



HITACHI

GE Hitachi Nuclear Energy

25A5675AB
Revision 7
October 2019

ABWR

Design Control Document

Tier 2

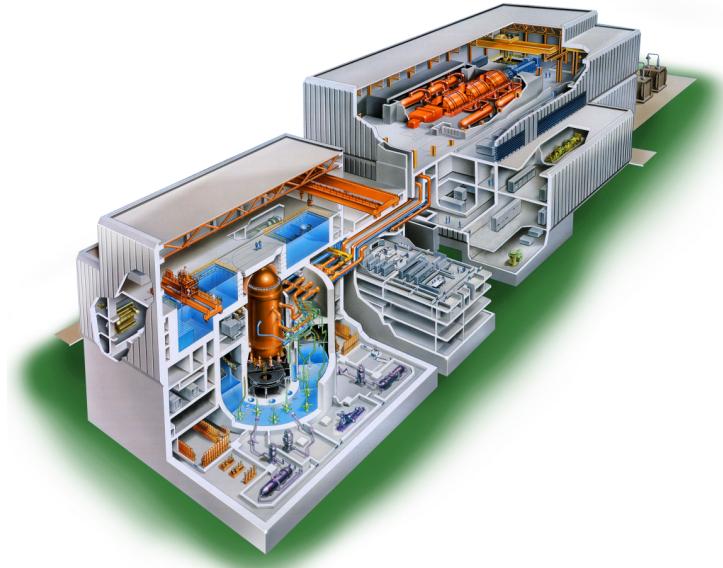


Table of Contents

*Copyright 1994, 2010, 2016, 2019 GE-Hitachi Nuclear Energy Americas LLC
All Rights Reserved*

LEGAL NOTICE

The design, engineering, and other information contained in this document is furnished by GE-Hitachi Nuclear Energy Americas LLC (GEH) for the purpose of supporting the GEH Certification Renewal Application to the United States Nuclear Regulatory Commission (NRC) for renewal of the certification of the ABWR nuclear plant design pursuant to Title 10 Code of Federal Regulations (10 CFR) Part 52.

No use of or right to copy any of the information contained in this document, other than by the NRC and its contractors in support of GEH's application, is authorized except by contract with GEH. The information provided in this document is part of and dependent upon a larger set of knowledge, technology, and intellectual property rights pertaining to standardized, nuclear powered, electric generating facilities that utilize the design certification, as designed and certified to U.S. Codes, Standards, and Regulations by GEH, and referred to as the ABWR nuclear power plant design. Without access and a GEH grant of rights to that larger set of knowledge, technology, and intellectual property rights, this document is not practically or rightfully usable by others, except by the NRC or through contractual agreements with Combined License Applicants and Licensees or customers and participating utilities.

Chapter 1

Table of Contents

1.0	Introduction and General Description of Plant	1.1-1
1.1	Introduction.....	1.1-1
1.1.1	Format and Content	1.1-1
1.1.2	ABWR Standard Plant Scope.....	1.1-1
1.1.3	Engineering Documentation.....	1.1-3
1.1.4	Design Process.....	1.1-3
1.1.5	Type of License Required	1.1-3
1.1.6	Number of Plant Units.....	1.1-3
1.1.7	Description of Location.....	1.1-3
1.1.8	Type of Nuclear Steam Supply.....	1.1-3
1.1.9	Type of Containment.....	1.1-3
1.1.10	Core Thermal Power Levels.....	1.1-4
1.1.11	COL License Information.....	1.1-4
1.2	General Plant Description.....	1.2-1
1.2.1	Principal Design Criteria	1.2-1
1.2.2	Plant Description	1.2-7
1.2.3	COL License Information.....	1.2-38
1.3	Comparison Tables	1.3-1
1.3.1	Nuclear Steam Supply System Design Characteristics	1.3-1
1.3.2	Engineered Safety Features Design Characteristics	1.3-1
1.3.3	Containment Design Characteristics	1.3-1
1.3.4	Structural Design Characteristics	1.3-1
1.3.5	Instrumentation and Electrical Systems Design Characteristics	1.3-1
1.4	Identification of Agents and Contractors	1.4-1
1.4.1	Technical Qualifications of Applicant.....	1.4-1
1.4.2	Use of Contractors	1.4-2
1.5	Requirements for Further Technical Information	1.5-1
1.6	GEH Topical Reports and Other Documents	1.6-1
1.7	Drawings	1.7-1
1.7.1	Piping and Instrumentation and Process Flow Drawings.....	1.7-1
1.7.2	Instrument, Control and Electrical Drawings.....	1.7-1
1.7.3	ASME Standard Units to Preferred Metric Conversion Factors	1.7-1
1.7.4	Preferred Metric Conversion to ASME Standard Units	1.7-1
1.7.5	Drawing Standards	1.7-1
1.7.6	COL License Information.....	1.7-1
1.8	Conformance with Standard Review Plan and Applicability of Codes and Standards	1.8-1
1.8.1	Conformance with Standard Review Plan.....	1.8-1
1.8.2	Applicability of Codes and Standards	1.8-1
1.8.3	Applicability of Experience Information.....	1.8-1
1.8.4	COL License Information.....	1.8-2

Chapter 1

Table of Contents (Continued)

1.9	COL License Information.....	1.9-1
1A	Response to TMI Related Matters	1A-1
1A.1	Introduction	1A-1
1A.2	NRC Positions/Responses	1A-1
1A.3	COL License Information.....	1A-33
1A.4	References	1A-34
1AA	Plant Shielding to Provide Access to Vital Areas and Protective Safety Equipment for Post-Accident Operation [II.B.2]	1AA-1
1AA.1	Introduction	1AA-1
1AA.2	Summary of Shielding Design Review	1AA-1
1AA.3	Containment Description and Post Accident Operations	1AA-3
1AA.4	Design Review Bases	1AA-4
1AA.5	Results of the Review.....	1AA-6
1B	Not Used	1B-1
1C	ABWR Station Blackout Considerations.....	1C-1
1C.1	Introduction	1C-1
1C.2	Discussion.....	1C-1
1C.3	Conclusions	1C-8
1C.4	COL License Information.....	1C-8
1C.5	References	1C-8

Chapter 1

List of Tables

Table 1.3-1	Comparison of Nuclear Steam Supply System Design Characteristics	1.3-2
Table 1.3-2	Comparison of Engineered Safety Features Design Characteristics	1.3-7
Table 1.3-3	Comparison of Containment Design Characteristics	1.3-9
Table 1.3-4	Comparison of Structural Design Characteristics	1.3-11
Table 1.4-1	Commercial Nuclear Reactors Completed, Under Construction, by GE/GEH.....	1.4-3
Table 1.6-1	Referenced Reports	1.6-2
Table 1.6-2	Reports Incorporated by Reference	1.6-7
Table 1.7-1	Piping and Instrumentation and Process Flow Diagrams.....	1.7-2
Table 1.7-2	Instrument Engineering, Interlock Block and Single-Line Diagrams	1.7-4
Table 1.7-3	Conversion to ASME Standard Units.....	1.7-6
Table 1.7-4	Conversion Tables—Metric to ASME Standard Units	1.7-9
Table 1.7-5	Drawing Standards	1.7-11
Table 1.8-1	Summary of Differences from SRP Section 1.....	1.8-3
Table 1.8-2	Summary of Differences from SRP Section 2.....	1.8-3
Table 1.8-3	Summary of Differences from SRP Section 3.....	1.8-3
Table 1.8-4	Summary of Differences from SRP Section 4.....	1.8-4
Table 1.8-5	Summary of Differences from SRP Section 5.....	1.8-4
Table 1.8-6	Summary of Differences from SRP Section 6.....	1.8-5
Table 1.8-7	Summary of Differences from SRP Section 7.....	1.8-5
Table 1.8-8	Summary of Differences from SRP Section 8.....	1.8-6
Table 1.8-9	Summary of Differences from SRP Section 9.....	1.8-6
Table 1.8-10	Summary of Differences from SRP Section 10.....	1.8-7
Table 1.8-11	Summary of Differences from SRP Section 11.....	1.8-7
Table 1.8-12	Summary of Differences from SRP Section 12.....	1.8-7
Table 1.8-13	Summary of Differences from SRP Section 13.....	1.8-7
Table 1.8-14	Summary of Differences from SRP Section 14.....	1.8-7

Chapter 1

List of Tables (Continued)

Table 1.8-15	Summary of Differences from SRP Section 15.....	1.8-7
Table 1.8-16	Summary of Differences from SRP Section 16.....	1.8-9
Table 1.8-17	Summary of Differences from SRP Section 17.....	1.8-9
Table 1.8-18	Summary of Differences from SRP Section 18.....	1.8-9
Table 1.8-19	Standard Review Plans and Branch Technical Positions Applicable to ABWR.....	1.8-10
Table 1.8-20	NRC Regulatory Guides Applicable to ABWR	1.8-25
Table 1.8-21	Industrial Codes and Standards Applicable to ABWR.....	1.8-36
Table 1.8-22	Experience Information Applicable to ABWR	1.8-49
Table 1.9-1	Summary of ABWR Standard Plant COL License Information	1.9-2
Table 1A-1	Responses to Questions Posed by Mr. C. Michelson [II.K.3(46)]	1A-36
Table 1AA-1	Radiation Source Comparison.....	1AA-10
Table 1AA-2	Post-Accident Emergency Core Cooling Systems and Auxiliaries.....	1AA-11
Table 1AA-3	Post-Accident Combustible Gas Control Systems and Auxiliaries.....	1AA-13
Table 1AA-4	Post-Accident Fission Product Removal and Control Systems and Auxiliaries.....	1AA-14
Table 1AA-5	Post-Accident Instrumentation and Controls, Power and Habitability Systems and Auxiliaries.....	1AA-15
Table 1C-1	ABWR Design Compliance with 10CFR50.63 Regulations.....	1C-9
Table 1C-2	ABWR Design Compliance with Regulatory Guide 1.155.....	1C-13
Table 1C-3	ABWR Design Compliance with NUMARC 87-00 Guidelines	1C-29

Chapter 1

List of Figures

Figure 1.1-1	ABWR Standard Plant Nomenclature.....	1.1-5
Figure 1.1-2	Heat Balance at Rated Power.....	1.1-6
Figure 1.2-1	Site Plan	1.2-39
Figure 1.2-2	Reactor Building, Arrangement Elevation, Section A-A	1.2-40
Figure 1.2-2a	Reactor Building, Arrangement Elevation, Section B-B	1.2-40
Figure 1.2-3	Upper Drywell, Arrangement Elevation, Section A-A	1.2-40
Figure 1.2-3a	Upper Drywell, Arrangement Elevation, Section B-B.....	1.2-40
Figure 1.2-3b	Lower Drywell, Arrangement Elevation, Section A-A.....	1.2-40
Figure 1.2-3c	Wetwell, Arrangement Elevation, Sections A-A & B-B	1.2-40
Figure 1.2-4	Reactor Building, Arrangement Plan at Elevation -8200 mm.....	1.2-40
Figure 1.2-5	Reactor Building, Arrangement Plan at Elevation -1700 mm	1.2-40
Figure 1.2-6	Reactor Building, Arrangement Plan at Elevation 4800/8500 mm.....	1.2-40
Figure 1.2-7	Not Used.....	1.2-40
Figure 1.2-8	Reactor Building, Arrangement Plan at Elevation 12300 mm.....	1.2-40
Figure 1.2-9	Reactor Building, Arrangement Plan at Elevation 18100 mm.....	1.2-40
Figure 1.2-10	Reactor Building, Arrangement Plan at Elevation 23500 mm.....	1.2-40
Figure 1.2-11	Reactor Building, Arrangement Plan at Elevation 27200 mm.....	1.2-40
Figure 1.2-12	Reactor Building, Arrangement Plan at Elevation 31700/38200 mm.....	1.2-40
Figure 1.2-13a	Drywell, Arrangement Plan at Elevation 12300 mm	1.2-40
Figure 1.2-13b	Drywell, Arrangement Plan at Elevation 15600 mm	1.2-40
Figure 1.2-13c	Drywell, Arrangement Plan at Elevation 18100 mm	1.2-40
Figure 1.2-13d	Drywell Steel Structure at Elevation 18100 mm.....	1.2-40
Figure 1.2-13e	Lower Drywell, Arrangement Plan at Elevation -6600 to -1850 mm	1.2-40
Figure 1.2-13f	Lower Drywell, Arrangement Plan at Elevation -1850 to 1750 mm	1.2-40
Figure 1.2-13g	Lower Drywell, Arrangement Plan at Elevation 1750 to 4800 mm	1.2-40
Figure 1.2-13h	Lower Drywell, Arrangement Plan at Elevation 4800 to 6700 mm	1.2-40

Chapter 1

List of Figures (Continued)

Figure 1.2-13i	Wetwell, Arrangement Plan at Elevation -8200 mm	1.2-40
Figure 1.2-13j	Wetwell, Arrangement Plan at Elevation -1700 mm	1.2-40
Figure 1.2-13k	Wetwell, Arrangement Plan at Elevation 4800 mm.....	1.2-41
Figure 1.2-14	Control and Service Building, Arrangement Elevation, Section A-A	1.2-41
Figure 1.2-15	Control and Service Building, Arrangement Elevation, Section B-B.....	1.2-41
Figure 1.2-16	Control Building, Arrangement Plan at Elevation -8200 mm	1.2-41
Figure 1.2-17	Control and Service Building, Arrangement Elevation -2150 mm	1.2-41
Figure 1.2-18	Control and Service Building, Arrangement Elevation 3500 mm	1.2-41
Figure 1.2-19	Control and Service Building, Arrangement Elevation 7900 mm	1.2-41
Figure 1.2-20	Control and Service Building, Arrangement Elevation 12300 mm	1.2-41
Figure 1.2-21	Control and Service Building, Arrangement Elevation 17150 mm	1.2-41
Figure 1.2-22	Control and Service Building, Arrangement Elevation 22200 mm	1.2-41
Figure 1.2-23a	Radwaste Building at Elevation -1500 mm	1.2-41
Figure 1.2-23b	Radwaste Building at Elevation 4800 mm.....	1.2-41
Figure 1.2-23c	Radwaste Building at Elevation 12300 mm.....	1.2-41
Figure 1.2-23d	Radwaste Building at Elevation 21000 mm.....	1.2-41
Figure 1.2-23e	Radwaste Building, Section A-A	1.2-41
Figure 1.2-23f	Not Used.....	1.2-41
Figure 1.2-23g	Not Used.....	1.2-41
Figure 1.2-24	Turbine Building, General Arrangement at Elevation 5300 mm	1.2-41
Figure 1.2-25	Turbine Building, General Arrangement at Elevation 12300 mm	1.2-41
Figure 1.2-26	Turbine Building, General Arrangement at Elevation 20300 mm	1.2-41
Figure 1.2-27	Turbine Building, General Arrangement at Elevation 30300 mm	1.2-41
Figure 1.2-28	Turbine Building, General Arrangement, Longitudinal Section A-A.....	1.2-41
Figure 1.2-29	Turbine Building, General Arrangement, Section B-B.....	1.2-41
Figure 1.2-30	Turbine Building, General Arrangement, Section C-C.....	1.2-41

Chapter 1

List of Figures (Continued)

Figure 1.2-31	Turbine Building, General Arrangement, Section D-D	1.2-41
Figure 1.7-1	Piping and Instrumentation Diagram Symbols (Sheets 1–2)	1.7-21
Figure 1.7-2	Graphical Symbols for Use in IBDs.....	1.7-22
Figure 1.7-3	Graphical Symbols for Use in Electrical SLDs (Sheets 1–4)	1.7-30

Chapter 2

Table of Contents

2.0	Site Characteristics	2.0-1
2.0.1	Summary.....	2.0-1
2.0.2	References	2.0-1
2.1	Limits Imposed on SRP Section II Acceptance Criteria by ABWR Standard Plant	2.1-1
2.2	Requirements for Determination of ABWR Site Acceptability	2.2-1
2.2.1	Design Basis Events	2.2-1
2.2.2	Severe Accidents	2.2-1
2.3	COL License Information.....	2.3-1
2.3.1	Envelope of Standard Plant Design Parameters	2.3-1
2.3.2	Standard Review Plant Site Characteristics	2.3-2
2.3.3	Severe Accident Consequence Computer Code Calculations	2.3-7
2A	Input to CRAC 2 Computer Code for Determination of ABWR Site Acceptability.....	2A-1

Chapter 2

List of Tables

Table 2.0-1	Envelope of ABWR Standard Plant Site Design Parameters	2.0-2
Table 2.1-1	Limits Imposed on SRP Section II Acceptance Criteria by ABWR Design.....	2.1-2
Table 2.2-1	Dose-Related Goals	2.2-3
Table 2.2-2	CRAC 2 Data Input Listing.....	2.2-3
Table 2A-1	Spatial Subgroup (NUREG/CR-2326, pg 2-11)	2A-1
Table 2A-2	Site Subgroup (NUREG/CR-2326, pg 2-13)	2A-1
Table 2A-3	Economic Subgroup (NUREG/CR-2326, pg 2-22)	2A-2
Table 2A-4	Population Subgroup (NUREG/CR-2326, pg 2-26).....	2A-3
Table 2A-5	Topography Subgroup, (NUREG/CR-2326, pg 2-33).....	2A-3
Table 2A-6	Isotopic Subgroup (NUREG/CR-2326, pg 2-37)	2A-4
Table 2A-7	Leakage Subgroup (NUREG/CR-2326, pg 2-41).....	2A-5
Table 2A-8	Dispersion Subgroup (NUREG/CR-2326, pg 2-45).....	2A-6
Table 2A-9	Evacuation Subgroup (NUREG/CR-2326, pg 2-47)	2A-6
Table 2A-10	Acute Subgroup (NUREG/CR-2326, pg 2-53).....	2A-6
Table 2A-11	Latent Subgroup (NUREG/CR-2326, pg 2-57)	2A-7
Table 2A-12	Chronic Subgroup (NUREG/CR-2326, pg 2-62)	2A-8
Table 2A-13	Scale Subgroup (NUREG/CR-2326, pg 2-72).....	2A-13
Table 2A-14	Results Subgroup (NUREG/CCR-2326, pg 2-72).....	2A-14
Table 2A-15	Individual Accident Event Groups Leakage Subgroup (NUREG/CR-2326, pg 2-41).....	2A-15
Table 2A-16	File 21 Dose Conversion File (NUREG/CR-2326, pg 4-3).....	2A-16

Chapter 3

Table of Contents

3.0	Design of Structures, Components, Equipment and Systems.....	3.1-1
3.1	Conformance with NRC General Design Criteria	3.1-1
3.1.1	Summary Description.....	3.1-1
3.1.2	Evaluation Against Criteria	3.1-1
3.2	Classification of Structures, Components, and Systems.....	3.2-1
3.2.1	Seismic Classification	3.2-1
3.2.2	Quality Group Classifications	3.2-1
3.2.3	Safety Classifications	3.2-2
3.2.4	Correlation of Safety Classes with Industry Codes	3.2-5
3.2.5	Non-Safety-Related Structures, Systems, and Components.....	3.2-5
3.2.6	Quality Assurance	3.2-8
3.3	Severe Wind and Extreme Wind (Tornado and Hurricane) Loadings.....	3.3-1
3.3.1	Severe Wind Loads.....	3.3-1
3.3.2	Extreme Wind Loads (Hurricanes and Tornados).....	3.3-2
3.3.3	COL License Information.....	3.3-3
3.3.4	References	3.3-3
3.4	Water Level (Flood) Design	3.4-1
3.4.1	Flood Protection	3.4-2
3.4.2	Analytical and Test Procedures	3.4-14
3.4.3	COL License Information.....	3.4-14
3.4.4	References	3.4-15
3.5	Missile Protection	3.5-1
3.5.1	Missile Selection and Description	3.5-1
3.5.2	Structures, Systems, and Components to be Protected from Externally Generated Missiles	3.5-11
3.5.3	Barrier Design Procedures.....	3.5-11
3.5.4	COL License Information.....	3.5-12
3.5.5	References	3.5-13
3.6	Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping.....	3.6-1
3.6.1	Postulated Piping Failures in Fluid Systems Inside and Outside of Containment	3.6-2
3.6.2	Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping.....	3.6-9
3.6.3	Leak-Before-Break Evaluation Procedures	3.6-28
3.6.4	As-Built Inspection of High-Energy Pipe Break Mitigation Features	3.6-31
3.6.5	COL License Information.....	3.6-31
3.6.6	References	3.6-32
3.7	Seismic Design	3.7-1
3.7.1	Seismic Input.....	3.7-2
3.7.2	Seismic System Analysis.....	3.7-5
3.7.3	Seismic Subsystem Analysis	3.7-19
3.7.4	Seismic Instrumentation	3.7-42
3.7.5	COL License Information.....	3.7-44

Chapter 3

Table of Contents (Continued)

3.7.6	References	3.7-45
3.8	Seismic Category I Structures.....	3.8-1
3.8.1	Concrete Containment.....	3.8-1
3.8.2	Steel Components of the Reinforced Concrete Containment.....	3.8-17
3.8.3	Concrete and Steel Internal Structures of the Concrete Containment.....	3.8-23
3.8.4	Other Seismic Category I Structures	3.8-30
3.8.5	Foundations	3.8-44
3.8.6	COL License Information.....	3.8-47
3.9	Mechanical Systems and Components	3.9-1
3.9.1	Special Topics for Mechanical Components	3.9-1
3.9.2	Dynamic Testing and Analysis.....	3.9-6
3.9.3	ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures	3.9-26
3.9.4	Control Rod Drive (CRD)	3.9-56
3.9.5	Reactor Pressure Vessel Internals	3.9-58
3.9.6	Testing of Pumps and Valves	3.9-69
3.9.7	COL License Information.....	3.9-78
3.9.8	References	3.9-80
3.10	Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.....	3.10-1
3.10.1	Seismic Qualification Criteria (Including Other Dynamic Loads).....	3.10-1
3.10.2	Methods and Procedures for Qualifying Electrical Equipment and Instrumentation.....	3.10-3
3.10.3	Methods and Procedures of Analysis or Testing of Supports of Electrical Equipment and Instrumentation	3.10-8
3.10.4	Operating License Review (Tests and Analyses Results)	3.10-11
3.10.5	COL License Information.....	3.10-11
3.11	Environmental Qualification of Safety-Related Mechanical and Electrical Equipment	3.11-1
3.11.1	Equipment Identification and Environmental Conditions	3.11-1
3.11.2	Qualification Tests and Analyses	3.11-3
3.11.3	Qualification Test Results	3.11-4
3.11.4	Loss of Heating, Ventilating, and Air Conditioning	3.11-4
3.11.5	Estimated Chemical and Radiation Environment.....	3.11-4
3.11.6	COL License Information.....	3.11-5
3.11.7	References	3.11-5
3.12	Tunnels.....	3.12-1
3.12.1	Main Steam Tunnel	3.12-1
3.12.2	Safety-Related Tunnels	3.12-1
3.12.3	Miscellaneous Non-Safety Related Tunnels	3.12-3
3.13	Secondary Containment and Divisional Separation Zones – Barrier Considerations	3.13-1
3.13.1	Introduction	3.13-1
3.13.2	Secondary Containment and Divisional Separation Barriers – General Design Basis	3.13-3

Chapter 3

Table of Contents (Continued)

3.13.3	General ABWR Containment Structures, Systems and Barrier Descriptions	3.13-6
3.13.4	General Safety Evaluation	3.13-8
3.13.5	Hardened–Softened Barrier Concept Approach– Special Critique	3.13-12
3.13.6	Specific Barrier Design Basis and Safety Evaluation	3.13-14
3.13.7	Protection of Environmentally Sensitive Equipment	3.13-16
3.13.8	Summary Conclusions.....	3.13-19
3A	Seismic Soil Structure Interaction Analysis	3A-1
3A.1	Introduction	3A-1
3A.2	ABWR Standard Plant Site Plan	3A-1
3A.3	Generic Site Conditions.....	3A-2
3A.4	Input Motion and Damping Values	3A-6
3A.5	Soil-Structure Interaction Analysis Method.....	3A-6
3A.6	Free-Field Site Responses Analysis	3A-12
3A.7	Soil-Structure Interaction Analysis Cases	3A-13
3A.8	Analysis Models	3A-14
3A.9	Analysis Results	3A-17
3A.10	Site Enveloping Seismic Response	3A-22
3A.11	References	3A-24
3B	Containment Hydrodynamic Loads	3B-1
3B.1	Introduction	3B-1
3B.2	Review of Phenomena.....	3B-1
3B.3	Safety/Relief Valve Discharge Loads	3B-6
3B.4	Loss-of-Coolant Accident Loads.....	3B-11
3B.5	Submerged Structure Loads	3B-27
3B.6	Loads Combination	3B-29
3B.7	References	3B-29
3C	Computer Programs Used in the Design and Analysis of Seismic Category I Structures.....	3C-1
3C.1	Introduction	3C-1
3C.2	Static and Dynamic Structural Analysis Systems (STARDYNE)	3C-1
3C.3	Concrete Element Cracking Analysis Program (CECAP)	3C-1
3C.4	Finite Element Program for Cracking Analysis (FINEL)	3C-2
3D	Computer Programs Used in the Design of Components, Equipment and Structures	3D-1
3D.1	Introduction	3D-1
3D.2	Fine Motion Control Rod Drive	3D-1
3D.3	Reactor Pressure Vessel and Internals.....	3D-1
3D.4	Piping.....	3D-1
3D.5	Pumps and Motors.....	3D-4
3D.6	Heat Exchangers.....	3D-4
3D.7	Soil-Structure Interaction	3D-5
3E	Guidelines for LBB Application.....	3E-1
3E.1	Introduction	3E-1
3E.2	Material Fracture Toughness Characterization	3E-4
3E.3	Fracture Mechanics Methods	3E-10

Chapter 3

Table of Contents (Continued)

3E.4	Leak Rate Calculation Methods	3E-16
3E.5	Leak Detection Capabilities	3E-21
3E.6	Guidelines for Preparation of an LBB Report.....	3E-22
3E.7	References	3E-27
3F	Not Used	3F-1
3G	Response of Structures to Containment Loads.....	3G-1
3G.1	Scope	3G-1
3G.2	Dynamic Response	3G-1
3G.3	Hydrodynamic Load Analysis Results	3G-4
3H	Design Details and Evaluation Results of Seismic Category I Structures.....	3H.1-1
3H.1	Reactor Building.....	3H.1-1
3H.2	Control Building.....	3H.2-1
3H.3	Radwaste Building.....	3H.3-1
3H.4	Structural Evaluation of R/B Compartment Walls Due to HELB.....	3H.4-1
3H.5	Structural Analysis Reports.....	3H.5-1
3H.6	Summary of Key Structural Design Features.....	3H.6-1
3I	Equipment Qualification Environmental Design Criteria	3I-1
3I.1	Introduction	3I-1
3I.2	Plant Zones	3I-1
3I.3	Environmental Conditions Parameters	3I-2
3J	Not Used	3J-1
3K	Designated NEDE-24326-1-P Material Which May Not Change Without Prior NRC Staff Approval.....	3K-1
3K.1	General Requirements for Dynamic Testing (4.4.2.5.1)	3K-1
3K.2	Product and Assembly Testing (4.4.2.5.2)	3K-3
3K.3	Multiple-Frequency Tests (4.4.2.5.3).....	3K-3
3K.4	Single- and Multi-axis Tests (4.4.2.5.4)	3K-3
3K.5	Single Frequency Tests (4.4.2.5.6).....	3K-4
3K.6	Damping (4.4.2.5.7).....	3K-4
3K.7	Qualification Determination (4.4.3.3)	3K-4
3K.8	Dynamic Qualification by Analysis (4.4.4.1.4).....	3K-4
3K.9	Required Response Spectra (4.4.4.1.4.6.2)	3K-5
3K.10	Time History Analysis (4.4.4.1.4.6.3)	3K-5
3L	Evaluation of Postulated Ruptures in High Energy Pipes	3L-1
3L.1	Background and Scope	3L-1
3L.2	Identification of Rupture Locations and Rupture Geometry	3L-2
3L.3	Design and Selection of Pipe Whip Restraints.....	3L-2
3L.4	Pipe Rupture Evaluation.....	3L-3
3L.5	Jet Impingement on Essential Piping	3L-6
3M	Resolution Of Intersystem Loss Of Coolant Accident For ABWR.....	3M-1
3M.1	Introduction	3M-1

Chapter 3

Table of Contents (Continued)

3M.2	ABWR Regulatory Requirements	3M-1
3M.3	Boundary Limits of URS.....	3M-2
3M.4	Evaluation Procedure.....	3M-4
3M.5	Systems Evaluated.....	3M-5
3M.6	Piping Design Pressure for URS Compliance	3M-6
3M.7	Applicability of URS Non-piping Components	3M-6
3M.8	Results	3M-7
3M.9	Valve Misalignment Due To Operator Error.....	3M-8
3M.10	Additional Operational Considerations	3M-8
3M.11	Summary.....	3M-8
3M.12	References	3M-9
 3MA	System Evaluation For ISLOCA	3MA-1
3MA.1	General Comments About the Appendix	3MA-1
3MA.2	Residual Heat Removal System	3MA-1
3MA.3	High Pressure Core Flooder System.....	3MA-10
3MA.4	Reactor Core Isolation Cooling System	3MA-14
3MA.5	Control Rod Drive System	3MA-21
3MA.6	Standby Liquid Control System	3MA-25
3MA.7	Reactor Water Cleanup System.....	3MA-27
3MA.8	Fuel Pool Cooling Cleanup System.....	3MA-28
3MA.9	Nuclear Boiler System.....	3MA-30
3MA.10	Reactor Recirculation System	3MA-31
3MA.11	Makeup Water System Condensate.....	3MA-33
3MA.12	Makeup Water System Purified.....	3MA-36
3MA.13	Radwaste System.....	3MA-38
3MA.14	Condensate and Feedwater (CFS) System	3MA-40
3MA.15	Sampling (SAM) System.....	3MA-41

Chapter 3

List of Tables

Table 3.2-1	Classification Summary.....	3.2-9
Table 3.2-2	Minimum Design Requirements for an Assigned Safety Designation.....	3.2-60
Table 3.2-3	Quality Group Designations—Codes and Industry Standards	3.2-61
Table 3.3-1	Importance Factor (I) for Wind Loads	3.3-4
Table 3.4-1	Structures, Penetrations, and Access Openings Designed for Flood Protection	3.4-16
Table 3.5-1	Requirement for the Probability of Missile Generation for ABWR Standard Plant.....	3.5-15
Table 3.6-1	Essential Systems, Components, and Equipment for Postulated Pipe Failures Inside Containment.....	3.6-34
Table 3.6-2	Essential Systems, Components, and Equipment for Postulated Pipe Failures Outside Containment.....	3.6-35
Table 3.6-3	High-Energy Piping Inside Containment	3.6-36
Table 3.6-4	High-Energy Piping Outside Containment.....	3.6-36
Table 3.6-5	Moderate-Energy Piping Inside Containment	3.6-37
Table 3.6-6	Moderate-Energy Piping Outside Containment	3.6-37
Table 3.6-7	Additional Criteria for Integrated Leakage Rate Test	3.6-38
Table 3.7-1	Damping for Different Materials.....	3.7-47
Table 3.7-2	Natural Frequencies of the Reactor Building Complex in X Direction (0°–180° Axis)—Fixed Base Condition.....	3.7-48
Table 3.7-3	Natural Frequencies of the Reactor Building Complex in Y Direction (90°–270° Axis)—Fixed Base Condition.....	3.7-49
Table 3.7-4	Natural Frequencies of the Reactor Building Complex in Z Direction (Vertical)—Fixed Base Condition.....	3.7-50
Table 3.7-5	Natural Frequencies of the Control Building—Fixed Base Condition	3.7-50
Table 3.7-6	Natural Frequencies of the Radwaste Building—Fixed Base Condition	3.7-51
Table 3.8-1	Load Combinations, Load Factors and Acceptance Criteria for the Reinforced Concrete Containment.....	3.8-49
Table 3.8-2	Major Allowable Stresses in Concrete and Reinforcing Steel	3.8-51
Table 3.8-3	Stress Intensity Limits	3.8-51

Chapter 3

List of Tables (Continued)

Table 3.8-4	Codes, Standards, Specifications, and Regulations Used in the Design and Construction of Seismic Category I Internal Structures of the Containment.....	3.8-52
Table 3.8-5	Load Combination, Load Factors and Acceptance Criteria for Reinforced Concrete Structures Inside the Containment	3.8-54
Table 3.8-6	Load Combination, Load Factors and Acceptance Criteria for Steel Structures Inside the Containment	3.8-55
Table 3.8-7	Load Combinations for Foundation Design	3.8-56
Table 3.8-8	Welding Activities and Weld Examination Requirements for Containment Vessel	3.8-57
Table 3.8-9	Staff Position on the Use of Standard ANSI/AISC N690 Nuclear Facilities-Steel Safety-Related Structures	3.8-58
Table 3.8-10	Staff Position on Steel Embedments	3.8-59
Table 3.9-1	Plant Events	3.9-82
Table 3.9-2	Load Combinations and Acceptance Criteria for Safety-Related, ASME Code Class 1, 2 and 3 Components, Component Supports, and Class CS Structures	3.9-84
Table 3.9-3	Pressure Differentials Across Reactor Vessel Internals	3.9-88
Table 3.9-4	Deformation Limit for Safety Class Reactor Internal Structures Only	3.9-89
Table 3.9-5	Primary Stress Limit for Safety Class Reactor Internal Structures Only	3.9-90
Table 3.9-6	Buckling Stability Limit for Safety Class Reactor Internal Structures Only	3.9-92
Table 3.9-7	Fatigue Limit for Safety Class Reactor Internal Structures Only.....	3.9-93
Table 3.9-8	Inservice Testing Safety-Related Pumps and Valves.....	3.9-94
Table 3.9-9	Reactor Coolant System Pressure Isolation Valves.....	3.9-138
Table 3.9-10	Welding Activities and Weld Examination Requirements for ASME Code, Section III Welds.....	3.9-139
Table 3A-1	Soil Properties for UB Profile	3A-26
Table 3A-2	Average Shear Wave Velocities in Layers.....	3A-27
Table 3A-3	Strain-Dependent Shear Modulus.....	3A-28
Table 3A-4	Strain-Dependent Soil Damping.....	3A-28
Table 3A-5	Case IDs for Site Conditions Considered.....	3A-29

Chapter 3

List of Tables (Continued)

Table 3A-6	SSE Free-Field Site Response Results for all Soil Profiles (Average Properties)	3A-30
Table 3A-7	Summary of SSI Cases Considered (Reactor and Control Buildings)	3A-31
Table 3A-8	Effect Of Soil Stiffness on Maximum Forces	3A-33
Table 3A-9	Effect Of Depth to Base Rock, UB Case.....	3A-34
Table 3A-10	Effect Of Depth to Base Rock, VP3 Case	3A-35
Table 3A-11	Effect Of Depth to Water Table Location	3A-36
Table 3A-12	Effect of Concrete Cracking.....	3A-37
Table 3A-13	Effect of Change in Soil Degradation Curves	3A-38
Table 3A-14	Effect Of Separation Between the Side Soil and Foundation Walls	3A-39
Table 3A-15	Effect Of Adjacent Buildings, UB Case.....	3A-40
Table 3A-16	Effect Of Adjacent Buildings, VP3 Case	3A-41
Table 3A-17	Effect Of Adjacent Buildings, VP5 Case	3A-42
Table 3A-18	Effect of Adjacent Buildings Enveloping Seismic Soil Pressures	3A-43
Table 3A-19a	ABWR Reactor Building Walls and Floors Summary of Enveloping Seismic Loads	3A-44
Table 3A-19b	ABWR Reactor Building RCCV Summary of Enveloping Seismic Loads	3A-45
Table 3A-19c	ABWR Reactor Building RSW/Pedestal Summary of Enveloping Seismic Loads....	3A-46
Table 3A-19d	ABWR Reactor Building Key RPV/Internal Components Summary of Enveloping Seismic Loads.....	3A-47
Table 3A-20	ABWR Control Building Summary of Enveloping Seismic Loads	3A-48
Table 3A-21a	ABWR Reactor Building Walls and Floors Summary of Enveloping Maximum Vertical Accelerations	3A-49
Table 3A-21b	ABWR Reactor Building RCCV Summary of Enveloping Maximum Vertical Accelerations	3A-50
Table 3A-21c	ABWR Reactor Building RSW/PED Summary of Enveloping Maximum Vertical Accelerations	3A-51
Table 3A-22	ABWR Control Building Summary of Enveloping Maximum Vertical Accelerations	3A-52

Chapter 3

List of Tables (Continued)

Table 3A-23a	ABWR Reactor Building Walls and Floors Summary of Enveloping Maximum Accelerations	3A-53
Table 3A-23b	ABWR Reactor Building RCCV Summary of Enveloping Maximum Accelerations	3A-54
Table 3A-23c	ABWR Reactor Building RSW/PED Summary of Enveloping Maximum Accelerations	3A-55
Table 3A-23d	ABWR Reactor Building RPV/Internals Summary of Enveloping Maximum Accelerations	3A-56
Table 3A-24	ABWR Control Building Summary of Enveloping Maximum Accelerations	3A-57
Table 3A-25a	ABWR Reactor Building Walls and Floors Summary of Enveloping Maximum Relative Displacements with Respect to Input Motion	3A-58
Table 3A-25b	ABWR Reactor Building RCCV Summary of Enveloping Maximum Relative Displacements with Respect to Input Motion	3A-59
Table 3A-25c	ABWR Reactor Building RSW/PED Summary of Enveloping Maximum Relative Displacements with Respect to Input Motion	3A-60
Table 3A-25d	ABWR Reactor Building RPV/Internals Summary of Enveloping Maximum Relative Displacements with Respect to Input Motion	3A-61
Table 3A-26	ABWR Control Building Summary of Enveloping Maximum Relative Displacements with Respect to Input Motion	3A-62
Table 3A-27a	ABWR Reactor Building Walls and Floors Summary of Enveloping Maximum Relative Displacements with Respect to Basemat.....	3A-63
Table 3A-27b	ABWR Reactor Building RCCV Summary of Enveloping Maximum Relative Displacements with Respect to Basemat.....	3A-64
Table 3A-27c	ABWR Reactor Building RSW/PED Summary of Enveloping Maximum Relative Displacements with Respect to Basemat.....	3A-65
Table 3A-27d	ABWR Reactor Building RPV/Internals Summary of Enveloping Maximum Relative Displacements with Respect to Basemat.....	3A-66
Table 3A-28	ABWR Control Building Summary of Enveloping Maximum Relative Displacements with Respect to Basemat.....	3A-67
Table 3B-1	Pool Swell Calculated Values	3B-31
Table 3B-2	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-32

Chapter 3

List of Tables (Continued)

Table 3B-3	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-34
Table 3B-4	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-34
Table 3B-5	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-35
Table 3B-6	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-35
Table 3B-7	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-36
Table 3B-8	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-36
Table 3B-9	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-37
Table 3E-1	Leak Before Break Candidate Piping System	3E-31
Table 3E-2	Electrodes and Filler Metal Requirements for Carbon Steel Welds.....	3E-31
Table 3E-3	Supplier Provided Chemical Composition and Mechanical Properties Information	3E-32
Table 3E-4	Standard Tension Test Data at Temperature	3E-32
Table 3E-5	Summary of Carbon Steel J-R Curve Tests.....	3E-33
Table 3E-6	Mass Flow Rate for Several fl/Dh Values.....	3E-33
Table 3E-7	Stresses in the Main Steam Lines (Assumed for Example)	3E-34
Table 3E-8	Critical Crack Length and Instability Load Margin Evaluations for Main Steam Lines (Example)	3E-34
Table 3E-9	Data for Feedwater System Piping (Example)	3E-34
Table 3E-10	Stresses in Feedwater Lines (Assumed for Example)	3E-35
Table 3E-11	Critical Crack Length and Instability Load Margin Evaluations for Feedwater Lines (Example)	3E-35
Table 3G-1	Analysis Parameters in Terms of Time/Frequency Steps.....	3G-5
Table 3G-2	Maximum Accelerations for AP Loadings (g)	3G-7
Table 3G-3	Maximum Accelerations for Hydrodynamic Loads (g)	3G-7

Chapter 3

List of Tables (Continued)

Table 3G-4	Maximum Displacements for AP Loadings (mm)	3G-7
Table 3G-5	Maximum Displacements for Hydrodynamic Loads (mm).....	3G-7
Table 3H.1-1	Equivalent Linear Temperature Distributions at Various Sections	3H.1-18
Table 3H.1-2	SIT and LOCA Pressure Loads	3H.1-19
Table 3H.1-3	Hydrodynamic Loads	3H.1-19
Table 3H.1-4	Maximum Vertical Acceleration	3H.1-20
Table 3H.1-5	Load Combinations, Load Factors and Acceptance Criteria for the Reinforced Concrete Containment.....	3H.1-21
Table 3H.1-5a	Selected Load Combinations for the RCCV	3H.1-21
Table 3H.1-5b	Selected Load Combinations for the Reactor Building.....	3H.1-22
Table 3H.1-6	Results of "Stardyne" Analysis for Unit Drywell Pressure: 6.9 kPa [Pd]	3H.1-23
Table 3H.1-7	Results of "Stardyne" Analysis for Unit Wetwall Pressure: 6.9 kPa [Pw].....	3H.1-30
Table 3H.1-8	Results of "Stardyne" Analysis for Safe Shutdown Earthquake (SSE) SRSS of Three Components [Ess]	3H.1-37
Table 3H.1-9	Results of "Stardyne" Analysis for Thermal Loads (6 Hours) [TA-II]	3H.1-44
Table 3H.1-10	Load Combination 1	3H.1-51
Table 3H.1-11	Load Combination 8	3H.1-56
Table 3H.1-12	Load Combination 15.....	3H.1-61
Table 3H.1-13	Load Combination 15a and 15b	3H.1-64
Table 3H.1-14	Rebar Ratios Used in the Analysis	3H.1-67
Table 3H.1-15	Rebar and Concrete Stresses Due to Load Combination 1.....	3H.1-69
Table 3H.1-16	Rebar and Concrete Stresses Due to Load Combination 8.....	3H.1-70
Table 3H.1-17	Rebar and Concrete Stresses Due to Load Combination 15.....	3H.1-72
Table 3H.1-18	Rebar and Concrete Stresses Due to Load Combinations 15a and 15b	3H.1-74
Table 3H.1-19	Containment Liner Plate Strains (Max).....	3H.1-76
Table 3H.1-20	Stresses in Pedestal.....	3H.1-79

Chapter 3

List of Tables (Continued)

Table 3H.1-21	Maximum Moments and Shears in Walls Due to Lateral Soil Pressure (At-Rest Condition).....	3H.1-79
Table 3H.1-22	Maximum Moments and Shears in Walls Due to SSE Soil Pressure (SSE Condition).....	3H.1-79
Table 3H.1-23	Factors of Safety for Foundation Stability	3H.1-80
Table 3H.2-1	Control Building SSE Loads	3H.2-16
Table 3H.2-2	Control Building Base Shear and Overturning Moments for Stability Evaluation.....	3H.2-16
Table 3H.2-3	Base Mat, Floor and Roof Slabs—Design Forces and Reinforcement	3H.2-17
Table 3H.2-4	Walls—Design Forces and Reinforcement	3H.2-18
Table 3H.2-5	Stability Evaluation—Factors of Safety	3H.2-20
Table 3H.3-1	Radwaste Building Design Seismic Loads.....	3H.3-12
Table 3H.3-2	Forces and Moments in Critical Elements for Dead Load (D).....	3H.3-13
Table 3H.3-3	Forces and Moments in Critical Elements for Live Loads (L).....	3H.3-14
Table 3H.3-4	Forces and Moments in Critical Elements for Soil Pressure @ Rest (H).....	3H.3-15
Table 3H.3-5	Forces and Moments in Critical Elements for Seismic Soil Pressure (H')	3H.3-16
Table 3H.3-6	Forces and Moments in Critical Elements for Seismic Load (E).....	3H.3-17
Table 3H.3-7	Forces and Moments in Critical Elements for Load Combination: 1.4D + 1.7L + 1.7H	3H.3-18
Table 3H.3-8	Forces and Moments in Critical Elements for Load Combination (D + L + H' ± E)Max. Tension	3H.3-19
Table 3H.3-9	Forces and Moments in Critical Elements for Load Combination (D + L + H' ± E)Max. Compression	3H.3-20
Table 3H.3-10	Rebar and Concrete Stresses for Load Combination: 1.4D + 1.7L + 1.7H.....	3H.3-21
Table 3H.3-11	Rebar and Concrete Stresses for Load Combination (D + L + H' ± E)Max. Tension	3H.3-22
Table 3H.3-12	Rebar and Concrete Stresses for Load Combination (D + L + H' ± E)Max. Compression	3H.3-23
Table 3H.3-13	Summary of Reinforced Steel	3H.3-24
Table 3H.3-14	Summary of Reinforcing Steel Ratios	3H.3-25

Chapter 3

List of Tables (Continued)

Table 3H.3-15	Summary of Structural Steel Safety Margins	3H.3-27
Table 3H.3-16	Maximum Soil Bearing Pressures	3H.3-28
Table 3H.4-1	Design of Type 1 (Shear) Walls Exposed to HELB Loadings	3H.4-3
Table 3H.4-2	Design of Type 2 (Non-Shear) Walls Exposed to HELB Loadings	3H.4-4
Table 3H.4-3	Design of Concrete Blocks for Removable Wall Exposed to HELB Loadings	3H.4-5
Table 3I-1	Plant Environment Location and Condition Cross Reference of Table Numbers.....	3I-5
Table 3I-2	Thermodynamic Environment Conditions Inside Primary Containment Vessel Plant Normal Operating Conditions1	3I-5
Table 3I-3	Thermodynamic Environment Conditions Inside Reactor Building (Secondary Containment) Plant Normal Operating Conditions	3I-6
Table 3I-4	Thermodynamic Environment Conditions Inside Reactor Building (Outside Secondary Containment) Plant Normal Operating Conditions	3I-7
Table 3I-5	Thermodynamic Environment Conditions Inside Control Building Plant Normal Operating Conditions.....	3I-7
Table 3I-6	Thermodynamic Environment Conditions Inside Turbine Building Plant Normal Operating Conditions.....	3I-8
Table 3I-7	Radiation Environment Conditions Inside Primary Containment Vessel Plant Normal Operating Conditions	3I-8
Table 3I-8	Radiation Environment Conditions Inside Reactor Building (Secondary Containment) Plant Normal Operating Conditions	3I-9
Table 3I-9	Radiation Environment Conditions Inside Reactor Building (Outside Secondary Containment) Plant Normal Operating Conditions	3I-10
Table 3I-10	Radiation Environment Conditions Inside Control Building Plant Normal Operating Conditions.....	3I-10
Table 3I-11	Radiation Environment Conditions Inside Turbine Building Plant Normal Operating Conditions.....	3I-11
Table 3I-12	Thermodynamic Environment Conditions Inside Primary Containment Vessel Plant Accident Conditions.....	3I-11
Table 3I-13	Thermodynamic Environment Conditions Inside Reactor Building (Secondary Containment) Plant Accident Conditions.....	3I-12
Table 3I-14	Thermodynamic Environment Conditions Inside Reactor Building (Outside Secondary Containment) Plant Accident Conditions	3I-15

Chapter 3

List of Tables (Continued)

Table 3I-15	Thermodynamic Environment Conditions Inside Control Building Plant Accident Conditions.....	3I-15
Table 3I-16	Radiation Environment Conditions Inside Primary Containment Design Basis Accident Conditions	3I-16
Table 3I-17	Radiation Environment Conditions Inside Reactor Building Design Basis Accident (Secondary Containment)	3I-16
Table 3I-18	Radiation Environment Conditions Inside Reactor Building Design Basis Accident Conditions (Outside Secondary Containment)	3I-17
Table 3I-19	Radiation Environment Conditions Inside Control Building Design Basis Accident Conditions	3I-17
Table 3M-1	Low Pressure Sink Component Sizes.....	3M-10

Chapter 3

List of Figures

Figure 3.2-1	Quality Group and Seismic Category Classification Applicable to Power Conversion System.....	3.2-62
Figure 3.2-2	Quality Group and Seismic Category Classification Applicable to Feedwater System	3.2-63
Figure 3.5-1	Missile Velocity and Displacement Characteristics Resulting from Saturated Steam and Water Blowdowns (7.2 MPaA Stagnation Pressure)	3.5-16
Figure 3.5-2	ABWR Standard Plant Low-Trajectory Turbine Missile Ejection Zone	3.5-17
Figure 3.6-1	Jet Characteristics.....	3.6-39
Figure 3.6-2	Typical Pipe Whip Restraint Configuration.....	3.6-40
Figure 3.6-3	Initial Blowdown and Wave Forces	3.6-41
Figure 3.6-4	Acceptable Types of Pipe Whip Restraints.....	3.6-42
Figure 3.7-1	Horizontal Safe Shutdown Earthquake Design Spectra.....	3.7-52
Figure 3.7-2	Vertical Safe Shutdown Earthquake Design Spectra	3.7-53
Figure 3.7-3	Horizontal, H1 Component Time History.....	3.7-54
Figure 3.7-4	Horizontal, H2 Component Time History.....	3.7-55
Figure 3.7-5	Vertical, Component Time History	3.7-56
Figure 3.7-6	2% Damped Response Spectra, H1 Component	3.7-57
Figure 3.7-7	3% Damped Response Spectra, H1 Component	3.7-58
Figure 3.7-8	4% Damped Response Spectra, H1 Component	3.7-59
Figure 3.7-9	5% Damped Response Spectra, H1 Component	3.7-60
Figure 3.7-10	7% Damped Response Spectra, H1 Component	3.7-61
Figure 3.7-11	2% Damped Response Spectra, H2 Component	3.7-62
Figure 3.7-12	3% Damped Response Spectra, H2 Component	3.7-63
Figure 3.7-13	4% Damped Response Spectra, H2 Component	3.7-64
Figure 3.7-14	5% Damped Response Spectra, H2 Component	3.7-65
Figure 3.7-15	7% Damped Response Spectra, H2 Component	3.7-66
Figure 3.7-16	2% Damped Response Spectra, Vt Component	3.7-67

Chapter 3

List of Figures (Continued)

Figure 3.7-17	3% Damped Response Spectra, Vt Component.....	3.7-68
Figure 3.7-18	4% Damped Response Spectra, Vt Component.....	3.7-69
Figure 3.7-19	5% Damped Response Spectra, Vt Component.....	3.7-70
Figure 3.7-20	7% Damped Response Spectra, Vt Component.....	3.7-71
Figure 3.7-21	Not Used.....	3.7-72
Figure 3.7-22	Not Used.....	3.7-72
Figure 3.7-23	Not Used.....	3.7-72
Figure 3.7-24	Power Spectral Density Function, H1 Component	3.7-73
Figure 3.7-25	Power Spectral Density Function, H2 Component	3.7-74
Figure 3.7-26	Power Spectral Density Function, VT Component.....	3.7-75
Figure 3.7-27	Damping Values for Electrical Raceway Systems.....	3.7-76
Figure 3.7-28	Seismic System Analytical Model	3.7-77
Figure 3.7-29	Reactor Building Elevation (0°–180° Section)	3.7-78
Figure 3.7-30	Reactor Building Elevation (90°–270° Section)	3.7-79
Figure 3.7-31	Reactor Building Model (see Figure 3A-8)	3.7-80
Figure 3.7-32	Reactor Pressure Vessel (RPV) and Internals Model (see Figure 3A-9)	3.7-80
Figure 3.7-33	Control Building Dynamic Model (see Figure 3A-27)	3.7-80
Figure 3.7-34	Radwaste Building Seismic Model	3.7-81
Figure 3.8-1	Reactor Building Arrangement Floor B2F Elevation –1700 mm	3.8-61
Figure 3.8-2	Reactor Building Arrangement Floor B3F Elevation –8200 mm	3.8-62
Figure 3.8-3	Reactor Building Arrangement Floor B1F Elevation 4800 mm	3.8-63
Figure 3.8-4	Reactor Building Arrangement Floor 1F Elevation 12300 mm.....	3.8-64
Figure 3.8-5	Reactor Building Arrangement Floor 2F Elevation 18100 mm.....	3.8-65
Figure 3.8-6	Reactor Building Arrangement Floor 3F Elevation 23500 mm.....	3.8-66
Figure 3.8-7	Reactor Building Arrangement Floor 4F Elevation 31700 mm.....	3.8-67
Figure 3.8-8	Reactor Building Arrangement Elevation 38200 mm.....	3.8-68

Chapter 3

List of Figures (Continued)

Figure 3.8-9	Typical Section of Containment Liner Plate and Anchor	3.8-69
Figure 3.8-10	Not Used.....	3.8-70
Figure 3.8-11	Not Used.....	3.8-70
Figure 3.8-12	Not Used.....	3.8-70
Figure 3.8-13	Not Used.....	3.8-70
Figure 3.8-14	Not Used.....	3.8-70
Figure 3.8-15	Reactor Building—Containment Upper Drywell Equipment Hatch	3.8-71
Figure 3.8-16	Not Used.....	3.8-72
Figure 3.8-17	Reactor Building RCCV Internal Structures Nomenclature	3.8-73
Figure 3.8-18	Reactor Building—RCCV Configuration.....	3.8-74
Figure 3.8-19	Not Used.....	3.8-75
Figure 3.8-20	Annual Temperature Profile of Suppression Pool Water During Normal Operation of a Typical Plant in Southern States	3.8-76
Figure 3.9-1	Transient Pressure Differentials Following a Steam Line Break.....	3.9-146
Figure 3.9-2	Reactor Internal Flow Paths and Minimum Floodable Volume	3.9-147
Figure 3.9-3	ABWR Recirculation Flow Path.....	3.9-148
Figure 3.9-4	Fuel Support Pieces.....	3.9-149
Figure 3.9-5	Pressure Nodes for Depressurization Analysis	3.9-150
Figure 3.9-6	Stress-Strain Curve for Blowout Restraints	3.9-151
Figure 3.10-1	Typical Vertical Board.....	3.10-13
Figure 3.10-2	Instrument Panel.....	3.10-13
Figure 3.10-3	Typical Local Rack	3.10-14
Figure 3.10-4	NEMA Type-12 Enclosure	3.10-14
Figure 3A-1	(Refer to Figure 1.2-1)	3A-68
Figure 3A-2	0°–180° Section View	3A-69
Figure 3A-3	Shear Wave Velocity Profiles Considered for SSI Analyses.....	3A-70

Chapter 3

List of Figures (Continued)

Figure 3A-4	Range of Shear Wave Velocities for Nuclear Power Plant Sites in High Seismic Areas.....	3A-71
Figure 3A-5	Strain Dependent Soil Properties	3A-72
Figure 3A-6	Strain Dependent Rock Properties	3A-73
Figure 3A-7	Substructuring of Interaction Model	3A-74
Figure 3A-8	Reactor Building Stick Model.....	3A-75
Figure 3A-9	RPV Stick Model	3A-76
Figure 3A-10	Reactor Building Stick Model with Rigid Arms for X & Z Shaking.....	3A-77
Figure 3A-11	Reactor Building Stick Model with Rigid Arms for Y Shaking	3A-78
Figure 3A-12	Reactor Building Foundation 2-D Model XZ Direction	3A-79
Figure 3A-13	The Excavated Soil Elements of Reactor Building 2-D Model	3A-80
Figure 3A-14	Connection of the Main Stick to the Side Walls (For Reactor Building UB Cases).....	3A-81
Figure 3A-15	R/B Excavated Soil Model (UB Soil Profiles).....	3A-82
Figure 3A-16	UB Case: Nodal Points at Elevation -13.70m	3A-83
Figure 3A-17	UB Case: Nodal Points at Elevation -10.95m	3A-84
Figure 3A-18	UB Case: Nodal Points at Elevation -8.20m	3A-85
Figure 3A-19	UB Case: Nodal Points at Elevation -4.95m	3A-86
Figure 3A-20	UB Case: Nodal Points at Elevation -1.70m	3A-87
Figure 3A-21	UB Case: Nodal Points at Elevation 1.55m	3A-88
Figure 3A-22	UB Case: Nodal Points at Elevation 4.80m	3A-89
Figure 3A-23	UB Case: Nodal Points at Elevation 8.40m	3A-90
Figure 3A-24	UB Case: Nodal Points at Elevation 12.00m	3A-91
Figure 3A-25	Plate Elements of the Side Wall (X = 29.80m).....	3A-92
Figure 3A-26	Plate Elements of the Side Wall (Y = 28.30m).....	3A-93
Figure 3A-27	Stick Model for the Control Building	3A-94
Figure 3A-28	1/4 Stick Model Showing Rigid Arms	3A-95

Chapter 3

List of Figures (Continued)

Figure 3A-29	Control Building Foundation 2-D Model XZ Direction	3A-96
Figure 3A-30	Control Building Excavated Soil 2-D Model XZ Direction	3A-97
Figure 3A-31	Connection of the Main Stick to the Side Wall (Control Building for UB Soil Profiles).....	3A-98
Figure 3A-32	C/B Excavated Soil Model (UB Soil Profiles).....	3A-99
Figure 3A-33	UB Case: Nodal Points at Elevation -11.20m	3A-100
Figure 3A-34	UB Case: Nodal Points at Elevation -8.20m	3A-101
Figure 3A-35	UB Case: Nodal Points at Elevation -6.20m	3A-102
Figure 3A-36	UB Case: Nodal Points at Elevation -4.20m	3A-103
Figure 3A-37	UB Case: Nodal Points at Elevation -2.15m	3A-104
Figure 3A-38	UB Case: Nodal Points at Elevation 0.60m	3A-105
Figure 3A-39	UB Case: Nodal Points at Elevation 3.50m	3A-106
Figure 3A-40	UB Case: Nodal Points at Elevation 5.50m	3A-107
Figure 3A-41	UB Case: Nodal Points at Elevation 7.90m	3A-108
Figure 3A-42	UB Case: Nodal Points at Elevation 9.50m	3A-109
Figure 3A-43	UB Case: Nodal Points at Elevation 12.00m	3A-110
Figure 3A-44	Plate Elements of the Side Wall (X = 12.00m).....	3A-111
Figure 3A-45	Plate Elements of the Side Wall (Y = 28.00m).....	3A-112
Figure 3A-46	Turbine Building Model.....	3A-113
Figure 3A-47	ABWR Reactor Bldg. Soil Stiffness Effect, Node 208 XZ Basemat Bottom, 2% Damping.....	3A-114
Figure 3A-48	ABWR Reactor Bldg. Soil Stiffness Effect, Node 33 X RPV/MS Nozzle, 2% Damping.....	3A-115
Figure 3A-49	ABWR Reactor Bldg. Soil Stiffness Effect, Node 89 X RCCV Top, 2% Damping.....	3A-116
Figure 3A-50	ABWR Reactor Bldg. Soil Stiffness Effect, Node 95 X R/B Top, 2% Damping.....	3A-117
Figure 3A-51	ABWR Reactor Bldg. Soil Stiffness Effect, Node 208 X Basemat Bottom, 2% Damping.....	3A-118

Chapter 3

List of Figures (Continued)

Figure 3A-52	ABWR Control Bldg. Soil Stiffness Effect, Node 121 XZ Basemat Top, 2% Damping.....	3A-119
Figure 3A-53	ABWR Control Bldg. Soil Stiffness Effect, Node 181 X C/B Top, 2% Damping.....	3A-120
Figure 3A-54	ABWR Control Bldg. Soil Stiffness Effect, Node 121 X Basemat Top, 2% Damping.....	3A-121
Figure 3A-55	ABWR Reactor Bldg. Soil Stiffness Effect, Node 33 Z RPV/MS Nozzle, 2% Damping.....	3A-122
Figure 3A-56	ABWR Reactor Bldg. Soil Stiffness Effect, Node 89 Z RCCV Top, 2% Damping.....	3A-123
Figure 3A-57	ABWR Reactor Bldg. Soil Stiffness Effect, Node 95 Z R/B Top, 2% Damping.....	3A-124
Figure 3A-58	ABWR Reactor Bldg. Soil Stiffness Effect, Node 208 Z Basemat Bottom, 2% Damping.....	3A-125
Figure 3A-59	ABWR Control Bldg. Soil Stiffness Effect, Node 108 Z C/B Top, 2% Damping.....	3A-126
Figure 3A-60	ABWR Control Bldg. Soil Stiffness Effect, Node 102 Z Basemat Top, 2% Damping.....	3A-127
Figure 3A-61	ABWR Reactor Bldg. Depth to Base Rock, Node 33 RPV/MS Nozzle, 2% Damping, UB	3A-128
Figure 3A-62	ABWR Reactor Bldg. Depth to Base Rock, Node 89 X RCCV Top, 2% Damping, UB	3A-129
Figure 3A-63	ABWR Reactor Bldg. Depth to Base Rock, Node 95 X R/B Top, 2% Damping, UB	3A-130
Figure 3A-64	ABWR Reactor Bldg. Depth to Base Rock, Node 208 X Basemat Bottom, 2% Damping, UB	3A-131
Figure 3A-65	ABWR Reactor Bldg. Depth to Base Rock, Node 33 X RPV/MS Nozzle, 2% Damping, VP3	3A-132
Figure 3A-66	ABWR Reactor Bldg. Depth to Base Rock, Node 89 X RCCV Top, 2% Damping, VP3	3A-133
Figure 3A-67	ABWR Reactor Bldg. Depth to Base Rock, Node 95 X R/B Top, 2% Damping, VP3	3A-134
Figure 3A-68	ABWR Reactor Bldg. Depth to Base Rock, Node 208 X Basemat Bottom, 2% Damping, VP3	3A-135

Chapter 3

List of Figures (Continued)

Figure 3A-69	ABWR Control Bldg. Depth to Base Rock, Node 181 X C/B Top, 2% Damping, UB	3A-136
Figure 3A-70	ABWR Control Bldg. Depth to Base Rock, Node 121 X Basemat Top, 2% Damping, UB	3A-137
Figure 3A-71	ABWR Control Bldg. Depth to Base Rock, Node 181 X C/B Top, 2% Damping, VP3	3A-138
Figure 3A-72	ABWR Control Bldg. Depth to Base Rock, Node 121 X Basemat Top, 2% Damping, VP3	3A-139
Figure 3A-73	ABWR Reactor Bldg. Depth to Water Table, Node 33 X RPV/MS Nozzle, 2% Damping.....	3A-140
Figure 3A-74	ABWR Reactor Bldg. Depth to Water Table, Node 89 X RCCV Top, 2% Damping.....	3A-141
Figure 3A-75	ABWR Reactor Bldg. Depth to Water Table, Node 95 X R/B Top, 2% Damping.....	3A-142
Figure 3A-76	ABWR Reactor Bldg. Depth to Water Table, Node 210 X Basemat Bottom, 2% Damping.....	3A-143
Figure 3A-77	ABWR Control Bldg. Depth to Water Table, Node 181 X C/B Top, 2% Damping.....	3A-144
Figure 3A-78	ABWR Control Bldg. Depth to Water Table, Node 121 X Basemat Top, 2% Damping.....	3A-145
Figure 3A-79	ABWR Reactor Bldg. Depth to Water Table, Node 33 Z RPV/MS Nozzle, 2% Damping.....	3A-146
Figure 3A-80	ABWR Reactor Bldg. Depth to Water Table, Node 89 Z RCCV Top, 2% Damping.....	3A-147
Figure 3A-81	ABWR Reactor Bldg. Depth to Water Table, Node 95 Z R/B Top, 2% Damping.....	3A-148
Figure 3A-82	ABWR Reactor Bldg. Depth to Water Table, Node 210 Z Basemat Bottom, 2% Damping.....	3A-149
Figure 3A-83	ABWR Control Bldg. Depth to Water Table, Node 108 Z C/B Top, 2% Damping.....	3A-150
Figure 3A-84	ABWR Control Bldg. Depth to Water Table, Node 102 Z Basemat Top, 2% Damping.....	3A-151
Figure 3A-85	ABWR Reactor Bldg. Concrete Cracking, Node 33 X RPV/MS Nozzle, 2% Damping.....	3A-152

Chapter 3

List of Figures (Continued)

Figure 3A-86	ABWR Reactor Bldg. Concrete Cracking, Node 89 X RCCV Top, 2% Damping.....	3A-153
Figure 3A-87	ABWR Reactor Bldg. Concrete Cracking, Node 95 X R/B Top, 2% Damping.....	3A-154
Figure 3A-88	ABWR Reactor Bldg. Concrete Cracking, Node 208 X Basemat Bottom, 2% Damping.....	3A-155
Figure 3A-89	ABWR Control Bldg. Concrete Cracking, Node 181 X C/B Top, 2% Damping.....	3A-156
Figure 3A-90	ABWR Control Bldg. Concrete Cracking, Node 121 X Basemat Top, 2% Damping.....	3A-157
Figure 3A-91	Shear Modulus vs Shear Strain	3A-158
Figure 3A-92	ABWR Reactor Bldg. Soil Curves, Node 33 X RPV/MS Nozzle, 2% Damping.....	3A-159
Figure 3A-93	ABWR Reactor Bldg. Soil Curves, Node 89 X RCCV Top, 2% Damping.....	3A-160
Figure 3A-94	ABWR Reactor Bldg. Soil Curves, Node 95 X R/B Top, 2% Damping	3A-161
Figure 3A-95	ABWR Reactor Bldg. Soil Curves, Node 208 X Basemat Bottom, 2% Damping.....	3A-162
Figure 3A-96	ABWR Control Bldg. Soil Curves, Node 181 X C/B Top, 2% Damping	3A-163
Figure 3A-97	ABWR Control Bldg. Soil Curves, Node 121 X Basemat Top, 2% Damping	3A-164
Figure 3A-98	ABWR Reactor Bldg. Side Soil Separation, Node 33 X RPV/MS Nozzle, 2% Damping.....	3A-165
Figure 3A-99	ABWR Reactor Bldg. Side Soil Separation, Node 89 X RCCV Top, 2% Damping.....	3A-166
Figure 3A-100	ABWR Reactor Bldg. Side Soil Separation, Node 95 X R/B Top, 2% Damping.....	3A-167
Figure 3A-101	ABWR Reactor Bldg. Side Soil Separation, Node 208 X Basemat Bottom, 2% Damping.....	3A-168
Figure 3A-102	ABWR Reactor Bldg. Side Soil Separation, Node 33 Z RPV/MS Nozzle, 2% Damping.....	3A-169
Figure 3A-103	ABWR Reactor Bldg. Side Soil Separation, Node 89 Z RCCV Top, 2% Damping.....	3A-170

Chapter 3

List of Figures (Continued)

Figure 3A-104	ABWR Reactor Bldg. Side Soil Separation, Node 95 Z R/B Top, 2% Damping.....	3A-171
Figure 3A-105	ABWR Reactor Bldg. Side Soil Separation, Node 208 Z Basemat Bottom, 2% Damping.....	3A-172
Figure 3A-106	ABWR Control Bldg. Side Soil Separation, Node 181 X C/B Top, 2% Damping.....	3A-173
Figure 3A-107	ABWR Control Bldg. Side Soil Separation, Node 121 X Basemat Top, 2% Damping.....	3A-174
Figure 3A-108	ABWR Control Bldg. Side Soil Separation, Node 108 Z C/B Top, 2% Damping.....	3A-175
Figure 3A-109	ABWR Control Bldg. Side Soil Separation, Node 102 Z Basemat Top, 2% Damping.....	3A-176
Figure 3A-110	ABWR Reactor Bldg. Structure-to-Structure, Node 33 X RPV/MS Nozzle, 2% Damping, UB1D150	3A-177
Figure 3A-111	ABWR Reactor Building Structure-to-Structure, Node 89 X, RCCV Top, 2% Damping, UB1D150	3A-178
Figure 3A-112	ABWR Reactor Building Structure-to-Structure, Node 95 X, R/B Top, 2% Damping, UB1D150	3A-179
Figure 3A-113	ABWR Reactor Building Structure-to-Structure, Node 210 (201 for 2D) X, Basemat Bottom, 2% Damping, UB1D150	3A-180
Figure 3A-114	ABWR Reactor Building Structure-to-Structure, Node 33 X, RPV/MS Nozzle, 2% Damping, VP3D150.....	3A-181
Figure 3A-115	ABWR Reactor Bldg. Structure-to-Structure, Node 89 X RCCV Top, 2% Damping, VP3D150.....	3A-182
Figure 3A-116	ABWR Reactor Bldg. Structure-to-Structure, Node 95 X R/B Top, 2% Damping, VP3D150.....	3A-183
Figure 3A-117	ABWR Reactor Bldg. Structure-to-Structure, Node 208 (201 for 2 D) X Basemat Bottom, 2% Damping, VP5D150.....	3A-184
Figure 3A-118	ABWR Reactor Bldg. Structure-to-Structure, Node 33X RPV/MS Nozzle, 2% Damping, VP5D150.....	3A-185
Figure 3A-119	ABWR Reactor Bldg. Structure-to-Structure, Node 89 X RCCV Top, 2% Damping, VP5D150.....	3A-186
Figure 3A-120	ABWR Reactor Bldg. Structure-to-Structure, Node 95 X R/B Top, 2% Damping, VP5D150.....	3A-187

Chapter 3

List of Figures (Continued)

Figure 3A-121	ABWR Reactor Bldg. Structure-to-Structure, Node 208 (201 for 2 D) X, Basemat Bottom, 2% Damping, VP3D150.....	3A-188
Figure 3A-122	ABWR Control Bldg. Structure-to-Structure, Node 181 X C/B Top, 2% Damping, UB1D150	3A-189
Figure 3A-123	ABWR Control Bldg. Structure-to-Structure, Node 121 X Basemat Top, 2% Damping, UB1D150	3A-190
Figure 3A-124	ABWR Control Bldg. Structure-to-Structure, Node 181 X C/B Top, 2% Damping, VP3D150.....	3A-191
Figure 3A-125	ABWR Control Bldg. Structure-to-Structure, Node 121 X Basemat Top, 2% Damping, VP3D150.....	3A-192
Figure 3A-126	ABWR Control Bldg. Structure-to-Structure, Node 181 X C/B Top, 2% Damping, VP5D150.....	3A-193
Figure 3A-127	ABWR Control Bldg. Structure-to-Structure, Node 121 X Basemat Bottom, 2% Damping, VP5D150.....	3A-194
Figure 3A-128	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 17–Horizontal.....	3A-195
Figure 3A-129	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 18–Horizontal.....	3A-196
Figure 3A-130	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 25–Horizontal.....	3A-197
Figure 3A-131	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 27–Horizontal.....	3A-198
Figure 3A-132	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 28–Horizontal.....	3A-199
Figure 3A-133	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 33–Horizontal.....	3A-200
Figure 3A-134	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 36–Horizontal.....	3A-201
Figure 3A-135	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 38–Horizontal.....	3A-202
Figure 3A-136	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 46–Horizontal.....	3A-203
Figure 3A-137	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 50–Horizontal.....	3A-204
Figure 3A-138	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 51–Horizontal.....	3A-205
Figure 3A-139	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 52–Horizontal.....	3A-206
Figure 3A-140	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 60–Horizontal.....	3A-207
Figure 3A-141	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 66–Horizontal.....	3A-208
Figure 3A-142	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 70–Horizontal.....	3A-209

Chapter 3

List of Figures (Continued)

Figure 3A-143	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 71–Horizontal.....	3A-210
Figure 3A-144	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 72–Horizontal.....	3A-211
Figure 3A-145	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 73–Horizontal.....	3A-212
Figure 3A-146	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 78–Horizontal.....	3A-213
Figure 3A-147	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 80–Horizontal.....	3A-214
Figure 3A-148	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 82–Horizontal.....	3A-215
Figure 3A-149	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 84–Horizontal.....	3A-216
Figure 3A-150	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 86–Horizontal.....	3A-217
Figure 3A-151	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 88–Horizontal.....	3A-218
Figure 3A-152	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 89–Horizontal.....	3A-219
Figure 3A-153	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 90–Horizontal.....	3A-220
Figure 3A-154	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 91–Horizontal.....	3A-221
Figure 3A-155	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 92–Horizontal.....	3A-222
Figure 3A-156	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 93–Horizontal.....	3A-223
Figure 3A-157	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 94–Horizontal.....	3A-224
Figure 3A-158	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 95–Horizontal.....	3A-225
Figure 3A-159	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 96–Horizontal.....	3A-226
Figure 3A-160	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 98–Horizontal.....	3A-227
Figure 3A-161	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 100–Horizontal.....	3A-228
Figure 3A-162	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 102–Horizontal.....	3A-229
Figure 3A-163	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 103–Horizontal.....	3A-230
Figure 3A-164	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 104–Horizontal.....	3A-231
Figure 3A-165	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 105–Horizontal.....	3A-232
Figure 3A-166	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 17–Vertical	3A-233
Figure 3A-167	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 18–Vertical	3A-234
Figure 3A-168	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 25–Vertical	3A-235

Chapter 3

List of Figures (Continued)

Figure 3A-169	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 27—Vertical	3A-236
Figure 3A-170	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 28—Vertical	3A-237
Figure 3A-171	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 33—Vertical	3A-238
Figure 3A-172	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 36—Vertical	3A-239
Figure 3A-173	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 38—Vertical	3A-240
Figure 3A-174	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 46—Vertical	3A-241
Figure 3A-175	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 50—Vertical	3A-242
Figure 3A-176	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 51—Vertical	3A-243
Figure 3A-177	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 52—Vertical	3A-244
Figure 3A-178	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 60—Vertical	3A-245
Figure 3A-179	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 66—Vertical	3A-246
Figure 3A-180	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 70—Vertical	3A-247
Figure 3A-181	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 71—Vertical	3A-248
Figure 3A-182	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 72—Vertical	3A-249
Figure 3A-183	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 73—Vertical	3A-250
Figure 3A-184	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 78—Vertical	3A-251
Figure 3A-185	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 80—Vertical	3A-252
Figure 3A-186	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 82—Vertical	3A-253
Figure 3A-187	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 84—Vertical	3A-254
Figure 3A-188	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 86—Vertical	3A-255
Figure 3A-189	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 88—Vertical	3A-256
Figure 3A-190	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 89—Vertical	3A-257
Figure 3A-191	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 90—Vertical	3A-258
Figure 3A-192	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 91—Vertical	3A-259
Figure 3A-193	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 92—Vertical	3A-260
Figure 3A-194	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 93—Vertical	3A-261

Chapter 3

List of Figures (Continued)

Figure 3A-195	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 94—Vertical	3A-262
Figure 3A-196	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 95—Vertical	3A-263
Figure 3A-197	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 96—Vertical	3A-264
Figure 3A-198	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 98—Vertical	3A-265
Figure 3A-199	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 100—Vertical	3A-266
Figure 3A-200	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 102—Vertical	3A-267
Figure 3A-201	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 103—Vertical	3A-268
Figure 3A-202	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 104—Vertical	3A-269
Figure 3A-203	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 105—Vertical	3A-270
Figure 3A-204	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 107—Vertical	3A-271
Figure 3A-205	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 108—Vertical	3A-272
Figure 3A-206	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 109—Vertical	3A-273
Figure 3A-207	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 110—Vertical	3A-274
Figure 3A-208	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 111—Vertical	3A-275
Figure 3A-209	ABWR Reactor Bldg. Broadened (Env of all Cases) Node 112—Vertical	3A-276
Figure 3A-210	ABWR Control Bldg. Broadened (Env of all Cases) Node 102—Horizontal	3A-277
Figure 3A-211	ABWR Control Bldg. Broadened (Env of all Cases) Node 103—Horizontal	3A-278
Figure 3A-212	ABWR Control Bldg. Broadened (Env of all Cases) Node 104—Horizontal	3A-279
Figure 3A-213	ABWR Control Bldg. Broadened (Env of all Cases) Node 105—Horizontal	3A-280
Figure 3A-214	ABWR Control Bldg. Broadened (Env of all Cases) Node 106—Horizontal	3A-281
Figure 3A-215	ABWR Control Bldg. Broadened (Env of all Cases) Node 107—Horizontal	3A-282
Figure 3A-216	ABWR Control Bldg. Broadened (Env of all Cases) Node 108—Horizontal	3A-283
Figure 3A-217	ABWR Control Bldg. Broadened (Env of all Cases) Node 102—Vertical	3A-284
Figure 3A-218	ABWR Control Bldg. Broadened (Env of all Cases) Node 103—Vertical	3A-285
Figure 3A-219	ABWR Control Bldg. Broadened (Env of all Cases) Node 104—Vertical	3A-286
Figure 3A-220	ABWR Control Bldg. Broadened (Env of all Cases) Node 105—Vertical	3A-287

Chapter 3

List of Figures (Continued)

Figure 3A-221	ABWR Control Bldg. Broadened (Env of all Cases) Node 106–Vertical	3A-288
Figure 3A-222	ABWR Control Bldg. Broadened (Env of all Cases) Node 107–Vertical	3A-289
Figure 3A-223	ABWR Control Bldg. Broadened (Env of all Cases) Node 108–Vertical	3A-290
Figure 3A-224	ABWR Control Bldg. Broadened (Env of all Cases) Node 109–Vertical	3A-291
Figure 3A-225	ABWR Control Bldg. Broadened (Env of all Cases) Node 110–Vertical	3A-292
Figure 3A-226	ABWR Control Bldg. Broadened (Env of all Cases) Node 111–Vertical	3A-293
Figure 3A-227	ABWR Control Bldg. Broadened (Env of all Cases) Node 112–Vertical	3A-294
Figure 3A-228	ABWR Control Bldg. Broadened (Env of all Cases) Node 113–Vertical	3A-295
Figure 3B-1	ABWR Primary Containment Configuration.....	3B-38
Figure 3B-2	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-39
Figure 3B-3	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-40
Figure 3B-4	Dimensions for P(r) Calculation	3B-41
Figure 3B-5	Circumferential Distribution	3B-42
Figure 3B-6	Quencher Bubble Pressure Time History.....	3B-43
Figure 3B-7	Spatial Load Distribution for SRV Loads.....	3B-44
Figure 3B-8	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-45
Figure 3B-9	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-46
Figure 3B-10	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-47
Figure 3B-11	Pool Boundary Pressure During Pool Swell, Normalized to Bubble Pressure	3B-48
Figure 3B-12	Deleted	3B-49
Figure 3B-13	Schematic of the Pool Swell Phenomenon.....	3B-50
Figure 3B-14	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-51

Chapter 3

List of Figures (Continued)

Figure 3B-15	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-52
Figure 3B-16	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-53
Figure 3B-17	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-54
Figure 3B-18	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-55
Figure 3B-19	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-56
Figure 3B-20	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-57
Figure 3B-21	ABWR CO Source Load Methodology	3B-58
Figure 3B-22	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-59
Figure 3B-23	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-60
Figure 3B-24	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-61
Figure 3B-25	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-62
Figure 3B-26	ABWR Chug Source Load Methodology	3B-63
Figure 3B-27	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-64
Figure 3B-28	Spatial Load Distribution for CH.....	3B-65
Figure 3B-29	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-66
Figure 3B-30	Circumferential Pressure Distribution on Access Tunnel Due to CH.....	3B-67
Figure 3B-31	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-68
Figure 3B-32	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-69

Chapter 3

List of Figures (Continued)

Figure 3B-33	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-70
Figure 3B-34	[Proprietary information not included in DCD (Refer to SSAR Appendix 3B, Amendment 34)]	3B-71
Figure 3E-1	Schematic Representation of Material J-Integral R and J-T Curves.....	3E-36
Figure 3E-2	Carbon Steel Test Specimen Orientation Code.....	3E-37
Figure 3E-3	Toughness Anisotropy of ASTM 106 Pipe (152 mm Sch. 80).....	3E-38
Figure 3E-4	Charpy Energies for Pipe Test Material as a Function of Orientation and Temperature	3E-39
Figure 3E-5	Charpy Energies for Plate Test Material as a Function of Orientation and Temperature	3E-40
Figure 3E-6	Comparison of Base Metal, Weld and HAZ Charpy Energies for SA 333 Grade 6.....	3E-41
Figure 3E-7	Plot of 288°C True Stress-True Strain Curves for SA 333 Grade 6 Carbon Steel	3E-42
Figure 3E-8	Plot of 288°C True Stress-True Strain Curves for SA 516 Grade 70 Carbon Steel	3E-43
Figure 3E-9	Plot of 117°C True Stress-True Strain Curves for SA 333 Grade 6 Carbon Steel	3E-44
Figure 3E-10	Plot of 177°C True Stress-True Strain Curves for SA 516 Grade 70 Carbon Steel	3E-45
Figure 3E-11	Plot of 288°C Test J-R Curve for Pipe Weld	3E-46
Figure 3E-12	Plot of 288°C J_{mod} , T_{mod} Data from Test J-R Curve.....	3E-47
Figure 3E-13	Carbon Steel J-T Curve for 216°C	3E-48
Figure 3E-14	Schematic Illustration of Tearing Stability Evaluation	3E-49
Figure 3E-15	A Schematic Representation of Instability Tension and Bending Stresses as a Function of Flaw Strength.....	3E-50
Figure 3E-16	SA 333 Grade 6 Stress-Strain Data at 288°C in the Ramberg-Osgood Format.....	3E-51
Figure 3E-17	Carbon Steel Stress-Strain Data at 177°C in the Ramberg-Osgood Format.....	3E-52
Figure 3E-18	Comparison of PICEP Predictions with Measured Leak Rates	3E-53
Figure 3E-19	Pipe Flow Model	3E-54

Chapter 3

List of Figures (Continued)

Figure 3E-20	Mass Flow Rates for Steam/Water Mixtures	3E-55
Figure 3E-21	Friction Factors for Pipes	3E-56
Figure 3E-22	Leak Rate as a Function of Crack Length in Main Steam Pipe (Example)	3E-57
Figure 3G-1	Horizontal Beam Model for AP Load	3G-8
Figure 3G-2	Nodal Point (R/B Horizontal/Vertical Shell Model).....	3G-9
Figure 3G-3	Nodal Point No. (RPV/Internal Vertical Shell Model)	3G-10
Figure 3G-4	Floor Response Spectrum—Case: APA1, Node: 33, Horizontal.....	3G-11
Figure 3G-5	Floor Response Spectrum—Case: APA1, Node: 81, Horizontal.....	3G-12
Figure 3G-6	Floor Response Spectrum—Case: APA1, Node: 85, Horizontal.....	3G-13
Figure 3G-7	Floor Response Spectrum—Case: APA2, Node: 33, Horizontal.....	3G-14
Figure 3G-8	Floor Response Spectrum—Case: APA2, Node: 81, Horizontal.....	3G-15
Figure 3G-9	Floor Response Spectrum—Case: APA2, Node: 85, Horizontal.....	3G-16
Figure 3G-10	Floor Response Spectrum—Case: APB1, Node: 33, Horizontal.....	3G-17
Figure 3G-11	Floor Response Spectrum—Case: APB1, Node: 81, Horizontal.....	3G-18
Figure 3G-12	Floor Response Spectrum—Case: APB1, Node: 85, Horizontal.....	3G-19
Figure 3G-13	Floor Response Spectrum—Case: APB2, Node: 33, Horizontal.....	3G-20
Figure 3G-14	Floor Response Spectrum—Case: APB2, Node: 81, Horizontal.....	3G-21
Figure 3G-15	Floor Response Spectrum—Case: APB2, Node: 85, Horizontal.....	3G-22
Figure 3G-16	Floor Response Spectrum—Case: APC1, Node: 33, Horizontal.....	3G-23
Figure 3G-17	Floor Response Spectrum—Case: APC1, Node: 81, Horizontal.....	3G-24
Figure 3G-18	Floor Response Spectrum—Case: APC1, Node: 85, Horizontal.....	3G-25
Figure 3G-19	Floor Response Spectrum—Case: APC2, Node: 33, Horizontal.....	3G-26
Figure 3G-20	Floor Response Spectrum—Case: APC2, Node: 81, Horizontal.....	3G-27
Figure 3G-21	Floor Response Spectrum—Case: APC2, Node: 85, Horizontal.....	3G-28
Figure 3G-22	Floor Response Spectrum—Case: SRVV, Node: 7, Vertical	3G-29
Figure 3G-23	Floor Response Spectrum—Case: SRVV, Node: 125, Vertical	3G-30

Chapter 3

List of Figures (Continued)

Figure 3G-24	Floor Response Spectrum—Case: SRVV, Node: 148, Vertical	3G-31
Figure 3G-25	Floor Response Spectrum—Case: SRVV, Node: 157, Vertical	3G-32
Figure 3G-26	Floor Response Spectrum—Case: SRVV, Node: 165, Vertical	3G-33
Figure 3G-27	Floor Response Spectrum—Case: SRVH1, Node: 33, Horizontal	3G-34
Figure 3G-28	Floor Response Spectrum—Case: SRVH1, Node: 71, Horizontal	3G-35
Figure 3G-29	Floor Response Spectrum—Case: SRVH1, Node: 125, Horizontal	3G-36
Figure 3G-30	Floor Response Spectrum—Case: SRVH1, Node: 157, Horizontal	3G-37
Figure 3G-31	Floor Response Spectrum—Case: SRVH1, Node: 165, Horizontal	3G-38
Figure 3G-32	Floor Response Spectrum—Case: SRVH2, Node: 33, Horizontal	3G-39
Figure 3G-33	Floor Response Spectrum—Case: SRVH2, Node: 71, Horizontal	3G-40
Figure 3G-34	Floor Response Spectrum—Case: SRVH2, Node: 80, Horizontal	3G-41
Figure 3G-35	Floor Response Spectrum—Case: SRVH2, Node: 125, Horizontal	3G-42
Figure 3G-36	Floor Response Spectrum—Case: SRVH2, Node: 157, Horizontal	3G-43
Figure 3G-37	Floor Response Spectrum—Case: SRVH2, Node: 165, Horizontal	3G-44
Figure 3G-38	Floor Response Spectrum—Case: SRVH3, Node: 33, Horizontal	3G-45
Figure 3G-39	Floor Response Spectrum—Case: SRVH3, Node: 71, Horizontal	3G-46
Figure 3G-40	Floor Response Spectrum—Case: SRVH3, Node: 80, Horizontal	3G-47
Figure 3G-41	Floor Response Spectrum—Case: SRVH3, Node: 125, Horizontal	3G-48
Figure 3G-42	Floor Response Spectrum—Case: SRVH3, Node: 157, Horizontal	3G-49
Figure 3G-43	Floor Response Spectrum—Case: SRVH3, Node: 165, Horizontal	3G-50
Figure 3G-44	Floor Response Spectrum—Case: HVV, Node: 7, Vertical	3G-51
Figure 3G-45	Floor Response Spectrum—Case: HVV, Node: 125, Vertical	3G-52
Figure 3G-46	Floor Response Spectrum—Case: HVV, Node: 148, Vertical	3G-53
Figure 3G-47	Floor Response Spectrum—Case: HVV, Node: 157, Vertical	3G-54
Figure 3G-48	Floor Response Spectrum—Case: HVV, Node: 165, Vertical	3G-55
Figure 3G-49	Floor Response Spectrum—Case: HVH, Node: 33, Horizontal	3G-56

Chapter 3

List of Figures (Continued)

Figure 3G-50	Floor Response Spectrum—Case: HVH, Node: 71, Horizontal	3G-57
Figure 3G-51	Floor Response Spectrum—Case: HVH, Node: 125, Horizontal	3G-58
Figure 3G-52	Floor Response Spectrum—Case: HVH, Node: 157, Horizontal	3G-59
Figure 3G-53	Floor Response Spectrum—Case: HVH, Node: 165, Horizontal	3G-60
Figure 3G-54	Floor Response Spectrum—Case: CHV1, Node: 7, Vertical	3G-61
Figure 3G-55	Floor Response Spectrum—Case: CHV1, Node: 125, Vertical	3G-62
Figure 3G-56	Floor Response Spectrum—Case: CHV1, Node: 148, Vertical	3G-63
Figure 3G-57	Floor Response Spectrum—Case: CHV1, Node: 157, Vertical	3G-64
Figure 3G-58	Floor Response Spectrum—Case: CHV1, Node: 165, Vertical	3G-65
Figure 3G-59	Floor Response Spectrum—Case: CHV2, Node: 7, Vertical	3G-66
Figure 3G-60	Floor Response Spectrum—Case: CHV2, Node: 125, Vertical	3G-67
Figure 3G-61	Floor Response Spectrum—Case: CHV2, Node: 148, Vertical	3G-68
Figure 3G-62	Floor Response Spectrum—Case: CHV2, Node: 157, Vertical	3G-69
Figure 3G-63	Floor Response Spectrum—Case: CHV2, Node: 165, Vertical	3G-70
Figure 3G-64	Floor Response Spectrum—Case: CHV3, Node: 7, Vertical	3G-71
Figure 3G-65	Floor Response Spectrum—Case: CHV3, Node: 125, Vertical	3G-72
Figure 3G-66	Floor Response Spectrum—Case: CHV3, Node: 148, Vertical	3G-73
Figure 3G-67	Floor Response Spectrum—Case: CHV3, Node: 157, Vertical	3G-74
Figure 3G-68	Floor Response Spectrum—Case: CHV3, Node: 165, Vertical	3G-75
Figure 3G-69	Floor Response Spectrum—Case: CHV4, Node: 7, Vertical	3G-76
Figure 3G-70	Floor Response Spectrum—Case: CHV4, Node: 125, Vertical	3G-77
Figure 3G-71	Floor Response Spectrum—Case: CHV4, Node: 148, Vertical	3G-78
Figure 3G-72	Floor Response Spectrum—Case: CHV4, Node: 157, Vertical	3G-79
Figure 3G-73	Floor Response Spectrum—Case: CHV4, Node: 165, Vertical	3G-80
Figure 3G-74	Floor Response Spectrum—Case: CHH1, Node: 33, Horizontal	3G-81
Figure 3G-75	Floor Response Spectrum—Case: CHH1, Node: 71, Horizontal	3G-82

Chapter 3

List of Figures (Continued)

Figure 3G-76	Floor Response Spectrum—Case: CHH1, Node: 125, Horizontal	3G-83
Figure 3G-77	Floor Response Spectrum—Case: CHH1, Node: 157, Horizontal	3G-84
Figure 3G-78	Floor Response Spectrum—Case: CHH1, Node: 165, Horizontal	3G-85
Figure 3G-79	Floor Response Spectrum—Case: CHH2, Node: 33, Horizontal	3G-86
Figure 3G-80	Floor Response Spectrum—Case: CHH2, Node: 125, Horizontal	3G-87
Figure 3G-81	Floor Response Spectrum—Case: CHH2, Node: 71, Horizontal	3G-88
Figure 3G-82	Floor Response Spectrum—Case: CHH2, Node: 157, Horizontal	3G-89
Figure 3G-83	Floor Response Spectrum—Case: CHH2, Node: 165, Horizontal	3G-90
Figure 3G-84	Floor Response Spectrum—Case: CHH3, Node: 33, Horizontal	3G-91
Figure 3G-85	Floor Response Spectrum—Case: CHH3, Node: 71, Horizontal	3G-92
Figure 3G-86	Floor Response Spectrum—Case: CHH3, Node: 125, Horizontal	3G-93
Figure 3G-87	Floor Response Spectrum—Case: CHH3, Node: 157, Horizontal	3G-94
Figure 3G-88	Floor Response Spectrum—Case: CHH3, Node: 165, Horizontal	3G-95
Figure 3G-89	Floor Response Spectrum—Case: CHH4, Node: 33, Horizontal	3G-96
Figure 3G-90	Floor Response Spectrum—Case: CHH4, Node: 71, Horizontal	3G-97
Figure 3G-91	Floor Response Spectrum—Case: CHH4, Node: 125, Horizontal	3G-98
Figure 3G-92	Floor Response Spectrum—Case: CHH4, Node: 157, Horizontal	3G-99
Figure 3G-93	Floor Response Spectrum—Case: CHH4, Node: 165, Horizontal	3G-100
Figure 3G-94	Floor Response Spectrum—Case: COV1, Node: 7, Vertical	3G-101
Figure 3G-95	Floor Response Spectrum—Case: COV1, Node: 125, Vertical	3G-102
Figure 3G-96	Floor Response Spectrum—Case: COV1, Node: 148, Vertical	3G-103
Figure 3G-97	Floor Response Spectrum—Case: COV1, Node: 157, Vertical	3G-104
Figure 3G-98	Floor Response Spectrum—Case: COV1, Node: 165, Vertical	3G-105
Figure 3G-99	Floor Response Spectrum—Case: COV2, Node: 7, Vertical	3G-106
Figure 3G-100	Floor Response Spectrum—Case: COV2, Node: 125, Vertical	3G-107
Figure 3G-101	Floor Response Spectrum—Case: COV2, Node: 148, Vertical	3G-108

Chapter 3

List of Figures (Continued)

Figure 3G-102	Floor Response Spectrum—Case: COV2, Node: 157, Vertical	3G-109
Figure 3G-103	Floor Response Spectrum—Case: COV2, Node: 165, Vertical	3G-110
Figure 3G-104	Floor Response Spectrum—Case: COV3, Node: 7, Vertical	3G-111
Figure 3G-105	Floor Response Spectrum—Case: COV3, Node: 125, Vertical	3G-112
Figure 3G-106	Floor Response Spectrum—Case: COV3, Node: 148, Vertical	3G-113
Figure 3G-107	Floor Response Spectrum—Case: COV3, Node: 157, Vertical	3G-114
Figure 3G-108	Floor Response Spectrum—Case: COV3, Node: 165, Vertical	3G-115
Figure 3H.1-1	(Refer to Figure 1.2-1)	3H.1-81
Figure 3H.1-2	Containment Structure ASME Code Jurisdictional Boundary.....	3H.1-82
Figure 3H.1-3	Normal Operating Temperature (°C) and Sections Location for Thermal Distribution Analysis	3H.1-83
Figure 3H.1-4	Distribution of Condensation-Oscillation (CO) Pressure	3H.1-84
Figure 3H.1-5	Distribution of Chugging Pressure.....	3H.1-85
Figure 3H.1-6	Distribution of Safety-Relief Valve (SRV) Actuation Pressure	3H.1-86
Figure 3H.1-7	Not Used.....	3H.1-87
Figure 3H.1-8	Design Seismic Shears and Moments for Reactor Building Outer Walls.....	3H.1-88
Figure 3H.1-9	Design Seismic Shears and Moments for RCCV.....	3H.1-89
Figure 3H.1-10	Design Seismic Shears and Moments for RPV Pedestal Reactor Shield Wall.....	3H.1-90
Figure 3H.1-11	Design Lateral Soil Pressures for RB Outerwalls	3H.1-91
Figure 3H.1-12	F.E.M. Isometric View of Model Representing Half of Structure	3H.1-92
Figure 3H.1-13	F.E.M. Location of Elements at Diaphragm Floor Elevation	3H.1-93
Figure 3H.1-14	F.E.M. Isometric View of Liner Plate.....	3H.1-94
Figure 3H.1-15	F.E.M. Developed Elevation of RCCV Wall	3H.1-95
Figure 3H.1-16	Section 0°–180° Soil Springs.....	3H.1-96
Figure 3H.1-17	Deformed Shape—Drywell Pressure (6.9 kPa)	3H.1-97
Figure 3H.1-18	Deformed Shape—Wetwell Pressure (6.9 kPa)	3H.1-98

Chapter 3

List of Figures (Continued)

Figure 3H.1-19	Deformed Shape—Thermal Load (6 Hours).....	3H.1-99
Figure 3H.1-20	Deformed Shape—SSE 0°-180°	3H.1-100
Figure 3H.1-21	Section Considered for Analysis.....	3H.1-101
Figure 3H.1-22	Flow Chart for Structural Analysis and Design	3H.1-102
Figure 3H.1-24	Not Used.....	3H.1-103
Figure 3H.1-25	Not Used.....	3H.1-103
Figure 3H.1-26	Not Used.....	3H.1-103
Figure 3H.1-27	Not Used.....	3H.1-103
Figure 3H.1-28	Configuration of RPV Pedestal.....	3H.1-103
Figure 3H.1-29	Rebar Arrangement of F/P Girder and Slab (1/2)	3H.1-103
Figure 3H.1-30	Containment Structure Wall Reinforcement.....	3H.1-103
Figure 3H.1-31	Containment Structure Opening Reinforcement.....	3H.1-103
Figure 3H.1-32	Containment Structure Opening Reinforcement.....	3H.1-103
Figure 3H.1-33	Containment Structure Top Slab Reinforcement	3H.1-103
Figure 3H.1-34	Reactor Building Foundation Reinforcement (Sheet 1).....	3H.1-103
Figure 3H.1-35	Reactor Building Foundation Reinforcement (Sheet 2).....	3H.1-103
Figure 3H.1-36	Diaphragm Floor Reinforcement	3H.1-103
Figure 3H.1-37	List of Seismic Wall Sections	3H.1-103
Figure 3H.2-1	Not Used.....	3H.2-21
Figure 3H.2-2	Not Used.....	3H.2-21
Figure 3H.2-3	Not Used.....	3H.2-21
Figure 3H.2-4	Not Used.....	3H.2-21
Figure 3H.2-5	Not Used.....	3H.2-21
Figure 3H.2-6	Not Used.....	3H.2-21
Figure 3H.2-7	Not Used.....	3H.2-21
Figure 3H.2-8	Not Used.....	3H.2-21

Chapter 3

List of Figures (Continued)

Figure 3H.2-9	Not Used.....	3H.2-21
Figure 3H.2-10	Not Used.....	3H.2-21
Figure 3H.2-11	Dead Load (D).....	3H.2-22
Figure 3H.2-12	Live and Snow Loads (L).....	3H.2-23
Figure 3H.2-13	Live and Snow Loads During SSE (L_o).....	3H.2-24
Figure 3H.2-14	At Rest Lateral Soil Pressures on Walls (H and H').....	3H.2-25
Figure 3H.2-15	Active and Passive Lateral Soil Pressures on Walls	3H.2-26
Figure 3H.2-16	Wind Loads (W).....	3H.2-27
Figure 3H.2-17	Tornado Loads (W_t)	3H.2-28
Figure 3H.2-18	Accident Pressure Load (P_a)	3H.2-29
Figure 3H.2-19	Accident Hydrostatic Load (F_a)	3H.2-30
Figure 3H.2-20	Control Building Static Analysis Model	3H.2-31
Figure 3H.2-21	Control Building Floor Plan at Elevation -8200 mm	3H.2-32
Figure 3H.2-22	Control Building Framing Plan at Elevation -2150 mm	3H.2-32
Figure 3H.2-23	Control Building Framing Plan at Elevation 3500 mm	3H.2-32
Figure 3H.2-24	Control Building Framing Plan at Elevation 7900 mm	3H.2-32
Figure 3H.2-25	Control Building Framing Plan at Elevation 12300 and 13100 mm.....	3H.2-32
Figure 3H.2-26	Control Building Framing Plan at Elevation 17150 and 18250 mm.....	3H.2-32
Figure 3H.2-27	Control Building Framing Plan at Elevation 22200 and 22750 mm.....	3H.2-32
Figure 3H.2-28	Control Building Section.....	3H.2-32
Figure 3H.2-29	Control Building Section and Details	3H.2-32
Figure 3H.2-30	Control Building Details	3H.2-32
Figure 3H.3-1	Lateral Soil Pressure on Walls	3H.3-29
Figure 3H.3-2	Active and Passive Lateral Soil Pressures on Walls	3H.3-30
Figure 3H.3-3	Stardyne Modal of Radwaste Building (Front Wall Removed for Clarity)	3H.3-31
Figure 3H.3-4	Basemat Element Reinforcing Regions	3H.3-32

Chapter 3

List of Figures (Continued)

Figure 3H.3-5	Wall Elements — 0° Wall.....	3H.3-33
Figure 3H.3-6	Wall Elements — 90° Wall.....	3H.3-34
Figure 3H.3-7	Wall Elements — 180° Wall.....	3H.3-35
Figure 3H.3-8	Wall Elements — 270° Wall.....	3H.3-36
Figure 3H.3-9	Section Locations	3H.3-37
Figure 3H.3-10	Element Coordinate System.....	3H.3-38
Figure 3H.3-11	Radwaste Building, Reinforced Concrete Basemat	3H.3-39
Figure 3H.3-12	Radwaste Building, Structural Steel Framing Plan, Typical Floor.....	3H.3-39
Figure 3H.3-13	Radwaste Building, Structural Steel Framing Plan, Elevation 28000 mm	3H.3-39
Figure 3H.3-14	Radwaste Building, Section A-A	3H.3-39
Figure 3H.3-15	Radwaste Building, Exterior Walls Sections	3H.3-39
Figure 3H.3-16	Radwaste Building, Sections and Details.....	3H.3-39
Figure 3H.4-1	Location of Walls Exposed to HELB, El. -8200 mm	3H.4-6
Figure 3H.4-2	Location of Walls Exposed to HELB, El. -5100 mm	3H.4-7
Figure 3H.4-3	Location of Walls Exposed to HELB, El. -1700 mm.....	3H.4-8
Figure 3H.4-4	Location of Walls Exposed to HELB, El. 1500 mm.....	3H.4-9
Figure 3H.4-5	Location of Walls Exposed to HELB, El. 4800 mm.....	3H.4-10
Figure 3H.4-6	Location of Walls Exposed to HELB, El. 8500 mm.....	3H.4-11
Figure 3H.4-7	Location of Walls Exposed to HELB, El. 12300 mm.....	3H.4-12
Figure 3H.4-8	Removable Precast Concrete Blocks	3H.4-13
Figure 3I-1	Zones in Primary Containment Vessel.....	3I-18
Figure 3L-1	Simplified Piping Models	3L-8
Figure 3L-2	Representation of Pipe With Both Ends Supported With a Longitudinal Break	3L-9
Figure 3L-3	Not Used.....	3L-10

Chapter 4

Table of Contents

4.0	Reactor	4.1-1
4.1	Summary Description	4.1-1
4.1.1	Reactor Pressure Vessel	4.1-1
4.1.2	Reactor Internal Components	4.1-1
4.1.3	Reactivity Control Systems	4.1-3
4.1.4	Analysis Techniques.....	4.1-4
4.1.5	References	4.1-8
4.2	Fuel System Design	4.2-1
4.2.1	Design Bases	4.2-1
4.2.2	Description and Design Drawings.....	4.2-2
4.2.3	Design Evaluation	4.2-5
4.2.4	Testing, Inspection, and Surveillance Plans.....	4.2-7
4.2.5	COL License Information.....	4.2-7
4.2.6	References	4.2-7
4.3	Nuclear Design	4.3-1
4.3.1	Design Basis	4.3-1
4.3.2	Description	4.3-1
4.3.3	Analytical Methods	4.3-6
4.3.4	Changes	4.3-6
4.3.5	COL License Information.....	4.3-6
4.3.6	References	4.3-6
4.4	Thermal-Hydraulic Design.....	4.4-1
4.4.1	Design Basis	4.4-1
4.4.2	Description of Thermal-Hydraulic Design of the Reactor Core	4.4-1
4.4.3	Description of the Thermal–Hydraulic Design of the Reactor Coolant System	4.4-7
4.4.4	Loose-Parts Monitoring System.....	4.4-11
4.4.5	Evaluation.....	4.4-14
4.4.6	Testing and Verification	4.4-16
4.4.7	COL License Information.....	4.4-17
4.4.8	References	4.4-17
4.5	Reactor Materials	4.5-1
4.5.1	Control Rod Drive System Structural Materials	4.5-1
4.5.2	Reactor Internal Materials	4.5-5
4.5.3	COL License Information.....	4.5-8
4.6	Functional Design of Reactivity Control System	4.6-1
4.6.1	Information for Control Rod Drive System.....	4.6-1
4.6.2	Evaluations of the CRD System.....	4.6-18
4.6.3	Testing and Verification of the CRDs	4.6-23
4.6.4	Information for Combined Performance of Reactivity Control Systems.....	4.6-26
4.6.5	Evaluation of Combined Performance	4.6-27
4.6.6	COL License Information.....	4.6-27

Chapter 4

Table of Contents (Continued)

4A	Typical Control Rod Patterns and Associated Power Distribution for ABWR	4A-1
4A.1	Introduction	4A-1
4A.2	Power Distribution Strategy	4A-1
4A.3	Results of Core Simulation Studies.....	4A-1
4A.4	References	4A-1
4B	Fuel Licensing Acceptance Criteria.....	4B-1
4B.1	Introduction	4B-1
4B.2	References	4B-1
4C	Control Rod Licensing Acceptance Criteria.....	4C-1
4C.1	Introduction	4C-1
4C.2	General Criteria	4C-1
4C.3	Basis for Acceptance Criteria.....	4C-1
4D	Reference Fuel Design Compliance with Acceptance Criteria	4D-1

Chapter 4

List of Tables

Table 4.3-1	Definition Of Fuel Design Limits.....	4.3-8
Table 4.3-2	Calculated Core Effective Multiplication and Control System Worth—No Voids, 20°C	4.3-8
Table 4.4-1	Typical Thermal-Hydraulic Design Characteristics of the Reactor Core.....	4.4-19
Table 4.4-2	Void Distribution for Analyzed Core.....	4.4-20
Table 4.4-3	Flow Quality Distribution for Analyzed Core.....	4.4-21
Table 4.4-4	Axial Power Distribution Used to Generate Void and Quality Distributions for Analyzed Core	4.4-22
Table 4.4-5	Reactor Coolant System Geometric Data.....	4.4-23
Table 4A-1	Basic Control Strategy for Typical ABWR.....	4A-2
Table 4A-2	Incremental Exposure Steps and Related Figures Numbers.....	4A-2

Chapter 4

List of Figures

Figure 4.1-1	Core Configuration with Location of Instrumentation.....	4.1-9
Figure 4.2-1	[Fuel Assembly].....	4.2-8
Figure 4.2-2	[Control Rod Assembly]	4.2-9
Figure 4.3-1	[Core Loading Map Used for Response Analyses].....	4.3-9
Figure 4.3-2	[Proprietary information not included in DCD (Refer to SSAR Section 4.3, Amendment 31)]	4.3-10
Figure 4.4-1	Power-Flow Operating Map Used for System Response Study	4.4-24
Figure 4.4-2	Power-Flow Operating Map Used for System Response Study (9 RIPS Operation)	4.4-25
Figure 4.4-3	ABWR Stability	4.4-26
Figure 4.4-4	Stability Controls and Protection Logic	4.4-27
Figure 4.6-1	Fine Motion Control Rod Drive Schematic	4.6-28
Figure 4.6-2	Fine Motion Control Rod Drive Unit (Cutaway).....	4.6-29
Figure 4.6-3	Continuous Full-in Indicating Device	4.6-30
Figure 4.6-4	Control Rod Separation Detection	4.6-31
Figure 4.6-5	Control Rod to Control Rod Drive Coupling.....	4.6-32
Figure 4.6-6	FMCRD Electro-mechanical Brake	4.6-33
Figure 4.6-7	Internal Blowout Support Schematic	4.6-34
Figure 4.6-8	Control Rod Drive System P&ID (Sheets 1-3).....	4.6-35
Figure 4.6-9	Control Rod Drive System PFD.....	4.6-35
Figure 4.6-10	FMCRD Anti-Rotation Devices.....	4.6-36
Figure 4A-1a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-3
Figure 4A-1b	Relative Axial Power at 8.5 GWd/t Cycle Exposure (Haling).....	4A-4
Figure 4A-1c	Relative Axial Exposure at 8.5 GWd/t Cycle Exposure (Haling).....	4A-4
Figure 4A-1d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-5

Chapter 4

List of Figures (Continued)

Figure 4A-1e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-5
Figure 4A-2a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-6
Figure 4A-2b	Relative Axial Power at 9.0 GWd/t Cycle Exposure (Haling).....	4A-7
Figure 4A-2c	Relative Axial Exposure at 9.0 GWd/t Cycle Exposure (Haling).....	4A-7
Figure 4A-2d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-8
Figure 4A-2e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-8
Figure 4A-3a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-9
Figure 4A-3b	Relative Axial Power at 0.2 GWd/t Cycle Exposure	4A-10
Figure 4A-3c	Relative Axial Exposure at 0.2 GWd/t Cycle Exposure	4A-10
Figure 4A-3d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-11
Figure 4A-3e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-11
Figure 4A-4a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-12
Figure 4A-4b	Relative Axial Power at 1.1 GWd/t Cycle Exposure	4A-13
Figure 4A-4c	Relative Axial Exposure at 1.1 GWd/t Cycle Exposure	4A-13
Figure 4A-4d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-14
Figure 4A-4e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-14
Figure 4A-5a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-15
Figure 4A-5b	Relative Axial Power at 2.2 GWd/t Cycle Exposure	4A-16
Figure 4A-5c	Relative Axial Exposure at 2.2 GWd/t Cycle Exposure	4A-16

Chapter 4

List of Figures (Continued)

Figure 4A-5d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-17
Figure 4A-5e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-17
Figure 4A-6a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-18
Figure 4A-6b	Relative Axial Power at 3.3 GWd/t Cycle Exposure	4A-19
Figure 4A-6c	Relative Axial Exposure at 3.3 GWd/t Cycle Exposure	4A-19
Figure 4A-6d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-20
Figure 4A-6e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-20
Figure 4A-7a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-21
Figure 4A-7b	Relative Axial Power at 4.4 GWd/t Cycle Exposure	4A-22
Figure 4A-7c	Relative Axial Exposure at 4.4 GWd/t Cycle Exposure	4A-22
Figure 4A-7d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-23
Figure 4A-7e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-23
Figure 4A-8a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-24
Figure 4A-8b	Relative Axial Power at 5.5 GWd/t Cycle Exposure	4A-25
Figure 4A-8c	Relative Axial Exposure at 5.5 GWd/t Cycle Exposure	4A-25
Figure 4A-8d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-26
Figure 4A-8e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-26
Figure 4A-9a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-27
Figure 4A-9b	Relative Axial Power at 6.6 GWd/t Cycle Exposure	4A-28

Chapter 4

List of Figures (Continued)

Figure 4A-9c	Relative Axial Exposure at 6.6 GWd/t Cycle Exposure	4A-28
Figure 4A-9d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-29
Figure 4A-9e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-29
Figure 4A-10a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-30
Figure 4A-10b	Relative Axial Power at 7.7 GWd/t Cycle Exposure	4A-31
Figure 4A-10c	Relative Axial Exposure at 7.7 GWd/t Cycle Exposure	4A-31
Figure 4A-10d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-32
Figure 4A-10e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-32
Figure 4A-11a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-33
Figure 4A-11b	Relative Axial Power at 8.0 GWd/t Cycle Exposure	4A-34
Figure 4A-11c	Relative Axial Exposure at 8.0 GWd/t Cycle Exposure	4A-34
Figure 4A-11d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-35
Figure 4A-11e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-35
Figure 4A-12a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-36
Figure 4A-12b	Relative Axial Power at 8.4 GWd/t Cycle Exposure	4A-37
Figure 4A-12c	Relative Axial Exposure at 8.4 GWd/t Cycle Exposure	4A-37
Figure 4A-12d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-38
Figure 4A-12e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-38
Figure 4A-13a	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-39

Chapter 4

List of Figures (Continued)

Figure 4A-13b	Relative Axial Power at 9.0 GWd/t Cycle Exposure	4A-40
Figure 4A-13c	Relative Axial Exposure at 9.0 GWd/t Exposure.....	4A-40
Figure 4A-13d	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-41
Figure 4A-13e	[Proprietary information not included DCD (Refer to SSAR Appendix 4A, Amendment 34)]	4A-41
Figure 4A-14	Minimum Critical Power Ratio (MCPR) as a Function of Cycle Exposure	4A-42

Chapter 5

Table of Contents

5.0	Reactor Coolant System and Connected Systems	5.1-1
5.1	Summary Description	5.1-1
5.1.1	Schematic Flow Diagrams.....	5.1-3
5.1.2	Piping and Instrumentation Diagrams	5.1-3
5.1.3	Elevation Drawings	5.1-3
5.2	Integrity of Reactor Coolant Pressure Boundary	5.2-1
5.2.1	Compliance with Codes and Code Cases	5.2-1
5.2.2	Overpressure Protection	5.2-1
5.2.3	Reactor Coolant Pressure Boundary Materials.....	5.2-10
5.2.4	Preservice and Inservice Inspection and Testing of Reactor Coolant Pressure Boundary	5.2-23
5.2.5	Reactor Coolant Pressure Boundary and Core Cooling Systems Leakage Detection.....	5.2-31
5.2.6	COL License Information.....	5.2-46
5.2.7	References	5.2-47
5.3	Reactor Vessel	5.3-1
5.3.1	Reactor Vessel Materials.....	5.3-1
5.3.2	Pressure/Temperature Limits.....	5.3-9
5.3.3	Reactor Vessel Integrity	5.3-11
5.3.4	COL License Information.....	5.3-18
5.3.5	References	5.3-19
5.4	Component and Subsystem Design	5.4-1
5.4.1	Reactor Recirculation System	5.4-1
5.4.2	Steam Generators (PWR)	5.4-8
5.4.3	Reactor Coolant Piping.....	5.4-8
5.4.4	Main Steamline Flow Restrictors	5.4-9
5.4.5	Main Steamline Isolation System.....	5.4-11
5.4.6	Reactor Core Isolation Cooling System	5.4-16
5.4.7	Residual Heat Removal System	5.4-26
5.4.8	Reactor Water Cleanup System.....	5.4-45
5.4.9	Main Steamlines and Feedwater Piping	5.4-49
5.4.10	Pressurizer	5.4-51
5.4.11	Pressurizer Relief Discharge System.....	5.4-51
5.4.12	Valves	5.4-51
5.4.13	Safety/Relief Valves	5.4-53
5.4.14	Component Supports	5.4-53
5.4.15	COL License Information.....	5.4-54
5.4.16	References	5.4-55
5A	Method Of Compliance For Regulatory Guide 1.150	5A-1
5A.1	Introduction	5A-1
5A.2	Discussion.....	5A-1
5A.3	Inspection System Performance Checks	5A-1
5A.4	Calibration	5A-3

Chapter 5

Table of Contents (Continued)

5A.5	Examination.....	5A-4
5A.6	Beam Profile.....	5A-4
5A.7	Scanning Weld Metal Interface	5A-5
5A.8	Recording and Sizing	5A-5
5A.9	Reporting Of Results	5A-6
5A.10	Conclusion.....	5A-6
5B	RHR Injection Flow And Heat Capacity Analysis Outlines.....	5B-1
5B.1	Introduction	5B-1
5B.2	Outline For Injection Flow Confirmation.....	5B-1
5B.3	Outline For Heat Exchanger Confirmation	5B-3

Chapter 5

List of Tables

Table 5.2-1	Reactor Coolant Pressure Boundary Components Applicable Code Cases	5.2-49
Table 5.2-1a	Reactor Coolant Pressure Boundary Components Applicable Code Cases	5.2-50
Table 5.2-2	Systems Which May Initiate During Overpressure Event	5.2-52
Table 5.2-3	Nuclear System Safety/Relief Valve Setpoints Set Pressures and Capacities	5.2-52
Table 5.2-4	Reactor Coolant Pressure Boundary Materials.....	5.2-53
Table 5.2-5	BWR Water Chemistry.....	5.2-56
Table 5.2-6	LDS Control and Isolation Function vs. Monitored Process Variables	5.2-57
Table 5.2-7	Leakage Sources vs. Monitored Trip Alarms.....	5.2-58
Table 5.2-8	Examination Categories.....	5.2-59
Table 5.2-9	Ultrasonic Examination of RPV: Reg. Guide 1.150 Compliance	5.2-72
Table 5.3-1	Comparison of 40 Year Fluences	5.3-20
Table 5.3-2	Key Dimensions of RPV System Components and Acceptable Variations.....	5.3-20
Table 5.4-1	Reactor Recirculation System Design Characteristics	5.4-56
Table 5.4-1a	Net Positive Suction Head (NPSH) Available to RCIC Pumps.....	5.4-57
Table 5.4-2	Design Parameters for RCIC System Components.....	5.4-58
Table 5.4-3	RHR Pump/Valve Logic.....	5.4-62
Table 5.4-4	RHR Heat Exchanger Design and Performance Data	5.4-64
Table 5.4-5	Component and Subsystem Relief Valves	5.4-65
Table 5.4-6	Reactor Water Cleanup System Equipment Design Data	5.4-66

Chapter 5

List of Figures

Figure 5.1-1	Rated Operating Conditions of the ABWR.....	5.1-4
Figure 5.1-2	Coolant Volumes of the ABWR	5.1-5
Figure 5.1-3	Nuclear Boiler System P&ID (Sheets 1–11).....	5.1-6
Figure 5.2-1	Safety-Action Valve Lift Characteristics	5.2-73
Figure 5.2-2	MSIV Closure with Flux Scram and Installed Safety/Relief Valve Capacity	5.2-74
Figure 5.2-3	Safety/Relief Valve Schematic Elevation	5.2-75
Figure 5.2-4	Safety /Relief Valve and Steamline Schematic.....	5.2-76
Figure 5.2-5	Not Used.....	5.2-77
Figure 5.2-6	Not Used.....	5.2-77
Figure 5.2-7a	RPV Examination Areas	5.2-78
Figure 5.2-7b	Typical Piping System Isometric (Feedwater Line from RPV to Valve F005A)	5.2-79
Figure 5.2-8	Leak Detection and Isolation System IED (Sheets 1–10).....	5.2-80
Figure 5.3-1	Minimum Temperature Required Versus Reactor Pressure.....	5.3-21
Figure 5.3-2a	Reactor Pressure Vessel System Key Features	5.3-22
Figure 5.3-2b	Pump Penetration and Shroud Leg Arrangement.....	5.3-23
Figure 5.3-3	Fast Neutron Flux as Function of Water Thickness.....	5.3-24
Figure 5.4-1	Reactor Internal Pump Cross Section	5.4-67
Figure 5.4-2	ABWR Recirculation Flow Path.....	5.4-68
Figure 5.4-3	Reactor Internal Pump Performance Characteristics	5.4-69
Figure 5.4-4	Reactor Recirculation System P&ID (Sheets 1–2)	5.4-70
Figure 5.4-5	Reactor Recirculation System PFD.....	5.4-70
Figure 5.4-6	Main Steamline Flow Restrictor	5.4-71
Figure 5.4-7	Main Steamline Isolation Valve.....	5.4-72
Figure 5.4-8	Reactor Core Isolation Cooling System P&ID (Sheets 1–3)	5.4-73
Figure 5.4-9	Reactor Core Isolation Cooling System PFD (Sheets 1–2)	5.4-73
Figure 5.4-10	Residual Heat Removal System P&ID (Sheets 1–7)	5.4-73

Chapter 5

List of Figures (Continued)

Figure 5.4-11	Residual Heat Removal System PFD (Sheets 1–2).....	5.4-73
Figure 5.4-12	Reactor Water Cleanup System P&ID (Sheets 1–4).....	5.4-73
Figure 5.4-13	Reactor Water Cleanup System PFD (Sheets 1–2).....	5.4-73
Figure 5.4-14	Reactor Water Cleanup System IBD (Sheets 1–11)	5.4-73
Figure 5A-1	GERIS-2000 Depth Sizing Results	5A-7
Figure 5B-1	Injection Flow	5B-5

Chapter 6

Table of Contents

6.0	Engineered Safety Features	6.0-1
6.0	General.....	6.0-1
6.1	Engineered Safety Feature Materials.....	6.1-1
6.1.1	Metallic Materials.....	6.1-1
6.1.2	Organic Materials	6.1-3
6.1.3	COL License Information.....	6.1-4
6.2	Containment Systems	6.2-1
6.2.1	Containment Functional Design	6.2-1
6.2.2	Containment Heat Removal System.....	6.2-37
6.2.3	Secondary Containment Functional Design	6.2-41
6.2.4	Containment Isolation System.....	6.2-53
6.2.5	Combustible Gas Control in Containment	6.2-66
6.2.6	Containment Leakage Testing.....	6.2-86
6.2.7	COL License Information.....	6.2-93
6.2.8	References	6.2-94
6.3	Emergency Core Cooling Systems	6.3-1
6.3.1	Design Bases and Summary Description	6.3-1
6.3.2	System Design	6.3-5
6.3.3	ECCS Performance Evaluation	6.3-13
6.3.4	Tests and Inspections.....	6.3-20
6.3.5	Instrumentation Requirements.....	6.3-23
6.3.6	COL License Information.....	6.3-23
6.3.7	Reference	6.3-24
6.4	Habitability Systems	6.4-1
6.4.1	Design Basis	6.4-2
6.4.2	System Design	6.4-4
6.4.3	System Operation Procedures.....	6.4-7
6.4.4	Design Evaluations	6.4-8
6.4.5	Testing and Inspection.....	6.4-9
6.4.6	Instrumentation Requirements.....	6.4-10
6.4.7	COL License Information.....	6.4-10
6.5	Fission Products Removal and Control Systems	6.5-1
6.5.1	Engineered Safety Features Filter Systems	6.5-1
6.5.2	Containment Spray Systems.....	6.5-11
6.5.3	Fission Product Control Systems.....	6.5-11
6.5.4	Not Used.....	6.5-12
6.5.5	COL License Information.....	6.5-12
6.5.6	References	6.5-12
6.6	Preservice and Inservice Inspection and Testing of Class 2 and 3 Components and Piping.....	6.6-1
6.6.1	Class 2 and 3 System Boundaries.....	6.6-1
6.6.2	Accessibility	6.6-3
6.6.3	Examination Categories and Methods	6.6-5

Chapter 6

Table of Contents (Continued)

6.6.4	Inspection Intervals	6.6-7
6.6.5	Evaluation of Examination Results	6.6-7
6.6.6	System Pressure Tests	6.6-7
6.6.7	Augmented Inservice Inspection	6.6-8
6.6.8	Code Exemptions.....	6.6-9
6.6.9	COL License Information.....	6.6-9
 6.7	 High Pressure Nitrogen Gas Supply System	 6.7-1
6.7.1	Functions	6.7-1
6.7.2	System Description.....	6.7-1
6.7.3	System Evaluation	6.7-2
6.7.4	Inspection and Testing Requirements	6.7-3
6.7.5	Instrumentation Requirements.....	6.7-3
6.7.6	Analysis and Testing of ADS Accumulator Capacity.....	6.7-3
 6A	 Regulatory Guide 1.52, Section C, Compliance Assessment	 6A-1
 6B	 SRP 6.5.1, Table 6.5.1-1 Compliance Assessment.....	 6B-1
 6C	 Containment Debris Protection for ECCS Strainers.....	 6C-1
6C.1	Background.....	6C-1
6C.2	ABWR Mitigating Features.....	6C-1
6C.3	Design Considerations.....	6C-3
6C.4	Discussion Summary	6C-5
6C.5	Strainer Sizing Analysis Summary.....	6C-6
6C.6	COL License Information.....	6C-7
6C.7	References	6C-7
 6D	 HPCF Analysis Outlines	 6D-1
6D.1	Introduction	6D-1
6D.2	Outline for Injection Flow Confirmation	6D-1
 6E	 Additional Bypass Leakage Considerations	 6E-1
6E.1	Bypass Mechanism through ACS Interconnection.....	6E-1
6E.2	Other Bypass Pathways	6E-1
6E.3	Effect on Existing Bypass Analyses.....	6E-1
6E.4	Conclusion.....	6E-3

Chapter 6

List of Tables

Table 6.1-1	Engineered Safety Features Component Materials	6.1-5
Table 6.2-1	Containment Parameters.....	6.2-95
Table 6.2-2	Containment Design Parameters	6.2-96
Table 6.2-2a	Engineered Safety Systems Information for Containment Response Analyses.....	6.2-97
Table 6.2-2b	Net Positive Suction Head (NPSH) Available to RHR Pumps	6.2-98
Table 6.2-2c	Net Positive Suction Head (NPSH) Available to HPCF Pumps	6.2-99
Table 6.2-2d	Secondary Containment Design and Performance Data	6.2-100
Table 6.2-3	Subcompartment Nodal Description	6.2-103
Table 6.2-4	Subcompartment Vent Path Description	6.2-105
Table 6.2-4a	Flow Loss Factor	6.2-107
Table 6.2-4b	Mass and Energy Release Rate.....	6.2-109
Table 6.2-5	Reactor Coolant Pressure Boundary (RCPB) Influent Lines Penetrating Drywell	6.2-114
Table 6.2-6	Reactor Coolant Pressure Boundary (RCPB) Effluent Lines Penetrating Drywell	6.2-114
Table 6.2-7	Containment Isolation Valve Information.....	6.2-115
Table 6.2-8	Primary Containment Penetration List	6.2-163
Table 6.2-9	Secondary Containment Penetration List	6.2-173
Table 6.2-10	Potential Bypass Leakage Paths	6.2-175
Table 6.3-1	Significant Input Variables Used in the Loss-of-Coolant Accident Analysis.....	6.3-25
Table 6.3-2	Operational Sequence of Emergency Core Cooling System Maximum Core Flooder Line Break.....	6.3-27
Table 6.3-3	Single Failure Evaluation	6.3-28
Table 6.3-4	Summary of Results of LOCA Analysis including Renewal PCT with 10 CFR § 50.46 Adjustments	6.3-29
Table 6.3-5	Key to Figures	6.3-30
Table 6.3-6	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)].....	6.3-31

Chapter 6

List of Tables (Continued)

Table 6.3-7	MAPLHGR Versus Exposure	6.3-32
Table 6.3-8	Design Parameters for HPCF System Components	6.3-33
Table 6.3-9	Design Parameters for RHR System Components	6.3-35
Table 6.3-10	Single Failure Evaluation With One HPCF Subsystem Out of Service.....	6.3-38
Table 6.3-11	Single Failure Evaluation With One RHR/LPFL Subsystem Out of Service	6.3-39
Table 6.3-12	Single Failure Evaluation With ECCS Division A Out of Service	6.3-40
Table 6.3-13	Single Failure Evaluation With ECCS Division B Out of Service	6.3-41
Table 6.3-14	Single Failure Evaluation With ECCS Division C Out of Service	6.3-42
Table 6.3-15	Single Failure Evaluation With Two ADS Valves Out of Service	6.3-43
Table 6.4-1	Identification of Failure/Effect in the Control Room Habitability Area HVAC System	6.4-11
Table 6.4-2	Control Room Habitability Area HVAC System Failure Analysis.....	6.4-12
Table 6.5-1	Summary of Major Standby Gas Treatment System Components.....	6.5-13
Table 6.5-2	Source Terms Used for SGTS Charcoal Adsorber Design	6.5-15
Table 6.6-1	Examination Categories and Methods.....	6.6-10
Table 6.7-1	Nitrogen Gas Demand	6.7-5
Table 6C-1	ECCS Strainer Debris Load.....	6C-8

Chapter 6

List of Figures

Figure 6.2-1	A Break in a Feedwater Line	6.2-183
Figure 6.2-2	Feedwater Line Break—RPV Side Break Area	6.2-184
Figure 6.2-3	Feedwater Line Break Flow—Feedwater System Side of Break.....	6.2-185
Figure 6.2-4	Feedwater Line Break Flow Enthalpy—Feedwater System Side of Break	6.2-186
Figure 6.2-5	Lower Drywell Air Transfer Percentage for Model Assumption Versus Actual Case	6.2-187
Figure 6.2-6	Pressure Response of the Primary Containment for Feedwater Line Break	6.2-188
Figure 6.2-7	Temperature Response of the Primary Containment for Feedwater Line Break	6.2-189
Figure 6.2-8	Temperature Time History After a Feedwater Line Break	6.2-190
Figure 6.2-8a	Pressure Time History After a Feedwater Line Break	6.2-191
Figure 6.2-9	ABWR Main Steamlines with a Break	6.2-192
Figure 6.2-10	MSLB Area as a Function of Time	6.2-193
Figure 6.2-11	Feedwater Specific Enthalpy as a Function of Integrated Feedwater Flow Mass	6.2-194
Figure 6.2-12	Pressure Time History for MSLB with Two-Phase Blowdown Starting at 2 Seconds.....	6.2-195
Figure 6.2-13	Temperature Time History for MSLB with Two-Phase Blowdown Starting at two Seconds.....	6.2-196
Figure 6.2-14	Pressure Time History for Long-term MSLB	6.2-197
Figure 6.2-15	Temperature Time History for Long-term MSLB	6.2-198
Figure 6.2-16	General Pressure Trends in the Containment During a Post-LOCA Depressurization Transient.....	6.2-199
Figure 6.2-17	Differential Pressures in Wetwell and Drywell Relative to Reactor Building for Vacuum Breaker Size of 0.82 m^2	6.2-200
Figure 6.2-18	Differential Pressures in Wetwell and Drywell Relative to Reactor Building with Wetwell Spray for Vacuum Breaker Size of 82 m^2	6.2-201
Figure 6.2-19	Temperature and Pressure Time Histories in the Containment During Stuck Open Relief Valve Transient.....	6.2-202
Figure 6.2-20	Not Used.....	6.2-203

Chapter 6

List of Figures (Continued)

Figure 6.2-21	Not Used.....	6.2-204
Figure 6.2-22	Break Flow Rate and Specific Enthalpy for the Feedwater Line Break Flow Coming from the Feedwater System Side.....	6.2-205
Figure 6.2-23	Break Flow Rate and Specific Enthalpy for the Feedwater Line Break Flow Coming from the RPV Side	6.2-206
Figure 6.2-24	Break Flow Rate and Specific Enthalpy for the Main Steamline Break with Two-Phase Blowdown Starting When the Collapsed Water Level Reaches the Steam Nozzle.....	6.2-207
Figure 6.2-25	Not Used.....	6.2-208
Figure 6.2-26	ABWR Containment Boundary Nomenclature.....	6.2-209
Figure 6.2-27	Three Basic Types of Leakage Paths	6.2-210
Figure 6.2-28	Containment Boundaries in the Reactor Building—Plan Section A-A (0°–180°).....	6.2-211
Figure 6.2-29	Containment Boundaries in the Reactor Building—Plan Section B-B (90°–270°).....	6.2-211
Figure 6.2-30	Containment Boundaries in the Reactor Building—Plan at Elevation –8200 mm	6.2-211
Figure 6.2-31	Containment Boundaries in the Reactor Building—Plan at Elevation –1700 mm	6.2-211
Figure 6.2-32	Containment Boundaries in the Reactor Building—Plan at Elevation 4800/8500 mm	6.2-211
Figure 6.2-33	Containment Boundaries in the Reactor Building—Plan at Elevation 12300 mm	6.2-211
Figure 6.2-34	Containment Boundaries in the Reactor Building—Plan at Elevation 18100 mm	6.2-211
Figure 6.2-35	Containment Boundaries in the Reactor Building—Plan at Elevation 23500 mm	6.2-211
Figure 6.2-36	Containment Boundaries in the Reactor Building—Plan at Elevation 31700 mm	6.2-211
Figure 6.2-37a	Secondary Containment Schematic Flow Diagram (ECCS/RCIC)	6.2-212
Figure 6.2-37b	Secondary Containment Schematic Flow Diagram (Main Steam/Feedwater)	6.2-213
Figure 6.2-37c	Secondary Containment Schematic Flow Diagram (CUW)	6.2-214

Chapter 6

List of Figures (Continued)

Figure 6.2-37d	Secondary Containment Schematic Flow Diagram (CUW) (Continued)	6.2-215
Figure 6.2-37e	Secondary Containment Schematic Flow Diagram (CUW) (Continued)	6.2-216
Figure 6.2-37f	Secondary Containment Schematic Flow Diagram (CUW) (Continued)	6.2-217
Figure 6.2-37g	Secondary Containment Schematic Flow Diagram (CUW) (Continued)	6.2-218
Figure 6.2-37h	Secondary Containment Flow Schematic Diagram (CUW) (Continued)	6.2-219
Figure 6.2-37i	Pressure Transient Due to High Energy Line Break in RCIC Compartments— Isolated Cases	6.2-220
Figure 6.2-37j	Temperature Transient Response Due to High Energy Line Break in RCIC Compartments	6.2-221
Figure 6.2-37k	Pressure Transient Due to High Energy Line Breaks in CUW Compartments	6.2-222
Figure 6.2-37l	Temperature Transient Due to High Energy Line Breaks in CUW Compartments	6.2-223
Figure 6.2-37m	Pressure Transient Due to High Energy Line Break in Steam Tunnel Compartments	6.2-224
Figure 6.2-37n	Temperature Transient Due to High Energy Line Break in Steam Tunnel Compartments	6.2-225
Figure 6.2-37o	Compartment Temperature Response Due to High Energy Line Break in CUW Rooms	6.2-226
Figure 6.2-37p	Compartment Transient Temperature Response Due to High Energy Line Break in CUW-Unisolated Case	6.2-227
Figure 6.2-38	Group Classification and Containment Isolation Diagram (Sheets 1–2)	6.2-228
Figure 6.2-39	Atmospheric Control System P&ID (Sheets 1–3)	6.2-228
Figure 6.2-40	Flammability Control System P&ID (Sheets 1–2)	6.2-228
Figure 6.2-41	Hydrogen and Oxygen Concentrations in Containment After Design Basis LOCA	6.2-229
Figure 6.2-42	Allowable Steam Bypass Leakage Capacity	6.2-230
Figure 6.2-43	Typical Pressure Fluctuation Due to CO (See Figure 3B-22)	6.2-231
Figure 6.2-44	Typical Pressure Fluctuation Due To CH (See Figure 3B-24)	6.2-232
Figure 6.2-45	Quencher Bubble Pressure Time History	6.2-233
Figure 6.3-1	High Pressure Core Flooder System PFD (Sheets 1–2)	6.3-44

Chapter 6

List of Figures (Continued)

Figure 6.3-2	Not Used (See Figure 5.4-9)	6.3-44
Figure 6.3-3	Not Used (See Figure 5.4-11)	6.3-44
Figure 6.3-4	Pressure Versus High Pressure Core Flooder Flow (Per System) Used in LOCA Analysis.....	6.3-45
Figure 6.3-5	Pressure Versus Reactor Core Isolation Cooling Flow Used in LOCA Analysis.....	6.3-46
Figure 6.3-6	Pressure Versus Low Pressure Flooder Flow (Per System) Used in LOCA Analysis.....	6.3-47
Figure 6.3-7	High Pressure Core Flooder System P&ID (Sheets 1–2).....	6.3-48
Figure 6.3-8	Not Used (See Figure 5.4-8)	6.3-48
Figure 6.3-9	Not Used (See Figure 5.4-10)	6.3-48
Figure 6.3-10	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-49
Figure 6.3-11	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-50
Figure 6.3-12	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-51
Figure 6.3-13	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-51
Figure 6.3-14	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-52
Figure 6.3-15	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-52
Figure 6.3-16	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-53
Figure 6.3-17	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-53
Figure 6.3-18	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-54
Figure 6.3-19	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-54

Chapter 6

List of Figures (Continued)

Figure 6.3-20	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-55
Figure 6.3-21	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-55
Figure 6.3-22	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-56
Figure 6.3-23	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-56
Figure 6.3-24	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-57
Figure 6.3-25	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-57
Figure 6.3-26	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-58
Figure 6.3-27	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-58
Figure 6.3-28	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-59
Figure 6.3-29	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-59
Figure 6.3-30	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-60
Figure 6.3-31	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-60
Figure 6.3-32	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-61
Figure 6.3-33	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-61
Figure 6.3-34	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-62
Figure 6.3-35	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-62
Figure 6.3-36	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-63

Chapter 6

List of Figures (Continued)

Figure 6.3-37	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-63
Figure 6.3-38	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-64
Figure 6.3-39	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-64
Figure 6.3-40	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-65
Figure 6.3-41	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-65
Figure 6.3-42	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-66
Figure 6.3-43	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-66
Figure 6.3-44	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-67
Figure 6.3-45	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-67
Figure 6.3-46	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-68
Figure 6.3-47	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-68
Figure 6.3-48	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-69
Figure 6.3-49	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-69
Figure 6.3-50	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-70
Figure 6.3-51	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-70
Figure 6.3-52	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-71
Figure 6.3-53	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-71

Chapter 6

List of Figures (Continued)

Figure 6.3-54	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-72
Figure 6.3-55	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-72
Figure 6.3-56	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-73
Figure 6.3-57	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-73
Figure 6.3-58	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-74
Figure 6.3-59	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-74
Figure 6.3-60	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-75
Figure 6.3-61	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-75
Figure 6.3-62	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-76
Figure 6.3-63	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-76
Figure 6.3-64	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-77
Figure 6.3-65	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-77
Figure 6.3-66	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-78
Figure 6.3-67	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-78
Figure 6.3-68	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-79
Figure 6.3-69	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-79
Figure 6.3-70	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-80

Chapter 6

List of Figures (Continued)

Figure 6.3-71	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-80
Figure 6.3-72	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-81
Figure 6.3-73	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-81
Figure 6.3-74	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-82
Figure 6.3-75	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-82
Figure 6.3-76	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-83
Figure 6.3-77	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-84
Figure 6.3-78	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-85
Figure 6.3-79	[Proprietary information not included in DCD (Refer to SSAR Section 6.3, Amendment 34)]	6.3-86
Figure 6.4-1	Plant Layout	6.4-13
Figure 6.5-1	Standby Gas Treatment System P&ID (Sheets 1-3).....	6.5-16
Figure 6.5-2	Secondary Containment Pressure Transient After Design Basis LOCA	6.5-17
Figure 6.7-1	High Pressure Nitrogen Gas Supply System P&ID	6.7-6
Figure 6D-1	Injection Flow	6D-3

Chapter 7

Table of Contents

7.0	Instrumentation and Control Systems.....	7.1-1
7.1	Introduction.....	7.1-1
7.1.1	Identification of Safety-Related Systems	7.1-1
7.1.2	Identification of Safety Criteria.....	7.1-5
7.2	Reactor Protection (Trip) System (RPS)—Instrumentation and Controls.....	7.2-1
7.2.1	Description	7.2-1
7.2.2	Conformance Analysis	7.2-22
7.3	Engineered Safety Feature Systems, Instrumentation and Control	7.3-1
7.3.1	Description	7.3-1
7.3.2	Analysis	7.3-64
7.3.3	COL License Information.....	7.3-91
7.3.4	References	7.3-91
7.4	Systems Required for Safe Shutdown	7.4-1
7.4.1	Description	7.4-1
7.4.2	Analysis	7.4-17
7.4.3	References	7.4-27
7.5	Information Systems Important to Safety	7.5-1
7.5.1	Systems Descriptions.....	7.5-1
7.5.2	Systems Analysis.....	7.5-4
7.5.3	COL License Information.....	7.5-13
7.5.4	References	7.5-14
7.6	All Other Instrumentation Systems Required for Safety	7.6-1
7.6.1	Description	7.6-1
7.6.2	Analysis	7.6-20
7.6.3	COL License Information.....	7.6-32
7.7	Control Systems Not Required for Safety	7.7-1
7.7.1	Description	7.7-1
7.7.2	Analysis	7.7-74
7.8	COL License Information	7.8-1
7.8.1	Effects of Station Blackout on the HVAC	7.8-1
7.8.2	Electrostatic Discharge on Exposed Equipment Components	7.8-1
7.8.3	Localized High Heat Spots in Semiconductor Materials for Computing Devices.....	7.8-1
7A	Design Response to Appendix B, ABWR LRB Instrumentation and Controls.....	7A-1
7A.1	Introduction	7A-1
7A.2	Multiplexing Systems.....	7A-1
7A.3	Electrical Isolators	7A-12
7A.4	Fiber Optic Cable	7A-16
7A.5	Programmable Digital Computer Software.....	7A-16
7A.6	Programmable Digital Computer Hardware	7A-16
7A.7	Responses to Subsections 7A.5 & 7A.6; Computer Hardware and Software	7A-17

Chapter 7

Table of Contents (Continued)

7B	Implementation Requirements for Hardware/Software Development	7B-1
7B.1	Software Management Plan.....	7B-1
7B.2	Configuration Management Plan.....	7B-4
7B.3	Verification and Validation Plan.....	7B-5
7C	Defense Against Common-Mode Failure in Safety-Related, Software-Based I&C Systems	7C-1
7C.1	Introduction	7C-1
7C.2	Design Techniques for Optimizing ABWR Safety-Related Hardware and Software.....	7C-2
7C.3	Defense Against Common-Mode Failure.....	7C-3
7C.4	Common Mode Failure Analysis.....	7C-5
7C.5	Details of Final Implementation of Diversity in ABWR Protection System	7C-11
7C.6	References	7C-14

Chapter 7

List of Tables

Table 7.1-1	Comparison of GESSAR II and ABWR I&C Safety Systems.....	7.1-33
Table 7.1-2	Regulatory Requirements Applicability Matrix for I&C Systems	7.1-36
Table 7.2-1	Reactor Protection System Instrumentation Specifications	7.2-45
Table 7.2-2	Channels Required for Functional Performance of RPS.....	7.2-46
Table 7.4-1	Reactor Shutdown Cooling Bypasses and Interlocks.....	7.4-28
Table 7.5-1	Design and Qualification Criteria for Instrumentation.....	7.5-15
Table 7.5-2	ABWR PAM Variable List	7.5-22
Table 7.5-3	ABWR Type A Variables.....	7.5-24
Table 7.5-4	Anticipated Operational Transients.....	7.5-25
Table 7.5-5	Abnormal Operational Transients	7.5-26
Table 7.5-6	Design Basis Accidents	7.5-27
Table 7.5-7	Special Events	7.5-28
Table 7.5-8	Summary of Manual Actions.....	7.5-29
Table 7.5-9	Definition of Symbols for Tables 7.5-4 Through 7.5-8.....	7.5-30
Table 7.6-1	SRNM Trip Function Summary	7.6-33
Table 7.6-2	APRM Trip Function Summary	7.6-34
Table 7.6-3	High Pressure/Low Pressure System Interlock Interfaces.....	7.6-35
Table 7.6-4	Outputs From SPTM System to Other Systems	7.6-36
Table 7.6-5	Reactor Operator Information for NMS	7.6-37
Table 7.7-1	RCIS Module Operation Environment.....	7.7-84
Table 7A-1	List of Equipment Interface with Essential MUX Signals	7A-22

Chapter 7

List of Figures

Figure 7.1-1	SSLC Self-Test System.....	7.1-40
Figure 7.1-2	Assignment of Interfacing Safety System Logic to SSLC Controllers.....	7.1-41
Figure 7.2-1	ABWR SSLC Control Power Scheme (See also Figure 8.3-3)	7.2-47
Figure 7.2-2	Reactor Protection System Equipment Arrangement (From Sensors Through Trip Actuators).....	7.2-48
Figure 7.2-3	Division 1 Trip Logic Turbine Stop Valve Closure and Turbine Control Valve Fast Closure	7.2-49
Figure 7.2-4	Division 1 Trip Logic.....	7.2-50
Figure 7.2-5	Division 1 Trip Logic Coincident and Non-Coincident NMS Trips.....	7.2-51
Figure 7.2-6	Division 1 Trip Logic.....	7.2-52
Figure 7.2-7	Not Used.....	7.2-53
Figure 7.2-8	SCRAM Solenoids and Air Header Dump Valves Power Distribution.....	7.2-54
Figure 7.2-9	Reactor Protection System IED (Sheets 1–11)	7.2-55
Figure 7.2-10	Reactor Protection System IBD (Sheets 1–72)	7.2-55
Figure 7.3-1	High Pressure Core Flooder System IBD (Sheets 1–17)	7.3-92
Figure 7.3-2	Nuclear Boiler System IBD (Sheets 1–37)	7.3-92
Figure 7.3-3	Reactor Core Isolation Cooling System IBD (Sheets 1–17).....	7.3-92
Figure 7.3-4	Residual Heat Removal System IBD (Sheets 1–20)	7.3-92
Figure 7.3-5	Leak Detection and Isolation System IBD (Sheet 1–77)	7.3-92
Figure 7.3-6	Standby Gas Treatment System IBD (Sheets 1–11)	7.3-92
Figure 7.3-7	Reactor Building Cooling Water / Reactor Service Water System IBD (Sheets 1–19).....	7.3-92
Figure 7.3-8	Not Used.....	7.3-92
Figure 7.3-9	HVAC Emergency Cooling Water System IBD (Sheets 1–11).....	7.3-92
Figure 7.3-10	High Pressure Nitrogen Gas System IBD (Sheets 1–3)	7.3-92
Figure 7.4-1	Standby Liquid Control System IBD (Sheets 1–6)	7.4-29
Figure 7.4-2	Remote Shutdown System IED.....	7.4-29

Chapter 7

List of Figures (Continued)

Figure 7.4-3	Remote Shutdown System IBD (Sheets 1–27)	7.4-29
Figure 7.6-1	Neutron Monitoring System IED (Sheets 1–4).....	7.6-40
Figure 7.6-2	Neutron Monitoring System IBD (Sheets 1–28).....	7.6-40
Figure 7.6-3	LPRM Detector Location.....	7.6-41
Figure 7.6-4a	Basic Configuration of a Typical Neutron Monitoring System Division	7.6-42
Figure 7.6-4b	Neutron Flux Monitoring Range.....	7.6-43
Figure 7.6-5	Process Radiation Monitoring System IED (Sheets 1–11)	7.6-44
Figure 7.6-6	Not Used.....	7.6-44
Figure 7.6-7	Containment Atmospheric Monitoring System IED (Sheets 1–4).....	7.6-44
Figure 7.6-8	Containment Atmospheric Monitoring System IBD (Sheets 1–10)	7.6-44
Figure 7.6-9	Instrumentation Location Definition for the Suppression Pool Temperature Monitoring System.....	7.6-45
Figure 7.6-10	Suppression Pool Temperature Monitoring System Sensor and Envelope Definition	7.6-46
Figure 7.6-11	Suppression Pool Temperature Monitoring System IED (Sheets 1–3).....	7.6-47
Figure 7.6-12	Suppression Pool Temperature Monitoring System IBD (Sheets 1–6)	7.6-47
Figure 7.6-13	LPRM Assignments to OPRM Channels.....	7.6-48
Figure 7.6-14	OPRM Logic	7.6-49
Figure 7.7-1	Water Level Range Definition	7.7-85
Figure 7.7-2	Rod Control and Information System IED (Sheets 1–5)	7.7-86
Figure 7.7-3	Rod Control and Information System IBD (Sheets 1–87)	7.7-86
Figure 7.7-4	Control Rod Drive System IBD (Sheets 1–8)	7.7-86
Figure 7.7-5	Recirculation Flow Control System IED (Sheets 1–2)	7.7-86
Figure 7.7-6	Not Used.....	7.7-86
Figure 7.7-7	Recirculation Flow Control System IBD (Sheets 1–9)	7.7-86
Figure 7.7-8	Feedwater Control System IED (Sheets 1–3)	7.7-86
Figure 7.7-9	Feedwater Control System IBD (Sheets 1, 2, 2a, and 3–14).....	7.7-86

Chapter 7

List of Figures (Continued)

Figure 7.7-10	Assignment of LPRM Strings to TIP Machines	7.7-87
Figure 7.7-11	Simplified Functional Diagram of the Automatic Power Regulation System	7.7-88
Figure 7.7-12	Steam Bypass and Pressure Control System IED (Sheets 1–2)	7.7-89
Figure 7.7-13	Steam Bypass and Pressure Control System IBD (Sheets 1–5).....	7.7-89
Figure 7.7-14	Fuel Pool Cooling and Cleanup System IBD (Sheets 1–8).....	7.7-89
Figure 7A-1	Safety System Logic and Control (SSLC)	7A-63
Figure 7A-2	Structure for Control and Instrumentation System Design	7A-64
Figure 7C-1	Implementation of Additional Diversity in SSLC to Mitigate Effects of Common-Mode Failures	7C-15

Chapter 8

Table of Contents

8.0	Electric Power.....	8.1-1
8.1	Introduction.....	8.1-1
8.1.1	Offsite Transmission Network	8.1-1
8.1.2	Electric Power Distribution System	8.1-1
8.1.3	Design Bases	8.1-5
8.1.4	COL License Information.....	8.1-10
8.1.5	References	8.1-11
8.2	Offsite Power Systems.....	8.2-1
8.2.1	Description	8.2-1
8.2.2	Analysis	8.2-6
8.2.3	Interface Requirements.....	8.2-8
8.2.4	COL License Information.....	8.2-9
8.2.5	Conceptual Design.....	8.2-10
8.2.6	References	8.2-14
8.3	Onsite Power Systems	8.3-1
8.3.1	AC Power Systems.....	8.3-1
8.3.2	DC Power Systems	8.3-27
8.3.3	General Onsite Power System Information.....	8.3-37
8.3.4	COL License Information.....	8.3-54
8.3.5	References	8.3-58
8A	Miscellaneous Electrical Systems.....	8A-1
8A.1	Station Grounding and Surge Protection.....	8A-1
8A.2	Cathodic Protection	8A-3
8A.3	Electric Heat Tracing.....	8A-4

Chapter 8

List of Tables

Table 8.1-1	Onsite Power System SRP Criteria Applicable Matrix.....	8.1-12
Table 8.2-1	Additional Requirements IEEE-765.....	8.2-15
Table 8.3-1	D/G Load Table—LOCA + LOPP	8.3-61
Table 8.3-2	D/G Load Table—LOPP (W/O LOCA).....	8.3-62
Table 8.3-3	Notes for Tables 8.3-1 and 8.3-2	8.3-63
Table 8.3-4	D/G Load Sequence Diagram Major Loads	8.3-64
Table 8.3-5	Diesel Generator Alarms	8.3-65

Chapter 8

List of Figures

Figure 8.2-1	Power Distribution System Routing Diagram (Sheets 1–7)	8.2-16
Figure 8.3-1	Electrical Power Distribution System SLD (Sheets 1–3)	8.3-67
Figure 8.3-2	Instrument and Control Power Supply System SLD.....	8.3-67
Figure 8.3-3	Plant Vital AC Power Supply System SLD (Sheets 1–2).....	8.3-67
Figure 8.3-4	Plant DC Power Supply System SLD (Sheets 1–3).....	8.3-67
Figure 8A-1	Site Plan (Grounding)	8A-6

Chapter 9

Table of Contents

9.0	Auxiliary Systems.....	9.1-1
9.1	Fuel Storage and Handling	9.1-1
9.1.1	New-Fuel Storage.....	9.1-1
9.1.2	Spent-Fuel Storage	9.1-2
9.1.3	Fuel Pool Cooling and Cleanup System.....	9.1-7
9.1.4	Light Load Handling System (Related to Refueling).....	9.1-13
9.1.5	Overhead Heavy Load Handling Systems (OHLH).....	9.1-33
9.1.6	COL License Information.....	9.1-41
9.1.7	References	9.1-43
9.2	Water Systems	9.2-1
9.2.1	Station Service Water System	9.2-1
9.2.2	Closed Cooling Water System.....	9.2-1
9.2.3	Demineralized Water Makeup System.....	9.2-1
9.2.4	Potable and Sanitary Water System	9.2-1
9.2.5	Ultimate Heat Sink	9.2-5
9.2.6	Condensate Storage Facilities and Distribution System.....	9.2-10
9.2.7	Plant Chilled Water System.....	9.2-10
9.2.8	Makeup Water (MWP) Preparation System.....	9.2-10
9.2.9	Makeup Water Condensate System.....	9.2-15
9.2.10	Makeup Water Purified System.....	9.2-17
9.2.11	Reactor Building Cooling Water System	9.2-19
9.2.12	HVAC Normal Cooling Water System	9.2-26
9.2.13	HVAC Emergency Cooling Water System	9.2-28
9.2.14	Turbine Building Cooling Water System	9.2-32
9.2.15	Reactor Service Water System	9.2-35
9.2.16	Turbine Service Water System.....	9.2-40
9.2.17	COL License Information.....	9.2-43
9.3	Process Auxiliaries	9.3-1
9.3.1	Compressed Air Systems.....	9.3-1
9.3.2	Process and Post-Accident Sampling System	9.3-1
9.3.3	Non-Radioactive Drainage System	9.3-7
9.3.4	Chemical and Volume Control System (PWR).....	9.3-10
9.3.5	Standby Liquid Control System	9.3-10
9.3.6	Instrument Air System.....	9.3-16
9.3.7	Service Air System.....	9.3-19
9.3.8	Radioactive Drain Transfer System.....	9.3-21
9.3.9	Hydrogen Water Chemistry System.....	9.3-27
9.3.10	Oxygen Injection System	9.3-29
9.3.11	Zinc Injection System.....	9.3-30
9.3.12	COL License Information.....	9.3-31
9.4	Air Conditioning, Heating, Cooling and Ventilating Systems	9.4-1
9.4.1	Control Building HVAC.....	9.4-1
9.4.2	Spent Fuel Pool Area HVAC System.....	9.4-9
9.4.3	Auxiliary Area HVAC System.....	9.4-9

Chapter 9

Table of Contents (Continued)

9.4.4	Turbine Island HVAC System.....	9.4-9
9.4.5	Reactor Building HVAC System.....	9.4-15
9.4.6	Radwaste Building HVAC System	9.4-29
9.4.7	R/B Safety-Related Diesel Generator HVAC System.....	9.4-32
9.4.8	Service Building HVAC System.....	9.4-32
9.4.9	Drywell Cooling System	9.4-35
9.4.10	COL License Information.....	9.4-37
 9.5	 Other Auxiliary Systems.....	9.5-1
9.5.1	Fire Protection System	9.5-1
9.5.2	Communication Systems.....	9.5-28
9.5.3	Lighting and Servicing Power Supply System.....	9.5-33
9.5.4	Diesel-Generator Fuel Oil Storage and Transfer System	9.5-43
9.5.5	Diesel-Generator Jacket Cooling Water System	9.5-47
9.5.6	Diesel-Generator Starting Air System.....	9.5-49
9.5.7	Diesel Generator Lubrication System	9.5-51
9.5.8	Diesel-Generator Combustion Air Intake and Exhaust System	9.5-52
9.5.9	Suppression Pool Cleanup System	9.5-55
9.5.10	Motor-Generator Set.....	9.5-56
9.5.11	Combustion Turbine/Generator.....	9.5-59
9.5.12	Lower Drywell Flooder.....	9.5-62
9.5.13	COL License Information.....	9.5-67
9.5.14	Reference	9.5-73
 9A	 Fire Hazard Analysis	9A.1-1
9A.1	Introduction	9A.1-1
9A.2	Analysis Criteria.....	9A.2-1
9A.3	Analysis Approach	9A.3-1
9A.4	Analysis	9A.4-1
9A.5	Special Cases	9A.5-1
9A.6	Fire Hazard Analysis Database	9A.6-1
 9B	 Summary of Analysis Supporting Fire Protection Design Requirements	9B-1
9B.1	Introduction	9B-1
9B.2	Fire Containment System	9B-1
9B.3	References	9B-10
 9C	 Regulatory Guide 1.52, Section C, Compliance Assessment.....	9C-1
9C.1	ABWR Compliance with RG 1.52, Revision 2, Section C	9C-1
 9D	 SRP 6.5.1, Table 6.5.1-1 Compliance Assessment.....	9D-1

Chapter 9

List of Tables

Table 9.1-1	Not Used.....	9.1-44
Table 9.1-2	Fuel Servicing Equipment	9.1-44
Table 9.1-3	Reactor Vessel Servicing Equipment	9.1-45
Table 9.1-4	Under-Reactor Vessel Servicing Equipment and Tools.....	9.1-45
Table 9.1-5	Tools and Servicing Equipment	9.1-46
Table 9.1-6	Reference Codes and Standards	9.1-47
Table 9.1-7	Heavy Load Equipment Used to Handle Light Loads and Related Refueling Handling Tasks.....	9.1-48
Table 9.1-8	Heavy Load Operations.....	9.1-49
Table 9.1-9	Legend for In-Plant Locations/Elevations.....	9.1-53
Table 9.1-10	Single-Failure-Proof Cranes	9.1-53
Table 9.1-11	Fuel Pool Cooling Heat Exchanger and Performance Data	9.1-54
Table 9.1-12	RHR-FPC Joint Heat Removal Performance Table (150 Hours Following Shutdown).....	9.1-55
Table 9.2-1	Users of Makeup Water-Condensate.....	9.2-45
Table 9.2-2	Users of Makeup Water-Purified.....	9.2-45
Table 9.2-2a	Water Quality Characteristics for the Makeup Water Purified System	9.2-46
Table 9.2-3	Capacity Requirements for Condensate Storage Tank.....	9.2-47
Table 9.2-4a	Reactor Building Cooling Water Division A	9.2-48
Table 9.2-4b	Reactor Building Cooling Water Division B.....	9.2-49
Table 9.2-4c	Reactor Building Cooling Water Division C.....	9.2-50
Table 9.2-4d	Design Characteristics for Reactor Building Cooling Water System Components	9.2-51
Table 9.2-5a	Reactor Building Cooling Water Active Failure Analysis	9.2-52
Table 9.2-5b	Reactor Building Cooling Water System Passive Failure Analysis.....	9.2-53
Table 9.2-6	HVAC Normal Cooling Water System Component Description.....	9.2-54
Table 9.2-7	HVAC Normal Cooling Water Loads	9.2-55
Table 9.2-8	HECW System Component Description	9.2-56

Chapter 9

List of Tables (Continued)

Table 9.2-9	HVAC Emergency Cooling Water System Heat Loads.....	9.2-57
Table 9.2-10	HVAC Emergency Cooling Water System Active Failure Analysis	9.2-58
Table 9.2-11	Turbine Island Auxiliary Equipment.....	9.2-58
Table 9.2-12	Not Used.....	9.2-59
Table 9.2-13	Reactor Service Water System (Interface Requirements)	9.2-59
Table 9.2-14	Potable and Sanitary Water System Components (Interface Requirements)	9.2-60
Table 9.2-15	Makeup Water Preparation System Component (Interface Requirements)	9.2-62
Table 9.2-16	Turbine Service Water System (Interface Requirement)	9.2-64
Table 9.3-1	Standby Liquid Control System Operating Pressure/Temperature Conditions.....	9.3-32
Table 9.3-2	Water Quality Instrumentation.....	9.3-33
Table 9.3-3	Service Air Consumption During Normal Plant Operation	9.3-37
Table 9.3-4	Instrument Air Consumption During Normal Plant Operation (Response to Question 430.215)	9.3-37
Table 9.4-1	Drywell Cooling System Non-Safety-Related Components	9.4-38
Table 9.4-2	Drywell Cooling System Non-Safety-Related Heat Loads	9.4-39
Table 9.4-3	HVAC Flow Rates (Response to Question 430.243)	9.4-40
Table 9.4-4	HVAC System Component Descriptions—Safety-Related Heating/Cooling Coils (Response to Question 430.243)	9.4-41
Table 9.4-4a	HVAC System Component Descriptions—Safety-Related Fans (Response to Question 430.243)	9.4-42
Table 9.4-4b	HVAC System Component Descriptions—Safety-Related Filter (Response to Question 430.243)	9.4-43
Table 9.4-4c	HVAC System Component Descriptions—Emergency Use Adsorption Units (Safety Related) (Response to Question 430.243)	9.4-43
Table 9.4-4d	Not Used.....	9.4-44
Table 9.4-4e	HVAC System Component Descriptions—Safety-Related Fan Coil Units (Response to Question 430.243).....	9.4-44
Table 9.4-4f	HVAC System Component Descriptions—Non-Safety-Related Heating Cooling Coils (Response to Question 430.243)	9.4-45

Chapter 9

List of Tables (Continued)

Table 9.4-4g	HVAC System Component Descriptions—Non-Safety-Related Fans (Response to Question 430.243).....	9.4-45
Table 9.4-4h	HVAC System Component Descriptions—Non-Safety-Related Filters (Response to Question 430.243).....	9.4-45
Table 9.4-4i	HVAC System Component Descriptions—Non-Safety-Related Air Handling Units (Response to Question 430.243)	9.4-46
Table 9.4-5	Turbine Building and Electrical Building HVAC System—Non-Safety-Related Equipment.....	9.4-47
Table 9.4-5a	Turbine Building and Electrical Building HVAC System—Non-Safety-Related Equipment (Continued)	9.4-48
Table 9.4-5b	Turbine Building and Electrical Building HVAC System—Non-Safety-Related Equipment (Continued)	9.4-49
Table 9.4-5c	Turbine Building and Electrical Building HVAC System—Non-Safety-Related Equipment (Continued)	9.4-50
Table 9.5-1	Normal and/or Standby Lighting (Non-Class 1E AC Power Supply).....	9.5-74
Table 9.5-2	Lighting and Power Sources.....	9.5-75
Table 9.5-3	Standby Lighting (Class 1E AC Power Supply)	9.5-75
Table 9.5-4	DC Emergency Lighting.....	9.5-76
Table 9.5-5	Summary of Automatic Fire Suppression Systems	9.5-77
Table 9A.2-1	Core Cooling	9A.2-8
Table 9A.5-1	Redundant Instrumentation or Equipment in Same Fire Area	9A.5-19
Table 9A.5-2	Summary of the Reactor Building Special Cases.....	9A.5-20
Table 9A.6-1	Fire Hazard Analysis Equipment Data Base—Sorted by MPL Number	9A.6-5
Table 9A.6-2	Fire Hazard Analysis Equipment Database Sorted by Room—Reactor Building	9A.6-6
Table 9A.6-3	Fire Hazard Analysis Equipment Data Base—Sorted by Room—Control Building	9A.6-96
Table 9A.6-4	Fire Hazard Analysis Equipment Database—Sorted by Room—Turbine Building	9A.6-106
Table 9A.6-5	Fire Hazard Analysis Equipment Database—Control Building Annex	9A.6-116
Table 9B-1	Estimated Fire Severity for Offices and Light Commercial Occupancies	9B-11

Chapter 9

List of Tables (Continued)

Table 9B-2	Fire Severity Expected by Occupancy	9B-12
Table 9B-3	Cable Type and Configuration for UL Tests	9B-13
Table 9B-4	Summary of Burning Rate Calculations.....	9B-13

Chapter 9

List of Figures

Figure 9.1-1	Fuel Pool Cooling and Cleanup System P&ID (Sheets 1–3).....	9.1-56
Figure 9.1-2	Fuel Pool Cooling and Cleanup System PFD (Sheets 1–2)	9.1-56
Figure 9.1-3	Fuel Preparation Machine Shown Installed in Facsimile Fuel Pool	9.1-57
Figure 9.1-4	New-Fuel Inspection Stand	9.1-58
Figure 9.1-5	Channel Bolt Wrench.....	9.1-59
Figure 9.1-6	Channel-Handling Tool.....	9.1-60
Figure 9.1-7	Fuel Pool Vacuum Sipper	9.1-61
Figure 9.1-8	General-Purpose Grapple	9.1-62
Figure 9.1-9	Not Used.....	9.1-63
Figure 9.1-10	Jib Crane Channel-Handling Boom	9.1-64
Figure 9.1-11	Fuel Assembly Sampler	9.1-65
Figure 9.1-12	Plant Refueling and Servicing Sequence	9.1-66
Figure 9.1-13	Simplified Section of Refueling Facilities	9.1-67
Figure 9.1-14	Simplified Section of New-Fuel Handling Facilities	9.1-68
Figure 9.2-1	Reactor Building Cooling Water System P&ID (Sheets 1–9)	9.2-65
Figure 9.2-1a	Not Used.....	9.2-65
Figure 9.2-2	HVAC Normal Cooling Water System P&ID	9.2-65
Figure 9.2-3	HVAC Emergency Cooling Water System P&ID (Sheets 1–3)	9.2-65
Figure 9.2-4	Makeup Water System (Condensate) P&ID	9.2-65
Figure 9.2-5	Makeup Water System (Purified) P&ID (Sheets 1–3).....	9.2-65
Figure 9.2-6a	Turbine Building Cooling Water System Diagram.....	9.2-66
Figure 9.2-6b	Turbine Building Cooling Water System Diagram.....	9.2-67
Figure 9.2-6c	Turbine Building Cooling Water System Diagram.....	9.2-68
Figure 9.2-7	Reactor Service Water System P&ID (Sheets 1–3).....	9.2-69
Figure 9.2-8	Turbine Building Service Water System.....	9.2-70
Figure 9.2-9	Potable and Sanitary Water System	9.2-71

Chapter 9

List of Figures (Continued)

Figure 9.2-10	Makeup Water Preparation System.....	9.2-72
Figure 9.3-1	Standby Liquid Control System P&ID	9.3-38
Figure 9.3-1a	Standby Liquid Control System PFD.....	9.3-38
Figure 9.3-2	Sodium Pentaborate Volume Concentration Requirements.....	9.3-39
Figure 9.3-3	Saturation Temperature of Sodium Pentaborate Solution.....	9.3-40
Figure 9.3-4	Sample Probe	9.3-41
Figure 9.3-5	Sample Probe	9.3-42
Figure 9.3-6	Instrument Air System P&ID (Sheets 1–2).....	9.3-43
Figure 9.3-7	Station Service Air System P&ID (Sheets 1–2).....	9.3-43
Figure 9.3-8	Hydrogen Water Chemistry System.....	9.3-44
Figure 9.3-9	Divisional Radioactive Floor Drains.....	9.3-45
Figure 9.4-1	Control Building HVAC Flow Diagram (Sheets 1–5).....	9.4-51
Figure 9.4-2a	Turbine Building Ventilation System Air Flow Diagram.....	9.4-51
Figure 9.4-2b	Turbine Building Ventilation System Control Diagram (Sheets 1–2)	9.4-51
Figure 9.4-2c	Electrical Building HVAC System Diagram	9.4-52
Figure 9.4-3	Secondary Containment HVAC System (Sheets 1–3).....	9.4-53
Figure 9.4-4	R/B Safety-Related Electrical Equipment HVAC System (Sheets 1–3)	9.4-53
Figure 9.4-5	Reactor Internal Pump Control Panel Room HVAC System.....	9.4-53
Figure 9.4-6	Not Used.....	9.4-53
Figure 9.4-7	Not Used.....	9.4-53
Figure 9.4-8	Drywell Cooling System P&ID	9.4-53
Figure 9.4-9	Drywell Heat Load Area Drawing	9.4-54
Figure 9.4-10	Radwaste Building HVAC (Sheets 1–3).....	9.4-55
Figure 9.5-1	Suppression Pool Cleanup System P&ID	9.5-79
Figure 9.5-2	Outline—Telephonic Communication Systems.....	9.5-80
Figure 9.5-3	Lower Drywell Flooder System Arrangement/Configuration	9.5-81

Chapter 9

List of Figures (Continued)

Figure 9.5-4	Fire Protection Water Supply System	9.5-82
Figure 9.5-5	Fire Protection Yard Main Piping	9.5-84
Figure 9.5-6	Standby Diesel Generator Fuel Oil and Combustion Air Intake and Exhaust Systems	9.5-86
Figure 9.5-7	Standby Diesel Generator Jacket Cooling Water System	9.5-86
Figure 9.5-8	Standby Diesel Generator Starting Air System.....	9.5-86
Figure 9.5-9	Standby Diesel Generator Lubricating Oil System.....	9.5-86
Figure 9A.4-1	Reactor Building Fire Protection at Elevation -8200 mm.....	9A.4-466
Figure 9A.4-2	Reactor Building Fire Protection at Elevation -1700 mm.....	9A.4-466
Figure 9A.4-3	Reactor Building Fire Protection at Elevation 4800/8500 mm.....	9A.4-466
Figure 9A.4-4	Reactor Building Fire Protection at Elevation 12300 mm	9A.4-466
Figure 9A.4-5	Reactor Building Fire Protection at Elevation 18100 mm	9A.4-466
Figure 9A.4-6	Reactor Building Fire Protection at Elevation 23500 mm	9A.4-466
Figure 9A.4-7	Reactor Building Fire Protection at Elevation 27200 mm	9A.4-466
Figure 9A.4-8	Reactor Building Fire Protection at Elevation 31700/38200 mm.....	9A.4-466
Figure 9A.4-9	Reactor Building Fire Protection, Section A-A	9A.4-466
Figure 9A.4-10	Reactor Building Fire Protection, Section B-B.....	9A.4-466
Figure 9A.4-11	Control Building Fire Protection, Section B-B	9A.4-466
Figure 9A.4-12	Control Building Fire Protection at Elevation -8200 mm.....	9A.4-466
Figure 9A.4-13	Control Building Fire Protection at Elevation -2150 mm	9A.4-466
Figure 9A.4-14	Control Building Fire Protection at Elevation 3500 mm	9A.4-466
Figure 9A.4-15	Control Building Fire Protection at Elevation 7900 mm	9A.4-466
Figure 9A.4-16	Control Building Fire Protection at Elevation 12300 mm	9A.4-466
Figure 9A.4-16a	Control Building Fire Protection at Elevation 17150 mm	9A.4-466
Figure 9A.4-16b	Control Building Fire Protection at Elevation 22200 mm	9A.4-466
Figure 9A.4-17	Turbine Building Fire Protection, Section A-A	9A.4-466

Chapter 9

List of Figures (Continued)

Figure 9A.4-18	Turbine Building Fire Protection at Elevation 5300 mm.....	9A.4-466
Figure 9A.4-19	Turbine Building Fire Protection at Elevation 12300 mm.....	9A.4-466
Figure 9A.4-20	Turbine Building Fire Protection at Elevation 20300 mm.....	9A.4-466
Figure 9A.4-21	Turbine Building Fire Protection at Elevation 30300 mm.....	9A.4-466
Figure 9A.4-22	Service Building Fire Protection, Section B-B (See Figure 9A.4-11)	9A.4-467
Figure 9A.4-23	Service Building Fire Protection at Elevation -2150 mm (See Figure 9A.4-13).....	9A.4-467
Figure 9A.4-24	Service Building Fire Protection at Elevation 3500 mm (See Figure 9A.4-14).....	9A.4-467
Figure 9A.4-25	Service Building Fire Protection at Elevation 7900 mm (See Figure 9A.4-15).....	9A.4-467
Figure 9A.4-26	Service Building Fire Protection at Elevation 12300 mm (See Figure 9A.4-16).....	9A.4-467
Figure 9A.4-27	Service Building Fire Protection at Elevation 17150 mm (See Figure 9A.4-16a).....	9A.4-467
Figure 9A.4-28	Radwaste Building Fire Protection, Section A-A	9A.4-467
Figure 9A.4-29	Radwaste Building Fire Protection at Elevation -1500 mm	9A.4-467
Figure 9A.4-30	Radwaste Building Fire Protection at Elevation 4800 mm.....	9A.4-467
Figure 9A.4-31	Radwaste Building Fire Protection at Elevation 12300 mm.....	9A.4-467
Figure 9A.4-32	Radwaste Building Fire Protection at Elevation 21000 mm.....	9A.4-467
Figure 9A.5-1	Typical RPS Contact Interface Turbine Building to Control Building.....	9A.5-28
Figure 9A.5-2	Typical Electrical Equipment Connection Block Diagrams of Special Cases.....	9A.5-29
Figure 9B-1	Possible Classification of Building Contents for Fire Severity and Duration	9B-14

Chapter 10

Table of Contents

10.0	Steam and Power Conversion System	10.1-1
10.1	Summary Description	10.1-1
	10.1.1 Protective Features	10.1-2
10.2	Turbine Generator.....	10.2-1
10.2.1	Design Bases	10.2-1
10.2.2	Description	10.2-2
10.2.3	Turbine Integrity.....	10.2-10
10.2.4	Evaluation.....	10.2-14
10.2.5	COL License Information.....	10.2-15
10.2.6	References	10.2-15
10.3	Main Steam Supply System.....	10.3-1
10.3.1	Design Bases	10.3-1
10.3.2	Description	10.3-2
10.3.3	Evaluation.....	10.3-3
10.3.4	Inspection and Testing Requirements	10.3-3
10.3.5	Water Chemistry (PWR)	10.3-3
10.3.6	Steam and Feedwater System Materials.....	10.3-3
10.3.7	COL License Information.....	10.3-5
10.4	Other Features of Steam and Power Conversion System	10.4-1
10.4.1	Main Condenser.....	10.4-1
10.4.2	Main Condenser Evacuation System.....	10.4-6
10.4.3	Turbine Gland Sealing System.....	10.4-8
10.4.4	Turbine Bypass System	10.4-11
10.4.5	Circulating Water System.....	10.4-14
10.4.6	Condensate Purification System.....	10.4-18
10.4.7	Condensate and Feedwater System	10.4-22
10.4.8	Steam Generator Blowdown System (PWR)	10.4-28
10.4.9	Auxiliary Feedwater System (PWR)	10.4-28
10.4.10	COL License Information.....	10.4-29

Chapter 10

List of Tables

Table 10.1-1	Summary of Important Design Features and Performance Characteristics of the Steam and Power Conversion System.....	10.1-4
Table 10.3-1	Main Steam Supply System Design Data.....	10.3-6
Table 10.4-1	Condenser Design Data	10.4-30
Table 10.4-2	Main Condenser Evacuation System.....	10.4-30
Table 10.4-3	Circulating Water System.....	10.4-31
Table 10.4-4	Condensate Purification System.....	10.4-31
Table 10.4-5	Condensate and Feedwater System Design Data	10.4-32
Table 10.4-6	Condensate and Feedwater System Component Failure Analysis	10.4-33

Chapter 10

List of Figures

Figure 10.1-1	Reference Steam & Power Conversion System	10.1-7
Figure 10.1-2	Reference Heat Balance for Guaranteed Reactor Rating	10.1-8
Figure 10.1-3	Reference Heat Balance for Valves-Wide-Open (VWO)	10.1-8
Figure 10.2-1	Turbine Stop Valve Closure Characteristic.....	10.2-16
Figure 10.2-2	Turbine Control Valve Fast Closure Characteristic	10.2-17
Figure 10.2-3	Acceptable Range for Control Valve Normal Closure Motion.....	10.2-18
Figure 10.2-4	Generator Hydrogen and CO ₂ System.....	10.2-19
Figure 10.3-1	Main Steam Supply System	10.3-7
Figure 10.3-2	Main Turbine System.....	10.3-8
Figure 10.4-1	Main Condenser Evacuation System	10.4-34
Figure 10.4-2	Turbine Gland Seal System.....	10.4-35
Figure 10.4-3	Circulating Water System	10.4-36
Figure 10.4-4	Condensate Purification System	10.4-37
Figure 10.4-5	Condensate System	10.4-39
Figure 10.4-6	Feedwater System	10.4-41
Figure 10.4-7	LP Extraction Steam Drains and Vent Systems	10.4-42
Figure 10.4-8	HP Extraction Steam Drains and Vent System	10.4-43
Figure 10.4-9	Bypass Valve Control, Electro-Hydraulic Control Unit	10.4-44
Figure 10.4-10	Signal Flow Chart for Turbine Bypass Control Unit	10.4-45

Chapter 11

Table of Contents

11.0	Radioactive Waste Management.....	11.1-1
11.1	Source Terms	11.1-1
11.1.1	Fission Products.....	11.1-1
11.1.2	Activation Products	11.1-3
11.1.3	Radionuclide Concentration Adjustment	11.1-5
11.1.4	Fuel Fission Production Inventory	11.1-6
11.1.5	Process Leakage Sources.....	11.1-6
11.1.6	References	11.1-7
11.2	Liquid Waste Management System	11.2-1
11.2.1	Design Basis	11.2-1
11.2.2	System Description.....	11.2-4
11.2.3	Estimated Releases	11.2-5
11.2.4	Tank Resistance to Vacuum Collapse	11.2-6
11.2.5	COL License Information.....	11.2-6
11.3	Gaseous Waste Management System.....	11.3-1
11.3.1	General	11.3-1
11.3.2	Design Criteria.....	11.3-1
11.3.3	Process Description	11.3-2
11.3.4	Offgas System Description.....	11.3-4
11.3.5	Other Radioactive Gas Sources	11.3-19
11.3.6	Instrumentation and Control.....	11.3-19
11.3.7	Quality Control.....	11.3-19
11.3.8	Seismic Design	11.3-20
11.3.9	Testing	11.3-21
11.3.10	Radioactive Releases	11.3-23
11.3.11	COL License Information.....	11.3-24
11.3.12	References	11.3-24
11.4	Solid Waste Management System.....	11.4-1
11.4.1	Design Bases	11.4-1
11.4.2	System Description.....	11.4-2
11.4.3	COL License Information.....	11.4-6
11.5	Process and Effluent Radiological Monitoring and Sampling Systems.....	11.5-1
11.5.1	Design Bases	11.5-1
11.5.2	System Description.....	11.5-4
11.5.3	Effluent Monitoring and Sampling.....	11.5-13
11.5.4	Process Monitoring and Sampling.....	11.5-13
11.5.5	Calibration and Maintenance.....	11.5-15
11.5.6	COL License Information.....	11.5-17
11.6	Offsite Radiological Monitoring Program	11.6-1
11A.0	Radioactive Waste Management - Additional Information	11A-1
11A.1	Introduction	11A-1
11A.2	Liquid Waste Management.....	11A-1

Chapter 11

Table of Contents (Continued)

11A.3	Not Used.....	11A-1
11A.4	Solid Waste Management System.....	11A-1

Chapter 11

List of Tables

Table 11.1-1	Noble Radiogas Source Terms in Steam	11.1-8
Table 11.1-2	Iodine Radioisotopes in Reactor Water.....	11.1-8
Table 11.1-3	Non-Volatile Fission Products in Reactor Water	11.1-9
Table 11.1-4	Coolant Activation Products in Reactor Water and Steam	11.1-10
Table 11.1-5	Non-coolant Activation Products in Reactor Water.....	11.1-10
Table 11.1-6	Plant Parameters for Source Term Adjustment.....	11.1-11
Table 11.1-7	Removal Parameters for Source Term Adjustment.....	11.1-11
Table 11.2-1	Equipment Codes for Radwaste Equipment (from Table 1, RG 1.143).....	11.2-8
Table 11.2-2	Capability of Liquid Radwaste Subsystems to Process Expected Wastes	11.2-8
Table 11.2-3	Reactor Coolant Activity (RCA) Fraction.....	11.2-9
Table 11.2-4	Capacities of Tanks, Pumps, and Other Components	11.2-10
Table 11.3-1	Estimated Air Ejector Offgas Release Rates Per Unit (51 sm ³ /h Inleakage).....	11.3-25
Table 11.3-2	Offgas System Major Equipment Items	11.3-26
Table 11.3-3	Equipment Malfunction Analysis.....	11.3-28
Table 11.3-4	Offgas System Instrument Setpoints	11.3-31
Table 11.4-1	Expected Waste Volume Generated Annually by Each “Wet” Solid Waste Source and Tank Capacities	11.4-7
Table 11.4-2	Estimate of Expected Annual “Dry” Solid Wastes and Becquerel Content.....	11.4-7
Table 11.4-3	Calculated Shipped Solid Waste Volumes and Becquerel Count	11.4-7
Table 11.5-1	Process and Effluent Radiation Monitoring Systems.....	11.5-19
Table 11.5-2	Process Radiation Monitoring System (Gaseous and Airborne Monitors)	11.5-21
Table 11.5-3	Process Radiation Monitoring System (Liquid Monitors)	11.5-24
Table 11.5-4	Radiological Analysis Summary of Liquid Process Samples	11.5-25
Table 11.5-5	Radiological Analysis Summary of Gaseous Process Samples	11.5-26
Table 11.5-6	Radiological Analysis Summary of Liquid Effluent Samples	11.5-27
Table 11.5-7	Radiological Analysis Summary of Gaseous Effluent Samples.....	11.5-28

Chapter 11

List of Figures

Figure 11.2-1	Radwaste System PFD	11.2-12
Figure 11.3-1	Offgas System PFD (Sheets 1-2)	11.3-37
Figure 11.3-2	Offgas System P&ID (Sheets 1-3)	11.3-37

Chapter 12

Table of Contents

12.0	Radiation Protection	12.1-1
12.1	Ensuring that Occupational Radiation Exposures are ALARA.....	12.1-1
12.1.1	Policy Considerations.....	12.1-1
12.1.2	Design Considerations.....	12.1-2
12.1.3	Operational Considerations	12.1-5
12.1.4	COL License Information.....	12.1-6
12.2	Radiation Sources	12.2-1
12.2.1	Contained Sources	12.2-1
12.2.2	Airborne and Liquid Sources for Environmental Consideration.....	12.2-9
12.2.3	COL License Information.....	12.2-11
12.2.4	References	12.2-11
12.3	Radiation Protection Design Features.....	12.3-1
12.3.1	Facility Design Features	12.3-1
12.3.2	Shielding.....	12.3-17
12.3.3	Ventilation	12.3-25
12.3.4	Area Radiation and Airborne Radioactivity Monitoring Instrumentation	12.3-28
12.3.5	Post-Accident Access Requirements	12.3-30
12.3.6	Post-Accident Radiation Zone Maps.....	12.3-31
12.3.7	COL License Information.....	12.3-32
12.3.8	References	12.3-32
12.4	Dose Assessment	12.4-1
12.4.1	Drywell Dose.....	12.4-1
12.4.2	Reactor Building Dose	12.4-4
12.4.3	Radwaste Building Dose	12.4-5
12.4.4	Turbine Building Dose	12.4-6
12.4.5	Work at Power	12.4-6
12.4.6	References	12.4-7
12.5	Health Physics Program.....	12.5-1
12.5.1	Operational Considerations	12.5-1
12.5.2	In-Plant and Airborne Radioactivity Monitoring	12.5-1
12.5.3	COL License Information.....	12.5-1
12A	Appendix 12A Calculation of Airborne Radionuclides.....	12A-1
12A.1	Calculation of Airborne Radionuclides	12A-1
12A.2	References	12A-4

Chapter 12

List of Tables

Table 12.2-1a	Basic Reactor Data	12.2-13
Table 12.2-1b	Basic Reactor Data—Material Densities (g/cm ³)	12.2-14
Table 12.2-1c	Basic Reactor Data—Typical Core Exposure Distribution.....	12.2-15
Table 12.2-1d	Basic Reactor Data—Typical Core Exposure Distribution—Axial Relative Exposure	12.2-16
Table 12.2-2	Core Boundary Neutron Fluxes.....	12.2-17
Table 12.2-3a	Gamma Ray Source Energy Spectra—Gamma Ray Sources in the Core During Operation.....	12.2-18
Table 12.2-3b	Gamma Ray Source Energy Spectra—Post-Operation Gamma Sources in the Core (pJ/W-sec).....	12.2-18
Table 12.2-3c	Gamma Ray Source Energy Spectra—Gamma Ray Source External to the Core During Operation.....	12.2-19
Table 12.2-4a	Gamma Ray and Neutron Fluxes Outside the Vessel Wall—Neutron Fluxes.....	12.2-20
Table 12.2-4b	Gamma Ray and Neutron Fluxes Outside the Vessel Wall—Gamma Ray Energy Fluxes.....	12.2-20
Table 12.2-5a	Radiation Sources— Radiation Sources.....	12.2-21
Table 12.2-5b	Radiation Sources—Source Geometry.....	12.2-23
Table 12.2-5c	Radiation Sources—Shielding Geometry in Meters	12.2-25
Table 12.2-5d	Radiation Source—Pipe Chase Detail.....	12.2-27
Table 12.2-6	Fission Product Gamma Source Strength in the RHR Heat Exchanger.....	12.2-29
Table 12.2-7	Fission Product Inventory in the RHR Heat Exchanger 2 Hours After Shutdown ...	12.2-30
Table 12.2-8	Reactor Coolant Concentration Values Entering the RCIC Turbine.....	12.2-32
Table 12.2-9	CUW Filter Demineralizer	12.2-34
Table 12.2-10	Reactor Water Cleanup, Regenerative Heat Exchanger Tube Sides	12.2-35
Table 12.2-11	Reactor Water Cleanup, Non-Regenerative Heat Exchanger Tube Sides.....	12.2-36
Table 12.2-12	Reactor Water Cleanup, Regenerative Heat Exchanger Shell Side	12.2-37
Table 12.2-13a	Liquid Radwaste Component Inventories—LCW Collector Tank	12.2-38
Table 12.2-13b	Liquid Radwaste Component Inventories—LCW Filter.....	12.2-39

Chapter 12

List of Tables (Continued)

Table 12.2-13c Liquid Radwaste Component Inventories—LCW Demineralizer	12.2-40
Table 12.2-13d Liquid Radwaste Component Inventories—LCW Sample Tank	12.2-41
Table 12.2-13e Liquid Radwaste Component Inventories—HCW Collector Tank.....	12.2-42
Table 12.2-13f Liquid Radwaste Component Inventories—HCW Demineralizer.....	12.2-43
Table 12.2-14 Offgas System Inventories	12.2-44
Table 12.2-15a Solid Radwaste Component Inventories CUW Backwash Receiving Tank	12.2-46
Table 12.2-15b Solid Radwaste Component Inventories CF Backwash Receiving Tank.....	12.2-47
Table 12.2-15c Solid Radwaste Component Inventories Phase Separator.....	12.2-48
Table 12.2-15d Solid Radwaste Component Inventories Spent Resin Storage Tank.....	12.2-49
Table 12.2-15e Solid Radwaste Component Inventories Concentrated Waste Tank	12.2-50
Table 12.2-15f Solid Radwaste Component Inventories Solids Dryer Feed Tank	12.2-51
Table 12.2-15g Solid Radwaste Component Inventories Solids Dryer (Outlet)	12.2-52
Table 12.2-15h Solid Radwaste Component Inventories Solids Dryer Pelletizer	12.2-53
Table 12.2-15i Solid Radwaste Component Inventories Solids Mist Separator (Steam)	12.2-54
Table 12.2-15j Solid Radwaste Component Inventories Solids Condenser	12.2-55
Table 12.2-15k Solid Radwaste Component Inventories Solids Drum	12.2-56
Table 12.2-16 FPC Filter Demineralizer	12.2-57
Table 12.2-17 Radioactive Sources in the Suppression Pool Cleanup System	12.2-58
Table 12.2-18a Radioactive Sources in the Control Rod Drive System.....	12.2-59
Table 12.2-18b Control Blade Principal Isotopes.....	12.2-59
Table 12.2-19 Annual Airborne Releases for Offsite Dose Evaluations (MBq)	12.2-60
Table 12.2-20 Airborne Concentrations	12.2-63
Table 12.2-21 Average Annual Doses from Airborne Releases.....	12.2-66
Table 12.2-22 Annual Average Liquid Releases	12.2-67
Table 12.2-23 Liquid Pathway Dose Analysis (Assuming 5678 L/min Flow and a Dilution Factor of 10)	12.2-69

Chapter 12

List of Tables (Continued)

Table 12.2-24	Activity Levels of the Transversing In-Core Probe System.....	12.2-71
Table 12.2-25	Activity Levels in the Reactor Internal Pump	12.2-71
Table 12.2-26	Activity in the Turbine Moisture Separator/Reheater	12.2-72
Table 12.2-27	Activity in the Turbine Condenser	12.2-74
Table 12.2-28	Activity in the Condenser Demineralizer	12.2-76
Table 12.2-29	Steam Jet Air Ejector Inventory	12.2-78
Table 12.2-30	Standby Gas Treatment System Inventory	12.2-80
Table 12.3-1	Computer Codes Used in Shielding Design Calculations	12.3-34
Table 12.3-2	Typical Nickel and Cobalt Content of Materials.....	12.3-34
Table 12.3-3	Area Radiation Monitors Reactor Building.....	12.3-35
Table 12.3-4	Area Radiation Monitors Control Building.....	12.3-36
Table 12.3-5	Area Radiation Monitors Service Building	12.3-36
Table 12.3-6	Area Radiation Monitors Radwaste Building.....	12.3-36
Table 12.3-7	Area Radiation Monitors Turbine Building	12.3-37
Table 12.3-8	Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information	12.3-38
Table 12.4-1	Projected Annual Radiation Exposure.....	12.4-8

Chapter 12

List of Figures

Figure 12.2-1	Radiation Source Model.....	12.2-81
Figure 12.3-1	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation -8200 mm (B3F)	12.3-47
Figure 12.3-2	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation -1700 mm (B2F)	12.3-47
Figure 12.3-3	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 4800/8500 mm (B1F).....	12.3-47
Figure 12.3-4	Not Used.....	12.3-47
Figure 12.3-5	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 12300 mm (1F)	12.3-47
Figure 12.3-6	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 18100 mm (2F)	12.3-47
Figure 12.3-7	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 23500 mm (3F)	12.3-47
Figure 12.3-8	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 27200 mm (3.5F)	12.3-47
Figure 12.3-9	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 31700/38200 mm (4FM).....	12.3-47
Figure 12.3-10	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation, Section A-A.....	12.3-47
Figure 12.3-11	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation, Section B-B	12.3-47
Figure 12.3-12	Reactor Building Radiation Zone Map Post LOCA at Elevation -8200 mm (B3F)	12.3-47
Figure 12.3-13	Reactor Building Radiation Zone Map Post LOCA at Elevation -1700 mm (B2F)	12.3-47
Figure 12.3-14	Reactor Building Radiation Zone Map Post LOCA at Elevation 4800/8500 mm (B1F).....	12.3-47
Figure 12.3-15	Not Used.....	12.3-47
Figure 12.3-16	Reactor Building Radiation Zone Map Post LOCA at Elevation 12300 mm (1F)	12.3-47
Figure 12.3-17	Reactor Building Radiation Zone Map Post LOCA at Elevation 18100 mm (2F)	12.3-47

Chapter 12

List of Figures (Continued)

Figure 12.3-18	Reactor Building Radiation Zone Map Post LOCA at Elevation 23500 mm (3F)	12.3-48
Figure 12.3-19	Reactor Building Radiation Zone Map Post LOCA at Elevation 27200 mm (3.5F)	12.3-48
Figure 12.3-20	Reactor Building Radiation Zone Map Post LOCA at Elevation 31700/38200 mm (4FM).....	12.3-48
Figure 12.3-21	Reactor Building Radiation Zone Map Post LOCA, Section A-A	12.3-48
Figure 12.3-22	Reactor Building Radiation Zone Map Post LOCA, Section B-B.....	12.3-48
Figures 12.3-23	thru 12.3-36 Not Used.....	12.3-48
Figure 12.3-37	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation -1500 mm.....	12.3-48
Figure 12.3-38	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation -4800 mm.....	12.3-48
Figure 12.3-39	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 12300 mm	12.3-48
Figure 12.3-40	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 21000 mm	12.3-48
Figure 12.3-41	Radwaste Building, Radiation Zone Map, Normal Operation, Section A-A.....	12.3-48
Figure 12.3-42	Control Building, Radiation Zone, Normal Operation at Elevation -8200 mm	12.3-48
Figure 12.3-43	Control and Service Building, Radiation Zone, Normal Operation at Elevation -2150 mm.....	12.3-48
Figure 12.3-44	Control and Service Building, Radiation Zone, Normal Operation at Elevation 3500 mm	12.3-48
Figure 12.3-45	Control and Service Building, Radiation Zone, Normal Operation at Elevation 7900 mm	12.3-48
Figure 12.3-46	Control and Service Building, Radiation Zone, Normal Operation at Elevation 12300 mm	12.3-48
Figure 12.3-47	Control and Service Building, Radiation Zone, Normal Operation at Elevation 17150 mm	12.3-48
Figure 12.3-48	Control and Service Building, Radiation Zone, Normal Operation, Side View, Cross Section B-B	12.3-48
Figure 12.3-49	Turbine Building, Radiation Zone at Elevation 5300 mm.....	12.3-49

Chapter 12

List of Figures (Continued)

Figure 12.3-50	Turbine Building, Radiation Zone at Elevation 12300 mm.....	12.3-49
Figure 12.3-51	Turbine Building, Radiation Zone at Elevation 20300 mm.....	12.3-49
Figure 12.3-52	Turbine Building, Radiation Zone at Elevation 30300 mm.....	12.3-49
Figure 12.3-53	Turbine Building, Radiation Zone at Normal Operation Longitudinal Section A-A.....	12.3-49
Figure 12.3-54	Control and Service Building, Radiation Zone, Post LOCA, Section B-B.....	12.3-49
Figure 12.3-55	Turbine Building, Radiation Zone, Post LOCA, Longitudinal Section A-A.....	12.3-49
Figure 12.3-56	Reactor Building, Area Radiation Monitors at Elevation -8200 mm.....	12.3-49
Figure 12.3-57	Reactor Building, Area Radiation Monitors at Elevation -1700 mm.....	12.3-49
Figure 12.3-58	Reactor Building, Area Radiation Monitors at Elevation 4800/8500 mm.....	12.3-49
Figure 12.3-59	Reactor Building, Area Radiation Monitors at Elevation 12300 mm.....	12.3-49
Figure 12.3-60	Reactor Building, Area Radiation Monitors at Elevation 23500 mm.....	12.3-49
Figure 12.3-61	Reactor Building, Area Radiation Monitors at Elevation 27200 mm.....	12.3-49
Figure 12.3-62	Reactor Building, Area Radiation Monitors at Elevation 31700/38200 mm.....	12.3-49
Figure 12.3-63	Reactor Building, Area Radiation Monitors, Section B-B.....	12.3-49
Figure 12.3-64	Control and Service Buildings, Area Radiation Monitors, Section B-B.....	12.3-49
Figure 12.3-65	Radwaste Building, Area Radiation Monitors at Elevation -1500 mm	12.3-49
Figure 12.3-66	Radwaste Building, Area Radiation Monitors at Elevation 4800 mm.....	12.3-49
Figure 12.3-67	Radwaste Building, Area Radiation Monitors at Elevation 12300 mm.....	12.3-49
Figure 12.3-68	Radwaste Building, Area Radiation Monitors at Elevation 21000 mm.....	12.3-49
Figure 12.3-69	Not Used.....	12.3-49
Figure 12.3-70	Turbine Building, Area Radiation Monitors at Elevation 12300 mm.....	12.3-49
Figure 12.3-71	Turbine Building, Area Radiation Monitors at Elevation 20300 mm.....	12.3-50
Figure 12.3-72	Turbine Building, Area Radiation Monitors at Elevation 30300 mm.....	12.3-50
Figure 12.3-73	Turbine Building, Area Radiation Monitors, Longitudinal Section A-A	12.3-50
Figure 12.3-74	Upper Drywell Shielding Radiation Dose Rates with Fuel Bundle on Refueling Bellows (Gy/h).....	12.3-51

Chapter 13 Table of Contents

13.0	Conduct of Operations	13.1-1
13.1	Organizational Structure of Applicant	13.1-1
13.2	Training.....	13.2-1
13.2.1	Reactor Operator Training.....	13.2-1
13.2.2	Training For Non-Licensed Plant Staff.....	13.2-1
13.2.3	COL License Information.....	13.2-1
13.3	Emergency Planning	13.3-1
13.3.1	COL License Information.....	13.3-1
13.3.2	References	13.3-1
13.4	Review and Audit	13.4-1
13.4.1	COL License Information.....	13.4-1
13.5	Plant Procedures	13.5-1
13.5.1	Administrative Procedures	13.5-1
13.5.2	Operating and Maintenance Procedures.....	13.5-1
13.5.3	COL License Information.....	13.5-1
13.5.4	References	13.5-9
13.6	Physical Security.....	13.6-1
13.6.1	Preliminary Planning	13.6-1
13.6.2	Security Plan.....	13.6-1
13.6.3	COL License Information.....	13.6-1

Chapter 13

List of Tables

Table 13.3-1 ABWR Design Considerations for Emergency Planning Requirements	13.3-2
---	--------

Chapter 14

Table of Contents

14.0 Initial Test Program	14.1-1
14.1 Specific Information to be Included in Preliminary Safety Analysis Reports.....	14.1-1
14.2 Specific Information to be Included in Final Safety Analysis Reports	14.2-1
14.2.1 Summary of Test Programs and Objectives	14.2-1
14.2.2 Organization and Staffing.....	14.2-3
14.2.3 Test Procedures	14.2-5
14.2.4 Conduct of Test Program.....	14.2-5
14.2.5 Review, Evaluation, and Approval of Test Results.....	14.2-6
14.2.6 Test Records	14.2-6
14.2.7 Conformance of Test Program with Regulatory Guides	14.2-6
14.2.8 Utilization of Reactor Operating and Testing Experience in the Development of Test Program	14.2-7
14.2.9 Trial Use of Plant Operating and Emergency Procedures.....	14.2-7
14.2.10 Initial Fuel Loading and Initial Criticality.....	14.2-8
14.2.11 Test Program Schedule.....	14.2-9
14.2.12 Individual Test Descriptions.....	14.2-10
14.2.13 COL License Information.....	14.2-181
14.3 Tier 1 Selection Criteria and Processes	14.3-1
14.3.1 Tier 1 Section: 1.0 Introduction.....	14.3-3
14.3.2 Tier 1 Section: 2.0 Certified Design Material for ABWR Systems	14.3-3
14.3.3 Tier 1 Section: 3.0 Additional Design Material	14.3-14
14.3.4 Tier 1 Section: 4.0 Interface Requirements.....	14.3-19
14.3.5 Tier 1 Section: 5.0 Site Parameters	14.3-21
14.3.6 Summary.....	14.3-21

Chapter 14

List of Tables

Table 14.2-1	Startup Test Matrix.....	14.2-183
Table 14.3-1	Core Cooling Analysis	14.3-23
Table 14.3-2	Containment Pressure/Temperature Response.....	14.3-26
Table 14.3-3	Transient Analysis.....	14.3-28
Table 14.3-4	Radiological Analysis.....	14.3-31
Table 14.3-5	Overpressure Protection	14.3-32
Table 14.3-6	Flooding Protection	14.3-33
Table 14.3-7	Fire Protection	14.3-36
Table 14.3-8	ATWS Analysis.....	14.3-37
Table 14.3-9	Generic Safety Issues	14.3-40
Table 14.3-10	TMI Issues	14.3-48
Table 14.3-11	Example of Tier 1 ITAAC Entry: Standby Liquid Control (SLC) System.....	14.3-57
Table 14.3-12	Interface Requirements for the Ultimate Heat Sink	14.3-58

Chapter 14

List of Figures

Figure 14.2-1 Power-Flow Operating Map and Testing Plateau Definitions 14.2-191

Chapter 15

Table of Contents

15.0	Accident and Analysis	15.0-1
15.0.1	Nuclear Safety Operational Analysis	15.0-1
15.0.2	Event Analytical Objective.....	15.0-2
15.0.3	Analytical Categories	15.0-2
15.0.4	Event Evaluation	15.0-2
15.0.5	COL License Information.....	15.0-6
15.1	Decrease in Reactor Coolant Temperature	15.1-1
15.1.1	Loss of Feedwater Heating	15.1-1
15.1.2	Feedwater Controller Failure—Maximum Demand	15.1-3
15.1.3	Pressure Regulator Failure—Open	15.1-7
15.1.4	Inadvertent Safety/Relief Valve Opening	15.1-10
15.1.5	Spectrum of Steam System Piping Failures Inside and Outside Containment in a PWR.....	15.1-12
15.1.6	Inadvertent RHR Shutdown Cooling Operation.....	15.1-12
15.2	Increase in Reactor Pressure	15.2-1
15.2.1	Pressure Regulator Failure—Closed	15.2-1
15.2.2	Generator Load Rejection.....	15.2-4
15.2.3	Turbine Trip.....	15.2-8
15.2.4	MSIV Closures	15.2-12
15.2.5	Loss of Condenser Vacuum.....	15.2-16
15.2.6	Loss of Non-Emergency AC Power to Station Auxiliaries.....	15.2-19
15.2.7	Loss of Feedwater Flow	15.2-22
15.2.8	Feedwater Line Break.....	15.2-24
15.2.9	Failure of RHR Shutdown Cooling	15.2-24
15.2.10	COL License Information.....	15.2-25
15.2.11	References	15.2-25
15.3	Decrease in Reactor Coolant System Flow Rate	15.3-1
15.3.1	Reactor Internal Pump Trip	15.3-1
15.3.2	Recirculation Flow Control Failure—Decreasing Flow.....	15.3-5
15.3.3	Reactor Internal Pump Seizure.....	15.3-7
15.3.4	Reactor Internal Pump Shaft Break	15.3-9
15.3.5	References	15.3-10
15.4	Reactivity and Power Distribution Anomalies	15.4-1
15.4.1	Rod Withdrawal Error—Low Power.....	15.4-1
15.4.2	Rod Withdrawal Error at Power	15.4-5
15.4.3	Control Rod Maloperation (System Malfunction or Operator Error)	15.4-6
15.4.4	Abnormal Startup of Idle Reactor Internal Pump.....	15.4-6
15.4.5	Recirculation Flow Control Failure with Increasing Flow	15.4-7
15.4.6	Chemical and Volume Control System Malfunctions.....	15.4-10
15.4.7	Mislocated Bundle Accident	15.4-10
15.4.8	Misoriented Fuel Bundle Accident.....	15.4-12
15.4.9	Rod Ejection Accident.....	15.4-13
15.4.10	Control Rod Drop Accident.....	15.4-14
15.4.11	COL License Information.....	15.4-16

Chapter 15

Table of Contents (Continued)

15.4.12	References	15.4-16
15.5	Increase in Reactor Coolant Inventory	15.5-1
15.5.1	Inadvertent HPCF Startup	15.5-1
15.5.2	Chemical Volume Control System Malfunction (or Operator Error)	15.5-2
15.5.3	BWR Transients Which Increase Reactor Coolant Inventory.....	15.5-2
15.6	Decrease in Reactor Coolant Inventory	15.6-1
15.6.1	Inadvertent Safety/Relief Valve Opening	15.6-1
15.6.2	Failure of Small Line Carrying Primary Coolant Outside Containment.....	15.6-1
15.6.3	Steam Generator Tube Failure.....	15.6-3
15.6.4	Steam System Piping Break Outside Containment	15.6-3
15.6.5	Loss-of-Coolant Accident (Resulting from Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary)—Inside Containment.....	15.6-7
15.6.6	Cleanup Water Line Break—Outside Containment.....	15.6-18
15.6.7	COL License Information.....	15.6-21
15.6.8	References	15.6-21
15.7	Radioactive Release from Subsystems and Components	15.7-1
15.7.1	Radiological Consequences of a Radioactive Gas Waste System Leak or Failure.....	15.7-1
15.7.2	Liquid Radioactive System Failure	15.7-2
15.7.3	Postulated Radioactive Release Due to Liquid Radwaste Tank Failure	15.7-2
15.7.4	Fuel-Handling Accident	15.7-4
15.7.5	Spent Fuel Cask Drop Accident	15.7-9
15.7.6	COL License Information.....	15.7-10
15.7.7	References	15.7-10
15.8	Anticipated Transients Without Scram.....	15.8-1
15.8.1	Requirements.....	15.8-1
15.8.2	Plant Capabilities.....	15.8-1
15A	Plant Nuclear Safety Operational Analysis (NSOA).....	15A-1
15A.1	Objectives	15A-1
15A.2	Approach to Operational Nuclear Safety	15A-2
15A.3	Method of Analysis	15A-8
15A.4	Display of Operational Analysis Results.....	15A-17
15A.5	Bases for Selecting Surveillance Test Frequencies and Allowable Outage Times.....	15A-19
15A.6	Operational Analyses.....	15A-20
15A.7	Remainder of NSOA	15A-43
15A.8	Conclusions	15A-44
15B	Failure Modes and Effects Analysis (FMEA)	15B-1
15B.1	Introduction	15B-1
15B.2	Control Rod Drive System	15B-1
15B.3	Reactor Internal Pump.....	15B-9
15B.4	Essential Multiplexing System	15B-16
15C	Not Used	15C-1

Chapter 15

Table of Contents (Continued)

15D	Probability Analysis of Pressure Regulator Downscale Failure	15D-1
15D.1	Introduction	15D-1
15D.2	System Description.....	15D-1
15D.3	Analysis	15D-1
15D.4	Results	15D-2
15E	ATWS Performance Evaluation	15E-1
15E.1	Introduction	15E-1
15E.2	Performance Requirements	15E-1
15E.3	Analysis Conditions.....	15E-1
15E.4	ATWS Logic and Setpoints.....	15E-2
15E.5	Selection of Events.....	15E-3
15E.6	Transient Responses	15E-5
15E.7	Conclusion.....	15E-9
15E.8	Reference	15E-9
15F	LOCA Inventory Curves.....	15F-1
15F.1	Introduction	15F-1

Chapter 15

List of Tables

Table 15.0-1	Input Parameters and Initial Conditions for System Response Analysis Transients	15.0-7
Table 15.0-1a	Computer Codes Used in the Analysis of Transients and Accidents	15.0-10
Table 15.0-2	Results Summary of System Response Analysis Transient Events	15.0-12
Table 15.0-3	Summary of Accidents	15.0-17
Table 15.0-4	Core-Wide Transient Analysis Results To Be Provided for Different Core Design	15.0-17
Table 15.0-5	Scram Reactivity Curves	15.0-18
Table 15.0-6	ABWR FMCRD Scram Time	15.0-18
Table 15.1-1	Sequence of Events for Loss of Feedwater Heating.....	15.1-14
Table 15.1-2	Loss of 55.6°C Feedwater Heating.....	15.1-14
Table 15.1-2a	Loss of 16.7°C Feedwater Heating.....	15.1-14
Table 15.1-3	Single Failure Modes for Digital Controls	15.1-15
Table 15.1-4	Sequence of Events for Figure 15.1-2	15.1-15
Table 15.1-5	Sequence of Events for Figure 15.1-3	15.1-16
Table 15.1-6	Sequence of Events for Figure 15.1-4	15.1-16
Table 15.1-7	Sequence of Events for Figure 15.1-5	15.1-17
Table 15.1-8	Sequence of Events for Inadvertent Safety/Relief Valve Opening	15.1-17
Table 15.1-9	Sequence of Events for Inadvertent RHR Shutdown Cooling Operation	15.1-18
Table 15.2-1a	Sequence of Events for Figure 15.2-1	15.2-26
Table 15.2-1b	Sequence of Events for Figure 15.2-1a	15.2-26
Table 15.2-2	Sequence of Events for Figure 15.2-2	15.2-26
Table 15.2-3	Sequence of Events for Figure 15.2-3	15.2-27
Table 15.2-4	Sequence of Events for Figure 15.2-4	15.2-27
Table 15.2-5	Sequence of Events for Figure 15.2-5	15.2-28
Table 15.2-6	Sequence of Events for Figure 15.2-6	15.2-28
Table 15.2-7	Sequence of Events for Figure 15.2-7	15.2-28

Chapter 15

List of Tables (Continued)

Table 15.2-8	Sequence of Events for Figure 15.2-8	15.2-29
Table 15.2-9	Sequence of Events for Figure 15.2-9	15.2-29
Table 15.2-10	Post-Transient Primary Containment Inventory (Air Plus Water) (megabecqueral)	15.2-30
Table 15.2-11	Activity Released to the Environment (megabecqueral).....	15.2-31
Table 15.2-12	Dose Evaluation and Meteorology	15.2-31
Table 15.2-13	Typical Rates of Decay for Condenser Vacuum	15.2-32
Table 15.2-14	Sequence of Events for Figure 15.2-10	15.2-32
Table 15.2-15	Trip Signals Associated with Loss of Condenser Vacuum	15.2-32
Table 15.2-16	Sequence of Events for Figure 15.2-11	15.2-33
Table 15.2-17	Sequence of Events for Figure 15.2-12	15.2-34
Table 15.3-1	Sequence of Events for Figure 15.3-1	15.3-11
Table 15.3-2	Sequence of Events for Figure 15.3-2	15.3-11
Table 15.3-3	Sequence of Events for Figure 15.3-3	15.3-11
Table 15.3-4	Sequence of Events for Figure 15.3-4	15.3-12
Table 15.3-5	Sequence of Events for Figure 15.3-5	15.3-12
Table 15.4-1	Causes of Control Rod Withdrawal Error	15.4-17
Table 15.4-2	Sequence of Events for Continuous Control Rod Withdrawal Error During Reactor Startup	15.4-17
Table 15.4-3	Sequence of Events for Abnormal Startup of Idle RIP	15.4-18
Table 15.4-4	Sequence of Events for Figure 15.4-2	15.4-18
Table 15.4-5	Sequence of Events for Figure 15.4-3	15.4-18
Table 15.4-6	Sequence of Events of the Mislocated Bundle Accident.....	15.4-19
Table 15.4-7	Sequence of Events of the Misoriented Fuel Bundle Accident.....	15.4-19
Table 15.5-1	Sequence of Events for Figure 15.5-1	15.5-3
Table 15.6-1	Instrument Line Break Accident Parameters.....	15.6-22
Table 15.6-2	Instrument Line Break Accident Isotopic Inventory	15.6-23

Chapter 15

List of Tables (Continued)

Table 15.6-3	Instrument Line Break Accident Results.....	15.6-24
Table 15.6-4	Sequence of Events for Steamline Break Outside Containment	15.6-24
Table 15.6-5	Steamline Break Accident Parameters	15.6-25
Table 15.6-6	Main Steamline Break Accident Activity Released to Environment (megabecquerel)	15.6-26
Table 15.6-7	Main Steamline Break Meteorology Parameters and Radiological Effects	15.6-27
Table 15.6-8	Loss of Coolant Accident Parameters	15.6-28
Table 15.6-9	Iodine Activities	15.6-30
Table 15.6-10	Iodine Activity Release to the Environment	15.6-32
Table 15.6-11	Noble Gas Activities.....	15.6-34
Table 15.6-12	Noble Gas Activity Release to Environment.....	15.6-37
Table 15.6-13	Loss of Coolant Accident Meteorology and Offsite Dose Results.....	15.6-38
Table 15.6-14	Loss of Coolant Accident Meteorology and Control Room Dose Results.....	15.6-38
Table 15.6-15	Sequence of Events for Cleanup Line Break Outside Containment.....	15.6-39
Table 15.6-16	Cleanup Line Break Accident Parameters.....	15.6-39
Table 15.6-17	Clean Up Water Line Break Isotopic Releases (megabecquerel)	15.6-40
Table 15.6-18	Clean Up Water Line Break Meteorology and Dose Results.....	15.6-40
Table 15.7-1	Offgas System Failure Accident Parameters.....	15.7-11
Table 15.7-2	Isotopic Source and Release to the Environment.....	15.7-12
Table 15.7-3	Offgas System Failure Meteorology and Dose Results.....	15.7-12
Table 15.7-4	Not Used.....	15.7-13
Table 15.7-5	Radwaste System Failure Accident Parameters	15.7-14
Table 15.7-6	Isotopic Release to Environment (megabecquerel).....	15.7-14
Table 15.7-7	Radwaste System Failure Accident Meteorology and Dose Results.....	15.7-14
Table 15.7-8	Fuel-Handling Accident Parameters.....	15.7-15
Table 15.7-9	Fuel-Handling Accident Reactor Building Inventory (megabecquerel)	15.7-16

Chapter 15

List of Tables (Continued)

Table 15.7-10	Fuel-Handling Accident Isotopic Release to Environment (megabecquerel)	15.7-17
Table 15.7-11	Fuel-Handling Accident Meteorological Parameters And Radiological Effects	15.7-18
Table 15.7-12	Fuel Cask Drop Accident Parameters.....	15.7-18
Table 15.7-13	Cask Drop Accident Radiological Results Fission Product Releases (megabecquerel)	15.7-19
Table 15A-1	Unacceptable Consequences Criteria Plant Event Category: Normal Operation.....	15A-45
Table 15A-2	Unacceptable Consequences Criteria Plant Event Category: Moderate Frequency Incidents (Anticipated Operational Transients).....	15A-45
Table 15A-3	Unacceptable Consequences Criteria Plant Event Category: Infrequent Incidents (Abnormal Operational Transients).....	15A-45
Table 15A-4	Unacceptable Consequences Criteria Plant Event Category: Limiting Faults (Design Basis Accidents)	15A-46
Table 15A-5	Capability Consequences Plant Event Category: Special Events.....	15A-46
Table 15A-6	General Nuclear Safety Operational Criteria	15A-47
Table 15A-7	BWR Operating States	15A-47
Table 15A-8	Normal Operation.....	15A-48
Table 15A-9	Moderate Frequency Accidents (Anticipated Operational Transients)	15A-49
Table 15A-10	Infrequent Accidents (Abnormal Operational Transients)	15A-51
Table 15A-11	Limiting Faults (Design Basis Accidents).....	15A-52
Table 15A-12	Special Events	15A-53
Table 15A-13	Safety Actions for Infrequent Incidents	15A-53
Table 15A-14	Safety Actions for Design Basis Accidents.....	15A-54
Table 15A-15	Safety Actions for Special Events	15A-55
Table 15B-1	Failure Mode and Effects Analysis for FMCRD.....	15B-17
Table 15B-2	Failure Mode and Effects Analysis for HCU Charging Water.....	15B-26
Table 15B-3	EMS Failure Mode and Effects Analysis	15B-28
Table 15D-1	Logic Equations.....	15D-3
Table 15E-1	Performance Requirements	15E-10

Chapter 15

List of Tables (Continued)

Table 15E-2	Initial Operating Conditions	15E-10
Table 15E-3	Equipment Performance Characteristics	15E-11
Table 15E-4	MSIV Closure Summary (ARI).....	15E-12
Table 15E-5	MSIV Closure Summary (FMCRD Run-In).....	15E-12
Table 15E-6	MSIV Closure Summary (Boron Injection)	15E-12
Table 15E-7	Loss of AC Power Summary (ARI)	15E-12
Table 15E-8	Loss of AC Power Summary (FMCRD Run-In).....	15E-13
Table 15E-9	Loss of AC Power Summary (Boron Injection).....	15E-13
Table 15E-10	Loss of Feedwater Summary (ARI)	15E-13
Table 15E-11	Loss of Feedwater Summary (FMCRD Run-In).....	15E-13
Table 15E-12	Loss of Feedwater Summary (Boron Injection)	15E-14
Table 15E-13	Loss of Feedwater Heating Summary (FMCRD Run-In)	15E-14
Table 15E-14	Turbine Trip with Bypass Summary (ARI).....	15E-14
Table 15E-15	Turbine Trip with Bypass Summary (FMCRD Run-In)	15E-14
Table 15E-16	Turbine Trip with Bypass Summary (Boron Injection)	15E-15
Table 15E-17	Loss of Condenser Vacuum Summary (ARI)	15E-15
Table 15E-18	Loss of Condenser Vacuum (FMCRD Run-In).....	15E-15
Table 15E-19	Loss of Condenser Vacuum Summary (Boron Injection)	15E-15
Table 15E-20	Feedwater Controller Failure Summary (ARI).....	15E-16
Table 15E-21	Feedwater Controller Failure Summary (FMCRD Run-In)	15E-16
Table 15E-22	Feedwater Controller Failure Summary (Boron Injection)	15E-16

Chapter 15

List of Figures

Figure 15.0-1	System Response Analysis Power/Flow Map	15.0-19
Figure 15.1-1	Simplified Block Diagram of Fault-Tolerant Digital Controller System.....	15.1-19
Figure 15.1-2	Runout of One Feedwater Pump	15.1-20
Figure 15.1-3	Feedwater Controller Failure—Maximum Demand	15.1-21
Figure 15.1-4	Inadvertent Opening of One Bypass Valve.....	15.1-22
Figure 15.1-5	Opening of All Control and Bypass Valves.....	15.1-23
Figure 15.2-1	Fast Closure of One Turbine Control Valve	15.2-35
Figure 15.2-1a	Slow Closure of One Turbine Control Valve.....	15.2-39
Figure 15.2-2	Pressure Regulator Downscale Failure	15.2-43
Figure 15.2-3	Generator Load Rejection with Bypass.....	15.2-44
Figure 15.2-4	Load Rejection with One Bypass Valve Failure	15.2-45
Figure 15.2-5	Load Rejection with All Bypass Valves Failure	15.2-46
Figure 15.2-6	Turbine Trip with Bypass.....	15.2-47
Figure 15.2-7	Turbine Trip with One Bypass Valve Failure	15.2-48
Figure 15.2-8	Turbine Trip with All Bypass Valves Failure	15.2-49
Figure 15.2-9	MSIV Closure Direct Scram	15.2-50
Figure 15.2-10	Loss of Condenser Vacuum	15.2-51
Figure 15.2-11	Loss of AC Power	15.2-52
Figure 15.2-12	Loss of All Feedwater Flow	15.2-53
Figure 15.2-13	Loss of All Feedwater Flow	15.2-54
Figure 15.3-1	Three Pump Trip	15.3-13
Figure 15.3-2	All Pump Trip	15.3-14
Figure 15.3-2a	Cladding Temperature During All Pump Trip	15.3-15
Figure 15.3-3	Fast Runback of One RIP.....	15.3-16
Figure 15.3-4	Fast Runback of All RIPS.....	15.3-17
Figure 15.3-5	One RIP Seizure.....	15.3-18

Chapter 15

List of Figures (Continued)

Figure 15.4-1	Transient Changes for Control Rod Withdrawal Error During Startup	15.4-20
Figure 15.4-2	Fast Runout of One RIP	15.4-21
Figure 15.4-3	Fast Runout of All RIPS	15.4-22
Figure 15.5-1	Inadvertent Startup of HPCF.....	15.5-4
Figure 15.6-1	Steam Flow Schematic for Steam Break Outside Containment.....	15.6-41
Figure 15.6-2	LOCA Radiological Analysis	15.6-42
Figure 15.6-3	Airborne Iodine in Primary Containment During Blowdown Phase	15.6-43
Figure 15.6-4	ABWR Plant Layout	15.6-43
Figure 15.6-5	Leakage Path for Clean Up Water Line Break.....	15.6-44
Figure 15.6-6	ABWR Limiting LPZ CHI/Q.....	15.6-45
Figure 15.7-1	Leakage Path for Fuel-Handling Accident.....	15.7-20
Figure 15.7-2	Offgas System (See Subsection 11.3)	15.7-21
Figure 15A-1	Block Diagram of Method Used to Derive Nuclear Safety Operational Requirements System-Level Qualitative Design Basis Confirmation Audits and Technical Specifications.....	15A-56
Figure 15A-2	Possible Inconsistencies in the Selection of Nuclear Safety Operational Requirements.....	15A-57
Figure 15A-3	Format for Protection Sequence Diagrams	15A-58
Figure 15A-4	Format for Safety System Auxiliary Diagrams.....	15A-59
Figure 15A-5	Format for Commonality of Auxiliary Diagrams	15A-60
Figure 15A-6	Safety System Auxiliaries — Group 1	15A-61
Figure 15A-7	Safety System Auxiliaries — Group 2	15A-62
Figure 15A-8	Safety Action Sequences for Normal Operation in State A	15A-63
Figure 15A-9	Safety Action Sequences for Normal Operation in State B	15A-64
Figure 15A-10	Safety Action Sequences for Normal Operation in State C	15A-65
Figure 15A-11	Safety Action Sequences for Normal Operation in State D	15A-66
Figure 15A-12	Protection Sequence for Manual or Inadvertent Scram	15A-67

Chapter 15

List of Figures (Continued)

Figure 15A-13	Protection Sequence for Loss of Plant Instrument or Service Air System	15A-68
Figure 15A-14	Protection Sequence for Recirculation Flow Control Failure—Maximum Demand—One Reactor Internal Pump (RIP) Runout.....	15A-69
Figure 15A-15	Protection Sequence for Recirculation Flow Control Failure—Decreasing Flow Runback of One Reactor Internal Pump (RIP)	15A-70
Figure 15A-16	Protection Sequence for Trip of Three Reactor Internal Pumps (RIPs).....	15A-71
Figure 15A-17	Protection Sequences for Isolation of All Main Steamlines	15A-72
Figure 15A-18	Protection Sequences for Isolation of One Main Steamline	15A-73
Figure 15A-19	Protection Sequence for Loss of All Feedwater Flow	15A-74
Figure 15A-20	Protection Sequence for a Loss of Feedwater Heating	15A-75
Figure 15A-21	Protection Sequence for Feedwater Controller Failure—Runout of One Feedwater Pump.....	15A-76
Figure 15A-22	Pressure Regulator Failure—Opening of One Bypass Valve	15A-77
Figure 15A-23	Pressure Regulator Failure—Closure of One Control Valve	15A-78
Figure 15A-24	Protection Sequences for Main Turbine Trip, Bypass On	15A-79
Figure 15A-25	Protection Sequences for Loss of Main Condenser Vacuum.....	15A-80
Figure 15A-26	Protection Sequences for Generator Load Rejection, Bypass On.....	15A-81
Figure 15A-27	Protection Sequence for Loss of Normal AC Power—Auxiliary Transformer Failure	15A-82
Figure 15A-28	Protection Sequence for Inadvertent Startup of HPCF Pumps	15A-83
Figure 15A-29	Protection Sequences for Inadvertent Opening of a Safety Relief Valve	15A-84
Figure 15A-30	Protection Sequence for Control Rod Withdrawal Error for Startup and Refueling Operations	15A-85
Figure 15A-31	Protection Sequences for Main Turbine Trip with Failure of One Bypass Valve	15A-86
Figure 15A-32	Protection Sequences for Generator Load Rejection with One Bypass Valve Failure	15A-87
Figure 15A-33	Protection Sequence for Control Rod Ejection Accident.....	15A-88
Figure 15A-34	Protection Sequence for Control Rod Drop Accident.....	15A-89

Chapter 15

List of Figures (Continued)

Figure 15A-35	Protection Sequence for a Control Rod Withdrawal Error During Power Operation.....	15A-90
Figure 15A-36	Protection Sequences for Fuel-Handling Accident.....	15A-91
Figure 15A-37	Protection Sequences for Loss of Coolant Piping Breaks in RCPB—Inside Containment	15A-92
Figure 15A-38	Protection Sequence for Loss of Coolant Piping Breaks in RCPB—Inside Primary Containment	15A-93
Figure 15A-39	Protection Sequences for Liquid and Steam, Large and Small Piping Breaks Outside Containment.....	15A-94
Figure 15A-40	Protection Sequence for Liquid and Steam, Large and Small Piping Breaks Outside Primary Containment.....	15A-95
Figure 15A-41	Protection Sequence for Gaseous Radwaste System Leak or Failure.....	15A-96
Figure 15A-42	Protection Sequence for Augmented Offgas Treatment System Failure	15A-97
Figure 15A-43	Protection Sequence for Liquid Radwaste System Leak or Failure.....	15A-98
Figure 15A-44	Protection Sequence for Liquid Radwaste System Storage Tank Failure.....	15A-99
Figure 15A-45	Protection Sequence for Abnormal Startup of a Reactor Internal Pump	15A-100
Figure 15A-46	Protection Sequence for Recirculation Flow Control Failure—Maximum Demand—All Reactor Internal Pumps (RIPs) Runout	15A-101
Figure 15A-47	Protection Sequence for Recirculation Flow Control Failure—Decreasing Flow—Runback of All Reactor Internal Pumps (RIPs).....	15A-102
Figure 15A-48	Protection Sequence for Trip of All Reactor Internal Pumps (RIPs).....	15A-103
Figure 15A-49	Protection Sequence for RHR—Loss of Shutdown Cooling	15A-104
Figure 15A-50	RHR—Shutdown Cooling Failure—Increased Cooling	15A-105
Figure 15A-51	Protection Sequences for Feedwater Controller Failure—Runout of Two Feedwater Pumps	15A-106
Figure 15A-52	Protection Sequences for Pressure Regulator Failure—Opening of All Bypass and Control Valves	15A-107
Figure 15A-53	Pressure Regulator Failure—Closure of All Bypass Valves and Control Valves.....	15A-108
Figure 15A-54	Not Used.....	15A-109
Figure 15A-55	Protection Sequences Main Turbine Trip—with Bypass Failure	15A-110

Chapter 15

List of Figures (Continued)

Figure 15A-56	Protection Sequences Main Generator Load Rejection—with Bypass Failure ...	15A-111
Figure 15A-57	Protection Sequence for Misplaced Fuel Bundle Accident.....	15A-112
Figure 15A-58	Protection Sequence for Reactor Internal Pump Seizure	15A-113
Figure 15A-59	Protection Sequence for RIP Shaft Break	15A-114
Figure 15A-60	Protection Sequence for Shipping Cask Drop.....	15A-115
Figure 15A-61	Protection Sequence for Reactor Shutdown—from Anticipated Transient Without Scram	15A-116
Figure 15A-62	Protection Sequence for Reactor Shutdown—from Outside Main Control Room	15A-117
Figure 15A-63	Protection Sequence for Reactor Shutdown—Without Control Rods	15A-118
Figure 15A-64	Protection Sequence for Core and Containment Cooling for Loss of Feedwater and Vessel Isolations	15A-119
Figure 15A-65	Commonality of Auxiliary Systems—DC Power Systems (125/250 Volts)	15A-120
Figure 15A-66	Commonality of Standby AC Power Systems (120/480/6900 Volts).....	15A-121
Figure 15A-67	Commonality of Auxiliary Systems—Reactor Building Cooling Water System (RCWS)	15A-122
Figure 15A-68	Commonality of Auxiliary Systems—Reactor Building Cooling Water System (RCWS) (Continued).....	15A-123
Figure 15A-69	Commonality of Auxiliary Systems—Reactor Building Cooling Water System (RCWS) (Continued).....	15A-124
Figure 15A-70	Commonality of Auxiliary Systems—Suppression Pool Storage.....	15A-125
Figure 15B-1	Simplified CRD System Process Flow Diagram	15B-29
Figure 15B-2	Simplified Hydraulic Control Unit P&ID	15B-30
Figure 15B-3	Fine Motion Control Rod Drive	15B-31
Figure 15B-4	Control Rod Drop Accident Scenario for FMCRD.....	15B-32
Figure 15B-5	Control Rod Separation Detection	15B-33
Figure 15B-6	Internal CRD Blowout Support Schematic	15B-34
Figure 15B-7	FMCRD Internal Support.....	15B-35
Figure 15D-1	Triple Redundant Control System.....	15D-4

Chapter 15

List of Figures (Continued)

Figure 15E-1a	ATWS Mitigation Logic (ARI, FMCRD Run-In, RPT, Manual Initiation)	15E-17
Figure 15E-1b	ATWS Mitigation Logic (SLCS Initiation, Feedwater Runback)	15E-18
Figure 15E-1c	ATWS Mitigation Logic (ADS Inhibit).....	15E-19
Figure 15E-2	ABWR MSIV Closure, ARI	15E-20
Figure 15E-3	ABWR MSIV Closure, FMCRD Run-in.....	15E-24
Figure 15E-4	ABWR MSIV Closure, SLCS.....	15E-28
Figure 15E-5	ABWR MSIV Closure, FMCRD Run-in.....	15E-32
Figure 15E-6	ABWR Loss of AC Power, ARI	15E-33
Figure 15E-7	ABWR Loss of AC Power, FMCRD Run-in	15E-37
Figure 15E-8	ABWR Loss of AC Power, SLCS.....	15E-41
Figure 15E-9	ABWR Loss of Feedwater Flow, ARI	15E-45
Figure 15E-10	ABWR Loss of Feedwater Flow, FMCRD Run-in	15E-49
Figure 15E-11	ABWR Loss of Feedwater Flow, SLCS	15E-53
Figure 15E-12	ABWR Loss of Feedwater Heating, ARI.....	15E-57
Figure 15E-13	ABWR Loss of Feedwater Heating, FMCRD Run-in.....	15E-61
Figure 15E-14	ABWR Loss of Feedwater Heating, SLCS.....	15E-65
Figure 15E-15	ABWR Loss of Feedwater Heating, Max. LHGR	15E-69
Figure 15E-16	ABWR Loss of Feedwater Heating, FMCRD Run-in.....	15E-70
Figure 15E-17	ABWR Turbine Trip w/ Bypass, ARI.....	15E-71
Figure 15E-18	ABWR Turbine Trip w/ Bypass, FMCRD Run-in.....	15E-75
Figure 15E-19	ABWR Turbine Trip w/ Bypass, SLCS	15E-79
Figure 15E-20	ABWR Loss of Condenser Vacuum, ARI	15E-83
Figure 15E-21	ABWR Loss of Condenser Vacuum, FMCRD Run-in	15E-87
Figure 15E-22	ABWR Loss of Condenser Vacuum, SLCS.....	15E-91
Figure 15E-23	ABWR Feedwater Controller Failure Maximum Demand, ARI	15E-95
Figure 15E-24	ABWR Feedwater Controller Failure Maximum Demand, FMCRD Run-in	15E-99

Chapter 15

List of Figures (Continued)

Figure 15E-25	ABWR Feedwater Controller Failure Maximum Demand, SLCS	15E-103
Figure 15F-1	Iodine Airborne Inventory in Primary Containment as a Function of Time.....	15F-2
Figure 15F-2	Reactor Building Airborne Inventory as a Function of Time	15F-3
Figure 15F-3	Condenser Inventory from Primary Containment as a Function of Time.....	15F-4
Figure 15F-4	Non-Organic I in Pipes and Condenser as a Function of Time.....	15F-5
Figure 15F-5	Releases from Plant as a Function of Time.....	15F-6

Chapter 16

Table of Contents

16.0	Technical Specifications	16.0-1
1.0	Use and Application.....	1.1-1
1.1	Definitions	1.1-1
1.2	Logical Connectors.....	1.2-1
1.3	Completion Times	1.3-1
1.4	Frequency	1.4-1
2.0	Safety Limits (SLs)	2.0-1
2.1	SLs.....	2.0-1
2.2	SL Violations.....	2.0-1
3.0	Limiting Condition For Operation (LCO) Applicability	3.0-1
3.0	Surveillance Requirement (SR) Applicability	3.0-3
3.1	Reactivity Control Systems	3.1-1
3.1.1	Shutdown Margin (SDM)	3.1-1
3.1.2	Reactivity Anomalies	3.1-4
3.1.3	Control Rod Operability.....	3.1-6
3.1.4	Control Rod Scram Times.....	3.1-10
3.1.5	Control Rod Scram Accumulators	3.1-13
3.1.6	Rod Pattern Control	3.1-15
3.1.7	Standby Liquid Control (SLC) System.....	3.1-17
3.2	Power Distribution Limits	3.2-1
3.2.1	Average Planar Linear Heat Generation Rate (APLHGR)	3.2-1
3.2.2	Minimum Critical Power Ratio (MCPR)	3.2-2
3.2.3	Linear Heat Generation Rate (LHGR) (Non-GE Fuel).....	3.2-3
3.3	Instrumentation.....	3.3-1
3.3.1.1	Safety System Logic and Control (SSLC) Sensor Instrumentation	3.3-1
3.3.1.2	Reactor Protection System (RPS) and Main Steam Isolation Valve (MSIV) Actuation	3.3-20
3.3.1.3	Standby Liquid Control (SLC) and Feedwater Runback (FWRB) Actuation	3.3-27
3.3.1.4	ESF Actuation Instrumentation.....	3.3-31
3.3.2.1	Startup Range Monitor (SRNM) Instrumentation.....	3.3-44
3.3.3.1	Essential Multiplexing System (EMS).....	3.3-49
3.3.4.1	Anticipated Transient Without Scram (ATWS) and End-of-Cycle Recirculation Pump Trip (EOC-RPT) Instrumentation	3.3-51
3.3.4.2	Feedwater and Main Turbine Trip Instrumentation.....	3.3-58
3.3.5.1	Control Rod Block Instrumentation	3.3-60
3.3.6.1	Post Accident Monitoring (PAM) Instrumentation.....	3.3-64
3.3.6.2	Remote Shutdown System	3.3-68
3.3.7.1	Control Room Habitability Area (CRHA) Emergency Filtration (EF) System Instrumentation	3.3-72
3.3.8.1	Electric Power Monitoring.....	3.3-75
3.3.8.2	Reactor Coolant Temperature Monitoring – Shutdown.....	3.3-77
3.4	Reactor Coolant System (RCS).....	3.4-1
3.4.1	Reactor Internal Pumps (RIPs) – Operating.....	3.4-1
3.4.2	Safety/Relief Valves (S/RVs)	3.4-2

Chapter 16

Table of Contents (Continued)

3.4.3	RCS Operational Leakage.....	3.4-4
3.4.4	RCS Pressure Isolation Valve (PIV) Leakage	3.4-6
3.4.5	RCS Leakage Detection Instrumentation.....	3.4-8
3.4.6	RCS Specific Activity	3.4-11
3.4.7	Residual Heat Removal (RHR) Shutdown Cooling System – Hot Shutdown	3.4-13
3.4.8	Residual Heat Removal (RHR) Shutdown Cooling System – Cold Shutdown.....	3.4-16
3.4.9	RCS Pressure and Temperature (P/T) Limits.....	3.4-18
3.4.10	Reactor Steam Dome Pressure.....	3.4-21
3.5	Emergency Core Cooling Systems (ECCS)	3.5-1
3.5.1	ECCS – Operating.....	3.5-1
3.5.2	ECCS – Shutdown	3.5-6
3.6	Containment Systems	3.6-1
3.6.1.1	Primary Containment	3.6-1
3.6.1.2	Primary Containment Air Locks	3.6-3
3.6.1.3	Primary Containment Isolation Valves (PCIVs).....	3.6-8
3.6.1.4	Drywell Pressure	3.6-17
3.6.1.5	Drywell Air Temperature.....	3.6-18
3.6.1.6	Wetwell-to-Drywell Vacuum Breakers.....	3.6-19
3.6.2.1	Suppression Pool Average Temperature.....	3.6-21
3.6.2.2	Suppression Pool Water Level	3.6-24
3.6.2.3	Residual Heat Removal (RHR) Suppression Pool Cooling	3.6-25
3.6.2.4	Residual Heat Removal (RHR) Containment Spray	3.6-27
3.6.3.1	Primary Containment Hydrogen Recombiners	3.6-29
3.6.3.2	Primary Containment Oxygen Concentration.....	3.6-31
3.6.4.1	Secondary Containment	3.6-32
3.6.4.2	Secondary Containment Isolation Valves (SCIVs).....	3.6-34
3.6.4.3	Standby Gas Treatment (SGT) System.....	3.6-38
3.7	Plant Systems.....	3.7-1
3.7.1	Reactor Building Cooling Water (RCW) System, Reactor Service Water (RSW) System and Ultimate Heat Sink (UHS) – Operating.....	3.7-1
3.7.2	Reactor Building Cooling Water (RCW) System, Reactor Service Water (RSW) System and Ultimate Heat Sink (UHS) – Shutdown	3.7-4
3.7.3	Reactor Building Cooling Water (RCW) System and Reactor Service Water (RSW) System and Ultimate Heat Sink (UHS) – Refueling.....	3.7-7
3.7.4	Control Room Habitability Area (CRHA) – Emergency Filtration (EF) System.....	3.7-9
3.7.5	Control Room Habitability Area (CRHA) – Air Conditioning (AC) System.....	3.7-12
3.7.6	Main Condenser Offgas	3.7-15
3.7.7	Main Turbine Bypass System	3.7-17
3.7.8	Fuel Pool Water Level	3.7-19
3.8	Electrical Power Systems	3.8-1
3.8.1	AC Sources – Operating.....	3.8-1
3.8.2	AC Sources – Refueling.....	3.8-18
3.8.3	Diesel Fuel Oil, Lube Oil, and Starting Air	3.8-21

Chapter 16

Table of Contents (Continued)

3.8.4	DC Sources – Operating.....	3.8-24
3.8.5	DC Sources – Shutdown	3.8-28
3.8.6	Battery Cell Parameters.....	3.8-30
3.8.7	Inverters – Operating.....	3.8-34
3.8.8	Inverters – Shutdown	3.8-36
3.8.9	Distribution Systems – Operating	3.8-38
3.8.10	Distribution Systems – Shutdown.....	3.8-42
3.8.11	AC Sources – Shutdown (Low Water Level)	3.8-44
3.9	Refueling Operations.....	3.9-1
3.9.1	Refueling Equipment Interlocks	3.9-1
3.9.2	Refuel Position Rod-Out Interlock.....	3.9-2
3.9.3	Control Rod Position.....	3.9-3
3.9.4	Control Rod Position Indication	3.9-4
3.9.5	Control Rod Operability – Refueling.....	3.9-6
3.9.6	Reactor Pressure Vessel (RPV) Water Level.....	3.9-7
3.9.7	Residual Heat Removal (RHR) – High Water Level.....	3.9-8
3.9.8	Residual Heat Removal (RHR) – Low Water Level.....	3.9-10
3.10	Special Operations.....	3.10-1
3.10.1	Inservice Leak and Hydrostatic Testing Operation.....	3.10-1
3.10.2	Reactor Mode Switch Interlock Testing	3.10-3
3.10.3	Control Rod Withdrawal – Hot Shutdown.....	3.10-5
3.10.4	Control Rod Withdrawal – Cold Shutdown	3.10-8
3.10.5	Control Rod Drive (CRD) Removal – Refueling.....	3.10-11
3.10.6	Multiple Control Rod Withdrawal – Refueling	3.10-13
3.10.7	Control Rod Testing – Operating.....	3.10-15
3.10.8	Shutdown Margin (SDM) Test – Refueling.....	3.10-16
3.10.9	Reactor Internal Pumps (RIPs) – Testing.....	3.10-19
3.10.10	Training Startups	3.10-20
3.10.11	Low Power Physics Test	3.10-21
3.10.12	Multiple Control Rod Drive Subassembly Removal – Refueling.....	3.10-24
4.0	Design Features.....	4.0-1
4.1	Site	4.0-1
4.2	Reactor Core.....	4.0-1
4.3	Fuel Storage.....	4.0-1
5.0	Administrative Controls.....	5.0-1
5.1	Responsibility	5.0-1
5.2	Organization	5.0-2
5.3	Unit Staff Qualifications	5.0-5
5.4	Technical Specifications (TS) Bases Control.....	5.0-6
5.5	Procedures, Programs, and Manuals	5.0-7
5.6	Safety Function Determination Program (SFDP).....	5.0-15
5.7	Reporting Requirements	5.0-17

Chapter 16

Table of Contents (Continued)

B 2.0 Safety Limits (SLs)	B 2.0-1
B 2.1.1 Reactor Core SLs	B 2.0-1
B 2.1.2 Reactor Coolant System (RCS) Pressure SL	B 2.0-6
 B 3.0 Limiting Condition For Operation (LCOs) and Surveillance Requirements (SRs).....	B 3.0-1
B 3.1 Reactivity Control Systems	B 3.1-1
B 3.1.1 Shutdown Margin (SDM)	B 3.1-1
B 3.1.2 Reactivity Anomalies	B 3.1-6
B 3.1.3 Control Rod Operability.....	B 3.1-10
B 3.1.4 Control Rod Scram Times.....	B 3.1-19
B 3.1.5 Control Rod Scram Accumulators	B 3.1-25
B 3.1.6 Rod Pattern Control	B 3.1-29
B 3.1.7 Standby Liquid Control (SLC) System.....	B 3.1-33
B 3.2 Power Distribution Limits	B 3.2-1
B 3.2.1 Average Planar Linear Heat Generation Rate (APLHGR)	B 3.2-1
B 3.2.2 Minimum Critical Power Ratio (MCPR)	B 3.2-4
B 3.2.3 Linear Heat Generation Rate (LHGR) (Non-GE Fuel).....	B 3.2-8
B 3.3 Instrumentation.....	B 3.3-1
B 3.3.1.1 Safety System Logic and Control (SSLC) Sensor Instrumentation	B 3.3-1
B 3.3.1.2 Reactor Protection System (RPS) and Main Steam Isolation Valve (MSIV) Actuation	B 3.3-74
B 3.3.1.3 Standby Liquid Control (SLC) and Feedwater Runback (FWRB) Actuation.....	B 3.3-89
B 3.3.1.4 Engineered Safety Features (ESF) Actuation Instrumentation	B 3.3-96
B 3.3.2.1 Startup Range Neutron Monitor (SRNM) Instrumentation	B 3.3-130
B 3.3.3.1 Essential Multiplexing System (EMS).....	B 3.3-139
B 3.3.4.1 Anticipated Transient Without Scram (ATWS) and End of Cycle Recirculation Pump Trip (EOC-RPT) Instrumentation	B 3.3-144
B 3.3.4.2 Feedwater and Main Turbine Trip Instrumentation.....	B 3.3-166
B 3.3.5.1 Control Rod Block Instrumentation	B 3.3-172
B 3.3.6.1 Post Accident Monitoring (PAM) Instrumentation.....	B 3.3-181
B 3.3.6.2 Remote Shutdown System	B 3.3-192
B 3.3.7.1 Control Room Habitability Area (CRHA) Emergency Filtration (EF) System Instrumentation	B 3.3-202
B 3.3.8.1 Electric Power Monitoring.....	B 3.3-209
B 3.3.8.2 Reactor Coolant Temperature Monitoring.....	B 3.3-214
B 3.4 Reactor Coolant System (RCS)	B 3.4-1
B 3.4.1 Reactor Internal Pumps (RIPs) – Operating.....	B 3.4-1
B 3.4.2 Safety/Relief Valves (S/RVs)	B 3.4-4
B 3.4.3 RCS Operational Leakage	B 3.4-8
B 3.4.4 RCS Pressure Isolation Valve (PIV) Leakage	B 3.4-12
B 3.4.5 RCS Leakage Detection Instrumentation.....	B 3.4-17
B 3.4.6 RCS Specific Activity	B 3.4-22
B 3.4.7 Residual Heat Removal (RHR) Shutdown Cooling System – Hot Shutdown	B 3.4-27
B 3.4.8 Residual Heat Removal (RHR) Shutdown Cooling System – Cold Shutdown	B 3.4-31
B 3.4.9 RCS Pressure and Temperature (P/T) Limits.....	B 3.4-35

Chapter 16

Table of Contents (Continued)

B 3.5	B 3.4.10 Reactor Steam Dome Pressure	B 3.4-42
	Emergency Core Cooling Systems (ECCS)	B 3.5-1
	B 3.5.1 ECCS – Operating.....	B 3.5-1
	B 3.5.2 ECCS – Shutdown	B 3.5-17
B 3.6	Containment Systems	B 3.6-1
	B 3.6.1.1 Primary Containment	B 3.6-1
	B 3.6.1.2 Primary Containment Air Locks	B 3.6-5
	B 3.6.1.3 Primary Containment Isolation Valves (PCIVs).....	B 3.6-12
	B 3.6.1.4 Drywell Pressure	B 3.6-27
	B 3.6.1.5 Drywell Air Temperature.....	B 3.6-29
	B 3.6.1.6 Wetwell-to-Drywell Vacuum Breakers.....	B 3.6-32
	B 3.6.2.1 Suppression Pool Average Temperature.....	B 3.6-37
	B 3.6.2.2 Suppression Pool Water Level.....	B 3.6-42
	B 3.6.2.3 Residual Heat Removal (RHR) Suppression Pool Cooling	B 3.6-45
	B 3.6.2.4 Residual Heat Removal (RHR) Containment Spray	B 3.6-49
	B 3.6.3.1 Primary Containment Hydrogen Recombiners	B 3.6-54
	B 3.6.3.2 Primary Containment Oxygen Concentration.....	B 3.6-59
	B 3.6.4.1 Secondary Containment	B 3.6-62
	B 3.6.4.2 Secondary Containment Isolation Valves (SCIVs).....	B 3.6-67
	B 3.6.4.3 Standby Gas Treatment (SGT) System	B 3.6-73
B 3.7	Plant Systems.....	B 3.7-1
	B 3.7.1 Reactor Building Cooling Water (RCW) System, Reactor Service Water (RSW) System, and Ultimate Heat Sink (UHS) – Operating.....	B 3.7-1
	B 3.7.2 Reactor Building Cooling Water (RCW) System, Reactor Service Water (RSW) System and Ultimate Heat Sink (UHS) – Shutdown	B 3.7-9
	B 3.7.3 Reactor Building Cooling Water (RCW) System, Reactor Service Water (RSW) System and Ultimate Heat Sink (UHS) – Refueling.....	B 3.7-14
	B 3.7.4 Control Room Habitability Area (CRHA) - Emergency Filtration (EF) System.....	B 3.7-18
	B 3.7.5 Control Room Habitability Area (CRHA) – Air Conditioning (AC) System.....	B 3.7-24
	B 3.7.6 Main Condenser Offgas	B 3.7-28
	B 3.7.7 Main Turbine Bypass System	B 3.7-31
	B 3.7.8 Fuel Pool Water Level	B 3.7-34
B 3.8	Electrical Power Systems	B 3.8-1
	B 3.8.1 AC Sources – Operating.....	B 3.8-1
	B 3.8.2 AC Sources – Refueling.....	B 3.8-34
	B 3.8.3 Diesel Fuel Oil, Lube Oil, and Starting Air Subsystem.....	B 3.8-40
	B 3.8.4 DC Sources – Operating.....	B 3.8-48
	B 3.8.5 DC Sources – Shutdown	B 3.8-58
	B 3.8.6 Battery Cell Parameters.....	B 3.8-61
	B 3.8.7 Inverters – Operating.....	B 3.8-66
	B 3.8.8 Inverters – Shutdown	B 3.8-70
	B 3.8.9 Distribution Systems – Operating	B 3.8-73
	B 3.8.10 Distribution Systems – Shutdown.....	B 3.8-82
	B 3.8.11 AC Sources – Shutdown (Low Water Level)	B 3.8-86

Chapter 16

Table of Contents (Continued)

B 3.9	Refueling Operations.....	B 3.9-1
B 3.9.1	Refueling Equipment Interlocks	B 3.9-1
B 3.9.2	Refuel Position Rod-Out Interlock.....	B 3.9-4
B 3.9.3	Control Rod Position.....	B 3.9-7
B 3.9.4	Control Rod Position Indication	B 3.9-9
B 3.9.5	Control Rod Operability – Refueling.....	B 3.9-12
B 3.9.6	Reactor Pressure Vessel (RPV) Water Level.....	B 3.9-15
B 3.9.7	Residual Heat Removal (RHR) – High Water Level.....	B 3.9-17
B 3.9.8	Residual Heat Removal (RHR) – Low Water Level.....	B 3.9-21
B 3.10	Special Operations.....	B 3.10-1
B 3.10.1	Inservice Leak and Hydrostatic Testing Operation.....	B 3.10-1
B 3.10.2	Reactor Mode Switch Interlock Testing	B 3.10-5
B 3.10.3	Control Rod Withdrawal – Hot Shutdown.....	B 3.10-9
B 3.10.4	Control Rod Withdrawal – Cold Shutdown.....	B 3.10-13
B 3.10.5	Control Rod Drive (CRD) Removal – Refueling.....	B 3.10-17
B 3.10.6	Multiple Control Rod Withdrawal – Refueling	B 3.10-21
B 3.10.7	Control Rod Testing – Operating.....	B 3.10-24
B 3.10.8	Shutdown Margin (SDM) Test – Refueling.....	B 3.10-27
B 3.10.9	Reactor Internal Pumps – Testing	B 3.10-31
B 3.10.10	Training Startups.....	B 3.10-34
B 3.10.11	Low Power Physics Tests.....	B 3.10-36
B 3.10.12	Multiple Control Rod Drive Subassembly Removal – Refueling.....	B 3.10-40

Chapter 17

Table of Contents

17.0 Quality Assurance.....	17.0-1
17.0 Introduction.....	17.0-1
17.0.1 COL License Information.....	17.0-1
17.1 Quality Assurance During Design and Construction.....	17.1-1
17.1.1 Organization	17.1-1
17.1.2 Quality Assurance Program.....	17.1-1
17.1.3 Design Control.....	17.1-2
17.1.4 Procurement Document Control.....	17.1-2
17.1.5 Instruction, Procedures, and Drawings.....	17.1-2
17.1.6 Document Control	17.1-3
17.1.7 Control of Purchased Material, Equipment, and Services.....	17.1-3
17.1.8 Identification and Control of Materials, Parts, and Components.....	17.1-3
17.1.9 Control of Special Processes	17.1-3
17.1.10 Inspection	17.1-3
17.1.11 Test Control.....	17.1-4
17.1.12 Control of Measuring and Test Equipment	17.1-4
17.1.13 Handling, Storage, and Shipping.....	17.1-4
17.1.14 Inspection, Test, and Operating Status	17.1-4
17.1.15 Nonconforming Materials, Parts, or Components	17.1-4
17.1.16 Corrective Action	17.1-4
17.1.17 Quality Assurance Records	17.1-4
17.1.18 Audits	17.1-5
17.1.19 References	17.1-5
17.2 Quality Assurance During the Operations Phase.....	17.2-1
17.3 Reliability Assurance Program During Design Phase	17.3-1
17.3.1 Introduction	17.3-1
17.3.2 Scope	17.3-1
17.3.3 Purpose	17.3-1
17.3.4 Objective.....	17.3-2
17.3.5 GE Hitachi Nuclear Energy Organization for D-RAP	17.3-2
17.3.6 SSC Identification/Prioritization	17.3-2
17.3.7 Design Considerations.....	17.3-3
17.3.8 Defining Failure Modes.....	17.3-3
17.3.9 Operational Reliability Assurance Activities	17.3-4
17.3.10 Owner/Operator's Reliability Assurance Program.....	17.3-4
17.3.11 D-RAP Implementation.....	17.3-6
17.3.12 Glossary of Terms	17.3-11
17.3.13 COL License Information.....	17.3-13
17.3.14 References	17.3-13

Chapter 17

List of Tables

Table 17.0-1	ABWR Compliance with Quality Related Regulatory Guides	17.0-2
Table 17.3-1	SLCS Components with Largest Contribution to System Unavailability.....	17.3-14
Table 17.3-2	Risk-Significant SSCs for SLCS.....	17.3-14
Table 17.3-3	Examples of SLCS Failure Modes and O-RAP Activities.....	17.3-15

Chapter 17

List of Figures

Figure 17.3-1	Design Evaluations for SSCs	17.3-16
Figure 17.3-2	Process for Determining Dominant Failure Modes of Risk-Significant SSCs	17.3-17
Figure 17.3-3	Use of Failure History to Define Modes	17.3-18
Figure 17.3-4	Analytical Assessment to Define Failure Modes	17.3-19
Figure 17.3-5	Inclusion of Maintenance Requirements in the Definition of Failure Modes	17.3-20
Figure 17.3-6	Identification of Risk-Significant SSC O-Rap Activities	17.3-21
Figure 17.3-7	Standby Liquid Control System (Standby Mode).....	17.3-22
Figure 17.3-8	Standby Liquid Control System Top Level Fault Tree	17.3-23

Chapter 18

Table of Contents

18.0 Human Factors Engineering	18.1-1
18.1 Introduction.....	18.1-1
18.2 Design Goals and Design Bases	18.2-1
18.3 Planning, Development, and Design.....	18.3-1
18.3.1 Introduction	18.3-1
18.3.2 Standard Design Features	18.3-1
18.3.3 Inventory of Controls and Instrumentation	18.3-2
18.3.4 Detailed Design Implementation Process.....	18.3-2
18.4 Control Room Standard Design Features	18.4-1
18.4.1 Introduction	18.4-1
18.4.2 Standard Design Feature Descriptions	18.4-1
18.4.3 Control Room HSI Technology.....	18.4-10
18.5 Remote Shutdown System.....	18.5-1
18.6 Systems Integration.....	18.6-1
18.6.1 Safety-Related Systems.....	18.6-1
18.6.2 Non-Safety-Related Systems.....	18.6-1
18.7 Detailed Design of the Operator Interface System	18.7-1
18.8 COL License Information	18.8-1
18.8.1 HSI Design Implementation Process.....	18.8-1
18.8.2 Number of Operators Needing Controls Access	18.8-1
18.8.3 Automation Strategies and Their Effect on Operator Reliability	18.8-1
18.8.4 SPDS Integration With Related Emergency Response Capabilities	18.8-1
18.8.5 Standard Design Features Design Validation.....	18.8-1
18.8.6 Remote Shutdown System Design Evaluation.....	18.8-1
18.8.7 Local Valve Position Indication	18.8-1
18.8.8 Operator Training	18.8-2
18.8.9 Safety System Status Monitoring.....	18.8-2
18.8.10 PGCS Malfunction	18.8-2
18.8.11 Local Control Stations.....	18.8-2
18.8.12 As-Built Evaluation of MCR and RSS.....	18.8-2
18.8.13 Accident Monitoring Instrumentation	18.8-2
18.8.14 In-Core Cooling Instrumentation	18.8-3
18.8.15 Performance of Critical Tasks	18.8-3
18.8.16 Plant Status and Post-Accident Monitoring	18.8-3
18A Emergency Procedure Guidelines.....	18A-1
18A.1 Table of Contents	18A-2
18A.2 Introduction	18A-3
18A.3 Operator Precautions	18A-8
18A.4 RPV Control Guideline	18A-12
18A.5 Primary Containment Control Guideline.....	18A-27

Chapter 18

Table of Contents (Continued)

18A.6	Secondary Containment Control Guideline.....	18A-51
18A.7	Radioactivity Release Control Guideline	18A-63
18A.8	Contingency #1, Alternative Level Control	18A-64
18A.9	Contingency #2, Emergency RPV Depressurization.....	18A-69
18A.10	Contingency #3, Steam Cooling.....	18A-72
18A.11	Contingency #4, RPV Flooding	18A-73
18A.12	Contingency #5, Level/Power Control	18A-81
18A.13	Contingency #6, Primary Containment Flooding.....	18A-90
18B	Differences Between BWROG EPG Revision 4 and ABWR EPG.....	18B-1
18B.1	Introduction	18B-1
18C	Operator Interface Equipment Characterization	18C-1
18C.1	Control Room Arrangement	18C-1
18C.2	Main Control Room Configuration	18C-1
18C.3	Large Display Panel Configuration.....	18C-2
18C.4	Systems Integration	18C-2
18D	Emergency Procedures Guidelines—Input Data and Calculation Results	18D-1
18D.1	Introduction	18D-1
18D.2	Input Parameters.....	18D-1
18D.3	Calculation Results	18D-1
18E	ABWR Human-System Interface Design Implementation Process	18E-1
18E.1	Introduction	18E-1
18E.2	HSI Design Implementation Process.....	18E-1
18E.3	HSI Implementation Requirements	18E-4
18F	Emergency Operation Information and Controls.....	18F-1
18F.1	Introduction	18F-1
18G	Design Development and Validation Testing	18G-1
18G.1	Introduction	18G-1
18G.2	Design Development	18G-1
18G.3	Validation Testing	18G-7
18H	Supporting Analysis for Emergency Operation Information and Controls	18H-1
18H.1	Introduction	18H-1
18H.2	Presentation of Results	18H-3
18H.3	Analysis of Changes to EPGs.....	18H-5
18H.4	References	18H-6

Chapter 18

List of Tables

Table 18B-1	Differences Between BWROG EPG Revision 4 and ABWR EPG	18B-2
Table 18D-1	BWROG EPG Rev. 4 Appendix C Input Data for ABWR	18D-2
Table 18D-2	BWROG EPG Rev. 4 Appendix C Results for ABWR	18D-12
Table 18E-1	Human Factors Engineering Design Team and Plans	18E-6
Table 18E-2	HFE Analysis.....	18E-37
Table 18E-3	Human System Interface Design.....	18E-40
Table 18E-4	Human Factors Verification and Validation.....	18E-41
Table 18F-1	Inventory of Controls Based Upon the ABWR EPGs and PRA	18F-3
Table 18F-2	Inventory of Displays Based Upon the ABWR EPGs and PRA	18F-10
Table 18F-3	Inventory of Alarms Based Upon the ABWR EPGs and PRA	18F-13
Table 18G-1	Large Screen Utilization Topics.....	18G-11
Table 18G-2	Validation Test Schedules	18G-11
Table 18G-3	Test Scenarios and Evaluations	18G-12

Chapter 18

List of Figures

Figure 18C-1	Control Room Arrangement.....	18C-3
Figure 18C-2	Main Control Console Configuration.....	18C-4
Figure 18C-3	Main Control Console Cross-Section A-A	18C-5
Figure 18C-4	Main Control Console Cross-Section B-B.....	18C-6
Figure 18C-5	Arrangement of Equipment of Main Control Console.....	18C-7
Figure 18C-6	Side View of Relative Positions of Main Console and Wide Display Device.....	18C-8
Figure 18C-7	Fixed-Position Display.....	18C-9
Figure 18C-8	Overall Configuration of Operator Interface System.....	18C-10
Figure 18E-1	ABWR Human-System Interface Design Implementation Process.....	18E-42
Figure 18G-1	Typical Data from Touch Screen Precision Tests.....	18G-13

Chapter 19

Table of Contents

19.0	Response to Severe Accident Policy Statement	19.1-1
19.1	Purpose and Summary	19.1-1
19.1.1	Purpose	19.1-1
19.1.2	Summary	19.1-1
19.1.3	References	19.1-2
19.2	Introduction	19.2-1
19.2.1	Definitions	19.2-1
19.2.2	Objective and Scope	19.2-1
19.2.3	PRA Basis	19.2-2
19.2.4	Methodology	19.2-5
19.2.5	References	19.2-8
19.3	Internal Event Analysis	19.3-1
19.3.1	Frequency of Core Damage	19.3-1
19.3.2	Frequency of Radioactive Release	19.3-12
19.3.3	Magnitude and Timing of Radioactive Release	19.3-19
19.3.4	Consequence of Radioactive Release	19.3-20
19.3.5	References	19.3-21
19.4	External Event Analysis and Shutdown Risk Analysis	19.4-1
19.4.1	External Event Review	19.4-1
19.4.2	Tornado Strike Analysis	19.4-2
19.4.3	Seismic Margins Analysis	19.4-3
19.4.4	Fire Protection Probabilistic Risk Assessment	19.4-10
19.4.5	ABWR Probabilistic Flooding Analysis	19.4-11
19.4.6	ABWR Shutdown Risk	19.4-12
19.4.7	References	19.4-13
19.5	Source Term Sensitivity Studies	19.5-1
19.5.1	Core Melt Progression and Hydrogen Generation	19.5-1
19.5.2	Effect of Overpressure Relief Rupture Disk on Fission Product Release	19.5-1
19.5.3	Alternate Definition of Containment Failure	19.5-2
19.6	Measurement Against Goals	19.6-1
19.6.1	Goals	19.6-1
19.6.2	Prevention of Core Damage	19.6-1
19.6.3	Prevention of Early Containment Failure For Dominant Accident Sequences	19.6-1
19.6.4	Hydrogen from 100% of Active Zirconium	19.6-2
19.6.5	Reliable Heat Removal to Reduce Probability of Containment Failure	19.6-2
19.6.6	Prevention of Hydrogen Deflagration and Detonation	19.6-3
19.6.7	Offsite Dose/Large Release	19.6-4
19.6.8	Containment Conditional Failure Probability	19.6-4
19.6.9	Safety Goal Policy Statement	19.6-5
19.6.10	Not Used	19.6-5
19.6.11	Conclusion	19.6-5
19.6.12	References	19.6-6

Chapter 19

Table of Contents (Continued)

19.7	PRA as a Design Tool	19.7-1
19.7.1	ABWR Design and Operating Experience.....	19.7-1
19.7.2	Early PRA Studies.....	19.7-1
19.7.3	PRA Studies During the Certification Effort	19.7-3
19.7.4	Conduct of the PRA Evaluations	19.7-9
19.7.5	Evaluation of Potential Design Improvements	19.7-9
19.8	Important Features Identified by the ABWR PRA.....	19.8-1
19.8.1	Important Features from Level 1 Internal Events Analyses.....	19.8-2
19.8.2	Important Features from Seismic Analyses	19.8-7
19.8.3	Important Features from Fire Analyses.....	19.8-9
19.8.4	Important Features from Suppression Pool Bypass and Ex-Containment LOCA Analyses	19.8-12
19.8.5	Important Features from Flooding Analyses.....	19.8-15
19.8.6	Important Features from Shutdown Events Analyses	19.8-18
19.8.7	ABWR Features to Mitigate Severe Accidents.....	19.8-21
19.9	COL License Information.....	19.9-1
19.9.1	Post Accident Recovery Procedure for Unisolated CUW Line Break.....	19.9-1
19.9.2	Confirmation of CUW Operation Beyond Design Bases	19.9-1
19.9.3	Event Specific Procedures for Severe External Flooding	19.9-2
19.9.4	Confirmation of Seismic Capacities Beyond the Plant Design Bases	19.9-3
19.9.5	Plant Walkdowns	19.9-3
19.9.6	Confirmation of Loss of AC Power Event.....	19.9-3
19.9.7	Procedures and Training for Use of AC-Independent Water Addition System.....	19.9-3
19.9.8	Actions to Avoid Common-Cause Failures in the Essential Multiplexing System (EMUX) and Other Common-Cause Failures.....	19.9-4
19.9.9	Actions to Mitigate Station Blackout Events	19.9-5
19.9.10	Actions to Reduce Risk of Internal Flooding.....	19.9-6
19.9.11	Actions to Avoid Loss of Decay Heat Removal and Minimize Shutdown Risk	19.9-7
19.9.12	Procedures for Operation of RCIC from Outside the Control Room.....	19.9-8
19.9.13	ECCS Test and Surveillance Intervals	19.9-9
19.9.14	Accident Management	19.9-9
19.9.15	Manual Operation of MOVs	19.9-10
19.9.16	High Pressure Core Flooder Discharge Valve	19.9-10
19.9.17	Capability of Containment Isolation Valves	19.9-10
19.9.18	Procedures to Insure Sample Lines and Drywell Purge Lines Remain Closed During Operation	19.9-10
19.9.19	Procedures for Combustion Turbine Generator to Supply Power to Condensate Pumps	19.9-10
19.9.20	Actions to Assure Reliability of the Supporting RCW and Service Water Systems	19.9-11
19.9.21	Housing of ACIWA Equipment.....	19.9-11
19.9.22	Procedures to Assure SRV Operability During Station Blackout.....	19.9-11
19.9.23	Procedures for Ensuring Integrity of Freeze Seals.....	19.9-11
19.9.24	Procedures for Controlling Combustibles During Shutdown	19.9-11
19.9.25	Outage Planning and Control	19.9-11
19.9.26	Reactor Service Water Systems Definition.....	19.9-11

Chapter 19

Table of Contents (Continued)

19.9.27	Capability of Vacuum Breakers	19.9-12
19.9.28	Capability of the Containment Atmospheric Monitoring System.....	19.9-12
19.9.29	Plant Specific Safety-Related Issues and Vendors Operating Guidance	19.9-12
19.9.30	PRA Update	19.9-12
19.10	Assumptions and Insights Related to Systems Outside of ABWR Design Certification.....	19.10-1
19.10.1	Reactor Service Water (RSW) System and Safety-Related Ultimate Heat Sink (UHS) Assumptions	19.10-1
19.10.2	Reactor Service Water (RSW) System and Safety-Related Ultimate Heat Sink (UHS) Insights	19.10-2
19.10.3	Power Cycle Heat Sink Assumptions	19.10-3
19.10.4	Power Cycle Heat Sink Insights.....	19.10-3
19.10.5	Offsite Power Assumptions.....	19.10-3
19.10.6	Offsite Power Insights.....	19.10-3
19.10.7	Fire Truck Assumption	19.10-3
19.10.8	Fire Truck Insights	19.10-3
19.11	Human Action Overview.....	19.11-1
19.12	Input to the Reliability Assurance Program	19.12-1
19.13	Summary of Insights Gained from the PRA.....	19.13-1
19.13.1	Licensing Review Bases Goals	19.13-1
19.13.2	The Search for Vulnerabilities	19.13-1
19.13.3	The Most Important Aspects of the Design	19.13-2
19.13.4	Additional Studies	19.13-2
19.13.5	Uncertainty and Sensitivity Studies	19.13-3
19.13.6	Systems and Effects Not Modeled in the PRA	19.13-3
19A	Response to CP/ML Rule 10 CFR 50.34(f).....	19A-1
19A.1	Introduction	19A-1
19A.2	NRC Positions/Responses	19A-2
19A.3	COL License Information	19A-19
19B	Resolution of Applicable Unresolved Safety Issues and Generic Safety Issues	19B-1
19B.1	Introduction	19B-9
19B.2	Safety Issues.....	19B-10
19B.3	COL License Information	19B-124
19C	Design Considerations Reducing Sabotage Risk.....	19C-1
19D	Probabilistic Evaluations	19D-1
19E	Deterministic Evaluations.....	19E-1
19E.1	Introduction	19E-1
19E.2	Deterministic Analysis of Plant Performance	19E-2
19E.3	Consequence Analysis	19E-292

Chapter 19

Table of Contents (Continued)

19EA	Direct Containment Heating.....	19EA-1
19EA.1	Summary Description.....	19EA-1
19EA.2	Description of Event Tree Analysis	19EA-2
19EA.3	Deterministic Model for DCH	19EA-11
19EA.4	Summary of Results	19EA-25
19EA.5	Conclusions	19EA-27
19EA.6	References	19EA-27
19EB	Fuel Coolant Interactions.....	19EB-1
19EB.1	Introduction.....	19EB-1
19EB.2	Applicability of Experiments	19EB-3
19EB.3	Explosive Steam Generation	19EB-7
19EB.4	Impulse Loads	19EB-9
19EB.5	Water Missiles.....	19EB-14
19EB.6	Containment Overpressurization.....	19EB-16
19EB.7	References	19EB-22
19EC	Debris Coolability and Core Concrete Interaction	19EC-1
19EC.1	Applicability of Experiments to ABWR	19EC-1
19EC.2	Description of Event Tree Analysis	19EC-3
19EC.3	Deterministic Model for Core Concrete Interaction	19EC-13
19EC.4	Pedestal Strength.....	19EC-17
19EC.5	Application of CCI Model to ABWR	19EC-17
19EC.6	Sensitivity to Various Parameters	19EC-21
19EC.7	Impact on Offsite Dose	19EC-24
19EC.8	Conclusions	19EC-24
19EC.9	References	19EC-24
19ED	Corium Shield.....	19ED-1
19ED.1	Issue.....	19ED-1
19ED.2	Design Description.....	19ED-1
19ED.3	Success Criteria.....	19ED-2
19ED.4	Channel Length Analysis	19ED-3
19ED.5	Long-Term Capability of the Shield Walls.....	19ED-21
19ED.6	Related Experimental and Analytical Work	19ED-24
19ED.7	References	19ED-25
19EE	Suppression Pool Bypass.....	19EE-1
19EE.1	Suppression Pool Bypass	19EE-1
19EE.2	Description of Decomposition Event Tree Analysis	19EE-1
19EE.3	Deterministic Analysis	19EE-6
19EE.4	Summary of Results	19EE-11
19EE.5	Conclusions	19EE-12
19EE.6	References	19EE-13
19F	Containment Ultimate Strength.....	19F-1
19F.1	Introduction and Summary.....	19F-1
19F.2	RCCV Nonlinear Analysis.....	19F-3

Chapter 19

Table of Contents (Continued)

19F.3	Prediction of Containment Ultimate Strength.....	19F-5
19F.4	References	19F-16
19FA	Containment Ultimate Strength.....	19FA-1
19G	Aircraft Impact Assessment.....	19G-1
19G.1	Introduction and Background.....	19G-1
19G.2	Scope of the Assessment.....	19G-1
19G.3	Assessment Methodology	19G-2
19G.4	Results of Assessment.....	19G-2
19G.5	Conclusions of Assessment.....	19G-6
19G.6	References	19G-6
19H	Seismic Capacity Analysis	19H-1
19H.1	Introduction	19H-1
19H.2	Fragility Formulation	19H-1
19H.3	Structural Fragility	19H-3
19H.4	Component Fragility	19H-13
19H.5	COL License Information	19H-16
19H.6	References	19H-19
19I	Seismic Margins Analysis	19I-1
19I.1	Introduction	19I-1
19I.2	Component and Structure Fragility - A_M , β_C	19I-2
19I.3	Event Tree Analysis	19I-2
19I.4	System Analysis	19I-4
19I.5	Accident Sequence HCLPF Analysis.....	19I-5
19I.6	Results of the Analyses	19I-8
19I.7	Containment Isolation and Bypass Analysis.....	19I-8
19I.8	References	19I-10
19J	Not Used.....	19J-1
19K	PRA-Based Reliability and Maintenance	19K-1
19K.1	Introduction	19K-1
19K.2	General Approach	19K-1
19K.3	Determination of “Important Structures, Systems and Components” for Level 1 Analysis.....	19K-1
19K.4	Determination of “Important Structures, Systems and Components” for Level 2 Analysis.....	19K-3
19K.5	Determination of “Important Structures, Systems and Components” for Seismic Analysis.....	19K-4
19K.6	Determination of “Important Structures, Systems and Components” for Fire Analysis.....	19K-5
19K.7	Determination of “Important Structures, Systems and Components” for Flood Analysis.....	19K-6
19K.8	Determination of “Important Structures, Systems and Components” for Shutdown Analysis.....	19K-6

Chapter 19

Table of Contents (Continued)

19K.9	Identification of Important Systems with Redundant Trains	19K-6
19K.10	Identification of Important Capabilities Outside the Control Room.....	19K-7
19K.11	Reliability and Maintenance Actions	19K-8
19K.12	References	19K-17
 19L	ABWR Shutdown Risk Evaluation	19L-1
19L.1	Purpose	19L-1
19L.2	Conclusions	19L-1
19L.3	Introduction	19L-1
19L.4	Scope of the Study	19L-2
19L.5	Reactivity Excursion Events	19L-3
19L.6	Reactor Pressure Vessel Draining Events.....	19L-10
19L.7	Loss of Core Cooling	19L-18
19L.8	Loss of Decay Heat Removal Events.....	19L-20
19L.9	Noncore-Related Accidents	19L-22
19L.10	References	19L-24
 19M	Fire Protection Probabilistic Risk Assessment.....	19M-1
19M.1	Introduction	19M-1
19M.2	Basis of the Analysis	19M-1
19M.3	Summary of Results	19M-2
19M.4	Phase I Scenario and Phase II Fire Frequency Analysis	19M-3
19M.5	Calculation of the Fire Ignition Frequency	19M-7
19M.6	Calculation of Core Damage Frequencies.....	19M-9
19M.7	COL License Information	19M-11
19M.8	References	19M-11
 19N	Analysis of Common-Cause Failure of Multiplex Equipment.....	19N-1
19N.1	Introduction	19N-1
19N.2	Results and Conclusions	19N-1
19N.3	Basis for the Analysis.....	19N-4
19N.4	Potential Causes of and Defenses Against EMUX CCF	19N-6
19N.5	Discussion of the Effect on Core Damage Frequency	19N-9
19N.6	Discussion of the Effect on Isolation Capability.....	19N-16
19N.7	Summary	19N-17
19N.8	References	19N-18
 19O	Not Used	19O-1
 19P	Evaluation of Potential Modifications to the ABWR Design.....	19P-1
 19Q	ABWR Shutdown Risk Assessment.....	19Q-1
19Q.1	Introduction	19Q-1
19Q.2	Evaluation Scope.....	19Q-1
19Q.3	Summary of Results	19Q-2
19Q.4	Features to Minimize Shutdown Risk	19Q-4
19Q.5	Instrumentation	19Q-15
19Q.6	Flooding and Fire Protection.....	19Q-16

Chapter 19

Table of Contents (Continued)

19Q.7	Decay Heat Removal Reliability Study	19Q-21
19Q.8	Use of Freeze Seals in ABWR	19Q-33
19Q.9	Shutdown Vulnerability Resulting from New Features	19Q-33
19Q.10	Procedures	19Q-34
19Q.11	Summary of Review of Significant Shutdown Events: Electrical Power and Decay Heat Removal.....	19Q-37
19Q.12	Results and Interface Requirements	19Q-40
 19QA	Fault Trees	19QA-1
 19QB	DHR Reliability Study.....	19QB-1
19QB.1	Offsite Dose and Operator Recovery Calculations	19QB-1
19QB.2	Time to Reach Boiling	19QB-2
19QB.3	Time for RPV Water Level to Reach Top of Active Fuel	19QB-2
19QB.4	Human Reliability Analysis (HRA)	19QB-2
19QB.5	Decay Heat Removal Capability of CUW and FPC	19QB-4
19QB.6	References	19QB-4
 19QC	Review of Significant Shutdown Events: Electrical Power and Decay Heat Removal	19QC-1
19QC.1	Review of Significant Shutdown Events.....	19QC-1
 19R	Probabilistic Flooding Analysis.....	19R-1
19R.1	Introduction and Summary.....	19R-1
19R.2	Scope of Analysis.....	19R-3
19R.3	Screening Analysis (Water Sources and Buildings)	19R-3
19R.4	Deterministic Flood Analysis.....	19R-4
19R.5	Probabilistic Flood Assessment	19R-15
19R.6	Results and Interface Requirements	19R-27

Chapter 19

List of Tables

Table 19.2-1	Key PRA Assumptions	19.2-10
Table 19.3-1	Initiating Event Frequencies	19.3-22
Table 19.3-2	Success Criteria to Prevent Initial Core Damage for Transient and LOCA Events With RPS Scram	19.3-23
Table 19.3-3	Success Criteria and Required Operator Actions For ATWS Events.....	19.3-26
Table 19.3-4	Frequency of Core Damage by Accident Class	19.3-28
Table 19.3-5	Frequency of Core Damage by Initiating Event	19.3-29
Table 19.3-6	Frequency Of Fission Product Release	19.3-30
Table 19.6-1	Summary of Goals in Licensing Review Bases	19.6-7
Table 19.8-1	Important Features from Level 1 Internal Events Analyses	19.8-27
Table 19.8-2	Important Features from Seismic Analyses	19.8-30
Table 19.8-3	Important Features from Fire Protection Analyses	19.8-32
Table 19.8-4	Important Features from Suppression Pool Bypass and Ex-Containment LOCA Analyses	19.8-33
Table 19.8-5	Important Features from Flooding Analyses	19.8-35
Table 19.8-6	Important Features From Shutdown Events Analyses.....	19.8-37
Table 19.8-7	Key Severe Accident Parameters	19.8-39
Table 19A-1	ABWR—CP/ML Rule Cross Reference.....	19A-21
Table 19E.2-1	Potential Suppression Pool Bypass Lines	19E-150
Table 19E.2-2	ABWR Plant Ability to Cope with Station Blackout for up to 8 Hours	19E-154
Table 19E.2-3	Definition of Accident Sequence Codes	19E-155
Table 19E.2-4	Grouping of Accident Classes into Base Sequences.....	19E-156
Table 19E.2-5	Sequence of Events for LCLP-PF-R-N.....	19E-156
Table 19E.2-6	Sequence of Events for LCLP-FS-R-N.....	19E-157
Table 19E.2-7	Sequence of Events for LCHP-PS-R-N	19E-157
Table 19E.2-8	Sequence of Events for LCHP-PF-P-M	19E-158
Table 19E.2-9	Sequence of Events for SBRC-FA-R-0	19E-158

Chapter 19

List of Tables (Continued)

Table 19E.2-10	Sequence of Events for SBRC-PF-R-N	19E-159
Table 19E.2-11	Sequence of Events for LHRC-00-R-0	19E-159
Table 19E.2-12	Sequence of Events for LBLC-PF-R-N	19E-160
Table 19E.2-13	Sequence of Events for NSCL-PF-R-N	19E-160
Table 19E.2-14	Sequence of Events for NSCH-PF-P-M.....	19E-161
Table 19E.2-15	Sequence of Events for NSRC-PF-R-N	19E-161
Table 19E.2-16	Summary of Critical Parameters for Severe Accident Sequences	19E-162
Table 19E.2-17	Important Parameters for Steam Explosion Analysis	19E-163
Table 19E.2-18	Potential Bypass Pathway Matrix	19E-163
Table 19E.2-19	Flow Split Fractions.....	19E-164
Table 19E.2-20	Failure Probabilities	19E-165
Table 19E.2-21	Summary of Bypass Probabilities	19E-166
Table 19E.2-22	NUREG/CR-4551 Grand Gulf APET Events by Category	19E-167
Table 19E.2-23	NRC Identified Parameters for Sensitivity Study from NUREG-1335	19E-172
Table 19E.2-24	Issues to be investigated in ABWR Sensitivity Analysis	19E-173
Table 19E.2-25	Comparison of Volatile Fission Product Releases.....	19E-174
Table 19E.2-26	Comparison of Low Pressure Core Melt Performance with and without Containment Overpressure Protection System	19E-175
Table 19E.2-27	Probability of Release Mode With and Without COPS.....	19E-175
Table 19E.2-28	Sensitivity Studies for Passive Flooder Reliability Frequencies of Important CET Results	19E-176
Table 19E.2-29	Equipment and Instrumentation Required to Survive Severe Accident Scenarios	19E-177
Table 19E.2-30	Material Properties Used in Tunnel Integrity Analysis	19E-178
Table 19E.3-1	GESSAR Reactor Release Parameters.....	19E-297
Table 19E.3-2	Population Density for Each Geographical Region	19E-298
Table 19E.3-3	Evacuation Parameters.....	19E-298

Chapter 19

List of Tables (Continued)

Table 19E.3-4	Evacuation Parameter Definition	19E-299
Table 19E.3-5	Site and Reactor Data for Meteorological Modeling	19E-299
Table 19E.3-6	Event Release Parameters	19E-300
Table 19E.3-7	Consequence Goals and Results	19E-301
Table 19EA-1	Containment Pressure at RPV Failure	19EA-30
Table 19EA-2	Comparison of Assumed Debris Mass Participating in DCH with BWRSAR Debris Discharge Results	19EA-30
Table 19EB-1	Core Concrete Interaction Tests with Water Addition to Debris.....	19EB-24
Table 19EB-2	Maximum Steam Generation for Steam Spikes.....	19EB-24
Table 19EC-1	Summary of Timing for Core Concrete Interaction Base Case	19EC-26
Table 19EC-2	Summary of CCI Deterministic Analysis for ABWR.....	19EC-27
Table 19ED-1	Material Properties.....	19ED-27
Table 19ED-2	Scenario Parameters.....	19ED-27
Table 19ED-3	Constituent Material Properties	19ED-28
Table 19ED-4	Results of Channel Length Calculation	19ED-28
Table 19ED-5	Effect of Parameter Variations.....	19ED-29
Table 19ED-6	Change in Energy due to Superheat.....	19ED-30
Table 19ED-7	Plug Formation Times with Superheat	19ED-30
Table 19ED-8	Required Channel Lengths with Superheat.....	19ED-31
Table 19EE-1	Summary of Volatile Fission Product Releases for Severe Accidents with Suppression Pool Bypass Leakage through Vacuum Breaker Valves	19EE-14
Table 19EE-2	Effect of Eliminating Aerosol Plugging Credit on Source Term Category Frequencies	19EE-15
Table 19F-1	Summary of Stresses and Strains	19F-17
Table 19F-2	Summary of Pressure Capabilities of Various Components of the RCCV	19F-18
Table 19H-1	Seismic Capacity Summary	19H-21
Table 19H-2	Seismic Fragility For Reactor Building	19H-23

Chapter 19

List of Tables (Continued)

Table 19H-3	Seismic Fragility For Containment.....	19H-24
Table 19H-4	Seismic Fragility For RPV Pedestal	19H-25
Table 19H-5	Seismic Fragility For Control Building	19H-26
Table 19H-6	Seismic Fragility For Reactor Pressure Vessel.....	19H-27
Table 19H-7	Seismic Fragility For Shroud Support	19H-28
Table 19H-8	Seismic Fragility For CRD Guide Tubes.....	19H-29
Table 19H-9	Seismic Fragility For CRD Housings	19H-30
Table 19H-10	Seismic Fragility For Fuel Assemblies	19H-31
Table 19I-1	ABWR Systems and Components/Structures Fragilities.....	19I-11
Table 19I-2	Seismic Margins for ABWR Accident Sequences (Convolution Method).....	19I-14
Table 19I-3	Seismic Margins for ABWR Accident Classes (Convolution Method)	19I-15
Table 19I-4	HCLPF Derivation for the ABWR Accident Sequences (MIN-MAX Method)....	19I-16
Table 19K-1	ABWR SSCs of Greatest Importance for CDF, Level 1 Analysis.....	19K-18
Table 19K-2	ABWR SSCs With Moderate Risk Achievement Worth For CDF, Level 1 Analysis.....	19K-19
Table 19K-3	ABWR Initiating Event Contribution to CDF, Level 1 Analysis	19K-20
Table 19K-4	Failure Modes and RAP Activities	19K-21
Table 19L-1	ABWR Modes of Operation	19L-26
Table 19L-2	Control Rod Drop Accident	19L-27
Table 19L-3	Control Rod Ejection Accident.....	19L-29
Table 19L-4	Refueling Error	19L-30
Table 19L-5	Potential for Draining RPV During RIP Maintenance.....	19L-30
Table 19L-6	Potential for Draining RPV Through Control Rod Drive Hydraulic System at Shutdown	19L-31
Table 19L-7	Potential for Draining RPV Through Reactor Water Cleanup System.....	19L-33
Table 19L-8	Potential for Draining RPV Through Residual Heat Removal System	19L-36
Table 19L-9	Dependency of Core Cooling Systems on Electrical Power.....	19L-41

Chapter 19

List of Tables (Continued)

Table 19L-10	Success Criteria for Long-Term Heat Removal for Operating Mode 4.....	19L-42
Table 19L-11	Dependency of Heat Removal Systems on Electrical Power	19L-42
Table 19L-12	ABWR Seismic PRA: Highest Class I Accident Frequency Sequences	19L-43
Table 19M-1	Fire Risk Screening Analysis Summary	19M-12
Table 19M-2	Weighting Factors for Adjusting Generic Location Fire Frequencies for Application to Plant-Specific Locations (References FIVE Table1.1).....	19M-13
Table 19M-3	Fire Compartment-Division 1 Ignition Source Data Sheet (ISDS) (Taken from Draft FIVE Methodology)	19M-15
Table 19M-4	Fire Compartment - Division 2 Ignition Source Data Sheet (ISDS) (Taken from Draft FIVE Methodology).....	19M-16
Table 19M-5	Fire Compartment - Division 3 Ignition Source Data Sheet (ISDS) (Taken from Draft FIVE Methodology).....	19M-17
Table 19M-6	Reactor and Control Building Fire Areas Explanatory Notes (for Tables 19M-3,4 & 5) (FIVE, Table 3).....	19M-18
Table 19M-7	Fire Compartment - Turbine Building Ignition Source Data Sheet (ISDS) (Taken from Draft FIVE Methodology)	19M-19
Table 19M-8	Turbine Building Explanatory Notes (For Table 19M-7) (FIVE, Table 3)	19M-20
Table 19M-9	Fire Compartment - Control Room Complex Ignition Source Data Sheet (ISDS) (Taken from Draft FIVE Methodology)	19M-21
Table 19M-10	Control Room Complex Explanatory Notes (For Table 19M-9) (FIVE, Table 3)	19M-22
Table 19M-11	ABWR Fire Screening Analysis Summary.....	19M-23
Table 19M-12	Divisional and Control Room Fire Risk W/Remote Control of RCIC & 4SRVs for CR Fires.....	19M-24
Table 19M-13	Summary of ABWR Risk Screening Analyses for Turbine Building Fire.....	19M-25
Table 19M-14	ABWR Control Room Fire Risk Screening Analysis Summary	19M-26
Table 19Q-1	ABWR Features That Minimize Shutdown Risk.....	19Q-44
Table 19Q-2	Success Criteria for Prevention of Core Damage	19Q-49
Table 19Q-3	Minimum Sets of Systems for Modes 3 and 4	19Q-49
Table 19Q-4	Minimum Sets of Systems for Mode 5 (Unflooded).....	19Q-50

Chapter 19

List of Tables (Continued)

Table 19Q-5	Minimum Sets of Systems for Mode 5 (Flooded)	19Q-50
Table 19Q-6	Shutdown Vulnerability Evaluation of new ABWR Features	19Q-51
Table 19QB-1	Time to Boiling for the RPV and RPV Plus SFP.....	19QB-5
Table 19QB-2	Time for RPV Water Level to Reach TAF	19QB-5
Table 19QB-3	Probability of Failure to Diagnose	19QB-5
Table 19QB-4	Probability of Failure to Start a Specified “Minimum-Set” System.....	19QB-6
Table 19QB-5	Control Room Alarms and Indications Aiding Diagnosis of “One RHR Lost”	19QB-6
Table 19QB-6	Times Available (in Hours).....	19QB-6
Table 19QC-1	Loss of Offsite Power Precursors.....	19QC-3
Table 19QC-2	Decay Heat Removal Precursors.....	19QC-14
Table 19R-1	Sources of Water.....	19R-30
Table 19R-2	Reactor Building Floor Descriptions	19R-32
Table 19R-3	ABWR Flood Frequency	19R-33
Table 19R-4	Reliability Data for ABWR Probabilistic Flood Analysis	19R-34
Table 19R-5	Conditional Failure Probability of Safe Shutdown.....	19R-35
Table 19R-6	Internal Flooding Core Damage Frequency (CDF)	19R-35
Table 19R-7	ABWR Features to Prevent/Mitigate Flooding.....	19R-36

Chapter 19

List of Figures

Figure 19.3-1	Overview of Methodology for Assessing Frequency of Core Damage and Fission Product Releases	19.3-31
Figure 19.3-2	Reactor Shutdown Event Tree	19.3-32
Figure 19B-1	Double Feedwater Nozzle-Thermal Sleeve	19B-125
Figure 19E.2-1	Simplified Sketch of N ₂ Supplies to Safety Grade ADS Valves.....	19E-179
Figure 19E.2-2a	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Vessel Pressure.....	19E-180
Figure 19E.2-2b	LCLP-PF-R-N: Loss of all core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Drywell Pressure.....	19E-181
Figure 19E.2-2c	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Gas Temperature.....	19E-182
Figure 19E.2-2d	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: UO ₂ Temperature.....	19E-183
Figure 19E.2-2e	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Water Mass.....	19E-184
Figure 19E.2-2f	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Mass of Non-Condensables.....	19E-185
Figure 19E.2-2g	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Noble Gases.....	19E-186
Figure 19E.2-2h	LCLP-PF-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Volatile Fission Products.....	19E-187
Figure 19E.2-2i	LCLP-PF-R-N: Loss of All Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Water Height	19E-188
Figure 19E.2-2j	LCLP-PF-R-N: Loss of All Core Cooling with Vessel Failure at Low Pressure, Passive Flooder Operates and Rupture Disk Opens: Water Temperature.....	19E-189

Chapter 19

List of Figures (Continued)

Figure 19E.2-3a	LCLP-FS-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Drywell Pressure.....	19E-190
Figure 19E.2-3b	LCLP-FS-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Gas Temperature.....	19E-191
Figure 19E.2-3c	LCLP-FS-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Water Mass.....	19E-192
Figure 19E.2-3d	LCLP-FS-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Noble Gas ...	19E-193
Figure 19E.2-3e	LCLP-FS-R-N: Loss of all Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Volatile Fission Products.....	19E-194
Figure 19E.2-3f	LCLP-FS-R-N: Loss of All Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Water Height	19E-195
Figure 19E.2-3g	LCLP-FS-R-N: Loss of All Core Cooling with Vessel Failure at Low Pressure, Firewater Spray Operates and Rupture Disk Opens: Water Temperature.....	19E-196
Figure 19E.2-4a	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Vessel Pressure.....	19E-197
Figure 19E.2-4b	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Drywell Pressure	19E-198
Figure 19E.2-4c	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: UO ₂ Temperature	19E-199
Figure 19E.2-4d	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Gas Temperature	19E-200
Figure 19E.2-4e	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: UO ₂ Mass	19E-201

Chapter 19

List of Figures (Continued)

Figure 19E.2-4f	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Water Mass.....	19E-202
Figure 19E.2-4g	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Global Mass.....	19E-203
Figure 19E.2-4h	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Noble Gases.....	19E-204
Figure 19E.2-4i	LCHP-PS-R-N: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder and Drywell Sprays Operate, Rupture Disk Opens: Volatiles	19E-205
Figure 19E.2-5a	LCHP-PF-P-M: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder Operates, Penetration Leakage: Drywell Pressure.....	19E-206
Figure 19E.2-5b	LCHP-PF-P-M: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder Operates, Penetration Leakage: Gas Temperature	19E-207
Figure 19E.2-5c	LCHP-PF-P-M: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder Operates, Penetration Leakage: UO ₂ Temperature	19E-208
Figure 19E.2-5d	LCHP-PF-P-M: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder Operates, Penetration Leakage: Water Mass	19E-209
Figure 19E.2-5e	LCHP-PF-P-M: Loss of all Core Cooling with Vessel Failure at High Pressure, Passive Flooder Operates, Penetration Leakage: Fission Product Release	19E-210
Figure 19E.2-6a	SBRC-FA-R-0: Station Blackout, RCIC Runs Eight Hours, Firewater Addition Prevents Core Damage, Rupture Disk Opens: Drywell Pressure.....	19E-211
Figure 19E.2-6b	SBRC-FA-R-0: Station Blackout, RCIC Runs Eight Hours, Firewater Addition Prevents Core Damage, Rupture Disk Opens: Water Temperature	19E-212
Figure 19E.2-6c	SBRC-FA-R-0: Station Blackout, RCIC Runs Eight Hours, Firewater Addition Prevents Core Damage, Rupture Disk Opens: UO ₂ Temperature	19E-213

Chapter 19

List of Figures (Continued)

Figure 19E.2-6d	SBRC-FA-R-0: Station Blackout, RCIC Runs Eight Hours, Firewater Addition Prevents Core Damage, Rupture Disk Opens: Vessel Water Height	19E-214
Figure 19E.2-6e	SBRC-FA-R-0: Station Blackout, RCIC Runs Eight Hours, Firewater Addition Prevents Core Damage, Rupture Disk Opens: Water Mass	19E-215
Figure 19E.2-7a	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: Vessel Pressure	19E-216
Figure 19E.2-7b	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: Drywell Pressure	19E-217
Figure 19E.2-7c	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: Gas Temperature	19E-218
Figure 19E.2-7d	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: UO ₂ Temperature	19E-219
Figure 19E.2-7e	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: Water Mass	19E-220
Figure 19E.2-7f	SBRC-PF-R-N: Station Blackout with RCIC Operating, Passive Flooder Operates and Rupture Disk Opens: Volatile Fission Product Release	19E-221
Figure 19E.2-8a	LHRC-00-R-0: Isolation with Loss of Containment Heat Removal and Rupture Disk Opens: Pressure	19E-222
Figure 19E.2-8b	LHRC-00-R-0: Isolation with Loss of Containment Heat Removal and Rupture Disk Opens: Water Temperature	19E-223
Figure 19E.2-8c	LHRC-00-R-0: Isolation with Loss of Containment Heat Removal and Rupture Disk Opens: Water Mass	19E-224
Figure 19E.2-9a	LBLC-PF-R-N: Large Break LOCA with Loss of all Core Cooling, Passive Flooder Operates and Rupture Disk Opens: Drywell Pressure	19E-225
Figure 19E.2-9b	LBLC-PF-R-N: Large Break LOCA with Loss of all Core Cooling, Passive Flooder Operates and Rupture Disk Opens: Gas Temperature	19E-226
Figure 19E.2-9c	LBLC-PF-R-N: Large Break LOCA with Loss of all Core Cooling, Passive Flooder Operates and Rupture Disk Opens: Water Mass	19E-227
Figure 19E.2-9d	LBLC-PF-R-N: Large Break LOCA with Loss of all Core Cooling, Passive Flooder Operates and Rupture Disk Opens: Volatile Fission Product Release	19E-228
Figure 19E.2-10a	NSCL-PF-R-N: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at Low Pressure, Passive Flooder and Rupture Disk: Drywell Pressure	19E-229

Chapter 19

List of Figures (Continued)

Figure 19E.2-10b	NSCL-PF-R-N: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at Low Pressure, Passive Flooder and Rupture Disk: UO ₂ Temperature.....	19E-230
Figure 19E.2-10c	NSCL-PF-R-N: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at Low Pressure, Passive Flooder and Rupture Disk: Water Mass	19E-231
Figure 19E.2-10d	NSCL-PF-R-N: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at Low Pressure, Passive Flooder and Rupture Disk: Volatile Fission Products.....	19E-232
Figure 19E.2-11a	NSCH-PF-P-M: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at High Pressure, Passive Flooder, Penetration Leakage: Drywell Pressure.....	19E-233
Figure 19E.2-11b	NSCH-PF-P-M: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at High Pressure, Passive Flooder, Penetration Leakage: Gas Temperature.....	19E-234
Figure 19E.2-11c	NSCH-PF-P-M: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at High Pressure, Passive Flooder, Penetration Leakage: UO ₂ Mass	19E-235
Figure 19E.2-11d	NSCH-PF-P-M: Concurrent Loss of all Core Cooling and ATWS with Vessel Failure at High Pressure, Passive Flooder, Penetration Leakage: Fission Products.....	19E-236
Figure 19E.2-12a	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: Vessel Pressure.....	19E-237
Figure 19E.2-12b	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: Drywell Pressure	19E-238
Figure 19E.2-12c	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: Power.....	19E-239
Figure 19E.2-12d	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: UO ₂ Temperature	19E-240
Figure 19E.2-12e	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: Water Mass.....	19E-241
Figure 19E.2-12f	NSRC-PF-R-N: Concurrent Station Blackout with ATWS, Passive Flooder Operates and Rupture Disk Opens: Volatile Fission Product Release.....	19E-242
Figure 19E.2-13	Steam Explosion Process.....	19E-243
Figure 19E.2-14a	Interfacial Instability.....	19E-244

Chapter 19

List of Figures (Continued)

Figure 19E.2-14b	Corium Stream in Liquid	19E-245
Figure 19E.2-15	Important Response Times	19E-246
Figure 19E.2-16	Self-Triggering Process	19E-247
Figure 19E.2-17	Conditions for Steam Explosion.....	19E-248
Figure 19E.2-18	Application to ABWR	19E-249
Figure 19E.2-19a	Suppression Pool Bypass Paths and Configurations	19E-250
Figure 19E.2-19b	Suppression Pool Bypass Paths and Configurations	19E-251
Figure 19E.2-19c	Suppression Pool Bypass Paths and Configurations	19E-252
Figure 19E.2-19d	Suppression Pool Bypass Paths and Configurations	19E-253
Figure 19E.2-19e	Suppression Pool Bypass Paths and Configurations	19E-254
Figure 19E.2-19f	Suppression Pool Bypass Paths and Configurations	19E-255
Figure 19E.2-19g	Suppression Pool Bypass Paths and Configurations	19E-256
Figure 19E.2-19h	Suppression Pool Bypass Paths and Configurations	19E-257
Figure 19E.2-19i	Suppression Pool Bypass Paths and Configurations	19E-258
Figure 19E.2-19j	Suppression Pool Bypass Paths and Configurations	19E-259
Figure 19E.2-19k	Suppression Pool Bypass Paths and Configurations	19E-260
Figure 19E.2-20a	Small LOCAs Outside Containment	19E-261
Figure 19E.2-20b	Intermediate LOCAs Outside Containment	19E-262
Figure 19E.2-20c	Large LOCAs Outside Containment	19E-263
Figure 19E.2-21	Sensitivity to Suppression Pool Decontamination Factor	19E-264
Figure 19E.2-22	Impact of COPS on Risk	19E-265
Figure 19E.2-23	Lower Drywell Flooder System	19E-266
Figure 19E.2-24	Flooder Valve Assembly	19E-267
Figure 19E.2-25	Limiting Configuration for COPS Blowdown Study	19E-268
Figure 19E.2-26a	Drywell Pressure for 100% Metal-Water Reaction Scenario	19E-269
Figure 19E.2-26b	Wetwell Pressure for 100% Metal-Water Reaction Scenario	19E-270

Chapter 19

List of Figures (Continued)

Figure 19E.2-26c	Drywell Temperature for 100% Metal-Water Reaction Scenario	19E-271
Figure 19E.2-26d	Vessel Temperature for 100% Metal-Water Reaction Scenario	19E-272
Figure 19E.2-26e	Suppression Pool Water Temperature for 100% Metal-Water Scenario.....	19E-273
Figure 19E.2-27a	Drywell Pressure for In-Vessel Core Melt Scenario	19E-274
Figure 19E.2-27b	Vessel Pressure for In-Vessel Core Melt Scenario.....	19E-275
Figure 19E.2-27c	Wetwell Pressure for In-Vessel Core Melt Scenario.....	19E-276
Figure 19E.2-27d	Drywell Temperature for In-Vessel Core Melt Scenario	19E-277
Figure 19E.2-27e	Vessel Temperature for In-Vessel Core Melt Scenario	19E-278
Figure 19E.2-27f	Suppression Pool Water Temperature for In-Vessel Core Melt.....	19E-279
Figure 19E.2-28a	Drywell Pressure for High Pressure Ex-Vessel Core Melt Scenario.....	19E-280
Figure 19E.2-28b	Vessel Pressure for Ex-Vessel High Pressure Core Melt Scenario	19E-281
Figure 19E.2-28c	Wetwell Pressure for Ex-Vessel High Pressure Core Melt Scenario	19E-282
Figure 19E.2-28d	Drywell Temperature for Ex-Vessel High Pressure Core Melt Scenario.....	19E-283
Figure 19E.2-28e	Vessel Temperature for Ex-Vessel High Pressure Core Melt	19E-284
Figure 19E.2-28f	Suppression Pool Water Temperature for High Pressure Ex-Vessel Core Melt Scenario.....	19E-285
Figure 19E.2-29a	Drywell Pressure for Low Pressure Ex-Vessel Core Melt Scenario	19E-286
Figure 19E.2-29b	Vessel Pressure for Ex-Vessel Low Pressure Core Melt Scenario.....	19E-287
Figure 19E.2-29c	Wetwell Pressure for Ex-Vessel Low Pressure Core Melt Scenario	19E-288
Figure 19E.2-29d	Drywell Temperature for Ex-Vessel Low Pressure Core Melt	19E-289
Figure 19E.2-29e	Vessel Temperature for Ex-Vessel Low Pressure Core Melt Scenario.....	19E-290
Figure 19E.2-29f	Suppression Pool Water Temperature for Low Pressure Ex-Vessel Core Melt Scenario.....	19E-291
Figure 19E.3-1	Whole Body Dose at 805 m (0.5 Mile) as Probability of Exceedence.....	19E-302
Figure 19EA-1	DCH Event Tree for Sequences with Low Containment Pressure.....	19EA-31
Figure 19EA-2	DCH Event Tree for Sequences with Intermediate Containment Pressure.....	19EA-32

Chapter 19

List of Figures (Continued)

Figure 19EA-3	DCH Event Tree for Sequences with High Containment Pressure	19EA-33
Figure 19EA-4	DET for Probability of Early Containment Failure—High RV Press and Low Cont Press Sequences.....	19EA-34
Figure 19EA-5	DET for Probability of Early Containment Failure—High RV Press and Inter Cont Press Sequences.....	19EA-35
Figure 19EA-6	DET for Probability of Early Containment Failure—High RV Press and High Cont Press Sequences	19EA-36
Figure 19EA-7	ABWR Containment Boundary Nomenclature	19EA-37
Figure 19EA-8	Calculated Probability Distribution Function for DCH Parameter F_{frag}	19EA-38
Figure 19EA-9	Comparison of Calculated and Assumed F_{frag} Distributions	19EA-39
Figure 19EA-10	Effective Drag Coefficient for Dense Dispersions	19EA-40
Figure 19EA-11	Zion Reactor Building	19EA-41
Figure 19EA-12	Schematic of Grand Gulf Containment	19EA-42
Figure 19EA-13	Comparison of Assumed Debris Discharge to ANL Data Fit	19EA-43
Figure 19EA-14	Cumulative Distribution for Peak Pressure Due to DCH	19EA-44
Figure 19EA-15	Uncertainty in Whole Body Dose at 805 m (0.5 Mile) Due to DCH	19EA-45
Figure 19EB-1	BETA V6.1 Configuration	19EB-25
Figure 19EB-2	HIPS Experimental Configuration.....	19EB-26
Figure 19EB-3	Peak Impulse Pressure from FCI	19EB-27
Figure 19EB-4	Maximum Response of Elastic-plastic One-degree Systems (Undamped) Due to Rectangular Load Pulses (Reference 19EB-18)	19EB-28
Figure 19EB-5	Rise Height of Water Missile	19EB-29
Figure 19EB-6	ABWR Containment Configuration	19EB-30
Figure 19EB-7	Pressure Head for Lower Drywell Flooder Flow	19EB-31
Figure 19EB-8	Ablated Radius of Vessel Failure	19EB-32
Figure 19EB-9	Mass Flow of Core Debris Through Vessel Failure	19EB-33
Figure 19EC-1	Core Debris Concrete Attack DET	19EC-28
Figure 19EC-2	Containment Event Evaluation DET for Pedestal Failure.....	19EC-29

Chapter 19

List of Figures (Continued)

Figure 19EC-3	Sample Calculation for CCI Upward Heat Flux 100 kW/m ² : Axial Concrete Attack	19EC-30
Figure 19EC-4	Sample Calculation for CCI Upward Heat Flux 100 kW/m ² : Wetwell Pressure.....	19EC-31
Figure 19EC-5	Sample Calculation for CCI Upward Heat Flux 100 kW/m ² : Upper Drywell Temperature.....	19EC-32
Figure 19EC-6	Sample Calculation for CCI Upward Heat Flux 100 kW/m ² : LDW Water Mass	19EC-33
Figure 19EC-7	Sample Calculation for CCI Upward Heat Flux 100 kW/m ² : Average Corium Temperature.....	19EC-34
Figure 19EC-8	Whole Body Dose at 805 m (0.5 Mile) as a Probability of Exceedence	19EC-35
Figure 19ED-1	Conceptual Design of Lower Drywell Floor Drain Sump Shield	19ED-32
Figure 19ED-2	Temperature Profile in Channel Region	19ED-33
Figure 19ED-3	Channel Flow Height Reduction During Freeze Process	19ED-34
Figure 19EE-1	Containment Event Evaluation DET for Suppression Pool Bypass	19EE-16
Figure 19EE-2	Impact of Aerosol Plugging Credit on Offsite Risk Measured by Whole Body Dose at 805 m (0.5 Mile) as Probability of Exceedence.....	19EE-17
Figure 19F-1	ABWR Reactor Building/ Primary Containment (0° - 180° Section View)	19F-19
Figure 19F-2	Primary Containment Configuration	19F-19
Figure 19F-3	FINEL Model	19F-20
Figure 19F-4	Drywell Head.....	19F-21
Figure 19F-5	Drywell Head Pressure Capability vs Temperature	19F-22
Figure 19F-6	Torispherical Head Buckling Test Data	19F-23
Figure 19F-7	Torispherical Head Buckling Test Data Statistical Distribution	19F-24
Figure 19F-8	Containment Liner Buckling	19F-25
Figure 19F-9	Definition of Squeeze for Seals	19F-26
Figure 19H-1	Typical Fragility Curves	19H-32
Figure 19L-1	Potential Paths for Draining RPV Through Control Rod Drive Hydraulic System	19L-44

Chapter 19

List of Figures (Continued)

Figure 19L-2	Potential Path for Draining RPV Through Reactor Water Cleanup System ...	19L-45
Figure 19L-3	Potential Path for Draining RPV Through Residual Heat Removal System (Pump On)	19L-46
Figure 19M-1	Phase I Qualitative Analysis Flow Chart.....	19M-27
Figure 19M-2	Phase II Qualitative Analysis Flow Chart	19M-28
Figure 19M-3	Division 1 Electrical Fire.....	19M-29
Figure 19M-4	Division 2 Electrical Fire.....	19M-30
Figure 19M-5	Division 3 Electrical Fire.....	19M-31
Figure 19M-6	Control Room Fire.....	19M-32
Figure 19M-7	Turbine Building Fire (Loss of Offsite Power and Station Blackout Event Tree).....	19M-33
Figure 19M-8	Loss of Offsite Power Event Tree (Recovery time: 30 min< t < 2 h)	19M-34
Figure 19M-9	Loss of Offsite Power Event Tree (Recovery time: 2 hrs< t < 8 h).....	19M-35
Figure 19M-10	Loss of Offsite Power Event Tree (Recovery time: t > 8 h).....	19M-36
Figure 19M-11	Station Blackout Event Tree (Recovery time: 30 min < t < 2 h).....	19M-37
Figure 19M-12	Station Blackout Event Tree (Recovery time: 2 hrs< t <8 h).....	19M-38
Figure 19M-13	Station Blackout Event Tree (Recovery time: t > 8 h)	19M-39
Figure 19N-1	Not Used.....	19N-19
Figure 19N-2	Not Used	19N-19
Figure 19N-3	Event Tree for Analysis of Common-Cause Failure of EMUX	19N-20
Figure 19N-4	Event Tree for Failure to Isolate Due to EMUX CCF	19N-21
Figure 19R-1	Control Building	19R-39
Figure 19R-2	Reactor Service Water System	19R-40
Figure 19R-3	Reactor Building Arrangement—Elevation -8200 mm (B3F).....	19R-41
Figure 19R-4	Reactor Building Arrangement—Elevation -1700 mm (B2F).....	19R-42
Figure 19R-5	Reactor Building Arrangement—Elevation 4800 mm (B1F).....	19R-43
Figure 19R-6	Reactor Building Arrangement—Elevation 12300 mm (1F)	19R-44

Chapter 19

List of Figures (Continued)

Figure 19R-7	Turbine Building Flooding (Low PCHS)	19R-45
Figure 19R-8	Turbine Building Flooding (High PCHS)	19R-46
Figure 19R-9	RSW Control Building Flood.....	19R-47
Figure 19R-10	Fire Water Flood in the Control Building	19R-48
Figure 19R-11	Reactor Building Flooding in ECCS Room	19R-49
Figure 19R-12	Reactor Building Flooding in Corridor	19R-50
Figure 19R-13	Fire Water Flood in the Reactor Building Outside Secondary Containment.....	19R-51

Chapter 20

Table of Contents

20.0	Question and Response Guide	20.1-1
20.1	Question Index	20.1-1
20.2	Questions	20.2-1
20.2.1	Chapter 1 Questions	20.2-2
20.2.2	Chapter 2 Questions	20.2-3
20.2.3	Chapter 3 Questions	20.2-4
20.2.4	Chapter 4 Questions	20.2-27
20.2.5	Chapter 5 Questions	20.2-31
20.2.6	Chapter 6 Questions	20.2-47
20.2.7	Chapter 7 Questions	20.2-65
20.2.8	Chapter 8 Questions	20.2-81
20.2.9	Chapter 9 Questions	20.2-101
20.2.10	Chapter 10 Questions	20.2-134
20.2.11	Chapter 11 Questions	20.2-140
20.2.12	Chapter 12 Questions	20.2-149
20.2.13	Chapter 13 Questions	20.2-155
20.2.14	Chapter 14 Questions	20.2-160
20.2.15	Chapter 15 Questions	20.2-161
20.2.16	Chapter 16 Questions	20.2-166
20.2.17	Chapter 17 Questions	20.2-167
20.2.18	Chapter 18 Questions	20.2-168
20.2.19	Chapter 19 Questions	20.2-176
20.3	Questions/Responses	20.3-1
20.3.1	Response to First RAI — Reference 1	20.3-2
20.3.2	Response to Second RAI — Reference 2	20.3-24
20.3.3	Response to Third RAI — Reference 3	20.3-101
20.3.4	Response to Fourth RAI — Reference 4	20.3-126
20.3.5	Response to Fifth RAI — Reference 5	20.3-162
20.3.6	Response to Sixth RAI — Reference 6	20.3-183
20.3.7	Response to Seventh RAI — Reference 7	20.3-207
20.3.8	Response to Eighth RAI — Reference 8	20.3-250
20.3.9	Response to Ninth RAI — Reference 9	20.3-353
20.3.10	Response to Tenth RAI — Reference 10	20.3-368
20.3.11	Response to Eleventh RAI — Reference 11	20.3-392
20.3.12	Response to Twelfth RAI — Reference 12	20.3-403
20.3.13	Response to Thirteenth RAI — Reference 13	20.3-412
20.3.14	Response to Fourteenth RAI — Reference 14	20.3-434
20.3.15	Response to Fifteenth RAI — Reference 15	20.3-466
20.3.16	Response to Sixteenth RAI — Reference 16	20.3-504
20.3.17	Response to Seventeenth RAI — Reference 17	20.3-542
20.4	References	20.4-1
20A	ODYNA/REDYA	20A-1
20A.1	ODYNA Changes	20A-1

Chapter 20

Table of Contents (Continued)

20A.2	REDYA Changes.....	20A-2
20A.3	Verification of Code Modifications.....	20A-5
20B	Equipment Data Base.....	20B-1

Chapter 20

List of Tables

Table 20.1-1	Identification Numbers for NRC Review Questions	20.1-31
Table 20.2-1	Comparison of requirements in ABWR standard safety analyses report and ABWR presentation to NRC staff (October 21 and 22, 1987)	20.2-36
Table 20.3.1-1	Sensitivity Study of Parameters for LOCA Analysis (Response to Question 470.4)	20.3-23
Table 20.3.2-1	Core Decay Heat Following LOCA Short-Term Analyses (Response to Question 430.21)	20.3-78
Table 20.3.2-2	Integrated Core Decay Heat Values Short-Term Analysis (Response to Question 430.21)	20.3-79
Table 20.3.2-3	Isolation Valve Arrangements Not Meeting the Explicit Requirements of GDC56 (Response to Question 430.41).....	20.3-80
Table 20.3.2-4	Line Whose Containment Isolation Requirements are Covered By GDC57 (Response to Question 430.44)	20.3-82
Table 20.3.2-5	Hot Startup Criticality Rod Sequence (Response to Question 440.11)	20.3-83
Table 20.3.3-1	Verification Matrix for SASSI Ver. 1.0 (Response to Question 220.3)	20.3-121
Table 20.3.3-2	Not Used.....	20.3-123
Table 20.3.4-1	Automatic Rod Movement (Response to Question 440.30)	20.3-156
Table 20.3.4-2	Manual Rod Movement (Response to Question 440.30)	20.3-156
Table 20.3.8-1	List of RCIC Equipment with Thermal Overload Relay Bypass (Response to Question 435.60).....	20.3-351
Table 20.3.16-1	Safety Related Valves Located in the Main Steam Tunnel (MST) (Response to Question 430.335	20.3-541
Table 20B-1	Equipment Data Base.....	20B-2

Chapter 20

List of Figures

Figure 20.3.2-1	Isolation Valve Arrangement of Standby Liquid Control System Line (Response to Question 430.40)	20.3-84
Figure 20.3.2-2	Rod Groups 1 – 4, Sequence A (Response to Question 440.11)	20.3-85
Figure 20.3.2-3	Rod Groups 5 – 10, Sequence A (Response to Question 440.11)	20.3-86
Figure 20.3.2-4	Hot Recovery Criticality Control (Response to Question 440.11)	20.3-87
Figure 20.3.2-5	5% Power Control Rod Pattern (Response to Question 440.11)	20.3-88
Figure 20.3.2-6	10% Power Control Rod Pattern (Response to Question 440.11)	20.3-89
Figure 20.3.2-7	25% Power Control Rod Pattern (Response to Question 440.11)	20.3-90
Figure 20.3.2-8	40% Power Control Rod Pattern (Response to Question 440.11)	20.3-91
Figure 20.3.2-9	53% Power Control Rod Pattern (Response to Question 440.11)	20.3-92
Figure 20.3.2-10	100% Power Control Rod Pattern (Response to Question 440.11)	20.3-93
Figure 20.3.2-11	Grouped HCU to Control Rod Drive Assignments (Response to Question 440.12).....	20.3-94
Figure 20.3.2-11a	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-95
Figure 20.3.2-11b	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-96
Figure 20.3.2-11c	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-97
Figure 20.3.2-11d	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-98
Figure 20.3.2-11e	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-99
Figure 20.3.2-11f	Drywell Pressure Versus Time (Response to Question 430.13).....	20.3-100
Figure 20.3.3-1	Shake Analysis Results – Soil Profile UB1D150 (Response to Question 220.8).....	20.3-124
Figure 20.3.3-2	Shake Analysis Results – Soil Profile VP2D150 (Response to Question 220.8).....	20.3-125
Figure 20.3.4-1	MSIV Closure with Flux Scram (Response to Question 440.14).....	20.3-157
Figure 20.3.4-2	Peak Vessel Pressure Versus Safety/Relief Valve Capacity (Response to Question 440.14).....	20.3-158
Figure 20.3.4-3	MSIV Closure-Flux Scram (Response to Question 440.16).....	20.3-159
Figure 20.3.4-4	Control Rod Drop Accident Scenario for FMCRD (Response To Question 440.32).....	20.3-160

Chapter 20

List of Figures (Continued)

Figure 20.3.4-5a	Low Pressure Core Flooder Sparger (Sheet 1)	20.3-161
Figure 20.3.4-5b	Low Pressure Core Flooder Sparger (Sheet 2)	20.3-161
Figure 20.3.4-5c	High Pressure Core Flooder Sparger (Response to Question 440.59).....	20.3-161
Figure 20.3.7-1	Stability Controls and Protection Logic (Response to Question 100.1)	20.3-247
Figure 20.3.7-2	Relationship Between Modes (Response to Question 100.1).....	20.3-248
Figure 20.3.7-3	Penetration Shielding Relationship to Core Midplane Dose (Response to Question 471.33).....	20.3-249
Figure 20.3.8-1	ABWR RPT Logic (Response to Question 420.106)	20.3-352
Figure 20.3.10-1	Simplified Functional Control Diagram of Turbine Digital Control and Monitoring System (Typical of One of Three Channels)	20.3-391
Figure 20.3.14-1	Relationship of System Training Material Preparation to Other Plant Design and Procurement Activities (Response to Question 620.8).....	20.3-465
Figure 20.3.15-1	Compressed Gas Systems Interconnections (Response to Question 430.217).....	20.3-503

Chapter 21 Volume 1

List of Figures

Figure 1.2-2	Reactor Building, Arrangement Elevation, Section A-A	21-1
Figure 1.2-2a	Reactor Building, Arrangement Elevation, Section B-B	21-2
Figure 1.2-3	Upper Drywell, Arrangement Elevation, Section A-A	21-3
Figure 1.2-3a	Upper Drywell, Arrangement Elevation, Section B-B	21-3
Figure 1.2-3b	Lower Drywell, Arrangement Elevation, Section A-A	21-4
Figure 1.2-3c	Wetwell, Arrangement Elevation, Sections A-A & B-B	21-5
Figure 1.2-4	Reactor Building, Arrangement Plan at Elevation -8200 mm	21-6
Figure 1.2-5	Reactor Building, Arrangement Plan at Elevation -1700 mm	21-7
Figure 1.2-6	Reactor Building, Arrangement Plan at Elevation 4800/8500 mm.....	21-8
Figure 1.2-8	Reactor Building, Arrangement Plan at Elevation 12300 mm.....	21-9
Figure 1.2-9	Reactor Building, Arrangement Plan at Elevation 18100 mm.....	21-10
Figure 1.2-10	Reactor Building, Arrangement Plan at Elevation 23500 mm.....	21-11
Figure 1.2-11	Reactor Building, Arrangement Plan at Elevation 27200 mm.....	21-12
Figure 1.2-12	Reactor Building, Arrangement Plan at Elevation 31700/38200 mm.....	21-13
Figure 1.2-13a	Drywell, Arrangement Plan at Elevation 12300 mm	21-14
Figure 1.2-13b	Drywell, Arrangement Plan at Elevation 15600 mm	21-15
Figure 1.2-13c	Drywell, Arrangement Plan at Elevation 18100 mm	21-16
Figure 1.2-13d	Drywell Steel Structure at Elevation 18100 mm.....	21-17
Figure 1.2-13e	Lower Drywell, Arrangement Plan at Elevation -6600 to -1850 mm.....	21-18
Figure 1.2-13f	Lower Drywell, Arrangement Plan at Elevation -1850 to 1750 mm	21-19
Figure 1.2-13g	Lower Drywell, Arrangement Plan at Elevation 1750 to 4800 mm	21-20
Figure 1.2-13h	Lower Drywell, Arrangement Plan at Elevation 4800 to 6700 mm	21-21
Figure 1.2-13i	Wetwell, Arrangement Plan at Elevation -8200 mm	21-22
Figure 1.2-13j	Wetwell, Arrangement Plan at Elevation -1700 mm	21-23
Figure 1.2-13k	Wetwell, Arrangement Plan at Elevation 4800 mm.....	21-24
Figure 1.2-14	Control and Service Building, Arrangement Elevation, Section A-A	21-25

Chapter 21 Volume 1

List of Figures (Continued)

Figure 1.2-15	Control and Service Building, Arrangement Elevation, Section B-B.....	21-26
Figure 1.2-16	Control Building, Arrangement Plan at Elevation -8200 mm.....	21-27
Figure 1.2-17	Control and Service Building, Arrangement Plan at Elevation -2150 mm.....	21-28
Figure 1.2-18	Control and Service Building, Arrangement Plan at Elevation 3500 mm	21-29
Figure 1.2-19	Control and Service Building, Arrangement Plan at Elevation 7900 mm	21-30
Figure 1.2-20	Control and Service Building, Arrangement Plan at Elevation 12300 mm	21-31
Figure 1.2-21	Control and Service Building, Arrangement Plan at Elevation 17150 mm	21-32
Figure 1.2-22	Control and Service Building, Arrangement Plan at Elevation 22200 mm	21-33
Figure 1.2-23a	Radwaste Building at Elevation -1500 mm	21-34
Figure 1.2-23b	Radwaste Building at Elevation 4800 mm.....	21-35
Figure 1.2-23c	Radwaste Building at Elevation 12300 mm.....	21-36
Figure 1.2-23d	Radwaste Building at Elevation 21000 mm.....	21-37
Figure 1.2-23e	Radwaste Building, Section A-A	21-38
Figure 1.2-24	Turbine Building, General Arrangement at Elevation 5300 mm	21-39
Figure 1.2-25	Turbine Building, General Arrangement at Elevation 12300 mm	21-40
Figure 1.2-26	Turbine Building, General Arrangement at Elevation 20300 mm	21-41
Figure 1.2-27	Turbine Building, General Arrangement at Elevation 30300 mm	21-42
Figure 1.2-28	Turbine Building, General Arrangement, Longitudinal Section A-A.....	21-43
Figure 1.2-29	Turbine Building, General Arrangement, Section B-B.....	21-44
Figure 1.2-30	Turbine Building, General Arrangement, Section C-C.....	21-45
Figure 1.2-31	Turbine Building, General Arrangement, Section D-D	21-46
Figure 1.7-1	Piping and Instrumentation Diagram Symbols (Sheets 1–2)	21-47
Figure 3H.1-23	Reactor Building Reactor Cavity Shield Blocks	21-49
Figure 3H.1-28	Configuration of RPV Pedestal	21-50
Figure 3H.1-29	Rebar Arrangement of F/P Girder and Slab (1/2)	21-51
Figure 3H.1-30	Containment Structure Wall Reinforcement.....	21-52

Chapter 21 Volume 1

List of Figures (Continued)

Figure 3H.1-31	Containment Structure Opening Reinforcement.....	21-53
Figure 3H.1-32	Containment Structure Opening Reinforcement.....	21-54
Figure 3H.1-33	Containment Structure Top Slab Reinforcement	21-55
Figure 3H.1-34	Reactor Building Foundation Reinforcement (Sheet 1).....	21-56
Figure 3H.1-35	Reactor Building Foundation Reinforcement (Sheet 2).....	21-57
Figure 3H.1-36	Diaphragm Floor Reinforcement	21-58
Figure 3H.1-37	List of Seismic Wall Sections	21-59
Figure 3H.2-21	Control Building Floor Plan at Elevation -8200 mm	21-60
Figure 3H.2-22	Control Building Framing Plan at Elevation -2150 mm	21-61
Figure 3H.2-23	Control Building Framing Plan at Elevation 3500 mm	21-62
Figure 3H.2-24	Control Building Framing Plan at Elevation 7900 mm	21-63
Figure 3H.2-25	Control Building Framing Plan at Elevation 12300 and 13100 mm.....	21-64
Figure 3H.2-26	Control Building Framing Plan at Elevation 17150 and 18250 mm.....	21-65
Figure 3H.2-27	Control Building Framing Plan at Elevation 22200 and 22750 mm.....	21-66
Figure 3H.2-28	Control Building Section.....	21-67
Figure 3H.2-29	Control Building Section and Details	21-68
Figure 3H.2-30	Control Building Details	21-69
Figure 3H.3-11	Radwaste Building, Reinforced Concrete Basemat	21-70
Figure 3H.3-12	Radwaste Building, Structural Steel Framing Plan, Typical Floor.....	21-71
Figure 3H.3-13	Radwaste Building, Structural Steel Framing Plan, Elevation 28000 mm	21-72
Figure 3H.3-14	Radwaste Building, Section A-A	21-73
Figure 3H.3-15	Radwaste Building, Exterior Walls Sections	21-74
Figure 3H.3-16	Radwaste Building, Sections and Details.....	21-75
Figure 4.6-8	Control Rod Drive System P&ID (Sheets 1–3)	21-76
Figure 4.6-9	Control Rod Drive System PFD.....	21-79
Figure 5.1-3	Nuclear Boiler System P&ID (Sheets 1–11).....	21-80

Chapter 21 Volume 1

List of Figures (Continued)

Figure 5.2-8	Leak Detection and Isolation System IED (Sheets 1–10).....	21-91
Figure 5.4-4	Reactor Recirculation System P&ID (Sheets 1–2)	21-101
Figure 5.4-5	Reactor Recirculation System PFD.....	21-103
Figure 5.4-8	Reactor Core Isolation Cooling System P&ID (Sheets 1–3)	21-104

Chapter 21 Volume 2

List of Figures

Figure 5.4-9	Reactor Core Isolation Cooling System PFD (Sheets 1–2)	21-107
Figure 5.4-10	Residual Heat Removal System P&ID (Sheets 1–7)	21-109
Figure 5.4-11	Residual Heat Removal System PFD (Sheets 1–2).....	21-116
Figure 5.4-12	Reactor Water Cleanup System P&ID (Sheets 1–4).....	21-118
Figure 5.4-13	Reactor Water Cleanup System PFD (Sheets 1–2).....	21-122
Figure 5.4-14	Reactor Water Cleanup System IBD (Sheets 1–11)	21-124
Figure 6.2-38	Group Classification and Containment Isolation Diagram (Sheets 1–2)	21-135
Figure 6.2-39	Atmospheric Control System P&ID (Sheets 1–3)	21-137
Figure 6.2-40	Flammability Control System P&ID (Sheets 1–2).....	21-140
Figure 6.3-1	High Pressure Core Flooder System PFD (Sheets 1–2).....	21-142
Figure 6.3-7	High Pressure Core Flooder System P&ID (Sheets 1–2).....	21-144
Figure 6.5-1	Standby Gas Treatment System P&ID (Sheets 1–3).....	21-146
Figure 6.7-1	High Pressure Nitrogen Gas Supply System P&ID	21-149
Figure 7.2-9	Reactor Protection System IED (Sheets 1–11)	21-150
Figure 7.2-10	Reactor Protection System IBD (Sheets 1–72)	21-161

Chapter 21 Volume 3

List of Figures

Figure 7.3-1	High Pressure Core Flooder System IBD (Sheets 1–17)	21-233
Figure 7.3-2	Nuclear Boiler System IBD (Sheets 1–37)	21-250
Figure 7.3-3	Reactor Core Isolation Cooling System IBD (Sheets 1–17)	21-287
Figure 7.3-4	Residual Heat Removal System IBD (Sheets 1–20)	21-304

Chapter 21 Volume 4

List of Figures

Figure 7.3-5	Leak Detection and Isolation System IBD (Sheets 1–77).....	21-324
Figure 7.3-6	Standby Gas Treatment System IBD (Sheets 1–11)	21-401
Figure 7.3-7	Reactor Building Cooling Water / Reactor Service Water System IBD (Sheets 1–19).....	21-412

Chapter 21 Volume 5

List of Figures

Figure 7.3-9	HVAC Emergency Cooling Water System IBD (Sheets 1–11)	21-431
Figure 7.3-10	High Pressure Nitrogen Gas System IBD (Sheets 1–3)	21-442
Figure 7.4-1	Standby Liquid Control System IBD (Sheets 1–6)	21-445
Figure 7.4-2	Remote Shutdown System IED.....	21-451
Figure 7.4-3	Remote Shutdown System IBD (Sheets 1–27)	21-452
Figure 7.6-1	Neutron Monitoring System IED (Sheets 1–4).....	21-479
Figure 7.6-2	Neutron Monitoring System IBD (Sheets 1–28).....	21-483
Figure 7.6-5	Process Radiation Monitoring System IED (Sheets 1–11)	21-511
Figure 7.6-7	Containment Atmospheric Monitoring System IED (Sheets 1–4).....	21-522
Figure 7.6-8	Containment Atmospheric Monitoring System IBD (Sheets 1–10)	21-526
Figure 7.6-11	Suppression Pool Temperature Monitoring System IED (Sheets 1–3).....	21-536
Figure 7.6-12	Suppression Pool Temperature Monitoring System IBD (Sheets 1–6)	21-539
Figure 7.7-2	Rod Control and Information System IED (Sheets 1–5)	21-545

Chapter 21 Volume 6

List of Figures

Figure 7.7-3	Rod Control and Information System IBD (Sheets 1–87)	21-550
Figure 7.7-4	Control Rod Drive System IBD (Sheets 1–8)	21-637
Figure 7.7-5	Recirculation Flow Control System IED (Sheets 1–2)	21-645
Figure 7.7-7	Recirculation Flow Control System IBD (Sheets 1–9)	21-647
Figure 7.7-8	Feedwater Control System IED (Sheets 1–3)	21-656
Figure 7.7-9	Feedwater Control System IBD (Sheets 1, 2, 2a, and 3–14).....	21-659
Figure 7.7-12	Steam Bypass and Pressure Control System IED (Sheets 1–2)	21-674
Figure 7.7-13	Steam Bypass and Pressure Control System IBD (Sheets 1–5).....	21-676
Figure 7.7-14	Fuel Pool Cooling and Cleanup System IBD (Sheets 1–8).....	21-681
Figure 8.2-1	Power Distribution System Routing Diagram (Sheets 1–7)	21-689

Chapter 21 Volume 7

List of Figures

Figure 8.3-1	Electrical Power Distribution System SLD (Sheets 1–3)	21-696
Figure 8.3-2	Instrument and Control Power Supply System SLD.....	21-699
Figure 8.3-3	Plant Vital AC Power Supply System SLD (Sheets 1–2).....	21-700
Figure 8.3-4	Plant DC Power Supply System SLD (Sheets 1–3).....	21-702
Figure 9.1-1	Fuel Pool Cooling and Cleanup System P&ID (Sheets 1–3).....	21-705
Figure 9.1-2	Fuel Pool Cooling and Cleanup System PFD (Sheets 1–2)	21-708
Figure 9.1-12	Plant Refueling and Servicing Sequence	21-710
Figure 9.2-1	Reactor Building Cooling Water System P&ID (Sheets 1–9)	21-711
Figure 9.2-1a	Not Used	
Figure 9.2-2	HVAC Normal Cooling Water System P&ID	21-720
Figure 9.2-3	HVAC Emergency Cooling Water System P&ID (Sheets 1–3)	21-721
Figure 9.2-4	Makeup Water System (Condensate) P&ID	21-724
Figure 9.2-5	Makeup Water System (Purified) P&ID (Sheets 1–3)	21-725
Figure 9.2-7	Reactor Service Water System P&ID (Sheets 1–3)	21-728
Figure 9.3-1	Standby Liquid Control System P&ID	21-731
Figure 9.3-1a	Standby Liquid Control System PFD.....	21-732
Figure 9.3-6	Instrument Air System P&ID (Sheets 1–2).....	21-733
Figure 9.3-7	Station Service Air System P&ID (Sheets 1–2).....	21-735
Figure 9.4-1	Control Building HVAC Flow Diagram (Sheets 1–5).....	21-737
Figure 9.4-2a	Turbine Building Ventilation System Air Flow Diagram.....	21-742
Figure 9.4-2b	Turbine Building Ventilation System Control Diagram (Sheets 1–2)	21-743
Figure 9.4-3	Secondary Containment HVAC System (Sheets 1–3)	21-745
Figure 9.4-4	R/B Safety-Related Electrical Equipment HVAC System (Sheets 1–3)	21-748
Figure 9.4-5	Reactor Internal Pump Control Panel Room HVAC System.....	21-751
Figure 9.4-8	Drywell Cooling System P&ID	21-752
Figure 9.4-10	Radwaste Building HVAC (Sheets 1–3).....	21-753

Chapter 21 Volume 7

List of Figures (Continued)

Figure 9.5-1	Suppression Pool Cleanup System P&ID	21-756
Figure 9.5-6	Standby Diesel Generator Fuel Oil and Combustion Air Intake and Exhaust Systems.....	21-757
Figure 9.5-7	Standby Diesel Generator Jacket Cooling Water System	21-758
Figure 9.5-8	Standby Diesel Generator Starting Air System.....	21-759
Figure 9.5-9	Standby Diesel Generator Lubricating Oil System.....	21-760
Figure 9A.4-1	Reactor Building Fire Protection at Elevation -8200 mm.....	21-761
Figure 9A.4-2	Reactor Building Fire Protection at Elevation -1700 mm.....	21-762
Figure 9A.4-3	Reactor Building Fire Protection at Elevation 4800/8500 mm.....	21-763
Figure 9A.4-4	Reactor Building Fire Protection at Elevation 12300 mm	21-764
Figure 9A.4-5	Reactor Building Fire Protection at Elevation 18100 mm	21-765
Figure 9A.4-6	Reactor Building Fire Protection at Elevation 23500 mm	21-766
Figure 9A.4-7	Reactor Building Fire Protection at Elevation 27200 mm	21-767
Figure 9A.4-8	Reactor Building Fire Protection at Elevation 31700/38200 mm.....	21-768
Figure 9A.4-9	Reactor Building Fire Protection, Section A-A	21-769
Figure 9A.4-10	Reactor Building Fire Protection, Section B-B	21-770
Figure 9A.4-11	Control Building Fire Protection, Section B-B	21-771
Figure 9A.4-12	Control Building Fire Protection at Elevation -8200 mm	21-772
Figure 9A.4-13	Control Building Fire Protection at Elevation -2150 mm.....	21-773
Figure 9A.4-14	Control Building Fire Protection at Elevation 3500 mm	21-774
Figure 9A.4-15	Control Building Fire Protection at Elevation 7900 mm	21-775

Chapter 21 Volume 8

List of Figures

Figure 9A.4-16	Control Building Fire Protection at Elevation 12300 mm	21-776
Figure 9A.4-16a	Control Building Fire Protection at Elevation 17150 mm	21-777
Figure 9A.4-16b	Control Building Fire Protection at Elevation 22200 mm	21-778
Figure 9A.4-17	Turbine Building Fire Protection, Section A-A	21-779
Figure 9A.4-18	Turbine Building Fire Protection at Elevation 5300 mm.....	21-780
Figure 9A.4-19	Turbine Building Fire Protection at Elevation 12300 mm.....	21-781
Figure 9A.4-20	Turbine Building Fire Protection at Elevation 20300 mm.....	21-782
Figure 9A.4-21	Turbine Building Fire Protection at Elevation 30300 mm.....	21-783
Figure 9A.4-22	Service Building Fire Protection, Section B-B (See Figure 9A.4-11)	21-771
Figure 9A.4-23	Service Building Fire Protection at Elevation -2150 mm (See Figure 9A.4-13)....	21-773
Figure 9A.4-24	Service Building Fire Protection at Elevation 3500 mm (See Figure 9A.4-14)	21-774
Figure 9A.4-25	Service Building Fire Protection at Elevation 7900 mm (See Figure 9A.4-15)	21-775
Figure 9A.4-26	Service Building Fire Protection at Elevation 12300 mm (See Figure 9A.4-16) ...	21-776
Figure 9A.4-27	Service Building Fire Protection at Elevation 17150 mm (See Figure 9A.4-16a).....	21-777
Figure 9A.4-28	Radwaste Building Fire Protection, Section A-A	21-784
Figure 9A.4-29	Radwaste Building Fire Protection at Elevation -1500 mm.....	21-785
Figure 9A.4-30	Radwaste Building Fire Protection at Elevation 4800 mm	21-786
Figure 9A.4-31	Radwaste Building Fire Protection at Elevation 12300 mm.....	21-787
Figure 9A.4-32	Radwaste Building Fire Protection at Elevation 21000 mm.....	21-788
Figure 10.1-2	Reference Heat Balance for Guaranteed Reactor Rating	21-789
Figure 10.1-3	Reference Heat Balance for Valves-Wide-Open (VWO)	21-790
Figure 11.2-1	Radwaste System PFD	21-791
Figure 11.3-1	Offgas System PFD (Sheets 1–2).....	21-792
Figure 11.3-2	Offgas System P&ID (Sheets 1–3)	21-794
Figure 12.3-1	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation -8200 mm (B3F)	21-797

Chapter 21 Volume 8

List of Figures (Continued)

Figure 12.3-2	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation -1700 mm (B2F)	21-798
Figure 12.3-3	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 4800/8500 mm (B1F).....	21-799
Figure 12.3-5	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 12300 mm (1F)	21-800
Figure 12.3-6	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 18100 mm (2F)	21-801
Figure 12.3-7	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 23500 mm (3F)	21-802
Figure 12.3-8	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 27200 mm (3.5F)	21-803
Figure 12.3-9	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 31700/38200 mm (4FM).....	21-804
Figure 12.3-10	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation, Section A-A.....	21-805
Figure 12.3-11	Reactor Building Radiation Zone Map for Full Power and Shutdown Operation, Section B-B	21-806
Figure 12.3-12	Reactor Building Radiation Zone Map Post LOCA at Elevation -8200 mm (B3F)	21-807
Figure 12.3-13	Reactor Building Radiation Zone Map Post LOCA at Elevation -1700 mm (B2F)	21-808
Figure 12.3-14	Reactor Building Radiation Zone Map Post LOCA at Elevation 4800/8500 mm (B1F).....	21-809
Figure 12.3-16	Reactor Building Radiation Zone Map Post LOCA at Elevation 12300 mm (1F)	21-810
Figure 12.3-17	Reactor Building Radiation Zone Map Post LOCA at Elevation 18100 mm (2F)	21-811
Figure 12.3-18	Reactor Building Radiation Zone Map Post LOCA at Elevation 23500 mm (3F)	21-812
Figure 12.3-19	Reactor Building Radiation Zone Map Post LOCA at Elevation 27200 mm (3.5F)	21-813
Figure 12.3-20	Reactor Building Radiation Zone Map Post LOCA at Elevation 31700/38200 mm (4FM).....	21-814

Chapter 21 Volume 8

List of Figures (Continued)

Figure 12.3-21	Reactor Building Radiation Zone Map Post LOCA, Section A-A	21-815
Figure 12.3-22	Reactor Building Radiation Zone Map Post LOCA, Section B-B.....	21-816
Figure 12.3-37	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation -1500 mm	21-817
Figure 12.3-38	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation -4800 mm	21-818
Figure 12.3-39	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 12300 mm	21-819
Figure 12.3-40	Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 21000 mm	21-820
Figure 12.3-41	Radwaste Building, Radiation Zone Map, Normal Operation, Section A-A.....	21-821
Figure 12.3-42	Control Building, Radiation Zone, Normal Operation at Elevation -8200 mm.....	21-822
Figure 12.3-43	Control and Service Building, Radiation Zone, Normal Operation at Elevation -2150 mm	21-823
Figure 12.3-44	Control and Service Building, Radiation Zone, Normal Operation at Elevation 3500 mm	21-824
Figure 12.3-45	Control and Service Building, Radiation Zone, Normal Operation at Elevation 7900 mm	21-825
Figure 12.3-46	Control and Service Building, Radiation Zone, Normal Operation at Elevation 12300 mm	21-826
Figure 12.3-47	Control and Service Building, Radiation Zone, Normal Operation at Elevation 17150 mm	21-827
Figure 12.3-48	Control and Service Building, Radiation Zone, Normal Operation, Side View, Cross Section B-B	21-828
Figure 12.3-49	Turbine Building, Radiation Zone at Elevation 5300 mm.....	21-829
Figure 12.3-50	Turbine Building, Radiation Zone at Elevation 12300 mm.....	21-830
Figure 12.3-51	Turbine Building, Radiation Zone at Elevation 20300 mm.....	21-831
Figure 12.3-52	Turbine Building, Radiation Zone at Elevation 30300 mm.....	21-832
Figure 12.3-53	Turbine Building, Radiation Zone at Normal Operation Longitudinal Section A-A.....	21-833
Figure 12.3-54	Control and Service Building, Radiation Zone, Post LOCA, Section B-B.....	21-834

Chapter 21 Volume 8

List of Figures (Continued)

Figure 12.3-55	Turbine Building, Radiation Zone, Post LOCA, Longitudinal Section A-A.....	21-835
Figure 12.3-56	Reactor Building, Area Radiation Monitors at Elevation -8200 mm.....	21-836
Figure 12.3-57	Reactor Building, Area Radiation Monitors at Elevation -1700 mm.....	21-837
Figure 12.3-58	Reactor Building, Area Radiation Monitors at Elevation 4800/8500 mm.....	21-838
Figure 12.3-59	Reactor Building, Area Radiation Monitors at Elevation 12300 mm.....	21-839
Figure 12.3-60	Reactor Building, Area Radiation Monitors at Elevation 23500 mm.....	21-840
Figure 12.3-61	Reactor Building, Area Radiation Monitors at Elevation 27200 mm.....	21-841
Figure 12.3-62	Reactor Building, Area Radiation Monitors at Elevation 31700/38200 mm.....	21-842
Figure 12.3-63	Reactor Building, Area Radiation Monitors, Section B-B.....	21-843
Figure 12.3-64	Control and Service Buildings, Area Radiation Monitors, Section B-B.....	21-844
Figure 12.3-65	Radwaste Building, Area Radiation Monitors at Elevation -1500 mm	21-845
Figure 12.3-66	Radwaste Building, Area Radiation Monitors at Elevation 4800 mm.....	21-846
Figure 12.3-67	Radwaste Building, Area Radiation Monitors at Elevation 12300 mm.....	21-847
Figure 12.3-68	Radwaste Building, Area Radiation Monitors at Elevation 21000 mm.....	21-848
Figure 12.3-70	Turbine Building, Area Radiation Monitors at Elevation 12300 mm.....	21-849
Figure 12.3-71	Turbine Building, Area Radiation Monitors at Elevation 20300 mm.....	21-850
Figure 12.3-72	Turbine Building, Area Radiation Monitors at Elevation 30300 mm.....	21-851
Figure 12.3-73	Turbine Building, Area Radiation Monitors, Longitudinal Section A-A	21-852
Figure 15B-3	Fine Motion Control Rod Drive.....	21-853
Figure 18C-5	Arrangement of Equipment of Main Control Console.....	21-854
Figure 18C-7	Fixed-Position Display	21-855
Figure 20.3.4-5a	Low Pressure Core Flooder Sparger (Sheet 1).....	21-856
Figure 20.3.4-5b	Low Pressure Core Flooder Sparger (Sheet 2).....	21-857
Figure 20.3.4-5c	High Pressure Core Flooder Sparger.....	21-858