iii) With cooldown and safety injection		
	incurgo	10	166
	insuige	10	168
	outsurgo	10	165
	outsurge	10	167
	Inadvertent RCS depressurization		
	1st-insurge	30	170
		30	172
	1st-outsurge	30	169
ll-e		30	173
	2st-insurge	30	170
		30	174
	2st-outsurge		171
		30	173
II-f	Control rod drop	30	175
		30	176

Table A1-1 Pressurizer surge line design transients (6/7)

Level B					
Mark	Transients	Occurrence	Load No.		
	Inadvertent safeguards actuation				
	insurge	30	178		
ll-g		30	180		
	outsurge	30	177		
-		30	179		
	Emergency feedwater cycling				
	insurge	700	182		
ll-h		700	184		
	outsurae	700	181		
		700	183		
	Cold over-pressure				
	insurge	30	187		
11-1		30	185		
	outsurge	30	186		
		30	188		
	Partial loss of emergency feedwater				
	1st-insurge	30	190		
		30	192		
	1st-outsurge	30	189		
-		30	193		
	2nd -insurge	30	190		
		30	194		
	2nd -outsurge	30	191		
		30	193		
Earthquake Loads		2(150)	195		
		2(150) '	196		

Note1. (150) indicate the number of dynamic cycle for each occurrence of Earthquake.

Note2. The number of 1000000 is for "Steady-state" and the number of 1600000 is for "Load Regulation".

Level A			
Mark	Transients	Occurrence	Load No.
	Plant heat-up & cooldown	120	1
l-a		720	2
	Plant heat-up	720	4
I-b-1	Plant cooldown (200F/h 2235~400psig)	720	5
		720	6
I-b-2	Plant cooldown (200F/h,lower than 400psig)	600	<u>/</u> 8
		120	9
I-b-1	Plant cooldown (auxiliary spray)	120	10
1-c-1	Ramp load increase between	600	11
1-0-1	15% and 100% of full power	600	12
I-c-2	Ramp load increase between	19200	13
	50% and 100% of full power	19200	14
I-d-1	Ramp load decrease between	1200	15
	15% and 100% of full power	1200	16
I-d-2	50% and 100% of full power	38400	18
		600	10
l-e	Step load increase of 10% of full power	600	20
	Step load decrease of 10% of full power	600	21
I-†		600	22
La	Large step load decrease with turbine bypass	60	23
i-y		60	24
l-h	Steady-state fluctuation and load regulation	100000	25
		1000000	26
I-i	Main feedwater cycling	2100	27
	, ,	2100	28
I-j	Refueling	60	29
	Ramp load increase between 0% and	00	31
l-k	15% of full power	600	32
	Ramp load decrease between 0% and	600	33
1-1	15% of full power	600	34
I-m	PCP startup & shutdown	3000	35
l-n	ROP startup & shutdown	3000	36
I-0	Core lifetime extension Primary leakage test Turbine roll test	60	37
· •		60	38
l-p		120	39
		120	40
l-q		10	41
I-r	Boron concentration equalization	39600	43
		39600	44

 Table A1-2 Pressurizer spray line design transients (1/2)

Level B	Level B					
Mark	Transients	Occurrence	Load No.			
و_ال	l oss of load	60	45			
11-a		60	46			
II-b	Loss of offsite power	60	47			
		60	48			
ll-c	Partial loss of reactor coolant flow	30	49			
		30	50			
	Reactor trip from full power	60	51			
	I) with no inadvertent cooldown	60	52			
ll-d	ii) With cooldown and no safety injection	30	53			
		30	55			
	iii) With cooldown and safety injection	10	56			
	Inadvertent RCS depressurization	10	57			
	i)Umbrella case	15	58			
ll-e	ii)Inadvertent auxiliary spray	15	59			
		15	60			
II-f	Control rod drop	30	61			
		30	62			
II-g	Inadvertent safeguards actuation	30	63			
		30	64			
Шb	Emergency feedwater cycling	700	65			
11-11		700	66			
II_i	Cold over-pressure	30	67			
		30	68			
11-1	Partial loss of emergency feedwater	30	69			
		30	70			
Earthquake Loads		2(150)	71			
		2(150) '	72			

 Table A1-2 Pressurizer spray line design transients (2/2)

Note1. (150) indicate the number of dynamic cycle for each occurrence of Earthquake.

E.

Transients	Occurrence	Load No.			
Plant heat-up & cooldown (200E/h, 2235~400psig)	120	1			
1 ant heat-up & cooldown (2001 /n, 2233 -400psig)	120	2			
Plant heat-up & cooldown (200F/h, lower than 400psig)	120	3			
	120	4			
Ramp load increase between 15% and 100% of full power	600	5			
	600	6			
Ramp load increase between 50% and 100% of full power	19200	7			
	19200	8			
Ramp load decrease between 15% and 100% of full	600	9			
power	600	10			
Ramp load decrease between 50% and 100% of full	19200	11			
power	19200	12			
Step load increase of 10% of full power	600	13			
	600	14			
Step load decrease of 10% of full power	600	15			
	600	16			
Large step load decrease with turbine bypass	60	17			
	60	18			
Steady-state fluctuation and load regulation	1000000	19			
	1000000	20			
ain feedwater cycling	2100	21			
	2100 22				
RCP startup & shutdown	3000	23			
	120	24			
Primary leakage test	120	20			
Turbine roll test	120	20			
	10	28			
	39600	29			
Boron concentration equalization	39600	30			
	TransientsPlant heat-up & cooldown (200F/h, 2235~400psig)Plant heat-up & cooldown (200F/h, lower than 400psig)Ramp load increase between 15% and 100% of full powerRamp load increase between 50% and 100% of full powerRamp load decrease between 15% and 100% of full 	TransientsOccurrencePlant heat-up & cooldown (200F/h, 2235~400psig)120Plant heat-up & cooldown (200F/h, lower than 400psig)120Ramp load increase between 15% and 100% of full power600Ramp load increase between 50% and 100% of full power19200Ramp load decrease between 15% and 100% of full power19200Ramp load decrease between 50% and 100% of full power19200Ramp load decrease between 50% and 100% of full power600Ramp load decrease between 50% and 100% of full power19200Ramp load decrease between 50% and 100% of full power600Ramp load decrease of 10% of full power600Step load decrease of 10% of full power600Step load decrease with turbine bypass60Gou targe step load decrease with turbine bypass60Ramp load decrease with turbine bypass60Steady-state fluctuation and load regulation1000000Main feedwater cycling2100RCP startup & shutdown3000Primary leakage test120Turbine roll test100Boron concentration equalization39600			
Level B					
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Mark	Transients	Occurrence	Load No.		
11.0		60	31		
II-a		60	32		
II-b	Loss of offsite power	60	33		
11-0		60	34		
II-c	Partial loss of reactor coolant flow	30	35		
		30	36		
	Reactor trip from full power	60	37		
	i) With no inadvertent cooldown	60	38		
ll-d	ii) With cooldown and no safety injection	30	39		
in u		30	40		
	iii) With cooldown and safety injection	10	41		
		10	42		
ll-e	Inadvertent RCS depressurization	30	43		
		30	44		
II-f	Control rod drop	30	45		
		30	46		
ll-g	Inadvertent safeguards actuation	30	47		
		30	48		
ll-h	Emergency feedwater cycling	700	49		
		700	50		
II-i	Cold over-pressure	30	51		
		30	52		
11-1	Partial loss of emergency feedwater	30	53		
Onesifi	30 54				
Specific transient of branch pipe		55			
-	Pressurizer safety depressurization valve actuation	60	50		
		2(150) <sup>1</sup>	50		
Earthqua	ake Loads	2(150)	09 60		
		∠(150)	00		

Table A1-3 Pressurizer safety depressurization valve line design transients (2/2)

Level A			
Mark	Transients	Occurrence	Load No.
I-b-1	Plant heat-up & cooldown	120	1
	(200F/N, 2235~400pSig)	120	2
I-b-2	Plant heat-up & cooldown (200F/h, lower than 400psig)	120 120	3 4
I-c-1	Ramp load increase between 15% and 100% of full power	600	5
	Romp load increase between E0% and 100% of full	19200	7
I-c-2	power	19200	8
	Ramp load decrease between 15% and 100% of full	600	9
I-0-1	power	600	10
14.2	Ramp load decrease between 50% and 100% of full	19200	11
1-u-2	power	19200	12
م_ا	Step load increase of 10% of full power	600	13
1-0		600	14
I_f	Step load decrease of 10% of full power	600	15
		600	16
I-a	I arge step load decrease with turbine bypass	60	17
''y		60	18
l-h	Steady-state fluctuation and load regulation	1000000	19
		1000000	20
l-i	Main feedwater cycling	2100	21
		2100	22
I-m	RCP startup & shutdown	3000	23
I-n		3000	24
I-p	Primary leakage test	120	25
· ·	, ,	120	26
I-q	Turbine roll test	10	27
		10	28
I-r	Boron concentration equalization	39600	29
1-1		39600	30

 Table A1-4 Pressurizer safety valve line design transients (1/2)

Level B

r safety valve line design transients (2/2)				
ransients	Occurrence Loa			
	60	31		
	60	32		
	60	33		
	60	34		
colort flow	30	35		
	30	36		

Table A1-4 Pressurizer safety valve	e line design	transients	(2/2)
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Mark	Transients	Occurrence	Load No.
ll-a	Loss of load	60	31
		60	32
II-b	Loss of offsite power	60	33
		60	34
ll-c	Partial loss of reactor coolant flow	30	35
		30	36
	Reactor trip from full power	60	37
	i) With no inadvertent cooldown	60	38
h-II	ii) With cooldown and no safety injection	30	39
II-U	ing with cooldown and no safety injection	30	40
	iii) With cooldown and safety injection	10	41
		10	42
مال	Inadvertent RCS depressurization	30	43
11-6	Umbrella case	30	44
II f	Control rod drop	30	45
11-1		30	46
Ша	Inadvertent safeguards actuation	30	47
n-y		30	48
Шb	Emorgoney foodwater eveling	700	49
11-11		700	50
	Cold over pressure	30	51
11-1		30	52
	Partial loss of amorganey feedwater	30	53
11-1		30	54
Specific	transient of branch pipe		
	Pressurizer safety value actuation	60	55
		60	56
Farthous	ke Loads	2(150) <sup>1</sup>	59
	Earlinguake Loads		60

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
	Pamp load increase between 500/ and 1000/ of full	19200	5
I-c-2	power	19200	6
I-d-1	Ramp load decrease between 15% and 100% of full	600	7
	power	600	8
I-d-2	Ramp load decrease between 50% and 100% of full	19200	9
	power	19200	10
l-e	Step load increase of 10% of full power	600	11
		600	12
I-f	Step load decrease of 10% of full power	600	13
		600	14
l-a	Large step load decrease with turbine bypass	60	15
. 9		60	16
l-h	Steady-state fluctuation and load regulation	1000000	17
		1000000	18
I-i	Main feedwater cycling	2100	19
		2100	20
I-i	Refueling	60	21
.,		60	22
l-k	Ramp load increase between 0% and	600	23
	15% of full power	600	24
1-1	Ramp load decrease between 0% and	600	25
	15% of full power	600	26
l-m	RCP startup & shutdown	3000	27
I-n		3000	28
I-o	Core lifetime extension	60	29
		60	30
l-p	Primary leakage test	120	31
і-р		120	32
I-q T	Turbine roll test	10	33
		10	34

 Table A1-5 RHRS Suction loop A line design transients (1/2)

Level B			
Mark	Transients	Occurrence	Load No.
د_اا	l oss of load	60	35
11-a		60	36
II-b	Loss of offsite power	60	37
		60	38
II-c	Partial loss of reactor coolant flow	30	39
		30	40
	Reactor trip from full power	60	41
	i) With no inadvertent cooldown	60	42
ll-d	ii) With cooldown and no safety injection	30	43
		30	44
	iii) With cooldown and safety injection	10	45
		10	46
II-e	Inadvertent RCS depressurization	30	47
110		30	48
II-f	Control rod drop	30	49
		30	50
II-a	Inadvertent safeguards actuation	30	51
11.9		30	52
ll-h	Emergency feedwater cycling	700	53
		700	54
II_i	Cold over-pressure	30	55
		30	56
11_1	Partial loss of emergency feedwater	30	57
11-1	T attailloss of emergency reedwater	30	58
Specifi	c transient of branch pipe		
a)	Plant heat-up & cooldown	120	59
b)		120	60
	Safe shutdown 1	1	61
-	Safe shutdown 2~6	1	62
		5	63
		5	64
Earthquake Loads		65	
		2(150) <sup>1</sup>	66

Table A1-5 RHRS suction loop A line design transients (2/2)

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full	600	3
		10200	4
I-c-2	Ramp load increase between 50% and 100% of full power	19200	5 6
1 d 1	Ramp load decrease between 15% and 100% of full	600	7
1-0-1	power	600	8
142	Ramp load decrease between 50% and 100% of full	19200	9
1-u-2	power	19200	10
م_ا	Step load increase of 10% of full power	600	11
1-0	Step load increase of 10% of full power	600	12
l f	Step load decrease of 10% of full power	600	13
1-1	Step load decrease of 10% of full power	600	14
l-a	Large step load decrease with turbine bypass	60	15
чg	Large step load decrease with tarbine bypass	60	16
l-h	Steady-state fluctuation and load regulation	1000000	17
		1000000	18
I_i	Main feedwater cycling	2100	19
		2100	20
I-i	Refueling	60	21
• )		60	22
l-k	Ramp load increase between 0% and	600	23
	15% of full power	600	24
1-1	Ramp load decrease between 0% and	600	25
	15% of full power	600	26
l-m	RCP startup & shutdown	3000	27
l-n		3000	28
I-0	Core lifetime extension	60	29
		60	30
l-n	Primary leakage test	120	31
۰ ۲		120	32
I-q	Turbine roll test	10	33
		10	34

Table A1-6 RHRS suction loop B line design transients (1/2)

MUAP-10016-NP	(R0)

Transients	Occurrence	Load No.
Loss of load	60	35
	60	36
Loss of offsite power	60	37
	60	38
Partial loss of reactor coolant flow	30	39
	30	40
Reactor trip from full power	60	41
i) With no inadvertent cooldown	60	42
ii) With cooldown and no safety injection	30	43
	30	44
iii) With cooldown and safety injection	10	45
· · · · · · · · · · · · · · · · · · ·	10	46
Inadvertent RCS depressurization	30	47
-	30	48
Control rod drop	30	49
	30	50
Inadvertent safeguards actuation	30	51
-	30	52
Emergency feedwater cycling	700	53
	700	54
Cold over-pressure	30	55
	30	50
Partial loss of emergency feedwater	30	57
transignt of branch ning		50
	120	59
Plant heat-up & cooldown	120	60
~/		61
Earthquake Loads		62
	TransientsLoss of loadLoss of offsite powerPartial loss of reactor coolant flowReactor trip from full power i) With no inadvertent cooldownii) With cooldown and no safety injectioniii) With cooldown and safety injectionInadvertent RCS depressurizationControl rod dropInadvertent safeguards actuationEmergency feedwater cyclingCold over-pressurePartial loss of emergency feedwatertransient of branch pipePlant heat-up & cooldown	TransientsOccurrenceLoss of load60Loss of offsite power60Partial loss of reactor coolant flow30Partial loss of reactor coolant flow30Reactor trip from full power60i) With no inadvertent cooldown60ii) With cooldown and no safety injection30iii) With cooldown and safety injection10Inadvertent RCS depressurization30Control rod drop30Inadvertent safeguards actuation30Emergency feedwater cycling700Cold over-pressure30Partial loss of emergency feedwater30Partial loss of emergency feedwater30Ke Loads2(150) 1

 Table A1-6 RHRS suction loop B line design transients (2/2)

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
	Pamp load increase between 50% and 100% of full	19200	5
I-c-2	power	19200	6
1.4.1	Ramp load decrease between 15% and 100% of full	600	7
1-u-1	power	600	8
142	Ramp load decrease between 50% and 100% of full	19200	9
I-u-Z	power	19200	10
٦٥	Step load increase of 10% of full power	600	11
1-6	Step load increase of 10% of full power	600	12
l f	Step load decrease of 10% of full power	600	13
1-1	Step load decrease of 10% of full power	600	14
l-a	Large step load decrease with turbine bypass	60	15
19		60	16
l-h	Steady-state fluctuation and load regulation	1000000	17
		1000000	18
I-i	Main feedwater cycling	2100	19
		2100	20
I-i	Refueling	60	
. ,		60	
I-k	Ramp load increase between 0% and	600	21
	15% of full power	600	22
-	Ramp load decrease between 0% and	600	23
	15% of full power	600	24
l-m	RCP startup & shutdown	3000	25
I-N		3000	26
I-o	Core lifetime extension	60	27
		60	28
l-p	Primary leakage test	120	29
i-h		120	30
l-q	Turbine roll test	10	31
		10	32

Table A1-7 RHR return line design transients (1/2)

Level B	-		
Mark	Transients	Occurrence	Load No.
ll-a	Loss of load	60	33
n-a		60	34
II-b	Loss of offsite nower	60	35
11-0		60	36
II-c	Partial loss of reactor coolant flow	30	37
110		30	38
	Reactor trip from full power	60	39
	i) With no inadvertent cooldown	60	40
ll-d	ii) With cooldown and no safety injection	30	41
na		30	42
	iii) With cooldown and safety injection	10	43
		10	44
II-e	Inadvertent RCS depressurization	30	45
		30	46
II-f	Control rod drop	30	47
		30	48
II-a	Inadvertent safeguards actuation	30	49
9		30	50
ll-h	Emergency feedwater cycling	700	51
		700	52
II-i	Cold over-pressure	30	53
		30	54
11-1	Partial loss of emergency feedwater	30	55
		30	56
Specifi	c transient of branch pipe		
	Plant heat-up & cooldown 1 Plant heat-up & cooldown 2	120	57
a)		120	58
C)		120	59
		120	60
b)	Refueling	60	61
,		60	62
Earthquake Loads		2(150)	63
		2(150)	64

Table A1-7 RHR return line design transients (2/2)

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
	Ramp load increase between 50% and 100% of full	19200	5
I-c-2	power	19200	6
I-d-1	Ramp load decrease between 15% and 100% of full	600	7
	power	600	8
I-d-2	Ramp load decrease between 50% and 100% of full	19200	9
	power	19200	10
I-e	Step load increase of 10% of full power	600	11
		600	12
I-f	Step load decrease of 10% of full power	600	13
		600	14
I-a	Large step load decrease with turbine bypass	60	15
0		60	16
I-h	Steady-state fluctuation and load regulation	1000000	17
	, ,	1000000	18
I-i	Main feedwater cycling	2100	19
	, ,	2100	20
I-j	Refueling	60	21
		60	22
l-k	Ramp load increase between 0% and	600	23
		600	24
I-I	Ramp load decrease between 0% and	600	25
		600	20
I-M I-n	RCP startup & shutdown	3000	21
		3000	20
I-o	Core lifetime extension	60	29
		120	30
I-p	Primary leakage test	120	30
		120	33
l-q	Turbine roll test	10	34
-		.0	07

Level B			
Mark	Transients	Occurrence	Load No.
Ша	Loss of load	60	35
II-a		60	36
ШЬ	Loss of offsite power	60	37
11-0		60	38
ll-c	Partial loss of reactor coolant flow	30	39
11-0		30	40
	Reactor trip from full power	60	41
	i) With no inadvertent cooldown	60	42
h-II	ii) With cooldown and no safety injection	30	43
n-u		30	44
	iii) With cooldown and safety injection	10	45
		10	46
م_اا	Inadvertent RCS depressurization	30	47
		30	48
II-f	Control rod drop	30	49
		30	50
II-a	Inadvertent safeguards actuation	30	51
		30	52
ll-h	Emergency feedwater cycling	700	53
		700	54
II-i	Cold over-pressure	30	55
		30	56
11-1	Partial loss of emergency feedwater	30	57
		30	58
Specifi	c transient of branch pipe		
a)	Inadvertent actuation of the accumulator tank	5	59
- /		5	60
d)	Inadvertent RCS depressurization	30	61
,		30	62
Earthquake Loads			
		2(150) <sup>1</sup>	64

## Table A1-8 Accumulator line design transient (2/2)

Level A	۱ <u>.</u>		
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
l-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
I-c-2	Ramp load increase between 50% and 100% of full power	19200 19200	5
I-d-1	Ramp load decrease between 15% and 100% of full power	600	7
I-d-2	Ramp load decrease between 50% and 100% of full	19200	9
I-e	Step load increase of 10% of full power	600	10
I-f	Step load decrease of 10% of full power	600	12
• •		600	14
l-a	Large step load decrease with turbine bypass	60	15
- 3		60	16
l-h	Steady-state fluctuation and load regulation	100000	17
		1000000	18
I-i	Main feedwater cycling	2100 2100	19 20
		60	21
I-J	Refueling	60	22
	Ramp load increase between 0% and	600	23
I-K	15% of full power	600	24
1_1	Ramp load decrease between 0% and	600	25
1-1	15% of full power	600	26
I-m	RCP startup & shutdown	3000	27
l-n		3000	28
I-o	Core lifetime extension	60	29
-		60	30
I-p	Primary leakage test	120	31
•		120	32
l-q	Turbine roll test	10	33
		10	34

## Table A1-9 DVI line design transients (1/3)

Level B	Level B				
Mark	Transients	Occurrence	Load No.		
Ша		60	35		
11-a		60	36		
II-b	Loss of offsite power	60	37		
11-0		60	38		
II-c	Partial loss of reactor coolant flow	30	39		
		30	40		
	Reactor trip from full power	60	41		
	i) With no inadvertent cooldown	60	42		
ll-d	ii) With cooldown and no safety injection	30	43		
in a		30	44		
	iii) With cooldown and safety injection	10	45		
		10	46		
II-e	Inadvertent RCS depressurization	30	47		
		30	48		
II-f	Control rod drop	30	49		
		30	50		
ll-a	Inadvertent safeguards actuation	30	51		
		30	52		
II-h	Emergency feedwater cycling	700	53		
		700	54		
II-i	Cold over-pressure	30	55		
		30	56		
_	Partial loss of emergency feedwater	30	57		
11-1		30	58		

## Table A1-9 DVI line design transients (2/3)

Specific	Specific transient of branch pipe					
Mark	Transients	Occurrence	Load No.			
a)	Reactor trip from full power with cooldown and safety	10	59			
a)	injection	10	60			
b)	Inadvertent PCS depressurization	30	61			
0)		30	62			
	Inadvertent safeguards actuation	30	63			
0)		30	64			
	Safe shutdown 1	1	65			
		1	66			
	Cofe shutdows 0. C	5	67			
d)		5	68			
u)	Sofo obutdown 7	1	69			
	Safe shutdown 7	1	70			
	Cofe ebutdown 9	1	71			
		1	72			
Contravales Loads 2		2(150) <sup>1</sup>	73			
		2(150) <sup>1</sup>	74			

## Table A1-9 DVI line design transients (3/3)

Mark Image: TransientsCocurrenceLoad No.I-a I-bPlant heat-up & cooldown1201I-c-1 Ramp load increase between 15% and 100% of full power (Charging flow 50% step decrease and return)6003I-c-2Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)192005I-d-1 Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)6007I-d-2 Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)192009I-d-2 (Charging flow 50% step increase and return)192009I-d-2 (Charging flow 50% step increase and return)60011I-d-2 (Charging flow 50% step increase and return)60012I-fStep load decrease of 10% of full power (Charging flow 50% step increase and return)60014I-g (Charging flow 50% step increase and return)60014I-g (Charging flow 50% step increase and return)60016I-hSteady-state fluctuation and load regulation100000017I-hSteady-state fluctuation and load regulation100000018I+iMain feedwater cycling (Charging flow 50% step increase and return)60022I-kRamp load decrease between 0% and 15% of full power60022I-hRefueling60023I+iRate floctuation and load regulation60024I-hRece startup & shutdown3000	Level A			
I-a I-b         Plant heat-up & cooldown         120         1           I-c-1         Ramp load increase between 15% and 100% of full power (Charging flow 50% step decrease and return)         600         3           I-c-2         Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)         19200         5           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         19200         6           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease of 10% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Ramp load decrease of 10% of full power (Charging flow 50% step increase and return)         1000         10           I-e         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         11           I-f         Step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         60         12           I-h         Steady-state fluctuation and load regulation         10000000         17           I-h         Refuelin	Mark	Transients	Occurrence	Load No.
I-b         Hummend of a consolution         120         2           I-c-1         Ramp load increase between 15% and 100% of full power (Charging flow 50% step decrease and return)         600         3           I-c-2         Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)         19200         6           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Ramp load decrease of 10% of full power (Charging flow 50% step decrease and return)         600         11           I-e         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         12           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Steady-state fluctuation and load regulation         600         22           I-k         Ramp load increase between 0% and 15% of full power <td>l-a</td> <td>Plant heat-up &amp; cooldown</td> <td>120</td> <td>1</td>	l-a	Plant heat-up & cooldown	120	1
I-c-1         Ramp load increase between 15% and 100% of full power (Charging flow 50% step decrease and return)         600         3           I-c-2         Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)         19200         5           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         19200         6           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Ramp load decrease of 10% of full power (Charging flow 50% step increase and return)         600         11           I-e         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease between 0% and return)         2100         10           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Ramp load increase between 0% and 15% of full power         600         22           I-i         Ramp l	I-b		120	2
ICH         (Charging flow 50% step decrease and return)         600         4           I-c-2         Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)         19200         5           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         10           I-e         Step load increase of 10% of full power (Charging flow 50% step increase and return)         600         11           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         60         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Main feedwater cycling (Charging flow 50% step increase and return)         2100         19           I-i         Refueling         600         21         10           I-h         Refueling         600         23 <t< td=""><td>I-c-1</td><td>Ramp load increase between 15% and 100% of full power</td><td>600</td><td>3</td></t<>	I-c-1	Ramp load increase between 15% and 100% of full power	600	3
I-c-2         Ramp load increase between 50% and 100% of full power (Charging flow 50% step decrease and return)         19200         5           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         10           I-e         Step load increase of 10% of full power (Charging flow 50% step increase and return)         600         11           I-e         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         60         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-i         Refueling         600         21         19           I-i         Refueling         600         22         22         14         600         24           I-j         Refueling wer		(Charging flow 50% step decrease and return)	600	4
IC a         (Charging flow 50% step decrease and return)         19200         6           I-d-1         Ramp load decrease between 15% and 100% of full power (Charging flow 50% step increase and return)         600         7           I-d-2         Ramp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         19200         9           I-d-2         Remp load decrease between 50% and 100% of full power (Charging flow 50% step increase and return)         600         11           I-e         Step load increase of 10% of full power (Charging flow 50% step increase and return)         600         12           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         15           I-g         Large step load decrease between 0°s and return)         1000000         17           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Main feedwater cycling (Charging flow 50% step increase and return)         600         21           I-i         Refueling         600         22         100         19           I-i         Refueling         600         24         2100         10<	I-c-2	Ramp load increase between 50% and 100% of full power	19200	5
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		(Charging flow 50% step decrease and return)	19200	6
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	I-d-1	Ramp load decrease between 15% and 100% of full power	600	7
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		(Charging flow 50% step increase and return)	600	8
$\begin{array}{c c c c c c c } \mbox{(Charging flow 50\% step increase and return)} & 19200 & 10 \\ \hline \mbox{Identify} & 10 \\ \hline \mbox{Step load increase of 10\% of full power} & 600 & 11 \\ \mbox{(Charging flow 50\% step decrease and return)} & 600 & 12 \\ \hline \mbox{Identify} & 12 \\ \hline \mbox{(Charging flow 50\% step increase and return)} & 600 & 14 \\ \hline \mbox{Identify} & 12 \\ \hline \mbox{Identify} & 12 \\ \hline \mbox{(Charging flow 50\% step increase and return)} & 600 & 14 \\ \hline \mbox{Identify} & 14 \\ \hline \mbox{Identify} & 12 \\ \hline \mbox{(Charging flow 50\% step increase and return)} & 60 & 16 \\ \hline \mbox{Identify} & 10 \\ \hline \mbox{Identify} & 10 \\ \hline \mbox{(Charging flow 50\% step increase and return)} & 60 & 16 \\ \hline \mbox{Identify} & 10 \\ \hline \mbox{Identify} & 10 \\ \hline \mbox{(Charging flow 50\% step increase and return)} & 10 \\ \hline \mbox{Identify} & 10 \\ \hline \mb$	I-d-2	Ramp load decrease between 50% and 100% of full power	19200	9
I-e         Step load increase of 10% of full power (Charging flow 50% step decrease and return)         600         11           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         13           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         60         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Steady-state fluctuation and load regulation         1000000         18           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-i         Refueling         60         21           I-i         Refueling         60         22           I-k         Ramp load increase between 0% and 15% of full power         600         24           I-I         Ramp load decrease between 0% and 15% of full power         600         25           I-m         RCP startup & shutdown         3000         27           I-n         Core lifetime extension         60         29           I-o         Core lifetime extension         60		(Charging flow 50% step increase and return)	19200	10
(Charging flow 50% step decrease and return)         600         12           I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         13           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         15           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Steady-state fluctuation and load regulation         1000000         18           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-i         Refueling         600         21           I-j         Refueling         600         23           I-k         Ramp load increase between 0% and 15% of full power         600         24           I-l         Ramp load decrease between 0% and 15% of full power         600         25           I-n         RCP startup & shutdown         3000         27           I-n         Core lifetime extension         60         30           I-p         Primary leakage test         120         31           I-q	l-e	Step load increase of 10% of full power	600	11
I-f         Step load decrease of 10% of full power (Charging flow 50% step increase and return)         600         13           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         15           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         600         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Main feedwater cycling (Charging flow 50% step increase and return)         2100         19           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-j         Refueling         600         21           I-j         Refueling         600         23           I-k         Ramp load increase between 0% and 15% of full power         600         24           I-l         Ramp load decrease between 0% and 15% of full power         600         25           I-m         RCP startup & shutdown         3000         27           I-n         Core lifetime extension         60         29           I-o         Core lifetime extension         60         30           I-p         Primary leakage test         120         31      <		(Charging flow 50% step decrease and return)	600	12
Image: (Charging flow 50% step increase and return)         600         14           I-g         Large step load decrease with turbine bypass (Charging flow 50% step increase and return)         60         15           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Steady-state fluctuation and load regulation         1000000         18           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-j         Refueling         60         21           I-j         Refueling         60         22           I-k         Ramp load increase between 0% and 15% of full power         600         23           I-i         Ramp load decrease between 0% and 15% of full power         600         25           I-m         RCP startup & shutdown         600         26           I-m         Core lifetime extension         60         29           I-o         Core lifetime extension         60         30           I-p         Primary leakage test         120         31           I-q         Turbine roll test         10         33	I-f	Step load decrease of 10% of full power	600	13
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		(Charging flow 50% step increase and return)	600	14
Image: bold constraint of the step increase and return)         60         16           I-h         Steady-state fluctuation and load regulation         1000000         17           I-h         Main feedwater cycling (Charging flow 50% step increase and return)         2100         19           I-i         Main feedwater cycling (Charging flow 50% step increase and return)         2100         20           I-j         Refueling         60         21           I-j         Refueling         600         23           I-k         Ramp load increase between 0% and 15% of full power         600         24           I-l         Ramp load decrease between 0% and 15% of full power         600         25           I-m         RCP startup & shutdown         600         26           I-m         RCP startup & shutdown         600         28           I-o         Core lifetime extension         60         29           I-o         Core lifetime extension         60         30           I-p         Primary leakage test         120         31           I-q         Turbine roll test         10         33	l-g	Large step load decrease with turbine bypass	60	15
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		(Charging flow 50% step increase and return)	60	16
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	l-h	Steady-state fluctuation and load regulation	1000000	17
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			1000000	18
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	I-i	Main feedwater cycling	2100	19
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	-		2100	20
$ \begin{array}{c c c c c c c c c } \hline & & & & & & & & & & & & & & & & & & $	I-j	Refueling	60	21
I-k         Ramp load increase between 0% and 15% of full power         600         23           I-I         Ramp load decrease between 0% and 15% of full power         600         24           I-I         Ramp load decrease between 0% and 15% of full power         600         25           I-I         RCP startup & shutdown         600         26           I-n         RCP startup & shutdown         3000         27           I-o         Core lifetime extension         60         29           I-o         Primary leakage test         120         31           I-p         Primary leakage test         120         32           I-q         Turbine roll test         10         33			60	22
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	l-k	Ramp load increase between 0% and	600	23
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		Percentaria de service en al contra a contra de service	600	24
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	1-1	15% of full power	600	20
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			3000	20
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	I-m	RCP startup & shutdown	3000	21
$\begin{array}{c c} I - 0 & Core lifetime extension & \hline 00 & 23 \\ \hline 00 & 120 \\ \hline 120 & 31 \\ \hline 120 & 32 \\ \hline 120 & 32 \\ \hline 10 & 33 \\ \hline 10 & 34 \end{array}$			5000 60	20
I-p         Primary leakage test         120         31           I-q         Turbine roll test         10         33	l-o	Core lifetime extension	00 60	30
I-p         Primary leakage test         120         31           I-q         Turbine roll test         10         33			120	31
I-q         Turbine roll test         10         33           10         34	I-p	Primary leakage test	120	32
I-q Turbine roll test 10 34	I-q		10	33
		Turbine roll test	10	34

 Table A1-10 CVCS charging line design transients (1/3)

Level B	-		
Mark	Transients	Occurrence	Load No.
	Loss of load	60	35
n-a	(Charging flow 50% step increase and return)	60	36
II-b	Loss of offsite power	60	37
	(Charging flow 50% step increase and return)	60	38
II-c	Partial loss of reactor coolant flow	30	39
	(Charging flow 50% step increase and return)	30	40
	Reactor trip from full power	60	41
	(Charging flow 50% step increase and return)	60	42
	ii) With cooldown and no safety injection	30	43
	Letdown line shut off and re-initiated	30	44
	ii) With cooldown and no safety injection	30	45
	(Charging flow 50% step increase and return)	30	46
ll-d	iii) With cooldown and safety injection Letdown line shut off and re-initiated	10	47
		10	48
	iii) With cooldown and safety injection	10	49
	Charging line shut off and re-initiated b) SI 1	10	50
	iii) With cooldown and safety injection	10	51
	Charging line shut off and re-initiated b) SI 2	10	52
	iii) With cooldown and safety injection	10	53
	(Charging flow 50% step increase and return)	10	54
	Inadvertent RCS depressurization	30	55
		30	50
ll-e	Inadvertent RCS depressurization	30	57
	In advantant DOC degrees with the	30	50
	(Charging flow 50% step increase and return)	30	60
		30	61
	Control rod dropLetdown line shut off and re-initiated	30	62
ll-f	Control rod drop (Charging flow 50% step increase and	30	63
	return)	30	64
II-g	Inadvertent safeguards actuation	30	65
	Charging line shut off and re-initiated b) SI 1	30	66

 Table A1-10 CVCS charging line design transients (2/3)

Level B				
Mark	Transients	Occurrence	Load No.	
	Inadvertent safeguards actuation	30	67	
Ша	Charging line shut off and re-initiated b) SI 2	30	68	
n-g	Inadvertent safeguards actuation	30	69	
	(Charging flow 50% step increase and return)	30	70	
II-h	Emergency feedwater cycling	700	71	
	(Charging flow 50% step increase and return)	700	72	
II-i	Cold over-pressure	30	73	
		30	74	
11-1	Partial loss of emergency feedwater	30	75	
		30	76	
Specific	transient of branch pipe			
	Charging line shut off and re-initiated	30	77	
	a) Maintenance 1	30	78	
1.B a)	Charging line shut off and re-initiated	30	79	
,		30	80	
	Charging line shut off and re-initiated	30	81	
	a) Maintenance 3	30	82	
	Letdown flow 50% step decrease and return 1	2900	83	
2.C		2900	84	
	Letdown flow 50% step decrease and return 2	2900	85	
		2900	86	
	Letdown flow 100% step increase and return 1	19800	87	
2.D		19800	88	
	Letdown flow 100% step increase and return 2	19800	89	
		19800	90	
Earthquake Loads		2(150)	91	
		2(150) '	92	

 Table A1-10 CVCS charging line design transients (3/3)

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
I-c-2	Ramp load increase between 50% and 100% of full power	19200	5
I-d-1	Ramp load decrease between 15% and 100% of full	600	7
	Ramp load decrease between 50% and 100% of full	19200	0 9
I-d-2	power	19200	10
	Stan land increase of 100/ of full neuror	600	11
I-e	Step load increase of 10% of full power	600	12
l f	Stop load docroase of 10% of full power	600	13
1-1	Step load decrease of 10% of full power	600	14
l-a	Large step load decrease with turbine bypass	60	15
. 9		60	16
l-h	Steady-state fluctuation and load regulation	1000000	17
		100000	18
I-i	Main feedwater cycling	2100	19
		2100	20
I-j	Refueling	60	21
		60	22
l-k	Ramp load increase between 0% and 15% of full power	600	23
	Pamp load decrease between 0% and	600	24
1-1	15% of full power	600	26
I-m		3000	27
l-n	RCP startup & shutdown	3000	28
	Care lifetime extension	60	29
1-0		60	30
l n	Primary leakage test	120	31
i-h		120	32
l-q	Turbine roll test	10	33
		10	34

Table A1-11 CVCS let dowr	n line design transients	(1/3)
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Level B			
Mark	Transients	Occurrence	Load No.
ll-a		60	35
Π-α		60	36
II-b	Loss of offsite power	60	37
		60	38
II-c	Partial loss of reactor coolant flow	30	39
		30	40
	Reactor trip from full power	60	41
	i) With no inadvertent cooldown	60	42
ll-d	ii) With cooldown and no safety injection	30	43
in a		30	44
	iii) With cooldown and safety injection	10	45
		10	46
ll-e	Inadvertent RCS depressurization	30	47
		30	48
II-f	Control rod drop	30	49
		30	50
II-a	Inadvertent safeguards actuation	30	51
		30	52
II-h	Emergency feedwater cycling	700	53
		700	54
II-i	Cold over-pressure	30	55
		30	56
11-1	Partial loss of emergency feedwater	30	57
11-1		30	58

 Table A1-11 CVCS let down line design transients (2/3)

Specific transient of branch pipe						
Mark	Transients	Occurrence	Load No.			
a) b)	Plant heat-up & cooldown	120	59			
		120	60			
c)	Letdown line shut off and re-initiated (maintenance)	30	61			
		30	62			
	Letdown line shut off and re-initiated (SI) With cooldown and no safety injection	30	63			
d)		30	64			
	Letdown line shut off and re-initiated (SI) With cooldown and safety injection	10	65			
		10	66			
	Letdown line shut off and re-initiated (SI) Control rod drop	30	67			
		30	68			
e)	RCS drain	120	69			
		120	70			
Earthquake Loads		2(150) <sup>1</sup>	71			
		2(150) <sup>1</sup>	72			

 Table A1-11 CVCS let down line design transients (3/3)

Level A			
Mark	Transients	Occurrence	Load No.
l-a	Plant heat-up & cooldown	120	1
I-b		120	2
I-c-1	Ramp load increase between 15% and 100% of full power	600 600	3
I-c-2	Ramp load increase between 50% and 100% of full power	19200	5
I-d-1	Ramp load decrease between 15% and 100% of full power	600	7
I-d-2	Ramp load decrease between 50% and 100% of full	19200	9
l-e	Step load increase of 10% of full power	600	10
		600	12
l-f	Step load decrease of 10% of full power	600	13
		60	15
I-g	Large step load decrease with turbine bypass	60	16
١b	Steady-state fluctuation and load regulation	1000000	17
1-11		1000000	18
I-i	Main feedwater cycling	2100	19
		2100	20
I-j	Refueling	60	21
		60	22
l-k	Ramp load increase between 0% and 15% of full power	600	23
		600	24
I-I	Ramp load decrease between 0% and 15% of full power	600	25
l-m	RCP startup & shutdown	3000	20
l-n		3000	28
	Core lifetime extension	60	29
I-0		60	30
l-p	Primary leakage test	120	31
		120	32
l-a	Turbine roll test	10	33
Ч		10	34

 Table A1-12 CVCS seal injection line design transients (1/2)

Level B						
Mark	Transients	Occurrence	Load No.			
	Loss of load	60	35			
II-a		60	36			
II-b	Loss of offsite power	60	37			
		60	38			
II-c	Partial loss of reactor coolant flow	30	39			
		30	40			
	Reactor trip from full power	60	41			
	i) With no inadvertent cooldown	60	42			
ll-d	ii) With cooldown and no safety injection	30	43			
in a		30	44			
	iii) With cooldown and safety injection	10	45			
		10	46			
II-e	Inadvertent RCS depressurization	30	47			
11-6		30	48			
II-f	Control rod drop	30	49			
		30	50			
ll-g	Inadvertent safeguards actuation	30	51			
		30	52			
ll b	Emergency feedwater cycling	700	53			
		700	54			
II-i	Cold over-pressure	30	55			
11-1		30	56			
-	Partial loss of emergency feedwater	30	57			
		30	58			
Earthquake Loads		2(150) <sup>1</sup>	59			
		2(150) 1	60			

 Table A1-12 CVCS seal injection line design transients (2/2)