

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
CHAPTER 7	INSTRUMENTATION AND CONTROLS.....	7.1-1
7.1	Introduction.....	7.1-1
7.1.1	The AP1000 Instrumentation and Control Architecture	7.1-2
7.1.2	Protection and Safety Monitoring System.....	7.1-5
7.1.2.1	Plant Protection Subsystems.....	7.1-5
7.1.2.2	Engineered Safety Features Coincidence Logic	7.1-5
7.1.2.3	Engineered Safety Features Actuation Subsystems	7.1-6
7.1.2.4	Reactor Trip Switchgear.....	7.1-6
7.1.2.5	Qualified Data Processing Subsystems.....	7.1-6
7.1.2.6	Main Control Room Multiplexers	7.1-6
7.1.2.7	Sensors	7.1-6
7.1.2.8	Communication Functions	7.1-7
7.1.2.9	Fault Tolerance, Maintenance, Test, and Bypass	7.1-7
7.1.2.10	Isolation Devices	7.1-7
7.1.2.11	Test Subsystem.....	7.1-8
7.1.2.12	Safety-Related Display Instrumentation	7.1-8
7.1.2.13	Auxiliary Supporting Systems.....	7.1-8
7.1.2.14	Verification and Validation	7.1-8
7.1.3	Plant Control System	7.1-10
7.1.3.1	Distributed Controllers.....	7.1-11
7.1.3.2	Signal Selector Algorithms.....	7.1-11
7.1.3.3	Operator Controls and Indication	7.1-12
7.1.3.4	Real-Time Data Network.....	7.1-12
7.1.3.5	Rod Control System	7.1-12
7.1.3.6	Rod Position Indication	7.1-13
7.1.3.7	Rod Drive Motor-Generator Sets.....	7.1-13
7.1.4	Identification of Safety Criteria.....	7.1-13
7.1.4.1	Conformance of the Safety System Instrumentation to Applicable Criteria	7.1-13
7.1.4.2	Conformance With Industry Standards	7.1-14
7.1.5	AP1000 Protective Functions	7.1-14
7.1.6	Combined License Information.....	7.1-15
7.1.7	References.....	7.1-15
7.2	Reactor Trip	7.2-1
7.2.1	Description.....	7.2-1
7.2.1.1	Functional Description	7.2-2
7.2.1.2	Design Basis for Reactor Trips.....	7.2-11
7.2.1.3	System Drawings.....	7.2-13
7.2.2	Analyses.....	7.2-14
7.2.2.1	Failure Modes and Effects Analysis (FMEA)	7.2-14
7.2.2.2	Conformance of the Reactor Trip Function to Applicable Criteria	7.2-14

TABLE OF CONTENTS (Cont.)

<u>Section</u>	<u>Title</u>	<u>Page</u>
	7.2.3 Combined License Information.....	7.2-16
	7.2.4 References.....	7.2-17
7.3	Engineered Safety Features	7.3-1
	7.3.1 Description.....	7.3-1
	7.3.1.1 Safeguards Actuation (S) Signal	7.3-2
	7.3.1.2 Engineered Safety Feature Descriptions.....	7.3-3
	7.3.1.3 Blocks, Permissives, and Interlocks for Engineered Safety Features Actuation.....	7.3-21
	7.3.1.4 Bypasses of Engineered Safety Features Actuation.....	7.3-21
	7.3.1.5 Design Basis for Engineered Safety Features Actuation	7.3-21
	7.3.1.6 System Drawings.....	7.3-23
	7.3.2 Analysis for Engineered Safety Features Actuation.....	7.3-23
	7.3.2.1 Failure Modes and Effects Analyses	7.3-23
	7.3.2.2 Conformance of Engineered Safety Features to the Requirements of IEEE 603-1991	7.3-23
	7.3.3 Combined License Information.....	7.3-25
	7.3.4 References.....	7.3-25
7.4	Systems Required for Safe Shutdown	7.4-1
	7.4.1 Safe Shutdown.....	7.4-3
	7.4.1.1 Safe Shutdown Using Safety-Related Systems.....	7.4-3
	7.4.1.2 Safe Shutdown Using Safety-Related and Nonsafety-Related Systems.....	7.4-5
	7.4.1.3 Safe Shutdown Using Nonsafety-Related Systems.....	7.4-6
	7.4.2 Safe Shutdown Systems.....	7.4-9
	7.4.2.1 Passive Core Cooling System.....	7.4-9
	7.4.2.2 Passive Containment Cooling System.....	7.4-10
	7.4.2.3 Containment Isolation	7.4-10
	7.4.2.4 Reactor Coolant System Circulation.....	7.4-10
	7.4.2.5 Other Systems Required for Safe Shutdown	7.4-10
	7.4.3 Safe Shutdown from Outside the Main Control Room	7.4-11
	7.4.3.1 Description	7.4-11
	7.4.3.2 Analysis.....	7.4-13
	7.4.4 Combined License Information.....	7.4-14
	7.4.5 References.....	7.4-14
7.5	Safety-Related Display Information	7.5-1
	7.5.1 Introduction.....	7.5-1
	7.5.2 Variable Classifications and Requirements.....	7.5-1
	7.5.2.1 Variable Types	7.5-2
	7.5.2.2 Variable Categories	7.5-4
	7.5.3 Description of Variables	7.5-9
	7.5.3.1 Type A Variables	7.5-9
	7.5.3.2 Type B Variables.....	7.5-9
	7.5.3.3 Type C Variables.....	7.5-10

TABLE OF CONTENTS (Cont.)

<u>Section</u>	<u>Title</u>	<u>Page</u>
	7.5.3.4 Type D Variables	7.5-10
	7.5.3.5 Type E Variables	7.5-10
	7.5.3.6 Type F Variables	7.5-11
7.5.4	Processing and Display Equipment.....	7.5-11
7.5.5	Combined License Information.....	7.5-12
7.6	Interlock Systems Important to Safety.....	7.6-1
7.6.1	Prevention of Overpressurization of Low-Pressure Systems.....	7.6-1
	7.6.1.1 Description of Normal Residual Heat Removal Isolation Valve Interlocks	7.6-1
	7.6.1.2 Analysis of Normal Residual Heat Removal Valve Interlocks.....	7.6-2
7.6.2	Availability of Engineered Safety Features.....	7.6-2
	7.6.2.1 Passive Residual Heat Removal Heat Exchanger Inlet Isolation Valve	7.6-2
	7.6.2.2 Core Makeup Tank Cold Leg Balance Line Isolation Valves.....	7.6-3
	7.6.2.3 Interlocks for the Accumulator Isolation Valve and IRWST Discharge Valve.....	7.6-5
	7.6.2.4 Interlock for Containment Vacuum Relief Isolation Valves.....	7.6-5
7.6.3	Combined License Information.....	7.6-6
7.7	Control and Instrumentation Systems.....	7.7-1
7.7.1	Description.....	7.7-2
	7.7.1.1 Reactor Power Control System.....	7.7-3
	7.7.1.2 Rod Control System	7.7-5
	7.7.1.3 Control Rod Position Monitoring	7.7-6
	7.7.1.4 Control Rod Insertion Limits.....	7.7-7
	7.7.1.5 Control Rod Stops	7.7-8
	7.7.1.6 Pressurizer Pressure Control System	7.7-8
	7.7.1.7 Pressurizer Water Level Control System	7.7-9
	7.7.1.8 Feedwater Control System.....	7.7-9
	7.7.1.9 Steam Dump Control System	7.7-10
	7.7.1.10 Rapid Power Reduction System	7.7-12
	7.7.1.11 Diverse Actuation System	7.7-14
	7.7.1.12 Signal Selector Algorithm	7.7-19
7.7.2	Analysis	7.7-20
7.7.3	Combined License Information.....	7.7-21

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
7.2-1	Reactor Trip Variables, Limits, Ranges, and Accuracies (Design Basis for Reactor Trip) (Nominal) (Sheets 1 – 3)	7.2-18
7.2-2	Reactor Trips (Sheets 1 – 2).....	7.2-21
7.2-3	Reactor Trip Permissives and Interlocks (Sheets 1 – 2)	7.2-23
7.2-4	System-Level Manual Inputs to the Reactor Trip Functions	7.2-25
7.2-5	Figure 7.2-1 Cross References	7.2-26
7.3-1	Engineered Safety Features Actuation Signals (Sheets 1 – 9).....	7.3-26
7.3-2	Interlocks for Engineered Safety Features Actuation System (Sheets 1 – 4).....	7.3-35
7.3-3	System-Level Manual Input to the Engineered Safety Features Actuation System (Sheets 1 – 2).....	7.3-39
7.3-4	Engineered Safety Features Actuation, Variables, Limits, Ranges, and Accuracies (Nominal) (Sheets 1 – 2).....	7.3-41
7.4-1	Systems Required for Safe Shutdown	7.4-15
7.5-1	Post-Accident Monitoring System (Sheets 1 – 12).....	7.5-13
7.5-2	Summary of Selection of Criteria	7.5-25
7.5-3	Summary of Qualification, Design, and Interface Requirements	7.5-26
7.5-4	Summary of Type A Variables	7.5-27
7.5-5	Summary of Type B Variables	7.5-28
7.5-6	Summary of Type C Variables	7.5-29
7.5-7	Summary of Type D Variables (Sheets 1 – 4).....	7.5-30
7.5-8	Summary of Type E Variables	7.5-34
7.5-9	Summary of Type F Variables (Sheets 1 – 4).....	7.5-35
7.7-1	Rod Control System Interlocks - Power Control Subsystem	7.7-22
7.7-2	Rod Control System Interlocks - Axial Offset Control Subsystem.....	7.7-23
7.7-3	Cross Reference Table for Defense-in-Depth Functions Supported by the Plant Control System (Sheets 1 – 3).....	7.7-24

LIST OF FIGURES

<u>Figure No.</u>	<u>Title</u>	<u>Page</u>
7.1-1	Instrumentation and Control Architecture	7.1-17
7.1-2	Common Q Standard Process and AP1000 Project-Specific Documents.....	7.1-19
7.1-3	(Figures 7.1-3 through 7.1-11 Not Used)	
7.2-1	Functional Diagram Index and Symbols (Sheet 1 of 21).....	7.2-27
7.2-1	Functional Diagram Reactor Trip Functions (Sheet 2 of 21)	7.2-29
7.2-1	Functional Diagram Nuclear Startup Protection (Sheet 3 of 21).....	7.2-31
7.2-1	Functional Diagram Nuclear Overpower Protection (Sheet 4 of 21).....	7.2-33
7.2-1	Functional Diagram Core Heat Removal Protection and Reactor Coolant Pump Trip (Sheet 5 of 21).....	7.2-35
7.2-1	Functional Diagram Primary Overpressure & Loss of Heat Sink Protection (Sheet 6 of 21).....	7.2-37
7.2-1	Functional Diagram Loss of Heat Sink Protection (Sheet 7 of 21).....	7.2-39
7.2-1	Functional Diagram Loss of Heat Sink Protection (Sheet 8 of 21).....	7.2-41
7.2-1	Functional Diagram Steam Line Isolation (Sheet 9 of 21)	7.2-43
7.2-1	Functional Diagram Feedwater Isolation (Sheet 10 of 21).....	7.2-45
7.2-1	Functional Diagram Safeguards Actuation (Sheet 11 of 21).....	7.2-47
7.2-1	Functional Diagram Core Makeup Tank Actuation (Sheet 12 of 21).....	7.2-49
7.2-1	Functional Diagram Containment and Other Protection (Sheet 13 of 21).....	7.2-51
7.2-1	Functional Diagram Turbine Trip (Sheet 14 of 21).....	7.2-53
7.2-1	Functional Diagram Automatic RCS Depressurization Valve Sequencing (Sheet 15 of 21)	7.2-55
7.2-1	Functional Diagram In-containment Refueling Water Storage Tank Actuators (Sheet 16 of 21)	7.2-57
7.2-1	Functional Diagram Passive Residual Heat Removal and Core Makeup Tank Isolation Valve Interlocks (Sheet 17 of 21).....	7.2-59
7.2-1	Functional Diagram Normal Residual Heat Removal System Isolation Valve Interlocks (Sheet 18 of 21).....	7.2-61
7.2-1	Functional Diagram Containment Vacuum Relief Protection (Sheet 19 of 21).....	7.2-63
7.2-1	Functional Diagram Diverse Actuation System Logic Automatic Actuations (Sheet 20 of 21).....	7.2-65
7.2-1	Functional Diagram Diverse Actuation System Logic, Manual Actuations (Sheet 21 of 21).....	7.2-67