2.4 Instrumentation and Control Systems

2.4.1 Protection System

1.0 Description

The protection system (PS) is provided to sense conditions requiring protective action and automatically initiate the safety systems required to mitigate the event.

The PS provides the following safety related functions:

- Performs automatic initiation of reactor trip (RT) functions.
- Performs automatic initiation of engineered safety feature (ESF) functions.
- Provides for manual initiation of RT.
- Provides for manual actuation of ESF functions.
- Generates permissive signals that authorize the activation or deactivation of certain protective actions according to current plant conditions.
- Generates permissive signals that maintain safety related interlocks.

2.0 Arrangement

2.1 The location of the safety related PS equipment is as listed in Table 2.4.1-1—Protection System Equipment.

2.2 Physical separation exists between the four divisions of the PS.

3.0 Mechanical Design Features

3.1 Equipment identified as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.

4.0 I&C Design Features, Displays and Controls

4.1 The PS generates an automatic RT signal for each of the parameters identified in Table 2.4.1-3—Protection System Automatic Reactor Trips.

4.2 The PS generates automatically actuated engineered safety feature signals, as identified in Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features.

4.3 The PS provides operating bypasses for the functions identified in Table 2.4.1-6—Protection System Operating Bypasses.

4.4 Communication independence is provided in the inter-division communication paths within the PS.

4.5 Bypassed or inoperable PS channels status information is retrievable in the MCR.

4.6 Setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a methodology that addresses the determination of applicable contributors to instrumentation loop errors, the method in which the errors are combined, and how the errors are applied to the design analytical limits.

4.7 The PS receives input signals from the sources listed in Table 2.4.1-2—Protection System Input Signals.

4.8 The PS provides signals to the non safety related control systems through electrical isolation devices.

4.9 Electrical isolation devices exist in the data communication paths between the PS and the non safety related displays and controls.

4.10 The PS equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to electromagnetic interference (EMI), radio-frequency interference (RFI), electrostatic discharges (ESD), and power surges.

4.11 Controls exist in the MCR to allow manual actuation at the system level of the functions identified in Table 2.4.1-5—Protection System Manually Actuated Functions.

4.12 Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives listed in Table 2.4.1-7—Protection System Permissives.

4.13 The PS interlocks exist as provided in Table 2.4.1-8— Protection System Interlocks.

4.14 The PS hardware and software are developed using a design process composed of five life cycle phases with each phase having design outputs which must conform to the requirements of that phase. The five life cycle phases are the following:

1. Basic design phase.
2. Detailed design phase.
3. Manufacturing phase.
4. Testing phase.
5. Installation and commissioning phase.

4.15 Controls exist in the RSS that allow manual actuation of RT.

5.0 Electrical Power Design Features

5.1 The components identified as Class1E in Table 2.4.1-1 are powered from the Class 1E division as listed in Table 2.4.1-1 in a normal or alternate feed condition.

6.0 System Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.1-9 lists the PS ITAAC.

Table 2.4.1-1—Protection System Equipment

Equipment Description	Equipment Tag Number (1)	Equipment Location	Seismic Category I	IEEE Class 1E(2)
PS Cabinets, Division 1	30CLE	Safeguard Building 1	Yes	1^N 2^A
PS Cabinets, Division 2	30CLF	Safeguard Building 2	Yes	2^N 1^A
PS Cabinets, Division 3	30CLG	Safeguard Building 3	Yes	3^N 4^A
PS Cabinets, Division 4	30CLH	Safeguard Building 4	Yes	4^N 3^A

1) Equipment Tag numbers are provided for information and are not part of the design certification.

2) ^{N} denotes the division the component is normally powered from. ^{A} denotes the division the component is powered from when alternate feed is implemented.

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
1	Neutron Flux from Self Powered Neutron Detectors (SPND)	JKS	4	Yes
2	Neutron Flux from Power Range Detector (PRD)	JKT	4	Yes
3	Neutron Flux from Intermediate Range Detector (IRD)	JKT	4	Yes
4	Rod Control Cluster Assembly (RCCA) positions	JDA	4	Yes
5	Pressurizer (PZR) Pressure-Narrow Range (NR)	JEF	4	Yes
6	PZR Level	JEF	4	Yes
7	Cold Leg Temperature (NR)	JEC	4	Yes
8	Cold Leg Temperature Wide Range (WR)	JEC	4	Yes
9	Hot Leg (HL) Temperature (NR)	JEC	4	Yes
10	Hot Leg Temperature (WR)	JEC	4	Yes
11	Hot Leg Pressure (WR)	JNA	4	Yes
12	Reactor Coolant Pump (RCP) Speed Sensor	JEB	4	Yes
13	RCP power supply current	JEB	4	Yes
14	RCS (Reactor Coolant System) Loop Flow Rate	JEC	4	Yes
15	RCS Loop Level	JEC	4	Yes
16	Chemical and Volume Control System (CVCS) Boron Concentration Measurement	KBA	4	Yes

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
17	CVCS Charging Flow	KBD	4	Yes
18	Steam Generator (SG) Pressure	LBA	4	Yes
19	SG Level (NR)	JEA	4	Yes
20	SG Level (WR)	JEA	4	Yes
21	Containment Equipment Compartments Pressure	KLA	4	Yes
22	Containment Service Compartments Pressure (NR)	KLA	4	Yes
23	Containment Service Compartments Pressure (WR)	KLA	4	Yes
24	Differential Pressure Across RCP	JEC	4	Yes
25	6.9 kV Bus Voltage	BD	4	Yes
26	Reactor Trip Breaker Position	BU	4	Yes
27	Main Steam Line Activity	LBA	4	Yes
28	Main Control Room (MCR) Air Intake Activity	KLK	4	Yes
29	Containment High Range Activity	JYK	4	Yes
30	Manual Reactor Trip	CWY	4	Yes
31	Manual Partial Cooldown Actuation	CWY	4	Yes
32	Manual Main Steam Relief Train (MSRT) Actuation	CWY	4	Yes
33	Manual MSRT Isolation	CWY	4	Yes
34	Manual MSIV Isolation	CWY	4	Yes
35	Manual MFW Isolation	CWY	4	Yes

Table 2.4.1-2—Protection System Input Signals (3 Sheets)

Item #	Signal	Source	# Divisions	IEEE Class 1E
36	Manual Containment Isolation	CWY	4	Yes
37	Manual SG Isolation	CWY	4	Yes
38	Manual MCR Air Intake Isolation and Filtering	CWY	4	Yes
39	Manual EDG Actuation	CWY	4	Yes
40	Manual Safety Injection System (SIS) Actuation	CWY	4	Yes
41	Manual EFWS Isolation	CWY	4	Yes
42	Manual EFWS System Actuation	CWY	4	Yes

Table 2.4.1-3—Protection System Automatic Reactor Trips

RT on Low PZR Pressure
RT on High PZR Pressure
RT on High PZR Level
RT on Low Hot Leg Pressure
RT on Low SG Pressure
RT on High SG Pressure
RT on High SG Pressure Drop
RT on Low SG Level
RT on High SG Level
RT on High Containment Pressure
RT on High Linear Power Density (HLPD)
RT on Low Departure from Nucleate Boiling Ratio (DNBR)
RT on Low DNBR and (Imbalance or Rod Drop)
RT on Low DNBR and Rod Drop
RT on Low DNBR- High Quality
RT on Low DNBR-High Quality and (Imbalance or Rod Drop)
RT on High Neutron Flux Rate of Change
RT on High Core Power Level (HCPL)
RT on Low Reactor Coolant System (RCS) Loop Flow Rate (Two Loops)
RT on Low-Low RCS Loop Flow Rate (One Loop)
RT on Low RCP Speed in Two Loops
RT on High Neutron Flux Intermediate Range (IR)
RT on Low Doubling Time Intermediate Range(IR)
RT on Low Saturation Margin
RT on SIS Actuation
RT on Emergency Feedwater System (EFWS) Actuation

Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features (2 Sheets)

SIS Actuation on Low PZR Pressure
SIS Actuation on Low ΔPSat
SIS Actuation on Low RCS Loop Level
RCP Trip on Low ΔP Over RCP and SIS Signal
RCP Trip on Containment Isolation Stage 2 Signal
Partial Cooldown Actuation on SIS Signal
LOOP Signal on a Bus Loss of Voltage
LOOP Signal on a Bus Degraded Voltage
EFWS Actuation on Low SG Level
EFWS Actuation on LOOP and SIS Actuation
EFWS Isolation on High SG Level
EFWS Isolation on SG Isolation Signal
Main Steam Relief Train (MSRT) Opening on High SG Pressure
MSRT Isolation (MSRIV, MSRCV) on Low SG Pressure
MSRT Setpoint Increase on SG Isolation Signal
Main Steam Isolation Valve (MSIV) Closure on High SG Pressure Drop
MSIV Closure on Low SG Pressure
MSIV Closure on SG Isolation Signal
Main Feedwater (MFW) Full Load Closure on High SG Level
MFW Full Load Closure on RT Confirmation
MFW Full Load and Startup Shutdown Isolation on SG Isolation Signal
MFW Startup and Shutdown Isolation on High SG Pressure Drop
MFW Startup and Shutdown Isolation on Low SG Pressure
MFW Startup and Shutdown Isolation on High SG Level for period of time following RT
Containment Isolation Stage 1 on High Containment Pressure
Containment Isolation Stage 1 on SIS Actuation
Containment Isolation Stage 2 on High Containment Pressure
Containment Isolation on High Containment Activity
EDG Actuation on LOOP Signal
EDG Actuation on SIS Actuation
First PSV Opening on High HL Pressure
Second PSV Opening on High HL Pressure
CVCS Charging Line Shutdown on High PZR Level (two stages)
CVCS Isolation on Anti-Dilution (Shutdown state with no RCP running)

Table 2.4.1-4—Protection System Automatically Actuated Engineered Safety Features (2 Sheets)

CVCS Isolation on Anti-Dilution (Standard shutdown state)
CVCS Isolation on Anti-Dilution (at power)
SG Isolation on Partial Cooldown signal and High SG Level
SG Isolation on Partial Cooldown signal and High Main Steam Activity
Control Room Heating Ventilation Air Conditioning (HVAC) Isolation and Filtering on High Intake Activity
Turbine Trip on RT Confirmation

Table 2.4.1-5—Protection System Manually Actuated Functions

Reactor Trip
SIS Actuation
Partial Cooldown Actuation
MSRT Actuation
MSRT Isolation
MSIV Isolation
MFW Isolation
Containment Isolation
SG Isolation
Control Room HVAC Isolation and Filtering
EDG Actuation
EFWS Isolation
EFWS Actuation

Table 2.4.1-6—Protection System Operating Bypasses (2 Sheets)

RT Functions:
RT on High Linear Power Density (HLPD)
RT on Low DNBR
RT on Low DNBR and Imbalance or Rod Drop
RT on Low DNBR and Rod Drop
RT on Variable Low DNBR and Insertion Signal
RT on Low DNBR- High Quality
RT on Low DNBR-High Quality and (Imbalance or Rod Drop)
RT on Low Loop Flow Rate (Two Loops)
RT on Low-Low Loop Flow Rate (One Loop)
RT on Low RCP Speed in Two Loops
RT on Low PZR Pressure
RT on HCPL
RT on Low Saturation Margin
RT on High Neutron Flux Intermediate Range
RT on Low Doubling Time Intermediate Range
RT on Low HL Pressure
RT on Low SG Pressure
RT on Low SG Level
RT on High SG Level
RT on EFWS Actuation
RT on High PZR Level
Engineered Safeguard Functions:
SIS Actuation on Low PZR Pressure
SIS Actuation on Low ΔPSat
SIS Actuation on Low RCS Loop Level
CVCS Charging Isolation on High PZR Level
CVCS Isolation on Anti-Dilution (Shutdown state with no RCP running)
CVCS Isolation on Anti-Dilution (Standard shutdown state)
CVCS Isolation on Anti-Dilution (at power)
Partial Cooldown Actuation on SIS Signal
EFWS Actuation on Low SG Level
EFWS Actuation on LOOP and SIS Signals
EFWS Isolation on High SG Level

Table 2.4.1-6—Protection System Operating Bypasses (2 Sheets)

MSRT Isolation on Low SG Pressure
Main Feedwater (MFW) Full Load Closure on High SG Level
MFW Startup and Shutdown Isolation on High SG Level for period of time following RT
MFW Startup and Shutdown Isolation on Low SG Pressure
MSIV Closure on Low SG Pressure
First PSV Opening on High HL Pressure
Second PSV Opening on High HL Pressure
SG Isolation

Table 2.4.1-7—Protection System Permissives

Permissive	Validation (Manual / Automatic)	Inhibition (Manual / Automatic)
P2	Automatic	Automatic
P3	Automatic	Automatic
P5	Automatic	Automatic
P6	Manual	Automatic
P7	Automatic	Automatic
P8	Automatic	Automatic
P12	Manual	Automatic
P13	Manual	Automatic
P14	Manual	Manual
P15	Manual	Automatic
P16	Manual	Automatic
P17	Manual	Automatic

Table 2.4.1-8—Protection System Interlocks

RHR Suction Valves
MHSI Large Miniflow Line Valves
Safety Injection Accumulator Valves

Table 2.4.1-9—Protection System ITAAC (5 Sheets)

Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
2.1	PS equipment is located as listed in Table 2.4.1-1.	Inspections will be performed of the location of the PS equipment.	The equipment listed in Table 2.4.1-1 is located as listed in Table 2.4.1-1.
2.2	Physical separation exists between the four divisions of the PS.	Inspections will be performed to verify that the divisions of the PS are located in separate safeguard buildings	The four divisions of the PS are located in separate safeguard buildings.
3.1	Equipment identified as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.	a. Type tests, analyses or a combination of type tests and analyses will be performed on the equipment listed as Seismic Category I in Table 2.4.1-1 using analytical assumptions, or under conditions, which bound the Seismic Category I design requirements.	a. Tests/analysis reports exist and conclude that the equipment listed as Seismic Category I in Table 2.4.1-1 can withstand seismic design basis loads without loss of safety function.
		b. Inspections will be performed of the as-installed Seismic Category I equipment listed in Table 2.4.1-1 to verify that the equipment including anchorage is installed as specified on the construction drawings.	b. Inspection reports exist and conclude that the as-installed Seismic Category I equipment listed in Table 2.4.1-1 including anchorage is installed as specified on the construction drawings.
4.1	The PS generates an automatic RT signal for each of the parameters identified in Table 2.4.1-3.	Tests will be performed on the as- built PS using test signals to simulate the RT functions listed in Table 2.4.1-3.	The PS generates an automatic RT signal for each of the parameters identified in Table 2.4.1-3.
4.2	The PS generates automatically actuated engineered safety feature signals, as identified in Table 2.4.1-4.	Tests will be performed on the as- built PS using test signals to simulate the engineered safety feature functions listed in Table 2.4.1-4.	The PS generates automatic actuation of engineered safety feature signals, as identified in Table 2.4.1-4.
4.3	The PS provides operating bypasses for the functions identified in Table 2.4.1-6.	Tests will be performed on the as- built PS using test signals.	The PS provides operating bypasses for the functions identified in Table 2.4.1-6.

Table 2.4.1-9—Protection System ITAAC (5 Sheets)

Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
4.4	Communication independence is provided in the inter-division communication paths within the PS.	Type tests, tests ,analyses or a combination of tests and analyses will be performed on components that establish communication independence in the inter-division communication paths within the PS	A verification and validation (V&V) report exists and concludes that communication independence exists in the inter-division communications paths within the PS.
4.5	Bypassed or inoperable PS channels status information is retrievable in the MCR.	A test of the as built PS will be performed.	Bypassed or inoperable PS channels status information is retrievable in the MCR.
4.6	Setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a methodology that addresses the determination of applicable contributors to instrumentation loop errors, the method in which the errors are combined, and how the errors are applied to the design analytical limits.	a. An inspection will be performed to verify the existence of an established methodology for determining the PS setpoints. b. An analysis will be performed to verify that the PS setpoints are determined using the documented methodology.	a. An established methodology for determining PS setpoints exists. b. A report exists and concludes that the PS setpoints associated with the automatic reactor trips listed in Table 2.4.1-3 and the automatically actuated engineered safety features listed in Table 2.4.1-4 are determined using a documented methodology: (1) For the determination of applicable contributors to instrument loop error. (2) For combining instrument loop errors. (3) For how the errors are applied to the design analytical limits.
4.7	The PS receives input signals from the sources listed in Table 2.4.1-2.	Tests will be performed using simulated signals.	The PS receives the input signals listed in Table 2.4.1-2.
4.8	The PS provides signals to the non safety related control systems through electrical isolation devices.	Inspections will be performed on the existence of the electrical isolation devices.	Electrical isolation devices exist in the signal path from the PS to the non safety related control systems.

Table 2.4.1-9—Protection System ITAAC (5 Sheets)

Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
4.9	Electrical isolation devices exist in the data communication paths between the PS and the non safety related displays and controls.	Inspections will be performed on the existence of the electrical isolation devices.	Electrical isolations devices exist in the data communication paths between the PS and the non safety related displays and controls.
4.10	The PS equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.	Type tests, tests, analyses or a combination of these will be performed on the Class 1E equipment listed in Table 2.4.1-1.	A report exists and concludes that the equipment listed as Class 1E in Table 2.4.1-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.
4.11	Controls exist in the MCR that allow manual actuation, at the system level, of the functions identified in Table 2.4.1-5.	a. Inspections will be performed to verify the existence of controls in the MCR . b. Tests will be performed to verify the correct functionality of the controls in the MCR.	a. Controls exist in the MCR that allow manual actuation at the system level of the functions listed in Table 2.4.1-5. b. For each function in Table 2.4.1-5, the correct actuation signals are present at the output of the PS actuation logic units (ALU) after the corresponding controls in the MCR are manually activated.
4.12	Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives listed in Table 2.4.1-7.	a. Inspections will be performed to verify the existence of controls in the RSS. b. Tests will be performed to verify the correct functionality of the controls in the RSS.	a. Controls exist in the MCR and RSS to allow validation or inhibition of manual permissives listed in Table 2.4.1-7. b. For each of the manual permissives in Table 2.4.1-7, the correct permissive status is present in the PS actuation logic units (ALU) after the corresponding controls in the MCR and RSS are manually activated.
4.13	The PS interlocks exist as provided in Table 2.4.1-8.	Tests will be performed on the operation of the interlocks listed in Table 2.4.1-8.	The PS interlocks exist as provided in Table 2.4.1-8.

Table 2.4.1-9—Protection System ITAAC (5 Sheets)

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
4.14	The PS hardware and software are developed using a design process composed of five life cycle phases with each phase having design outputs which must conform to the requirements of that phase. The five life cycle phases are the following: 1) Basic design phase. 2) Detailed design phase. 3) Manufacturing phase. 4) Testing phase. 5) Installation and commissioning phase.	a. Inspections will be performed to verify that the PS basic design phase process has design outputs. b. Analyses will be performed to verify that the design outputs for the PS basic design phase conform to the requirements of that phase. c. Inspections will be performed to verify that the PS detailed design phase process has design outputs. d. Analyses will be performed to verify that the design outputs for the PS detailed design phase conform to the requirements of that phase. e. Inspections will be performed to verify that the PS manufacturing phase process has design outputs. f. Inspections will be performed to verify that the PS testing phase process has design outputs. g. Analyses will be performed to verify that the design outputs for the PS testing phase conform to the requirements of that phase. h. Inspections will be performed to verify that the PS installation and commissioning phase process has design outputs.	a. A report exists and provides the design outputs for the basic design phase of the PS hardware and software design process. b. A verification and validation (V&V) report exists and concludes that the design outputs conform to the requirements of the PS basic design phase. c. A report exists and provides the design outputs for the detailed design phase of the PS hardware and software design process. d. A V&V report exists and concludes that the design outputs conform to the requirements of the PS detailed design phase. e. A report exists and provides the design outputs for the manufacturing phase of the PS hardware and software design process. f. A report exists and provides the design outputs for the testing phase of the PS hardware and software design process. g. A V&V report exists and concludes that the design outputs of the testing phase conform to the requirements of the PS testing phase. h. A report exists and provides the design outputs for the installation and commissioning phase of the PS hardware and software design process.

Table 2.4.1-9—Protection System ITAAC (5 Sheets)

Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
		i. Analyses will be performed to verify that the design outputs for the PS installation and commissioning phase conform to the requirements of that phase.	i. A V&V report exists and concludes that the design outputs of the PS installation and commissioning phase conform to the requirements of the installation and commissioning phase.
4.15	Controls exist in the RSS that allow manual actuation of RT.	a. Inspections will be performed to verify the existence of controls in the RSS. b. Tests will be performed to verify the correct functionality of the controls in the RSS.	a. Controls exist in the RSS that allow manual actuation of RT. b. The correct actuation signals are present at the RT devices after the corresponding controls in the RSS are manually activated.
5.1	The components identified as Class1E in Table 2.4.1-1 are powered from the Class 1E division as listed in Table 2.4.1-1 in a normal or alternate feed condition.	a. Testing will be performed for components identified as Class 1E in Table 2.4.1-1 by providing a test signal in each normally aligned division. b. Testing will be performed for components identified as Class 1E in Table 2.4.1-1 by providing a test signal in each division with the alternate feed aligned to the divisional pair.	a. The test signal provided in the normally aligned division is present at the respective Class 1E components identified in Table 2.4.1-1. b. The test signal provided in each division with the alternate feed aligned to the divisional pair is present at the respective Class 1E components identified in Table 2.4.1-1.

Next File